THE

VOYAGE OF H.M.S. CHALLENGER.

NARRATIVE—VOL. I.

SECOND PART.

Permanent Phototype.

Crater of Kilauea, Mona Loa.

REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND THE LATE

CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF

THE LATE

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DIRECTOR OF THE CIVILIAN SCIENTIFIC STAFF ON BOARD

AND NOW OF

JOHN MURRAY

ONE OF THE NATURALISTS OF THE EXPEDITION

NARRATIVE—VOL. I.

SECOND PART.

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NARRATIVE

OF THE

CRUISE OF H.M.S. CHALLENGER

WITH A

GENERAL ACCOUNT OF THE SCIENTIFIC RESULTS OF THE EXPEDITION

BY

STAFF-COMMANDER T. H. TIZARD, R.N.; PROFESSOR H. N. MOSELEY, F.R.S.;
MR. J. Y. BUCHANAN, M.A.; AND MR. JOHN MURRAY, PH.D.;
MEMBERS OF THE EXPEDITION.

Partly Illustrated by Dr. J. J. WILD, Artist to the Expedition.

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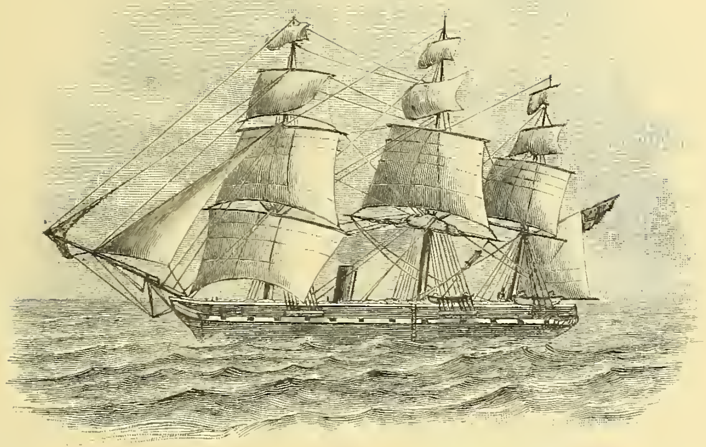


H.M.S. Challenger—Shortening Sail to Sound.

CHAPTER XIII.

Fiji Islands to the New Hebrides Islands—Halobates—Api—The Macrura—Raine Island—Cape York—Arrou Islands—Ki Islands—Banda Group.

Fiji Islands to the New Hebrides.

On the 11th August 1874, at 6 p.m., after swinging for magnetic purposes, the ship finally left the Fiji Islands, all sail being made to the westward. Mount Washington was in sight all day.

On the 12th, at 6 a.m., a sounding, trawling, and temperatures were taken in 1350 fathoms, at Station 175 (see Sheet 27). The trawl caught at the bottom, but was successfully cleared and brought to the surface at 3 p.m.

On the 15th another sounding and serial temperatures were taken in 1450 fathoms. From the 11th to the 15th, wet changeable weather was experienced, the wind blowing chiefly from N.E., but never remaining steady. On the 13th the fore topgallant mast and flying jib-boom were carried away in a rain squall before sail could be shortened.

The deposits at 1350 and 1450 fathoms were Globigerina oozes of a reddish colour, closely resembling the red clays in that respect. They contained respectively 45 and 61 per cent. of carbonate of lime, consisting of Rhabdoliths, Coccoliths, the shells of *Globigerina, Orbulina, Hastigerina, Pulvinulina, Sphæroidina, Pullenia*, and some bottom-living species. A few of the *Globigerina* shells had still the delicate spines attached as in the specimens taken on the surface. The absence of Pteropod, Heteropod, and other pelagic Molluscan shells from these deposits is somewhat remarkable, for they were very abundant on the surface, and at a similar depth and latitude in the Atlantic they were usually present in considerable numbers. The Foraminifera shells were in some instances quite white, or with a rosy tinge as if lately fallen from the surface, but the great majority were brown coloured, and in some instances black, from a deposit of oxide of manganese on their surface. When one of these dark coloured shells from 1450 fathoms is broken, three zones can be distinguished: at the centre an internal cast of the shell, then the white carbonate of lime shell itself, and outside this an external cast of the same nature and aspect as the internal one, to which it is connected by little red pillars which fill up the foramina of the shell. These casts do not appear to be formed by a simple filling of the shell, but to be due to a chemical combination. There were in these deposits none of the smooth pale yellow and green casts so abundant in the green muds along continental shores. If the brown casts be treated with warm hydrochloric acid and the iron thus extracted, a number of colourless globules are obtained, which have resisted the action of the acid. It has been found that these casts consist of a hydrated silicate containing alumina, lime, magnesia, and alkalies. The mean diameter of the minerals in these deposits—felspars, black mica, augite, hornblende, and magnetite—rarely exceeded 0·05 mm. The great bulk of the residue, however, after removal of the lime, consisted of pumice stone in a fine state of division, with argillaceous matter. Radiolarians and Diatoms made up about 2 per cent. of the whole deposit.

The trawling at 1350 fathoms gave a few deep-sea animals, many rounded fragments of pumice covered with oxide of manganese, and the branch of a tree several feet in length which was carbonised in some places.

There were many very productive hauls with the surface nets between the Fiji Islands and the New Hebrides, Pteropods, Heteropods, and pelagic Foraminifera being specially abundant. With the exception of a very large cylindrical species of *Etmodiscus,* Diatoms were very rare both on the surface and at the bottom. It was observed that the larger Foraminifera, such as *Sphæroidina dehiscens, Pulvinulina menardii,* and thick shelled *Orbulinæ,* were procured in greatest abundance when the tow-net was dragged at a depth of 80 or 100 fathoms.

On one occasion the otter trawl was towed for some time from the lower boom, a short distance beneath the surface. It was not so successful in catching fish as was hoped; it contained, however, large masses and strings of jelly, which on examination turned out to be the eggs of a Cephalopod.

Flying Fish (*Exocetus*) were especially abundant during this trip, and at night frequently dashed on board ship near the exposed lights.

Halobates.—Specimens of this insect, of which very many were collected during the cruise, were especially abundant on the surface between the Fijis and the New Hebrides. This group of Hemiptera is interesting as containing (along with the allied genus

Halobatodes) the only insects with an organisation adapted to a truly pelagic mode of life. The head, in addition to the antennæ (fig. 179, *a*), bears three tubercles on either side, surmounted by a single hair, but of unknown function. The mandibles are pointed and serrated, and serve to puncture the creatures upon which they feed, whilst they suck out the juices through a kind of tubular proboscis formed by the united maxillæ. The thorax forms by far the largest part of the body; the first segment is transverse and collar-like, the second and third elongated and fused, and produced behind and below into the acetabula with which the hinder legs are articulated (fig. 179, ♂, ♀). The abdomen is larger in the male than in the female; it consists of six ring-like segments followed by three others specially modified (fig. 179, *g*, *g.a*). The abdomen of the female consists of

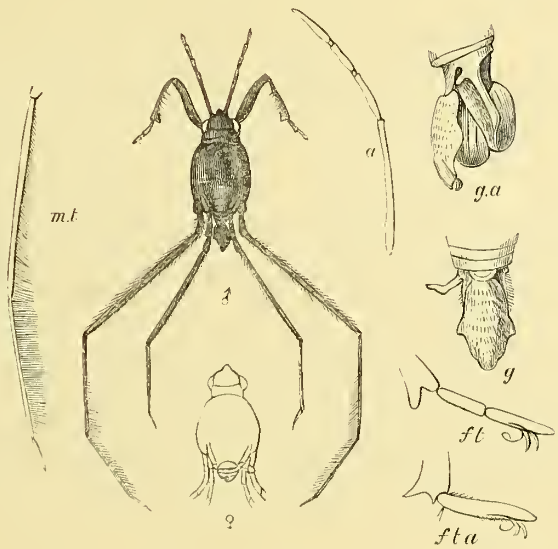


Fig. 179.—*Halobates wüllerstorffi*, Frauenfeld.
♂, Male, upper side; ♀, outline of the body of the female; *a*, antenna; *ft*, front tarsus; *fta*, front tarsus of the larva; *m.t*, middle tibia and tarsus; *g*, genital segments of the male, from above; *g.a*, the same in profile.

the same number of segments and carries an ovipositor made up of four valves; in both sexes the ventral surface of the first segment bears a curious tubercle whose extremity is pierced by a transverse perforation. The fore-legs are short, and for the greater part of their length lie well in advance of the body, without being raptorial they are fitted for grasping; and the second joint of the tarsus is furnished with two curved sharp-pointed claws, as well as a thin ribbon-like process (fig. 179, *ft*). The two hinder legs are long, and by their means the little creatures scud over the surface of the water.

The tarsus of the middle legs (fig. 179, *m.t*) has a fringe of long hairs, which probably serves to aid the animal in swimming or to prevent its being so readily driven by the wind.

The genus was first founded by Eschscholtz in 1822 for the reception of three species taken during von Kotzebue's voyage round the world; at present it appears from the investigations of Dr. F. Buchanan White[1] to contain eleven species, of which six were discovered by the Challenger. The allied genus *Halobatodes* contains four species, two being new, but only one is certainly known to be marine.

They appear to live upon the juices of dead animals floating upon the surface. Some species, at all events, have the power of diving, and have been seen to do so in order to avoid being captured.

Their distribution is very wide, for they occur in all the great oceans. Mr. Murray noted their occurrence twenty-one times in the Atlantic between the parallels of 35° N. and 20° S., and thirty-eight times in the Pacific between lats. 37° N. and 23° S., so that they would seem to be confined to the warmer waters of the ocean. The region between the eastern part of the Indian Ocean and the Western Pacific seems to be the metropolis of the genus, nine out of the eleven known species occurring there, and five nowhere else; it is also interesting to note that the species of the genus *Halobatodes* occur in this region.

It is very desirable that those who have the opportunity should make further investigations into their life-history and habits, especially with respect to:—

1. Their food and the manner in which it is seized and retained.

2. The manner of locomotion, and especially whether all species have the power of diving. Experiments might also be made as to the effects of compulsory submergence.

3. What enemies they have, and what means of defence.

4. The use of the peculiar tubercles on the head, the perforated tubercle of the abdomen, and the ribbon-like process connected with the claws of the tarsi.

The New Hebrides.

On the 17th August, at noon, the island of Tongariki, one of the New Hebrides, was sighted ahead, and shortly after Makura Island on the port bow. A course was shaped to pass between Makura and Three Hills Island, the wind being a fresh trade, with numerous rain squalls. At 5.45 P.M., having cleared the channel between Makura and Three Hills Island, sail was shortened to topsails, and the vessel "hove to" on the port tack. The weather, being thick and rainy, was not very favourable for making observations, but, so far as could be ascertained, the islands of Tongariki, Bunina, Three Hills, Makura, Two Hills, and Monument, are correctly placed relatively to each other in Admiralty chart 1380, and the positions assigned them cannot be far out.

The island of Tongariki has a high solitary peak on its northeast end, while the western part is flat-topped and about 400 feet high; Bunina Island is round-backed, and about

[1] F. Buchanan White, Report on the Pelagic Hemiptera, Zool. Chall. Exp., part xix., 1883.

500 feet high; Three Hills Island is readily distinguished, the peaks all being high, the middle one the lowest; there is not much difference in their height, and the saddles between them are comparatively low. Two Hills Island has one sharp peak on its north side, the other hill is flat-topped and comparatively low, and between the two hills the island is very low, so that seen from a distance this island appears as two. The Monument is a small high rock with precipitous sides. Makura Island is wedge-shaped, "steep-to" to the southward, sloping to the northward, its summit bare, but on the northern slope are bushes and trees, and at its northwest point a small sandy beach; the sea was seen to break against the island itself, so that it can have but a very small fringing reef, if any. Occasionally through the rain squalls a lofty peak was seen, which by its bearing must have been on the east side of Sandwich Island. Westward of Three Hills Island and Two Hills Island no bottom could be obtained at 250 fathoms.

At 1.30 A.M., on the 18th, the ship wore and "hove to" on the starboard tack. At 6 A.M. Two Hills Island bore E. $\frac{1}{4}$ S., and the left peak of Three Hills Island N.E. $\frac{1}{2}$ E., and a course was shaped to pass westward of Cook's Reef, which, however, was not seen. At 7 A.M., when Three Hills Island bore east, a course was shaped for the southwest point of Api Island, as some natives of the New Hebrides had been brought from the Fiji Islands to be landed at Api. At 8 A.M. the right extremity of Api Island bore N. 72° E., and the left extremity, the Foreland, N. by W. $\frac{1}{2}$ W.; from this position the ship was steered along the west coast a short distance, and at 9 A.M. sails were furled and the vessel steamed in towards the land. At this time, when the right extremity of Api bore S. 57° E., the apex of the Foreland N. 9° W., and a high hill over the coast N.E. by E., a sounding was obtained in 130 fathoms, hard ground, about $1\frac{1}{2}$ miles off the shore. Steering in eastwards towards the land, soundings of 125, 95, 55, and eventually 15 fathoms were successively obtained, the latter close to a reef which fringes the point next north of the S.W. point of the island, and extends about $1\frac{1}{2}$ cables from the shore. This being the spot where the Api men wished to be landed, an armed boat was sent in to the shore as the natives were reported to be treacherous; they proved, however, friendly enough, coming down to the beach with green branches, bows and arrows, and other weapons, so in the afternoon the officers and naturalists landed, whilst the ship dredged in the offing, there being no secure anchorage (see fig. 180).

Api lies south of Ambrym and Malicolo, between these islands and Efate or Sandwich Island, and in about the same latitude as the northern part of the Fiji group. The island is upwards of 20 miles long, and its highest peak is about 1500 feet above the sea level. The island rises in steep slopes from the sea, with only here and there a stretch of flat shore land, and consists of a series of peaks and steep-sided valleys and ridges. The whole is entirely covered with the densest possible vegetation, except on very small spots with difficulty discerned with a glass, where plots are cleared by the natives for cultivation. The ship steamed close in to the island, opposite a spot where a valley terminated towards the sea with a widened mouth, evidently containing a river. There was a stretch of flat land at the bottom of the valley on which were conspicuous amongst the other foliage some cocoanut trees and another species of palm.

As the vessel came near natives appeared on the shore, some hiding in the bushes, others running along at full speed, whilst some shouted a loud "hoa." One man stood on the shore and waved a green branch with untiring perseverance. These natives were said to be hostile and dangerous, a character which they have fully proved themselves worthy of since the visit of the Expedition, and therefore Captain Nares' boat, the first which landed, was armed. The returned labourers, however, acted as an introduction and

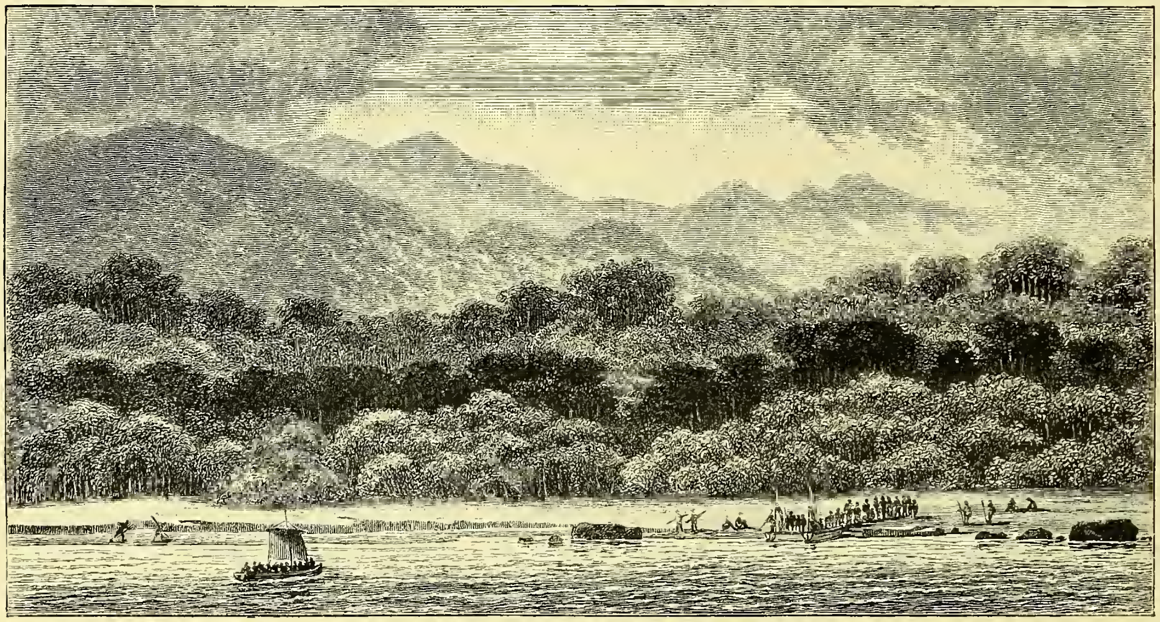


Fig. 180.—Landing of natives at Api, New Hebrides.

made matters smooth; still, as all the natives were armed, either with bows and poisoned arrows, clubs, or trade muskets, and as the inhabitants of these islands are noted for treachery, no one was allowed to leave the beach. Thus very little was seen of this island, which had certainly never been landed on before by any scientific man or naval officer.

The shore is formed of a banked-up beach, composed of small fragments of volcanic rock and volcanic sand, mingled with a large proportion of coral fragments, and is fringed by a narrow shore platform of coral, which, near the place of landing, was not much more than 100 yards wide. This shore reef is remarkable for its extreme flatness. Almost everywhere the living corals embedded in it are growing only laterally, the upper surfaces being dead from want of sufficient depth of water. In some small specimens of a massive *Porites* the consequent flattening of the top and the expansion of the lateral dimensions were most excellently shown in pieces convenient for museum purposes.

The corals, which were few in number as regards species, were finer grown towards the outer verge of the reef, as is always the case on shore platforms, and on the outer edge of barrier reefs. In some places were deep holes in the coral platform, reminding one of glacier crevasses on a small scale, evidently arising from the loose nature of the sloping beach on which the coral structure here rests. On the reef lay weathered remains of a more ancient shore platform which were honeycombed and wave-worn. The rock composing them was, however, undoubtedly *in situ*, and proved elevation of the island to the extent of five feet or so. Similar fragments of raised reef were found by Mr. Murray a short distance up the bed of the stream already mentioned. Some specimens of *Porites* were unattached, though living, being in the form of rounded masses entirely covered with living polyps, and probably from time to time rolled over by the waves; an *Alcyonium* occurs on the coasts of England also forming rounded unattached colonies which are rolled about from place to place on the sand. They call to mind the similarly detached rounded masses formed by some Lichens (*Lecanora esculenta*) which are carried about over the land by the winds as are these coral colonies by the waves.

On the reefs were comparatively few free-living animals, but one of the huge *Synaptæ*, so abundant amongst the East Indian Islands and at the Philippines, was met with. The animal was a yard long and two inches in diameter, and looked like an ugly brown and black snake.

Above the shore the first land plant met with was the ubiquitous tropical littoral plant (*Ipomœa pes-capræ*), which is always the first plant above high water mark on these tropical shores. Above a skirting of this commenced a thick growth of rather large trees, a species of *Barringtonia*, a fig, and the common *Pandanus* of the Pacific Islands, occupies the shore margin. A few paces within the wood it was gloomy, from the thickness of the growth of trees and creepers overhead. The same climbing Aroids grow here as at Fiji, and a *Dracæna* was common, as also a beautiful climbing Asclepiad (*Hoya*) with white waxy flowers, and one or two ferns. The explorers were not permitted to penetrate the wood far enough to get any adequate idea of the nature of the vegetation.

The Api men wore as clothing nothing but a narrow bandage of dirty European fabric of various kinds. They are a small race, few being above five feet in height, and are much darker in colour than the Fijians; their limbs, and especially their legs, are small and badly shaped. Notwithstanding the bad character they have received, they seemed quiet enough. Several amongst those seen were returned labourers, and were at once known by their having fastened to their waist-cloth the key of the chest which every labourer brings back with him, containing the fruits of his toil, so that they thus retain, even in Api, the property for which they have worked. Two men joined the party on the reef, one of whom had been in Queensland, the other in Fiji; both spoke a good deal of English, and one said he was willing to go to Fiji again. Nearly all the men wore round their necks a small triangular ornament, cut out of one of the septa from the shell of the pearly *Nautilus*, and threaded by the hole through which the syphon passes. Many had broad flat tortoiseshell bracelets, and nearly all wore ear-rings made of narrow strips of tortoiseshell moulded into a flat spiral from which the tips of pigs' tails sometimes hung as ornaments.

The bows used by the natives are made of hard wood. The arrows are without feathers, but notched for the string, and made of reeds with heavy wooden ends, frequently with tips of human bone. The tips are all covered with poison, in the form of a black incrustation. The arrows have an elaborate and artistic coloured decoration in the binding round the part where the bone tips are inserted. They prize these arrows highly, and were unwilling to part with them. They carry them rolled up in an oblong strip of plantain leaf, and showed by signs that they considered the poison deadly, and were much in awe of it.

All the men have cicatrices on their bodies, usually representing a human face, and placed sometimes on the shoulder, but more often upon the breast, and sometimes on both breasts. They understood the value of the usual trade articles very well. Knives, tobacco, and pipes were what they wanted most, but they were not at all eager to trade, and few weapons or ornaments were obtained from them. The tortoiseshell bracelets they would not part with at any price.

It was very trying to the scientific staff of the Expedition to be obliged to leave a totally unknown island like Api after spending only two hours on shore.

Swallows (*Hirundo tahitica*) and Swifts (*Collocalia uropygialis*) were flying about in considerable numbers near the landing place. Specimens of a Kingfisher (*Halcyon juliæ*), a Shrike (*Artamus melaleucus*), and a Pigeon (*Carpophaga pacifica*) were also procured; and in addition to these a Heron, Tern, and a few other birds were observed. A Gannet (*Sula piscator*) which came on board had specimens of a Cephalopod (*Ommastrephes oualaniensis*) in its stomach.

Several Spiders[1] were obtained at Api:—*Epeira moluccensis*, Dol., *Epeira mangareva*, Walck., *Nephila victorialis*, L. Koch, *Meta* sp. ?, *Argyrodes* sp. ?, and *Trochosa* sp. ?; seven species of land shells[2] were collected, of which four are new:—*Pythia apiensis*, *Melania apiensis*, *Melania turbans*, and *Melania ordinaria*.

The landing place was in the bay north of the first point north of the southwest extremity of the island, on a steep black sandy beach a cable south of the entrance to a small stream, and inside a large coral border, the northernmost rock above water.

Whilst the officers and naturalists were on shore, some very rich hauls of the dredge

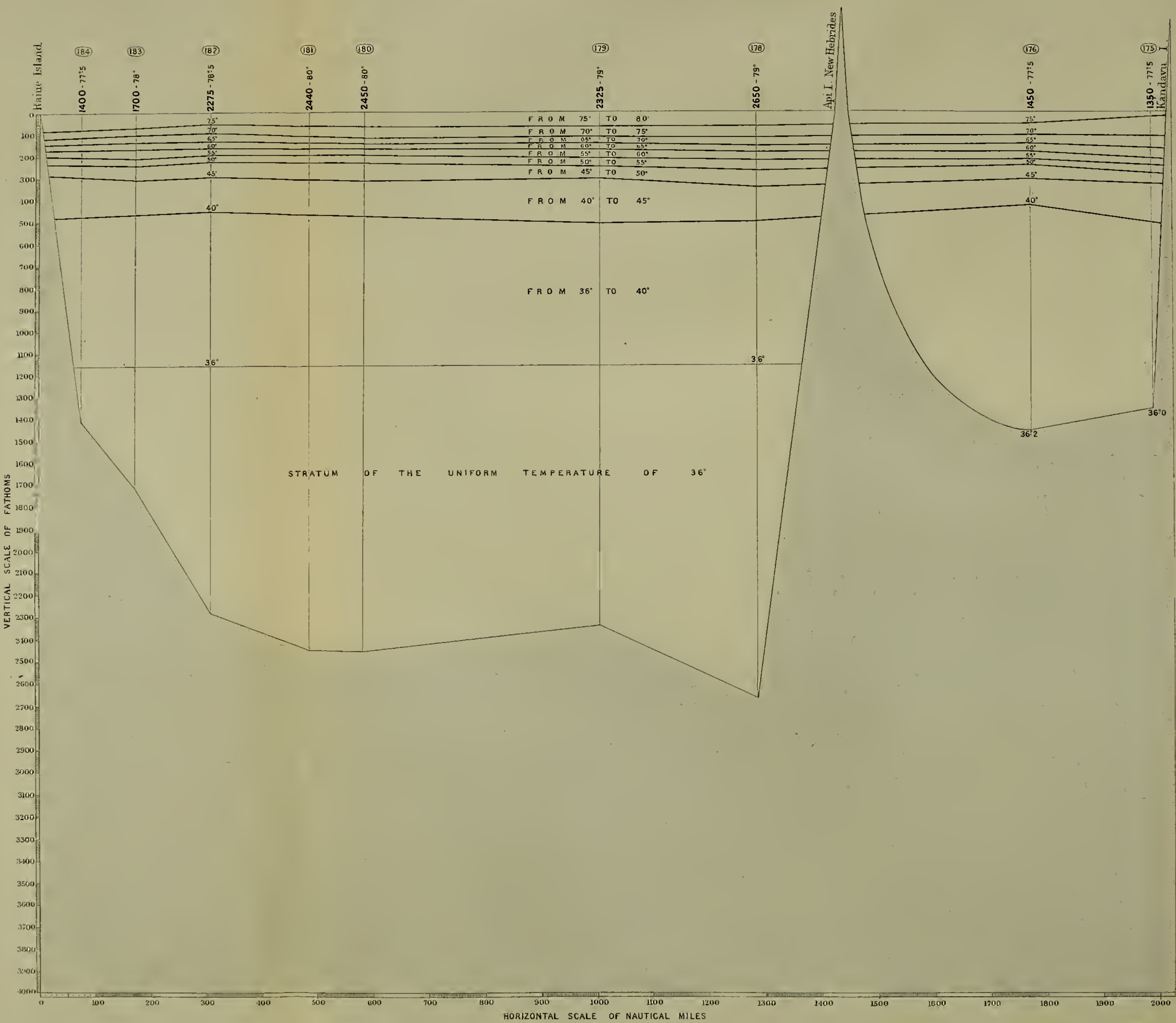
[1] Determined by Rev. O. P. Cambridge.

[2] E. A. Smith, *Proc. Zool. Soc. Lond.*, p. 268, 1884.

DIAGRAM 13

PACIFIC OCEAN . Longitudinal Temperature Section . Fiji Islands to the Barrier reef , Australia .

For explanation of Symbols see Appendix 1.



Engraved by Malby & Sons

and trawl were obtained, in depths varying from 63 to 130 fathoms, at a distance of from half a mile to a mile from the shore. The weather was squally, rainy, and cloudy all day, so that the summit of Api Island was not visible. So far as could be distinguished, the land was intersected by numerous deep ravines and water-courses, and covered with a rich vegetation.

At 4 P.M. the boats returned from the shore, and sail was made to the westward for Raine Island.

Api to Raine Island and Cape York.

On the 19th August, a sounding and serial temperatures were taken in 2650 fathoms. The bottom temperature here proved to be the same as that at 1300 fathoms, viz., 35°·8. Between Australia and New Zealand, and as far north as the 25th parallel, the temperature of the water at the bottom was 34°·5.

On the 21st a sounding and serial temperatures were obtained in 2325 fathoms, the thermometer at the bottom again registering the same as those at 1300 fathoms (36°·0).

On the 24th the depth was 2450 fathoms, and the temperature observations showed results similar to those on the 21st; the same phenomenon continued for the remainder of the Stations between the New Hebrides and Raine Island, at which depths of 2440, 2275, 1700, and 1400 fathoms were obtained (see Sheet 27).

The section from the Fiji Islands to Raine Island *via* Api Island shows that depths of 1400 fathoms exist between the Fiji and New Hebrides Islands, and of 2650 fathoms between the New Hebrides and Raine Island (see Diagram 13). The bottom shows a rapid fall from the Fijis and New Hebrides, but a very gradual rise to the Barrier Reef of Australia.

The bottom temperature the whole way from the Fiji group to the Barrier Reef was uniform at about 36°, and this temperature was also found at a depth of 1300 fathoms. There exists therefore between the New Hebrides and the Barrier Reef a mass of water 1300 miles long, and 1200 fathoms in depth, of the uniform temperature of 36°. The isotherms from the surface to the depth of 1300 fathoms are very nearly parallel, the isotherm of 40° occupying a mean depth of 480 fathoms, that of 50° a mean depth of 230 fathoms, that of 60° a mean depth of 160 fathoms, and that of 70° a mean depth of 100 fathoms. There can be little doubt that the uniform temperature of the water from the depth of 1300 fathoms to the bottom, between the New Hebrides Islands and Australia, is caused by the "Coral Sea" being cut off from the colder water by an elevated ridge on the floor of the ocean over which the greatest depth of water cannot exceed 1300 fathoms.

The deposits between the New Hebrides and Raine Island presented considerable variety, and were very interesting. At 2650 fathoms not a trace of carbonate of lime could be detected either by the microscope, or by treating the red clay with weak acid. At 2325 fathoms there was 32 per cent. of carbonate of lime, consisting of the dead shells of pelagic Foraminifera and a few Rhabdoliths. At 2450 fathoms there was 1 or 2 per cent. of carbonate of lime, consisting of a few broken fragments of Foraminifera. At 2440 fathoms there was a red clay on the surface with only a small percentage of carbonate of lime, but three inches beneath the surface a much lighter coloured deposit containing a very large number of Foraminfera. It very frequently happened during the cruise that the deeper layers contained less carbonate of lime than the surface ones, but only on two or three occasions were more calcareous shells noticed in the deeper layer of the deposit as in this case. The surface layer, it will be observed, was the same in nearly all respects as the deposit in 2450 fathoms 80 miles to the eastward, and the deeper layer resembled that at 2325 fathoms still farther to the eastward, or the deposits in a lesser depth towards Raine Island, which contained over 50 per cent. of carbonate of lime. It is clearly illustrated in this section, that all the other conditions remaining the same or nearly so, the quantity of carbonate of lime found in a deposit is less the greater the depth. It has been stated above that this basin below 1300 fathoms is probably cut off from the colder water farther south, and, indeed, from general oceanic circulation below that depth. In all such basins the surface shells appear to be removed from the deposits at lesser depths than in areas where there is no interruption to free communication arising from the existence of submarine barriers.

The mineral particles in these deposits consisted chiefly of angular fragments of volcanic rocks and minerals, all of small size except the pieces of pumice which were numerous in all the dredgings. There were many manganese particles, and, at the sounding in 1400 fathoms, some of the Foraminifera shells were filled with the peroxide of manganese, so that a complete internal cast of the shell was left after treatment with weak acid.

Amongst Cœlenterata two specimens of *Umbellula leptocaulis*, Köll., and one of *Bathyactis symmetrica*, Moseley, and of fishes a new genus of Ophidiidæ, *Typhlonus nasus*, Günth.,[1] and a new species of Stomiatidæ, *Echiostoma microdon*, Günth.,[2] were obtained with the trawl from 2440 fathoms, together with a few other animals.

The Ophidiid above mentioned had a large, rounded, fleshy head; no trace of an eye could be seen other than a small dark spot a considerable distance underneath the skin. The fins were black, but the body of the fish was white; with the exception of one or two, all the scales had been rubbed off, and with them apparently a thin, black skin, so that probably the fish when first caught by the trawl was of a uniform black colour; the mouth and gill chambers were black. The total length was 10 inches, depth at vent 2 inches.

[1] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. ii. p. 21, 1878. [2] *Ibid.*, p. 180.

The new species of *Echiostoma* was uniformly black, the total length being $9\frac{1}{2}$ inches. It showed signs of life when taken out of the trawl, so that probably it had not come from any great depth. It had one club-shaped spot of a rose colour directly below the eye, and another, about half the size, directly in front of this, of the same colour; these spots turned yellow in spirit. The two rows of probably phosphorescent dots along the body were red, surrounded by a circle of pale violet; these dots turned white in spirit.

It several times happened during the cruise that the back bone of a fish and some of the bones of the head were taken out of the trawl. These probably belonged to delicate deep-sea fish, the flesh of which had been completely torn away by the rapid passage of the trawl through the water.

At 1400 fathoms, some distance to the east of the Barrier Reef, there was a very successful trawling, a large number of deep-sea genera and species being obtained, together with many pumice stones and several cocoanuts. There were two other new genera of Ophidiidæ, *Bathynectes gracilis*, Günth.,[1] and *Aphyonus gelatinosus*, Günth.,[2] of which latter there were three specimens. The latter were transparent, the head round and gibbous; immediately behind the nostrils was a small dark spot at a considerable distance beneath the skin, which probably was the rudimentary eye. A Scopelid (*Alepocephalus niger*, Günth.[3]), 12 inches in length, was also obtained; the whole animal was of a light blue colour, of a deeper tint about the fins and gill covers.

The surface and subsurface waters in this region were teeming with life, all the usual tropical forms being found in great abundance. The list of animals obtained was nearly identical with that observed in the tropical regions of the Atlantic (see pp. 221, 222), although considerable differences were noticed in the relative abundance of the species. *Leptocephali* and young Pleuronectids were very numerous; some specimens of the former were 9 inches in length.

Birds were seldom seen when far from land, but on approaching shore Boatswain Birds, Gannets, Terns, and Frigate Birds were observed, the two former occasionally alighting on the ship.

On the 30th August, at 5 A.M., the position was ascertained by observations of Aldebaran, Sirius, and Canopus, and a course steered for Raine Island, which, as well as the Great Detached Reef, was sighted at noon. Contrary to expectation, only a slight northerly set was experienced, less than half a mile per hour, from 5 A.M. to noon. Previously to 5 A.M., the current was N. 18° E. (true), three quarters of a mile per hour. From the time of leaving the New Hebrides to the 29th August, the amount of current experienced was very little, the total set being N. 74° W., 36 miles in ten days. The ship was steered northward of Raine Island, so as to round it and ascertain whether there was good landing. Passing at a distance of a quarter of a mile from the north and west

[1] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. ii. p. 21, 1878. [2] *Ibid.*, p. 22. [3] *Ibid.*, p. 248.

sides, it was seen that landing was practicable, but this was put off until the next day, the ship standing to the southward, on the port tack, for the Great Detached Reef, anchoring there at 3.30 P.M., with the northwest point of the reef N. by E., distant half a mile, the depth being 20 fathoms.

The Macrura.—Mr. C. Spence Bate, F.R.S., who is preparing a Report on the

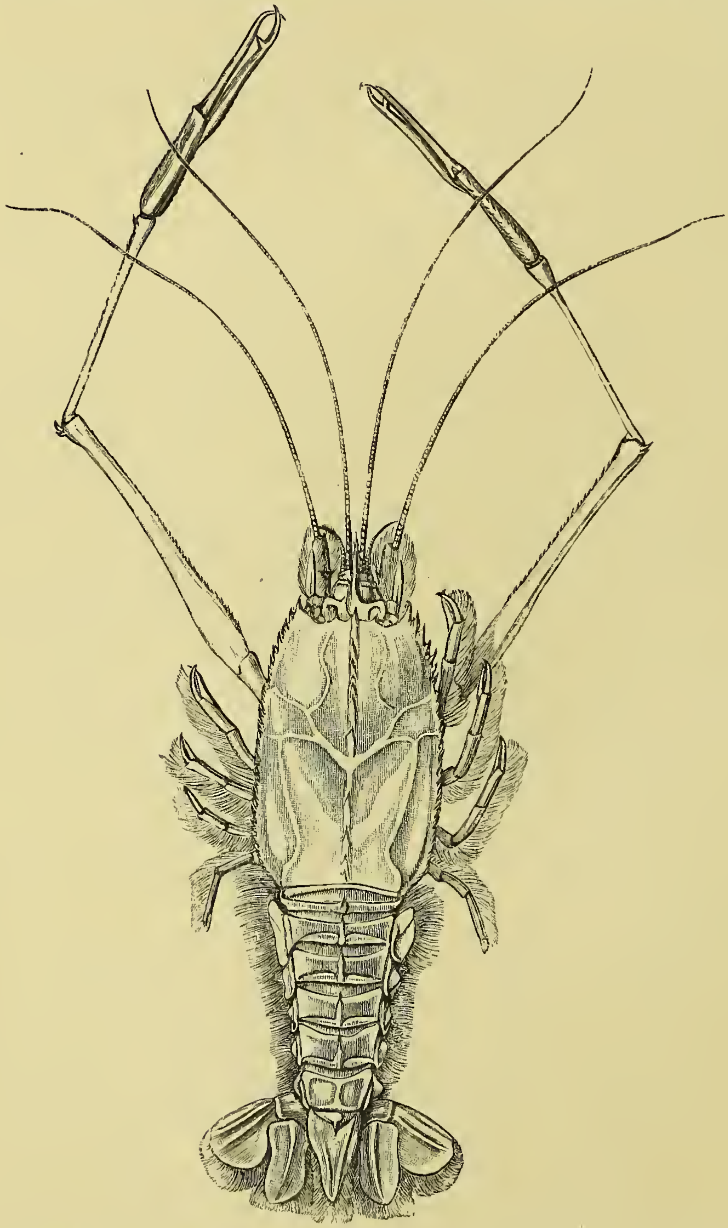


FIG. 181.—*Willemœsia leptodactyla*, Suhm; male, natural size. From 1900 fathoms, North Atlantic.

Macrurous Crustaceans, writes:—"Although several expeditions have recently explored the depths of the ocean, in special localities, the Challenger Expedition appears to have anticipated the discovery of nearly every characteristic form belonging to the group of animals that I have had to examine.

"In this order the new species amount to more than one hundred and fifty—about thirty in the Trichobranchiata, sixty in the Dendrobranchiata, and eighty in the Phyllobranchiata. But the great value of the Expedition consists not so much in the number of new genera and species added to our knowledge, as in the large amount of

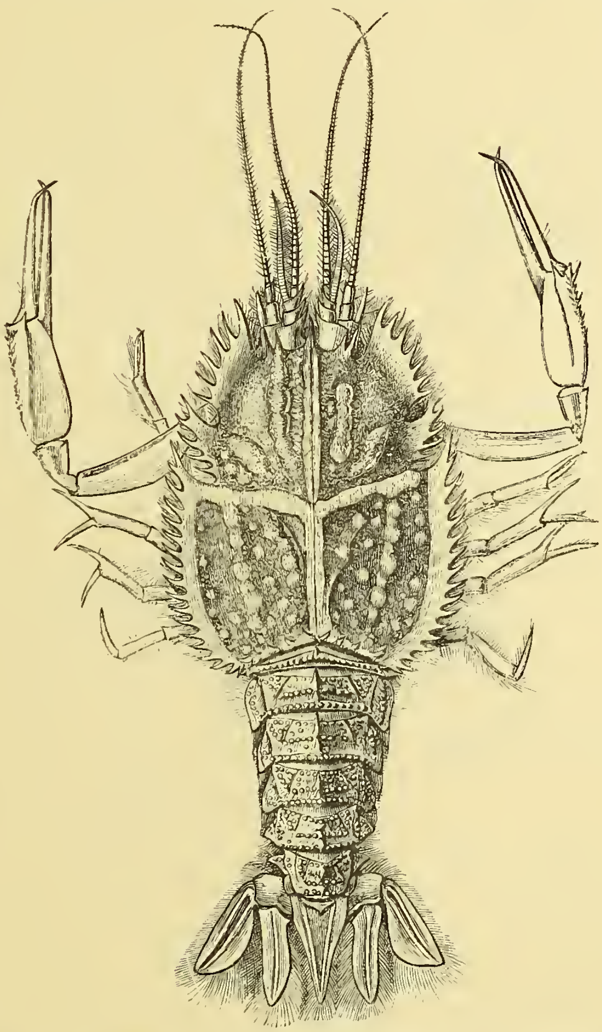


Fig. 182. —*Polycheles crucifera*, Suhm; twice the natural size. From 450 fathoms, off Sombrero, West Indies

information which has been obtained concerning the earlier stages of many Crustaceans and the conditions under which they exist.

"The family Polychelidæ bears a general appearance and close anatomical relation to that of the fossil *Eryon* from the lithographic limestones of Bavaria and the Lias of England. *Polycheles*, *Willemœsia*, and their congeners are inhabitants of the deepest parts of the ocean that have been explored with the dredge or trawl, and I believe there is little doubt that they have been brought up from the bottom of the sea, the largest specimens having been taken from the greatest depths. *Willemœsia leptodactyla* (see fig. 181) has been taken from a depth of 1900 fathoms, or rather more than two miles, both in the Pacific and Atlantic Oceans. *Polycheles,* which is represented by four species, has been taken in the Mediterranean and off the coast of Spain, in the Mid Atlantic, and off the Fiji Islands, as well as near the Kermadec and New Guinea groups. The beautiful *Polycheles crucifera* (see fig. 182) was captured in the West Indian seas.

"The closely-allied genus *Pentacheles,* which is represented by six species that differ from each other in no very remarkable degree in their external features, is scattered over a large area, the specimens being captured when the dredge or trawl was let down to depths ranging from 120 to 1070 fathoms. They were taken on the western shores of South America, around the broken coast, and in the channels between the rocky islands that lie along the shore, of Patagonia; among the Philippine Islands; from the deeper water around New Guinea; off the Fiji Islands; and from near the New Hebrides.

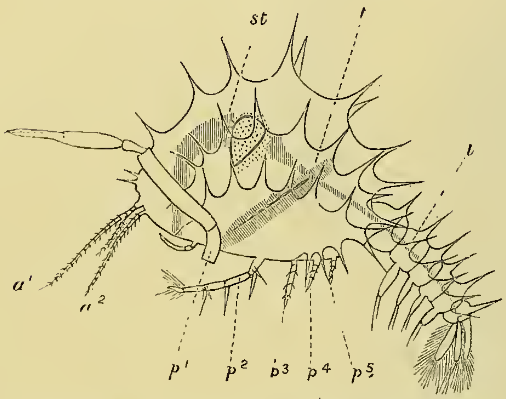


FIG. 183.—*Eryoneicus cæcus.* After a drawing by von Willemoes Suhm. a^1, first antennæ; a^2, second antennæ; p^1, p^2, p^3, p^4, p^5, perciopoda; *st*, stomach; *t*, testis(?); *i*, intestinal canal.

"The organs of vision are entirely absent in *Eryoneicus* (see fig. 183), and are so hidden in *Willemœsia* and the other genera that they were long supposed not to exist, and in the fossil representative they have not yet been detected.[1] It has generally been supposed that this rudimentary condition of the organs of vision in animals that live in deep waters is largely due to their being far beyond the reach of sunlight. The genus *Glyphocrangon,* in which the eyes are remarkable for their large and well-developed condition, was taken when the trawl was sent to great depths, and frequently associated with *Willemœsia;* and taking the several Stations from which species have been obtained, the average depth of the Willemœsian group is less than that of other deep-sea forms in which the eyes are large and conspicuous organs. An examination of the embryo before it has quitted the egg, shows that in its earliest stages of development the young has organs of vision conformable to the ordinary Crustacean type.

"The genus *Thaumastocheles* (fig. 184) taken by the Challenger in the West Indies is totally blind, without even the rudiment of an organ of vision. It is related to the genus *Calocaris* of the British seas, which has only very small visual organs, and is also allied to *Gebia.*

[1] In the typical *Eryon* eyes have never been preserved, but Dr. Woodward figures them as being present in a restored figure of *Eryon barrovensis,* M'Coy.

"*Phoberus*, a genus named by Professor A. Milne-Edwards, was first taken by the Challenger in about 500 fathoms of water in the West Indies; it is nearly allied to the genus *Nephrops*, which lives at no very great depth, and it grows to a considerable

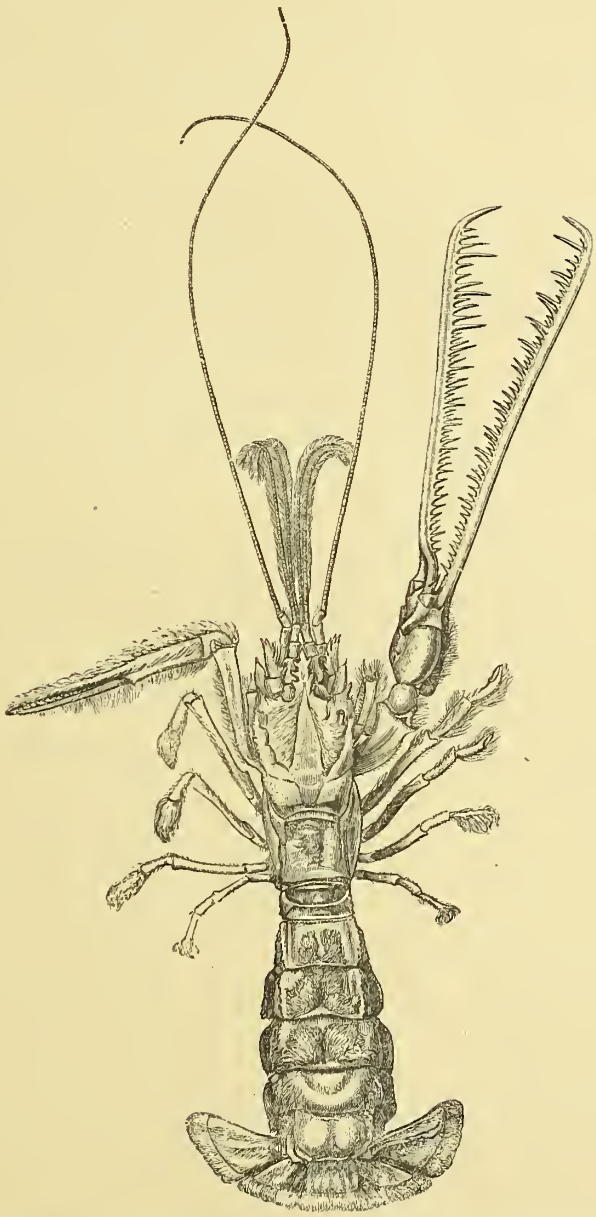


FIG 184.—*Thaumastocheles zaleuca*, Suhm; male, natural size. From 450 fathoms, off Sombrero, West Indies.

size, the Challenger specimen being eight inches in length, and that taken in the 'Blake' expedition being a little larger; the ophthalmopoda are reduced to the smallest dimensions, and the eye to a rudimentary condition.

"The genus of long-legged prawns to which A. Milne-Edwards has given the name of *Nematocarcinus* was frequently taken in the trawl when let down to great depths, and has a very extended geographical range. There are specimens from the following localities, the depths being the greatest reached by the trawl or dredge :—off the western and northwestern coast of Celebes Island, 255 to 2150 fathoms ; off Japan, 350, 560, 1875, and 3000 fathoms ; near the Island of Juan Fernandez, 1375 and 1450 fathoms ; in the Southern Ocean, 1260 fathoms; off the Kermadec and Fiji Islands, in 600 fathoms.

"The fact that the depths vary from 255 to 3000 fathoms suggests that the animals do not live at the greatest depths reached by the nets, but that they are caught while swimming in mid-water and brought to the surface. Two Stations with the greatest depths are not far distant from two or three of the shallower ones, hence in the same regions the species have either the power of living under very different conditions of temperature and bathymetrical influences, or they live suspended in the ocean over the greater depths. The several species brought home vary in points of little importance from each other, such as a longer or shorter rostrum, a shorter or a longer foot. They extend from the Polar regions to the Equator.

"One of the most abundant of specific forms is that of the genus *Alphæus,* in which I include those congeners that have been separated from it, more for the convenience of classification than on account of any structural value. It contains twenty recognised species, which with a single exception have been taken within a depth of 50 fathoms. They are mostly recorded from muddy bottoms, but they are also frequently found sheltered among masses of Sponge or Coral. I am induced, from the peculiar localities in which they are found, and the protected condition of their eyes, to believe that they burrow beneath the surface of the mud. They are mostly inhabitants of the warm seas, abounding in tropical and subtropical regions, becoming more scarce in the temperate, and gradually disappearing towards the cold temperate and Arctic regions. One species, *Betæus truncatus,* is recorded from Cape Horn, where it was dredged in about 10 fathoms. With this exception none has been observed farther south than New Zealand or 50° S. lat., or farther north than the English Channel or 50° N. lat. They are essentially a sublittoral form, for the instances of their having been taken in depths greater than 20 fathoms are few. *Alphæus avarus* in the Challenger collection is recorded as having been twice taken off the coast of Australia, once at a depth of 8 fathoms, and once when the dredge had been sent down to 2675 fathoms.

"The members of the Penæid division exist most numerously in the open waters of the ocean, some genera passing their whole existence within 100 fathoms of the surface; others are found as constantly in deep water below 300 fathoms, while others again appear to exist in the more remote abysses of the deepest parts of the ocean in close contact with the sea bottom.

"The numerous species of *Sergestes* together with those of the allied forms *Acetes* and *Leucifer* exist everywhere in the ocean within a few fathoms of the surface, from the cold temperate regions of the north to those of the south. Of the genus *Acetes* I have not seen an indubitable specimen in the collection, but in the locality from which the type, first described by Milne-Edwards, was taken, Sir Walter Elliot records it as being abundant, and forming the staple food of some of the larger species of fish that frequent the Bay of Bengal. In *Leucifer* the posterior two pairs of walking legs have entirely disappeared, although the penult pair is present at one stage of its existence. Four or five species of this genus have been named by authors, but a close analytical examination of all the numerous specimens brought home by the Challenger, enables me to determine with confidence that the several forms described are but different stages in the growth of two species, or perhaps only two varieties of the same species.

"When the ocean is searched at a depth greater than 100 fathoms the true *Penæus* and its gallant congener *Aristeus* are found to exist in more or less abundance. These, if we may judge from the uniform appearance of the long sweeping pleopoda, are powerfully swimming animals, and the form of *Aristeus* with its long and slender rostrum, its narrow and compressed condition with polished surface, shows that it is capable of swimming through the water with considerable velocity; when at rest, the large and leaf-like scaphocerites are probably extended laterally on each side in the water. The rostrum, which is generally long and powerful in several genera of this division, acts not only as a sharp cutwater but probably also as a weapon of offence. The genus *Sicyonia* appears to have the scaphocerite especially formed for attack, and instead of being broad and leaf-like, flexible and membranaceous, has the outer margin developed as a long and powerful spear, and the inner division tapers towards the extremity into a plate of extreme tenuity; this organ with its strong and spear-like point is under the animal's control, becoming when fixed a strong and formidable bayonet-like weapon of offence, or when relaxed a harmless balancing organ.

"A similar offensive weapon is formed by the telson of the genus *Glyphocrangon*, which is a rigid, sharp-pointed, and powerful organ. This the animal has the power of locking and unlocking at will, and according to its size and power is capable of striking, scorpion-like, with much force, inflicting thereby no slight wound.

"Such genera as *Gennadas* and *Benthesicymus* (see fig. 185) dwell apparently in deep water, probably far beneath the predaceous pelagic animals. The former seems to lose the osseous texture of its integument, and with it all power of defence. The eyes become less brilliant through the diminishing quantity of black pigment, while the small phosphorescent organ increases in size and value. With the exception of *Glyphocrangon*, which is a powerful combatant, all the animals brought from great depths are soft and flexible creatures, being incapable of attack or defence.

"That the existing species of Crustacea live, each of them, within certain limits varying according to temperature and bathymetrical conditions is well shown by the Challenger observations, and as these creatures are a very considerable and common source of food for the larger animals, the knowledge of their life history becomes an important element in that of others.

"Before we shall be able to determine with accuracy the relative bathymetrical

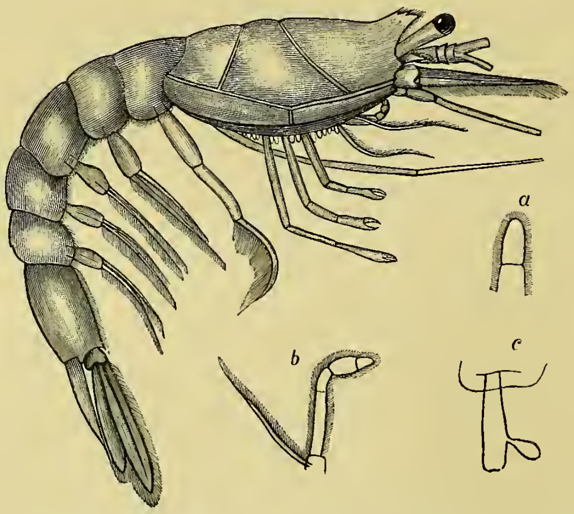


FIG. 185.—*Benthesicymus altus*, n. sp. From a drawing by von Willemoes Suhm.
a, extremity of mandibular appendage; *b*, maxillipede; *c*, first joint of first pair of pleopoda with small leaf-like appendage on the inner side.

distribution of the Crustacea, it is desirable that we should be able to sweep the ocean at various depths without fear of entangling specimens from other strata than those required. Owing to the construction of the apparatus in use for dredging and trawling, it is difficult to determine whether a specimen from a Station with a recorded depth may or may not have become entangled in the nets during the downward or upward passage through the water."

Raine Island.

On the 31st, at 5.40 A.M., the ship proceeded under steam towards Raine Island, stopping off it at 8 A.M., and landing a party to inspect the beacon and collect birds. The tide was half flood, with a strong southeast trade wind blowing, raising a considerable sea in the passage. The gig succeeded in landing without difficulty on the beach, but at low water the coral would have prevented a boat from reaching the shore; as it was, the cutter could not cross the ledge.

The Beacon Tower on Raine Island is well described in the sailing directions. It is a substantial sandstone tower, 60 feet in height, which would need no restoration if required as a lighthouse, the woodwork inside has long since decayed, but in falling has not injured the masonry. There are now no supplies of any sort at the beacon, even the iron tank is completely worn out, nor would it be of any use landing another, unless the tower were re-roofed; however, as any party which made Raine Island could reach the settlement at Cape York in twenty-four hours, there is no necessity to re-victual the beacon.

The birds form the most striking feature at Raine Island. They are in such numbers as to darken the air as they fly overhead, and the noise of their various mingled screams is very trying to the ears at first, but not so painful as that of a penguin rookery. Eleven species of birds were seen on the island. A Heron, seen only at a distance, the cosmopolitan "Turnstone" (*Strepsilas interpres*), and a small Gull (*Larus novæ-hollandiæ*) appeared to be casual visitors to the island, as they were not nesting there, the Turnstones being seen in flocks on the shore. The birds breeding on the island were as follows:—A Landrail (*Rallus pectoralis*), a widely spread species, occurring commonly in Australia, Central Polynesia, the Moluccas, and the Philippines. These birds were so tame that they could be knocked down with sticks and caught by the hand; they had full-fledged young running about. A Tern (*Sterna fuliginosa*), a widely spread species, the well-known "Wideawake" of Ascension Island, was exceedingly abundant. The stretches of flat ground above the shore line covered with grass were absolutely full of the brown fledged young of this bird, and eggs were already very scarce. A Noddy (*Anous stolidus*), the same bird as that at St. Paul's Rocks and Inaccessible Island, so far off in the Atlantic, makes here a rude nest of twigs and grass amongst the low bushes, but often nests also on the ground. There were plenty of eggs of this bird, it being not so advanced in breeding as the Tern. Two species of Gannets (*Sula leucogastra* and *Sula cyanops*) were nesting on the ground, and especially on a plot quite flat and bare of vegetation, probably the site of the dwellings of the men employed in 1844 in putting up the beacon. *Sula leucogastra*, the "Booby" of St. Paul's Rocks, makes a slight nest of green twigs and grass on the ground. *Sula cyanops* makes a circular hole in the earth, about 1½ inches deep. This species is nearly white, with the naked parts about the head of a dull blue, and a bright yellow iris, which gives the bird a ferocious look as it ruffles its feathers and croaks at an intruder. It would almost seem as if the cause of the colouring of the eye might be the savage appearance which it gives to the bird, possibly thus protecting it from attack. A third smaller species of Gannet (*Sula piscator*) has red feet, which distinguish it at once from the other two; one or two of its nests were observed made in the bushes, like those of the noddies, raised 6 inches from the ground. There remain to be mentioned the Frigate Birds (*Fregata minor*), whose nests were nearly all confined to a small area near the cleared patch already referred to. They are, like those of *Sula piscator*, raised on the bushes, and are compact platform-like masses of twigs and grass matted together with dung, about 8 inches in diameter.

There were no eggs of the birds in the nests, but mostly far advanced young which were covered with frills of a rusty coloured down. The old birds soared overhead, and could only be obtained by being shot; whereas the Gannets were easily knocked over on the nests with sticks. It was curious to see the Frigate Birds, the nesting place of which is usually on high cliffs as at Fernando Noronha, here, through the entire security of the locality, nesting on the ground. The main body of the Frigate Birds remained during the stay of the party on the island soaring high up in the air with their eagle-like flight, far above the cloud of other birds beneath. In the stomachs of some of these birds which were shot, small cuttle-fish and *Spirula* shells were found. One *Phaëthon æthereus* was seen.

The shells of numerous turtles which had died on the island were lying about. In one place there was quite a heap of these at a sort of miniature gully, bounded by a perpendicular wall of rock about 2 feet in height. It appeared as though the turtles had crawled up from the sea shore to spawn, and being stopped by this small cliff, had been unable to turn round or go backwards, and had died there. A Locust (*Acridium*) was very common amongst the grass on the island, and a large Earwig (*Forficula*) under the stones.

Whilst the naturalists were on shore, the ship obtained a few soundings close to the island, the position of the soundings being fixed by the officer at the beacon taking a bearing and masthead angle of the ship at each cast. The exploring parties returned at 11 A.M., when two hauls of the dredge to leeward of the island were obtained, but they were not very productive.

Raine Island is situated on the west or leeward edge of a small coral atoll, which extends over two miles in a southeast and northwest direction, and is about a mile broad (see Sheet 27). The lagoon of this atoll is represented merely by shallow patches of water with sandy bottoms. The atoll is separated from the Great Detached Reef and the Barrier Reef by channels with a depth exceeding 100 fathoms, and the outer edge of the reef has a very steep slope. The island itself is about a third of a mile long and a quarter of a mile broad, and is composed of a blown calcareous sand which has consolidated towards the centre of the island into a compact limestone. In some places there is a soil from 2 to 3 inches thick. Numerous fragments of pumice were picked up on the island.

The soundings and dredgings in 135, 150, and 155 fathoms showed that the deposit was a coral sand, composed of white and brownish coloured fragments of Corals, Molluscs, and Foraminifera shells, with a considerable admixture of calcareous Algæ. Mr. H. B. Brady, F.R.S.,[1] found in this deposit a larger number of species of Foraminifera than in any other taken during the cruise. The deposit contained 87 per cent. of carbonate of lime, and it was estimated that more than half of this consisted of pelagic Molluscs and pelagic Foraminifera. The few mineral particles in the deposit consisted of rounded fragments of quartz, felspars, mica, apatite, and fragments of pumice.

[1] Zool. Chall. Exp., part xxii. pp. 93, 94, 1884.

By treating this deposit with dilute acid, casts of the Foraminifera shells are obtained, the majority of which are of a brick red colour, although a few are of a yellowish, or even greenish, tinge. They are not so compact or well-marked in outline as the white and pale straw-coloured casts usually met with in glauconitic muds, and have very frequently a porous aspect, from the solution of the carbonate of lime being, in many instances, associated with the red material forming the casts. If some of the Foraminifera be treated with dilute acid, and the action stopped after it has continued for some time, and the substance dried and examined by reflected light, a number of casts of the organisms are seen in carbonate of lime looking quite like milky quartz. If, however, the action be continued, it is seen that they are composed of lime as they quite disappear, leaving a small residue of a reddish colour, or very areolar casts of the shells in the same red substance. Examined in thin sections, it is observed that the shells are filled with a red, yellowish, or greenish matter, frequently extending into the foramina. The shell is at once distinguished from the cast by its structure, transparency, and optical properties. It is sometimes observed that two or three shells or fragments are cemented by the same red substance forming the casts. This substance when sufficiently transparent appears of a yellowish red colour, and gives sometimes aggregate polarisation, but is never extinguished between crossed Nicols. Often the casts enclose small mineral particles. Seen by transmitted light, there is a great difference between the calcareous casts and the carbonate of lime constituting the shells themselves. These casts are but slightly transparent, greyish coloured, or almost opaque, the opacity being due to infinitesimal foreign particles which remain as a red residue after treatment with dilute hydrochloric acid. With very high powers it is seen that the structure of the grey calcareous casts is granular, and between crossed Nicols it is evident that the grains are crystalline.

An analysis of the red coloured casts above described, obtained by treating the deposit with very dilute acid, was made by Dr. Sipöcz; and, although the analysis shows that they are composed of a hydrated silicate containing all the constituents of typical glauconite (iron, alumina, magnesia, and alkalies), yet the various percentages, especially that of silica, differ so considerably from the mean numbers obtained for glauconite, that the substance cannot be grouped with that mineral species. Perhaps these casts are in the process of becoming true glauconite. The large percentage of ferric oxide (39 to 93), which is in the form of hydrate, gives the red-brown colour to the casts.

Raine Island to Cape York.

At 1.30 P.M. Raine Island beacon bore N. 52° E., and the extremities of the Great Detached Reef S. 81° E. and S. 63° E. From here the ship was steered S.W. ¼ W. (under sail) towards the Ashmore Banks, which were sighted at 3.30 P.M., Hardy Island being seen shortly afterwards. Crossing the edge of the barrier, the 5 and 6 fathom patches were not seen, but the shoal patches southward of the 5 fathom patch were readily distinguished from aloft. When near the Ashmore Banks the position of the ship by bearings of them placed her considerably farther to the northward than the bearing of Hardy Island, which would indicate that these banks are not so far apart as shown on the chart. At 4.20 P.M. sail was shortened and the vessel stood on under the jib and spanker, with the intention of anchoring on one of the shoal patches of from 6 to 10 fathoms; several were passed, but they were in each case so small that before the ship could "round to" the depth was again 25 fathoms. Eventually the vessel was anchored in 10 fathoms, but slipped off into 21 fathoms, the anchorage bearings being right extremity of Hardy Island S. 68° W., and the south small island S. 44° W. The weather was very misty, the trade wind strong, and there was a nasty sea which made it necessary to veer 125 fathoms of cable.

On the 1st September the anchor was weighed, and sail made at 7 A.M., the vessel standing towards the Cockburn Reef, which was sighted at 7.30 A.M. The route pursued was that recommended by the sailing directions and chart, the position of the ship being fixed by the Cockburn and Hardy Islands, the main reliance, of course, being placed in the lookout from aloft, which duty was personally undertaken by the Captain. When abreast of the sandbank on the small reef just to the northwestward of the northwest point of the Cockburn Reef, the ship passed between it and the reef, steering towards the Bird Islands, no bottom being obtained at 20 fathoms with the deep-sea lead. At 0.30 P.M. the vessel passed Halfway Island, and at 2.30 P.M. between Cairncross Islands and Bushy Rocks. At 5 P.M. York Island was seen in line with Osnaburgh Point, and a course shaped for Port Albany, and, shortening sail, the ship proceeded into the pass under steam, and was moored opposite the settlement at Somerset at 6 P.M. The wind was fresh all day, the ship going 10 knots per hour, and making, with the current, 11½ knots over the ground; the atmosphere was very misty.

Somerset, Cape York.

As the vessel entered Albany Pass every one was struck with the strange appearance of the wonderful Termite hills, which stood in numbers on each grassy point, some 12 feet in height, red pinnacles looking like the chimneys of pottery kilns (see Pl. XX.).

The half dozen houses of the settlement are those built originally by the marines, who were taken away in 1867. They are one-storied wooden bungalows, situated on the hills which rise on each side of a bay, and are readily seen from the anchorage. One was occupied temporarily by the London Missionary Society, who were then endeavouring to establish themselves in New Guinea, gradually working their way from the islands to the mainland.

Plate XX

HORSBURGH, EDINBURGH

PERMANENT PHOTOTYPE

TERMITES NESTS, CAPE YORK.

The barren sandy appearance of the coast, as the ship ran quickly past it towards Albany Pass, gave anything but pleasing or hopeful impressions, nor were they bettered during the few days' stay at this distant, solitary outpost of the colony of Queensland. Whilst the large and profitable pearl fishery continues to be carried on in Torres Strait, it is necessary to maintain a station in the vicinity. The site occupied was convenient and healthy, two very important factors in choosing a place for a new settlement, and there seemed little object in changing it. However, since the Expedition's visit, the Government staff has been transferred to Thursday Island in Torres Strait, and the mail steamers now call there. No fresh provisions are procurable at Thursday Island, and the water is bad. There is a small quantity of coal in a hulk belonging the the Eastern and Australian Steamship Company.

Owing to the anchorage opposite the settlement of Somerset being occupied by two or three small vessels, the Challenger had to moor rather farther out in the stream than otherwise would have been necessary. This necessitated the ship being steered when she swung to the ebb tide, as the wind was then aft, and when not steered, the vessel sheered five to six points away from the true direction of the stream; and on one occasion, with the strength of the tide on the broadside, the northwest anchor dragged a considerable distance over the rocky ground before the ship could be brought head on to the stream. This only occurred during the night, the day tides being much weaker. In mooring or anchoring here it is well to keep the cable slack when first the anchor is let go, as the holding ground is so bad, being all rock, that the cables require to be at a good angle before the anchor will bite at all.

In entering the Albany Pass it was surprising to find that the calculated time of high water corresponded neither with the actual time of high water by the shore, nor the turn of the stream. The calculation was made on the assumption that the age of the tide was two days. No age of tide is given in the sailing directions, nor is any mention made of peculiarities in the tidal wave, or stream, either there or in the voyages of the "Fly" and "Rattlesnake," the only remark made being relative to velocity. During the stay a tide pole was established on shore, and a register kept of the turn of the stream, &c. The four days' observations showed that there were two regular tides, and tidal streams, in the twenty-four hours, but there was a marked difference between them; although they both fell to nearly the same level, the night tide rose nearly twice the height of the day tide above low water. The ebb and flow during the night occupied fourteen hours, and during the day ten hours. In each case the stream turned one hour after high or low water by the shore, the flood running northwest and the ebb southeast. The highest tide registered was nine days after full and change, or when, ordinarily speaking, neap tides might be expected, and the velocity of the stream was also greatest at this time. These peculiarities may possibly extend over the whole of Torres Strait, for the same phenomena are recorded as taking place in the channels north of Prince of Wales Island.[1] It appears evident that some further investigations of tidal phenomena in this neighbourhood are requisite in order that some means may be found to enable the seamen to calculate with certainty the time and height of high water, and the change of the streams, a matter of considerable importance where these run with great velocity through narrow channels.

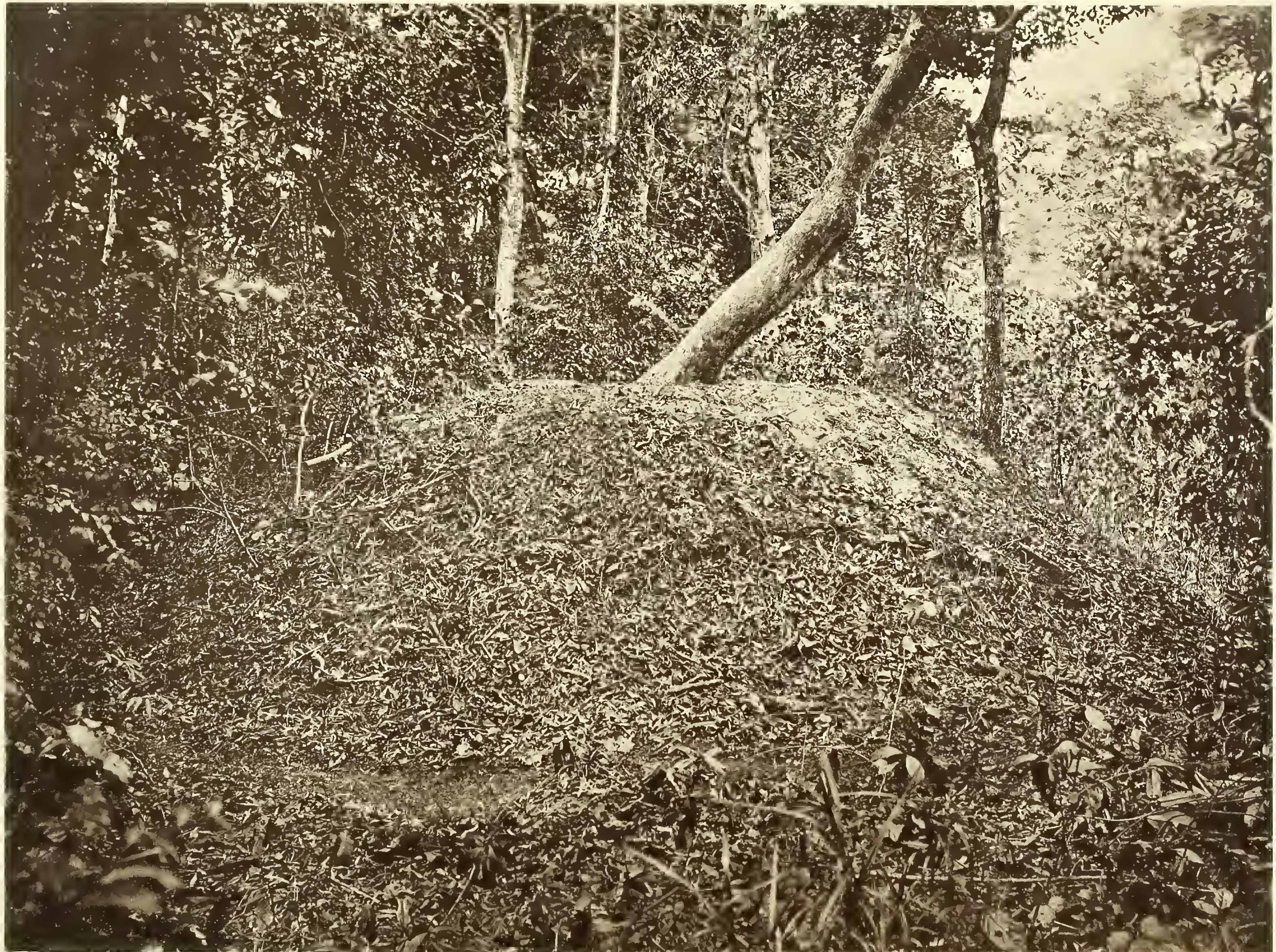
Behind the shore of the small bay in which Somerset lies, the land rises steeply, and is covered with wood, except where clearings have been made around two conspicuous sets of wooden buildings, the one the residence of the magistrate, the other the barracks of the water police.

The country is wooded in every direction, but with constantly recurring open patches covered with scattered Acacias, Gum Trees, and Proteaceæ with only grass growing beneath. In the dense woods, with their tall forest trees and tangled masses of creepers, one might for a moment imagine oneself back in Fiji or Api, but the characteristic open spaces, with scattered *Eucalypti*, remind one at once that one is in Australia. The principal features of Australian and Indian vegetation are, as it were, dove-tailed into one another. In the woods, the tree trunks are covered with climbing Aroids, and often with Orchids. Two Palms, an *Areca* with a tall slender stem not thicker than a man's wrist, but 50 feet high, and a most beautiful *Caryota*, strong evidence of Indian affinities in the flora, are abundant. The cocoanut palm, as is well known, is not found growing naturally anywhere in Australia, though it is abundant in islands not far from Cape York. At Cape York some trees had been planted, but they did not appear to thrive. One of them, already more than eight years old, at which age it ought to have been bearing fruit, had as yet a trunk only a few feet in height. A Rattan Palm (*Calamus* sp.), trailing everywhere between the underwood, is a terrible opponent as one tries to creep through the forest in search of birds.

The number and variety of birds at Cape York is astonishing. Two species of *Ptilotis* (*Ptilotis chrysotis* and *Ptilotis filigera*), different from those at Fiji, but closely resembling them, suck the honey from, or search for insects on, the scarlet blossoms of the same *Erythrina* tree as that at Fiji. With these are to be seen a *Myzomela*, and the gorgeous little Brush-tongued Parroquet (*Trichoglossus swainsoni*), which flies screaming about in small flocks, and gathers so much honey from the flowers, that it pours out of the bird's beak when it falls shot to the ground. Amongst the same flowers is to be seen also a true Honey Bird (*Nectarinia frenata*), with brilliant metallic blue tints on its throat. The common White Crested Cockatoo (*Cacatua galerita*) is here wary and difficult to get near, though not so much so as in the frequented parts of Victoria. The Great Black Cockatoo (*Microglossus aterrimus*) is to be found at Cape York, but none were seen. The Pheasant Cuckoo (*Centropus phasianus*) rises occasionally from the long grass in the opens, and though of the cuckoo tribe, has exactly the appearance of a pheasant

[1] Australian Directory, vol. ii. p. 337, 3rd ed.

Plate XXI



HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

NEST OF MEGAPODIUS, CAPE YORK.

when on the wing. On one of the excursions a large brown Owl (*Ninox boobook*) was shot; it was sitting at daybreak in the fork of a large tree, and the native guide espied it at once.

The great prize at Cape York is, however, the Rifle Bird (*Ptilorhis alberti*), one of the Birds of Paradise. It is velvety black, except on the top of the head and breast, where the feathers are brightly iridescent with a golden and green lustre, and in the tail also are two iridescent feathers. The bird lives in the woods, where the trees and undergrowth are twined with creepers, and does not frequent the higher forest trees much, but the tops of the shorter sapling-like growths and masses of creepers binding these together. The call of the bird consists of three loud shrill short whistling notes, the third somewhat louder and shorter than the first two, followed by a similar but much lower pitched note. This is the full call of the bird, sometimes only two notes are uttered before the low note, and sometimes only a single whistle. The call is most striking and peculiar, and, guided by it, one steals gradually through the wood, treading cautiously upon the dead leaves, and trying to creep within shot of the birds. The call is uttered usually only at intervals of several minutes; it is very easily imitated by whistling, and thus a call may often be elicited, and the bird's whereabouts discovered. The bird is extremely shy, and the snapping of a dead twig is sufficient to scare it, so that it requires great patience and perseverance to shoot one. One may often approach within 15 or 20 yards of a Rifle Bird, and stand gazing into the thick tangled mass of creepers overhead, where one knows that the bird is, without being able to get a glimpse of it, until at last it darts out. The bird takes short rapid flights from one part of the bush to another, the rounding of the front of the wings giving it a peculiar appearance when on the wing. The blacks pointed out the red fruit of the Areca Palm as the food of the bird, and abundance of the seeds of this palm were found in the stomachs of birds shot. The male in full plumage is indeed a splendid object; the female and the young birds of both sexes are of a dull brown colour, as is the case with all the Birds of Paradise.

When walking in the woods in search of birds, a slight rustling in the fallen leaves may attract one's attention, upon which the black guide becomes greatly excited. It is a pair of the "Mound Birds" (*Megapodius tumulus*), which are disturbed and are seen running off like barn-door fowls, and when thus luckily hit upon are easily shot. Several "Brush Turkeys" (*Talegalla lathami*) were shot during the stay at Somerset, and the huge mounds thrown up by them were common objects at the borders of the scrubs, but the season was not far enough advanced for them to have commenced laying eggs (see Pl. XXI.). A brilliant Bee-eater (*Merops ornatus*) was common at Cape York, and to be seen seated, as is the wont of Bee-eaters, on some dead branch, and darting thence from time to time after its prey. A little Ground Pigeon (*Geopelia*), not much bigger than a sparrow, was also abundant. A species of Swallow-shrike (*Artamus* *leucopygialis*) was very common, sitting in small flocks in rows on wires stretched for drying clothes near one of the houses, just as swallows sit on telegraph wires in England. The birds made excursions after flies, flying just like swallows, and returning to their perch. All those shot had their feathers at the base of the bill clogged with pollen from the flowers, in which no doubt they had been searching for insects; like some humming birds, they must act as fertilizers, carrying pollen from one flower to another.

Two Bats (*Phyllorhina cervina*, Gould, and *Taphozous australis*, Gould), a Lizard (*Lialis punctulata*), a Snake (*Acanthophis antarctica*), and an immature specimen of *Mus alexandrinus*, Geof., were collected at Cape York.

"In all my excursions," writes Mr. Moseley, "I was accompanied by blacks. A small encampment of natives, composed of the remnants of three tribes, lay about half a mile from the shore. There were twenty-one natives in this camp when I visited it early one morning in search of a guide, before daybreak, before the blacks were awake. Of these twenty-one, about six were adult males, one of whom was employed at the water police station during the daytime; there were four boys of from ten to fourteen years, two young girls, two old women, two middle-aged women, and the remainder were young women. One of the old women was the mother of Longway, who acted as my guide, and who had a son about ten years old.

"The blacks were mostly of the Gudang tribe, a vocabulary of whose language is given in the Appendix to Macgillivray's Voyage of the 'Rattlesnake.'[1] About 35 miles from Somerset is a tribe of fierce and more powerful blacks, of whom the Gudangs are in great terror. The natives were in a lower condition than I had expected. Their camp consisted of an irregularly oval space concealed in the bushes, at some distance from one of the paths through the forest. In the centre were low heaps of wood ashes with fire-sticks smouldering on them. All around was a shallow groove or depression, caused partly by the constant lying and sitting of the blacks in it, partly by the gradual accumulation of ashes inside, and the casting of these and other refuse immediately outside it. On the outer side of this groove or form were stuck up at an angle large leaves of a Fan Palm here and there so as to form a shelter, and under the shelter of these the blacks huddled together at night to sleep (see Pl. XXII.).

"A camp of this shape with a slight mound inside, and a bank outside, formed involuntarily by primitive man, may have given the first idea of the mound, the ditch, and rampart. The large amount of wood-ashes accumulated in such a camp, accounts for their occurrence in such large quantities in kitchen-middens, where camping must have been in the same style. A good many shells brought from the shore lay here and there about the camp. There were besides in the neighbourhood remains of shelters of the common Australian form, long huts made of bushy branches set at an angle to meet

[1] For a further account of Cape York, see J. Beete Jukes, Narrative of the Surveying Voyage of H.M.S. "Fly," London, 1847.

Plate XXII.

HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

PALM-LEAF HUTS CAPE YORK.

one another above, and partially covered with palm leaves and grass; these the blacks used occasionally.

"In the daytime the young women and the men were usually away searching for food, but two miserable old women, reduced nearly to skeletons, but with protuberant stomachs, with sores on their bodies and no clothing but a narrow bit of dirty mat, were always to be seen sitting huddled up in the camp. These hags looked up at a visitor with an apparently meaningless stare, but only to see if any tobacco or biscuit were going to be given them; they exhibited no curiosity, but only scratched themselves now and then with a pointed stick.

"The younger women had all of them a piece of some European stuff round their loins. Some of the men had tattered shirts, but one, who acted as my guide, was invariably absolutely without clothing, as was his son, who always accompanied him. The only property to be seen about the camp were a few baskets of plaited grass, in the making of which the old women were sometimes engaged, and which were used by the "gins" (women) for collecting food in. Two large *Cymbium* shells with the core smashed out had been used also to hold food or water, but were replaced for the latter purpose now by square gin bottles, of which there were plenty lying about the camp, brought from the settlement.

"The most prized possession of these blacks is, however, the bamboo pipe, of which there were several in the camp. The bamboos are procured by barter from the Murray Islanders, who visit Cape York from time to time, and the tobacco is smoked in them by the blacks in nearly the same curious manner as that in vogue amongst the Dalrymple Islanders. No doubt the Australians have learnt to smoke from the Murray Islanders.[1] The tobacco pipe is a large joint of bamboo as much as 2 feet in length and 3 inches in diameter. There is a small round hole on the side at one end and a larger hole in the extremity of the other end. A small cone of green leaf is inserted into the smaller round hole and filled with tobacco, which is lighted at the top as usual. A woman (sometimes a man performs the operation) then opening her mouth wide covers the cone and lighted tobacco with it and applies her lips to the bamboo all round it, having the leaf cone and burning tobacco thus entirely within her mouth. She then blows and forces the smoke into the cavity of the bamboo, keeping her hand over the hole at the other end, and closing the aperture as soon as the bamboo is full. The leaf cone is then withdrawn and the pipe handed to the smoker, who, putting his hand over the bottom hole to keep in the smoke, sucks at the hole in which the leaf was inserted, and uses his hand as a valve meanwhile to allow the requisite air to enter at the other end. The pipe being empty the leaf is replaced and the process repeated. The smoke is thus inhaled quite cold. The pipes are ornamented by the blacks with rude drawings. The bamboo pipes of Dalrymple Island are described as having bowls made of smaller bamboo tubes instead

[1] J. Beete Jukes, Narrative of the Surveying Voyage of H.M.S. "Fly," vol. i. p. 65, London, 1847.

of the leaf cone; there are many such in museums. Possibly the leaf is only a make-shift. The Dalrymple Islanders, however, sucked the bamboo full of smoke from the large hole at the end instead of blowing. It is remarkable that the Southern Papuans should have invented this peculiar method of smoking for themselves, since there can be little doubt that they derived the idea of smoking from the Malays, probably through the Northern and Western Papuans. There seems no doubt that the habit of smoking was first introduced into Java by the Portuguese, as well as the tobacco plant itself,[1] and the habit and plant no doubt spread thence to New Guinea. The Papuans at Humboldt Bay smoke their tobacco in the form of cigarettes.

"No other property than that mentioned was to be seen about the camp of the Gudangs, but on our asking for them, Longway produced some small spears and a throwing stick, which were hidden in the bush close by; and a second lot of spears was produced afterwards from a similar hiding-place. The blacks keep what property they have thus hidden away, just as a dog hides his bone, and not in the camp; hence it is impossible to find out what they really have. I saw no knife or tomahawk. No doubt the practice of thus hiding things away from the camp has arisen from constant fear of surprise from hostile tribes.

"The blacks feed on shell fish, snails (a very large *Helix*), snakes and grubs, and such things, which are hunted for by the women, who go out into the woods in a gang every day for the purpose of collecting food, and also dig wild yam roots with a pointed stick hardened in the fire. They have not got the perforated stone to weight their digging-stick, and are thus behind the Bushmen of the Cape in this matter. A staple article of food with these blacks is afforded by the large seeds of a climbing bean (*Entada scandens*), and their only stone implements are a round flat-topped stone and another long conical one, suitable for grasping in the hands. This is used as a pestle with which to pound these beans on the flat stone. Both stones are merely selected and not shaped in any way.

"These blacks never seem to have had any stone tomahawks, and their spear-heads are of bone. They do not hunt the Wallabies or climb after the Opossums, like the more southern blacks, but live almost entirely on creeping things and roots, and on fish, which they spear with four-pronged spears. Staff-Surgeon Crosbie of the Challenger saw Longway and his boy smashing up logs of drift-wood and pulling out Teredos and eating them one by one as they came to them.

"I tested Longway and also several of the blacks together at the camp, by putting groups of objects such as cartridges before them, but could not get them to count in their language above three—piama, labaima, damma.[2] They used the word 'nurra'[3] also,

[1] A. de Candolle, Géographie Botanique, t. ii. p. 850.
[2] Macgillivray gives "epiamana, elabaiu, dāma" (Voyage of the "Rattlesnake," Appendix).
[3] =unora? Macgillivray.

apparently for all higher numbers. It was curious to see their procedure when I put a heap of five or six objects before them. They separated them into groups of two, or two and one, and pointing to the heaps successively said, 'labaima, labaima, piama,' 'two,' 'two,' 'one.' Though another of the guides had been long with the whites he had little idea of counting; after he had picked up two dozen birds which had been shot, and seen them packed away, he was asked how many there were in the tin; he said six. No doubt amongst such people language changes with remarkable rapidity, especially as here, where tribes are mixed; some of the words at least seem to have changed since Macgillivray's time.

"The blacks are wonderfully forgetful, and never seem to carry an idea long in their heads. One day when Longway was out with me he kept constantly repeating to himself 'two shilling,' a sum I had promised him if I shot a Rifle Bird, and he constantly reminded me of it, evidently with his thoughts full of the idea. After the day was over, and we were near home, he suddenly left me and disappeared, having been taken with a sudden desire to smoke his bamboo, and gone by a short cut to the camp. When I found him there he seemed astonished, and to have forgotten about his day's pay altogether, although he had successfully earned it.

"The blacks spend what little money they get in biscuit at the store, and they know that for a florin they ought to get more biscuit than for a shilling, but that is all; food is their greatest desire. Their use of English is most amusing, especially that of the word 'fellow.' 'This feller gin, this feller gin, this feller boy,' said Longway, when I asked whether some young blacks crouched by the fire were boys or girls. They apply the term also to all kinds of inanimate objects. There are several graves of blacks near Somerset. I asked Longway what became of the black fellows when they died; he said 'fly away,' and that they became white men.

"When I wanted some plants which were a little way up a tree, Longway was not at all inclined to climb, but let a sailor who was with me do it. Longway's boy said he could not climb.

"As I have said, Longway was always completely naked. He not only had no clothing of any description, but no ornament of any kind whatsoever, and he was not even tattooed. Further, he never carried, when he walked with me, any kind of weapon, not even a stick. His boy, who was always with him, was in the same natural condition. It was some time before I got quite accustomed to Longway's absolute nakedness, but after I had been about with him for a bit, the thing seemed quite familiar and natural, and I noticed it no more.

"On one of our excursions, Longway begged me to shoot him some parroquets to eat; I killed half a dozen at a shot, but should not have done so if I had known the result, for Longway insisted on stopping and eating them there and then, so I was obliged to wait, whilst he and his boy lighted a fire of grass and sticks, tore a couple of clutches of feathers off each of the birds and threw them on the fire for the rest of the feathers to singe partly off. Before they were well warm through, they pulled the birds out and tore them to pieces, and ate them all bleeding, devouring a good deal of the entrails.

"On one occasion, when I wished to start very early on a shooting expedition in order to come upon the birds about daybreak, which is always the best time for finding them in the tropics, I went to the camp of the blacks to fetch Longway, just as it was beginning to dawn. The blacks were not by any means so easily roused as I had expected; I found them all asleep, and had to shout at them, but then they all started up scared, as if expecting an attack. I had great difficulty in persuading Longway to go with me at that early hour, and he complained of the cold for some hours. I think the blacks usually lie in camp till the sun has been up some little time, and the air has been warmed.

"With regard to expression, I noticed that the Gudangs used the same gesture of refusal or dissent as the Api men, namely, the shrugging of one shoulder, with the head bent over to the same side. Their facial expressions were, as far as I saw them, normal, I mean like those of Europeans.

"Altogether, these blacks are, I suppose, nearly as low as any savages. They have no clothes (some have bits of European ones now), no canoes, no hatchets, no boomerangs, no chiefs. Their graves, described in the Voyage of the 'Fly,' are remarkable in their form, being long low mounds of sand, with a wooden post set up at each of the corners. There is far more trouble taken with them than would be expected."

The beach at Somerset is composed of siliceous sand. The European voyager amongst coral islands becomes so used to see the beaches made up of calcareous sand, that it appears quite a novel feature to him when he meets again with siliceous sand, to which he is accustomed at home. The sandy beach slopes down, to end abruptly on a nearly horizontal mud flat, bare at low water, which is mainly calcareous, and in fact a shore platform reef. At low water, during spring tides, blocks of dead massive corals, such as Astræidæ, are seen to compose the verge of these mud flats, and it is from the detritus of these that the mud is formed. Amongst these blocks are a few living corals, a species of *Euphyllia*, a small *Astræa*, and a cup or mushroom-shaped *Turbinaria*.

There is a considerable variety of species of seaweeds on the flats, and also several forms of sea-grasses, as a species of *Halophila*, the large hairy *Enhalus*, and a *Thalassia* growing together, and spreading in abundance over the mud, which was matted with their roots in many places.

The channel between Somerset and Albany Island is shallow, being nowhere more than 14 fathoms in depth. The dredge here brought up a rare species of *Trigonia*, and the "Lancelet" (*Amphioxus lanceolatus*), which seems to have an extremely wide range of distribution. The fauna on the whole was very like that of Port Jackson.

Feather-stars belonging to the genus *Actinometra*, coloured dark purple, were numerous in the dredgings in from 8 to 12 fathoms. Dr. von Willemoes Suhm mentions that, in eighty specimens which he examined, he found the following animals living on them parasitically, and all coloured like them:—(1) an Ophiurid, (2) an *Alpheus*, (3) a *Myzostomum* (large species, two or three on about every tenth specimen), (4) an Aphroditacean Annelid, (5) an Isopod (*Anilocra*, found in the stomach of the *Actinometræ*). The dark purple colouring matter of these *Actinometræ* (*Actinometra strata*), unlike the colouring matters of most Comatulidæ, gives a very characteristic banded absorption spectrum, and has been named by Mr. Moseley "Antedonin." The same colouring matter was found in a Holothurian dredged in the South Indian Ocean from 1975 fathoms.[1]

Cape York is a sort of emporium of savage weapons and ornaments. Pearl-shell gathering vessels ("pearl-shellers" as they are called) come to Somerset with crews which they have picked up at all the islands in the neighbourhood, from New Guinea, and from all over the Pacific, and they bring weapons and ornaments from all these places with them. Moreover, the Murray Islanders visit the port in their canoes, and bring bows and arrows, drums, and such things for barter. The water police stationed at Somerset deal in these curiosities, buying them up and selling them to passengers in the passing steamers, or to other visitors. Hence all kinds of savage weapons have found their way into English collections, with the label "Cape York," and the northern Australians have got credit for having learnt the use of the bow and arrow. Apparently, however, no Australian natives use the bow at all. Weapons from very remote places find their way to Cape York, and thus no doubt the first specimens of Admiralty Island javelins reached the English museums. Accurate determination of locality is of course essential to the interest of savage weapons. Surgeon Maclean of the Challenger had a large New Guinea drum of the crocodile form thrust upon his acceptance as a fee for visiting a patient on board one of the "pearl-shellers."

Dr. von Willemoes Suhm broke into five of the large Termite hills with pickaxes, and secured some females, but never more than one in each hill. He states that this *Termes* is different from the Indian forms, in which the female always resides in a larger hole at the bottom of the hill, and is two inches in length.

Cape York to the Arrou (Aru) Islands.

At 11 A.M. on the 8th September the ship left Somerset, Cape York, and proceeded to the westward through the Albany Pass, crossing over the tail of the bank from Sextant Rock, with the left extremity of Ida Island in line with the rocky point in Muddy Bay; 5 fathoms being the least depth obtained at high water. A course was then steered

[1] H. N. Moseley, On the Colouring Matters of Various Animals, and especially of Deep-Sea Forms, *Quart. Journ. Micr. Sci.*, N. S., vol. xvii. pp. 8–10, 1877.

for rock (a), and passing eastward of it, the regular track was followed to the Prince of Wales Channel. It was intended to search for Edward's Rock, but the water was too muddy, and the weather too misty, to afford any reasonable hope of finding it. At 2.45 P.M. several rich hauls of the dredge were obtained at the entrance to the Prince of Wales Channel (Station 186, 8 fathoms), and then the ship anchored between Wednesday and Hammond Islands, where the Expedition was rejoined by the steam pinnace, which had sailed from Albany Pass over to Flinders Pass on a dredging excursion. A rock specimen obtained at Hammond Island is a quartz porphyry.

Rock (a) is about 40 feet high; Horned Hill on Horn Island is a prominent saddle; Strait Rock is bushy, and some 60 to 70 feet high; Tuesday Islets are about 100 feet high, and Wednesday Island 200 feet. The whole of the reefs in the vicinity of the anchorage were dry at 3 P.M., and but little tidal stream was felt until 4 P.M., when a strong southeast set was experienced, which lasted till 8.15 P.M., after which the tide turned to the northwestward. The time of low water appears, therefore, to be nearly the same as at Port Albany, but there the northwest stream would begin at 5 P.M., while at this anchorage it did not commence until 8.15 P.M. The ship remained swung to the northwest tide until 3.45 A.M., when slack water ensued, and at 4 A.M. the southeast stream commenced to flow. At Port Albany the northwest stream finished at 1 A.M.

On the 9th, at 5.45 A.M., the anchor was weighed and the vessel proceeded under sail through the Prince of Wales Channel. The mail steamer, from Singapore to Brisbane, being met with at the west end of this channel, was communicated with, and through the kindness of the captain some newspapers were received from her. At 8 A.M. Ipili Reef was passed and a course shaped as necessary towards Booby Island, off which sail was shortened, and at 10 A.M. a party of naturalists landed, the ship obtaining some hauls of the dredge (Station 187). The dredgings were very successful, amongst other things a remarkably large Starfish (*Oreaster*), two feet in diameter, being obtained. At 1.30 P.M. the party returned from Booby Island, and the ship bore up for the passage between Proudfoot Shoal and Cook's Reef, carrying a line of soundings of from 8 to 10 fathoms until 5.50 P.M., when the patent log showed the vessel had passed Cook's Reef, and 16 fathoms were obtained, after which the course was altered to W. by N.

The Ipili Reef is marked on the chart as though the rocks were always above high water, and the sailing directions also lead one to suppose so by calling them a cluster of high rocks,[1] whereas they must certainly all be covered at high water, as when they were passed at dead low water, they were but a foot or two uncovered, and looked like the elevated part of a reef which dries at low water, or perhaps half-tide.

On Booby Island there were a few cases of biscuits, but the cases were fast decaying, and shipwrecked people should not trust to this island for supplies, but push on at once for the settlement at Cape York.

[1] See Australian Directory, vol. ii. p. 240, 2nd Ed.

SHEET 31


C YORK TO HONGKONG
touching at the
ARROU Ies, KI Ies, BANDA Ies
AMBOINA I., TERNATE Id, SAMBOANGAN
ILO ILO AND MANILA
Sept., Oct., Novr 1874
also
HONGKONG TO YOKOHAMA
touching at
MANILA, ZEBU, SAMBOANGAN
HUMBOLDT BAY AND THE ADMIRALTY Ies
Jany, Feby, March, April 1875
For explanation of abbreviations &c. see Appendix I.
CHINA
Formosa I.
Yokohama
Kiusiu
Bonin Is
Luzon I.
Manila
St Bernardino St
Mindoro I.
Samar I.
Panay I.
Palawan I.
Surigao St
Negros I.
Mindanao I.
SULU SEA
Basilan St
CHINA SEA
Pelew I.
Guam I.
Caroline Is
CELEBES SEA
Banka Passage
Molucca Passage
Gilolo I.
Waigiou I.
BORNEO
Macassar St
Celebes I.
Xulla Is
Bouro I.
Ceram I.
Banda Is
Ki Is
Arrou Is
Timor Laut
BANDA SEA
JAVA SEA
JAVA
Flores I.
Sumba I.
Timor I.
ARAFURA SEA
Torres St
AUSTRALIA
PAPUA OR NEW GUINEA
Humboldt B.
Admiralty I.
130° Long. East from Greenwich

On the 10th, 11th, 12th, and 13th September, the ship dredged each day, shortening sail and putting over the trawl or dredge; the water being shallow, no steam was required. The dredging on the 10th (Station 188) was remarkable for the number of Cephalopods it yielded; there were five species of *Sepia*, of which four are certainly new, an undescribed species of *Loligo*, and an *Octopus*, too young to determine with certainty. A sounding was also obtained every two hours to ascertain the depths between Torres Strait and the Arrou Islands. On the 11th, the cutter was anchored by the trawl, and no current was detected.

On the 14th September, at 10 A.M., the Arrou Islands were observed on the starboard bow from the masthead, and at 11 A.M. from the decks. At noon the north side of Ngor Island bore N. 53° E. (true) distant 8 or 9 miles, and a N.W. by N. course was steered until 3.25 P.M., when the coast of Trangan Island could be distinctly made out, soundings of from 19 to 17 fathoms being obtained. At this time the two small islets off the south point of Trangan Island were seen; the outer one is merely a rock, which appears white when seen against the green background, and was consequently named White Rock. It is in lat. 6° 58′ S., long. 134° 13′ E., and about 20 feet high. The other islet close to White Rock is small, with a few scattered trees, and just north of it is the south point of Trangan Island, about which there is nothing remarkable; eastward of the south point, however, are some red cliffs, which are very conspicuous (see Sheet 32).

The islands of Krei and Batu Goyang were not seen, although the ship passed within 5 or 6 miles of the positions assigned them; so that if they exist they are not correctly placed on the chart.

From the south point of Trangan Island, the coast trends northwest for 2 or 3 miles (to a cleared point), and then runs away to the northward, forming a bay, the southwest point of which is a bluff, with a red patch near its extremity, by which it may readily be distinguished. The extremity of this Red Patch Point is in lat. 6° 51½′ S., long. 134° 4½′ E., and as it was seen at a distance of 10 miles, it cannot be less than 200 feet in height to the top of the trees. Three or four miles northeast of Red Patch Point is a flat-topped hill in lat. 6° 49′ S., long. 134° 8½′ E., which is conspicuous from the southward. The tops of the trees on it were estimated as 300 feet above the sea level. The whole of Trangan Island is covered with trees, which give it a very uniform appearance from the sea.

At 5.40 P.M., White Rock bore N. 87° E., Red Patch Point N. 18° W., and Flat Hill N. 11° E., the depth being 13 fathoms. From this position the ship was steered W.N.W. until 8 P.M., and then N.W. by W., but at 9.30 P.M. the water suddenly shoaling from 13 to 7 and then 5 fathoms, the anchor was at once let go and sail shortened, the wind being very light, so that the ship had barely steerage way. On anchoring the tide was found setting W.N.W.; at 2.15 A.M. on the 15th it turned to E.S.E., its velocity being a quarter of a mile per hour.

On the 15th, at daylight, the position of the anchorage by star observations was found to be lat. 6° 54′ 38″ S., long. 133° 57′ 30″ E., Red Patch Point bearing N. 66° E., and White Rock S. 79° E. The wind being light and variable steam was raised, and at 6.45 A.M. the anchor was weighed and the ship proceeded to the northward round a shallow patch with about 1 fathom on it, on which the vessel would certainly have run had the anchor not been promptly let go the previous evening. This patch, which was named "Blackburne Shoal," in lat. 6° 55′ S., long. 133° 57′ E., is about one mile in diameter and circular in form, as seen from the masthead. In rounding it soundings of from 4 to 7 fathoms were obtained, and there was apparently shallow water to the westward. After passing Blackburne Shoal a course was shaped to the northward, soundings of from 7 to 10 fathoms being obtained until 11 A.M., when in lat. 6° 35′ S., long. 133° 54′ E. the water deepened, and at noon the depth was 33 fathoms. The Arrou Islands were in sight all day, but presented a flat uniform appearance, owing to their being entirely covered with a virgin jungle. The only conspicuous object north of Red Patch Point was a small hill, slightly elevated above the adjacent land, in lat. 6° 40′ S., long. 134° 6′ E. The flat hill close to Red Patch Point can hardly be distinguished when seen from the northwestward. A breeze springing up just before noon enabled the ship to proceed under sail again, a great advantage in the tropics. In the afternoon the course was altered towards the northwest point of Lutor Island, which ends abruptly, and as the vessel proceeded, Maika and Babi Islands, which are flat and covered with trees, were sighted. At 6 P.M. Babi Island bore N.E. by N., the left extremity of Maika Island N. 43° E., the left extremity of Lutor Island S. 76° E., and the water having shoaled to 10 fathoms, a course was shaped to the north until 8 P.M., when, the depth being 45 fathoms, the ship hove to under topsails for the night.

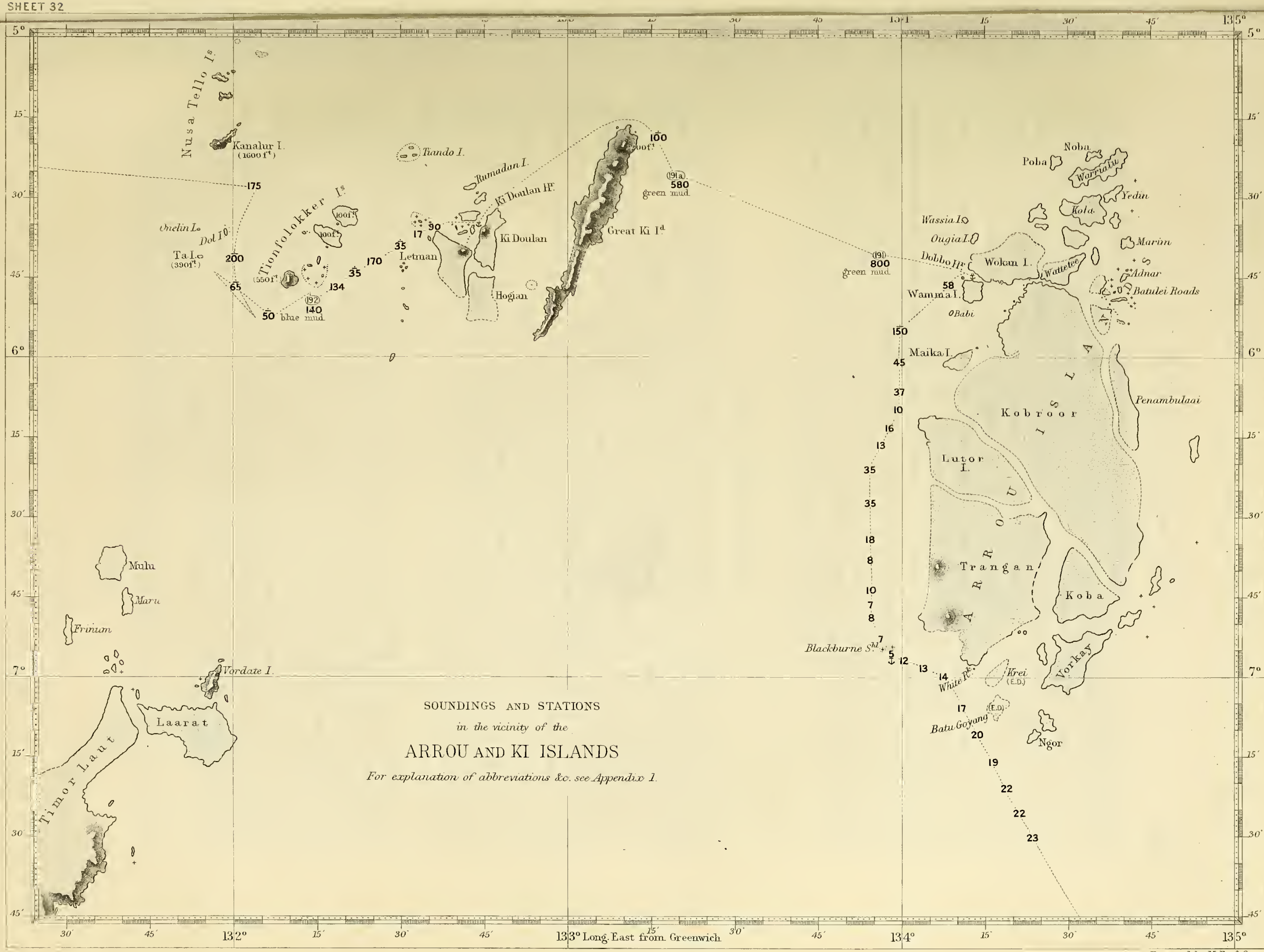
On the 16th, whilst drifting slowly away from the land, the water deepened until at 4 A.M. no bottom could be obtained at 150 fathoms. At 6 A.M. Babi Island bore N. 68° E., the left extremity of Maika Island S. 89° E., and the right extremity S. 52° E., and from this position the vessel was steered for Dobbo Harbour, and at 9 A.M. proceeded into the harbour under steam, with Dobbo Spit bearing E.S.E. When the rock off the northwest point of Wamma Island bore S. by W., several casts of 6 to 5½ fathoms were obtained. At 11 A.M. the ship anchored in 16 fathoms off the town of Dobbo, with the rock off the northwest point of Wamma Island bearing west, the left extremity of Wokan Island N. 38° W., and Dobbo Spit S. 31° E.

The deposits in 6 and 7 fathoms around and near Booby and Wednesday Islands consisted of siliceous sand with large numbers of non-pelagic Foraminifera, fragments of calcareous Algæ, Polyzoa, and Mollusc shells. Between the Arrou Islands and Cape York the depth in the Arafura Sea never exceeded 50 fathoms, usually ranging from 28 to 40 fathoms. The deposit was a greenish mud in all cases, containing fragments of quartz, mica, felspars, glauconite, &c., about 0·5 mm. in diameter. In the dredgings there were fragments of sandstone and other continental rocks. The carbonate of lime in these deposits rarely exceeded 10 per cent., and consisted of the shells of *Textularia* and *Rotalia*, fragments of Echinoderms and Molluscs.

A very remarkable new compound coral was obtained at the entrance to the Prince of Wales Channel, Station 186, 8 fathoms, which has been made by Mr. Quelch the type of a new genus, *Moseleya*, and provisionally referred by him to a new subfamily of the Astræidæ, Moseleyinæ. This coral is of great importance as showing an approach to the Rugosa in its structure, possessing dissepiments disposed in concentric circles and forming nearly complete tabulæ.[1]

The surface nets in the Arafura Sea yielded large numbers of Diatoms, being frequently filled with a yellow shiny mass, which recalled the hauls of Diatoms made during

[1] J. J. Quelch, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiii. p. 292, 1884.



Engraved by Malby & Sons.

the cruise in the Antarctic Ocean. As the Arrou Islands were approached Oscillatoriæ (*Trichodesmium*) were very numerous, colouring the sea in some places dull red or yellowish brown. The bundles of *Trichodesmium* were usually massed in great patches or long lines. These algæ appeared to be confined to the immediate surface layers, as tow-nets dragged several fathoms beneath the surface captured very few. Between Cape York and the Arrou Islands not a single specimen of pelagic Foraminifera was taken in the nets, and none were noticed in the deposits. The water was greenish in colour, but as the ship neared the Arrou Islands it became blue, and a few of the truly pelagic and open ocean organisms were again noticed in the tow-nets. As the water of the Arafura Sea has a low specific gravity, it is most probable that one or more large rivers enter it from New Guinea; the surface fauna and that of the bottom and the deposits are also more like that of a large bay than of the ocean. A few Frigate Birds, Boatswain Birds, and Terns were noticed during the trip, and Dolphins were very numerous.

Arrou (Aru) Islands.

Dobbo.—Immediately on anchoring, the head traders of Dobbo and the Dutch missionaries came off to visit the ship, all of them Malays from Macassar, their boats flying the Dutch flag. The traders came off in a Malay boat, with a double row of paddlers, dressed in gold embroidered coats, and full white trousers, supported by an ornamental belt. The missionaries who came from the village on the west side of Wamma Island were dressed in black tailed coats, trousers, and tall hats; each of them bore a silver-topped stick, with the Dutch royal arms on it, as their badge of office. They all appeared very hot and uncomfortable in their ceremonial dress, and brought off in their boats boxes containing their ordinary costume, into which they got as soon as their visit was paid, and they certainly looked much better in their picturesque dress of "sarong and baju" than they did in the by no means handsome black coat and hat of Europeans.

The time of the visit to Dobbo, the capital of the Arrou Islands, was at the end of the southeast monsoon, so that nearly all the trading vessels had taken their departure for Singapore, and the population of the village was reduced to about three hundred, of whom twenty were Chinese, ten Arrou Islanders (see Pl. XXV.), and the rest Malays; and a short time later the village would have been found nearly deserted, as the men left behind would have resumed their fishing, on the east coast of the group, for trepang, pearl-shells, and tortoiseshell. The price of the tortoiseshell at Dobbo was 15s. per pound, pearl-shells 2s. per pound, and Great Birds of Paradise 10s. each. The headquarters of the fishery on the east coast is at a place called Gomo Gomo, a small detached island, on which there are goats and plenty of poultry.

On Pulo Ougia and Pulo Wassia are some deer, which were no doubt originally landed by the Dutch, and have since rapidly increased, and the Malays said that alligators are met with in the swamps all over the islands.

The village of Dobbo was not in the least altered in the few years which had elapsed since Wallace's visit. Its line of Macassar trading vessels was drawn up on the beach. It is built on a spit of sand, extending a quarter of a mile from the shore, and about a cable broad; it consists of three rows of houses, divided by two narrow streets. The houses, of the usual Malay type, are raised on heavy piles, and have bamboo lath sides and floors, the whole covered with a high pitched roof of thick thatch. The ground floor, *i.e.*, the space between the piles enclosed by matwork, is used as storehouse and shop, and the floor above as the residence of the Malay families. Plate XXIII. shows a view up the main street of Dobbo; some timber for shipbuilding is seen lying about. The village appeared fairly healthy. The inhabitants procured their water from wells close to the town, near a burying place, a very unsanitary arrangement, which might give rise to sickness.

The Arrou group is nominally under Dutch authority. The Resident at Banda pays periodical visits to Dobbo, and inquires into the condition of the people, but there is no regular governor or magistrate on the islands, and the inhabitants do not appear to need one.

The Dutch have established a coal depôt at the east point of Wamma Island, called by the Malays "Blakan Ammara," which consists of a long shed 90 feet by 30 feet, and about 20 feet high, the coals contained in it being estimated at 300 to 350 tons. The water was deep right up to the beach on which the coaling shed was built, and boats can probably load at any time of tide, whilst ships requiring coals can find secure anchorage at a distance of about half a mile from the point.

The sun was excessively powerful at Arrou, the glare on the white sandy beach being felt more severely than anywhere else during the voyage. In wading in search of seaweeds on the coral shore platform, the water was positively found much warmer than was pleasant to the legs. The water was very shallow, only half way up to the knees, and the bottom white; the unusual heating being probably caused by the strong insolation on the water in these conditions.

Frequent excursions were made on shore with guides. The manner in which these guides met a heavy storm of rain was most amusing; they had, of course, no umbrellas, but did not wish their clothes, which consisted merely of two cloths, one worn round the shoulders, and the other round the loins, to get wet. They therefore simply stripped naked, rolled their clothes up tightly inside a large Screw-pine leaf, and so walked along till the rain was over, when they shook themselves dry and put their clothes on again.

A very large species of Screw-pine (*Pandanus*), a common East Indian littoral plant, with fruit as big as a man's head, is found along the shore. The stem, though large, is

Plate XXIII.

Horsburgh, Edinburgh. Permanent Phototype.

NATIVE HOUSES, DOBBO.

soft and succulent, and hence with a small axe one can enjoy all the pleasure of felling a large tree without any fatigue.

On the Island of Wokan, not far from the anchorage, sago palms abound in the swamps. Several parties of natives from the back country were living near the shore, having come from a distance in their boats, to prepare a store of sago to take home with them. They lived in small low-roofed houses made of poles and reeds, and raised on posts about two feet above the swampy ground. These temporary houses were so low that the natives could only squat or lie in them; two of them are shown on Pl. XXIV., the one in the background being merely a frame-work unfinished. The men were darker than the inhabitants of Wokan in the neighbourhood, and looked more Papuan in appearance. They were armed with finely-made spears with iron blade-like points, 6 or 8 inches long, and ornamented handles of carefully shaped wood. They would not part with these at any price.

They resented an attempt to look into their house, no doubt because of the presence of the women, who seemed extremely shy, and huddled together out of the way, as was also the case at Wanumbai. The men had wrist ornaments, which were closely similar in make to those common at Humboldt Bay, New Guinea, and at the Admiralty Islands, and consisted of broad band-shaped wristlets made of plaited fibres (of *Pandanus* ?), yellow and black worked into a pattern. The belts of the Admiralty Islanders are figured on Pl. H. figs. 2 and 3.

The bracelets of the Arrou Islanders were ornamented with European shirt buttons in lieu of the small ground-down shells (*Neritina*) used at New Guinea and the Admiralty Islands for the same purpose. The buttons came, no doubt, from the Chinese traders, and probably the natives thought they were intended for this purpose, as they do not look so very unlike the shells. The men had a number of buckets made of leaves full of sago, ready prepared, and their rude kneading-trough and strainers of palm fibre were seen in a swamp close by.

The trees are excessively high and large in the Arrou forests. To a botanical collector, with no time to spare, such a forest is a hopeless problem. Only the few low-growing plants can be gathered, and the orchids and ferns that hang on the stems low down, especially along the coast. A few small palms can be cut down, but not the forest trees, the flowers and fruits of which, the main features of the plant, and those most likely to prove of especial interest, are far out of reach. It would take a day at least to fell one of the trees. The only hope is for the botanist to lie on his back and look for blossoms or fruit with a binocular glass, and then try and shoot a branch down with shot. Very often, however, the trees are far too high for that, and then the matter must be given up altogether.

Some most enormous Stag's-horn Ferns (*Platycerium*), which appeared to be at least 8 feet in the height of the fronds, were seen growing on the high trees in Wokan Island but unfortunately only small specimens could be reached. The rattans are a serious obstacle in excursions in the forests. The tendrils of these trailing and climbing palms are beset with rows of recurved hooks, which, as they are drawn across the explorer's flesh in a dash made to get a shot at a bird, or by a stumble, cut into it as readily as knives, and inflict a more unpleasant wound.

An immense tree with a tall stem free from branches, until at a great height it spreads out into a wide and evenly shaped crown, was full of the nests of the Metallic Starling (*Calornis metallica*), a very beautiful small starling with dark plumage, which displays a brilliant purple metallic glance all over its surface. The Starlings breed thus gregariously; there must have been three or four hundred nests in the tree, every available branch being full of them. The birds were busy flying to and fro, and were quite safe, for the tree was so high that they were out of shot.

On one of the excursions in the forest a flock of brilliant plumaged parrots was met with, apparently feeding in company with a flock of white cockatoos. One of the parrots was successfully stalked and shot, whereupon the cockatoos set up the most angry harsh screaming, evidently making common cause with the parrots. They sat and screamed at the shooter on a tree close by, as angrily as if one of their own flock had been shot, and then flew overhead high up out of reach of the gun, looking down at the dead bird and still screaming.

The splendid large Bird-winged Butterfly (*Ornithoptera poseidon*), with brilliant green and velvety black wings, was common in the woods, but flew high and was difficult to catch. One or two were shot with dust shot, without their being utterly damaged, but the best chance of catching them is when a flock of males can be met with, fluttering round and mobbing a single female; they are then hovering slowly, quite close to the ground, and can easily be caught. The female has thus a large body of gaudy admirers from which to make her choice. Interesting results might possibly be derived from a series of experiments in which, in the case of brightly coloured and decorated butterflies, the colours should be rubbed off the wings of a few amongst a number of males, or painted over of a black or brown colour. It might be tested whether the females would always prefer the brightly coloured ones, and dark coloured butterflies might have the wings of the male touched up with a little colour.

A Snake (*Dipsas arruensis*) was obtained at Wokan. Amongst the insects collected were three new species of Lepidoptera,[1] viz., *Thanaos inornatus*, *Plesioneura proserpina*, and *Papilio alcidinus*, the last of which furnishes an interesting case of mimicry, which will be alluded to in the sequel (p. 581); a new species of Coleoptera (*Cautires amabilis*), and specimens of *Telephorus præustus*, Guérin, which have been made the type of a new genus (*Sphærarthrum*) by Mr. Waterhouse.[2]

[1] A. G. Butler, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xi. pp. 423, 424, 1884.
[2] C. O. Waterhouse, *Ibid.*, vol. xiii. pp. 280–282, 1884.

Plate XXIV.

Horsburgh, Edinburgh. Permanent Phototype.

NATIVE HUT, WOKAN.

One day was devoted to an excursion to the mainland of the Arrou Islands, to Wanumbai, Mr. Wallace's old hunting ground, in the channel between Maykor and Wokan Islands called by the Malays "Sungei Wateiai." For this purpose the steam pinnace was used; and as the right position of the channel was unknown to the navigating officers a guide was taken from the shore.

The guide having been procured, the pinnace proceeded for the Wateiai Channel, passing a large sea-snake on the surface of the water on the way, and at 1.30 P.M. arrived at the entrance and steamed up it about 1½ miles to the small village of Wanumbai, where a stream of fresh water fell into the channel from a height of about 15 feet. The channel runs east and west through the island, dividing the island of Wokan from that of Maykor; it is about a quarter of a mile wide, and the depth in the centre was found to vary from 4 to 5 fathoms.

The scene on the beach as the pinnace steamed into the village was most picturesque; none of the inhabitants having ever seen so small a craft propelled by steam, the whole population turned out to inspect the boat, Malays, Chinamen, and Arrou Islanders, al mixed together in a high state of curiosity and excitement. The people of Wanumbai were very much scared at the appearance of the pinnace, full of men with guns, but the Malay guide from Dobbo introduced the party; he jumped on shore and addressed the people of Wanumbai (Orang Wanumbai) and soon made matters right, telling them that the strangers had only come to shoot "dead birds" (Burong mate), the trade term by which the Birds of Paradise are known.

On the margin of the narrow sea channel was a compound house, a number of families living, as in Papua and elsewhere, under a single roof. It was an oblong building raised on numerous posts above the ground; inside was a central passage, leading from the door to the back wall, and on either side of this it was divided into small pens by low irregularly made partitions. Each of these pens held a family, and the women huddled together to hide themselves in the corners of them, just as did those in Wokan Island.

Bows and arrows were purchased from the natives. The arrows are very like New Guinea arrows in the various forms of their points, but, unlike them, are all provided with a notch and feathers, the latter often bright parrots' feathers. Some have a blade-like point of bamboo, and a man who was watching a native plantation, to keep wild animals off, said he used these for shooting pigs. Some are tipped with Cassowary bone, some are many-pronged; these latter are used for shooting birds, and are not exclusively fish arrows, as is often supposed. Besides these, there are the arrows with a large blunt knob at the end, used for stunning the large Birds of Paradise, without spoiling their skins, as described by Mr. Wallace.[1] Pointed arrows are, however, used more frequently for this purpose, as Wallace relates, because the birds are so strong as to escape being stunned, and the points are more certain weapons. It is curious that closely

[1] Wallace, Malay Archipelago, vol. ii. p. 220, London, 1869.

similar knobbed arrows are used in South America by certain tribes, to kill Trogons and other fine plumaged birds. One man brought for sale a large Bird of Paradise, dried in the usual manner, but he wanted the full price for it asked by the Chinese dealers at Dobbo.

Mr. Moseley writes of this excursion as follows :—"I procured two guides, a man and a boy, and promised them a florin for every Bird of Paradise that I shot. I had previously been in pursuit of the birds at Wokan, but they were not so common there, and I believe that the native guides did not exert themselves to show us the birds, as they no doubt regard them more or less as property, and a source of wealth.

"My first acquaintance with the great Bird of Paradise (*Paradisea apoda*) was at Wokan. I was making my way through the forest with a guide in the very early morning, when a flock of birds flew by in the misty light, passing right over my head. They flew somewhat like a flock of jackdaws, and I was disgusted to realize when too late that they were a flock of the very birds I was in search of. I did not fire for fear of disturbing the woods. I heard them cry soon after 'wauk, wauk,' but could not come up with them.

"At Wanumbai with my guides, I first encountered a number of Fruit Bats, which were on the wing in the early morning, and I killed one with a young one hanging at its breast. We soon heard the cry of the great Bird of Paradise, 'wauk, wauk.' I crept up within shot with my guides several times, but as usual, though they saw the bird plainly amongst the foliage, I could not make it out in time, though I saw the leaves rustle, and I did not want to fire without making sure. The guides, in view of the florin, were as excited as I was, and kept seizing my arm and pointing, 'burong mate, burong mate,' but away went the bird without showing itself to me. The birds seemed to keep constantly on the move in the trees, hopping from branch to branch, and were very quick and silent in their flight away to a fresh spot. Several times I saw them amongst the branches of trees so high that it was useless to shoot at them, for my cartridges, specially prepared with nearly four drachms of powder, had no effect. The birds seemed to be as often single as in companies, and were evidently on the feed in the early morning. At last a hen bird flew up off the ground close to me, with a small lizard in her beak, and pitched on a dead branch to eat it, and I shot her. But, of course, what I wished was a male in full plumage. This, however, was not to be obtained, for not a single one was shot. It is remarkable what a very large proportion of young males and females of the great Bird of Paradise there seems to be, to the comparatively small number of males in full dress. I believe I saw one at the top of a high tree, but am not certain. Probably the old males are warier, being often hunted, and keep out of the way. They require four or five years to develop full dress.[1] At the breeding

[1] It is improbable that *Paradisea apoda* loses its breeding plumage as soon as the breeding season is over. *Paradisea minor*, as has been observed in the case of specimens kept in confinement in the Zoological Gardens, London, certainly loses its plumes only at the moulting season, like other richly ornamented birds. *Paradisea apoda* moults, according to Wallace, in January or February, and is in full plumage in May. At all events there must have remained birds with plumes in September.

Plate XXV.

HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

ARU ISLANDERS.

season, when the natives kill most of them, they assemble, and are easily obtained. The cry 'wauk,' is not so far removed from such cries as those of the Rook and others of the Corvidæ, to which the Paradise Birds are allied. The voices of birds need, however, no more necessarily be a test of the pedigrees of the birds themselves, than need language be a test of true race connection amongst mankind.

"In the case of the other smaller species of Paradise Birds found in the Arrou Islands, the King Bird (*Cicinnurus regius*), the males in full plumage seemed as common as the simple brown young males and females. The natives knew these latter well, as forms of the brilliant red bird, though so vastly different, and several times pointed them out to me, as 'Gobi, gobi,' their name for the King Bird. The King Birds were even more abundant at Wanumbai than the larger species. The males when settled in the trees constantly uttered a cry which is very like that of the Wryneck or Cuckoo's Mate. I saw most of them in the lower trees of the forest, at about 30 feet from the ground. One shot by Mr. Abbott, one of the Challenger engineers, when in Wokan, hovered and hopped for some time about a mass of creepers hanging from a large tree, apparently searching for insects, and as it hovered, it showed its bright scarlet back like a flash of fire. Usually the bird sitting on the twigs and seen from below shows none of its beauty. The birds seem very tame, but like the Rifle Bird and the Great Bird of Paradise, are usually in constant motion. One full-plumaged bird sat on a twig about four feet from the ground, and looked at me for a while at not more than three yards distance, and then darted away, more out of natural impulse, I imagine, than fear. I shot five of the birds in one day. One of them had the wonderful spiral green tail feathers, only just growing out. The bright lapis-lazuli blue colour of the birds' legs and feet when fresh greatly enhances its beauty. Luckily the skin of the Paradise Birds is tough, and I found the King Bird easy to skin. The short red feathers encroach on the base of the bill on its upper surface, in an unusual manner, the tip of the bill only being free, and this gives the head a curious appearance."

The coral rock of Wokan Island is exposed in section on the shore not far from Dobbo, in a cliff about 11 feet in height. The strata are inclined towards the sea at an angle of about 20°. Inland, the surface is marked by a series of ridges of small elevation, and from the presence of numerous bivalve shells, seems to have been raised above sea level.

There is a freshwater stream not far from Wanumbai, which flows over the coral rock, overhung by dense vegetation. In the bed of the stream, a constant deposit of carbonate of lime is taking place, and the bed is partitioned into a series of pools, separated by ridges and projections of stalactite-like substance, which lines also the pools themselves.

The following account of the weather at Dobbo was obtained from the Malays:— The southeast monsoon commences early in May, and continues until the end of

August or middle of September, after which light variable winds are experienced, until the middle or end of November, when the northwest monsoon sets in. Although during the southeast monsoon rain squalls are frequent, the regular rainy season is the northwest monsoon; the finest months are September and October.

The tides in Dobbo Harbour are somewhat irregular; during the stay, however, the diurnal inequality was very slight. It is high water at full and change at 2 hours 30 minutes, and the tides rise 6 feet. The flood stream was of very little strength, but the ebb ran to the westward at the rate of from 1 to $1\frac{1}{2}$ miles per hour at the anchorage.

The coin in circulation at the village was the Dutch dollar, 4s. 2d., and rupee, 1s. 8d., but the Chinamen were eager to obtain English gold.

The Arrou Islands appear to be by no means visited so infrequently as one would suppose. The Malays stated that a Russian frigate had called there about two years previously, a small Italian vessel had been there not long before, and they also asserted that an English yawl had lately visited Dobbo, and the main islands of the group; besides which a party of Americans, two years previously, stopped a considerable time in Kobroor, and one of them died and was buried there.

The only supplies that could be obtained were a few poor fowls at two shillings each, and some eggs, twopence each; occasionally a few fish were brought alongside.

The Arrou Islands to the Ki Islands.

Having procured astronomical and magnetic observations, the ship left Dobbo Harbour on the 23rd September for the Ki Islands. In going out of the harbour the water suddenly shoaled to $3\frac{1}{2}$ fathoms, with the northwest point of Wamma Island S. 86° W., and Dobbo Spit S. 68° E. When Pulo Babi came open of Wamma Island, the water deepened to 16 and 20 fathoms, and shortly afterwards to 48 fathoms, with the extremity of Dobbo Spit S. 66° 40′ E., the left extremity of Wassia Island N. 32° 40′ E., and the right extremity of Pulo Babi S. 17° E. At 10 A.M. a sounding, trawling, and temperatures were taken in 800 fathoms (Station 191), with Dobbo Spit S. 66° 40′ E., the left extremity of Wassia Island N. 44° 20′ E., and the right extremity of Pulo Babi S. 26° E., and at 6 P.M. sail was made for the north point of Great Ki Island (see Sheet 32). Whilst trawling, the tide was setting northwest until 4 P.M.; and as it was ebbing in Dobbo Harbour, it is probable that the ebb sets northwest, and the flood southeast.

The Ki (Ké) Islands.

On the 24th, at daylight, Great Ki Island was observed ahead. By observations and bearings of the land, it was found that there had been a current of 20 miles to the westward since 6 P.M. of the previous day, at the rate of $1\frac{1}{2}$ miles per hour. At 6 A.M. a sounding and serial temperatures were taken in 580 fathoms, and then sail was made for the north end of the island. Whilst the ship was off the coast of Great Ki Island several boats full of natives came off. The boats have been described by Wallace;[1] they are shaped like whale boats, and are constructed of planks fastened together with pegs and rattans. The crews used paddles with long blades pointed at the ends and with cross handles. They paddled in time to a chanted cadence identical with one used by the Fijians in their dances, "ē ai ō tum tum." At intervals the sound rose loud from the approaching boats as it was taken up in chorus. The chant was accompanied by a drum with a tense membrane on which two sounds were made by striking it slightly with the tips of the fingers or more violently with the palm of the hand, the sound reminding one that the course was tending towards India, for such a method of tomtom playing is not known in Melanesia or Polynesia, but is in vogue in Ceylon and India, especially by Tamil coolies.

The men, a boat-load of whom came on board, were like the Arrou Islanders, but for the most part more strongly built. They wore their hair long and loose, and had no ornaments; most of them wore only an apron of cloth. All of them were in the most horrible state of cutaneous disease, the skin being in a rough scurfy condition in many cases all over the body. Worse cases of vegetable itch could not occur. The disease is due to a parasitic fungus, and closely allied to or identical with *Pityriasis versicolor*. Dr. Crosbie, Staff-Surgeon of the Challenger, made a careful microscopical examination of it. The disease is widely spread in Melanesia and Polynesia.[2] The men kept constantly scratching themselves violently, and life can be scarcely bearable in Great Ki Island; yet the disease is one easily cured.

The men begged for all kinds of things, and especially spirits and tobacco. One of the boats had well-made pottery, nicely ornamented with patterns in red, for barter, but unfortunately no specimens were procured. The men, as did also the Malays at Dobbo, used a slight click with the tongue, accompanied by a very slow shaking of the head to express astonishment. At 1 P.M. the ship rounded the north end of Great Ki Island, and steered towards Little Ki Island.

The position of the north point of Great Ki Island (which is called Tanjong Burong) was made to be lat. 5° 16′ 45″ S., long. 133° 10′ 45″ E. It is a bluff point readily distinguished, and has on each side a small bay where probably anchorage may be found; there were a few huts in these bays. The northeast point of Great Ki Island is low and sandy, with a group of *Casuarina* trees; it lies S. 50° E., just over two miles from Tanjong Burong, and off the point are two small islets, the outermost of which is 40 feet high. From here the land trends to the southward for three miles, and then recedes to the westward, forming a small bay, on the south point of which (lat. 5° 24′ S., long. 133° 11′ E.) is the village of Ali Bandang, from which the land runs S. by W. ½ W. to a conspicuous point in lat. 5° 34′ S., long. 133° 8′ E. Between the northeast point

[1] Malay Archipelago, vol. ii. pp. 183–186, London, 1869.
[2] See Tilbury Fox, M.D., On the Tokelau Ringworm and its Fungus, *The Lancet*, p. 304, 1874.

and the village of Ali Bandang are two other small villages. Nearly two miles westward of Tanjong Burong is the northwest point of Great Ki Island, off which is a small detached rock 30 to 40 feet in height. From the northwest point the land trends S.S.W. for a considerable distance without any conspicuous object on the coast. The whole of Great Ki Island is mountainous, but the tops of the hills were capped with cloud during the day, so that it was impossible to obtain the heights of any but the extreme northern mountain, which was found to be 2000 feet above the sea. The land is densely wooded, but here and there in the vicinity of the villages are clearings.

Little Ki Island, with its off-lying islets, is low, but as they are all covered with trees, the tops of which are at least 100 feet in height, they can be seen at a distance of 15 or 16 miles.

At 4 P.M. the peak of Kalamit was distinguished, and bringing it in line with the northwest point of Ki Doulan, the ship was steered in for the anchorage off Tamandan, where she was brought up at dusk in 8 fathoms, with the left extremity of Dranan Island west, the right extremity of Pulo Bandang N. 22° W., Tanjong Serbat S. 81° E., Bukit Krain S. 31° W.

Shortly after anchoring, several boats came off to the ship flying the Dutch flag and paddling to a chant different from that sung by the inhabitants of Great Ki, but very similar. The men being shipbuilders by profession were delighted with the ship and ran all over her, and climbed into the rigging.

A dance was got up on the quarter deck. The drum was beaten by two performers and a song accompanied it, but there was no clapping of hands as at Fiji; the whole mode of dancing was absolutely different, and the attitudes of the dancers were sufficient alone to have told one that one was amongst Malays and not Melanesians or Polynesians. The dance, in which only two or three performers danced at a time, consisted of a very slowly executed series of poses of the body and limbs. There was no exact keeping of time to the accompaniment, nor union of action between the dancers. The hands and arms during the action were slowly moved from behind to the front, the palms being held forwards, and the thumbs stretched out straight from them. In another dance a motion as of pulling a rope was used. The chant to one dance was the words "uela a uela." There was also a dance of two performers with sticks to represent a combat with swords. The whole was closely like the dancing of the Lutaos seen afterwards at Samboangan, which will be described in the sequel.

On the 25th, at 6 A.M., the ship proceeded for the anchorage off Ki Doulan, where the Rajah resides, and at 7 A.M. "came to" in 19 fathoms, very close to the reef, abreast a small pier running out in front of the village. The pier, which is formed of loose coral stones, has a depth of 5 or 6 feet at its outer end at low water.

The Rajah of Ki Doulan came on board shortly after the anchor was down, and breakfasted in the cabin, making a hearty meal off curried meat and sardines. He

Plate XXVI.

Horsburgh, Edinburgh. Permanent Phototype.

VILLAGE, KÉ DOULAN.

was afterwards conducted round the ship, and was evidently struck with the superior comfort of the style of living in comparison with his own.

The day was employed in surveying the harbour, in taking astronomical and magnetic observations, in observing the tides and exploring the islands. There was a large number of cocoanut trees by the villages on the beaches, and numerous bread fruit and sago trees, sago being the staple food of the natives (see Pl. XXVII.).

The houses of the village of the Ki Doulan were all raised on posts, except the Mohammedan Mosque, which building shows a curious development of the high-peaked Malay roof into a sort of half tower, half spire, representing no doubt an equivalent of the dome (see Pl. XXVI.). Under the eaves of the houses baskets were hung up for the fowls to nest in.

Some boys were playing near the village, and, as a toy, they had a very ingeniously made model of a spring gun, or rather spring bow, a trap by which a large arrow is shot into a wild pig, on its setting loose a catch. A boy who acted as guide, and wore a turban, placed his hand upon it and said, "Mohammed," and explained to Captain Tizard that the small boys at play, whose heads were bare, were heathen; he was evidently very proud of his religion.

The Ki Islanders, besides arrows like those of the Arrou Islanders, use others which are peculiar. They are light, thin narrow strips cut out of the long leaves of what is believed to be a species of *Canna*. The strips are so cut that the stiff midrib of the leaf forms the shaft of the arrow, and portions of the wings of the leaf are left on at the base of the arrow to act as feathers; the point is simply sharpened with the knife. These leaf arrows when dry are hard and stiff, and are very easily made by a few strokes of the knife. A large bundle of them is carried by the archer, and they are shot away at a bird in the bush without the trouble being taken to find them again, as in the case of other arrows. They are so small and light that they make very little show in their flight, and no noise; and a youth was seen to shoot at least a dozen of them, at a large Nutmeg Pigeon, without the bird's doing more than move its head, and start a little as they flew by almost touching it. These Nutmeg Pigeons (*Carpophaga concinna*) are very large heavy birds; some of those shot weighed 2 lbs., and a considerable supply was obtained.

A Fruit Bat (*Pteropus melanopogon*) and several Lizards (*Varanus indicus, Hemidactylus* sp., *Cyclodus* sp., and *Heteropus* sp.), as also several of the Scincidæ, were obtained.

A large collection of insects was made, of which the following species are new:—Lepidoptera,[1] *Hamadryas niveipicta, Lampides ætherialis, Terias photophila, Papilio thomsonii, Pamphila moseleyi*; Coleoptera,[2] *Pelops gularis*; Hymenoptera,[3] *Bracon stigmaticus, Dielis wallacei.*

[1] A. G. Butlers, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiii. p. 191 *et seq.*, 1884.
[2] C. O. Waterhouse, *Ibid.*, p. 279.
[3] W. F. Kirby, *Ibid.*, pp. 404, 407.

Among the land shells *Nanina citrina*, Linn., was collected, which has not been previously recorded from these islands.[1]

Mr. Darwin in his Journal[2] refers to *Epeira clavipes*, as said by Sloane to make webs so strong as to catch birds. At Little Ki Island von Willemoes Suhm actually found a strong and healthy "Glossy or Metallic Starling" (*Calornis metallica*) caught fast in a yellow spider's web, made by a large *Nephila*, and he took the bird out alive and brought it on board the ship to be preserved.

A few fowls, eggs, pumpkins, and plantains were procured, but the supply was limited. There were several large patches of cleared ground under cultivation, and boat-building was being carried on briskly, for here the boats are built with which the pearl fishers at the Arrou Islands pursue their occupation.

The natives appeared to be very jealous of their women, for not one was seen by any of the exploring parties.

The tidal observations showed that it is high water at full and change at 1 hour 26 minutes, and that spring tides rise 7 feet.

Ki Islands to the Banda Islands.

On the 26th September, at 6.30 a.m., the vessel left Ki Doulan for the Banda Islands, passing out to the westward, where the Malay people said a passage existed, and making a running survey of the channel. The ship was steered south of Pulo Doulan Laut, and between it and the islands of Oboor and Oot, and then between the northwest point of Pulo Letman and the Gadang Islands. Deep water was found from the anchorage to the northeast end of Pulo Oboor, when depths of from 7 to 10 fathoms were obtained, whilst rounding the north point of that island at a distance of three cables. When the west point of Oboor bore south, the water again deepened, and no bottom was obtained at 25 fathoms, although the ship was passing between coral reefs nearly dry. Off the southwest extremity of the shore reef, from Pulo Doulan Laut, the soundings were 21 to 28 fathoms, and a little farther westward 9 to 12 fathoms over what appeared to be a ledge joining the northwest extremity of Pulo Letman with Pulo Doulan Laut. Farther on the water again deepened until the depth was 90 fathoms between the Gadang Islands and Pulo Letman, from whence a S.W. by W. course was steered for a group of islands marked on the chart, "Tionfolokker, P.D." At 3.30 p.m. a running survey of the Tionfolokker Islands was completed, and the ship stopped and trawled in 129 to 140 fathoms, and then steamed to the westward until 8 p.m., when sail was made for the night.

The two trawlings, taken in 129 to 140 fathoms (Station 192), off the southwest

[1] E. A. Smith, *Proc. Zool. Soc. Lond.*, p. 259, 1884.

[2] Journal of Researches during the Voyage of H.M.S. "Beagle," p. 36, ed. 1879.

Horsburgh, Edinburgh. Permanent Phototype.

Breadfruit Tree, Ké Doulan.

point of the Tionfolokker Islands, were the richest in new species and number of specimens obtained during the cruise, siliceous Sponges. Corals. Pennatulids, and Echinoderms being especially abundant.

The deposit at this Station was also of considerable interest. The sounding tube brought up specimens of a blue mud, containing about 10 per cent. of carbonate of lime, and in the trawls, besides pumice stones, were several large concretions or fragments of a calcareous rock, differing very considerably from the deposit.

The Concretions were of two kinds. First, many more or less rounded agglutinations loosely held together, and from 1 to 7 centimetres in diameter. Second, several large honeycombed pieces of rock, several decimetres in diameter, and requiring a sharp blow from a hammer to break them.

Those belonging to the first variety are grey or brown, sometimes slightly greenish, granular, and it can be seen with the lens that they are essentially composed of Foraminifera. An examination of thin sections of these nodules shows that they are agglutinated or coagulated by an argillo-calcareous cement which is not in great abundance. Some of the shells are entirely filled with pale green glauconite, others only partially. The intervals between the shells are not filled up with the cementing matter, and appear to be the first phase of agglutination.

Those of the second variety are very irregular in shape, and consist of large pieces of a hard rock traversed in all directions by large and small perforations, with a diameter varying from 1 to 4 centimetres. These blocks have thus a cavernous or coarse cellular appearance. The perforations are covered, like the surface of the rock, with organisms, as Sponges, Polyzoa, &c., and rough to the touch; the smaller perforations have sometimes the appearance of having been produced by lithophagous Molluscs. These concretions have the hardness of calcite; the freshly broken fragments are white-grey. A microscopic examination shows that they are mainly composed of various species of pelagic Foraminifera. Treated with weak acid the concretions decompose with effervescence, leaving a residue of 20·44 per cent., the rest being carbonate of lime. The residue is essentially composed of argillaceous matter, together with a few grains of felspar and quartz, and glauconitic casts of the Foraminifera, these last being brown or green and feebly transparent. The greenish casts present most of the characters of true glauconite. Examined with the microscope in thin sections, the Foraminifera composing the rock are seen to be the same as those in the first variety and also in the muds of the same region; mixed up with these are fragments of Echinoderms, &c. They are sometimes filled with greenish glauconite, but more generally with a semi-opaque greyish matter which constitutes the cement of the various elements of the rock, and must be considered as impure carbonate of lime. It has a slightly opaline aspect, is homogeneous under low powers, but with higher powers a fine granulation can be seen which the optical properties show to be due to minute crystalline particles. A section of these concretions resembles in most respects a section of a hardened Globigerina ooze from tropical regions. In this case, however, the shells are nearly all filled and cemented by the finely granular carbonate of lime, while in a Globigerina ooze they are empty.

It is not improbable that these large concretions or rock-fragments are hardened portions of a deep-sea deposit formed at a much greater depth, and subsequently elevated into the position in which they were found, probably by the same elevation as that which upheaved the neighbouring islands.

On the 27th, at 5.30 A.M., the position was obtained by star observations, and from that time until 4.30 P.M. the course was altered as necessary to complete the survey of the Brother Islands and the Tionfolokker group.

It was found that the Tionfolokker group consisted of three large and four small islands, with a few outlying rocks. The southwesternmost island of the group is 550 feet high, and round-backed, the other islands are all low and flat, but covered with trees, so that they are visible at a distance of from 12 to 15 miles. They lie in a N.E. by N. and S.W. by. S. direction, between the parallels of 5° 31′ and 5° 47′ S. latitude, and the meridians of 132° 8′ and 132° 23′ E. longitude. Passing the group on the southeast side, soundings of 170 to 140 fathoms were obtained. On the northeast side of the high, or southwestern, island are two small islets, from which a reef extends to the southward a distance of three miles, and near the edge of this reef are some rocks above water; with this exception no danger was seen, but ships should be cautious in venturing amongst these islands until the channels between them have been sounded (see Sheet 32).

The Brother Islands are three in number. The southern island, Pulo Ta, 390 feet high, is in lat. 5° 40½′ S., long. 131° 55′ E., circular in shape, about one mile in diameter, and a small reef fringes its shore. The northwest Brother, Pulo Onelin, is low, but covered with trees, circular in shape, and about half a mile in diameter, bears N. by W. 5 miles from Pulo Ta, and is in lat. 5° 26′ 15″ S., long. 131° 54½′ E. Pulo Dol, the northeasternmost island of the Brother group is also low, but is larger than the other two islands, being a mile and a quarter long in a N. by W. and S. by E. direction, and one mile wide; it lies 6 miles N.E. by N. from Pulo Ta, and is in lat. 5° 36½′ S., long. 131° 58½′ E. A coral reef fringes the shores of all three islands, but does not extend to any great distance from them; the channels between them appear free from danger.

Kanalur Island, the southern island of the Nusa Tello group, is of considerable size, and rises in a succession of terraces to a height of 1600 feet. The summit is in lat. 5° 20½′ S., long. 131° 57′ E. In the passage between the Brother Islands and Kanalur Island, which is 12 miles wide, a sounding of 175 fathoms was obtained.

The Brother Islands and Kanalur are inhabited, for cocoanut trees were seen growing on them, and boats pulling from one island to the other, besides smoke rising from Kanalur. It could not be ascertained whether the Tionfolokker Islands were inhabited or not. The officers forbore naming the various islands of that group, as doubtless they have already received names from the Malays, and it would have been a pity to introduce others.

All these islands appeared to be of coral formation. Even Kanalur, 1600 feet high, looked like a succession of raised reefs, but whether they really are all of coral formation it was impossible to determine, as landing was not effected on any of them.

At 5 P.M. Pulo Ta bore S. 32° W., and Kanalur peak N. 44° W. From this position the ship proceeded under steam for Bird Island, in order to fix its position, which appeared to be very uncertain, the chart and Horsburgh's Directory disagreeing considerably.

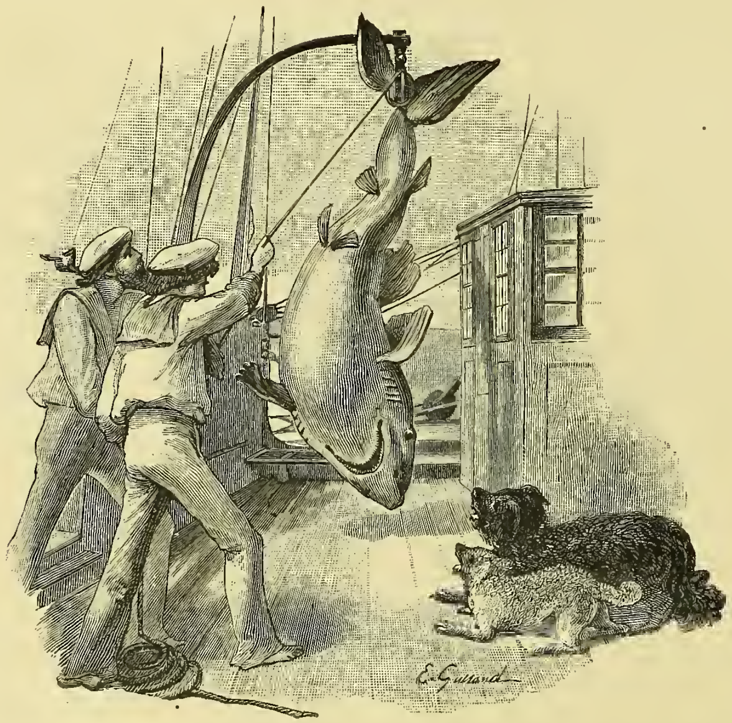
At daylight on the 28th Bird Island was sighted, and at 9 A.M. a sounding and temperatures were taken in 2800 fathoms (see Sheet 31). The temperature from 900 fathoms to the bottom remained the same, showing that the Banda Sea is separated from the Arafura Sea and Pacific Ocean by a ridge, the greatest depth over which cannot exceed 900 fathoms. At noon the ship proceeded to the westward, and at 2.45 P.M., when Bird Island bore south (true) sights for longitude and a meridian altitude of Venus were obtained, which enabled the position of the island to be fixed accurately. The result was considerably different from the position assigned it on the chart. At 6 P.M. no bottom was obtained at 600 fathoms, and the course then altered for the Banda Islands.

Bird Island, in lat. 5° 33½′ S., long. 130° 18′ E., is about one mile long, N.N.W. and S.S.E., and half a mile wide. In shape it is somewhat like a small prism, and rises at an angle of 30° from the sea to the summit, which attains an elevation of 980 feet. There are trees on the island, but they do not completely cover it, as the southern part of the summit and the western side of its slopes were bare. Smoke was seen on shore, but whether this was due to volcanic agency, or merely to a fire lit by natives, could not be determined.

On the 29th, at daylight, the Banda Islands were seen ahead, Pulo Rhun bearing N.N.W. ¾ W., and Pulo Rozengain N.N.E. ½ E. Steering for the passage between Banda and Rozengain Islands, the islands were found placed incorrectly relatively to each other on the chart, so a running survey of them was made. At 10 A.M. no bottom was obtained with 300 fathoms, the left extremity of Pulo Waii, in line with the left extremity of Banda N. 76½ W., and the right extremity of Banda N. 14° W. Proceeding a short distance farther to the northward, a sounding and dredging were obtained in 200 fathoms with the left extremity of Banda S. 65° W., the peak of Rozengain S. 67° E., and the right extremity of Banda N. 29° W.; and again in 360 fathoms, with Gunung

Api S. 81° W., Banda S. 45° 30′ W., and the left peak of Rozengain S. 47° 15′ E. At 1.30 P.M. the ship was steered in for the anchorage, passing between Pulo Pisang and Tangong Boerong, and at 2.15 P.M. anchored in 7 fathoms, with the right extremity of Pulo Neira N. 35° E., Fort Nassau N. 5° W., and the left extremity of Gunung Api Island N. 86° W.

The deposit at 2800 fathoms in the Banda Sea was a blue mud, without any traces of carbonate of lime or shells of pelagic Foraminifera. The deposits at lesser depths in the same region usually contained many Foraminifera in the surface layers, while the deeper layers, which were of a blue colour, contained very few. Glauconite was present in all the deposits, together with the usual mineral particles derived from continental land. In the trawling in 360 fathoms, close to the island of Banda, a *Spirula*, with the soft tissues preserved, was taken—the only one obtained during the cruise. It had possibly been disgorged from the stomach of some animal, perhaps a fish, as the epidermis was partially digested, as is the case in most specimens known.



CHAPTER XIV.

Banda Islands—The Monaxonida—Banda to Amboina—Actiniaria—Amboina—Mimicry in Butterflies and Moths—The Brachyura—Amboina to Ternate—Ternate—The Medusæ.

Banda Islands.

The Banda Islands,[1] twelve in number, were known to, and frequently visited by, the Malays and Javanese before the advent of Europeans. The first European who landed at Banda was Bartema, of Bologna, who returned to Europe in 1506, and gave the first account of the clove tree. In 1511 Affonso Alboquerque, after his conquest of Malacca, despatched Antonio d'Abreu, one of his lieutenants, to trade with, and take possession of, the Spice Islands. On his way d'Abreu touched at Gressie, in Java, and procured Malay and Javanese pilots, who took him first to Amboina and then to Banda. He loaded his ships with mace and nutmegs, and left the islands well satisfied with his reception.

The Banda group consists of twelve islands, the names of which are written as follows on the Admiralty charts :—Banda (or Great Banda), Neira, Goonong Api, Kraka, Pisang, Kapal, Waii, Rhun, Naailaka, Swangi, Rozengain, and Poeloe (see Sheet 33). Their names were correctly given by the Malayan traders who had frequented them for ages. Banda, correctly Bândan, means in Javanese, "the thing or things tied or united," or with the word Pulo, "united islands." Pulo Nera is the "island of palm-wine," Lontar, written by Europeans Lonthor, is the name of the palm, the leaf of which is used for writing on, the word being half Sanscrit and half Javanese. Pulo Ai, properly Pulo Wai, means "water island." Pulo Pisang, "banana island." Pulo Run (Rung), "chamber island." Pulo Suwanggi, "sorcery island." Gunung-api, "fire mountain" or "volcano."

The whole Banda group, which has an area of not less than 18 square miles, is of volcanic formation, and the island of Gunung Api is an active volcano, the summit of which is 1860 feet above the level of the sea.

The eruptions of this mountain have been frequent and destructive. The first of which there is any record took place in 1629; this was followed by others in 1690 and the five following years, also in the years 1765, 1775, 1816, 1820, and 1852. In the months of November and December of 1852 a succession of fearful earthquakes, unaccompanied by any eruption of Gunung Api, took place, which nearly overwhelmed the islands of

[1] Crawfurd's Descriptive Dictionary of Indian Islands; Crawfurd's Indian Archipelago; Wallace's Malay Archipelago; Hakluyt Society's Publications; Pinkerton's Voyages, 1808–14; Stavorinus' Voyages; Somerot's Spice Islands; Rozengain, Een der Eilanden van de Banda Groep; Samuel Purchas, his Pilgrimes, Lond. 1625; Harris's Collection of Voyages.

Banda and Neira, overthrowing houses, and destroying ships and nutmeg plantations. The eruptions of Gunung Api are generally accompanied by violent earthquakes and an earthquake wave. In the eruption of 1690 the sea is said to have risen 25 feet above the level of high water at springs, to have swept off every dwelling near the shore, and to have destroyed all the ships in the harbour; a cannon weighing 3500 lbs. was carried away from the quay on which it stood to the distance of 30 feet. In the eruption of 1691 the succesion of earthquakes which took place was such as to terrify the inhabitants, many of whom emigrated to Amboina and Celebes. The eruption of 1852 seems to have been as disastrous as that of 1690.

At the time of the visit of the Portuguese to the Banda Islands in 1512, the natives, although few in number, were a spirited and independent people, living under a kind of rude republican government, and Mohammedan in religion. Soon after 1512 the Portuguese established a factory here for the purchase of spices, and remained in possession of the nutmeg trade for nearly a century, when in 1609 the Dutch, with three ships, and seven hundred soldiers, made their appearance, took possession of the islands, and began constructing a fort on the ruins of one which had belonged to the Portuguese. The natives resisted, seduced the Dutch Admiral and forty-five of his companions into an ambuscade, and massacred them. This led to a war of extermination, which was not closed until 1627. The unfortunate natives in these contests behaved with much courage and perseverance, virtues which would have been successful in the expulsion of the invaders but for the disunion and feebleness incident to their geographical position and to their want of civilization. In 1615 a large fleet and military expedition attempted the conquest of the group, but the Banda men conducting themselves with extraordinary courage, the Dutch were defeated, and the governor-general, who accompanied the troops, died of chagrin on account of the failure. In 1616 the islanders were subdued and forced into treaties more hostile to their prosperity than ever. In 1620 the Banda men again attempted to regain their independence. At this period the Dutch and English were reconciled to each other, and the latter regretted their inability, from want of means, to join the Dutch in a league for the subversion of the natives. The Dutch governor-general piously declared he would undertake the enterprise with the assistance of Heaven, which he boasted had hitherto been so favourable to him. In 1621 all the islands but Great Banda submitted to the rule of the Dutch; but there the natives betook themselves to the mountains, where in time they were starved and hunted down until at length the survivors, a poor remnant of eight hundred persons, surrendered themselves, were transported to Batavia, and in the course of time absorbed into the ranks of the inhabitants of Java, so that now no vestige of the language or customs of the original inhabitants can be traced. In this manner the Dutch became undisputed masters of the nutmeg monopoly, and introduced slaves for the purpose of carrying on the cultivation; when slavery was abolished, convict labour was substituted.

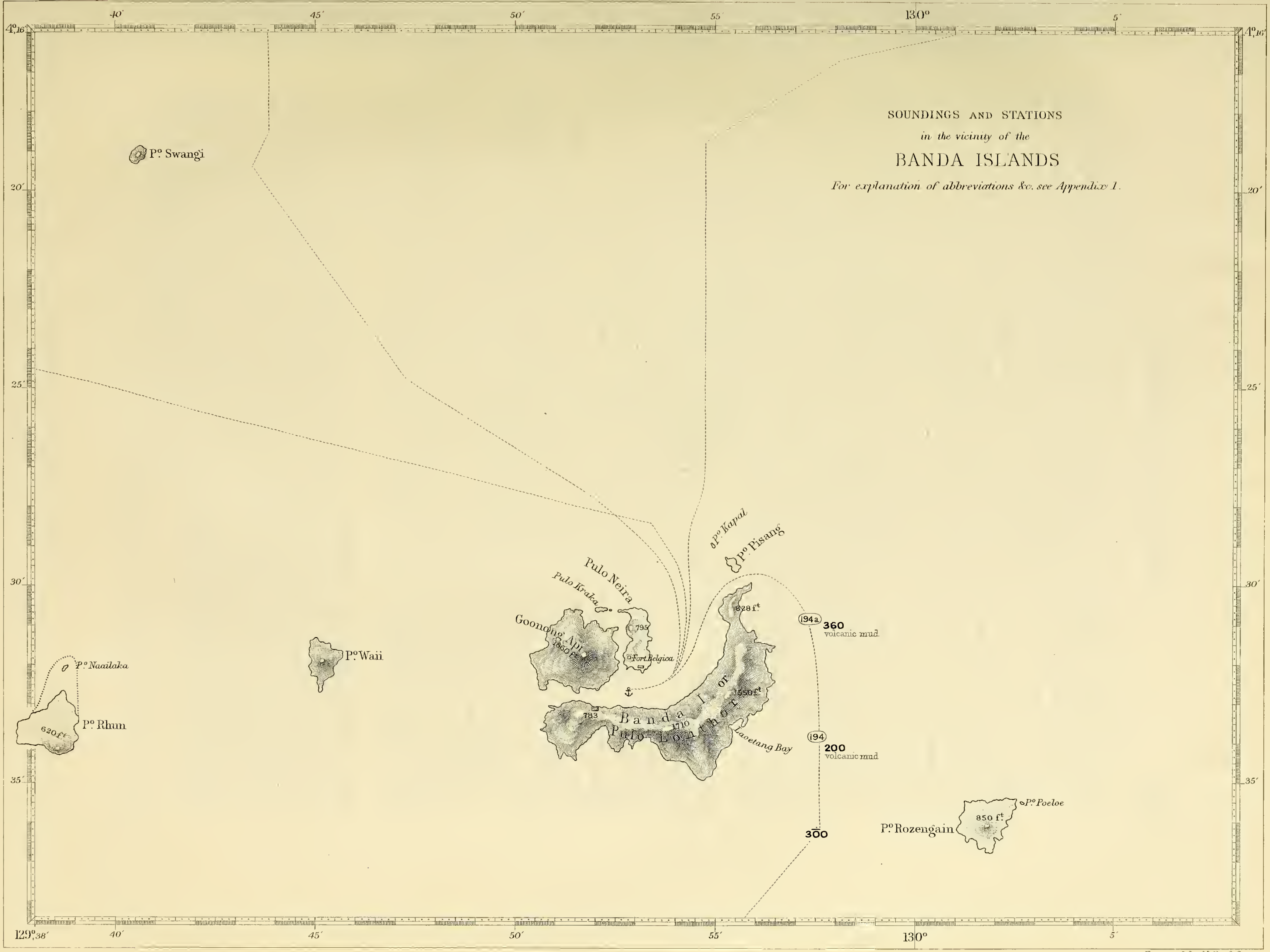
SHEET 33

SOUNDINGS AND STATIONS

in the vicinity of the

BANDA ISLANDS

For explanation of abbreviations &c. see Appendix I.



Engraved by Malby & Sons.

At present a great part of the labour is imported from Java, by contract between the labourer and the owner of an estate; the man agrees to work for a term of years, the wages being, after £15 passage money has been paid, from £10 to £20 per annum. As many women are encouraged to follow the men as possible; but it is difficult to induce the better class of men to emigrate. Here as elsewhere the native does not appreciate hard manual labour, whilst the European sits in his verandah, smoking, with plenty of cooling drinks at hand. The management of these imported labourers is a matter of no small difficulty; the only punishment allowed by the Government is imprisonment, and consequent loss of the man's services; and a blow given by a European is also punished with imprisonment, a fine for such an offence being disallowed. This naturally most effectually prevents ill treatment, but does not commend itself to the planter's notion of justice.

Almost the whole of the low ground and many of the slopes of the Banda group are planted with nutmegs grown under the shade of lofty Canary trees (*Canarium commune*). The light volcanic soil, the shade, and the excessive moisture of these islands, where it rains more or less every month in the year, seem exactly to suit the nutmeg tree, which requires no manure and but little attention.

A party from the ship ascended the east side of Gunung Api. It appears to be but seldom climbed either by Dutch residents or natives. The mountain is a steep simple cone covered with bushes up to within about 700 or 800 feet of the summit, and with the help of these, climbing is easy enough. Above the limit of the bushes there are steep slopes of loose stones, wearisome to climb and constantly falling. Above these, again, the surface of the cone is hard, the fine ashes and lava fragments, of which it is composed, being cemented together so as to form a hard crust. This is roughened by the projection of fragments, but still smooth enough to require some care in the placing of the feet to men wearing boots. The Malay guides with naked feet stood with ease upon it anywhere.

The inclination of the slope is about 33°; and to a man who easily becomes giddy no doubt would be rather formidable in descent. An American traveller, Mr. Bickmore, has written a most appalling account of the danger which he encountered in descending, but to a man with an ordinarily good head there are no difficulties either in the ascent or descent.

At the summit the fragments of rock were undergoing slow decomposition under the action of heated vapours issuing in all directions from amongst them, and were softened and turned white, like chalk. Any of these fragments when broken showed part of their mass still black and unaltered, and the remainder white; the decomposition not having reached as yet through the whole. The rocks collected at Gunung Api are augite-andesite, the augite is generally pleochroic, the plagioclase very much decomposed. Along with these rocks are some specimens of more scoriaceous character, but having the same mineralogical composition as the first ones.

Jets of hot steam issued in many places from fissures. Around the mouths of these were growing gelatinous masses formed by lowly organized Algæ closely similar in appearance to those found growing around the mouths of hot springs in the Azores. Here, however, there was no water issuing, the only moisture being supplied by the condensation of the steam. There was no accumulation of water, but drops of moisture hung on the sides of the fissures. In some places the gelatinous algæ, and a white mineral incrustation, formed alternate layers coating the mouths of the fissures. The steam on issuing within the fissure had a temperature of 250° F.; and where the crust of algæ was flourishing the thermometer showed 140° F. The steam had a strongly acid and sulphurous smell.

On the summit of the mountain, where the ground is cool, grow a Fern, a Sedge, and a Melastomaceous plant. Besides these was found another flowering plant, growing in a crack in the midst of a strongly sulphurous smoke which issued constantly from it. The thermometer when laid on the surface of the ground where this plant was growing showed a temperature of 100° F.; and at a depth of one and a half feet below it the soil about the fissure had a temperature of 220° F.

At the summit of the mountain were numerous flying insects of various kinds, although there was nothing for them to feed upon, and large numbers of them lay dead in the cracks, killed by the poisonous volcanic vapours. So numerous were they that the swallows had come up to the top of the mountain to feed on them.

Similarly, large numbers of insects were noticed at the summit of the volcano of Ternate, at an altitude of more than 5000 feet. Insects are commonly to be seen being carried along before the wind in successive efforts of flight, and no doubt they are blown up to the tops of these mountains, there being no vegetation towards the summits for them to hold on to. The winds pressing against the mountains form currents up their slopes, and in the case of volcanoes, which are heated at the summits, there is no doubt a constant upward draught towards their tops, caused by the ascending column of hot air. The accumulation of insects at the tops of these mountains is interesting, because when blown off into the free air from these great elevations by heavy winds, as no doubt they often are, the insects are likely to fly and drift before the wind to very long distances, and thus become the means of colonizing far-off islands.

The skull of a Woolly Phalanger (*Cuscus maculatus*) was found on the mountain; the animal is common in the Banda group, and occurs also in the Moluccas and elsewhere. Its occurrence on the Banda Islands seems most easily accounted for on the supposition that it escaped from confinement, having been brought there at some time by Malay voyagers. Malays seem fond of keeping wild animals in confinement, or taming them; there were several such pets about the houses at Dobbo at the time of the visit.

At the base of the Banda volcano, on the shores of the island, a belt of living corals composed of a considerable variety of species is easily accessible at low tide. Of these corals the most numerous are massive Astræids, of which about ten different forms were collected; a massive *Porites* is also very abundant. One species of "Brain Coral," and an *Astræa*, form huge masses, often as much as 5 feet in diameter, which have their bases attached to the bare basaltic rock of the shore. The tops of all of these coral masses are dead and flat and somewhat decayed; but on these dead tops fresh growth is taking place, showing that slight oscillations in the level of the shore of a foot at least have taken place recently. Such slight oscillations are to be expected at the base of an active volcano. The tops of the corals have been certainly killed by being left exposed above water, and the present growth is due to the corals being now again submerged. The fact that these corals are to be seen growing on the bare rock itself, and not on débris of older corals, shows that the coral growth is very recent. The Brain Coral grows in convex, mostly hemispherical, masses, the *Astræa* more in the form of vertically standing cylindrical masses, or masses which may be described as made up of a number of fused cylinders. The masses of the *Astræa* are usually higher than those of the *Mæandrina* by about a foot, because they are able to grow in shallower water, and they thus range also higher up on the beach. Many of the masses of this *Astræa* in the shallower water are left dry at each low tide, and appear to suffer no more in consequence than do the common sea anemones of our English coasts, which are so closely allied to them. There seem to be but few instances of species of Madreporarian corals which thus grow where they are exposed at low tide. The Brain Coral apparently cannot survive exposure, and hence the tops of its masses have been killed during the change of depth of the water at about a foot below the height at which those of the *Astræa* have perished. The common Mushroom Coral (*Fungia* sp.), so often to be seen as a chimney-piece ornament in England, is most extraordinarily abundant on the shore, at a depth of 1 or 2 feet at low water, and with it an allied larger, similarly free-growing Coral (*Herpetolitha limax*, Esch.). The Mushroom Corals cover the bottom in places in such large quantities that a cart-load of them might be picked up in a very short time; nowhere else were they seen so common during the voyage. A Reef Coral (*Physogyra aperta*) was found, which has been made the type of a new genus.[1]

Many visits were paid to the nutmeg plantations. The nutmeg is the kernel of a fruit very like a peach in appearance, which makes an excellent sweetmeat when preserved in sugar. The owner of a plantation, a very wealthy Malay native of Banda, said that about one male tree to every fifty females was planted on the estate; he had a superstition that if a nutmeg seed were planted with its flatter side uppermost, it would be more likely to produce a male seedling. Formerly, before the Dutch Government renounced its monopoly of the growth of nutmegs in the Moluccas, the trees were strictly and most jealously confined to the island of Great Banda. The utmost care was taken that no seeds fit for germination should be carried away from the island, for fear of rival plantations being formed elsewhere; seeds were, however, often smuggled out. The Government destroyed the nutmeg trees on all the other islands of

[1] Quelch, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiii. p. 293, 1884.

the group. It was, however, found necessary to send a commission every year to uproot the young nutmeg trees sown on these islands by the Fruit Pigeons (*Carpophaga concinna*), called "Nutcrackers" by the Dutch residents.

The various Fruit Pigeons must have played a most important part in the dissemination of plants, and especially trees, over the wide region inhabited by them. Sir Charles Lyell,[1] referring to the transportation of seeds by the agency of birds, noted especially this transportation effected by pigeons, and quotes Captain Cook's Voyages to the effect that at Tanna "Mr. Forster shot a pigeon (obviously a *Carpophaga*) in whose craw was a wild nutmeg."[2] At the Admiralty Islands the officers of the Challenger shot very large numbers of a Fruit Pigeon (*Carpophaga rhodinolæma*), whose crops were full of fruits of various kinds. Amongst them were abundance of wild nutmegs and wild coffee-berries; many of the fruits were entirely uninjured, and the seeds quite fit for germination. No doubt, when frightened or wounded by accident, the pigeons eject the whole fruits, and they habitually eject the hard kernels, as I saw quantities of them lying about under the trees on a small island at the Admiralty Islands, on which the birds roost in vast numbers. As soon as a few littoral trees, such as *Barringtonia* and *Calophyllum inophyllum*, have established themselves by means of their drifting seeds on a freshly dry coral islet, the Fruit Pigeons alight in the branches in their flight from place to place, and drop the seeds of all kinds of other trees with succulent fruits. The pigeons were seen thus resting on two or three small littoral trees, which as yet form almost the only vegetation of Observatory Islet, a very small islet in Nares Harbour, Admiralty Islands.

The Resident or Governor at Banda, like all the Europeans, received the Expedition in a most friendly manner, and held a reception at his house in its honour, where nearly the whole community assembled. A very good Malay band performed a selection during the evening, which was spent by most of the guests in playing cards and smoking.

One day was devoted to a visit to the nutmeg plantation of Mr. Laws, called Laoetang, on Great Banda Island. The party started in the steam pinnace at 6 A.M., accompanied by the Resident, his Secretary, and Mr. de Borges. The Resident's large canoe with high pointed bow and stern, profusely decorated with banners, and paddled by eighteen Malays, who kept stroke to the beat of tom-toms and gongs, accompanied the party. The semi-savage appearance of the Malays, their mode of throwing their paddles straight up in the air in exact time and all together between each stroke, the song with which they accompanied their efforts, together with their decorated canoe, presented a most picturesque and pleasing effect. The speed of the canoe was considerable, but not sufficient to keep up with the steam pinnace (see fig. 186).

[1] Principles of Geology, 10th ed., vol. ii. p. 69.
[2] Cook's Second Voyage, London, 1877, vol. ii. p. 69.

Outside the harbour a slight southeasterly swell was experienced, which rendered the landing on the weather shore of Banda Island a little difficult. A coral reef, which dries at low water, skirted the shore for about 50 yards at the landing place, immediately outside of which the depth was 20 fathoms, so that the pinnace was barely able to anchor. The party was conveyed on shore in small boats, the native labourers from the plantation running the canoes clear of the worst seas, and then carrying the members of it to land in arm-chairs.

Whilst breakfast was being prepared, a Javanese band of a dozen musicians and two dancing girls, hired for the amusement of the labourers, and evidently a part of the establishment, gave an entertainment. At first it was thought that stringed music was

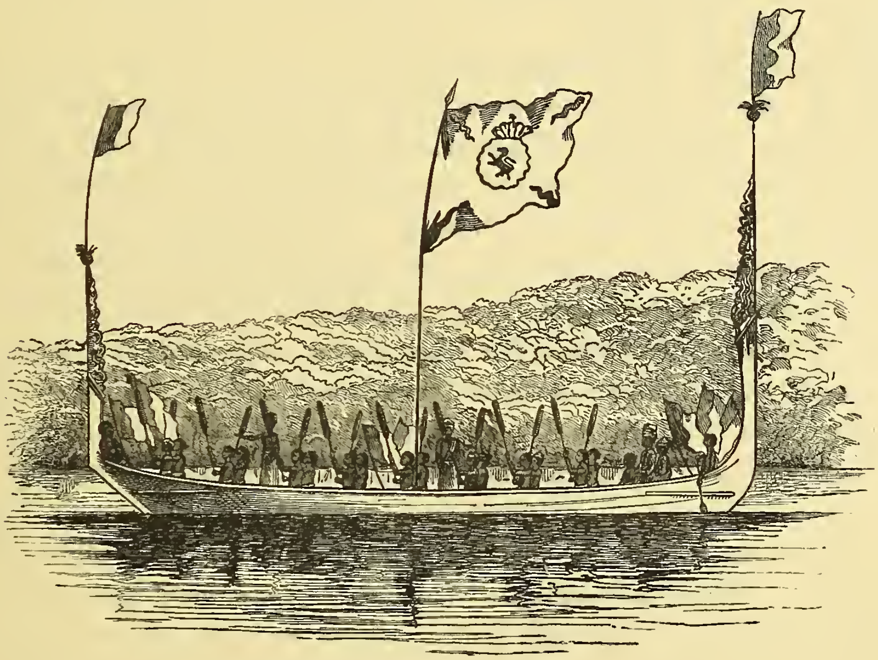


Fig. 186.—Resident's Canoe, Banda.

heard, but it was found that the sound was produced from the usual Javan instruments, some dozen bell-shaped gongs with raised knobs on their tops, standing on the ground, and a number of melophones made from bamboo laths, arranged like musical glasses. The girls were dressed in the usual sarongs, with a long scarf crossed gracefully over their shoulders, the face, arms, and hands were coloured with a yellowish dye, and the hair bound into a knot above their heads, and ornamented with a wreath of flowers. The dance consisted of graceful bendings of the body accompanied with movements of the arms and scarf, and a musical chant.

After breakfast the party rode to the top of the range of hills running through the island. When the land is viewed from seaward, it appears to be covered with an almost impenetrable jungle, but it is really more like a park, as all the undergrowth is cleared away. At the summit of the hills the Malays brought some freshly-cut bamboos, the spaces between the joints of which were filled with deliciously cool water.

After remaining some time on the hills admiring the nutmeg plantations and the tall Canary trees with the numerous orchids on them, the party rode to the north side of the island, where the pinnace had been sent to await its arrival. On dismounting near the shore a party of men appeared dressed in parti-coloured garments, amongst which red and yellow predominated, armed with decorated swords and spears, with brass shields sufficiently long to protect the arm as high as the elbow, and flat silver filigree helmets adorned with the feathers of the Birds of Paradise. They danced to the sound of a drum and small gong, keeping excellent time, and imitated the attack and defence of war parties amidst the firing of guns.

The seat of government, principal fort, and European settlement at the Banda group are on the island of Neira. Two piers run out from the shore to facilitate landing at low water, one on the southwest point of the island opposite the fort, which is the commercial pier, and the other on the south coast of the island, opposite the Resident's house, which is the official pier. A road with trees on each side, and grass plots towards the sea, runs parallel with the coast from the fort, round the south and east sides of the island, and by the side of this road are the residences of the Dutch officials, and the usual club house. The club house is a regular feature in all the Dutch settlements of the East, and every night the officials and residents assemble there to talk over the affairs of the day, and enjoy their cigars in the open air in the cool of the evening, sitting either on chairs round a table placed on the grass flat in front of the club house, or in easy chairs in the verandah.

Life at Banda is similar to that at Batavia, and, in fact, all over the Dutch possessions in the Indian Archipelago. The whole community rises at daybreak, and after a light breakfast of fruit and coffee, attend at their offices until 11 A.M.; at this hour practically all work for the day is over, for after a bath and luncheon at noon, they indulge in a siesta until between 3 and 4 P.M., when they rise, dress themselves for the evening, and take a stroll before dinner, after which they meet at the club.

Supplies at Banda are scanty, for as the islands produce nothing but the nutmeg, rice and all other necessaries for the maintenance of the population have to be imported. Beef could be procured occasionally, fowls were 3s. to 4s. each, and eggs 2½d. each. Yams, cucumbers, pumpkins, and plantains are grown, and can be purchased at moderate rates, coal is stored on the island, and could also generally be procured.

The population of the Banda Islands in 1870 was 6224, of whom 589 were Europeans, 5479 Natives, 128 Chinese, and 28 Arabs. There were also at this time 1063 head of cattle and 30 horses on the islands.

The nutmeg trees on the island, about half a million in number, produced in 1870 1,022,207 lbs. of nutmegs, and 197,143 lbs. of mace.

The weather at Banda is rainy and moist throughout the year, August to November being the driest months. The northwest monsoon blows occasionally with violence, while the southeast monsoon seldom exceeds a moderate breeze. There is monthly mail communication with Banda from Batavia.

The Resident and some of the other gentlemen at Banda stated that in July and August the water was usually milky white, but during the Challenger's visit it was exceptionally clear; in connection with this it may be mentioned that on the 28th September, shortly before reaching Banda, Mr. Buchanan procured in the water-bottles from 400 and 600 fathoms a milky-white water, the appearance being due to an amorphous precipitate.

It having been ascertained from the Resident during the stay that a small steamer which had been for a cruise to Ceram had broken down on its return when within a few miles of Banda, and that the crew had no provisions on board, the steam pinnace was sent out to search. In the evening the pinnace returned, having found a small boat, containing the Dutch master and half a dozen Malays so exhausted from want of food as to be unable to reach the islands. They reported leaving the steamer two days previously, and that its crew had then no water left; under these circumstances the ship proceeded out in search of the steamer, and steamed nearly over to Ceram without seeing it or its crew, natives of that island, consequently it was concluded that they had reached a harbour there, and the Challenger returned to Banda. While the ship was away, the steam pinnace remained with some of the naturalists dredging in 20 to 30 fathoms, close to Banda, when along with other specimens numerous Monaxonid sponges were obtained. Mr. S. O. Ridley, F.L.S., of the British Museum, who is preparing a Report on this group, has furnished the following notes:—

"*The Monaxonida* (as it is proposed, in accordance with principles laid down by Professor Sollas[1] and advocated by Professor F. E. Schulze, to term that group of the Siliceous Sponges named Monactinellidæ by Professor Zittel) are, as the investigations of the 'Lightning' and 'Porcupine' in the North Atlantic, those of Dr. Bowerbank in the Shetland seas, and those of Professor Agassiz in the Gulf of Mexico would lead us to expect, well represented in the Challenger collections, viz., by about two hundred species, of which about seventy are new to science; and they are by no means confined to the more moderate depths. Representatives of the group were obtained at seventy-three distinct localities out of the total number of dredging and trawling Stations.

"Of the six marine families, Renieridæ, Chalinidæ, Desmacidinidæ, Ectyonidæ, Axinellidæ, and Suberitidæ, commonly recognised in this suborder, the Desmacidinidæ take inequivocally the first place in the collection, both from their abundance and

[1] See Cassell's Natural History, vol. vi. p. 326, 1883.

from the interest attaching to the types represented. At the same time no form has been discovered in this family of sufficient distinctness from the known genera to rank as the representative of a new generic type. Those extraordinary forms allied to *Esperia*, with which the researches of Professor G. O. Sars, Sir Wyville Thomson, Mr. Carter, and Professor O. Schmidt have made us familiar, viz., *Chondrocladia* and *Cladorrhiza*, are present to the number of at least nine species, of which three *Cladorrhizæ* and as many *Chondrocladiæ* are certainly new to science; among the points of interest which they present not the least is the fact that the majority of the species do not exhibit the same shrubby form as the original species to which these names were applied, but a shape the peculiarities of which led Professor Schmidt to found the genus *Crinorrhiza* for a specimen belonging to this division of the Desmacidines obtained off Barbados. *Crinorrhiza* has a relatively small, subglobular body, from the equatorial aspect of which radiate in a horizontal direction a number of strong spicular tufts; a central root may also be present. While, however, Professor Schmidt considered these, certainly remarkable, external characteristics of sufficient importance to justify the erection of a genus, the Challenger specimens show that the spiculation of the five species which exhibit them belongs to two distinct types, the one that of *Chondrocladia*, the other that of *Cladorrhiza*. It therefore becomes necessary (having regard to the superior weight which must be admitted to attach to spicular characters in contrast to those derived from the external form) to abandon the genus *Crinorrhiza*, as constituting a mere growth-type, comparable to the 'artificial genera,' *Amphoriscus, Olynthus*, &c., recognized by Professor Haeckel among the Calcarea. Of the more familiar genera *Esperia* has nine or ten species, of which probably one-half are new to science. *Esperia rotalis*, Bowerbank, is remarkable for ranging from Britain to Port Jackson; a new species from the Cape is distinguished by its immense tricurvate and bihamate spicules. *Alebion* is represented by some new species in which the 'bipocillate' spicule attains a size and beauty hitherto unknown. *Myxilla* is rich in individuals, but there is a sameness about the characters of the species which contrasts strongly with the manifold forms assumed by *Esperia*; a new species from Japan will be termed *Myxilla japonica*.

Fig. 187.—*Amphilectus challengeri*, Ridley, as seen from the front, reduced to one-half natural size. Molucca Sea, 825 fathoms.

"A type characterised by a smooth acuate skeletal and an equianchorate parenchyma spicule, to which the name *Amphilectus*, Vosmaer, has been restricted, produces one of the few new Monaxonida possessing a striking external habit. *Amphilectus challengeri* (see fig. 187) differs very slightly in the characters of its skeleton from *Amphilectus edwardi*, a species common in British seas, but whereas the habit of the other known species of the genus is either massive or simply ramose, that of the species from the Molucca Sea is altogether novel in its family, although it simulates somewhat *Caulospongia*, Kent, which has been placed among the Suberitidæ, and *Foliolina*, Schmidt, a Renierid. A new species of *Crella* (*Crella navicelligera*) is remarkable for the extraordinary lateral extension of the shaft of its small anchorate spicule, giving it the general outline of those reproductive bodies of the Gregarinidæ known as 'pseudo-navicellæ.' The Stations between the Cape and Kerguelen Island exhibit a rich fauna of European facies, among which may be mentioned a new *Vomerula* and a fine *Gellius* of extraordinarily delicate and vitreous character, recalling that of many Lyssacine Hexactinellida, and with the ends of the usually doubly-pointed skeletal spicule quite rounded off. Of the curious, probably almost cosmopolitan, genus *Rhizochalina*, immense examples, in which the body alone attains a diameter of 6 inches, were obtained in Bass Strait; they are evidently identical with a specimen from South Australia, described by Lamarck in 1815 under the name of *Alcyonium putridosum*, and are closely related to *Desmacidon fistulosa*, Bowerbank. A study of the genus *Tedania*, by hardening and staining the soft tissues, shows that its systematic position is with the Desmacidinidæ rather than the Renieridæ. The long fine acerate spicules commonly occur in bundles, and evidently represent the 'trichites' of *Esperia*.

"In all, the collection contains about eighty species belonging to this family, of which upwards of thirty are new to science.

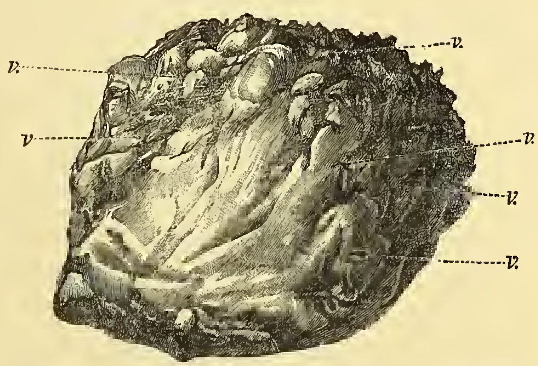


Fig. 188.—*Amorphina megalirrhaphis*, Carter. Variety with distinct dermal and primary skeletal fibres, and numerous vents (*v*), natural size, from the side. Christmas Harbour, Kerguelen Island, 60 fathoms.

"The Renieridæ proper are not numerous. The difficulty of finding constant and distinctive generic and specific characters in this subdivision is well illustrated by the large series of *Amorphina megalirrhaphis*, Carter, from Kerguelen Island. Most of these specimens, like the typical ones, have a rather pale brown colour and a glabrous surface, and consist of low irregularly-shaped masses; the only traces of skeletal fibre consist of some short strands apparently representing the primary or vertical fibres of other Renierids; however, the specimen figured (fig. 188), besides its definite, regularly lobate form and dark amber-brown coloration, possesses a very distinct set of primary fibres and a dermal reticulation like that of *Pellina*, with which genus it might have been placed if its relations to the other typically Amorphinoid specimens were not obvious. A *Pellina*, forming flat sheets of large size, occurs in 600 fathoms at the mouth of the Rio de la Plata.

Stylorrhiza extends as far south as Kerguelen Island, where it is abundant. The Renieridæ amount to about thirty species, of which five are new. The Chalinidæ comprise about twenty species, but are not as a whole in a very satisfactory state of preservation; *Pachychalina*, with three new species, is the only genus of much interest. The Ectyonidæ are remarkably few in number.

"The Axinellidæ are, after the Desmacidinidæ, of the greatest interest. For a species from near Bahia having the erect slender digitate habit of the European species of *Raspailia*, but distinguished by remarkably elongate dermal spicules, blunt at one end and terminating at the other in three short and scarcely divergent points, and occurring in groups, a new genus is necessary, which will be called *Thrinacophora*;[1] the main skeletal spicule is acerate, and the parenchyma contains bundles of slender acerate 'trichites'; it appears to stand to some extent between the Axinellidæ and Desmacidinidæ. Another species of similar habit approaches the curious discoid *Halicnemia patera* of the Shetland seas so closely in spiculation as to enforce very strongly the doctrine that external form must be only used with the greatest caution as a guide to affinity. About thirty species, of which fully one-third are undescribed, belong to the family.

"The Suberitidæ (excluding *Tethya*, which has been relegated to the Tetractinellida on the ground of its spiculation and skeletal arrangement) are surprisingly scanty, considering their abundance in both shallow and deep water in the North Atlantic area. They number about thirty species. Of the essentially bathybial forms, the range of *Trichostemma* (*Radiella*, Schmidt) is extended by the Challenger collection from the North Sea and equatorial Atlantic to the equatorial Indo-Pacific area, whence comes a new species. *Sceptrella* (*Latrunculia*, Bocage) is represented by two new species from the southern hemisphere, in one of which the outer end of the characteristic sceptre-like spicule is prolonged into a spike. *Bursulina muta*, Schmidt, which is closely related to *Polymastia brevis* of Bowerbank, extends to the North American Atlantic coast, *Thecaphora* to the Tristan da Cunha group of islands.

"*General Distribution.*—The most prolific localities are the neighbourhood of Bahia, the southern and western coasts of Patagonia (distinguished by the abundance of individuals of *Alebion* and *Tedania*), the Philippine Islands (a very varied fauna), and (as already shown by the investigations of the 'Alert') Torres Strait, also Kerguelen Island (especially Renieridæ and Suberitidæ). But little of striking novelty was obtained in the Atlantic; on the other hand, at the few (eight) very deep Stations in the Pacific which produced Monaxonida, the captures were almost exclusively new Desmacidines of the important genera *Chondrocladia* and *Cladorrhiza* mentioned above, almost every Station having a species peculiar to it.

"Some idea of the proportions in which *Monaxonida* occur at different depths may be

[1] θρῖναξ, a three-pronged fork.

gathered from the following table, if it is remembered that the productiveness of a locality in sponges of this group is usually in inverse proportion to its depth."

Depths of Stations.	Number of Stations of this depth at which Monaxonida were obtained.
3000 fathoms.	1
2900 „	1
2000–2600 „	7
1000–2000 „	5
200–1000 „	11
100– 200 „	17
Less than 100 „	31

Banda to Amboina.

The vessel left Banda at 8 P.M. on the 2nd October, passing out by the channel between the islands of Neira and Pisang, and then between the islands of Swangi and Rhun.

On the 3rd, at 5.30 A.M., the ship was stopped, being then close to the position of a sounding of 4000 fathoms marked on the chart, and the trawl put over. The weather was unfortunately cloudy, so that the position could not be ascertained by observation. After paying out 4400 fathoms of trawl rope, bottom was found by sounding in 1425 fathoms. At this time the weather cleared a little, and sights were obtained and a bearing of Gunung Api, which placed the ship about six miles west of the position of the 4000 fathoms sounding. The bottom temperature was 38°, the same as that at 900 fathoms. At 4 P.M. the trawl was hove in, after which sail was made for Amboina, the weather being squally, with heavy rain.

The deposit at the above depth was a blue mud containing 31 per cent. of carbonate of lime. The surface layer, about half an inch in thickness, was brownish in colour, while the deeper ones were blue and very compact. Pelagic Foraminifera, Radiolarians, and Coccoliths were abundant. The mineral particles consisted of quartz, mica, magnetite, felspar, pumice, and fragments of rocks.

The trawl brought up a considerable quantity of mud, which, with the exception of a few lumps, all belonged to the brownish surface layer. Mixed up with the mud were many large fragments of pumice, pieces of wood, leaves, and fragments of cocoanuts and other fruits. As was usually the case when the trawl brought up mud from the immediate surface layer, there was a large quantity of the algæ-like branching Rhizopod described by Mr. H. B. Brady, F.R.S., under the name of *Rhizammina algæformis*, and in addition many deep-sea animals. A Cephalopod was found here which does not seem to be specifically distinct from *Enoploteuthis margaritifera*, Rüpp., hitherto known only from the Mediterranean. Mr. Moseley described from this trawling a new genus and species of Actiniaria, *Corallimorphus rigidus*, full particulars regarding which are given by Professor Richard Hertwig in his Report[1] on this group. Professor Hertwig has summed up the principal peculiarities of the deep-sea Actiniaria in the following notes :—

The Actiniaria.—" The soft-bodied Zoantharia (Actiniæ, or Malacodermata) are among the groups which are represented in the depths of the sea by a relatively considerable number of members. The Challenger Expedition discovered at depths varying from 280 to 2300 fathoms some twenty species, many of them in great numbers. In most cases the species and genera are new, and not unfrequently they belong to new families, so that it has been demonstrated by the Expedition that the organisation of these animals is much more varied than was previously known.

" All Anthozoa, whether solitary or colonial, agree with one another in certain general features of structure. The body of the individual polyp is a hollow cylinder, which is enclosed by a membrane called the 'wall.' The ends of this cylinder are constituted above by the 'pedal disk' or 'base,' below by the 'oral disk'; both of which are intimately connected with the wall, and for the most part abut at right angles against it. Along the margin of the oral disk arise the tentacles, hollow evaginations, into which the lumen of the hollow cylinder is produced.

" In the centre of the oral disk lies the mouth, which has the form of a narrow slit, always placed in a certain definite direction, the sagittal axis of the body of the Actinia being always indicated by the length of the slit, whilst its shortest diameter indicates the transverse axis (fig. 189).

" A tube open below, which is compressed transversely in accordance with the form of the mouth, and must be regarded as an invaginated portion of the oral disk, hangs down from the mouth into the body cavity. This tube, formerly called stomach, now more correctly œsophagus, is held in position by radial septa, which arise from the body wall as well as from the oral and pedal disks, and are inserted into the œsophagus. The number and arrangement of the septa are of morphological significance; in most Actiniæ they are united in pairs; the number of such pairs is at least 6, and increases in multiples of 6, so that 12, 24, 48, &c., pairs of septa are met with. Exceptions to this arrangement, which also occurs in the hexamerous skeleton-forming corals, were previously known, in the case of the Edwardsiæ, Zoantheæ, and Ceriantheæ, but by the Challenger Expedition the number of exceptions has been increased. Thus, although in

[1] Zool. Chall. Exp., part xv., 1882.

the Paractiniæ and Monauleæ the septa are grouped in pairs, some number other than 6 is the basis of their arrangement.

"One Paractinia, *Sicyonis crassa*, certainly, and another, *Polyopis striata*, probably belong to the tetramerous Actiniæ, and probably bear to the fossil Tetracorallia a relation similar to that which the hexamerous Actiniæ bear to the recent Hexacorallia.

"*Scytophorus striatus*, the sole representative of the family Monauleæ, possesses an uneven number of pairs of septa, because in it there is wanting one of the two pairs which correspond to the extremities of the sagittal axis, and are called 'directive septa' from their peculiar position and structure.

"It is of interest to observe that in the Actiniæ, as in other groups, types of structure

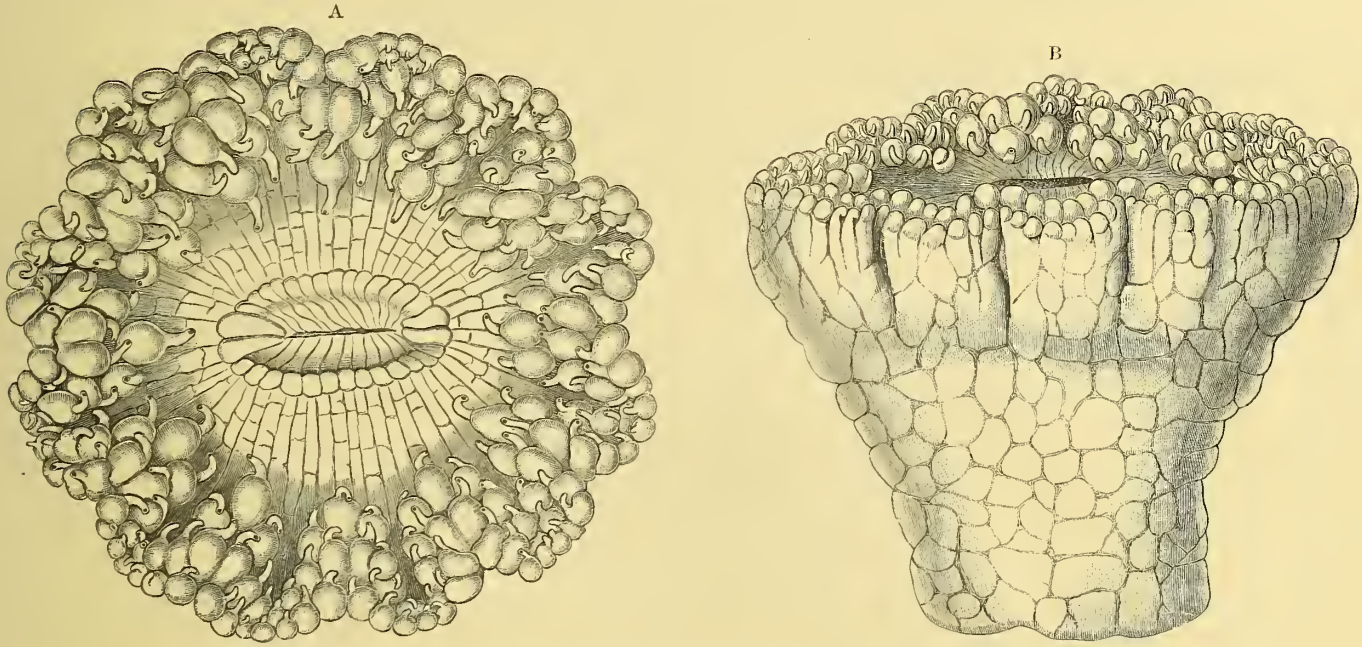


Fig. 189.—*Polysiphonia tuberosa*, Hertwig; A, oral view, and B, lateral view. Station 235, 4th June 1875, off Japan, 565 fathoms; natural size.

which have died out in shallow water have maintained themselves in the deep sea. Still more striking is a second peculiarity of the Challenger collection, which is also explained by the fact that all the specimens come from great depths; it contains numerous forms in which the tentacles have undergone a more or less extensive retrograde metamorphosis, by means of which they become converted first into short tubes and finally into simple openings surrounding the mouth. This modification can be followed step by step in different species. *Paractis tubulifera* (1875 fathoms) has still well-developed tentacles, like most Actiniæ, except that the terminal aperture, which in these is quite small or even entirely absent, has expanded into a widely gaping orifice.

Next comes *Polysiphonia tuberosa* (565 fathoms), whose handsome calycine form is shown in fig. 189B, while fig. 189A represents the animal as seen from above. The tentacles have here become short wide-mouthed tubes, whose bases are swollen into curiously shaped pads (fig. 190). In *Sicyonis crassa* (1600 fathoms) the tentacles are only small warty or sucker-like rings; in *Polystomidium patens* (1825 fathoms) and *Polyopis striata* (2160 fathoms) their walls are almost entirely lost, so that the terminal opening has become a slit in the oral disk, an annular ridge, which surrounds the aperture, being the sole remnant of the tentacle-wall. Finally, in the genus *Liponema* (1875 fathoms), only simple openings indicate the places where the tentacles should stand.

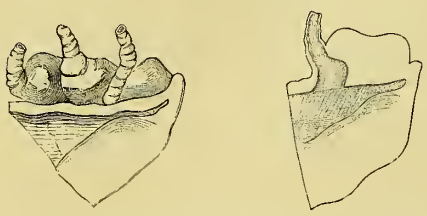


Fig. 190.—Tentacles of *Polysiphonia tuberosa*, Hertwig; side view and section; nat. size.

"Thus then, of the twenty species hitherto described from depths of 500 to 2600 fathoms, not less than six species have shown modifications of the tentacles in one direction, whilst no such change has been observed in any one of the very numerous forms which belong to the coast-fauna. This makes it probable that the retrograde metamorphosis of the tentacles is a consequence of living in the deep sea; and, indeed, peculiarities in the conditions of existence which there obtain can be suggested which might be favourable to a metamorphosis of the tentacles into tubes. Probably the nutriment of the deep-sea animals consists of matters which are far advanced in decomposition and of soft consistence. Such substances, suspended in water or embedded in mud, could not be seized by tentacles, but might be readily absorbed by suctorial apertures or tubes."

Amboina.

On the 4th October, at daylight, the green hills of Amboina were in sight 18 miles off, but the summits were hidden in the clouds; it was found that a current of 12 miles to the westward had been experienced during the night. At 7 A.M. the ship was swung to ascertain the errors of the dipping needle, but the day was far from favourable for this purpose, the weather being overcast with frequent rain squalls, so that it was impossible to complete the observations, and at 3 P.M. the ship rounded Noessaniva Point, and proceeded up the harbour.

On the peninsula of Leytimur, the southeast peninsula of Amboina, three distinct hills are seen from seaward, the easternmost being the highest (2030 feet by the chart); about 5 miles to the westward of this peak is a second hill, longbacked and slightly lower; the land then falls to the westward in a series of rugged slopes, rising again at a distance of 2 or 3 miles from Noessaniva Point, to a round grass-covered hill, which bears a few scattered clumps of cocoanut trees, and appears like an island at a distance of 25 miles. The ravines and lower lands are all well wooded. The western extremity of Noessaniva Point is a bluff some 300 feet high.

The island of Melano is about 700 feet high, steep to the southeast, sloping to the northwest.

The island of Saparoea has a hill some 1000 feet in height on its northwest end, the east point as seen from a distance of 25 miles appears low.

The centre of Haruku Island is about 1200 feet in height.

At 5 P.M. the ship "came to" in Amboina Bay, off Fort Victoria, in 24 fathoms, one cable W. by N. from the pier and, sending a hawser to an anchor on the shore just south of the pier, moored with the off anchor and hawser. This method of securing the ship is necessary in Amboina Bay, for the water is so deep that it becomes extremely awkward anchoring at a sufficient distance from the shore to allow the ship to swing, consequently the Dutch authorities have placed anchors at convenient distances apart, on the mud flat before the town, to which vessels may fasten a cable or hawser, using their own anchors as off moorings. As these anchors are only partially uncovered at low water, it is necessary to dive to fasten the hawser to the ring, but the Malays are first-rate divers, and their services can be hired at a very cheap rate, so that it is much better to obtain one of these men (numbers of whom are sure to be on the beach or on the pier) than to expose Europeans to the hot sun of the tropics. The edge of the shoal abreast the town of Amboina is well marked with fishing stakes, which indeed are to be seen stretching out from the shore at intervals all down the bay.

The existence of Amboina (like Banda) was first known to Europeans in 1506, and about 1521 the island was taken possession of by a Portuguese squadron of nine ships, commanded by Antonio de Britto, who built a fort on the island.

The Portuguese occupation continued until 1605, when the natives called on the Dutch to assist them in expelling the Portuguese. In February of that year a Dutch fleet of five sail, under the command of Admiral Van der Hagen, anchored off the Portuguese fort of Amboina, and landing some men summoned the Governor to surrender, the ships opening fire. The Portuguese, without defending themselves, capitulated, and the Dutch admiral took possession of the island, which his countymen have since held with one short exception, when Admiral Rainier, during the great continental war, captured it in 1796, and it was held by the English until 1813, when at the general peace it was returned to the Dutch. The terms of capitulation between the Dutch and Portuguese were, that the single men, six hundred in number, should be granted a passage to their own country, and the married men, forty-six in number, should remain on the island provided they took the oath of allegiance to the States-general. This bloodless contest was attended by one tragic circumstance, for the wife of the Governor (Gasper de Melo), apprehensive of his disgrace, poisoned him.

The Dutch had scarcely obtained possession of Amboina, when the natives began to entertain the same wish for their expulsion as they had formerly for that of the Portuguese, and eventually they were so oppressed that they took up arms, and being numerous and powerful, their efforts to regain their independence were not finally overcome until 1670. Shortly after the Dutch obtained possession of the island, the jealousies that existed between them and the English caused them to seize on the English factory and execute its occupiers after torturing them. This crime, which is generally known as the massacre of Amboina, led to many disputes between the two nations, which were not finally settled until the peace of Breda in 1667.

Amboina Island consists of two peninsulas, joined together by a low narrow isthmus, thus forming two large bays. The smaller or southeast peninsula, on which is the town, is called "Leytimur," the larger or northwest peninsula, "Hitoe," the low isthmus "Baguala," the bay on the southwest side of the island "Amboina Bay," and that on the northeast "Baguala Bay." In 1683 the Dutch Governor formed a design of cutting a canal through the isthmus of Baguala, and so joining the bay of that name to Amboina Bay. This idea was frustrated partly by the superstitions of the Amboinese, who asserted that blood spouted from the ground each time they inserted their spades, and partly by a notion, promulgated without reason, that the level of the sea in Baguala Bay was considerably higher than that in Amboina Bay.

The Governor or Resident of Amboina has jurisdiction over the neighbouring islands of Ceram, Bouro, Amblau, Manipa, Kelang, Bonoa, Ceram Laut, Nussa Laut, Saparoea, Haruku, and Melano.

The whole island is mountainous, and rises to an elevation of 4000 feet above the level of the sea. The highest mountain, Capaha, is in Hitoe Peninsula; the highest mountain in Leytimur is Soya, 2030 feet above the sea. There are records of an eruption from a volcano on the west side of the island in the years 1674, 1694, 1816, and 1820, and in 1824 a new crater was formed; since that date, however, all eruptions have ceased, and some of the European inhabitants appear ignorant that there ever was an active volcano on the island. Earthquakes are occasionally felt, but, from a record kept by the Dutch authorities, appear to happen only between the months of December and June, or during the northwest monsoon.

The chief advantage derived by the Dutch from the possession of Amboina was the monopoly of the clove cultivation. They would not, however, have succeeded in securing to themselves the exclusive trade in this spice, which is spontaneously produced in all the Molucca Islands, had they not confined the cultivation of the tree to Amboina by destroying all they found elsewhere. Besides cloves, considerable quantities of Cajeput oil are exported.

Fort Victoria at Amboina, formed by the Portuguese in 1521, is situated close to the landing place; in fact, the main road goes through the centre of the fort, there being only a pathway to the town outside the glacis. The fort itself is completely commanded from the neighbouring heights, but can scarcely be said to be armed, as there are only two or three guns mounted for saluting purposes, the rest lying on the ground. Outside the fort is a shallow wet ditch, and inside it is in excellent order and beautifully clean; indeed, one cannot but admire the scrupulous cleanliness of the Dutch in all their Eastern settlements, so well are they kept that there is hardly a dead leaf or twig to be seen on the roads. On arrival, the Challenger saluted the Dutch flag, but the salute from the fort in reply was fired at intervals of about two minutes between each gun, and occupied three quarters of an hour; of course no one had patience to count the number of guns; all breakfast time it was said, "Now surely that's the last," when bang would go another gun.

The mercantile part of the town is a long street facing the sea, with another behind it. Running at right angles to the streets are roads leading into the country, bordered on each side by country houses or native huts, each building detached with a plot of ground round it. Many of the native houses had a small covered stall, by the road-side, where some parcels of eatables were exposed for sale. The hedges were generally formed of Crotons, which were very fine. The detached houses naturally give the settlement a long straggling appearance.

Here, as at Banda, the officers and civilian staff were made honorary members of the club, where the illustrated papers of London, Paris, and Berlin, besides numerous Dutch periodicals, were found. During the stay the monthly steamer from Sourabaya arrived, after making the usual round by Koepang and Dilli, in Timor, and the Banda Islands before calling at Amboina, proceeding thence to Ternate and either Kema or Menado in Celebes Island on the return voyage to Sourabaya.

There is a large market near the west end of the town of Amboina, which was well attended; the articles for sale were the usual sago cakes, rice, areca palm nuts, sweet potatoes, fish, &c.; the fruit consisted of pine apples, oranges, and bananas. The supplies were for Europeans scanty and dear; beef 2s. per pound, fowls 1s. 6d. each, ducks 3s. to 4s. each, eggs 2s. 6d. per dozen. Washing is fairly and moderately done, the price being 2s. per dozen. The Malay term for a washerman is "Orang Menatu."

The population appears to consist of Europeans, Amboinese, Malays, and Chinamen, with a few Arabs. The Chinamen appear to monopolise the small trade, and two or three Europeans the wholesale business. The articles for sale are usually of a very trashy nature, the stalls being more like those at a fair than anything else, and the goods of the cheapest description.

A large quantity of coal is kept in stock under sheds at Tanjong Mungayen, a point a little over a mile south of the town pier. Running out from this point is a rickety wharf, which has four fathoms water alongside it. Vessels proceeding there to coal should steer in, with their heads to the southeastward, keeping about half a cable outside the extremity of the wharf, and when the centre of it is abreast the centre part of the ship, let go the port anchor (which will then be dropped in about 10 fathoms), and haul in by means of the wooden piles placed at convenient distances along the shore. A red buoy is moored to the northward as an off-fast for the stern, but large vessels will require to lay out an anchor in addition, as the moorings of the buoy being light, the anchors "come home" with any strain. The price paid for the coal was £3 per ton, but with labour for coaling ship, it amounted to £3, 4s. 11d. per ton. The hire of the labourers was a Dutch rupee, or 1s. 8d. per day, but since here, as in all Dutch places, they cease work at 11 A.M., and do not commence again until 4 P.M., the coaling is necessarily slow and irritating.

On the shore of the harbour of Amboina, coral reef rock occurs raised many hundred feet above sea level, forming a steep hillslope. At the summit of the ridges so formed the rock stands out here and there, weathered into fantastic pinnacles, with surfaces honeycombed by the action of rain, just as at Bermuda. The rocks collected beneath the coral reef rock at Amboina were serpentine, granitite, and altered diabase.

Some of the smaller trees growing on the coral rock ridges are covered with the curious Epiphytes, *Myrmecodia armata* and *Hydnophytum formicarum*, belonging to the natural order Cinchonaceæ. Both are associated in their growth with certain species of ants; as soon as the young plants develop a stem, the ants gnaw at the base of this, and the irritation produced causes the stem to swell; the ants continuing to irritate and excavate the swelling, it assumes a globular form, and may become larger than a man's head. The globular mass contains within a labyrinth of chambers and passages, which are occupied by the ants as their nest. The walls of these chambers and the whole mass of the inflated stem retain their vitality and thrive, continuing to increase in size with growth. From the surface of the rounded mass are given off small twigs, bearing the leaves and flowers. It appears that this curious gall-like tumour on the stem has become a normal condition of the plants, which cannot thrive without the ants. In *Myrmecodia armata* the globular mass is covered with spine-like excrescences. The trees referred to at Amboina had these curious spine-covered masses perched in every fork, and with them also the smooth-surfaced masses of *Hydnophytum formicarum.*

Two Lizards (*Keneuxia smaragdina* and *Bronchocela cristatella*) were obtained near Amboina, also a new species of Orthopterous Insect (*Necroscia moderata*, Kirby).[1] A large collection of Lepidoptera was made, including the following new species :—*Vadebra murrayi, Gerydus boisduvalii, Terias biformis, Artaxa simulans, Pegella ichorina*, and *Spiramia funestis.*

The Moth (*Artaxa simulans*) is shown in fig. 191, and is interesting as representing

[1] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiii. pp. 477–479, 1884.

one of those cases of protective mimicry so often described in works on natural history; it mimics very exactly *Ophthalmis lincea* (fig. 192), another moth belonging to a different family.

Mr. Butler writes :—" This is one of those instances of mimetic assimilation so perfect as to catch the eye at the first glance. That the Agaristid is the species copied cannot

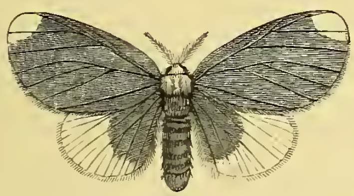


Fig. 191.—*Artaxa simulans*, A. G. Butler.

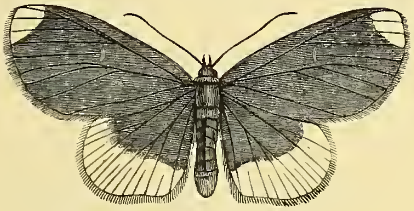


Fig. 192.—*Ophthalmis lincea*, Cramer.

be questioned, since it is not only a common form, but it belongs to a group which, like the allied Zygænidæ, is evidently distasteful to insect enemies." [1]

Another illustration of this protective mimicry occurs in a new species of Butterfly obtained at the Arrou Islands (see p. 548), in which the Butterfly (*Papilio alcidinus*,

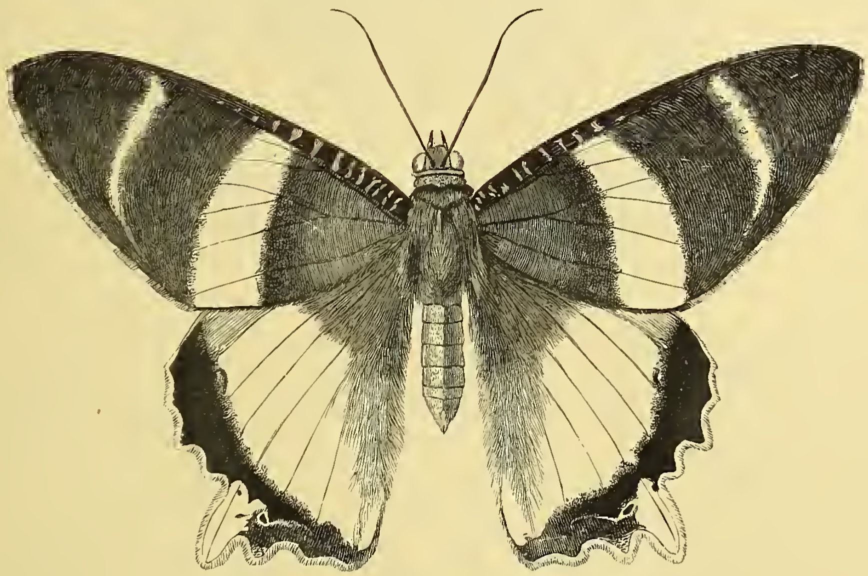


Fig. 193.—*Alcidis aruus*, Felder.

fig. 194) imitates a day-flying Moth (*Alcidis aruus*, fig. 193) common in the same locality. Mr. A. G. Butler, who described the species, calls attention to an important peculiarity, in addition to the general resemblance of the upper surface :—" On the under surface, however, is a character which strongly supports the

[1] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiii. p. 200, 1884.

view held by Messrs. Bates, Wallace, Trimen, and others, that resemblances of this kind are due to the assimilation of species in need of protection to the pattern of others which, owing to their odour, taste, or uneatable aspect, enjoy immunity from the attacks of insect enemies. This character consists in a longitudinal orange streak, so placed upon the abdominal area of the hind wings as to simulate (when the butterfly is in repose) the orange ventral surface of the abdomen in the moth; the same character may also be seen in *Papilio laglaizei*. If the *Papiliones* in repose retained the same flattened wing surface as do the species of *Alcidis*, it is obvious that the orange streak would rather hinder than assist the resemblance between the two; it is, however, well known that the abdominal border in *Papilio* is in this position so folded that the streak would appear to be on the body.

"One must not, however, overlook one fact in connection with this question, and that

Fig. 194.—*Papilio alcidinus*, A. G. Butler.

is the fact of the apparent rarity of these copying Papilionidæ. If it be of great importance for one species to resemble another, inasmuch as that thereby the copying species shares, in common with its model, immunity from evil, one would naturally suppose that this advantage would be evidenced by abundance of specimens. It seems to me, however, that on the other hand, if the numbers of the butterfly and moth were equal, many of the former would fall victims to the inexperience of young birds before the association of an evil taste or smell with such a type of coloration was discovered; this would greatly reduce the number of the butterfly, whilst the moth escaped.[1] On the other hand, many of the butterflies which resemble Euplœinæ appear to be abundant; and I think we must look for the explanation of this in the abundance of examples in the species of that group, coupled with the abundance of species all much alike, and therefore repre-

[1] In fact, the young birds are taught by the parents, and thus profit by accumulated experience.—H. N. M.

senting an army of unpalatable individuals greatly exceeding in numbers the so-called 'mimicking species.'"[1]

Another interesting Moth (*Phyllodes*) is represented in this region by several species, and some new ones were discovered by the Expedition which furnish links in a remarkable chain of modifications in the colouring of the wings. The posterior wing bears a red patch near the anal border, in one species a white patch appears in the centre of this, and then in other different species is observed successively nearer and nearer to the apex, until at length it reaches it. These changes are shown in the accompanying cut.

FIG. 195.—Hind wings of *Phyllodes* (reduced).

1. *Phyllodes roseigera*, Butler, the red patch touching the anal margin, slightly suffused with white in some examples. Andaman Islands.
2. *Phyllodes consobrina*, Westw., the red patch more rounded, of a more crimson tint, with a conspicuous snow-white centre. Silhet.
3. *Phyllodes cerasifera*, Butler, the red patch considerably larger, the white patch within it also larger, extending nearly to the inner edge of its red zone. Philippines.
4. *Phyllodes floralis*, Butler, the red patch only extending half-way round the white patch, which is rounded and very large. Borneo.
5. *Phyllodes verhuellii*, Vollenh., the red patch still more abbreviated, so as only to encircle one-third of the white patch. Java.
6. *Phyllodes conspicillator*, Cramer, the red patch dark elongated, not suffused with or interrupted by white; the apex broadly ash-grey or white. Amboina.

It may be noticed that as the white emerges from the red it seems to give off atoms in advance, so that the apical patch becomes gradually larger and whiter from its commencement in *Phyllodes floralis*. For this alteration in the position of colour-patches Dr. Leuthner proposes the term "chromatropy." Such cases show how important it is to describe all the local forms which are known to be constant, since only by this means will it be possible to discover the laws which regulate the disposition of the colours and markings on the Lepidoptera.[2]

Numerous dealers brought trays of the shells, for which Amboina is famous, to the ship, but the prices asked were so high, that it would probably pay to bring some of the shells back again from Europe to Amboina for sale to passing visitors. Cassowaries' eggs were also offered for sale, and large quantities of horns of the Deer (*Rusa moluccensis*).

The deer are very abundant in Amboina, and a party from the ship went in pursuit of them. They had a letter to a native head-man in one of the villages on the shores of the inlet in which the harbour lies, who treated them hospitably, and collected about a dozen beaters. The deer were lying down concealed on a plain of some extent close to the shore, covered with tall grass in some places about 3 feet high, and skirted by bushes. A stag and two hinds were seen to make off out of range, as the party made its way along the edge of the tall grass. The men beat the bushes at the edges of the grass, and at last drove a hind out of one clump to the

[1] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xi. p. 404, 1883. [2] *Ibid.*, p. 426.

guns, and it was shot. The numerous tracks in the grass showed that plenty of deer must come there to feed. Another party from the ship, on returning from a deer hunt in a native canoe, narrowly escaped a serious accident, from the swamping of the canoe.

The monsoons do not affect the weather at Amboina in the same manner as at Java, Bali, Lombok, Sumbawa, the south coast of Borneo, and the west coast of Celebes, for when the southeast monsoon prevails at those places it is accompanied by fine, dry, pleasant weather; whereas it is the rainy season at Amboina, Ceram, Banda, and the east coast of the Celebes. On the contrary the northwest monsoon, which brings rain to the former islands, is the fine season at the latter.

The accompanying table of the climate of Amboina has been compiled from a register kept for four years, kindly supplied by the Dutch authorities. By this table it appears

METEOROLOGICAL TABLE compiled from a Register kept by the Dutch authorities for four years at Amboina.

Month.	Mean Maximum Temperature in the Shade, Fahrenheit.		Mean Minimum Temperature in the Shade, Fahrenheit.		Number of days Rain.	Rainfall in English Inches.	General Directions of Wind.
	Dry Bulb.	Wet Bulb.	Dry Bulb.	Wet Bulb.			
January,	86°·8	82°·3	74°·7	74°·1	13	6·75	N. to N.W.
February,	87·6	82·7	73·1	72·5	10	4·25	N. to W.N.W.
March,	87·9	84·3	74·7	74·1	18	9·00	N.W. to S.W.
April,	88·0	83·0	74·6	74·1	13	7·26	N.W. to W.S.W.
May,	85·5	81·3	74·3	73·7	20	17·70	Variable.
June,	84·2	80·9	74·1	73·4	22	38·75	E. to S.S.E.
July,	83·4	81·0	74·1	73·6	20	30·75	E. to S.S.E.
August,	84·0	81·2	72·7	72·2	22	24·33	S.E.
September,	85·2	81·8	72·9	72·0	19	22·30	Variable.
October,	87·9	82·6	73·8	73·2	16	9·70	E., S.E. to S.W.
November,	88·5	83·5	74·3	73·8	10	11·75	S.E., S.W. to N.W.
December,	88·3	83·0	74·1	73·5	14	9·20	N. through W. to S.
Means and Totals,	86·4	82·3	74·1	73·5	197	191·74	

that even in the driest season (November, December, January, and February) rain falls on an average twelve days in each month, the mean fall for the month being 8 inches; whilst in the rainy season (May, June, July, August, and September), rain falls on an average twenty-one days in each month, the mean fall per month being 27 inches. The northwest monsoon appears to commence about November, and lasts until April, but only in January, February, and March do steady north and northwest winds prevail. The southeast monsoon sets in in May, and lasts until the beginning of September; in the other months the winds are variable.

During the stay at Amboina the pinnace was engaged several days in dredging in depths from 15 to 130 fathoms. Among the new species obtained were two Brachyurous Crabs, referred to in the following notes by Mr. Edward J. Miers, of the British Museum, who is preparing a Report on the Brachyura collected by the Expedition:—

The Brachyura.—"The Brachyura collected during the voyage of H.M.S. Challenger are of much interest, not only because many of the new species are remarkable for beauty of form and structure, but also by reason of the additional facts relating to the distribution of several already described, which a study of the collection enables us to record. The groups richest in new genera and species are the *Oxyrhyncha* (*Maioidea*) and *Oxystomata* (*Leucosiidea*), and to these belong most of the new forms collected at depths exceeding 100 fathoms. The *Cyclometopa* (*Cancroidea*) and *Catometopa* (*Grapsoidea*) are for the most part terrestrial, littoral, or shallow-water species, but exceptions occur, notably in the genus (or rather sub-genus) *Pilumnoplax*, and among the swimming crabs (Portunidæ). No Brachyurous Crab was brought up in any of the deep-water dredgings at depths exceeding 1000 fathoms; at this depth a small female Crab, nearly allied to or identical with *Ethusa microphthalma*, Smith, was dredged at the Azores (Station 73); and but very few were dredged at depths exceeding 400 fathoms, but between 100 and 400 fathoms occurred nearly all the most interesting new forms in the collection. Sir Wyville Thomson's statement is therefore correct as regards the Challenger Crustacea 'that the Brachyurous Decapoda appear to be confined almost entirely to comparatively shallow water.'[1]

"In the following brief account of the Brachyura, I have referred, as a general rule, to the more interesting new species in the order in which they were collected. As regards the pelagic species, I need only say that the Gulf Weed Crab, *Nautilograpsus minutus*, occurred not only in the north and northwest Atlantic, and at the Bermudas, West

[1] Voyage of the Challenger, The Atlantic, vol. ii. p. 349. *Cf.* Rev. A. M. Norman, President's Address in *Trans. Nat. Hist. Soc. North. and Durham*, vol. viii. (pt. 1) p. 42 (1883). But Prof. S. I. Smith, in a note on the Crustacea of the "Albatross" Dredgings in 1883, mentions the occurrence of a new genus of Brachyura allied to *Ethusa* in the N.W. Atlantic, in 1496 to 1735 fathoms (*Amer. Journ. Sci. and Arts*, vol. xxviii. p. 53, 1884; reprinted in *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiv. p. 179, 1884). Since these notes have been in type I have received, in a consignment taken from among the Anomura by Mr. Henderson, some remarkable forms (probably Dorippidæ) dredged at depths varying from 310 to 800 fathoms, and one species dredged at Station 237 in 1875 fathoms.

Indics, Canaries, and Azores, but also at the Kermadec Islands, South Pacific, off Volcano Island in the North Pacific, and on the coast of Japan. *Neptunus sayi*, A. M.-E., was taken on weed only in the western North Atlantic and south of Nova Scotia (Station 49). *Plagusia immaculata*, Lamarck, and *Varuna litterata*, Fabr., occurred in abundance on floating driftwood north of New Guinea, on the 22nd February 1875; but the two latter are not strictly pelagic species.[1]

"*Atlantic Region.*—Little need be said respecting the Brachyura taken in the Atlantic. The species collected at the Bermudas, Azores, and Cape Verde Islands are somewhat numerous, but are for the most part littoral and shallow-water forms. No Brachyurous Crustacean occurred at any of the deep-water stations in the North Atlantic except the carapace of a small swimming crab allied to *Bathynectes*, which was dredged off the Bermudas in 435 fathoms (Station 33), and *Heterocrypta maltzani*, Miers, in 450 fathoms, off Fayal (Station 75). Of a dozen littoral or shallow-water species collected at the Cape Verde Islands, several are common West Indian forms. At St. Paul's Rocks, besides the common and very widely distributed *Grapsus maculatus* (Catesby), the only crab taken was a new species of *Stenorhynchus* (*Stenorhynchus spinifer*), distinguished from all its congeners by the strongly developed supra-ocular and post-ocular spines (depth, 10 to 80 fathoms).

"At Ascension Island, which H.M.S. Challenger visited on the homeward voyage, occurred the Land Crab (*Gecarcinus lagostoma*) referred to by Mr. Moseley[2] as swarming everywhere on the island; the common *Grapsus maculatus* (Catesby) and *Pseudozius mellissi*, Miers, received with the fishes of H.M.S. Challenger and described in 1881.[3]

"The Brachyura collected at Fernando Noronha (7 to 20 fathoms) are few in number, and for the most part belong to genera common at the West Indian Islands and on the South American coasts; they include species of *Pericera*, *Macrocœloma*, *Mithraculus*, and *Mithrax*. There is also in the collection a small Crab, apparently referable to the rare Floridan *Apocremnus septemspinosus*, A. M.-E. The localities on the Brazilian coast at which Brachyura were collected are Barra Grande (Station 122) in 30 to 350 fathoms, and Bahia in shallow water; I may particularly mention the occurrence at the former locality of the remarkable *Neptunus* (*Hellenus*) *spinicarpus* (Stimpson), characterised by the extraordinary development of the carpal spine of the chelipedes, and also a very interesting variety (*oculiferus*) of the West Indian deep-water *Bathyplax typhlus*, A. M.-E., in which the ocular *corneæ*, although small, are distinctly developed. Milne-Edwards' types, it is to be noted, were dredged in deeper water.

"At the Tristan da Cunha group (Nightingale Island), in 100 fathoms, occurred a new

[1] *Cf.* H. N. Moseley, Notes by a Naturalist on the Challenger, p. 434, London, 1879.
[2] *Loc. cit.*, p. 561.
[3] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. viii. p. 432, 1881.

species of Grapsoid Crustacean (*Pseudorhombila* [*Pilumnoplax*] *normani*), which was taken also on the Agulhas Bank (Station 142) in 150 fathoms, and which has a bilobated front, three antero-lateral marginal teeth (the first obtuse), and the chelipedes granulated, the granules most numerous on the smaller chela.

"The species collected in the South African seas show affinities both with the Atlantic and Oriental Crustacea. At the Cape of Good Hope several Brachyura were collected at Simon's Bay and Sea Point near Cape Town; among them are specimens of the West Indian *Pericera cornuta*, M.-E., and *Calappa flammea* (Herbst). *Mursia cristimana*, Desmarest (with which I believe the Oriental *Cryptosoma orientis*, Adams and White, to be identical), occurred both at these localities and in 150 fathoms, on the Agulhas Bank (Station 142), where also were taken *Lispognathus thomsoni* (Norman), common in the deep waters of the North Atlantic and Mediterranean, to which is also doubtfully referred a mutilated male trawled off Sydney in 410 fathoms (Station 164B), a new Grapsoid Crustacean (*Brachygrapsus kingsleyi*) distinguished from the New Zealand *Brachygrapsus lævis*, Kingsley, by the bilobated front, and specimens of *Ebalia tuberculosa* (A. M.-E.), which was also taken frequently on the South Australian coast and in the New Zealand seas.

"*Antarctic Region.*—The only crab occurring in the Southern Ocean between the Cape and Australia is the *Halicarcinus planatus*, Fabr., common everywhere on the coasts and islands of the Southern Ocean, which was taken at Marion Island (50 to 75 fathoms), off Prince Edward Island (85 to 150 fathoms), and at Kerguelen Island, New Zealand, and the Falklands (Station 316), and which besides *Eurypodius latreillei*, Guér.-Ménév., and *Peltarion spinulosum*, White, common in Magellan Strait and at the Falklands, is the only Brachyurous species taken by the Expedition in the Antarctic or Austral circumpolar region.[1]

"*Oriental or Indo-Pacific Region.*—The Brachyura taken in Bass Strait and on the coasts of Victoria and New South Wales are numerous, and for the most part included in Mr. Haswell's recently-published Catalogue of the Australian Crustacea; among them, however, are several species apparently new to science. At Port Philip (Station 161, 33 fathoms) occurred the European *Portunus corrugatus* (Pennant), and at Port Jackson (3 to 8 fathoms) specimens of a species of *Pachygrapsus*, which I think cannot be distinguished from the West Indian *Pachygrapsus transversus*, Gibbes. *Pachygrapsus transversus* occurred also at the Bermudas and St. Vincent, and may itself prove to be identical with the Mediterranean *Pachygrapsus maurus*, Lucas.

"The only Station on these coasts where any Brachyura (beside the *Lispognathus thomsoni* already referred to) occurred at a greater depth than 100 fathoms is Station

[1] Dr. R. v. Willemoes Suhm (*Zeitschr. f. wiss. Zool.*, Bd. xxiv. p. xvi, 1874) remarks "dass höhere Crustaceen den Ufern der antarctischen Inseln fast ganz fehlen."

163A, off Twofold Bay, in 150 fathoms, where two or three species were dredged; among them a new species of the Cancroid genus *Medæus* (*Medæus haswelli*) allied to *Medæus elegans,* A. M.-E., from New Caledonia, but distinguished by the different areolation of the carapace, and the absence of the numerous small spines and tubercles which in *Medæus elegans* exist between the antero-lateral marginal teeth of the carapace.

"At Tongatabu (Station 172), in 18 to 240 fathoms, several new and interesting forms were collected, notably in 240 fathoms a new species (*Randallia granulata*) of the rare Leucosoid genus *Randallia,* Stimpson, distinguished from the Californian *Randallia ornata* by the coarsely and evenly granulated carapace, the less prominent front, and slenderer chelipedes. This species occurred also at the Fijis (Station 173) in 315 fathoms, together with *Pseudorhombila* (*Pilumnoplax*) *abyssicola,* n. sp., a species with nearly glabrous carapace, straight entire front, and three antero-lateral marginal teeth, of which the two last only are spiniform and acute, and a new species of *Mursia* (*Mursia curtispina*) allied to *Mursia armata,* de Haan.

"The Crustacea of the northern and northeastern coasts of Australia are as a rule very distinct from those of the eastern and southern shores; but few species collected by the Challenger in the Torres Strait and Arafura Sea are new to science. At the Ki (Ké) Islands, however, in 140 fathoms, occurred some of the most interesting and remarkable forms in the collection. There are specimens of a large and beautiful Maioid Crustacean which I have designated *Cyrtomaia murrayi,* a new genus and species (see fig. 196), apparently allied to *Euprognatha,* Stimpson, but distinguished by the remarkable convexity of the carapace, which is almost vertically deflexed at the gastric region, by the great development of the gastric spines, and by the elongated and spinuliferous chelipedes; also *Oxypleurodon stimpsoni,* a new genus and species allied to *Leucippe, Epialtus,* and *Eupleurodon,* and characterized by the subpyriform deeply channelled carapace, the slender divergent rostral spines, the distinct præocular and branchial spines, and the non-dentigerous ambulatory legs; and apparently new species of *Pugettia, Hyastenus, Pilumnus, Lupocyclus,* and *Platyonychus* (*Platyonychus iridescens*). The last-named is a very fine species, and is distinguished by the strongly granulated and spiniferous palm and dactyl of the chelipedes, and by the iridescent reflections of the carapace.

"At Banda and Ternate the few crabs taken were common species. At Amboina new species of *Naxia* and *Gonoplax* were dredged in 100 and in 15 to 25 fathoms; the latter (*Gonoplax sinuatifrons*) very nearly allied to the common European *Gonoplax rhomboides,* and distinguished only by the sinuated frontal margin and shorter chelipedes. In the Molucca Passage *Oncinopus aranea,* de Haan, was dredged at Station 196 in 825 fathoms; this, with two exceptions, referred to above, is the greatest depth at which any Brachyurous Crab was taken by the Expedition.

"At the Philippines, Brachyura were collected at several different localities on the beach or in shallow water, but the most interesting forms from these islands occurred at Station 210 in 375 fathoms, where were dredged a new species of *Amathia* (*Amathia pulchra*) nearly allied to the Mediterranean *Amathia rissoana* (Roux) and the West Indian deep-water *Amathia hystrix*, Stimpson, but distinguished from both by having six spines on the gastric region of the carapace and from *Amathia rissoana* by the distinctly developed præocular spine; it is distinguished from *Amathia agassizi*, S. I. Smith, by the more robust and carinated palms of the chelipedes; here also occurred

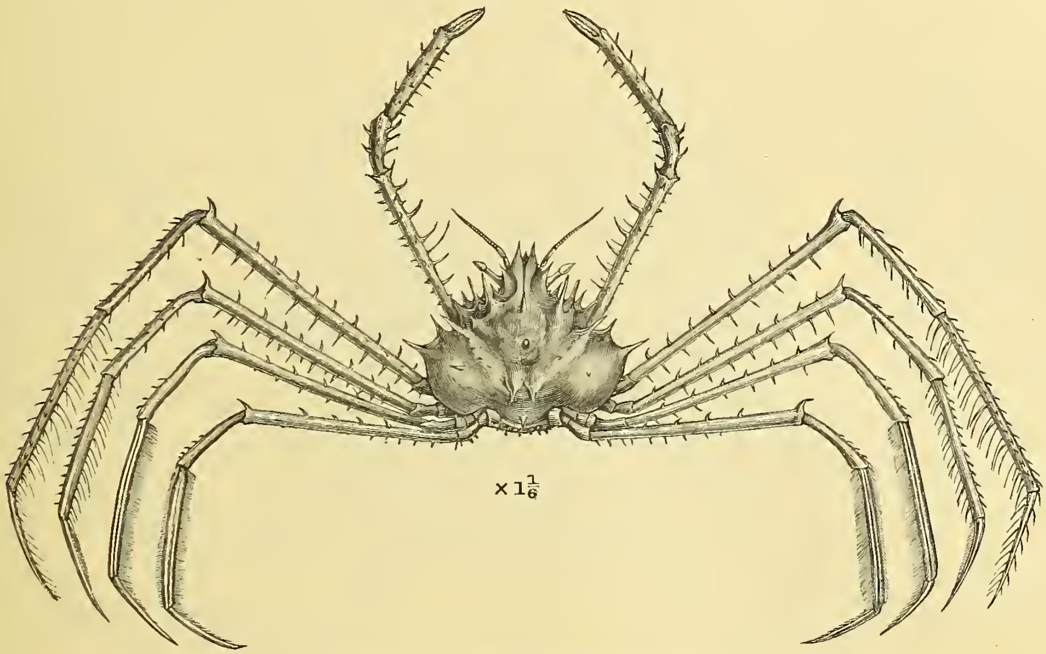


FIG. 196.—*Cyrtomaia murrayi*, n. gen. et sp.

Echinoplax moseleyi, a new genus and species very nearly allied to *Amathia*, but having the carapace covered with very numerous small spines and spinules, and the spines of the rostrum armed with small accessory spines; and the *Oxypleurodon stimpsoni* already referred to as occurring at the Ki Islands (Station 192).

"The few Brachyura taken at Hong Kong were common and well-known species, and need not be specially mentioned. Off Celebes some more interesting crabs were taken in 10 fathoms (Station 212), among them a species of *Lissocarcinus*, probably new, and a new *Leucosia*, which had already occurred in the Arafura Sea.

"At Station 214, between the Meangis and Tulur Islands, in 500 fathoms, occurred a second species (*Cyrtomaia suhmi*) of the remarkable new genus *Cyrtomaia*, distinguished from *Cyrtomaia murrayi*, dredged at the Ki Islands, by the greater development of the gastric spines, the longer rostrum, and the shorter thicker eyes.

"At the Admiralty Islands species were trawled in 150 fathoms (Station 219), among which are some of the most interesting new forms collected by the Expedition; these are *Platymaia wyville-thomsoni* (see fig. 197), a large and fine new genus and species allied to *Cyrtomaia* and to *Euprognatha*, Stimpson, but characterised by the depressed suborbiculate carapace, and the remarkably elongated and dissimilar ambulatory legs, the first pair of which have the fourth to last joints armed with strong spines; the second to last pairs are almost devoid of spines, but have the penultimate joints dilated and compressed as in *Eurypodius*; here also was taken a new species (*Ergasticus naresi*) of the genus

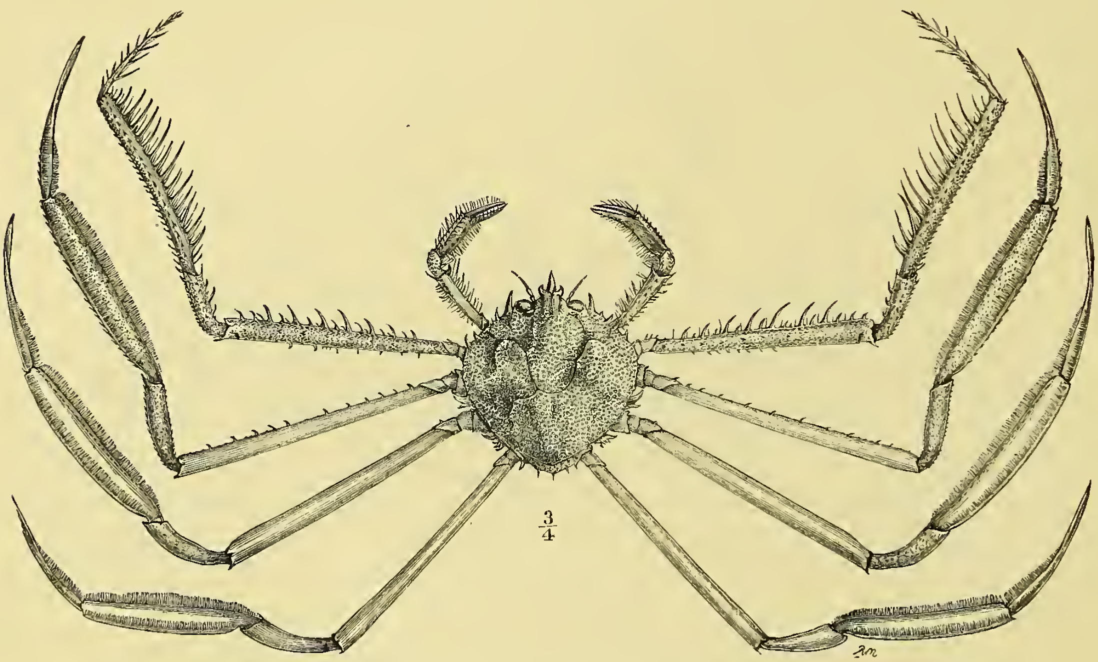


FIG. 197.—*Platymaia wyville-thomsoni*, n. gen. et sp.

Ergasticus, A. M.-E.,[1] distinguished from the type of the genus *Ergasticus clouei*, A. M.-E., found in the deep waters of the Mediterranean, by the different disposition of the spines and spinules of the carapace, and by having spines on the inferior as well as the superior wall of the orbit; lastly, a remarkable new genus and species of Oxystomatous Brachyura which I propose to designate *Paracycloïs milne-edwardsi* (see fig. 198), allied to *Calappa*, *Cryptosoma*, and *Platymera*, but distinguished from the first mentioned genus by the rudimentary lateral wings of the carapace, which in *Calappa* are developed so as to cover the bases of the ambulatory legs, and from the two last by the absence of the lateral marginal spines of the carapace and by other characters.

[1] Rapport sur la faune sous marine dans les grandes profondeurs de la Mediterranée et de l'Ocean Atlantique, p. 17 (1882).

"At Japan, Brachyura were collected at several different localities, but among them are few novelties or species of special interest; I need only refer to the Land-crab *Telphusa* (*Geotelphusa*) *dehaani*, White, which was taken at Hakoui at an elevation of 2500 feet above the sea level, and occurred also at Kobe and near Lake Biva. Its occurrence at this remarkable elevation has already been alluded to by Mr. Moseley.[1]

"The Brachyura collected at the Sandwich Islands (Hilo and Honolulu) and Society Islands (Tahiti) require no special mention. None were taken at Juan Fernandez, where the ship remained for two or three days.

"*Chili, Magellan Strait, and Falkland Islands.*—At Valparaiso, Chili, the only crabs taken were the well-known *Cancer longipes*, Bell, *Leptograpsus variegatus* (Fabr.).

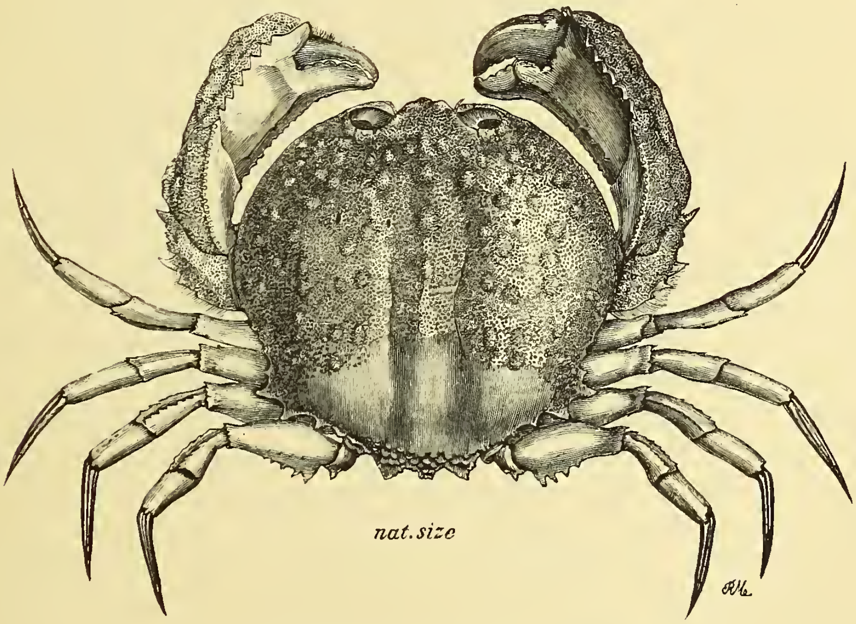


Fig. 198.—*Paracycloïs milne-edwardsi*, n. gen. et sp.

and *Acanthocyclus gayi*, M.-Edw. and Lucas, which occurred also on the coast of Chiloe in fresh water. Off the coast of Chiloe occurred also two apparently new species of the Maioid genus *Libinia*, the first, *Libinia smithi*, taken at Station 311 in 245 fathoms, is characterised by the great length of the spines of the dorsal surface of the carapace, of which there are four in a longitudinal and median series, and three on each branchial region, one (the lateral spine) extremely long; the second (*Libinia gracilipes*), was dredged at Station 304 in 45 fathoms; and an *Eurypodius* (*Eurypodius longirostris*), which I have regarded as new, but which may possibly be a deep-water variety of *Eurypodius latreillei*. It is distinguished by the elongated and remarkably reflexed

[1] Notes by a Naturalist on the Challenger, p. 561, London, 1879.

rostrum of the male, whose spines toward the apex are laterally divergent, and was trawled at Station 308 in 175 fathoms. In Magellan Strait and at the Falklands the only Brachyura taken were, as I have noted above, *Eurypodius latreillei*, Guér.-Ménév., *Halicarcinus planatus* (Fabr.), and *Peltarion spinulosum*, White."

Amboina to Ternate.

On the 10th October, at 3.30 P.M., after obtaining the requisite observations for rating the chronometers, the Expedition left Amboina for Ternate. When off the entrance to the bay the ship was swung for the errors of the compass, but a bank of clouds gathering in the western horizon hid the sun, and prevented the completion of the circle, so that after finishing swinging for the errors of the dipping needle, at 8 P.M., a course was shaped to the northward towards Suangi Island, sail being made at 10 P.M. to a fine easterly breeze.

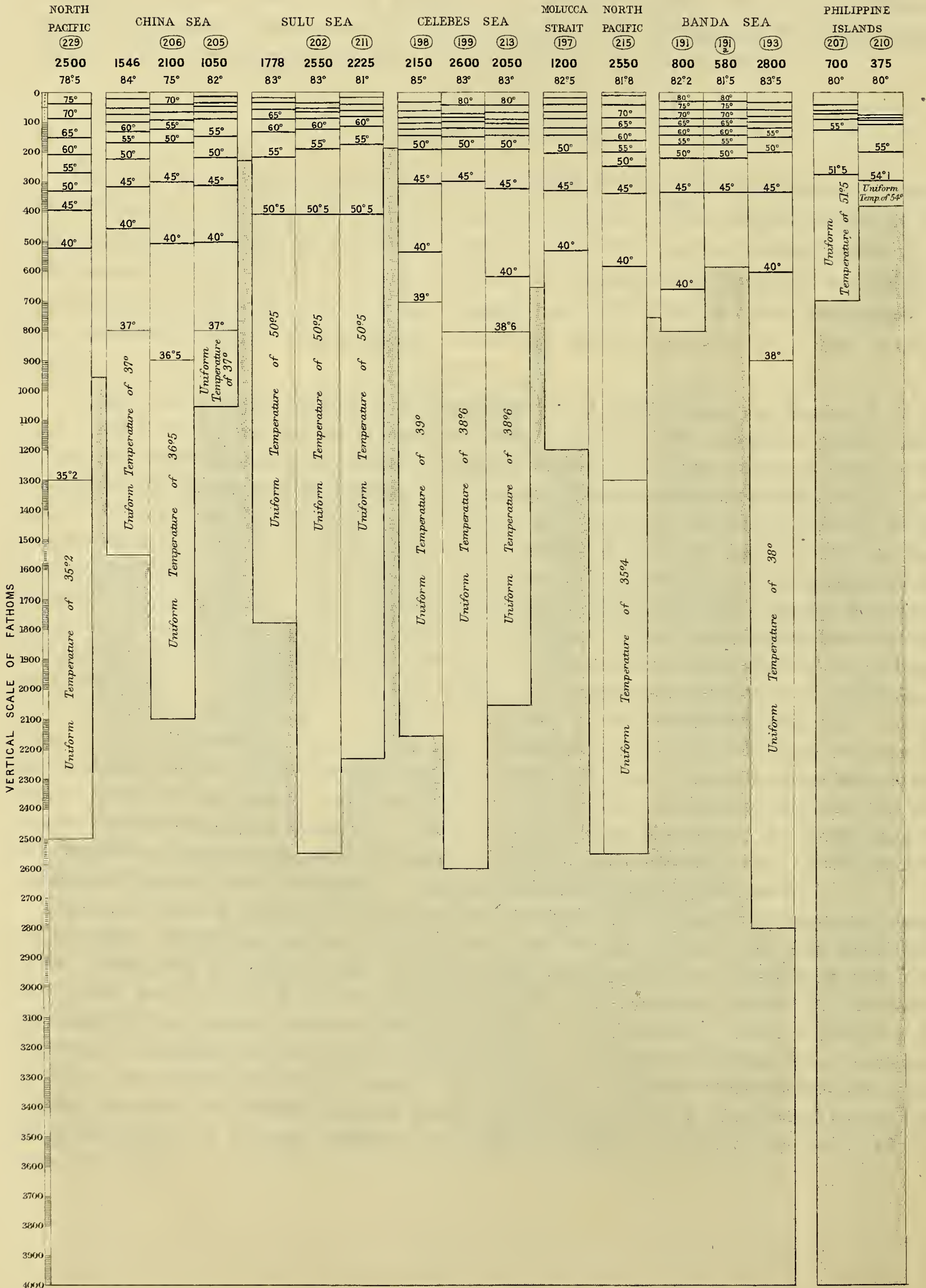
On the 11th, at daylight, Suangi Island bore N. 17° W., the right extremity of Manipa, N. 33° E., Sial Point S. 87° E., and the left extremity of Bouro Island S. 67° W., showing a set of 7 miles to the northwestward during the night. Advantage was taken of a fine sunrise to complete the observations for the errors of the compass, again resuming the course to the northward at 8 A.M. The peaks of Manipa and Kelang, which were stated on the chart to be 500 and 600 feet in height respectively, are much higher, Manipa rising to an elevation of 2100 feet, Kelang to 2400 feet, and Suangi Island to 327 feet. Passing between Suangi Island and Bouro the bearings and angles obtained indicated a discrepancy between the position of the islands on the eastern side of Manipa Straits and Bouro on the western side. This may be owing to the position of Bouro Island having been based on the observations of Sir E. Belcher at Cajeli, whilst the islands on the other side of the strait are based on Dutch positions. A pleasant breeze with slightly misty weather was experienced the whole day.

On the 12th, at 5.30 A.M., the position of the ship by star observations was lat. 1° 53′ S., long. 127° 5′ E., showing a slight westerly set. At daylight the island of Obi Major was seen on the starboard bow, and a course shaped to pass just outside Obi Lato. As the bearings taken to the various islands did not agree, a running survey of them was attempted as the ship passed, but this was rendered extremely difficult, owing to the varying velocity of the tide, and to the cloudy state of the weather in the afternoon, which prevented the latitude being obtained either by the meridian altitude of Venus, or, later, by the stars. Some few observations were, however, made.

Gomomo Island is round-backed and about 850 feet high, but appeared to be incorrectly placed on the chart; its summit is in lat. 1° 50½′ S., long. 127° 38′ E. Obi Lato is a high island with three or four sharp well-defined peaks of nearly equal height, reaching an elevation of 2400 feet; the highest peak is in lat. 1° 25′ S., long. 127° 18½′ E. The northwest point of Obi Major has a remarkable bluff near its extremity, with apparently a knob (probably a clump of trees) on its highest part; the knob is in lat. 1° 24′ S., long. 127° 24′ E. Five miles southward of this knob is a projecting point which looks like an island. The interior of Obi Major is mountainous, but clouds capping the summit of the hills prevented their height being ascertained. Tapa Island has a single round-backed hill on it about 1000 feet in height, the summit of which is in lat. 1° 12′ S., long. 127° 23′ E.

Diagram showing the Distribution of Temperature in the Seas enclosed by the Islands of the EASTERN ARCHIPELAGO.

For explanation of Symbols see Appendix 1.



Engraved by Malby & Sons

During the day numerous tide ripples were passed, but from observations the tide did not appear to run stronger amongst than between them. At 5.50 P.M., when abreast of Obi Lato, steam was raised and the vessel proceeded N. by E. for 20 miles, and then stood N.W. by N., partly to avoid the Bahia Shoal, and partly to get into a position for sounding and dredging off Batian Islands. During the night there was very vivid lightning.

On the 13th, at 5.30 A.M., the position of the ship by star observations being lat. 0° 48′ 37″ S., long. 126° 58′ 30″ E., a sounding, trawling, and temperatures were taken in 825 fathoms (see Sheet 31). At daylight the adjacent land could be clearly made out, and angles were obtained verifying the positions, given above, of Tapa and Obi Lato Islands, angles being also obtained to all the prominent objects on the Batian Islands as far north as Tapi Island. At 11 A.M. the trawl was hove up, and sail was made towards Tapi Island, a running survey being made as the ship proceeded. At 3 P.M. a latitude by Venus was fortunately obtained, and observations for longitude at the same time, which, with the observations obtained at daylight, and at frequent intervals since, enabled the prominent peaks of the Batian group to be fixed satisfactorily, and rendered the results to a great extent independent of the tide.

The islands of Mandioli, Sao, Tawali, and Tapi, and the summit of Mount Laboa, on Batian Island, are correct relatively to each other on Sheet 3 of the Admiralty Charts of the Indian Archipelago, but they all require to be shifted S. 75° E. (true) 3 miles to make them agree with the positions obtained by the Challenger (depending on the longitude of Amboina). Mount Laboa is a remarkable flat-topped mountain, 7150 feet high, in lat. 0° 44′ 30″ S., long. 127° 31′ 45″ E. Mandioli Island is about 1000 feet high, and is also flat-topped. Sao Islets are low. Tawali Island is high and flat-topped, but has a peak rising above the surrounding hills, 2650 feet high, in lat. 0° 20′ S., long. 127° 10′ E. The highest peak of Tapi, 1300 feet above the level of the sea, is in lat. 0° 15′ S., long. 127° 4′ E. Off the south and west extremities of Tapi are two small islets, about 200 feet high and 3 miles to the northward of its north point, in lat. 0° 11′ S., long. 127° 1′ E., are three small rocks 130 feet high and close together.

From the position of the ship at 6 P.M., 10 miles due west of the peak of Tapi, the islands of Ternate, Tidore, and Metir were seen, as well as one of the islands northward of Little Tawali, probably Guaricha.

A fine breeze was experienced from 6 A.M. to 4 P.M., when the weather became calm and showery, so steam was raised and the vessel proceeded N.W. by N. outside the Wolf Rock. Whilst sounding in the morning a strong southerly set was observed, but this changed after 11 A.M., as the sights at 3 P.M. showed a greater run than the patent log. There can be no doubt, therefore, that tides are experienced in the Molucca Passage occasionally, although they may be irregular.

On the 14th, at 1.40 A.M., the ship rounded the Wolf Rock, and at 5.30 A.M. stopped and sounded in 1200 fathoms, obtaining temperature observations, in lat. 0° 42′ N., long. 126° 37′ 30″ E. The serial temperatures here showed that the Molucca Strait or Passage was open to the Pacific Ocean to, at any rate, the depth of 1200 fathoms (see Sheet 31 and Diagram 14).

At daylight all the Molucca Islands, as well as the island of Meyo, were in sight, but Tifore was not seen ; it must, therefore, be much lower than supposed. At this time the view was magnificent—looking east no less than ten volcanic cones were visible, several of them in eruption, extending from the northern end of Gillolo to Makyan Island, the clouds, however, quickly capped their summits and limited the view to the lower parts of the land. At 7 A.M. the ship proceeded under steam towards Ternate, steering for the channel between it and Tidore Island (see fig. 199).

Hieri, the northernmost islet of the Molucca group, 2200 feet high, is a small but very steep truncated volcanic cone, not in eruption, circular in shape, its diameter being about one and three quarter miles. Close off its north and northwest sides are small rocks. Ternate is a single grand volcanic cone, from the summit of which smoke is constantly issuing. Its height was found to be 5600 feet, and position lat. 0° 48′ 30″ N., long. 127° 19′ E. The summit itself is bare, but the sides are thickly wooded. The slope of the side is about 30° from the horizontal for about two thirds of the distance down, after which it becomes more gradual, and ends in a margin of gently rising ground all round the base, which is cultivated in some way or other. Tidore, the highest and

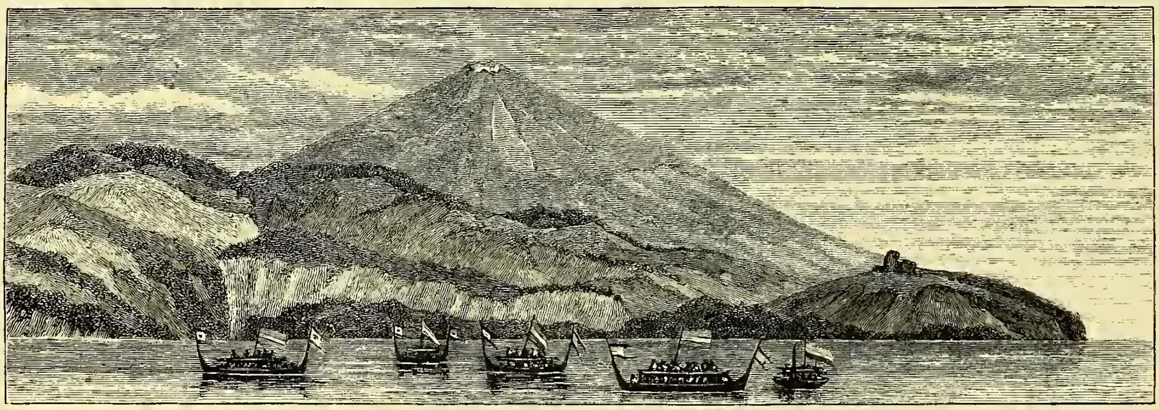


FIG. 199.—Island of Tidore.

most perfect cone, is now entirely quiescent. It was found to be 5900 feet in height, and its position lat. 0° 39′ N., long. 127° 23′ E. As in Ternate, the lower grounds on this island are everywhere cultivated, in fact the clearings extend far up the hillsides, and appear to be increasing. Mareh is about 700 or 800 feet in height, with two peaked hills. Metir is another volcanic cone in lat. 0° 28′ N., long. 127° 23′ E., attaining an elevation of 2800 feet.

As the entrance between Tidore and Ternate was neared, the small but perfect cone of Mitara Island was very conspicuous. On its summit at the edge of an old crater is a signal station. During the passage between this island and Ternate, the eddies were so strong and the water so much discoloured from a recent heavy thunderstorm that it was thought for a moment that the ship was steaming on to the edge of a reef, and the engines were stopped. It was however only a tide ripple, and the vessel soon proceeded for the anchorage, arriving there at 6 P.M., and anchoring off the coaling pier in 13 fathoms.

Ternate.

A small Dutch gunboat was lying here, the officer in command of which supplied a plan of the anchorage, and furnished every information.

On the 15th, in the morning, the Dutch flag was saluted, and the salute was returned by the gunboat, the echo from the high mountains giving a very peculiar ringing report to the guns. In the afternoon the Resident or Governor came on board and was saluted on leaving with thirteen guns. The usual salute allowed by the Dutch authorities is eleven guns, but as the Sultan of Ternate is entitled to that number, the Resident at this station is allowed thirteen.

The Moluccas consist of the islands of Ternate, Tidore, Metir, Makyan, and Batian, with the adjacent islets. The first European to visit them was Bartema of Bologna in 1506. He was followed in 1512 by Francisco Serrao, who commanded an expedition despatched by the Portuguese from Malacca.

In November 1521 the Moluccas were visited by the ships of Magellan's squadron after Magellan had been killed at Zebu. They anchored off Tidore Island, where they were honourably entertained by the King, who entered into a league of friendship with them. At that time the islands were rich in productions of all kinds: cloves, ginger, sago, rice, figs, almonds, oranges, lemons, and sugar cane. Neither was there any want of goats and fowls, the ships being furnished with provisions in such quantities, that, to use their own expression, "it was marvellous to behold."

Shortly after the visit of Magellan's squadron in the same year (1521), the Portuguese appeared in force in the Moluccas, with nine ships, commanded by Antonio de Britto. The simple sovereigns of the Moluccas received their guests with caresses, and contended for the honour of entertaining them, and even allowed them to establish a military settlement in their country. For this purpose the island of Ternate was selected, and here, in the kingdom of the most powerful chieftain of the islands, the Portuguese Commander established himself. De Britto, to his astonishment, found in the Moluccas some of the companions of Magellan; these he seized and imprisoned.

After the Portuguese had established themselves at the Moluccas, disputes arose between them and the Spaniards respecting the ownership of the islands, and a commission met near Badajos to decide the question, but like a great many other conferences it ended in talk, each side maintaining their own view of the question. In 1529, however, the Emperor Charles V. relinquished to the Portuguese all the countries lying west of a meridian 17° east of the Moluccas. Notwithstanding this treaty, in 1545 a Spanish expedition under Villalobos visited the islands, and entered into an offensive and defensive treaty with the King of Tidore against the Portuguese, but this only lasted until their differences were for a time patched up with that nation, when Villalobos abandoned the Tidore Islanders to the Portuguese.

Shortly after this the Portuguese were driven out of Ternate by the Rajah of that island, and took up their quarters at Tidore, for when Drake arrived at the Moluccas in 1579, there were no Portuguese at Ternate; consequently Drake anchored off that island, and traded with the King, carefully avoiding the Portuguese.

In 1599 the Dutch admiral Van Warwyck established intercourse with, and a factory on, Ternate Island; it was, in fact, in this year that the Dutch first began to trade with the Spice Islands,[1] and very soon quarrels arose between them and the Portuguese, so that the Dutch resolved if possible to drive the Portuguese from the Moluccas, and reap for themselves the benefit of the spice trade, and in the year 1603, twelve ships under the command of Stephen Verbayen left Holland for this purpose. After capturing Amboina the fleet divided, five ships being sent to Tidore, and the others to Banda. Arriving at Tidore on the 2nd May 1605, the Dutch summoned the Portuguese to yield on the 5th, and a spirited contest took place between the ships and the fort; but the magazine in the fort blowing up, and killing sixty or seventy men, the Portuguese surrendered. The Dutch were assisted in this action by the Rajah of Ternate.

The early period of the Dutch history consists of an account of their commercial transactions, their wars with the Spaniards, and their aggressions upon the natives. In the beginning of 1606, the garrisons at Ternate and Tidore were overpowered by the Spaniards under Pedro de Acuña, and it was not until ten years later that the Dutch recovered their ascendency in these islands, at which time they had the dexterity to inveigle the greater number of the Rajahs into treaties, conferring upon themselves the exclusive right of buying cloves. These treaties, imperfectly understood by the Molucca Islanders, led to wars which desolated their country, with little interruption, to the year 1681, when, enfeebled and broken spirited by their ineffectual efforts, they submitted to the rule of the Dutch, who have since remained in possession of this fertile group.

As stated above, the island of Ternate is a volcanic cone, the summit of which rises to a height of 5600 feet above the level of the sea. There have been, during the Dutch occupation, no fewer than fourteen different important eruptions, beginning with the year 1608. In the eruption of 1840, the earthquakes lasted from the 2nd to the 15th February, with intervals of a few hours only. The inhabitants fled to the beach, or took to their boats. Every stone building in the town was overthrown, and the people were on the point of abandoning the island altogether, until ordered to remain by the supreme Government at Batavia. It is singular that no earthquake wave accompanied this earthquake.

The members of the Expedition were fortunate enough to find in the Resident of Ternate the late distinguished naturalist Mr. S. C. J. van Musschenbroek, who rendered every assistance in his power, and treated them with the greatest kindness and hospitality, even getting up a ball on the shortest notice. The musicians were Malays who were indefatigable, but knew only one tune.

[1] Purchas, pp. 709, 710.

Ternate is again rising into importance as a spice island, for the Dutch no longer confine the cultivation of cloves to the island of Amboina, or that of nutmegs to the island of Banda; consequently, the rich soil of this island will soon again be most productive. Already there are nutmeg, pepper, cinnamon, and clove trees growing, besides a profusion of fruit trees. The dúrian, mangosteen, mango, and pine-apple all flourish on the island, which also produces oranges, lemons, pomegranates, &c., and there is hope that coffee and cocoa may likewise thrive. Sago is still, as it was two centuries ago, the staple food of the inhabitants. The supplies are, as they were in the time of Magellan, plentiful and moderate: beef 1s. per lb., fowls 8s. per dozen, ducks 2s. 9d. to 3s. each, geese 6s. or 7s. each, and sweet potatoes 5s. per picul ($133\frac{1}{2}$ lbs.).

A fair supply of coal is kept in stock, and vessels may be certain of always obtaining sufficient here to take them on to Amboina, the main depôt of the Dutch amongst these islands. A pier runs out from the shore, alongside which a vessel may lie whilst receiving the coal, but as it is very rickety, off-fasts are required. There are 5 fathoms alongside the end of this pier at low water. From the beach abreast the town three piers run out; the northernmost and best is opposite the Resident's house, the second is for the use of the natives, and the third and southernmost is the coaling pier.

After the pier has been traversed, a well-kept road is reached, running parallel with the shore, on each side of which trees are planted, as closely together as possible, affording a grateful shade from the vertical rays of the sun. By the side of this road is the residence of the Governor, and also those of the officials, and here again, in a most pleasant situation, is the usual club house, to which the members of the Expedition were made most welcome. If this road is further pursued, Fort Orange, the stronghold of the Dutch in the island, is at last reached, which, founded in about 1616, yet remains as a shelter for the European inhabitants, in case of a revolt of the natives, but is of no use against foreign aggression.

From Ternate a trade is carried on with New Guinea under the general direction of the Rajah of Tidore, who claims a certain jurisdiction over all the land to the meridian of 141° E. longitude, or rather the Dutch do for him. Very considerable distrust appeared to exist between the New Guinea people and these traders. During the season of 1873 three Malay proas, wrecked on the New Guinea coast, were plundered, and most of the crew slain; but it seemed probable that the influence of the travellers engaged in the exploration of the interior of New Guinea, together with the abolition of slavery throughout the Dutch possessions, and the establishment of legitimate trade, would produce more amicable feelings between the Papuan race and the outside world.

There was a report at Ternate, during the stay, that there were a number of piratical proas in the neighbourhood of Batian Island, and the Resident of Ternate intended, after the Challenger's departure, to go to Batian, in the Dutch gunboat, and make inquiries as to the truth of this statement. If he found there really were pirates thereabouts, he would, with the assistance of the Tidore proas, attack them at once.

The coin in circulation at Ternate is the Dutch dollar, 4s. 2d., and the Dutch rupee, 1s. 8d. An English shilling only passes as a half rupee, but English sovereigns can be exchanged in small quantities at their proper value in dollars and rupees.

The Malay collectors who are sent every year with the traders to New Guinea from Ternate, to collect Birds of Paradise and other birds, are some of them extremely expert in preparing and preserving bird-skins. They mount them with a small stick stuck into the tow stuffing, and protruding at the tail; the skin is handled by the stick, and thus the bird's feathers are prevented from being injured. There are several Mohammedan dealers in bird-skins in the town of Ternate. A Papuan Bird of Paradise (*Paradisea papuana*), well-skinned, costs about eight shillings, and a well-skinned Red Bird of Paradise (*Paradisea rubra*) fourteen shillings. Skins of various Paradise Birds, prepared flat, and dried in the old native style, were common and cheap enough. Amongst these skins were a large quantity of what appeared to be the very rare black and scarlet-coloured Parrot (*Dasyptilus pequeti*). These birds could hardly have been killed and thus prepared for sale, as ornaments, like the batch they were amongst, but they were unfortunately of no use as natural history specimens in their mangled condition.

Mr. Moseley and Lieutenant Balfour ascended the Peak of Ternate accompanied by four Malay guides provided by the Resident for the purpose. Mr. Moseley thus describes the ascent:—"We passed a night at the house of one of the Government officials, who kindly offered us hospitality, at an altitude of about 1000 feet. Leaving the house at 4.30 A.M. on the following morning, we commenced the climb through a field of sugar cane. The path led nearly straight up the cone all the way, and was excessively steep, and the ground was very slippery from a heavy fall of rain the night before.

"It was pitch-dark for the first hour, and we slipped and fell constantly. At an altitude of about 2000 feet above sea level, the last cleared and cultivated land, a rice field, was passed. On the border of the field grew several of the Saguir Palms (*Arenga saccharifera*), which are abundant in the gardens at sea level. An intoxicating drink is made from the juice of this palm, and like many other palms it yields sugar. Above the rice fields, woods were entered at about daylight, and these extend up to an altitude of about 4150 feet. Jack-fruit and a wild plantain were observed to grow up to a height of about 2600 feet. In the woods was a small hut, used by men who come up to hunt the deer, which are abundant on the mountains. On a tree close to the hut was cut the name of Miklucho-Maclay, the well-known explorer of New Guinea. From the verge of the woods at 4150 feet altitude, for about 650 feet farther ascent, a dense growth of tall reeds was traversed. At this height (4800 feet above sea level) a ridge was reached from which a descent of about 100 feet was made into an outer ancient crater, corresponding to the Cañadas of the Peak of Tenerife. There are two such outer ancient craters at the summit of the Peak of Ternate, and the ridges forming the old borders of these craters and the outer portions of the bottoms of the craters themselves are traversed in succession on the way to the terminal modern cone of eruption which stands in the inner of the two. The outermost and oldest of the craters is a wild-looking place, inhabited by numerous wild pigs and deer, and is covered with a growth of bushes and a small tree fern, and three other species of ferns,[1] and with these grow a Club-moss (*Lycopodium*) and a Whortleberry (*Vaccinium*). The shrubs apparently belonged to only two species, and the flora seemed a very poor one in number of species. The second ridge, marking the summit of the inner extinct crater, is about 50 feet higher than the outer one. Within this inner crater there is scarcely any vegetation, only a few scattered blades of grass. Here a large mass of lava was met with, evidently recently ejected from the active crater, and hurled to this distance. The mass had a smooth reddened surface, and was deeply split all over by cracks evidently formed by contraction on cooling. The terminal cone itself is entirely devoid of vegetation. The cavity of the inner extinct crater from which it rises is filled up, except at its margin, by the results of later eruptions, hence the base of the terminal cone lies about 60 feet above the level of the margin of this crater, and is approached by a gentle ascent. The cone itself rises steeply and suddenly, with a slope of 30°, and is about 350 feet in height. The guides had hesitated somewhat when we ascended the slope leading out of the first extinct crater, and had done their best to persuade us not to go any farther, telling us that it was dangerous to proceed. They lagged behind as we approached the terminal cone, and as soon as we began to climb it, turned round and ran back as fast as they could go. We were told afterwards that they have strong superstitious fears concerning the volcano, and believe that if any one climbs the terminal cone, a terrible eruption and earthquake are certain to ensue. It appeared as if there might be some real risk in the ascent. The cone is not composed of ashes, but of masses of basaltic lava of various sizes; all of these on the surface appeared freshly fractured and split, as if quite recently thrown out of the crater, and broken up on cooling. At the summit, a slope of 30°, exactly the same as that of the outside of the cone, the natural slope, no doubt, of the lava fragments, leads down into the crater, from a sharp ridge, along which we walked. A dense smoke rose from the interior of the crater, and hid its form and extent entirely from view. The wind was easterly (E. by N.), and drove the smoke away from the side of the crater on which we were. The smoke is excessively suffocating, and a sudden shift in the wind might be fatal to any one who was a short way down within the crater, or even at some places on its margin. It would not be easy to get down it in some places, at all events in a hurry. It was only possible to descend about 20 yards into the crater, and even then the vapours inhaled were very trying. Steam and acid vapours issued from cracks

[1] *Gleichenia dichotoma, Pteris incisa, Polypodium phlebiscopum*; J. G. Baker, F.R.S., On the Polynesian Ferns of the Challenger Expedition, *Journ. Linn. Soc. Lond.* (Bot.), vol. xv. pp. 104–113, 1877.

everywhere, decomposing the lava amongst which they passed; in most of the cracks were small quantities of sulphur. From the margin of the crater overlooking the town of Ternate there was a magnificent view, embracing the island of Halmahera (Gillolo), which lay spread as a map beneath us, and the peak of Tidore, and many far-distant islands. Our guides rejoined us when we came down to the outer crater. For the benefit of any future explorers of the Peak, which is very seldom ascended, I give the time required for the ascent. We left the house at 1000 feet altitude at 4.30 A.M., reached the margin of the outer crater at 8.30 A.M., and the summit at 9.30 A.M. The temperature of the air at an altitude of 4800 feet was 71° F. at 8.30 A.M., at the summit of the mountain it was 68°·5 F. at 9.30 A.M."

The rocks collected at Ternate were augite-andesite with pleochroic augites and probably with some hypersthene crystals.

From a record of the temperature kept at Ternate for eight years, it appears that the climate is very uniform, the mean temperature for each month varying only from 80° to 81°. Rain falls on a average 216 days in the year, or 18 days per month. The number of days' rain per month being rather under the average during the northerly, and over the average during the southerly, monsoon. The northerly monsoon commences in January and ends in March, the southerly monsoon in April and lasts until the beginning of November.

Each day whilst the ship was at Ternate the clouds banked up over the hills towards the afternoon, and about 5 or 6 P.M. a heavy rain squall was experienced, which lasted about three quarters of an hour, and produced a deliciously cool atmosphere after the heat of the day.

The rise and fall of the tide at springs is about 4 feet, but may vary with the season of the year.

The zoological collections at Ternate included a new species of Snake of the family Calamaridæ, and a new Butterfly (*Gerydus stygianus*, Butler), as well as a Sphynx Moth (*Protoparce cingulata* [Fabr.]), concerning which Mr. Butler remarks:—"The appearance of this New World species at Ternate is very surprising; it is probably only an accidental immigrant. The specimen was much worn and shattered, and may have been long on the wing. Some of the Sphingidæ have been taken at an almost incredible distance from land, showing that their flight is not only extremely rapid, but capable of being sustained for a considerable time."[1]

The Medusæ.—Professor Haeckel, who has drawn up a Report on the Medusæ collected during the Expedition, has indicated the more important points in his Report[2] in the following notes:—"Few classes of animals appear so ill-suited for life in the deep

[1] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiii. pp. 194, 199, 1884.
[2] Report on the Deep-Sea Medusæ, Zool. Chall. Exp., part xii., 1881.

sea as the Medusæ, with their soft, gelatinous, watery bodies and their natatory life. There are, however, some few species of this class which descend to great depths. In the Memoir only eighteen such species are described, and in many of these cases it is very doubtful whether they are really inhabitants of the deep sea, or whether they have not been accidentally caught by the dredge while it was being drawn up to the surface.

"Two families of peculiar Medusæ can, with a considerable degree of certainty, be regarded as characteristic inhabitants of the deep sea, namely, the Pectyllidæ among the Craspedota, and the Periphyllidæ amongst the Acraspeda.

"The Pectyllidæ (genera *Pectis*, *Pectyllis*, and *Pectanthis*) belong to the order of Trachomedusæ; they are nearly related to the Trachynemidæ, and are especially remarkable for their peculiar suctorial tentacles, which are distributed in great numbers around the margin of the stiff almost cartilaginous umbrella (shown in the contracted state in fig. 200). These tentacles closely resemble the ambulacral tube-feet of the Echinodermata; they are highly contractile and elastic, and are armed at the ends with a strong sucker. The living Pectyllid uses these for attaching itself, and also to creep with, just in the same

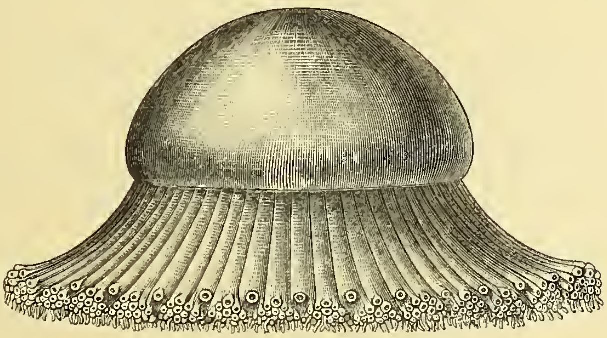


FIG. 200.—*Pectis antarctica*, Haeckel; twice the natural size.

manner as a starfish or a sea urchin. Another peculiarity of the Pectyllidæ consists in eight radial "Mesogonia" or sexual mesenteries; these are membranous septa in the hollow of the umbrella, which divide it into eight "adradial" partitions, and are extended between the subumbrella, on the one hand, and the eight gonades or sexual glands, which surround the basis of the stomach, on the other.

"The Periphyllidæ (represented by the two genera *Periphylla* and *Periphema*) are Acraspedote Medusæ of a very curious and complicated structure, and belong to the peculiar order Peromedusæ, which was first constituted by Professor Haeckel in 1880, in his System der Medusen. They possess many important characteristics common to the Lucernaridæ on the one hand, and to the Charybdeidæ on the other. The highly arched and conical umbrella bears on its margin four interradial sense organs of very remarkable structure, and between these, twelve very long and powerful tentacles (four perradia and eight adradial). On the inner margin of the umbrella is a very strong coronary muscle, which is divided by means of sixteen subradial septa into the same number of quadrilateral portions. The septa are attached to the central ribs of the sixteen marginal lobes.

"Just internal to this powerful coronary muscle are attached to the subumbrella eight horse-shoe shaped gonades or sexual glands, which alternate with eight three-cornered deltoid muscles (four perradial and four interradial). In the centre there arises a large and almost cubical manubrium, on which four wide perradial buccal pouches (*bursæ buccales*) are separated by means of four strong interradial buccal columns. On the edge of the mouth are found eight oral tentacles. The cavity of the manubrium opens into a large central stomach, which is filled for the most part with extremely long and

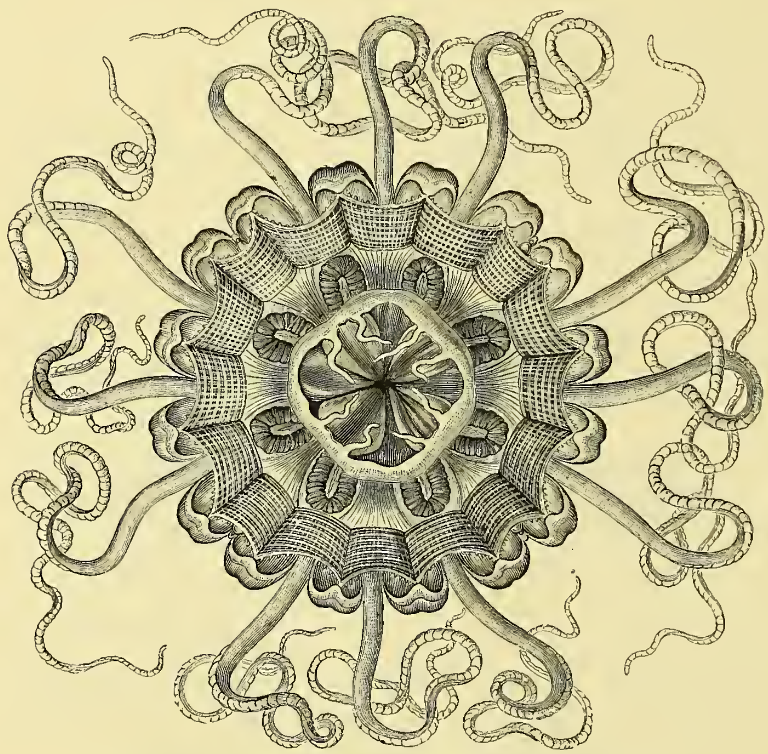


FIG. 201.—*Periphylla mirabilis*, Haeckel; half the natural size.

numerous gastral filaments; and this, by means of four long perradial slits (or gastral-ostia), communicates with a colossal annular sinus. About half way up the stomach are four interradial cathammata or septal knots, in which the subumbrella and the exumbrella are fused. Complicated pouches pass downwards from the circular sinus to the umbrella margin.

"*Periphylla mirabilis* (see fig. 201), 160 mm. high, 120 mm. broad, was taken by the Challenger, on the east coast of New Zealand, when the trawl was lowered to a depth of 1100 fathoms, and *Periphema regina*, 180 to 200 mm. high, and about the same in breadth, in the lat. 62° Southern Ocean, when the depth was 1975 fathoms. Two other remarkable deep-sea Medusæ discovered by the Challenger are *Nauphanta challengeri* (from Tristan da Cunha, depth 1425 fathoms) and *Atolla wyvillii*, both belonging to the group of Ephyridæ, which are the oldest of the Discomedusæ, and are nearly related to *Nausithoe*. *Atolla* seems to be very widely distributed in the deep sea. It was captured in the Antarctic Ocean (Station 157, depth 1950 fathoms) and also in the South Atlantic Ocean (Station 318, depth 2040 fathoms). In August 1882 it was again found by Mr. John Murray in the Færöe Channel, at a depth of 430 to 640 fathoms."

CHAPTER XV.

Ternate to Samboangan—The Asteroidea—Samboangan to Ilo Ilo—The Amphipoda—Ilo Ilo to Manila—The Lamellibranchiata—Manila to Hong Kong—The Annelida—The Calcarea and Keratosa.

Ternate to Samboangan.

On the 17th October, at 11.30 a.m., the Challenger left Ternate for the Philippines, passing out northwards of Hieri Island. During the passage the surveyors made many observations referring to the position of the land sighted.

The point on the coast of Gillolo opposite Hieri Island was wrongly placed on the chart; it lies N.E. ¾ N., 8 miles from the peak of Hieri Island. Just over this point, in lat. 1° 2½′ N., long. 127° 24′ E., is a hill 1050 feet high, and N. by E., 3 miles from this hill, is a remarkable sharp peak 3450 feet high, in lat. 1° 5′ N., long. 127° 25′ E. About 8 miles north of this mountain is a flat-topped hill with four knobs on it, in lat. 1° 13′ N., long. 127° 25′ E. The coast of Gillolo did not appear to extend west of the meridian of 127° 23′ E. At 6 p.m. Ternate Peak bore S. 44½° E., Hieri Peak S. 65° E., and Tidore Peak S. 37° E. From this position a course was shaped for Tifore Island.

On the 18th, at daylight, Tifore Island was in sight ahead, and Meyo Island to the northward. A clear day, which allowed of numerous astronomical observations being obtained, including the meridian altitude of Venus at 3 p.m., permitted the correct position of the two islands to be ascertained.

Meyo Island is about 3½ miles long, in an east and west direction, and rises gradually from the shore to the summit, 1280 feet above the level of the sea, which is in lat. 1° 20½′ N., long. 126° 22′ 40″ E.

Tifore Island is about 2 miles in length, in an E. by N. and W. by S. direction, and 1½ miles in breadth. On its northwest end is a saddle peak 530 feet high, the eastern and highest summit of which is in lat. 1° 1′ N., long. 126° 8′ 20″ E. A cable from its north point is a small islet, which has a steep bluff at the north end, sloping gradually to the southward. On the eastern side of Tifore Island there is said to be a bay, in which the depths are reported as being 20 or 30 fathoms, but there is a ridge of coral across its entrance with but from 1 to 3 fathoms water over it. The Malay proas frequently take shelter here, and it is sometimes used as a rendezvous for pirates. Outside the harbour is anchorage for large ships; from the description given of this harbour, it would appear to be formed by an extinct crater. It was a matter of regret that time did not permit landing on this uninhabited island. The Malays also state that anchorage may be found either north or south of Meyo Island. The channel between Meyo and Tifore Islands is 21 miles wide, and free from danger.

The wind was very light all day, nearly calm, so that very little progress was made. At 5 p.m., however, a breeze sprang up from the northeastward which lasted until 10 p.m. At 8 p.m. Meyo Island bore east, and Tifore S. by. E. ½ E., from whence a N.W. course was steered for Bejaren Island.

On the 19th, at daylight, the ship was found to be 20 miles southeast of Bejaren Island, having been set 8 or 10 miles to the northwest during the night. The Talautse Islands, as far north as Siao, were in sight, as well as the land about the northeast point of Celebes Island. At 7 A.M. the position of the ship could be fixed by the hills and islands off the northeast point of Celebes, and from that time until 6 P.M. the surveyors were enabled, by so ascertaining the ship's position, to correct the position of the Talautse Islands.

Bejaren Island has a remarkable precipitous conical hill, 1240 feet in height, on the eastern side of its centre. The summit was found to be in lat. 2° 6′ 30″ N., long. 125° 21′ 30″ E. The rest of the island is covered with trees. No patches of cleared land could be seen, but it is probably inhabited, as smoke was observed on the northwest side, and a canoe was seen off that point. So far as could be made out it was perfectly free from coral, the sea breaking against the shore. A sounding in 250 fathoms, hard ground, was obtained $2\frac{1}{4}$ miles south of the south point.

Roang Island has three peaks, the eastern and highest being 2450 feet above the level of the sea in lat. 2° 19′ N., long. 125° 21′ E. Smoke was rising from the central peak throughout the day, and scoriæ and lava extended down the slope of the hill to a height of about 300 feet above the level of the sea, beneath which vegetation commenced.

Passigi Island, a small flat island covered with trees, the tops of which are about 100 feet above the level of the sea, is in lat. 2° 22′ N., long. 125° 17′ E.

Tagulanda Island has two peaks, the eastern and highest, in lat. 2° 21′ 30″ N., long. 125° 25′ 30″ E., is round-backed, and attains an elevation of 2550 feet; two miles west is the other peak, 2450 feet high.

Mount Klobat is a very conspicuous volcanic cone standing by itself, rising to the height of 6694 feet from a low base in the northeast extremity of Celebes Island. Gunung Sodara, the double peak northeast of Klobat, is 4300 feet high. Banka and Salice Islands are each about 1100 feet high, and the island of Tua Manado 2750 feet, instead of 1500 as marked on the chart. All the foregoing positions depend on Mount Klobat being in lat. 1° 27′ 30″ N., long. 125° 0′ E. After rounding Bejaren Island a course was shaped to the northward towards Basilan Strait.

On the 20th, at 7 A.M., the island of Siao and the small islet of Makaléhé were seen. At 9.30 A.M. a sounding, trawling, and serial temperatures were taken in 2150 fathoms, in lat. 2° 55′ 18″ N., long. 124° 53′ 30″ E. (see Sheet 31). From this position a true bearing of Roang Peak was obtained, S. 37° 21′ E. (true), and the following angles were taken with that peak as zero:—

⇥ Makaléhé	16° 55′	Roang Island Peak.
Apex Do.	18° 20′	
⇤ Do.	19° 50′	
⇥ Siao Island	23° 40′	
⇤ Do.	40° 50′	
Passage or Kalama Island	82° 45′	

These angles are sufficient to show that the islands of Siao and Makaléhé are much out of position on the chart, but they could not be fixed, as trawling operations were being carried on all day. The island of Makaléhé appeared much smaller than that laid down in the chart; it is round-backed, with cocoanut trees on its highest ridge. Maquiliere Island was not seen from the ship, so it must be low. Sanguir Island could just be distinguished to the northeastward, but no part of it was sufficiently clear to allow of angles being taken to it.

Siao Island has a most remarkable range of four volcanic cones perfectly distinct from each other. The northern one is an active volcano, estimated as 6000 feet high; the other three are lower, gradually decreasing to the lowest in the south part of the island, southeast of which the land appears much broken up.

The trawl was hove up at 6.45 P.M., and at 7 P.M. the ship proceeded towards Basilan Strait under steam, the weather being quite calm. Whilst trawling a slight westerly current was experienced.

On the 21st the calm continued throughout the day, rendering it necessary to proceed under steam. At noon the surface temperature rose to 88°, the black bulb thermometer in the sun showing at the same time 142°.

On the 22nd, at daylight, the high land of Mindanao Island was seen on the starboard bow. At 7.45 A.M. a sounding and serial temperatures were taken in 2600 fathoms, and at 11.30 A.M. the ship again proceeded towards Basilan Strait. At 10 P.M. Basilan Island was sighted, and at midnight the left extremity of that island bore W. ½ S., Mount Matanal W. by N., and Sibago Island N.W. by W. ½ W.

On the 23rd, at daylight, Sibago Island bore S. 12° W., Mount Matanal S. 29° W., Tulnalutan Island N. 25° W., and Malanipa Island N. 66° W. At this position the ship was swung to ascertain the errors of the compass and dipping needle. At 2.35 P.M. the swinging was completed and two hauls of the trawl obtained in 250 fathoms, with Mount Matanal 45° 0′ L.T. Lambil Island 62° 30′ Tulnalutan Island. At 5 P.M. the vessel proceeded towards Samboangan, anchoring off that town at 8.50 P.M. in 17 fathoms, with the lighthouse N. 49° E., summit of Sibago Island S. 65° 20′ E., Apex Cocos Island S. 49° 20′ E., Mount Matanal S. 40° E., L.T. Santa Cruz Island S. 3° E., right extremity of Chica S. 65° 40′ W.

The chart of Basilan Strait is by no means as correct as it should be, for it was found that bearings or angles taken to objects on the south shore placed the ship in a different position from those taken to objects on the north shore. The height of Tulnalutan Island was found to be 260 feet, Malanipa 360 feet, and Sacol Island 720 feet.

The Expedition obtained, in the eastern part of the Celebes Sea, in addition to the two soundings above referred to in 2150 and 2600 fathoms, another sounding in 2050 fathoms in the following February. The serial temperature observations showed that the water had the same temperature at 700 fathoms as at the bottom, which indicates that this sea is cut off from general oceanic circulation by a ridge about that height.

The deposits at the depths just mentioned contained only very slight traces of carbonate of lime, and microscopic examination showed an absence of the shells of pelagic Foraminifera, but in a sounding of 255 fathoms there were many of these shells. Radiolaria were numerous in all the deposits, but the great bulk of the mud was composed of broken-down fragments of pumice and clayey matter. The deeper layers were compact and of a blue colour, while the surface layer was oozy and reddish brown.

In passing through the Celebes Sea calm weather was generally experienced, and boats were lowered while sounding to enable the naturalists to make observations. Several species of Oscillatoriæ were very abundant, and when the sea was examined through a water-glass these minute algæ caused it to look as if filled with chopped hay. On the surface of the sea there were also an immense number of small spheres of gelatinous matter about the size of a pea, in which no structure could be observed; probably the jelly masses of some Diatoms, in which were entangled Coccospheres, Rhabdospheres, Radiolarians, and the threads of *Trichodesmium*. The tow-nets when hauled in were covered with a sticky substance resembling thin glue, due to the presence of these little globular masses. The tow-nets when sunk and dragged at a depth contained a much greater variety of organisms and less of the jelly-like matter and fewer Oscillatoriæ, so that very probably these last were confined chiefly to the immediate surface layers. Globigerinas, Pulvinulinas, Orbulinas, and Pullenias were very numerous in the deeper hauls; some of the spines of the Globigerinas were very long and delicate, being eleven times the diameter of the shell in length.

The trawling in 2150 fathoms (Station 198) yielded several fragments of volcanic rock; some palm fruits, pieces of wood and bark, together with numerous animals among which were specimens of the rare deep-sea Fishes *Ipnops murrayi* (see p. 239) and *Typhlonus nasus*. There were several Starfish belonging to the families Brisingidæ and Archasteridæ, two families which are referred to as characteristic deep-sea forms in the following notes by Mr. W. Percy Sladen, F.L.S., who is at present engaged in the preparation of a Report on the Asteroidea collected during the Expedition:—

The Asteroidea.—"As the Starfishes are a group of animals universally distributed throughout the whole of the marine portion of the globe, and inhabit alike the shallow waters of the coast and the abyssal depths of the ocean, the collection made during such a cruise as that of the Challenger is necessarily a very large one. It is also, unquestionably, the most important addition which has ever been made to our knowledge of the group, both from a geographical and a zoological point of view. That such should be the case is not very surprising when it is borne in mind how little was previously known about deep-water Asterids, or even about those inhabiting very moderate depths, excepting only the limited areas of the Atlantic, north of the Equator, which have been systematically investigated by European and American naturalists within the past twenty years.

"The Challenger has contributed to the previous lists of Asterid species upwards of one hundred and fifty forms new to science; and twenty-eight new genera have been established. A few remarks upon the most interesting of these types and upon their habitats will in the meantime be acceptable to the naturalist.

"In all the great ocean depths below 1000 fathoms the characteristic forms are genera belonging to the Pterasteridæ, Brisingidæ, Archasteridæ, and Porcellanasteridæ; a few genera referable to the Astropectinidæ proper also occur; and the Echinasteridæ and Goniasteridæ are still more feebly represented.

"Twenty-six genera of Starfishes have been found living in depths greater than 1000 fathoms, and all but eight of these were discovered by the Challenger.

"In the abyssal depths beneath this limit in the Atlantic the Archasteridæ predominate; in the Pacific, on the other hand, the Pterasteridæ and Porcellanasteridæ are the most conspicuously represented; whilst the Asterid fauna of the great Southern Ocean holds somewhat of an intermediate character between the two.

"In the Atlantic the Pterasteridæ are represented by the genus *Hymenaster* (fig. 202), which in the South Atlantic at Station 325 descends to a depth of 2650 fathoms. At the

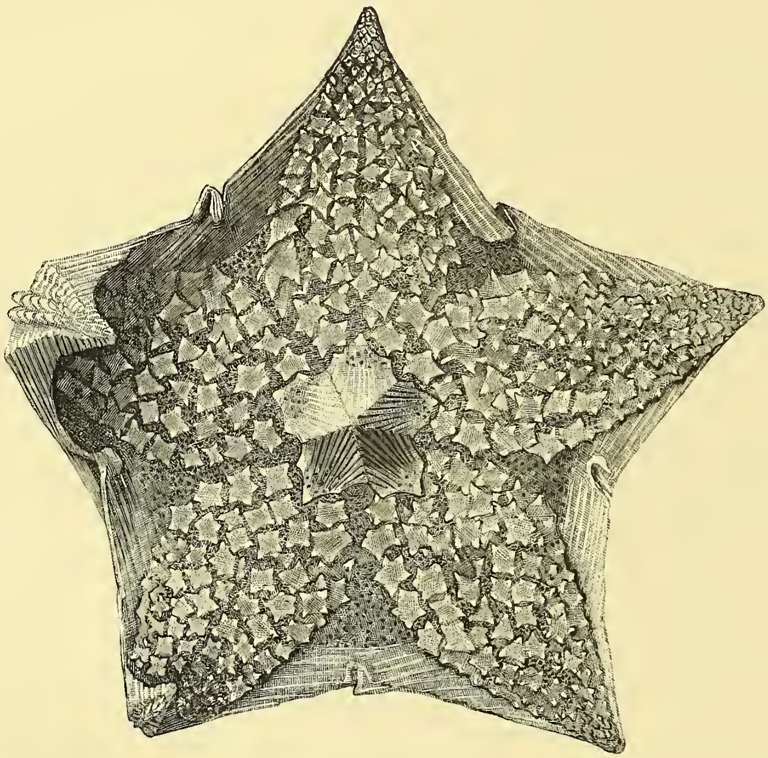


Fig. 202.—*Hymenaster sacculatus*, Sladen. Abactinal aspect. Slightly enlarged.

same Station was dredged the genus *Dytaster*, an Archasterid type with a more or less inflated disk, and having very long attenuate rays, subcarinate along their median dorsal line, and very slightly flexible. The marginal plates, which form a square vertical wall, are granulated, and each plate of either series bears one thin, thorn-like spine. Abactinal area covered with small rounded scale-like plates, bearing pseudo-paxillæ which form a closely-packed covering, in which no order of arrangement is discernible. Papulæ distributed over the whole area. Actinal interradial areas well developed, with plates arranged in more or less definite columns. Armature of the adambulacral plates in longitudinal series parallel with the furrow; spinelets on the outer part of the plate usually granuliform. Actinostome widely expanded; large fleshy lip. Enormous compound madreporiform body. Numerous pedicellariæ, subvalvuliform, on abactinal surface and actinal interradial areas.

"A very remarkable and abnormal Asterid, the morphological structure of which would appear to justify its inclusion in the family Pterasteridæ, notwithstanding its very different habit, was found at Station 323, in 1900 fathoms. *Pythonaster* (fig. 203) is characterised by very elongate, flexible, subcarinate rays, which are slender and tapering outwardly, but considerably swollen or inflated at the base; this inflation being further emphasized by a well-defined constriction which extends along the interradial line up to the dorsocentral aperture. This aperture is closed by five triangular fan-like valves, as in *Hymenaster* and its allies. The rays and corresponding radial areas of the disk are covered with small regularly placed fasciculi of short spinelets; each fasciculus is enclosed in a membranous sac, and the whole arranged in regular obliquely transverse lines on either side of the median dorsal line, which pass along the side of the ray up to the adambulacral plates. The armature of the adambulacral plates forms transverse series, the spines being united by membrane into fan-like structures comparable to those in *Pteraster*.

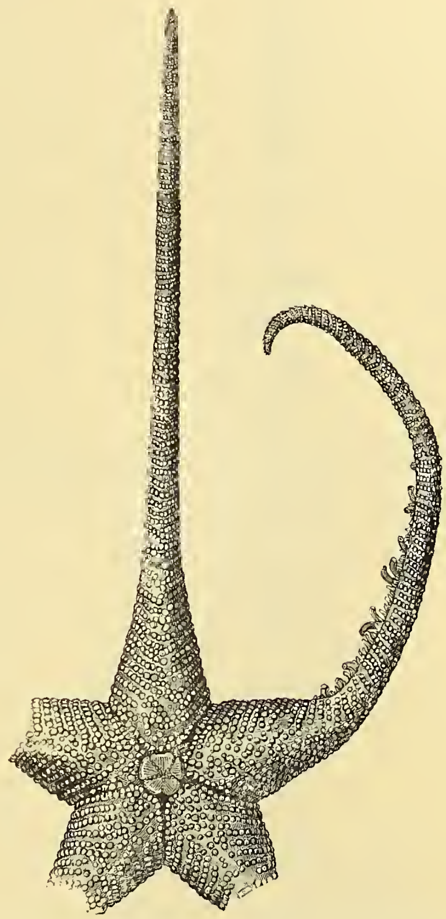


FIG. 203.—*Pythonaster murrayi*, Sladen. Abactinal aspect. Three fourths the natural size.

"*Brisinga* occurs both in the North and South Atlantic, and was dredged from a depth of 2400 fathoms at Station 89, where it was accompanied by the genera *Lonchotaster* and *Thoracaster*. The former is an Archasterid with some affinities to *Dytaster*. The rays however, are but slightly longer than the diameter of the disk, and are remarkably tapering, pointed, and subcylindrical, and, in the specimens preserved in spirit, are in every instance turned back over the abactinal area. The marginal plates are short and numerous, recalling those of *Leptoptychaster*, excepting that the superior series are well developed. The adambulacral plates have a compact and powerful armature; pedicellariæ are large and numerous, especially on the actinal interradial areas; and the madreporiform body is immense. *Thoracaster* is an aberrant member of the Porcellanasteridæ, having a large pentagonal disk and moderately long cylindrical rigid rays, which are entirely encased by the smooth marginal plates, the form of the ray bearing a fanciful resemblance to an elongated Belemnite.

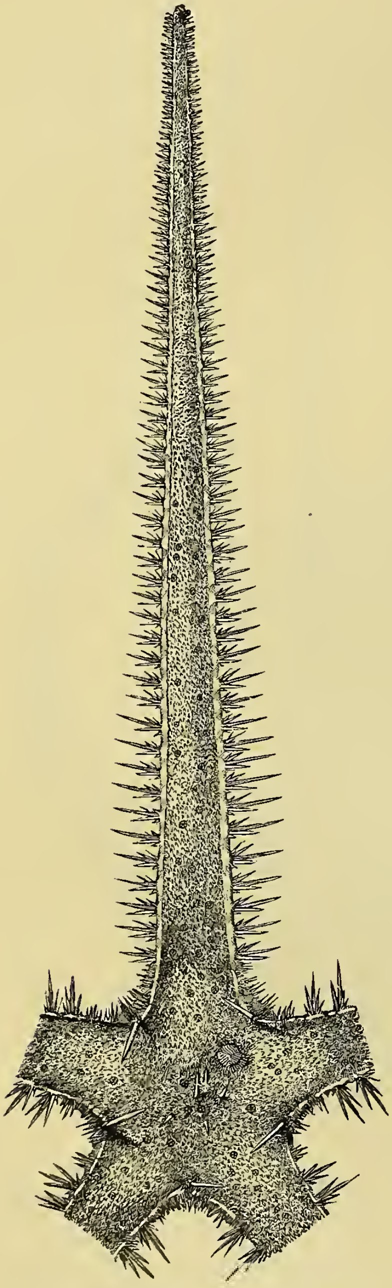


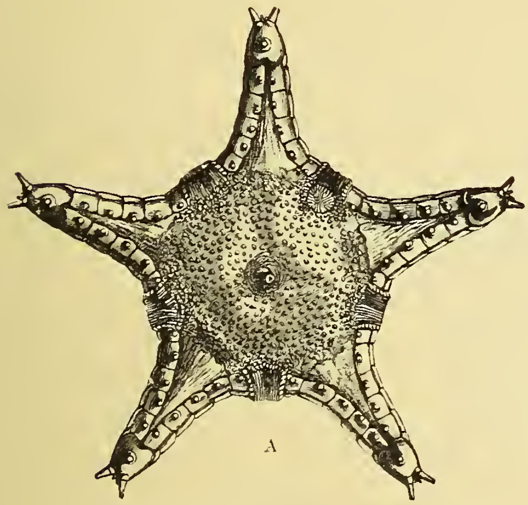
Fig. 204.—*Pararchaster pedicifer*, Sladen. Abactinal aspect. Natural size.

"In the deep water off the eastern coast of the United States, a very rich assemblage of forms was met with, Station 46 being especially remarkable for its varied Asterid fauna. Here at a depth of 1350 fathoms are *Brisinga*, *Cribrella*, *Zoroaster*, *Porcellanaster*, and the three Archasterid genera, *Pontaster*, *Pararchaster*, and *Plutonaster*. *Pontaster* is a genus established for the reception of *Archaster tenuispinus*, Düben and Koren, and its allied species, whose structure does not admit of their being classed along with *Archaster typicus*, Müller and Troschel, which by reason of priority naturally stands as the type of *Archaster*, *sensu stricto*.

"*Plutonaster* has a comparatively large flat disk, with elongate and more or less rigid rays. The marginal plates are broad, and form a well-rounded margin; both series are granulated, the superior being devoid of large spines, but the inferior may have one small more or less rudimentary spine. The abactinal area is covered with small closely packed pseudo-paxillæ; papulæ are distributed over the whole area, and the abactinal plates at the sides of the rays are arranged in oblique transverse series. The actinal interradial areas are large, with well-defined plates in regular columns, decreasing in breadth towards the margin. Armature of the adambulacral plates in longitudinal series, parallel with the furrow; several of the outer series usually granuliform. No pedicellariæ.

"*Pararchaster* (fig. 204) is a remarkable form with a small disk and very long, tapering, flexible rays. Marginal plates more or less suboval or subtriangular, elongate in the direction of the ray, and confined to the margin entirely; each with a prominent boss. The supero-marginal series with one long cylindro-conical spine, the infero-marginals with one or more similar spines. The general surface of the plates of both series is nominally naked, or only with minute isolated spiniform granules. A large odd interradial marginal plate present at the summit of the interbrachial angle, with prominent boss and very large spine. Abactinal area covered with squamiform plates, bearing one to three spicules (spinelets); no true paxillæ; no definite order of arrangement. Papulæ confined to the area at the base of the rays. Actinal interradial areas with very few ventral plates; in some cases apparently wanting altogether, but these may only be young forms. Armature of adambulacral plates consisting of a semicircular furrow series of small uniform spines, radiating fan-like, with one or more large, conical, outer spines. Madreporiform body close to the odd interradial plate. Peculiar comb-like pedicellariæ frequently present.

"Associated with the above-mentioned genera at Station 46 is an interesting little Starfish which appears to hold an intermediate position between *Ilyaster*, recently described by Danielssen and Koren, and such forms as *Bathybiaster* and *Psilaster*. It also occurs at Station 44 in 1700 fathoms. This genus, which is named *Phoxaster*, resembles in



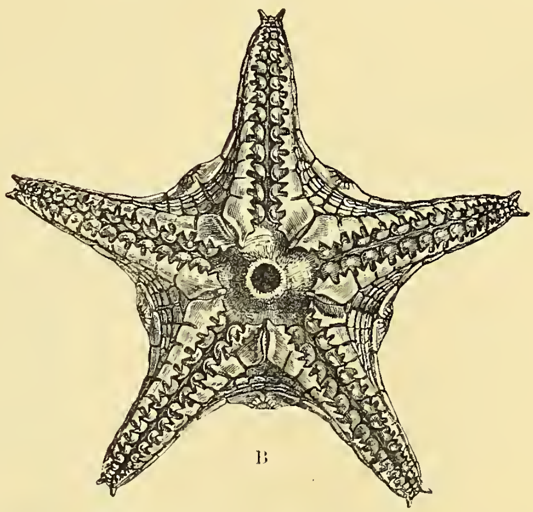


FIG 205.—*Porcellanaster cœruleus*, Wyv. Thoms. A, abactinal aspect; B, actinal aspect. Natural size.

miniature the outline of the northern species of *Psilaster*; the sides of the rays being, however, comparatively deeper and more vertical. The marginal plates are covered with uniform squamules and are devoid of any larger spinelets whatever. The actinal interradial areas are covered with squamiform spinelets encased in membrane, simulating those on the marginal plates. A well-defined dorsocentral protuberance or epiproctal cone is present, but by no means so specially developed as in *Ilyaster*. The character of the adambulacral armature is intermediate between that of *Ilyaster* and *Psilaster*.

"*Psilaster* is a genus which includes the well-known North Atlantic form originally described under the name of *Astropecten andromeda*, Müller and Troschel. The Challenger has discovered several allied species, but in the Atlantic none are found at so great a depth as 1000 fathoms.

"At Stations 44 and 45 *Dytaster* is associated with *Pontaster* and *Pararchaster;* at the former Station in company with *Phoxaster*, and at the latter with *Porcellanaster* (fig. 205). *Porcellanaster* is found in the South Atlantic between Tristan da Cunha and the Cape of Good Hope at a depth of 2550 fathoms (Station 137); and at Station 346, north of Ascension, at 2350 fathoms, is the very remarkable allied genus *Styracaster* (fig. 206). In this form the rays are long and attenuate, with the supero-marginal plates meeting in the median dorsal line so as to encase the ray, and bearing long robust cylindro-conical spines which form a single series along the median dorsal line. The actinal interradial areas are paved with thin smooth imbricated plates arranged in columns; and the ambulacral furrows are narrow and more or less enclosed.

"At Station 78, in a depth of 1000 fathoms, associated with *Pontaster*, is an elegant form, *Aphroditaster*, the type of a genus especially interesting on account of its intermediate character between the Archasteridæ and Goniasteridæ. The disk is rather small, with the rays elongate and tapering; and the interbrachial angle well-rounded. Marginal plates broad, forming a well-rounded margin; intermediate abactinal area narrow and sunken. Superior marginal plates with rounded granules, inferior series with small uniform conical, pointed, adpressed spinelets. No prominent spines on either series. Abactinal area with large oblong hexagonal paxillæ, the major axis in the direction of the axis of the ray; a conspicuous medio-radial series larger than the rest, each of these paxillæ being well spaced from its neighbours in the series. Papulæ regularly distributed. Abactinal plates arranged in lines parallel with the axis of the ray. Ventral areas small, plates with small conical-pointed spinelets similar to those on the infero-marginal plates. Armature of the adambulacral plates in two longitudinal series parallel with the furrow. A post-adambulacral series of plates present with fascioles (*sensu* A. Agassiz) at the margins obliquely transverse to the axis of the ray. Madreporiform body small. No pedicellariæ.

"At Stations 3 (1525 fathoms), 106 (1850 fathoms), and south of the Equator at Station 125 (1200 fathoms), were dredged representatives of a very handsome Goniasterid genus, *Nymphaster*. The disk is large and flat, with more or less elongate, slender, tapering rays, almost square in section. The marginal plates form a broad border to the disk, and may either unite along the median line of the ray or admit a single series of medio-radial plates. The marginal plates are granulated and bear no spines. The abactinal area of the disk is covered with large and regularly arranged hexagonal tabulated paxillæ, those in the radial area well separated, and each usually furnished with a sunken pedicellaria. Large entrenched pedicellariæ are frequently present on the marginal plates. Ventral plates well-defined, covered with uniform granules, and with occasional pedicellariæ. Adambulacral armature arranged in longitudinal series.

"At Station 73, at a depth of 1000 fathoms, in company with *Plutonaster*, is an interesting genus, *Glyptaster*, which seems to unite the characters of *Zoroaster* and *Stichaster*. *Glyptaster* has a small disk and comparatively long, subrigid, tapering rays. The disk

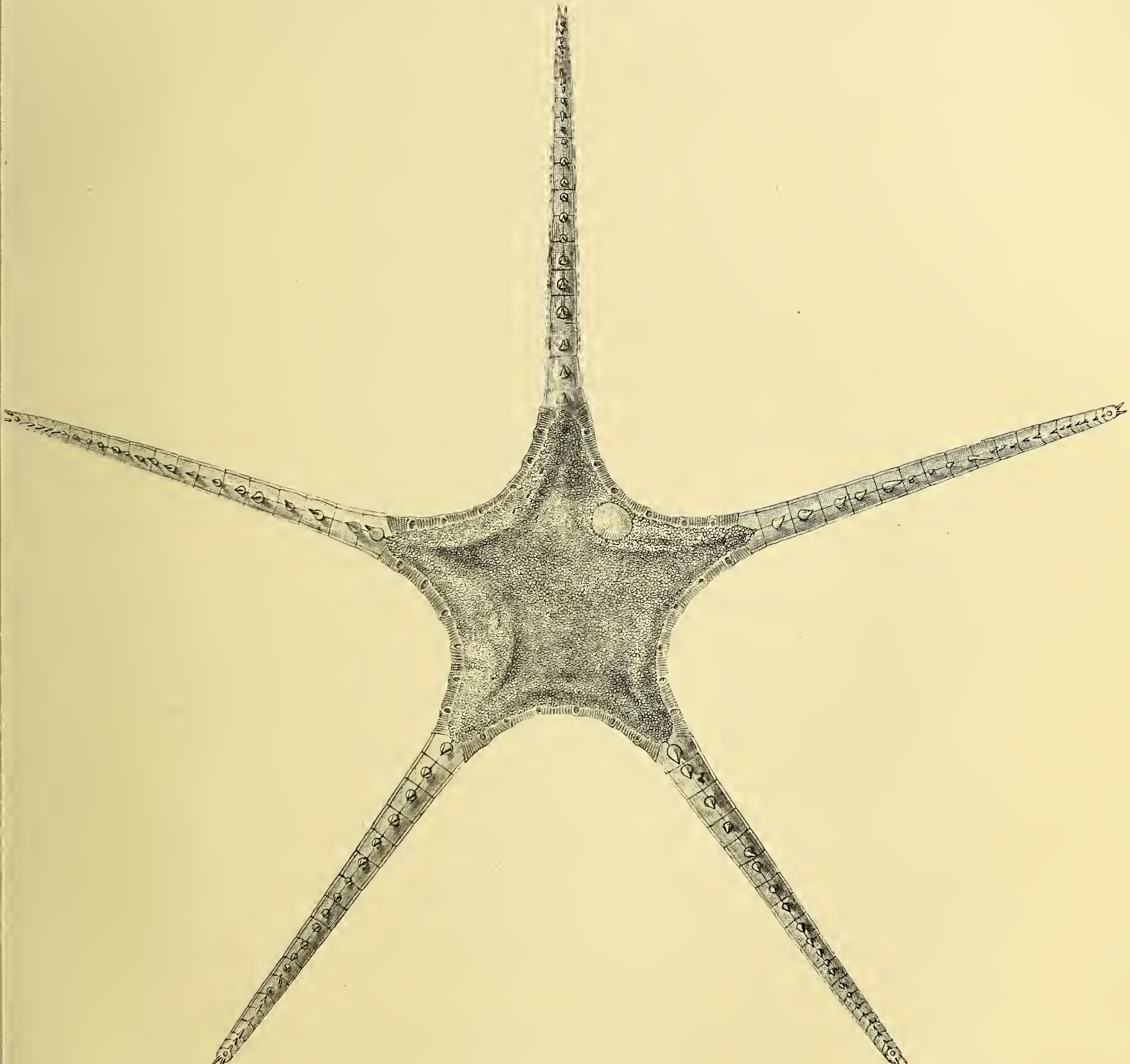


Fig. 206.—*Styracaster horridus*, Sladen. Abactinal aspect. Slightly enlarged.

is occupied with largely developed permanent primary plates, the regularly placed symmetrical interradials (basals), radials, and underbasals being especially prominent and conspicuous. The rays are covered with large, subhexagonal and slightly convex plates arranged in perfectly regular longitudinal lines, the plates diminishing regularly in size as they proceed outward, and those of the median line being the largest. The plates bear a few widely-spaced semicircular translucent granules, and a single large papula occurs in the interspace left at the angles of adjoining plates. Each adambulacral plate bears two short, thick, cylindrical spines, one directed towards the furrow and the other outward, which form two regular longitudinal series. External to the adambulacral plates is a complete longitudinal series of plates which bear two or rarely three spines placed side by side, and on the inner portion of the ray a few additional plates similarly armed form an incomplete pseudo-ventral series in large specimens. A few small pedicellariæ (forcipiform) are present on the lateral regions of the ray, and also, but less frequently, on the abactinal area in the neighbourhood of the papulæ.

"In the Southern Ocean the genus *Hymenaster* occurs in depths varying from 1375 to 1950 fathoms, and *Brisinga* also shows a similar bathymetrical range. Both were dredged at three Stations, but were associated only at one, Station 146 (1375 fathoms). *Pararchaster*, though likewise found at three Stations in depths varying from 1600 to 1900 fathoms, occurs in company with *Brisinga* only at Station 147 (1600 fathoms); and this genus is not found associated with the Pterasteridæ in any area. The allied genus *Pontaster* occurs at Station 146 along with *Hymenaster* and *Brisinga* above mentioned. The genus *Leptoptychaster* is associated with *Brisinga* at Station 156, south of the 60th parallel, at a depth of 1975 fathoms, and is accompanied by an interesting new form, remarkable for the way in which it appears to unite the characters of Echinasteridæ and Goniasteridæ mimetically. *Chitonaster* is a small stellate Asterid, with convex and inflated disk and short rigid rays. The abactinal surface of disk and rays with short thick isolated and well-spaced rigid conical truncate spinelets, each appearing as if standing perpendicularly on a hexagonal plate, the whole surface at the base of the spines being covered with membrane. A double series of marginal plates are present, likewise hidden in membrane, the inferior the larger, and each plate with three spinelets similar to those above described, forming a line transverse to the axis of the ray; the supero-marginal plates with one or two spinelets. The armature of the adambulacral plates consists of three isolated spines forming a line transverse to the furrow and similar to the other spines. Actinal interradial areas very small. No pedicellariæ.

"The Porcellanasteridæ are represented in the Southern Ocean only by a species of *Hyphalaster*, which occurs in company with *Hymenaster* at Station 157 at a depth of 1950 fathoms.

"In the Eastern or Malay Archipelago only six genera of Starfishes occur at depths greater than 1000 fathoms. In the area north of the Equator are *Brisinga* and *Pontaster*, associated together at depths of 1050 and 2150 fathoms; whilst south of the Equator are *Hymenaster*, *Benthaster*, and *Zoroaster* in company at 1070 fathoms; and *Brisinga* descends to a depth of 2440 fathoms.

"In the Pacific area the Pterasteridæ and the Porcellanasteridæ are the predominant forms in depths below 1000 fathoms. The first named family is represented by the genera *Marsipaster*, *Hymenaster*, and *Benthaster*. *Marsipaster* occurs in Mid South Pacific at Station 286 in 2335 fathoms, and nearer the South American continent at Station 299, between Juan Fernandez and Valparaiso, in 2160 fathoms. *Hymenaster* is found both in the North and South Pacific at depths ranging from 1500 to 2900 fathoms. The latter (Station 244), situated due west of Yokohama, near the meridian of 170° W. long., is the greatest depth at which Starfishes have as yet been obtained. Here at 2900 fathoms, in company with *Hymenaster*, are *Benthaster* and *Brisinga*. *Brisinga* also occurs in the North Pacific at depths of 1875 and 2300 fathoms (Stations 237 and 226 respectively), and south of the Equator, off Valparaiso, in 2550 fathoms.

"In the South Pacific the Archasteridæ are represented below 1000 fathoms only by *Dytaster*, and in the North Pacific by *Dytaster* and *Pararchaster*. Associated with the last named genus at Station 237 (1875 fathoms) is *Psilaster*, the only representative of the true Astropectinidæ below 1000 fathoms in the Pacific, and this its only occurrence. *Porcellanaster* and *Hyphalaster* are found at the same Station, and also *Brisinga* as mentioned above. *Porcellanaster* is associated with *Marsipaster* and *Hymenaster* in Mid South Pacific at Station 286 in 2335 fathoms; and is also found off Valparaiso in 2225 fathoms. *Hyphalaster* is found in Mid Pacific a little south of the Equator (Station 274) in 2750 fathoms, and off Valparaiso in 2160 fathoms. The allied genus *Styracaster* occurs at Station 224 at a depth of 1850 fathoms. Near the southern point of South America, at Station 303, at a depth of 1325 fathoms, are the northern genera *Lophaster*, *Mimaster*, and *Ctenodiscus*.

"Comparing now the Asterid fauna of the Atlantic, Southern, and Pacific Oceans respectively, including with the latter the Malay Archipelago, it will be found that of the twenty-six genera which live at depths below the 1000 fathom line, seventeen genera are represented in the Atlantic, seven in the Southern, and fifteen in the Pacific Ocean. Four only are common to the three areas, viz., *Hymenaster*, *Brisinga*, *Pontaster*, and *Pararchaster*. Four are common to the Atlantic and Pacific, but do not occur in the Southern Ocean, viz., *Zoroaster*, *Dytaster*, *Porcellanaster*, and *Styracaster*. One genus, *Hyphalaster*, is common to the Southern and Pacific Oceans.

"Seven genera are peculiar to the Atlantic, viz., *Pythonaster*, *Glyptaster*, *Aphroditaster*, *Plutonaster*, *Lonchotaster*, *Phoxaster*, and *Thoracaster*. One genus, *Chitonaster*, is peculiar to the Southern Ocean; and two, viz., *Marsipaster* and *Benthaster* are peculiar to the Pacific,—a number which appears very small in consequence of those genera being omitted from the category which have representatives in other areas at depths less than 1000 fathoms. The latter occurrences have, for the sake of brevity, not been referred to in the present notes.

"It may be remarked that the distribution of the deep-water Asterids fully supports the views already propounded by Mr. Murray that abyssal depths near to continents are more prolific in the number of genera and variety of forms than are similar depths in mid ocean remote from land.

"Mention only can be made here of the fact that a further and special interest attaches to the abyssal forms living under these conditions of isolation, on account of their furnishing a more striking presentment of archaic and permanent pseudembryonic characters than any other recent Asterids with which we have hitherto been acquainted.

"It is scarcely necessary to state that the importance of the collection is not confined to the deep-water Asterids only, as many valuable additions have been made to the fauna inhabiting much shallower waters than those referred to in the foregoing notes, and several interesting new genera have been discovered. Amongst these may be named *Pholidaster*, a form allied to *Zoroaster*, of which two species were dredged in the Malay Archipelago in depths between 100 and 130 fathoms. It differs from the latter genus in having peculiar naked primary plates on the disk and along the median radial line, margined by flat, skin-covered squamules; the other plates being covered with similar uniform squamules, and the ventro-laterals with regularly-disposed, small, delicate, elongate, and slightly flattened spinelets.

"*Peribolaster* is an interesting form obtained off the western coast of Patagonia at Station 304 in a depth of 45 fathoms. This Asterid is at first sight suggestive of a large species of *Korethraster*, but is readily distinguished by the reticulated abactinal skeleton, composed of cruciform ossicles; by the fasciculi, which upon the rays have seldom more than four spinelets in each, being enveloped in a membranous sheath; and by the immense madreporiform body.

"*Leptogonaster* is a handsome Goniasterid genus with large thin pentagonal disk, slightly inflated; and well produced flat tapering rays with a widely rounded interbrachial angle. The marginal plates form a bevelled angular margin, with three or four short conical spinelets at the line of junction of the superior and inferior series, in the curve of the angle, but decreasing in number outwards. The whole of the abactinal surface is granulated and the plates are marked out by very numerous papulæ. A few peculiar pincer-formed sessile pedicellariæ are found here and there on the surface. Actinal interradial areas covered with membrane through which the thin hexagonal plates are hardly visible; each of those in the series immediately behind the adambulacral plates bearing a large well-developed tubercle, which is greatly diminished in size or wholly wanting in the other plates of the area. The armature of the adambulacral plates consists of a semicircular furrow series of five or six radiating spines with one equal-sized pincer-formed pedicellaria at the adoral extremity of the series; and two large tubercles standing side by side within the area of the curve, simulating an outer series.

"*Paragonaster* is a form allied to *Nymphaster* and *Dorigona*, having a small pentagonal disk and elongate slender rays, the supero-marginal plates being separated from those of the opposite side of the ray by a single lineal series of regular quadrate plates, all uniformly granulated. The disk, which is slightly inflated in the radial areas, is covered with uniform hexagonal tabulated paxillæ. The adambulacral plates are broad, and bear on the margins at right angles to the furrow a number of small uniform spinelets directed towards the adjacent plate, forming a continuous series with the spinelets on the furrow margin of the plate, the latter being larger, flattened transversely, peculiarly curved, and arranged in a semicircle, radiating apart. Within this marginally disposed armature, whose base line forms a parabolic curve, a transverse line of three or four isolated conical spinelets traverses the breadth of the plate. This form comes from the Malay Archipelago, Station 192, depth 129 fathoms.

"An interesting link in addition to that already mentioned between the Archasteridæ and Goniasteridæ is furnished by the genus *Pseudarchaster*. This Starfish has a rather large, slightly inflated, disk; and moderately long, tapering, almost rigid rays; with the interbrachial angles well-rounded. The marginal plates form a well-rounded margin; both series covered with granules, those on the inferior plates with a tendency to become squamiform. No prominent spines on either series. Abactinal area with uniform substellate plates, bearing an oblong prominence, whose major axis lies parallel with the axis of the ray, covered with a compact paxilliform spinulation or granulation. A medio-radial line of plates distinguishable; plates arranged in longitudinal series along the rays; papulæ regularly distributed. Actinal interradial areas well developed. Armature of the adambulacral plates palmo-radiate; the outer portion more or less irregularly grouped. Madreporiform body small. No pedicellariæ. Species of *Pseudarchaster* occur in localities so widely separated as Station 49 off the coast of the United States, Simon's Bay, Cape of Good Hope, and Station 307 off the west coast of Patagonia. The greatest depth is 147 fathoms, at the last Station.

"Amongst the general results deducible from the data furnished by the Challenger Asteroidea not the least noteworthy will be found to be the indication of the existence of a number of remarkable local groups, or associations of forms, reciprocally representative of others which occur in widely distant areas. The enumeration of these and various other topics of special interest to the systematic zoologist would occupy more space than is consistent with the present sketch. Such observations will be discussed in the forthcoming detailed Report on the group."

Samboangan to Ilo Ilo.

As the Expedition visited Samboangan again in February 1875, an account of the place is deferred until that portion of the Narrative is reached (see p. 655).

On the 26th October, at 6 A.M., the ship left Samboangan for Ilo Ilo. After passing through Basilan Strait, trawling and sounding operations were carried on for a few hours at its western entrance. On leaving as on entering this strait it was found that the bearings taken from the ship disagreed in fixing the position on the chart. A re-survey of this part of the Philippine Islands would be appreciated by the navigator.

On the 27th, at 9 A.M., a sounding and temperatures were taken in the Sulu Sea in 2550 fathoms (see Sheet 31). The temperature observations here showed that this sea was cut off at the depth of 400 fathoms from the surrounding waters, the temperature being 50°·5 at all depths beneath 400 fathoms. A similar result was obtained in the following January a little to the south of this position, where a depth of 2225 fathoms was obtained. At 10 P.M. Negros Island was seen on the starboard bow, and at midnight its extremities bore N.E. $\frac{1}{2}$ N. and E. $\frac{1}{2}$ S.

On the 28th, at daylight, Mount Malaspina bore N. 67° E., and Point Sojoton S. 85° E., showing a set of 10 miles N.W. by N. since noon yesterday. From this position the ship was steered towards Bondulan Point, and at a little before noon stopped, intending to obtain a haul of the trawl if the water were shallow, but finding no bottom with 270 fathoms of line, the vessel proceeded towards Ilo Ilo, steering in with Bondulan Point N.E. $\frac{3}{4}$ N., until the clump of trees on the north side of Ilo Ilo was distinguished, when, keeping them half their own breadth open of the point, soundings of from 10 to 6$\frac{1}{2}$ fathoms were obtained, between Port Santa Ana, and the point next south of Point Cabalic; after which deep water was found until opposite the Sandy Bay, one-third the distance from Cabalic to Bondulan Point; when, edging out a little towards the cathedral (a large building with two towers on its northwest side), the fort was brought open of Bondulan Point, which was rounded with Point Dedap in line with the southwest angle of the fort; then, steering for the anchorage, the ship came to in 10 fathoms, off the spit on which the fort stands, with the southeast angle of the fort S. 75° W., and the right extremity of the spit N. 2° W., a cable's length from the shore.

The surface nets yielded some rich hauls in the Sulu Sea, Amphipods being especially abundant. The Rev. T. R. R. Stebbing, who is preparing a Report on the Amphipoda, gives the following notes:—

The Amphipoda.—" In this group the Expedition has brought to light a large number of new species. This remark applies especially to the Amphipoda Gammarina, for the Hyperina, which are very numerous, have not yet been examined with the care required to determine whether the species are for the most part new or chiefly such as are already known. The Caprellina, though few in number, contain the notable new genus *Dodecas*, which is unlike all the other genera of Caprellidæ in the number of the feet attached to the peræon or thorax; of these there are six pairs. Those of the fourth segment are wanting, while those of the fifth segment are rudimentary, and those of the third but feebly developed. In the arrangement of the Caprellidæ, according to the scale of completeness with which their thorax-feet are developed,[1] *Dodecas* will obviously stand after *Proto* with its seven pairs fully developed and *Protella* with its five complete and two rudimentary pairs. It will as obviously stand before *Caprellina* (G. M. Thomson's genus, not to be confused with the divisional name above given) and *Podalirius*, which have four well-developed pairs and one rudimentary. But whether it should stand before or after *Cercops, Ægina, Æginella,* and *Caprella*, each of which has five fully-developed pairs of feet, though those of the third and fourth segments are wanting altogether, is a question that may require some consideration and debate. By having more than two joints in the flagellum of its lower antennæ, it will stand with *Proto* and *Caprellina* apart from the rest of the group, and again, on a third principle of classification, by the presence of a mandibular palp and of branchiæ on the second, third, and fourth segments of the peræon, it will be united with *Proto, Caprellina,* and *Cercops.*

"Like the Caprellidæ in general, the new species *Dodecas elongata* is very slenderly built, in thickness resembling a thread or piece of fine twine. It attains, however, the exceptional length of 3 inches, half of that measurement being constituted by the hind legs and the long upper antennæ.

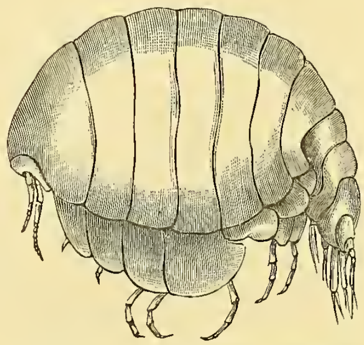


FIG. 207.—*Andania gigantea*, Stebbing.

"In contrast with the tenuity of the species just mentioned we have the dimensions of *Andania gigantea* here figured of the natural size (see fig. 207). Two specimens of this bulky Amphipod were obtained between 46° and 47° south latitude, the larger at a depth of 1375 fathoms, the smaller some 200 miles from the other at a depth of 1600 fathoms. Two other species of *Andania* have been brought home by the Challenger, one of them from lat. 8° 37′ S., long. 34° 28′ W., where the depth was 675 fathoms; the other, from lat. 40° 28′ S., long. 177° 43′ E., where the depth was 1100 fathoms. The three species of the genus hitherto known are the type species *Andania abyssi*, A. Boeck, *Andania nordlandica*, A. Boeck, and *Andania pectinata*, G. O. Sars. The specific name of the type species would have better suited one of those from the southern waters. Looking to the various places of capture, it would seem that the genus is suited for life at very considerable depths. In point of size the members of it exhibit great variations, since *Andania gigantea* is one of the largest of the known Amphipods, while the three

[1] Mayer, Dr. P., Fauna u. Flora d. Golfes v. Neapel, vi., Die Caprelliden, p. 8, Leipzig, 1882.

northern species have a length ranging between a tenth and a quarter of an inch; at the same time the species at the two extremes of size are by no means dissimilar in general appearance. Among the Gammarina very few, and among the Caprellina none, are reported from very great depths. In the deep waters explored over a vast tract of the Pacific Ocean from Japan to Juan Fernandez the record for these tribes is almost a complete blank. Nevertheless it should not be hastily inferred that the creatures themselves are wanting in those localities, simply because sixty or seventy dips of the dredge over a course of many thousands of miles have not brought any to the surface. A collector exploring some small fraction of coast round his own home takes a species on a single occasion, and with repeated researches in the same locality does not find it again for years. He finds also that species abundant at one part of the year or in one locality of his district are not to be met with at all in the same place at other parts of the year or in other than the special locality at any part of the year. With this experience he will be little inclined to yield to the negative evidence as showing that the floor of the ocean even at its greatest depths is barren of any particular tribe of Amphipods. He will reflect that in the Southern Ocean a haul of the dredge from 1375 fathoms below the surface brought up a single specimen of a single species of the Gammarina, and that 200 miles away another haul from a still greater depth brought up another solitary specimen of the same species. The securing of these two specimens can be explained on the not very probable hypothesis that numbers of the species are distributed over the area where they were taken, so that dredging there was more likely to find them than not, or it may be explained on the more probable hypothesis of a lucky coincidence. Had the dredge often brought up Crustaceans of this division from great depths, the inference would scarcely have been a hasty one that there was an enormous population of them in the abysses of the sea; as it very rarely brought them up, not indeed from the greatest depths, but from waters which not so long ago would have been thought extraordinarily profound for the existence of life at all, it may be at least suspected that no depth is necessarily out of their reach, and no large region of the ocean necessarily, from present evidence, out of their range. From a general point of view, and as showing the danger of arguing non-existence from non-appearance, it may be noticed that, whereas the Amphipodan fauna described from Kerguelen Island and its neighbourhood has hitherto been very scanty, it is this locality that has yielded more than any other searched by the Challenger. The dredgings indeed here were very numerous, and in shallow water; but the question may still remain open whether similarly restricted areas of the Pacific at depths between 2000 and 3000 fathoms might not, if they could be explored with similar minuteness, produce at any rate a few representatives of the divisions of Amphipoda now under discussion.

"In the large number of new species collected, none are very eccentric in difference of form from those already known. One of the most striking for its outward armature is

Acanthozone tricarinata, shown in fig. 208, enlarged. How far the present distribution into genera can be maintained under the light thrown on the subject by the details of structure found in new forms, will have to be discussed in the detailed Report. Meanwhile it is interesting to observe that wherever the species have been dredged, either in localities or at depths not previously explored, such species are almost invariably found to be new ones. Species living at or near the surface of the ocean, and not therefore requiring to be taken with the dredge, are, as might be expected, widely distributed. Some that occupy very moderate depths are found to be identical or scarcely distinguishable in

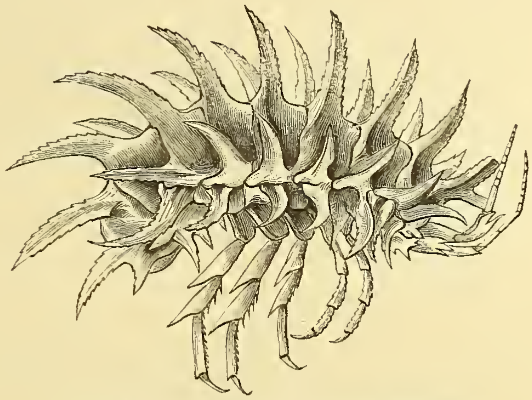


FIG. 208.—*Acanthozone tricarinata*, Stebbing.

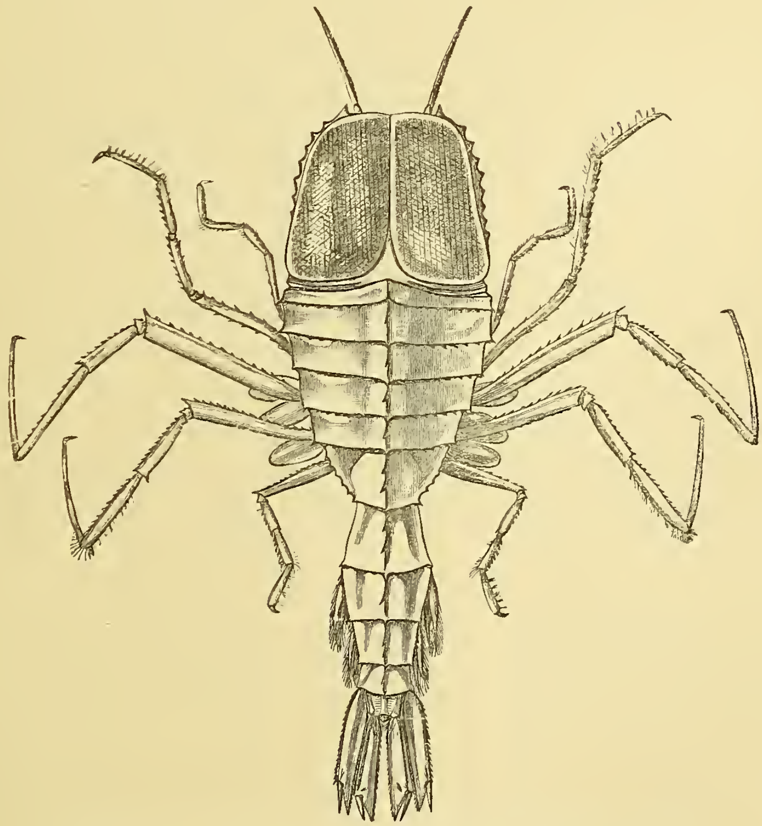


FIG. 209.—*Cystosoma neptuni* (Guérin-Méneville), Suhm ; slightly reduced.

form at the most widely separated localities, and it is possible that occasionally some specimens while living may have a free passage from one extremity of the world to the other on the very exploring vessel which eventually brings them back round half the globe preserved in spirit for home inspection.

"It would not be proper to conclude this brief abstract without calling attention to the fine *Cystosoma* figured and described *en route* by the late Dr. v. Willemoes-Suhm [1] (see fig. 209), a specimen which, if colour be put out of the question, surpasses in beauty, as also it probably exceeds in size, every other known Amphipod."

Ilo Ilo.

Ilo Ilo is situated on the island of Panay, one of the most fertile and densely populated isles of the Philippine group. Well irrigated by abundant mountain streams, it produces rice, sugar cane, cotton, coffee, tobacco, pepper, and cocoa; its forests yield ebony, and its shores and rivers abound with fish; the chief town of the island, Ilo Ilo, is, therefore, an important commercial emporium, and from it a brisk coasting trade is carried on. In Ilo Ilo there is also the largest manufactory of piña, a fabric made of thread stripped from fibres of the leaves of the pine-apple. This fabric cannot be woven at all times, as extreme heat or humidity affects the fibre; it is stronger than any other of equal fineness, and its colour is unaffected by time or washing. The machinery employed in its manufacture is of rude construction and entirely of wood. The use of piña is extensive, and the value of the annual export to Europe for dresses, handkerchiefs, collars, scarfs, and finely embroidered shirts is considerable.

The harbour of Ilo Ilo is formed by a narrow strait separating the island of Guimaras from that of Panay; a small river runs into the strait on the Panay shore, which has a low sandy flat on its right bank on which the town stands; at the end of this flat is a spit, on which a fort is built, and close to which there is deep water. Vessels of moderate draught (16 feet and under) may ascend the river a short distance and lie alongside wharves which communicate with the merchants' storehouses, but large vessels should anchor off the fort.

Strong tides run through Ilo Ilo Strait, forming numerous eddies and causing vessels to sheer considerably. At its full strength the tide ran 3 miles per hour, but a patent log registered only 10·25 miles as the total distance traversed by one tide of six hours' duration. The stream turns at high and low water by the shore. The eddies appeared to be fewest off the mouth of the Ilo Ilo river; this, therefore, would be a good place for a ship to anchor. Coal may be obtained in small quantities at this port; other supplies are plentiful and moderate in price.

[1] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, vol. i. p. 24, 1875.

Ilo Ilo to Manila.

On the 31st October, at 6 A.M., the ship left Ilo Ilo for Manila, proceeding to the northwards by the coasting steamer route, through the channel north of Yguana Shoal with the Siete Pecados on a W. $\frac{1}{4}$ N. bearing, 27 feet being the least depth of water obtained at low tide.

After clearing the Yguana Bank the ship proceeded to the northwestward towards Tagubanhan Island, off which a trawling was obtained in 20 fathoms, and then anchored for the night at 5.40 P.M. in 10 fathoms, with the right extremity of Tagubanhan north, Anauayan Island south, and the left extremity of Tagubanhan S. 53° W.

Mount Oroc and Mount Saligit are both low hills, about 300 feet high; Mount Colan is a long flat hill about 200 feet high, Mount Parapari is about 2000 feet high, and from it a range of hills stretches to the northeast; Ylacaon Island is about 180 feet high, and Tagubanhan about 1000 feet.

On the 1st November, at 6 A.M., the vessel left the anchorage under Tagubanhan Island and proceeded towards Baliguian Island, which was passed at 8 A.M., after which it was kept on a south bearing until Sicogon Island was rounded, when a course was shaped for the channel between Tulunanaun and Balbagan. At 1 P.M., when the left extremity of North Gigantes Island bore N. 59° E., the right extremity of Lulugban N. 59° W., and the left extremity of Tulunanaun S. 13° W., soundings of 28 feet, hard ground, were obtained, and the engines eased to slow speed, as the ship was then steaming northwest, to avoid the $2\frac{3}{4}$ fathom patch off Lulugban Island. Soundings of from 28 feet to 7 fathoms were obtained until the west point of Lulugban Island bore S. 20° W., and the north point of North Gigantes N. 78° E. and Manigonigo S. 84° W., when the depth increased to 13 fathoms, and the ship proceeded toward Zapata Mayor. Rounding the Zapata Islands at 5 P.M., a course was shaped N.W. by W. $\frac{1}{2}$ W. towards the channel between Tablas and Romblon Islands, and sail made to a light breeze from the northeastward.

Tulunanaun Island has a hill on its north extremity about 200 feet high, Balbagan and Lulugban Islands are about 100 feet high, and Culebra about 200 feet. The channels between Ilo Ilo and the Zapata Islands require to be used with caution until they have been surveyed in detail. There are several shoals shown on the small scale chart of the Mindoro Sea in these channels, and doubtless more exist. Vessels of large draught would do well to take the passage north of the Gigantes Islands rather than that between Tulunanaun and Balbagan Islands.

On the 2nd, at daylight, the left extremity of Sibuyan Island bore N.E. $\frac{3}{4}$ E., the right extremity N.E. by E. $\frac{1}{2}$ E., and the left extremity of Romblon N. $\frac{1}{2}$ W., showing a set of 10 miles W.S.W. during the night. From this position the ship steamed towards the channel between Tablas and Romblon, sounding at 10 A.M. in 705 fathoms, with the left extremity of Sibuyan Island S. 67° E., Apunan Point N. 79° E., the left extremity of Cobrador Island N. 2° W., and Mount Cabezo de Tablas N. 28° W., afterwards steaming through the channel. At 2 P.M. a trawling was obtained in 100 fathoms, with the rock off the north end of Tablas Island S. 51° W., the right extremity of Banton Island N. 13° W., and the left extremity of Cobrador S. 62° E., and at 3.45 P.M., in 115 fathoms, with the left extremity of Simara Island N. 74° W., the right extremity of Banton Island N. 17° W., and the left extremity of Cobrador S. $46\frac{1}{2}$° E. (see Sheet 31). At 5.30 P.M. the ship proceeded for the channel between Simara and Banton Islands, after passing which the course was altered for the channel between Banton and Bantoncillo, and then to the southward of Dos Hermanos, after passing which the course lay along the northeast shore of Mindoro for Verde Island. A number of fishing lights were noticed on the shore of Simara and Banton Islands as they were passed.

On the 3rd, at 2 A.M., a breeze springing up from the N.N.E. allowed of sail being made, and the engines stopped. The wind gradually drew aft as Verde Island was neared, and continued well to the eastward until the strait had been cleared at 7 P.M. At 11 P.M. the light on Corregidor Island, at the entrance of Manila Bay, was sighted.

The bearings of the points on Mindoro Island did not agree very well with those on Luzon. Considering, however, the small scale of the charts between Cape York, Australia, and Manila, and the few surveys that have been made, it is wonderful how accurately the position of the numerous islands are laid down, and although, doubtless, much is required to perfect the knowledge of these parts, he would be a very poor navigator who could not with their aid, and a little extra care in lookouts, traverse these seas with confidence.

On the 4th November, at 1 A.M., the ship passed Fortune Island, and proceeded north of Corregidor Island for Manila, anchoring there at 2.45 P.M. in $4\frac{1}{4}$ fathoms.

Between Ilo Ilo and Manila the trawlings in 15, 100, and 115 fathoms were moderately productive, yielding among other things a considerable number of Mollusca. Mr. Edgar A. Smith, F.L.S., of the British Museum, has furnished the following notes on the Lamellibranchiata, on which group he is engaged in preparing a Report :—

The Lamellibranchiata.—"The collection of Bivalve Mollusca brought home by the Challenger is in some respects disappointing. Considering the appliances with which the vessel was furnished, and the able staff of scientific men on board, and the number of dredging Stations, it certainly does seem surprising that scarcely more than five hundred different species of Lamellibranchs should have been obtained. Then again this comparatively small number in very many, indeed I think I may say in the majority, of instances, is only poorly represented in specimens, of dozens of the species there being but single or a few odd valves, many in a bad state of preservation. This comparative paucity[1] of species is probably attributable to the scarcity of Molluscan life at great depths, for the chief part of the collection consists of species from rather shallow water, Torres Strait, the Arafura Sea, Port Jackson, and Kerguelen Island supplying a large number of species. At only about 100 out of the 282 Stations investigated were Lamellibranchs obtained, and 2900 fathoms (Station 244, in Mid North Pacific) was the greatest depth at which any species was found living.

"The single form from this spot is a small fragile shell which I have named *Callocardia pacifica*, and it is a very remarkable fact that a second species (*Callocardia atlantica*) was also brought up from a depth of 1000 fathoms off the Azores, which is all but identical with the Pacific shell. The habitats of these two species, although so remote, are almost on the same parallels. A third species of this genus (*Callocardia*

[1] The nearly exclusive use of the trawl in deep water may, possibly, to some extent account for the paucity of Deep Sea Molluscs obtained by the Expedition.—J. M.

adamsii, see fig. 210) was also obtained at a great depth (2450 fathoms) in the Atlantic, southwest of Sierra Leone. Yet this genus does not always dwell in such deep water, for the typical species (*Callocardia guttata*) was dredged by Arthur Adams off Quelpart, south of the Korea, at a depth of only 48 fathoms. As might be expected, the deep-water forms present no colour-markings, but in *Callocardia guttata* a few pale orange spots are scattered over the surface.

It is a curious fact, that, as far as the collection of Lamellibranchs has been studied, although the number of new species is very considerable, only a single new generic form has been discovered. This is contrary to one's expectations, and even among the few species dredged at depths exceeding 2000 fathoms I do not find one which we might not have expected from 100 fathoms or less. The new genus *Silenia* was obtained from 2650 fathoms, two Arcas from 2050 and 2150 fathoms, a *Malletia* from 2550 fathoms, and a *Lima* from 2500 fathoms, genera of which species are already known from less than 100 fathoms, and indeed in the case of *Arca* and *Lima* from low-water mark. Although the genera have such a wide bathymetrical range, of course it does not follow

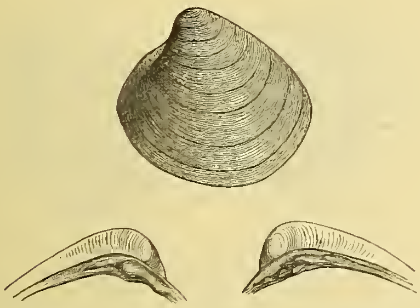


Fig. 210.—*Callocardia adamsii*, n. sp. Station 348, 2450 fathoms. Enlarged.

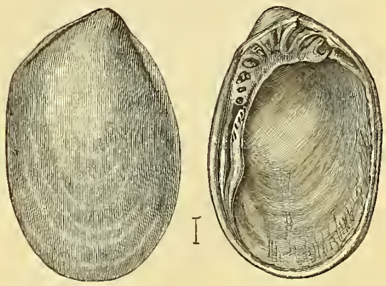


Fig. 211.—*Nuculina ovalis*, Searles Wood. Simon's Bay, Cape of Good Hope, 15 to 20 fathoms. Ten times the natural size.

that the species will always exhibit a similar distribution. In some cases, however, this is known to occur, and it will no doubt be discovered in many more. As an instance of this I may cite the well-known *Ervilia castanea*, which may be dredged in less than 50 fathoms off Great Britain and elsewhere. Specimens of this species were obtained by the Challenger in 450 and 1000 fathoms off the Azores, agreeing precisely with shells from shallow water, *Cryptodon flexuosus* and *Cryptodon croulinensis* respectively, from 450 fathoms and 1000 fathoms off the Azores may also be got in British seas in less than 50 fathoms. I was in hopes that certain types which at present are known only in a fossil state, might still have been found existing at great depths. The discovery of some of the remarkable forms of *Trigonia*, *Pholadomya*, and other genera which abound as fossils have been hoped for in vain. One interesting occurrence, however, of a species in a living state hitherto known only from the 'crag,' is worth recording. The little *Nuculinaovalis* of Searles Wood (see fig. 211) was brought up from a depth of only 15 to 20 fathoms in Simon's Bay off the Cape of Good Hope. This is not, however, the first record of the genus as recent, a species from the Catalina Islands and another from the Korean Straits having already been described.

"Judging from this collection, the conclusion may be drawn that forms from very deep water, as a rule, have thin shells and are devoid of colour. As an instance of this I may cite a very beautiful species of *Modiola* from Stations 191 and 207. The specimens from the first locality, dredged in 800 fathoms, besides being very fragile, are totally white, those from Station 207, from 700 fathoms, being faintly tinged with olive on one side, showing a return to the usual olive or brownish tint which mostly prevails in species of this genus. Among the prizes of the Expedition are one or two very beautiful forms of *Amussium* from depths exceeding 1000 fathoms. Unlike the type of the genus, *Amussium pleuronectes*, these are excessively thin, semitransparent, and

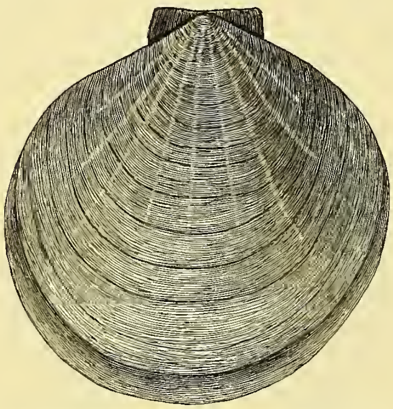


Fig. 212.—*Amussium watsoni*, n. sp. Station 218, 1070 fathoms. Natural size.

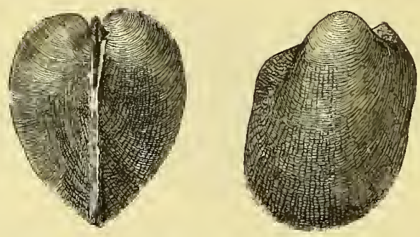


Fig. 213.—*Arca corpulenta*, n. sp. Station 184; 1400 fathoms; Station 194, 200 to 360 fathoms; Station 198, 2150 fathoms; Station 216A, 2000 fathoms; Station 271, 2425 fathoms; Station 300, 1375 fathoms. Natural size.

destitute of colour, but a species dredged off the Philippine Islands in 375 fathoms, although equally fragile, has the central portion of the valves of an orange tint. Among the species of *Arca* are a few from very great depths which have comparatively thin shells, but which maintain the fibrous character and usual colour of the epidermis prevailing in many well-known forms found in shallow water.

"From the above notes it will therefore be seen that the abyssal fauna of the ocean, so far as the Lamellibranchiata are concerned, does not apparently (judging from the Challenger collection) differ greatly in the known generic types from that of shallower seas. The species met with in very deep water may have been gradually modified from those living nearer shore, and become scarcer through inhabiting regions where food is less abundant and the general conditions of existence less favourable."

Manila.

Manila, the capital of the Philippine Islands, and the most ancient European town in the East after Goa, has been so much visited and so well described that it is unnecessary to say much respecting it.

The Jesuit fathers at Manila were kind enough to furnish a copy of the meteorological results, taken at their well-known magnetic, meteorological, and seismographic observatory, from which the following table, showing the climate, has been compiled :—

Meteorological Table compiled from observations made at the Jesuits' College, Manila, from 1866 to 1871 inclusive. Position of observing station, lat. 14° 35′ 58″ N., long. 120° 58′ E. Barometer reduced to 32° and sea level.

Month.	Barometer.		Mean Temp. in shade.	Mean Range of Temp.	Max. Temp. in shade registered.	Min. Temp. in shade registered.	Clouds —0 to 10. Mean Amount.	Rain.		Wind.											No. of days Gales.	No. of days Fogs.
	Mean Height.	Ext. Range.						Total fall.	No. of days.	Av. Hourly velocity.	No. of days from										
											N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	C'lm		
	ins.	ins.	°	°	°	°		inches.													
January,	29·892	0·54	79·2	14·9	92	61		1·32	7	5·6	6	5	5	2	1	2	4	3	3		
February,	29·897	0·40	80·3	16·2	94	63		0·40	2	5·5	3	5	6	3	1	2	4	1	3		
March,	29·873	0·30	83·4	16·8	96	61		0·39	2	7·4	1	5	9	4	1	3	4	2	2		
April,	29·827	0·37	86·0	16·9	100	68		0·66	3	7·5	1	4	8	6	1	2	4	2	2		
May,	29·822	0·38	85·6	16·2	97	68		3·62	10	7·1	2	3	5	6	2	6	4	2	1		
June,	29·782	0·44	83·7	13·9	97	66		11·74	16	7·3	2	2	5	5	2	7	3	2	2		
July,	29·780	0·38	81·7	12·5	92	68		11·73	20	6·6	3	3	3	2	3	8	3	3	3		
August,	29·748	0·41	82·1	13·1	92	67		13·00	21	9·0	3	2	2	3	3	11	3	2	2		
September,	29·743	0·50	81·6	13·2	91	67		22·70	23	9·0	2	2	2	2	2	10	4	3	3		
October,	29·788	0·45	80·3	14·1	93	63		11·60	18	6·1	5	4	3	2	2	6	3	2	4		
November,	29·810	0·60	80·1	14·3	92	61		6·65	12	5·5	8	5	3	1	1	3	3	5	1		
December,	29·855	0·44	78·9	16·0	90	54		1·55	10	5·9	9	5	4	2	1	2	2	3	3		
Means and Totals,	29·818	0·60	81·9	14·8	100	54·0		95·36	144	6·9	45	45	55	38	20	62	41	30	29		

Manila to Hong Kong.

On the 11th November, at 2.30 p.m., the ship left Manila for Hong Kong, passing Corregidor Island at 11 p.m., and proceeding to the northward along the coast of Luzon, sometimes under sail and sometimes under steam, the wind being variable with a nasty swell.

On the 13th, at 6 a.m., Mount St. Thomas (7000 feet high) bore S. 85° E., Mount Calvario S. 54° E., and Mount Piedra S. 74° E., showing a strong northerly set. At

9 A.M. a sounding, trawling, and temperatures were taken in 1050 fathoms, a strong northerly set being experienced the whole time. The temperature of the water decreased regularly from the surface to the bottom, or nearly to the bottom, showing that the China Sea was open to the influence of the Pacific to a depth of between 900 and 1000 fathoms (see Sheet 31 and Diagram 14). At 4 P.M. the trawl was hove up, and at 5 P.M. sail was made to a northeast breeze, which gradually freshened as the land disappeared.

The deposit at 1050 fathoms was a bluish coloured mud containing 20 per cent. of carbonate of lime, which was chiefly composed of the shells of pelagic organisms.

The trawl brought up several pieces of pumice and some leaves and palm fruits, to which a *Chiton*, a *Patella*, and a few worm tubes were attached. There were also two species of Macruridæ and many Echinoderms, among others *Cystechinus clypeatus*, A. Ag.; *Phormosoma luculentum*, A. Ag.; *Phormosoma bursarium*, A. Ag.; *Podocidaris prionigera*, A. Ag.; *Ophioglypha radiata*, Lyman; *Ophiomitra plicata*, Lyman; and many others.

The 14th and 15th were cloudy days, with a fresh northeast monsoon and strong southwesterly current; on the 15th the velocity of the current was a little over 2 miles per hour.

On the 16th, at 7 A.M., the land was observed ahead; at 8 A.M. the northeast head of Lema Island bore N. 2° W., Pountin Island N. 25° W., Peaked Rock N. 62° W., showing a current of 26 miles S. 37° W. since noon on the previous day. At 11 A.M. the ship passed through the Taitami Channel, and steering through the Lamma and Sulphur Channels, anchored at Hong Kong at 2.15 P.M.

There is one point in connection with the navigation of China waters that it may be as well to mention here, namely, that the numerous junks met with off the principal ports carry no lights, but on the approach of vessels burn a flare up light from the stern. They generally sail in couples, and are nearly all rigged in the same way, carrying two sails, the smaller one forward. These facts are, of course, well known to all seamen who traverse the China Sea, but may nevertheless be useful to the navigator who first makes his landfall on the China coast during the night.

In the surface nets on the 13th there were enormous numbers of Foraminifera and Radiolaria, the most abundant hauls of the former being procured when the net was sent down to 100 fathoms beneath the surface. In the same nets there were several fine specimens of *Alciope*, several new forms of which were obtained by the Expedition as stated in the following notes by Professor M'Intosh, F.R.S., whose Report on the Annelida collected by the Naturalists during the cruise is now being printed:—

The Annelida.—"The collection of Annelids procured by the Challenger is both extensive and valuable, and though many are fragmentary, it is to be recollected that the bristles and other parts form very reliable features in diagnosis. The total number of species is over three hundred, and they include representatives of almost every family.

"Amongst the pelagic forms the most conspicuous are the Alciopidæ, a group which seldom comes under the eye of the British zoologist, and which are so delicate that great care is necessary in preserving them. One of the best memoirs on these Annelids has recently been published by R. Greeff, and most of the forms collected by the Challenger agree generally in structure with those described by him. Two or three new forms however occur, one (*Alciope antarctica*) frequenting the surface of the Antarctic Ocean in company with *Cleodora*, and the others in the warmer waters near Honolulu. The first mentioned has its head formed almost wholly by its two great eyes, which project prominently outward in front of the constricted neck. Moreover, the corneæ of these eyes are invisible from the dorsum, being so placed that they look outward and downward. The anterior feet have the form of large globular processes. Another (*Alciope quadrioculata*) is characterised by the presence of four eyes, two occupying almost the entire central area of the head, with the corneæ directed outward, while two others, somewhat rudimentary, look outward, forward, and slightly downward. The third form (*Nauphanta*) with massive lateral lamellæ, somewhat resembles *Notophyllum*, one of the Phyllodocidæ, the head however bearing two great eyes with the corneæ directed outward.

"The presence of large eyes has hitherto been associated with the Alciopidæ, but the explorations of the Challenger have made us acquainted with a similar condition in a closely allied group, viz., the Phyllodocidæ. This new form (*Genetyllis oculata*), instead of being a surface form, frequents a depth of 500 fathoms near the Pacific entrance of the Celebes Sea, south of Mindanao. In the form of its body and the size of its eyes it resembles an *Alciope*. The eyes (fig. 214) occupy most of the head, only a small triangular space being left anteriorly and posteriorly. The large transparent corneæ look outward, downward, and forward, and are surrounded by a belt of brownish pigment. The minute anatomy of these organs, as well as those of the Alciopidæ, has been carefully investigated by Dr. Marcus Gunn, one of the oculists of the Moorfields Hospital, London, and he finds that the head is composed of little more than the eyes and a great median nerve-mass, with which the retinæ of both eyes are continuous. It is interesting that the *Ioida*-forms (sexual buds) of the Syllidæ with large eyes are also pelagic, occurring near the surface of the ocean amongst *Sagittæ*, Copepods, Nauplii, Zoœæ, and the minute free young and ova of fishes.

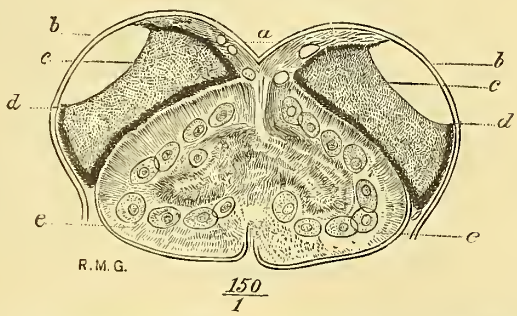


Fig. 214.—Horizontal section through both eyes of *Genetyllis oculata*, showing their relation to the cerebral ganglion (somewhat diagrammatic). *a*, Junction of the anterior part of the sclerotic,—the oval spaces are blood-vessels cut across; *b*, the cornea; *c*, finely granular, clear, structureless material, probably of the nature of vitreous; *d*, pigment-layer of retina; *e*, the large cerebral ganglion.

"In viewing the collection of Annelida brought home by the Challenger as a series of families, it is found that while the Euphrosynidæ present no new forms, the Amphinomidæ have at least four, two of which fall under Grube's interesting group *Notopygos*. The Aphroditidæ, again, for the most part come from deep water, a feature amongst others somewhat dividing them from the three other groups (Polynoidæ, Acoetidæ, and Sigalionidæ) usually associated with them. Some of the species from their intermediate structure help to clear up the relationships between *Aphrodita*, *Lætmonice*, and *Hermione*, and especially to indicate the steps between the two first mentioned.

"The great group of the Polynoidæ is very fully represented by about fifty different forms. The rotate and stalked papillæ on the scales of *Euphione elisabethæ*, n. sp., give this form a characteristic appearance, even more so than the remarkable lobes on the scales of *Lepidonotus cristatus*, Grube, also present in the collection. The short and ovoid type is represented by *Polynoë iphionoides*, n. sp., in which the fleshy part of the foot is largely developed. *Polynoella levisetosa*, n. sp., also short and somewhat elliptic in outline, is peculiar in having only a single bristle in the ventral division of the foot. A singular modification of the head takes place in *Macellicephala mirabilis*, n. sp., which from this cause and the form of its body might at first sight be mistaken for one of the Hesionidæ. The sexual differences existing in *Polynoë grandipalpa*, n. sp., are both marked and interesting, the males being more elongated than the females.

"Four or five of the groups are commensalistic. One frequents the hexactinellid Sponge containing *Syllis ramosa*, a second accompanies the Crustaceans in *Euplectella*, while a third occurs in the branchial chamber of an Ascidian, and a fourth in the tube of *Spiochætopterus* just as *Polynoë scolopendrina* and others do in Britain in the tubes of various species.

"Two species of Grube's new genus *Eulepis* are present. Provisionally they may be placed here, though the structure of the body wall somewhat differs from that in the Polynoidæ.

"Without going into detail in regard to the other families, it may be mentioned that in all of them new species occur, and in many new genera, but it has not been deemed necessary to constitute a new family.

"Amongst the most remarkable forms is the branched *Syllis*[1] (*Syllis ramosa*, M'Intosh, fig. 215), dredged at Station 192, in 140 fathoms off the Ki Islands in the Banda Sea, and again in 95 fathoms off Zebu, one of the Philippines; in both instances the greyish mud being peculiarly rich in *Euplectellæ* and other hexactinellid sponges and *Sipunculi*. The Annelid occurred in the canals of a cup-shaped hexactinellid sponge, just above the wisp, but was only observed after preservation. The intricate manner in which the branches are arranged makes it difficult to dissect them out, when the friable nature of the animal and the sharp spicules of the sponge are taken into account. Even after removal from the sponge it is a laborious operation to unravel the Annelid. The body of this *Syllis* is about the thickness of fine sewing thread, branched in a

[1] *Journ. Linn. Soc. Lond.* (Zool.), vol. xiv. p. 720, 1879.

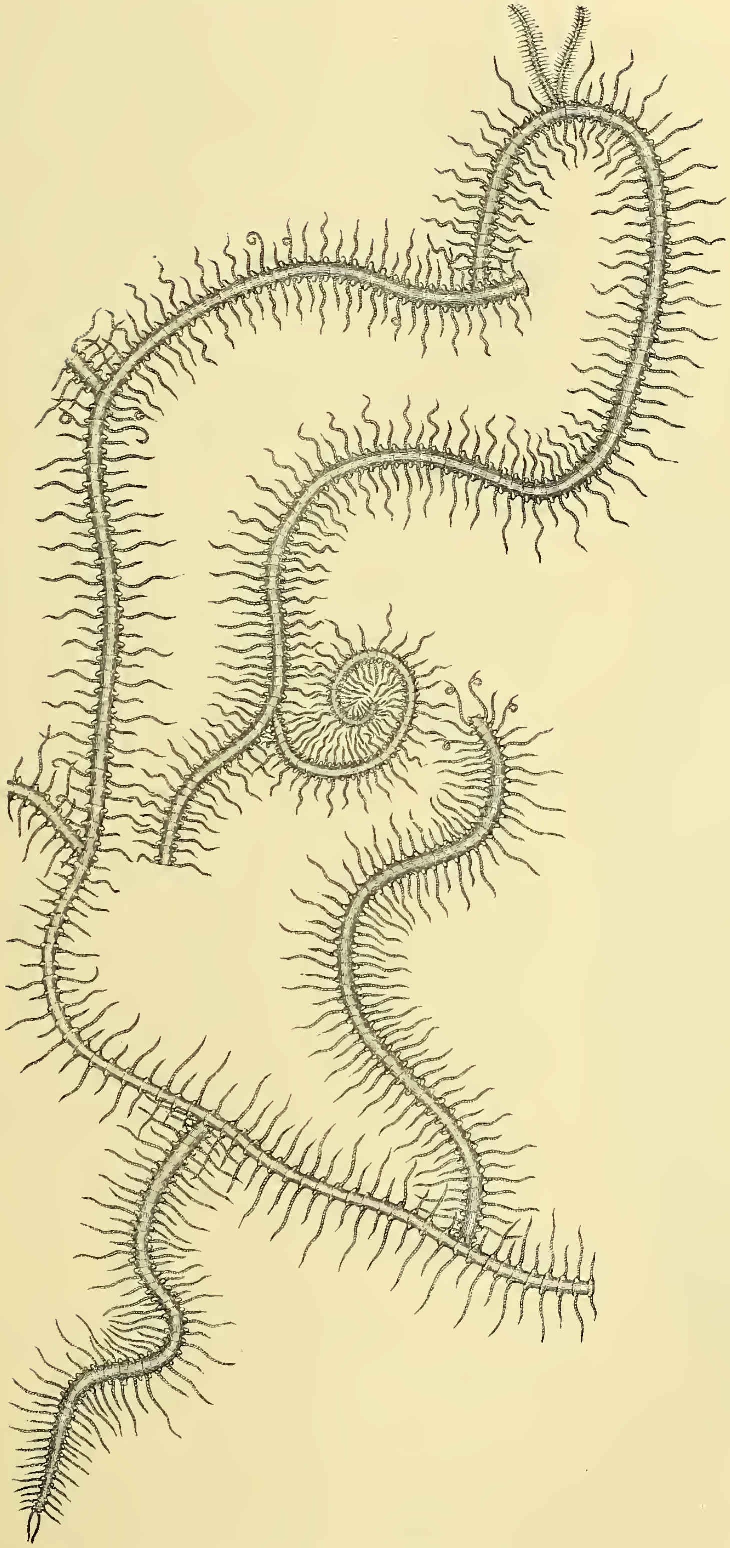


Fig. 215.—*Syllis ramosa*, M'Intosh. Off Zebu, Philippines; 95 fathoms.

complex manner and consisting of narrow segments with well-formed feet. The latter have dorsally a long and gracefully curved cirrus, a conical setigerous region with a few simple bristles, and inferiorly a broad and stout ventral cirrus. The dorsal cirri are alternately longer and shorter, as in certain other forms, *e.g.*, those described by Grube from the Philippines. The buds appear laterally, terminally, and wherever a broken surface occurs, and a diverticulum of the alimentary canal enters each. These buds on attaining a certain size give off other buds, so that the whole has a remarkably branched form.

"The tail of the bud (*i.e.*, the distal part) is early formed, and soon presents two long cirri. No head appeared in the examples from Zebu, but in a particularly broad bud, on a specimen from the Flores Sea, a head occupied the free end. This bud came off at right angles, had shorter segments and a more distinctly moniliform alimentary canal. The anterior margin of the snout is depressed and carries on each side a slender cirrus, while another appendage of the same kind occurs just in front of the eye. A sulcus separates this area from the more elevated one behind, the latter resembling a broad wedge with the eye on each angle anteriorly. The ocular pigment is dark red, the edge being somewhat irregular. The folds on the posterior margin of the head are symmetrical and the nuchal border is clearly marked. Several female buds were found. The head in an attached example is bilobed and somewhat like the sexual form termed *Ioida* by Dr. G. Johnston, having a large reddish brown eye on each side, and a still larger pair on the ventral surface. The head is terminated posteriorly by two short cirri and a setigerous process furnished with a spine. The entire fusiform body and the bases of the feet are filled with ova, showing germinal vesicle and spot. The anterior segments are provided with bristles of the same type as the parent stock, though the terminal appendage is more differentiated. An older (free) bud seemed to differ from the foregoing chiefly in the size of the ova (some of which appear to contain embryos), and in the presence of long translucent bristles with broad flattened tips (the 'Pubertätsborsten' of Professor Langerhans). A fragment of the posterior end of a male also occurred. The feet have dorsally a convex margin, and the same outline exists ventrally at the base, but the edge slopes upward distally. A short dorsal cirrus of a few segments is present, and beneath it a tuft of long straight translucent sword-shaped bristles similar to those in the female bud. The body contained a large number of granules and masses, apparently of spermatozoa.

"In no group of the Annelida is budding more conspicuous than in the Syllidæ. The linear division of *Autolytus* and *Procerœa*, the lateral buds of *Exogone*, and the ease with which heads and tails are reproduced, are examples; but the foregoing (*Syllis ramosa*) marks a new era in the invertebrates, for the branches occur as freely as in a hydroid zoophyte, and the open ends of the ruptured alimentary canal would seem to be sufficient for the nourishment of the various parts. In connection with this subject the slightly branched tubes of *Eunice magellanica* form an interesting feature, since they demonstrate that branching tubes by no means indicate a divided condition of the Annelid.

"From a depth of 1950 fathoms in the Antarctic Ocean an equally peculiar example of the Chloræmidæ occurs. This form (*Trophonia wyvillei*, n. sp., fig. 216) is large and broadly elliptical, the long pale papillæ which cover its surface giving it the aspect of grey plush or loose felt. These papillæ are densely coated with the siliceous organisms of the Diatom ooze, besides having these loose in the interstices. The oral aperture is ventral, and has two large foliaceous tentacles, which in life must have approached a circular outline. The branchiæ are clavate, and like the tentacles tinted of a pale brown colour. The anus is also ventral, and is situated a little within the posterior border. The beautiful tufts of pale golden bristles which flank the sides are twenty-two in number; the ventral, in the case of all except the first, being stronger and much more conspicuous than the dorsal.

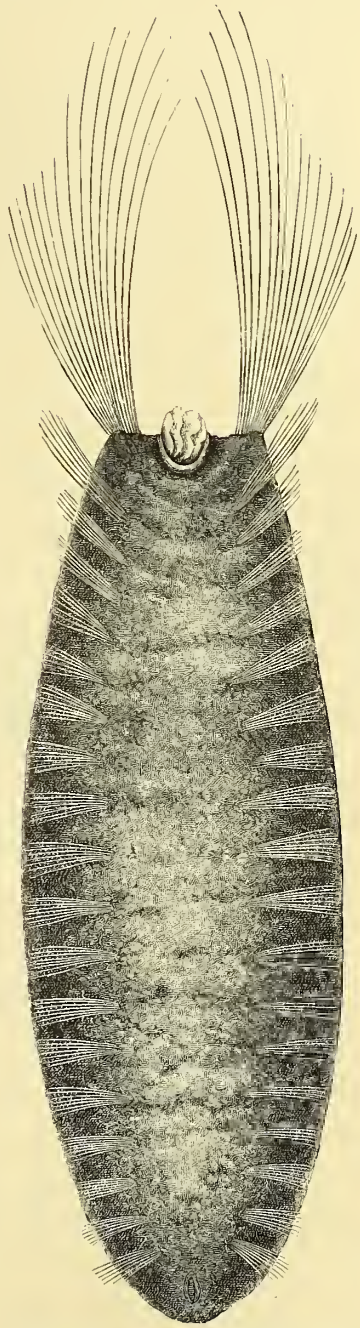


FIG. 216.—*Trophonia wyvillei*, n. sp. Station 157, March 3, 1874; 1950 fathoms.

"The wide range and peculiar form of another member of the Chloræmidæ, viz., *Flabelligera* (?) *abyssorum*, n. sp., frequenting the abysses of the Atlantic and Pacific, opens up the question as to ancestral forms being driven into the still depths by commoner and more hardy types. Unfortunately all the specimens, though of considerable size, are fragmentary, but it is probable that the type is intermediate between the Chloræmidæ and the Chætopteridæ. The anterior end of this remarkable Annelid (fig. 217) is formed by the dark brownish muscular lip, which is convex dorsally, concave ventrally, thus forming a horse-shoe-like projection. The upper and posterior angles run into a double foliaceous and somewhat frilled brownish mass which constitutes the superior boundary of the oral aperture. Close behind the latter is a stout process having a median filament with an enlargement at the tip, and two lateral processes considerably shorter and with filiform extremities. The feet have long delicate flattened dorsal bristles which possess a sheen like spun glass, and articulations so large as to be visible under a lens. These tufts extend outward about 18 mm. The ventral bristles are equally translucent but devoid of articulations. The hyaline cuticle invests the body with a gelatiniform coating, but the contingencies connected with its capture may have altered it, though numerous granules and elongated glands are still evident.

"The mouth leads into a dark brownish thick-walled pharynx, which in the preparation is somewhat moniliform. The latter terminates in a firm white and nearly cylindrical region, somewhat narrowed posteriorly where it merges into a longitudinally furrowed glandular part (stomach) continuous with the intestinal canal. The nervous system is evident on the ventral surface as a double cord, two ganglia being placed antero-posteriorly in each segment, the larger in front and the smaller behind.

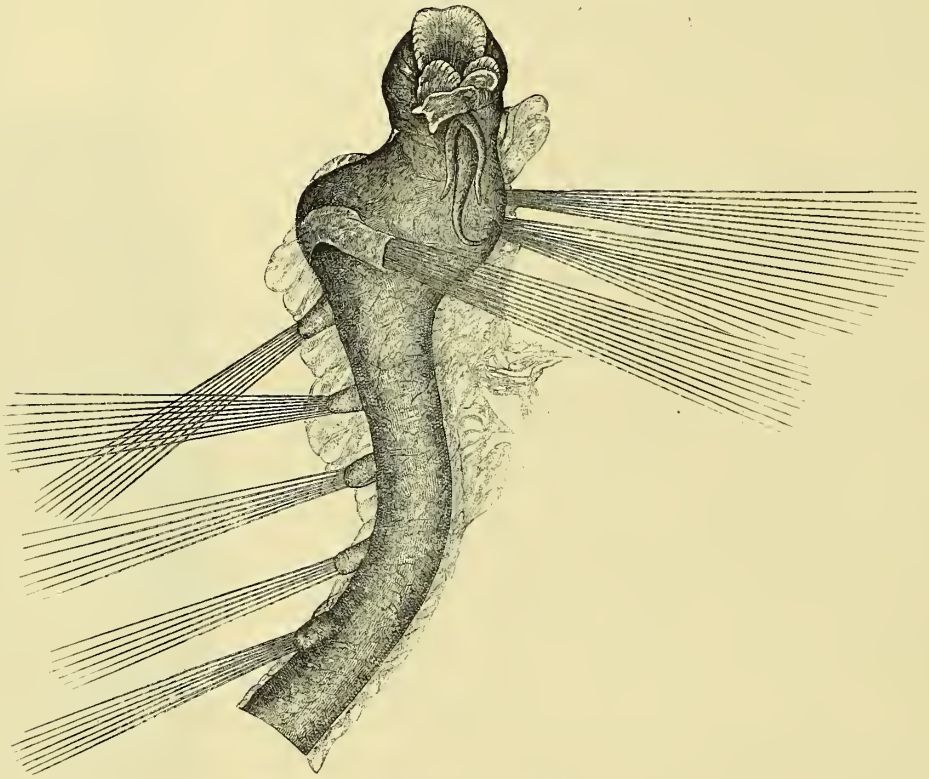


Fig. 217.—*Flabelligera* (?) *abyssorum*, n. sp.

"Many interesting deep-sea forms occur in the family Maldanidæ, which with the closely allied Ammocharidæ appear to abound in the abysses. Amongst the Ampharetidæ the Atlantic and Antarctic Oceans produced some curious new types, such as *Rhynchoscaphia antarctica*, n. gen. and sp., from Station 151, a form in which the snout is flattened and broadly spathulate as well as devoid of tentacles. Traces of four branchial processes are present and there are fifteen pairs of bristle-bundles.

"Two or three new genera come from great depths, ranging from 1100 to 2300 fathoms.

"The large number of the Terebellidæ is noteworthy. Amongst the new genera are *Eupista*, in which the branchial processes are simple, and *Euthelepus*, in which the three post-cephalic segments have a process or lobe jutting forward from the anterior border on each side, and a long simple branchial filament. This family, like that of the Serpulidæ, reaches very profound depths (such as 3125 fathoms), and both range to shallow water.

"The tubes fashioned by many forms are peculiar. Thus the tube of a large *Hyalinœcia* is as wide as a goose-quill, which it much resembles in texture, but it is nine or ten inches in length. *Nothriæ* from the deep sea have their tubes strengthened by long glassy spicules of sponges, by long arenaceous Foraminifera, by tubes of *Serpulæ*, and in the case of a Japanese form, by the long linear leaves of the Coniferæ carried to the sea by rivers. Perhaps the most remarkable tube of the group, however, is that of *Nothria willemoesii*, n. sp. It is a large, rounded, and firm tube, externally composed of of greyish sandy mud, and internally of a tough whitish secretion. The greater part of the surface is furnished with a series of long, slightly bent elastic spines composed (after the manner of a sponge spicule) of layer upon layer of a hyaline secretion, probably of the same nature as the inner wall of the tube. The great length (500 mm.), again, of the tubes of *Nothria ehlersi*, n. sp., is noteworthy. The new abyssal forms of the Ampharetidæ inhabit tubes of mud lined by a chitinous layer. The tubes of *Pista mirabilis*, n. sp., one of the Terebellidæ, are firm, rounded, chitinous structures tapering from the anterior to the posterior extremity and studded all over with long spinous processes, the wall of the tube being minutely marked by fine—almost linear—transverse wrinkles. The tube is apparently free in the majority, but in others it is immersed in sponges."

Hong Kong.

The colony of Hong Kong consists of the island of that name and the opposite peninsula of Kowloon. The island is about 9 miles long, N.W. by W. and S.E. by E., and from 2 to 5½ miles broad; its shores are much indented, particularly on the south side. The Kowloon Peninsula, on the main coast of China, opposite Hong Kong, is 2 miles in length and 1 in breadth. The total area of the colony does not much exceed 30 square miles. The island was originally ceded to Great Britain in 1841, and the peninsula of Kowloon in 1861.

The harbour of Hong Kong is formed by the strait separating the island from the China coast; it is almost completely landlocked, and possesses anchorage ground extending over nearly 10 square miles.

The general aspect of Hong Kong, and of the neighbouring part of China, is very fine, for the island consists for the most part of rocky ranges, culminating in Mount Victoria, 1825 feet above the level of the sea, and the hills on the China coast are similar in character, rising to heights of 4000 feet, and the clear weather so frequently experienced shows to advantage the wild mountain scenery, which offers a *coup d'œil* that can hardly be excelled.

The city of Victoria, on the north side of Hong Kong Island, extends for upwards of 3 miles along the coast at the base of the hills. Owing to the nature of the ground, which rises abruptly from the sea, the streets are built in terraces, rising one above the other, nearly a third of the way to the peak, which renders the view of the town from the sea exceedingly picturesque. Along the coast, in front of the city, some land has been reclaimed, embanked, and formed into a handsome esplanade, 3 miles in length, from which a few wharves extend to facilitate landing merchandise. A good military road, 22 miles in length, encircles the island, and other roads cross the mountains, the principal being the road to Victoria Peak, on the summit of which is a signal station, and near it a sanatorium and a few bungalows. The city of Hong Kong is remarkably well built and laid out. Besides several handsome Government Buildings there is a cathedral and bishop's palace, several good hospitals, extensive barracks, and club houses. At the back of the town, near Government House, on the slope of the hill, are the botanical gardens, from which a fine view of the harbour is obtained, and at the eastern extremity of the town is the only flat piece of land on the island, called "Happy Valley," utilised as a racecourse, and close to which, in somewhat awkward proximity, are the cemeteries.

The occupation of Hong Kong was originally of considerable cost to England, the vote from Parliament in 1845 being nearly £50,000 in addition to military expenditure. Since 1867, however, the colony has been self-supporting.

Lying as it does just within the tropics, Hong Kong is subject to an excessively hot and a somewhat cool season, coinciding with the southwest and northeast monsoons. The city being situated on the north side of the island, under the hills, does not receive any benefit from the southwest monsoon, which on the southern side agreeably tempers the violent heat. July and August are the hottest months, and November to January the coolest period. March and April are foggy, with a penetrating damp, requiring great care to be taken of books or instruments liable to injury from that cause. The rainy season proper commences in May, and continues until the beginning of August, and during this period the rain falls almost without intermission, frequently causing floods which do great damage.

A meteorological register has been kept at Hong Kong for fourteen years, from which the following table has been compiled, showing with far greater precision than a long explanation what the average climate of the island is. To this is added a register for two years on Victoria Peak, and for the sake of comparison one for the same period at the sea level:—

Hong Kong.

Meteorological Table compiled from observations made at the Government Civil Hospital for fourteen years, viz., from 1861–74. The wind observations are from 1868–74, and the cloud observations from 1872–74. The Barometer reduced to 32° and sea level.

Month.	Barometer.		Mean Temp. in shade.	Mean Range of Temp.	Max. Temp. in shade registered.	Min. Temp. in shade registered.	Clouds—0 to 10 Mean Amount.	Rain.		Wind.										No. of days Gales.	No. of days Fogs.
	Mean Height.	Ext. Range.						Total Fall.	No. of days.	Av. Hourly velocity.	No. of days from N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W	C'lm		
	ins.	ins.	°	°	°	°		inches.		miles.											
January,	30·138	0·64	60·6	7·5	76·0	43·0	5·9	0·65	3	8·1	2	8	9	2	0	1	3	1	5		
February,	30·102	0·60	60·5	8·0	76·0	41·0	6·3	1·02	5	8·3	1	7	11	2	0	0	1	1	5		
March,	30·023	0·59	64·5	7·8	81·0	43·0	7·6	2·83	8	8·7	0	5	15	3	0	1	0	2	5		
April,	29·964	0·55	72·4	7·4	86·5	56·0	6·5	3·27	7	7·9	1	3	12	4	0	3	1	0	6		
May,	29·838	0·51	78·7	6·0	87·5	62·0	7·4	12·61	14	6·8	0	2	9	4	1	7	2	1	5		
June,	29·787	0·58	82·6	6·2	90·0	71·0	6·7	14·59	17	4·1	0	1	7	3	2	7	2	1	7		
July,	29·780	0·49	83·5	6·7	91·0	73·0	6·1	13·62	13	4·0	0	1	5	3	2	11	2	1	6		
August,	29·789	0·55	83·1	6·9	92·0	75·0	6·7	13·25	14	3·5	1	1	7	2	1	9	2	0	8		
September,	29·842	1 00	81·8	7·2	90·0	69·0	6·4	12·99	11	...	2	7	8	2	0	3	2	1	5		
October,	29·993	0·85	77·3	6·1	88·0	64·0	5·7	4·40	6	13·4	3	10	11	2	0	1	0	1	3		
November,	30·130	0·75	69·9	7·9	88·0	52·0	4·7	0·37	2	6·6	4	12	9	1	0	0	0	1	3		
December,	30·142	0·59	64·4	7·6	82·0	36·0	4·7	0·54	3	9·0	3	10	10	1	0	0	1	1	5		
Means and Totals,	29·961	1·0	73·3	7·1	92·0	36·0	6·2	80·14	103	...	17	67	113	29	6	43	16	11	63		

Hong Kong—Sea Level.

Meteorological Table compiled from observations taken at the Civil Hospital from Nov. 30th, 1872 to Nov. 30th, 1874. Barometer reduced to 32° and sea level.

Month.	Barometer.		Mean Temp. in shade.	Mean Range of Temp.	Max. Temp. in shade registered.	Min. Temp. in shade registered.	Clouds—0 to 10 Mean Amount.	Rain.		Wind.										No. of days Gales.	No. of days Fogs.
	Mean Height.	Ext. Range.						Total Fall.	No. of days.	Av. Hourly velocity.	No. of days from N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	C'lm		
	ins.	ins.	°	°	°	°		inches.													
January,	30·140	0·51	58·8	7·9	76·0	47·0		0·90	4		5	4	11	1	0	0	6	3	1		
February,	30·105	0·54	62·0	10·0	74·0	50·0		0·72	3		1	3	15	3	1	0	2	2	1		
March,	30 035	0·39	64·7	6·7	75·5	53·0		1·67	7		1	1	21	2	1	0	2	1	2		
April,	29·955	0·46	71·3	5·7	83·0	56·0		2·98	11		2	2	21	0	0	1	1	1	2		
May,	29·802	0·46	78·5	5·0	86·0	70·0		20·77	20		1	1	13	3	1	3	4	2	3		
June,	29·795	0·48	84·1	5·0	90·0	71·0		7·97	12		1	1	11	2	2	4	6	1	2		
July,	29·745	0·49	83·7	6·5	91·0	76·0		15·12	14		1	1	9	2	3	7	6	1	1		
August,	29·790	0·31	83·1	6·7	89·0	75·0		14·18	18		2	2	12	1	1	5	3	1	4		
September,	29·812	0·53	83·0	6·3	90·0	76·0		13·85	13		3	3	9	2	0	2	6	1	4		
October,	30·017	0·45	78·3	5·9	88·0	65·0		1·08	5		3	4	19	1	0	1	1	1	1		
November,	30·145	0·29	69·8	7·1	78·0	52·0		0·44	1		5	7	16	1	0	0	1	0	0		
December,	30·105	0·48	67·0	6·8	75·0	56·0		0·52	2		2	10	16	1	0	0	1	0	1		
Means and Totals,	29·954	0·54	73·7	6·6	91·0	47·0		80·20	110		27	39	173	19	9	23	39	14	22		

Hong Kong—Victoria Peak.

Meteorological Table compiled from observations taken at the Signal House, Victoria Peak, between Nov. 30th, 1872 and Nov. 30th, 1874. Barometer reduced to 32° but not to sea level. Height of Victoria Peak on Admiralty Chart, 1825 feet.

MONTH.	Barometer. Mean Height.	Barometer. Ext. Range.	Mean. Temp. in shade.	Mean Range of Temp.	Max. Temp. in shade registered.	Min. Temp. in shade registered.	Clouds—0 to 10 Mean Amount.	Rain. Total Fall.	Rain. No. of days.	Wind. Av. Hourly velocity.	Wind. No. of days from N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	C'lm	No. of days Gales.	No. of days Fogs.
	ins.	ins.	°	°	°	°		inches.													
JANUARY, ...	28·426	·42	51·8	7·5	67·0	40·0		1·14	7		5	6	12	1	0	1	1	5	0	2	
FEBRUARY. . . .	28·407	0·43	55·4	7·1	69·0	39·5		1·00	7		3	4	14	2	2	0	1	1	1	4	
MARCH	28·343	0·27	58·5	6·5	71·0	44·0		2·53	14		2	2	16	8	2	0	0	1	0	3	
APRIL, ...	28·286	0·33	64·3	6·0	73·5	49·0		4·21	16		2	1	16	4	4	1	0	1	1	2	
MAY, ...	28·134	0·32	70·8	4·6	77·5	61·0		23·44	26		0	1	9	3	10	5	1	2	0	4	
JUNE, ...	28·122	0·39	74·1	4·1	79·5	64·0		7·17	21		0	0	8	4	11	6	0	0	1	3	
JULY, ...	28·125	0·34	74·7	3·9	82·0	68·0		14·50	21		1	0	4	4	11	9	1	1	0	3	
AUGUST, ...	28·131	0·41	74·9	4·2	81·5	68·0		11·77	21		0	1	10	5	7	7	0	0	1	1	
SEPTEMBER, . . .	28·114	0·73	75·0	5·0	83·0	67·0		8·53	16		4	3	10	2	4	2	2	2	1	4	
OCTOBER, . . .	28·230	0·34	70·1	6·0	80·0	56·0		2·31	7		4	3	21	0	1	1	0	1	0	0	
NOVEMBER, . . .	28·281	0·49	61·7	6·8	72·0	42·0		0·42	2		6	6	17	0	0	0	0	0	1	1	
DECEMBER. . . .	28·452	0·29	60·9	8·1	70·5	47·5		1·07	6		3	3	21	1	0	1	0	1	1	1	
Means and Totals, .	28·254	0·73	66·0	5·8	83·0	39·5		78·09	164		30	30	158	34	52	33	6	15	7	28	

All the zoological and other specimens collected during the cruise between Sydney and Hong Kong were landed at Kowloon and placed in a house belonging to the dockyard, where they were carefully packed; one hundred and twenty-nine cases and several casks being placed on board H.M.S. "Adventure" on the 1st January 1875 for transmission to England.

The British residents and naval and military officers at Hong Kong received the members of the Expedition with great hospitality, and a similar hospitality was extended to those members of the Expedition who visited Canton.

The chief event during the stay at Hong Kong was, however, the appointment, much to the regret of every one on board, of Captain Nares to the command of the Arctic Expedition, and his departure for England accompanied by Lieutenant Aldrich, the first lieutenant of the ship; previous to their departure they were entertained to dinner by the naval officers and members of the Civilian Scientific Staff.

The late Captain Frank Turle Thomson of H.M.S. "Modeste," who was then serving on the China station, was appointed to the Challenger, and joined the Expedition on the 2nd January 1875.

The water at Hong Kong was brilliantly phosphorescent during the whole of the stay of the ship. *Noctiluca miliaris*, various species of *Ceratium* and Diatoms were always present in great numbers, and in addition Copepods, Cirriped larvæ, Annelid larvæ, Hydromedusæ, *Appendicularia*, and *Diphyes*.

The Calcarea and Keratosa.—On the return of the Expedition to England, Dr. N. Poléjaeff, of the University of Odessa, undertook to prepare a Report on the collections of Calcareous and Horny Sponges, and his two separate Reports appear in the zoological series.[1] Dr. Poléjaeff gives the chief results of his investigations in the following notes:—"The adequate discussion of questions bearing upon geographical distribution as well as upon the relation of the deep-sea fauna to the fauna of the later geological periods is quite impossible as regards the Calcareous and Horny Sponges. Both the Calcarea and the Keratosa belong not to the deep-sea, but to the littoral, fauna, the greatest depth from which they have hitherto been obtained not exceeding 400 to 450 fathoms, and even this only in exceptional cases (*Leucosolenia blanca*, var. *bathybia*, *Leuconia crucifera*, *Cacospongia levis*, *Stelospongos longispinus*, *Verongia tenuissima*). Again, up to this time, there are in palæontological literature no trustworthy statements as to their occurrence in the earlier geological periods. The question as to whether the Pharetrones, or at least a part of them, are really to be referred to the Calcarea remains still open to discussion, and on the other hand the nature of a couple of fossils described by Zittel and Carter as Horny Sponges is no less ambiguous. Finally, and with regard to the geographical distribution of the two groups in question, it must be noticed that most of their representatives in the Challenger collection have been found to present new forms, almost every one of which is represented only by a single specimen, so that in this respect also no further conclusions and generalisations were possible. Accordingly the scientific investigation of the Challenger Calcarea and Keratosa was possible only from a purely zoological point of view.

"Apart from the systematic description of new forms, the chief results with regard to the Calcarea find their expression in the attempt to frame a new and more natural classification than that proposed by Ernst Haeckel in his splendid monograph Die Kalkschwämme. The necessity of this measure has been recognised for some years, but there was a want of conditions appropriate to its realisation, since the reformer ought also to have proved that the phylogenetic ideas on which Haeckel's system is based are false, the execution of this latter task involving, in its own turn, a similar proceeding with respect to many of his statements as to the anatomy of the Calcarea in general. Of course, numerous contributions to a more correct knowledge of their organisation and mutual affinities have long since been made, as for instance the statements of F. E. Schulze as to the impossibility of adopting Haeckel's strobiloid gemmation hypothesis of the origin of the Sycones from the Ascones. Again, what we have learned from

[1] Report on the Calcarea, Zool. Chall. Exp., part xxiv., 1883; Report on the Keratosa, *Ibid.*, part xxi., 1884.

Barrois's Embryologie de quelques Éponges de la Manche and from Vosmaer's paper on *Leucandra aspera*, proved that, contrary to Haeckel's assertions, the Leucones seem to be more closely allied to the Sycones than to the Ascones. But all these statements, valuable and important as they were from a morphological point of view, could not serve as a basis for a new arrangement of the group. They rendered every one still more conscious of the fact that Haeckel's system is quite artificial, but they were too fragmentary for any systematic deductions. In order to construct for the group in question a new systematic edifice, not merely the study of a single species but the revision of a whole collection was indispensable, together with the simultaneous examination of certain original forms examined and described by Haeckel. Such a collection had been made during the voyage of H.M.S. Challenger, and, further, thanks to the kindness of many naturalists, the author of the Report was enabled to obtain, for the purpose of comparison, most of the original Calcarea of interest and importance. The main results of the Report conducted under these very favourable circumstances are the following :—

"The group of Calcarea is not to be subdivided directly into families as proposed by Haeckel, but primarily into two orders, namely (1) Homocœla, represented by the single family Asconidæ, and characterised by a complete absence of differentiated flagellated chambers, the whole central cavity being covered with a continuous layer of flagellated cells; and (2) Heterocœla, embracing the families Syconidæ, Leuconidæ, and Teichonidæ, characterised by the fact that their central cavity, together with its derivates, are coated partly with pavement epithelium (inhalent and exhalent canal system), partly with flagellated epithelium (flagellated chambers).

"The above deduction is perhaps the most important in the Memoir, and therefore the communication here of the facts and arguments on which it is founded may not be superfluous.

"The striking resemblance of the Asconidæ to the phase of development of Calcarea known under the name of Olynthus was remarked long ago, and Haeckel as well as Vosmaer take the Olynthus in their phylogenetic speculations for the starting point, identifying it with the primitive Ascon representing the stock of the whole group of Calcarea. The deductions of Haeckel having been rejected by Vosmaer, those of Vosmaer—and particularly his flagellated epithelium theory—are now in their turn rejected by Dr. Poléjaeff, who does not identify the Ascon with the Olynthus, this latter being, according to him, 'a neutral being, and the Ascon one of its modifications, the Sycon another.' He states that 'an Olynthus may increase longitudinally without lateral growth, and in that case it will give origin to an Ascon.' 'An Olynthus,' he further suggests, 'may also grow in all directions in length as well as laterally,' and on the ground of certain, so to speak, geometric arguments in connexion with others concerning the question as to what histological elements do in the Calcarea take in the nutritious particles, he regards as a necessary result of such a kind of growth the substitution of pavement epithelium for flagellated epithelium covering the central cavity in the Olynthus, as well as the formation of differentiated flagellated chambers (radial tubes). In harmony with all this, and since, through forms like *Leucilla uter*, *Leucilla connexiva*, *Amphoriscus elongatus* and *Amphoriscus poculum*, the typical Syconidæ are most closely connected with typical Leuconidæ, Dr. Poléjaeff upholds the existence of an *absolute* distinction between the Asconidæ and all other Calcarea, and gives systematic expression to it by subdividing the group into two orders.

"Although the above theory is regarded as quite plausible, it must however be noticed that it stands in a certain contradiction to some embryological data which, though mentioned by the author, are not brought into harmony with his hypothesis. Poléjaeff regards his Homocœla and Heterocœla as systematically equivalent groups, *i.e.*, to present divergent branches from the same spot of the genealogical tree of the animals. Again, on page 21 of his Memoir, he adopts the opinion upheld by Metschnikoff that in Parenchymula we have to do with a larva of more primary characters than those of Amphiblastula, both these larvæ, as is well known, being characteristic of the Calcarea. But it is also known that these larvæ are not distributed in such a manner that Parenchymula characterises the development of Homocœla and Amphiblastula that of Heterocœla. The latter is of course true, but the development of Homocœla is characterised in some instances by Parenchymula, in others by Amphiblastula. The contradiction above alluded to is clear. And it is equally plain that the hypothesis under consideration will become theory only when it has been proved either that the statements of Barrois and Keller as to the occurrence of Amphiblastula within the Asconidæ are based on a mistake, or that the opinion of Metschnikoff above mentioned is erroneous, or finally that the Amphiblastula of Heterocœla and that of Homocœla are only analogous and not homologous larvæ.

To return to the results of the Report, which concern the Heterocœla almost exclusively. As to the order of Homocœla, the author believes it to contain only a single family, but he is not prepared to say whether this family consists of but one or of many genera. On the whole he believes our knowledge on this head to be still very deficient.

"In the order Heterocœla three families are distinguished, all already established by former systematists. The inducement to adopt the family Teichonidæ established by Carter for a single genus, *Teichonella*, has been given by the circumstance that the Challenger collection contained a form, the beautiful *Eilhardia schulzei* (see fig. 218), with its silvery lustre, which, closely allied to the genus *Teichonella* as it is, differs from it so very much that the creation of a new genus, and thus the adoption of the whole family, became indispensable. The family is characterised by having the outer surface differentiated into two different planes, one bearing oscula, the other pores, and the internal organisation of its representative in the Challenger collection recalling vividly that of the typical Leuconidæ, a great stress is laid upon the close relationship of both these families in spite of the want of intermediate forms connecting them directly. Such being the case with regard to the Teichonidæ, a series of illustrations are given in the Report which, beginning with the internal structure of one of the typical Syconidæ (*Sycon arcticum*), lead us gradually to that of one of the typical Leuconidæ (*Leuconia multiformis*). The results of this argument are formulated as follows :—'The Leucones are nothing but modified Sycones with a non-articulated tubar skeleton, their flagellated chambers are complete homologues of the radial tubes; their exhalent canals owe their origin to the invaginations of the inner cavity, and their inhalent canals are to be regarded as homologous with the intercanals of the Sycones.'

"The author adopts the families established by Haeckel, although with considerable

FIG. 218.—*Eilhardia schulzei*, Poléjaeff.

modifications as to their diagnosis; but this is not the case so far as Haeckel's genera are concerned. As is well known, the definitions of these latter are based on spicular characters exclusively. Dr. Poléjaeff regards this proceeding as thoroughly artificial, and comes to the conclusion that 'the spicules of the Calcarea being very variable in every direction, could not serve as a basis for the distinction of genera, even if there were in the Calcareous Sponges no other characters fit for very distinct systematic definitions.' The principle upon which he proceeds is *the consideration of all the organs in their mutual correlation*. Following it he distinguishes—in the family of Syconidæ six genera (*Sycon*, *Grantia*, *Ute*, *Amphoriscus*, *Heteropegma*, and *Anamixilla*), two of which, namely *Anamixilla* and *Heteropegma*, are new; in the family of Leuconidæ four genera (*Leucilla*, *Leuconia*, *Leucetta*, and *Pericharax*), the genus *Pericharax* being created for forms partly collected by the Challenger, partly described by Haeckel; and as above mentioned in the family of Teichonidæ two genera, one created by Carter, the other new. The whole collection being represented by thirty species (twenty-three new); four species (one new) have been found to belong to the Asconidæ, ten species (seven new) to the Syconidæ, fifteen species (fourteen new) to the Leuconidæ, and one species (new) to the Teichonidæ.

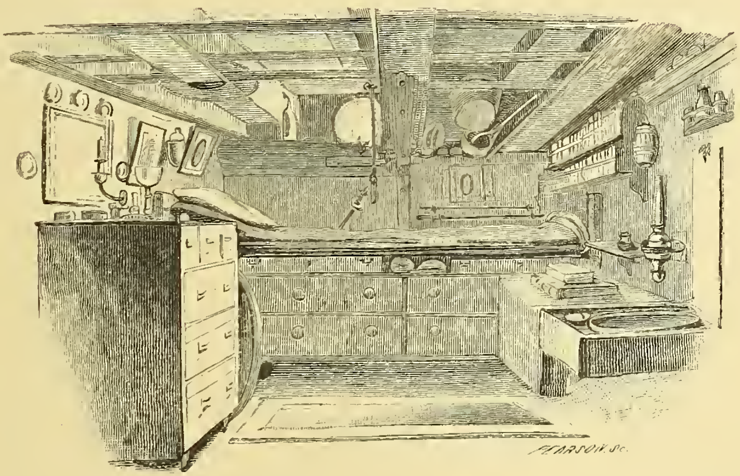
"The Challenger collection of Horny Sponges proved to be but little larger than that of Calcarea, consisting of thirty-seven species, twenty-one of which have been found to be new. The collection proved, however, to embrace all the genera of the group distinguished up to this time, with the exception of *Darwinella*, *Aplysilla*, *Aplysina*, and *Phyllospongia*. The author has abstained from describing three species represented only by specimens quite devoid of soft parts, the whole systematic proceeding of the Memoir having been conducted according to the principles upheld by Professor F. E. Schulze, and demanding the examination of the soft parts in no less degree than of the properties of the skeleton. It is for the first time that a comparatively large collection of Keratosa has been classified and described according to the present state of our spongiological knowledge. But in spite of the fact that the brilliant researches of F. E. Schulze have considerably increased within the Keratosa the number of characters fit for systematic application, the author of the report is still of opinion that on the whole the arrangement of the group lately proposed by Dr. Vosmaer, and based on the investigations of F. E. Schulze above mentioned, is still to be regarded as a provisional one, and that so long as Spongiology will not attach due influence to Comparative Physiology in its systematic proceedings, no hopes can be entertained of a natural arrangement of the Keratose Sponges. This is the chief idea of the Memoir, and even the description of the Challenger specimens is to a certain degree subordinated to it and devoted to its foundation. The Memoir opens with the discussion on the organisation of the Keratosa in general and on their chief systematic characters. Its results are that all these characters (namely the structure of the horny skeleton, the tendency of the skeletal fibres to take in foreign bodies, the presence of filaments, the differences in anatomical organisation) are either of little systematic importance, or of such a relative nature that the subdivision of the Keratosa into two main groups (orders) as proposed by Hyatt, Carter, and v. Lendenfeld is impossible. On the other hand the author comes to the conclusion that a direct subdivision into families as suggested by Vosmaer is also of an undoubtedly artificial nature; for such a subdivision, although it pays attention to the relative character of the main systematic characters of the Keratose Sponges, does not give sufficient weight to the circumstance that the application of these characters—namely the structure of the canal system, and the properties of the skeletal fibres, whether homogeneous or heterogeneous—gives rise to systems which are antagonistic to one another; and furthermore, the representatives of Dr. Vosmaer's families show such manysided affinities that the above mentioned subdivision of them could not be expressed graphically in a satisfactory manner.

"The second chapter of the Report is devoted to the characters of the Keratosa generally regarded as of generic importance, and it renders obvious that, firstly, these characters are really of more subordinate consequence than those discussed before, and that, secondly, most of the genera hitherto distinguished are created on the basis of thoroughly relative and often very ambiguous characters.

"The third chapter is that dealing with the description of the Challenger forms, and though not interrupted by any considerations of a more general character, it neglects no opportunity to point out that the classifier, following the principles used at the present time, is on the whole 'to be compared with a man wandering in the dark.'

"The 'concluding remarks' summarize the general results of the Memoir, and after having discussed the systematic position of the Keratosa with respect to other groups of Porifera, Dr. Poléjaeff asserts that the Keratosa form probably in this type or subtype nothing more than a single family, and that accordingly they are to be subdivided into genera directly. In order to have no heterogeneous genera among them, he proposes to enlarge the definition of the genus, and for the instances when some undoubtedly good species are constant to a *relative* character to unite them into a subgenus. According to this the family in question would consist of the genera *Darwinella*, *Simplicella* (including the subgenera *Aplysilla* and *Dendrilla*), *Ianthella*, *Spongia* (including the subgenera *Coscinoderma*, *Euspongia*, *Hippospongia* (?), *Cacospongia*, and *Stelospongos*), *Phyllospongos* (including the subgenera *Phyllospongia* and *Carteriospongia*), and *Velaria* (including the subgenera *Aplysina*, *Verongia*, and *Luffaria*). He believes, however, that it would have been premature to follow up in his Report the arrangement just mentioned. Sure as he is that this arrangement is in the main natural in every direction, he confesses that by its adoption only the simplest part of the problem would have been cleared up, its most important part consisting in the task of proving actually which of the subgenera just mentioned are really to be regarded as subgenera (*i.e.*, groups which, although connected by numerous intermediate stages with their systematic neighbours, still present in their organisation a new principle fit for a further development) and not as species and even varieties. This latter question is, according to him, to be decided (perhaps exclusively) by the methods of comparative physiology. Many passages are devoted to the definition of the idea of the genus. In his report on the Challenger Calcarea Dr. Poléjaeff regarded the generic character to be a 'character of sufficient constancy, and together with this, allowing numerous modifications either in the direction of a further development, or in the direction of different variations.' His experience whilst examining the Challenger Keratosa leads him to the suggestion that at least in the instances where but one character—and not a series of them as is the case with the Calcarea—decides the question as to whether the given specimen is to be referred to this genus or to the other, the existence of an *absolute* distinction (in the sense of Nägeli) is indispensable.

"The whole Report is almost exclusively of a critical character. Its most interesting *positive* statements are the following:—on the structure of the skeletal fibres and their development; statements on the formations which Dr. Poléjaeff feels inclined to connect with the filaments; some statements of a more detailed character on the anatomical structure of the soft parts; organisation of *Darwinella*, *Ianthella*, *Psammoclema*, *Psammopemma*, *Carteriospongia*, *Phyllospongia*, *Luffaria*, and *Verongia;* and data on the spermatogenesis in the last mentioned genus."



CHAPTER XVI.

Hong Kong to Manila and Zebu—Mactan and Zebu—Zebu to Camiguin Island and Samboangan—Samboangan—Samboangan to Humboldt Bay—The Polyzoa—Cephalodiscus—Humboldt Bay—Humboldt Bay to the Admiralty Islands—The Alcyonaria—The Nudibranchiata.

Hong Kong to Manila.

On the 6th January 1875, the Challenger left Hong Kong just before noon, steaming out to the eastward through the Lyemun Pass; then between the Tathong Rock and Hong Kong Island for the channel between Sunkong and Pootoy Islands, after passing through which the ship was steered for the northeast head of Lema Island, which was passed at 3.30 p.m., when sail was made and the fires put out.

On the 8th the wind, which had been blowing fresh from the northeast, moderated sufficiently to allow of sounding and trawling, at 11 a.m., in 2100 fathoms (see Sheet 31). The temperature at the bottom proved to be precisely the same as that at 900 fathoms, indicating that the China Sea is cut off from the Pacific Ocean by a ridge of about that depth. At 5 p.m. the trawl was hove up, and sail was again made towards Manila.

On the 9th, the wind having fallen light and hauled to the eastward, sails were furled, and the ship proceeded at 4 p.m. under steam.

On the 10th, at 8 a.m., the land about Yba was seen, and the vessel was steered to the southward as necessary. At 3 p.m. a dismasted vessel was sighted to the eastward, which proved to be an abandoned coaster named the "Santa Maria," and being dangerous to passing vessels was taken in tow. At 5 p.m. Point Silanguin bore S. 48° E., and Point Botolan N. 84° E.

On the 11th, at 4.30 p.m., the vessel anchored in Manila Bay in 4½ fathoms, with the Mole lighthouse N. 48° E., the Cathedral N. 70° E., and Cavité light S. 20° W.

On the passage from Manila to Hong Kong, as well as on this the return voyage, the surface temperature was found to be 3° higher within 60 miles of the coast of Luzon than it was at a greater distance from that island, and this change of temperature was sudden, taking place in the voyage to Hong Kong in a distance of 10 miles, and in the return voyage in 6 miles. On each occasion, so long as the ship was in the belt of warm water, a northerly current was experienced. This stream is shown on the Current Chart of the World, published in 1872, but on the chart of the China Sea (northern portion, sheet 2) a current arrow is drawn as if a S.S.W. set were always experienced in the neighbourhood. The source of this warm current on the Luzon coast has not yet been satisfactorily determined. On the Current Chart of 1872, it is depicted as issuing from the Sulu Sea through Mindoro Strait; but it is highly probable that only a small portion of it is derived from that sea, the greater part being the continuation of the current which is known to set to windward in the middle of the China Sea during the northeast monsoon. This weatherly current in the centre of the China Sea, extending from the Natuna Islands certainly as far as the North Danger, appears to be caused by the resurging of the water driven into this sea by the wind; for it is known that along the western shores of the sea a very strong current, amounting at times to 60 miles a day, runs to the southwestward, that in the southern part of the China Sea the mean level of the tide is higher in the northeast than in the southeast monsoon, and that from this cause the stream is almost constantly running out of the China Sea through the Straits of Singapore, Banka, Gaspar, and Carimata. These facts being known, and also that a northeast current is met with in the centre of the sea, it may be inferred that the straits leading from the China Sea to the Indian Ocean are insufficient to relieve the southern part of the China Sea from the head of water accumulated, and consequently the weatherly current is established in its centre. The existence of this weatherly current was well known to the captains of the old opium clippers, who always worked to windward in the neighbourhood of the reefs; and the mail steamers, in their passage from Singapore to Hong Kong during the northeast monsoon, now take advantage of this weatherly set, and keep just west of the reefs which form the eastern boundary of the main route to China. The tracing of these currents would be a most interesting work, more especially as to whether the Luzon Current joins the stream running northeast along the east coast of Formosa.

Manila to Zebu.

On the 15th January the Expedition left Manila for Zebu, passing through Saint Bernardino Strait, where a small Spanish station was noticed on Santiago Point. On the 16th a sounding and a trawling were obtained in 700 fathoms in Romblon Strait, and on the 17th in 11 fathoms east of the Gigantes Islands. After passing the Gigantes Islands the ship proceeded north of Tanguingui Island, and then through the channel between Malaspascua and Chocolate Islands, round the north end of Zebu Island. Gato Island is pyramidal in shape, about 150 feet high, Chocolate Island is also conspicuous, Malaspascua is low, as is the north extremity of Zebu.

On the 18th, at 1.30 P.M., the vessel arrived at Zebu, and anchored in $10\frac{1}{2}$ fathoms off the town. Steering towards Zebu Harbour from the northward, it was noticed that Baguey Point, when first seen, looked like an island, as there is upon it a round-backed hill about 150 feet high. Mactan and Olango Islands are both very low.

When the ship entered the port, the edges of the shoals were by no means readily distinguished, for muddy water extended right across the narrowest part of the channel. The mud patch northeast of Mandanui tower had only grass and small bushes on its outer southwest part, the remainder being bare.

Zebu.

Mactan Island.—Mactan Island consists of an old coral reef raised a few feet (8 or 10 at most) above the present sea level. At one part of the island, where a convent stands, a low cliff fringes the shore, being the edge of an upper stratum of the upheaved reef. This raised reef is here preserved, but has, over the portion of the island immediately fronting Zebu, been removed by denudation, with the exception of a few isolated pillar-like blocks which remain, and which are conspicuous from the anchorage. These show that the whole island was once of the same height as the distant cliff. Opposite the town of Zebu, the island of Mactan is bordered by a wide belt of denuded coral flat, partly covered at high tide. The surface is scooped out into irregular basins and sharp projecting pinnacles, and covered in all directions with mud, resulting from the denudation. Very few living corals are to be found on these flats, but small beds of them fringe their seaward margin.

These muddy expanses are the haunt of numerous shore birds. In the pools a large Sea Anemone, belonging to the genus *Cerianthus,* expands its tentacles in the full blaze of the sun. *Cerianthus* uses its nematocysts, which in all its widely varying allies are apparently only employed as offensive stinging organs, to construct a dwelling. The cysts are shed out in enormous abundance, and with their protruded filaments matted together and combined with abundant secreted slime, form a tough leathery tube with a smooth and glistening inner surface, which is buried upright in the mud. Within this tube the anemone lives, expanding its tentacles at the mouth of the tube, on a level with the surface of the mud. It has the power of moving itself with extreme rapidity down its tube, and disappears like a flash when alarmed. The species at Mactan Island is very large; the tube measures 1 foot 4 inches in length, and is very thick and heavy; the animal itself is 6 inches in length. This species of *Cerianthus* lives in shallow water in the full heat and glare of the sun, while another species of the same genus, *Cerianthus bathymetricus,* Moseley,[1] differing from it in hardly any particular, except that it is of much smaller size, inhabits the sea at a depth of 3 miles, in almost entire, if not absolute absence of sunlight, at a temperature near freezing point, and under a pressure of, roughly, 3 tons to the square inch.

Zebu.—Zebu (Cebu) is celebrated as being the scene of the death of Ferdinand Magellan (in Portuguese Fernão de Magalhães), the first circumnavigator. Magellan arrived here on the 5th April 1521 (the ships entering the port with all their colours fly-

[1] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, vol. i. p. 302, 1877.

ing, and saluting with their cannon), and met with a most friendly reception from the Rajah of Zebu, who allowed him to erect a chapel on shore and celebrate mass, and who eventually became a Christian, being with all his family publicly baptized; an example followed by most of his subjects. Notwithstanding their Christianity, the natives were wholly addicted to pleasure and idleness. Five or six hours every day were occupied by their meals, their meat being very little cooked and much salted, making them drink much and often. Their dress consisted only of a light covering round the middle, and their houses were built on poles, the ground floor being occupied by their pigs, goats, or poultry. In the villages many houses were constructed in trees. The domestic animals at Zebu were dogs, cats, pigs, goats, and poultry, the two former being used for food equally with the latter. The vegetable provisions were rice, maize, cocoanuts, sugar cane, oranges, pumpkins, and lemons.

Magellan, unfortunately for himself, shortly after his arrival began interfering in the wars between the various Rajahs of Zebu and the neighbouring islands, and was killed at Maetan, on the 27th April, in a quarrel unnecessarily engaged in, and for an unjust cause. On the spot where he was killed a monument has been erected to his memory.

In April 1565, forty-four years after the death of Magellan, Miguel Lopez de Legaspi arrived at Zebu, having been commissioned to annex the Philippine Islands as a colony of Spain, and to convert the natives. He also was peacefully and well received by the Zebu people, but quarrels arising respecting provisions, the natives took up arms and were then conquered and subjected by the Spaniards, who founded here their first settlement, which they named the "City of Jesus," because they found in one of the native huts a carved image of Christ, which it was believed had remained there from the time of Magellan. This image is still in the monastery of St. Augustine in the city.

The island of Zebu is 120 miles in length, and varies from 10 to 17 miles in breadth; its area is about 1200 square miles. A lofty mountain range traverses the island from north to south, reducing the ground sufficiently level for cultivation to a minimum, so that although the island produces sugar, tobacco, maize, and rice, and, in the mountains, potatoes, the quantity of rice grown is not sufficient for the population, the deficiency being supplied from Panay.

The town of Zebu has a population of about 34,000; it is the seat of government of the Bisayans and the residence of a bishop. A considerable export trade is carried on, the articles exported being principally sugar and Manila hemp (abaca). The sugar is of inferior quality, and principally used in the distillery and for making beer, its value being from £12 to £15 per ton.

Zebu possesses considerable beds of coal, but the surface crop only is worked. The ship took in 10 tons to report on its quality, and found it very inferior; the price paid was 8 dollars a ton, whilst for Australian coal the price was 16 dollars a ton; small quantities only of the latter can, however, be procured here. The rock near the town is a diabase, probably an olivine-diabase in which the olivine is almost entirely decomposed.

The land in Zebu belongs for the most part to the Mestizes (half-breeds), and is let out by them to the peasants. The owners of the soil know how to keep the peasants in a state of dependence by usurious loans, and consequently agriculture in this island stands lower than in almost any other part of the Philippine group.

The imported goods, which consist for the most part of cotton stuffs, come from Manila though the Chinese traders there, who purchase from the foreign merchants. Among the importations in 1868 were twenty chests of images.

The tides at Zebu at this season of the year (January) appear to be rather peculiar. It was high water at full and change at midnight. Immediately after high water the tide ebbed 7 feet in about seven hours; it then rose 3½ feet in six and a half hours, after which it fell about 6 inches in three hours, and then rose 4 feet in eight hours, reaching its culminating point at about the time of the moon's transit. The tidal stream however sets regularly six hours each way, the flood tide coming from the southward; but the ebb or south-going stream, immediately following the moon's superior transit, ran with far greater strength than either of the other tides. Its velocity at its greatest strength at the anchorage off Zebu was two miles per hour. Whilst lying at anchor the ship had to be steered for the six hours during which this strong ebb stream was running; during the remaining eighteen hours this was unnecessary. As a surface stream of two knots cannot be considered out of the way, the sheering of the ship can only be accounted for by supposing the under current to have a much greater rapidity than that on the surface.

Supplies at Zebu are scanty; beef very bad, 10 to 12 cents per lb.; fowls $3 to $3½ per dozen, ducks $8 to $10 per dozen; vegetables and fruit very scarce; fish plentiful and moderate; and eggs $3½ per hundred.

South of the town of Zebu the beacons on the reefs had, at the time of the visit, been all blown down, but the buoys remained in position; the one on the Mactan side of the channel was red and white, the others red. These beacons and buoys are maintained by a tax of from one to two cents per ton levied on ships entering the port.

When St. Nicholas Church tower bears N. ¼ E., which is the mark given for leading through the south channel into Zebu, it is in line with the central apex of a triple peaked hill 10 or 12 miles north of the town.

Zebu had a special interest for the naturalists as being the locality from which the beautiful siliceous Sponge, *Euplectella aspergillum* (Venus' flower basket), had been for many years obtained in considerable abundance. It is called by the natives "Reckaderos," and is dredged for in 100 fathoms in the channel between Bohol and Zebu. The form of dredge used by the natives is a very ingenious and effective one. It is represented in fig. 219, and consists of a light framework made of split bamboo, with two long straight strips about 8 feet in length forming its front, and meeting at a wide angle to form a point, which is dragged first in using the machine. The long straight strips have fish-hooks bound to them at intervals all along their length, the points of the hooks being directed towards the angle of the machine. The whole is very ingeniously strengthened by well-planned cross pieces, and is weighted with stones. It is dragged on the bottom by means of a light Manila hemp cord not more than one-eighth of an inch in diameter, which is attached to the angle. A stone attached to a stick is fastened just in front of the angle to keep the point down on the bottom.

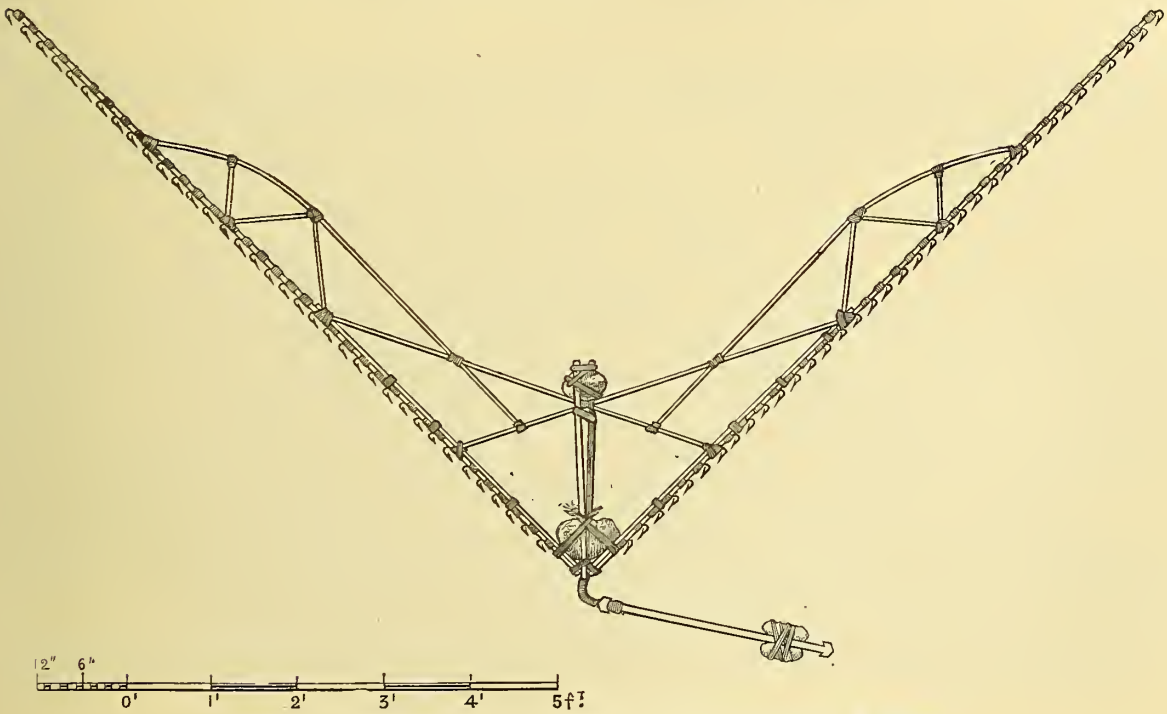


Fig. 219.—Dredge used by the Native Fishermen at Zebu for obtaining *Euplectella*.

The hooks creeping over the bottom and sweeping an area nearly 14 feet wide, catch in the upright sponges and drag their bases out from the mud.

In addition to the *Euplectella*, a good many other siliceous Sponges were obtained both by the native dredge and the ship's dredges and trawls, as well as Echini, Starfishes, Annelids, *Pentacrinus*, Pennatulids, and many other invertebrates. Four parasitic animals were found living on or in the *Euplectella:* an Isopod (*Æga spongiophila*), an Aphroditacean Annelid an inch in length, a small *Pecten*, and a *Palæmon*. Dr. von Willemoes Suhm succeeded in hatching the eggs of the last and keeping the young, which was an ordinary zoœa, in water for some time.

The steam pinnace made several visits to the *Euplectella* ground along with the native fishermen, and many trials were made with the different forms of dredges and trawls. The ship also spent one day in similar work. The position where the greatest number of these sponges were obtained was: the village of Tuiaan 48° 0′ a conspicuous red house at Talisay 54° 0′ St. Nicholas Church, Zebu, the depth being 95 fathoms. The deposit was a green-blue mud containing about 15 per cent. of carbonate of lime, which consisted of a few pelagic and a large number of other Foraminifera, fragments of Echinoderms, Molluscs, and Polyzoa.

Zebu to Camiguin Island and Samboangan.

On the 24th January the vessel left Zebu for Samboangan, intending to touch at Camiguin Island on the way. Steering to the southward through the channel separating Zebu from Bohol Island, a favourable current of two miles per hour was experienced. This current would appear to be by no means uncommon during the northeast monsoon, for Captain Riches of the British Ship "Glamorganshire," who happened to be at Zebu at the time of the Expedition's visit, and who has had much experience amongst the Philippine Islands, said that he had always failed in attempting to work to the northward in this channel. On one occasion he struggled against wind and current for six days without making a mile, and eventually bore up and went round Negros and Panay Islands and came to Zebu from the northward, making this passage in four days from the south end of Bohol.

After rounding Balicasay Island, steam was got up and a sounding, dredging, trawling and temperatures were obtained in 375 fathoms, with Balicasay Island N. 73° W., the left extremity of Siquijor S. 4° W., and Pamilacan Island N. 73° E. (see Sheet 31); at 6 P.M., the ship proceeded under easy steam towards Camiguin Island.

Camiguin Island.—On the 26th January, at daylight, the volcano on Camiguin Island was seen quite distinctly. At noon the ship stopped about a mile from the land, sounded in 185 fathoms, and sent a cutter on shore with a party of naturalists and photographers to examine the volcano, afterwards proceeding for Agajo, anchoring there at 1.30 P.M., with the north points of Camiguin in line N. 78° E., the lighthouse at Agajo S. 45° E., the N.W. point of Camiguin S. 50° W., and the Sandy Cay on the reef off Agajo N. 40° W., in 6 fathoms. The Sandy Cay on the southwest extremity of the reef off Agajo is small and has bushes growing on it.

The volcano at Camiguin Island burst forth in July 1871 from some low land on the west side of the island, and in two months had thrown up a hill two thirds of a mile long, one third wide, and about 450 feet high, destroying the whole vegetation for miles round, as also the flourishing village of Catarman on the western shore. The volcano had at the time of the visit attained a height of 1950 feet and was still in vigour, as denoted by the column of smoke seen by day and the series of small fires visible at its summit by night. Nearly all the inhabitants of Camiguin, the population of which formerly amounted to 11,000 had left the island in consequence of the outburst. The volcano, a dome-shaped mass standing on the sea shore, was found red and glowing with heat in cracks at the summit, and smoke was ascending from it. There appeared to be no crater, and Mr. Buchanan, who was one of the landing party, drew attention to the fact that the lava of which it was composed was entirely trachytic. It recalled in form at once some of the smaller trachytic domes of the Puy de Dome district, in the Auvergne, concerning the mode of formation of which there has been much doubt. The mass in this case appeared never to have had any crater, but rose with steep walls directly from the soil, formerly covered

Fig. 220.—New Volcano, Camiguin Island.

with vegetation which it had destroyed, and it appeared as if the trachytic lava had issued from a central cavity and boiled over, as it were, till it set into the form of the dome. The rocks collected at the volcano were amphibolic andesite containing some crystals of augite, and augite-andesite with hornblende, the specimens showing often transition between the two types of rocks.

The ground around the crater was still almost bare of vegetation, but some plants were beginning to colonize the denuded soil, strongly impregnated as it was with various volcanic chemical products. Three species of ferns, as first colonists, grew as isolated plants here and there; and along the courses of two small streams fed by hot springs, issuing from the base of the volcano, where the poisoned ground was constantly washed, a good deal of vegetation was to be found, amongst which were several sedges and grasses and a rush. About the mouths of the cavities from which hot gases were slowly being exhaled, a moss was found growing in great abundance, with several lowly organised Cryptogams; the whole being confined to the spot occupied by these fumeroles, and forming green patches in the midst of the surrounding entirely bare rock.

The hot streams were full of green Algæ, and as these streams, being very small, became cooler and cooler from their source downwards, the temperature at which the Algæ commenced to flourish could be determined. At the source of one of these streams, as it issued from beneath the volcano, the water had a temperature of 145°·2 F., and was thus too hot to be borne by the hand. Here there were no Algæ at all growing in the water. There were, however, small green patches on stones projecting out of the bed of the stream into the air, and also along the margins of the stream where they were not bathed by the hot water itself, but only soaked up the moisture and received the spray occasionally. At a distance of a few yards lower down, in a little side pool fed by the stream, abundance of Algæ were growing, but the pool had a temperature of only 101°·5 F., though the stream which fed it constantly was at 122° F. Lower down again, Algæ were growing in the middle of the stream, in water at 113°·5 F., and this seems thus to be the limit of temperature at which the particular Algæ gathered will flourish in water impregnated with a certain amount of salts in solution. No doubt the amount of salts present has a limiting effect as well as the temperature. Oscillatoriæ have been observed growing in water, at a much higher temperature, even 178° to 185° F.[1] The fact is interesting, as showing that green algæ of some considerable complexity may have commenced life on the earth in its early history, before the water on its surface had anywhere cooled down to a temperature sufficient to be borne by the human hand, and which may have been strongly impregnated with various volcanic gases and salts.

The upper slopes of the mountains of Camiguin Island were thickly wooded; while the lower slopes were cleared and planted with Manila hemp. A Manila hemp plantation is not at all pleasant or easy to traverse; the large trees, a species of Banana (*Musa textilis*), from the stems of which the fibres known as Manila hemp are obtained by maceration, are planted close together. The plantations are full of fallen stems in a half decayed condition, nasty pasty masses, which block the way and are very unpleasant to handle and climb over, or crawl beneath.

At 6 P.M. the vessel left the anchorage and steered to the westward towards Silino Island. In steering towards, as well as on leaving, the anchorage, the north points of Camiguin Island were kept in line, and no soundings were obtained with 15 fathoms until the Sandy Cay on the reef bore west of north. Whilst the ship was at anchor, the tide was falling until 4 P.M., after which it began to rise; the ebb stream set N.E., the flood S.W.

[1] See W. T. Thiselton Dyer, *Proc. Linn. Soc. Lond.* (Bot.), vol. xiv. p. 327, 1875.

On the 27th, at 9.15 A.M., the ship passed between Silino Island and Point Tagolo, and then steered to pass inside Aliquay Island. At noon, whilst the position of the ship was being ascertained, a small coral patch of 6 fathoms was passed over between Aliquay Island and Point Sigayac, the bottom being distinctly seen. Only two casts of the lead were obtained on it, there being no bottom with 20 fathoms on either side. From it the extremities of Aliquay Island bore N. 13° W., and N. 27° W., and Point Tagolo N. 81° E. The ground in this vicinity would appear to be patchy, as H.M.S. "Nassau" got shoal soundings three miles north of Aliquay Island. After passing Aliquay Island the ship was steered to the W.S.W. along the shore of Mindanao Island.

The islands of Silino and Aliquay are both low and flat. On the chart there is said to be an obelisk at Dauit Point; this was not seen in passing.

On the 28th, at 8 A.M., a sounding and serial temperatures were obtained in 2225 fathoms, in lat. 8° 0′ N., long. 121° 42′ E. (see Sheet 31), partly to see if any alteration had taken place in the temperatures since sounding in the Sulu Sea in October last, and partly to test a new instrument for obtaining temperatures, the invention of Messrs. Negretti & Zambra. A full account of this apparatus is given with the description of the other instruments and therefore need not be here repeated (see p. 88). At 11 A.M. the ship again proceeded towards Samboangan. The island of Mindanao was in sight all day, but there were no points visible by which the position of the ship could be fixed.

Samboangan (Zamboanga).

On the 29th, at 7 A.M., the vessel anchored off Samboangan in 10 fathoms, with the lighthouse N. 10° W., the right extremity of Tigtauan Island, in line with Mariqui Point, S. 71° E., and the left extremity of Santa Cruz Island S. 3° W. Lying here were four large Spanish gunboats employed in the blockade of the Sulu Archipelago. Having obtained equal altitudes, the ship left the anchorage at Samboangan the same day and proceeded for the anchorage off Malanipa Island, in order to be on the ground ready for swinging ship the next morning. The ship passed between the great bank off Malanipa, Tigtauan, and Sacol Islands, and anchored in 20 fathoms off Malanipa at 6.20 P.M., with the extremities of that island bearing S.S.W. ¼ W. and S.E. by S.

On the 30th, at 4 A.M., the vessel left the anchorage off Malanipa and proceeded to the eastward, ready to commence swinging at sunrise. At 8 A.M., the errors of the compass having been ascertained, swinging was commenced for the dipping needle and was completed at 1 P.M., when, having obtained a few dredgings off Malanipa, the ship returned to Samboangan, anchoring off that town at 7 P.M.

The object in coming to Samboangan again was to complete the stock of coal before standing to the eastward into the Pacific, as it was known that from the time of leaving Samboangan no more fuel could be procured until Japan was reached. The Spanish authorities were daily expecting the arrival of a transport, and the ship remained at Samboangan waiting for her, but on the 3rd February, seeing no signs of her approach, the Spanish Governor very kindly allowed the vessel to proceed to Port Isabella, in Basilan Island, and fill the bunkers from the stock of coal there remaining. This was the more obliging on the part of the Governor, since they had but 200 tons remaining at that time, and the Challenger required half that quantity.

The ship left Samboangan at 8 A.M. on the 3rd February, and steered to the westward until Point Caldera bore north, when the course was altered for Malamaui Island. In crossing the strait, soundings were struck on a small coral patch of 10 fathoms, with the right extremity of Malamaui (the S.W. part), in line with a flat-topped hill on Basilan Island, S. 8° E., north point of Basilan Island S. 72° E., the summit of Lampinigan Island S. 22° W., and the right extremity of Santa Cruz Island N. 66° E. It will be seen that these bearings, plotted on Admiralty chart 961, do not agree in fixing the position of this patch of 10 fathoms, nor in fact have any of the bearings coincided in one point when plotted on this sheet; the whole place certainly requires re-surveying. At 11 A.M. the vessel rounded the southwest point of Malamaui Island and was steered as necessary into Port Isabella, passing north of the island at the entrance. Being provided with a Spanish chart of the port, there was no difficulty in piloting the ship by it, especially as there were beacons on most of the dangers. These beacons consisted of a stake with a ball on the top, the balls being coloured black on the Malamaui side of the channel and white on the Basilan side. The coral and sand reef on the southeast side of Mow Island is very conspicuous; part of the sand is always above water, and mangrove bushes are beginning to grow there.

The ship steamed up to the coaling wharf, which projects from Malamaui Island opposite the town of Isabella, and letting go an off anchor, was hauled alongside. The wharf was merely a rough wooden jetty, with a depth of 3 fathoms at its outer extremity, and so slightly built that even small vessels could not lash alongside, but were compelled to use off anchors, both ahead and astern; nor were there any anchors, or posts, on shore to which hawsers could be secured; in fact it was difficult to find any stable thing to which attachments could be made. There were, however, a number of large flat stones in the vicinity, and by backing one of these stones with another, it was managed, with some little difficulty, to secure the ship properly. The stock of coal was completed by 11 A.M. on the 4th February, and at 2 P.M. the ship left for Samboangan, anchoring there at 7 P.M.

From a table of tides for Port Isabella kindly lent by the Spanish authorities, it appears to be high water at full and change at 9^{h} 15^{m}. Spring tides rise 4 feet; age of the tide twenty-four hours. The flood stream comes from the N.E., the ebb runs N.E. Its velocity is said to be sometimes very considerable, but whilst lying alongside the pier it did not exceed $1\frac{1}{2}$ miles per hour.

At Samboangan the extremity of Tigtauan Island in line with Mariqui Point is an excellent mark for the edge of the bank off Samboangan (between the extremities of the town). Outside this line of transit the water is deep; when on it, the soundings vary from 10 to 13 fathoms, whilst inside the water shoals rapidly. Vessels intending to remain at Samboangan for more than twenty-four hours should moor, as it is almost impossible to keep a clear anchor owing to the strong tide and frequent calms. It was noticed whilst lying at Samboangan that the stream did not turn at the time of high and low water by the shore, but from two to three hours after high or low water. The captain of the Spanish surveying vessel said that the tides in Basilan Strait were very irregular, and that the high water at full or change of the moon varies from seven to ten hours after the moon's transit. The diurnal inequality here follows the same law as over the whole of the China Sea, the day tide being highest when the sea is north of the Equator, and the night tide when it is south.

Samboangan is a small Spanish town at the southwest extremity of Mindanao Island. From the town a pier extends to the edge of the shallow water to facilitate landing; at the outer end of this pier is a lighthouse, and at its inner end the captain of the port's office; just behind which again is the church. Running parallel with the beach, between the office of the captain of the port and the church is a canal, which is used by the inhabitants as a bathing place. At low tide the water in the canal is fresh, but brackish at high water. At the eastern end of the town is a quadrangular fort with four bastions, founded in 1635. The town itself is small, but contains a few shops and a hotel.

At the cemetery at Samboangan there are a number of small niches built against the wall like ovens, into which the dead bodies are first placed and covered with quick-lime. After remaining in these niches for three years, the bones are collected and thrown into a common receptacle.

A plain extends from Samboangan some three miles, to the foot of the hills, which is cultivated principally with rice; this tract of land is so low and swampy as to appear unhealthy, but the authorities do not give it that character. The traffic into the country is kept up by means of sledges, drawn by water buffaloes, probably the soft muddy road does not allow wheeled vehicles to be used. Small ponies can be hired at a moderate rate for a ride into the interior, but they are not up to more than about a dozen miles a day.

A Spanish surveying vessel was found here at anchor, engaged in the survey of the Tawi Tawi group; but as the Spaniards were at war with the Rajah or Sultan of Sulu they were not able to prosecute their work satisfactorily.

On landing at Samboangan on the way from Australia the naturalist could not fail to be reminded that the Expedition was nearing India, and scenes in Ceylon were recalled at once to memory. Swampy paddy fields stretched everywhere round the town with plenty of snipe in them, and the domestic buffaloes lay about wallowing in mud pools and throwing water over their backs with their scoop-like ears. In one pool, several native women were bathing in company with the buffaloes.

Especially interesting in the Philippines are the various stages in development and modification of pile-dwellings. All the native buildings are pile-dwellings or modifications of them, and some of the better houses, built under European influence, are evidently copied directly from the same models. Pile-dwellings are first invented as an expedient for raising houses in the water for protection; but when the race which for generations has thus dwelt surrounded by water takes to living on dry land, actuated somewhat no doubt by sanitary considerations, it follows the ancient pattern of architec-

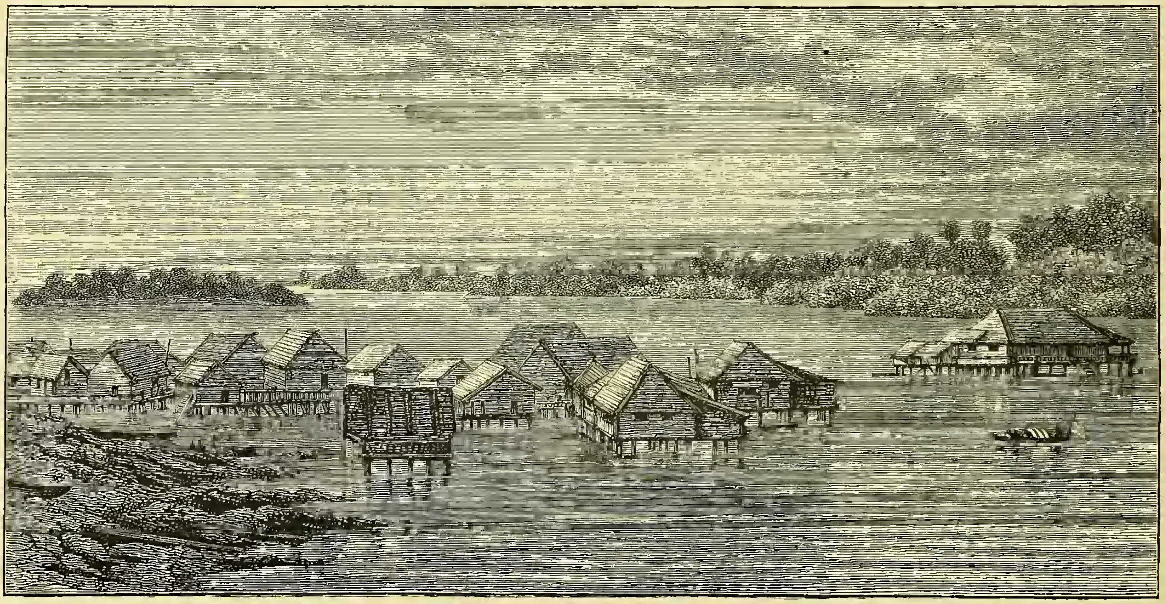


Fig. 221.—Pile-Dwellings of Lutaos, Samboangan.

ture with slavish exactness, and only by gradually introduced modifications of that plan arrives at last at a house supported directly on the ground.

At Samboangan and at the neighbouring island of Basilan are settlements of a considerable number of a race called by the Spanish "Moros" (*i.e.*, Mohammedans), who keep themselves strictly apart from the Bisayan and other Malay races, amongst which they here dwell. The Moros at Basilan still build their pile-dwellings out in the sea, so that they can only be approached by boats. At Samboangan, however, where the Moros seem somewhat more tamed by Spanish influence, they have so far come on shore with their houses, that these are built in a row along the beach, and at low tide are not entirely surrounded with water, whilst the shore can always be reached from them by means of a plank. The main inhabitants of the Philippines, in the course of successive generations, have taken their houses altogether on shore, except that occasionally there are houses in swampy ground, which form a sort of gradation between the two conditions.

The Moros or "Lutaos" are said to have settled in Mindanao in the seventeenth century, and to have considered themselves until quite recently as subjects of the Sultan of Ternate.[1] They are a fierce and warlike race; pirates by profession at all events not long ago at Basilan and Mindanao, and still so at the Sulu Islands. They seem but half subjected to the Spanish rule. The men are short and broad shouldered, with powerful chests and thick-set bodies, and extremely active; their features are of the Malay type, but peculiar; their eyes are remarkably bright; their colour is light yellowish brown; they have often a slight beard and moustache; they wear bright coloured shirts and rather tight fitting trousers, buttoned close round the leg at the ankle. The Moro women are short and small, and delicate limbed, most of them very handsome when young; many of them are very light coloured in complexion; their eyes, like the men's, being extremely bright. They are fond of bright yellows and reds in their dress, and are very fully clad. The men are armed with circular shields and spears, and also used, formerly at least, suits of armour made of plates of buffalo horn, linked together with wire, which are very rare objects in ethnological museums.

At Port Isabella, Basilan Island, the Moro houses are constructed on piles in a small lagoon-like offset of the channel between this island and the small outlying island of Malamaui. The houses are entirely isolated from the shore by the water. They stand together, and a wide rickety platform connects many of them with one another.[2] At Samboangan the Moro houses are also built in a group. The main house in each case is usually supported on three rows of piles, but various additions and out-buildings are supported on irregularly added piles; there is always a platform before the entrance, and sometimes one for canoes behind. It was odd to see a horse left tied by its Moro owner to the door-post, standing up to its belly in the water, through the rising of the tide.

The houses of the other native inhabitants throughout the towns of Samboangan and Ilo Ilo are mostly of closely similar pattern, and they stand in like manner on piles, though on dry ground, and have a platform usually at one end, which is reached by a short steep ladder, with widely separated and irregular rounds, up which the house dogs, from practice, run as nimbly and easily as the children and their mothers. The platforms are now used for drying clothes upon, and such purposes.

The first process of modification of the pile-dwelling gone on shore, is the putting up of a fence of palm leaves in the lower part of the spaces between the piles supporting the house. A pen is thus formed in which pigs or other animals are kept. Then well-made mats or reed walls are put up, entirely enclosing the space between the piles, with a

[1] Dr. Th. Waitz, Anthropologie der Naturvölker, Th. v. Hft. 1, Die Malaien, p. 56, Leipzig, 1865.

[2] For an account of the inhabitants of the Sulu Islands, the same race as the Moros, with descriptions and figures of their houses, see Wilkes, Narrative of the U.S. Exploring Expedition, vol. v. chap. ix., New York, 1856.

regular door for entrance, and the place becomes a convenient store-house. As a further stage, boards are nailed between the piles, and a secure chamber is obtained. Pl. XXVIII. is a photograph of two Bisayan pile-dwellings at Samboangan which are thus placed on shore, although still, as is to be seen, close to the water's brink. In the smaller one on the right remains of the platform are seen in front of the door with the ladder leading up to it. The space beneath the house occupied by the supporting piles is in its primitive condition unenclosed. In the case of the larger house on the left, the area between the piles beneath the actual house is completely enclosed by a fence; the platform ladder and entrance are not seen, being on the other side of the house.

A further step again, is the adoption of stone pillars for the wooden piles. Wooden houses thus supported on stone representatives of piles, may often be seen with an iron railing, passing from pillar to pillar beneath, and in this way forming an enclosure. From stone pillars the step is easy to arches, supported on pillars of masonry as a substructure; and some houses of business, although their upper structures have ceased to be wooden, and are built of more solid materials, are still to be seen amongst the rest, supported thus on the descendants of piles. In the last stage the arches are discarded, and continuous walls of masonry substituted as a support to the wooden superstructure. Even then the ground floor is often still used only as a storehouse or piggery, but in many cases is regularly occupied. Thus in these houses, what would seem almost an impossibility is nevertheless the fact: the ground floor is an addition to the first storey, which latter is older than it, and preceded it. The verandah is the representative of the platform originally intended for the inhabitants to land on from canoes. The building of one house was watched, which, when finished, looked perfectly two-storied, the lower part being neatly boarded in, and provided with a door and windows. Nevertheless, in the construction of the house, the history of its development was exactly recapitulated, just as is the case familiarly in natural history. The roof and first storey were built first complete upon the piles, and the lower structure added in afterwards.

The remarkable resemblance of many of these Malay houses to Swiss châlets is most striking. In the châlet the basement enclosed with stone walls is usually only a cattle stall, the first storey is the dwelling house, and as in the Malay building, is constructed of wood. It seems possible that the châlet is the ancient lake-dwelling gone on shore, like the Malay pile-dwelling, and that the substructure of masonry represents the piles which formerly supported the inhabited portion of the house. There are similar balconies in the châlets representing possibly the platforms. A good deal of the carving of balconies, and some of the staircases, in the better constructed wooden houses in Ilo Ilo, reminded one very much of that of the same structure in châlets, though the resemblance in this case is accidental.

The most interesting feature about pile-dwellings seems to be their very wide geographical extension. Representatives of almost all races of men seem to have arrived at the

HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

BISAYAN HOUSES, ZAMBOANGAN.

same expedient, apparently not by any means a simple one, independently of one another. There are the well-known Pfahlbauten in Switzerland, in Scotland, and in South America the similar houses of the Cuajiro Indians on the Gulf of Maracaibo. In North America the Haidahs on the northwest coast construct similar habitations. Commander Cameron lately observed similar dwellings in Lake Mohrya, in Central Africa.[1] In New Zealand the Lake Pas, which were mostly used as storehouses, are known from the Rev. Richard Taylor's description;[2] in this case, piles were driven into the bottom of the lake, and the interstices filled in with stones and mud, so as to form a platform. There are the well-known New Guinea pile-dwellings, such as seen at Humboldt Bay, and there are also the pile-dwellings of all the Malay races. The Gilbert Islanders also construct houses raised on piles, and a number of these natives from the island of Arorai, who were taken to Tahiti to serve as labourers on cotton estates, have put up houses of this kind for themselves in the latter island, amongst the very different dwellings of the Tahitians themselves.

It seems probable that the idea of a pile-dwelling has in many cases arisen from the escape of natives from enemies by getting into a canoe or raft, and putting off from shore into a lake or the sea, out of harm's way. If the attacked had to stay on such a raft or canoe for some time, they would anchor it in shallow water with one or more poles, as the Fijians do with their canoes on rivers, and hence might easily be derived the idea of a platform supported on piles. With a maritime race the difficulty connected with clearing away the jungle on shore may have led them to adopt pile-dwellings as more easily constructed, as well as safer.

The officers of a Spanish man-of-war in the port of Samboangan at the time of the visit, hospitably gave an entertainment on shore, and got the Lutaos to dance. Two men danced with spears and shields in imitation of a combat, in which the utmost rage was simulated on both sides; the teeth were clenched and exposed, the head jerked forward, and the eyes starting as they advanced to the attack (see fig. 222). The dance of the women was like that already described as performed by the Ki Islanders. The body was kept nearly rigid, and turned round slowly or moved a short distance from side to side by motion of the feet alone. The feet were kept close together, and side by side, and moved parallel to one another with a shuffling motion. The principal display in the dancing consisted in the very slow and gradual movement of the arms, wrists, and hands. One arm was maintained directed forwards and somewhat upwards, the other at about the same angle downwards, and the position of the two was at intervals gradually reversed; the hands were turned slowly round upon the wrists, and often the dancing consisted for some interval merely in the graceful pose of the

[1] V. L. Cameron, R.N., Across Africa, vol. ii. p. 65, London, 1872.

[2] Rev. Richard Taylor, F.L.S., On the New Zealand Lake Pas, *Trans. N. Zeal. Inst.*, vol. v. p. 101, 1872.

body, and this movement of the hands (see Plate F.). The main point in the dancing seemed to be that all the motions should follow and pass one into the other with perfect gradation in time, and without any jerk or quickening. The thumbs were always maintained extended at right angles to the palms of the hands, as at the Ki Islands. A young boy danced a somewhat similar dance to that of the girls. During his performance he at one time put forward one leg and curved the sole of his foot so that only the toe and heel touched the floor, and turned round with the foot in that position. At another time he shuffled along slowly with the heel of one foot in the hollow of the other.

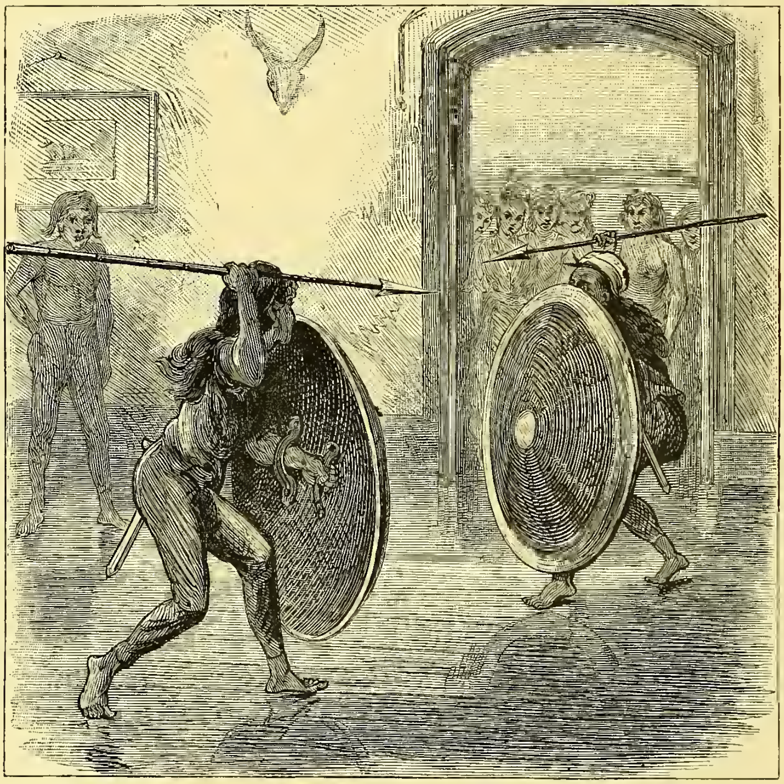


Fig. 222.—Spear Dance of two Lutaos at Samboangan. From a sketch by Lieut. Swire, R.A.

From a Moro boy a Jew's-harp was obtained made of bamboo, on which he was playing. The instrument is most ingeniously cut out of a single splinter of bamboo, the vibrating tongue being extremely delicately shaped, and cleverly weighted by means of a knob of the wood left projecting on its back. The instrument produces a tone indistinguishable from that of a metal Jew's-harp, and is quite unlike Melanesian bamboo Jew's-harps in its form.

In the tide-way between Samboangan and the Island of Santa Cruz Major, whilst the water was running in both directions, a most unusual abundance and variety of surface-living oceanic animals and larvæ of shore forms was obtained with the tow-net; amongst

M. Hanhart lith.

Hanhart imp.

LUTAO GIRL AND BOY, DANCING, AT SAMBOANGAN.

these were Tornaria, and larvæ of Sipunculids and *Chirodota.* The place would be a most convenient and productive one to a working zoologist.

The Brachiopod, *Lingula,* is so abundant in shallow water close to the town, that two boys gathered more than a hundred specimens at a single low tide at the request of von Willemoes Suhm.

A King Crab (*Limulus rotundicaudatus*) is not uncommon near Samboangan, and is called "cancreio." Von Willemoes Suhm thought that he had obtained a series of young larvæ of *Limulus* amongst the surface animals collected by the net, but he subsequently came to the conclusion that he had been mistaken, and that the larvæ were probably those of Cirripeds.[1] At low tide, by wading and turning over stones, enormous Planarians belonging to the genus *Thysanozoon* are to be found in abundance; they are of a dark purple colour, and measure, some of them, as much as 5 inches in length and 2 inches in breadth.

Mr. Moseley, accompanied by von Willemoes Suhm, paid a visit to the island of Santa Cruz Major, sailing over in a Lutao canoe managed by two of these natives; the boat was armed with a large number of bamboo spears, simple light bamboos cut off slanting at one end so as to form a sharp cutting point like that of a quill tooth-pick in shape. A bamboo so cut is extremely sharp, and the spears must be formidable weapons, especially against a thinly clad adversary. Two or three dozen of these spears were placed on rests on either gunwale of the boat, and there were besides two round shields of a kind of basket-work in the boat.

The object in visiting Santa Cruz Major Island was to search for the great Cocoanut-eating Crab (*Birgus latro*). It is called "Tatos" at Samboangan, and survives in Santa Cruz Major because there are no pigs in the island. Wild pigs destroy not only these crabs, but dig up Shore Crabs (*Ocypoda*) and Land Crabs from their holes. In Ceylon, near Trincomali, the wild swine come down every night to the beach to dig up crabs, and large tracts of sandy beach are ploughed up by them in the search. The "tatos" is sought for and eaten as a delicacy by the inhabitants of Samboangan.

Landing was effected close to a Moro house built out into the sea, so as to be surrounded at high water. The inhabitants were lolling about in the shade, and though offered good pay they would not go a quarter of a mile to look for "tatos." At last a boy consented to go as guide; instead of searching for the crabs under the cocoanut trees as expected, he showed as the haunts of the animals hollows at the roots of mangrove and other trees in swampy ground, amongst the holes of ordinary land crabs, but no "tatos" was discovered. Von Willemoes Suhm was anxious to investigate the development of the *Birgus* from the egg. An intelligent native at Samboangan, who collected for the Expedition, said that the female crab carries about large masses of eggs with it in the month of May, and retains them so attached until the young are

[1] See *Quart. Journ. Micr. Sci.*, N. S., vol. xxiii. p. 145, 1883.

developed, just like the parent; he said the crabs went down to the sea occasionally to "drink."

A Mound Bird (*Megapodius*) is common in Santa Cruz Major Island. The calcareous sand amongst the bushes close to the sea shore was scratched and turned over in many places by these birds in burying their eggs. The guide dug out half a dozen eggs closely resembling hen's eggs in appearance from one of these places. They were buried in the clean sand at a depth of 3½ or 4 feet, and with no mound over them, or vegetable rubbish of any kind. The eggs are thus hatched by the simple warmth of the sand received from the sun and retained during the night, just in the same manner as turtle's eggs are hatched, indeed turtle's eggs are found in precisely similar holes. It was midday, and the surface sand was not much hotter than the sand below where the eggs lay, which felt, as well as the eggs, distinctly cool to the touch. These birds do not therefore, as commonly supposed, hatch their eggs solely by means of the heat derived from decayed vegetable matter.

Alcyonarians (social Polyps distinguished by having eight tentacles) are extraordinarily abundant about the beach of Santa Cruz Major. The reef rocks are covered with the soft spongy forms, which form extensive beds, soft and boggy to tread on in wading. Amongst these grows a stony coral which is likewise, as was discovered by Mr. Moseley on examining its minute structure, Alcyonarian, forming thick erect plate-like masses of a chocolate colour when living. The coral is remarkable because its hard calcareous skeleton is of a bright blue colour instead of white, as is usually the case, and is hence named *Heliopora cærulea*. It is, as far as is known, the only surviving representative of a large number of extinct forms of Palæozoic age, which are familiar in the fossil condition, and is nearly allied to the well known red coral of commerce.[1] Again, another interesting Alcyonarian is abundant, together with those just described, namely, the red Organpipe Coral (*Tubipora musica*). There were cartloads of this coral, dead and dried, lying on the beach, which was entirely composed of various coral débris. The Organpipe Coral was not to be found living in shallow water on the reefs, but living specimens were dredged from a depth of 10 fathoms.

The houses of the Moros at Basilan Island have already been referred to; the town was mostly, at the time of the visit, in process of construction by families of Bisayans moved from Samboangan, and much of it was being built on causeways and made ground constructed with coral rock on tidal mud flats; some families newly arrived were camped on the sites of the houses they were building.

Separated from Basilan Island by a narrow strait is the very small island of Malamaui, mostly covered by a dense forest of lofty trees, many of which have the curious vertically projecting plank-like roots so fully described by Mr. Wallace in Tropical

[1] H. N. Moseley, On the Structure and Relations of the Alcyonarian Heliopora cærulea, &c., *Phil. Trans.*, vol. clxvi. pt. i. pp. 91–129, 1876.

Nature.[1] The natives cut solid wheels for their buffalo carts directly out of these natural living planks, and the large circular window-like holes left in the roots at the bases of the trees are curious features in the forest. When traversing the forest one was constantly put on the alert by the rustling of what sounded like some large animal amongst the dead leaves, and expected every minute to get a shot at a deer, but at last it appeared that the animal disturbing the silence of the forest was a huge Lizard (probably *Hydrosaurus marmoratus*) which bolted up the trees when approached, and sat in a fork to gaze at the intruder. The forest was full of these reptiles. In the same forest occurs the well-known aberrant flying insectivorous mammal (*Galeopithecus philippinensis*), which, like a flying squirrel, has membranes of skin (patagia) stretched between its legs and out on to its tail; so that, supported on this as by a parachute, it skims through the air in its leaps from tree to tree with a partial flight. On one of a group of trees standing isolated, not having been as yet felled in the process of the formation of a clearing, after much search, a Kaguan (*Galeopithecus*) was seen hanging to the shady side of the tall trunk. It was an object very easily seen, much more so than would be expected, and moved up the tree with a shambling jerky gait, hitching itself up apparently by a series of short springs. It was found when shot to be a female with a young one clinging to the breast, and was in a tree at least 40 yards distant from any other, and must have flown that length to reach it. The guide said that numbers of the animals were caught when trees were cut down in clearing. They are especially abundant at the island of Bohol, north of Mindanao, and their skins were for sale at Zebu at four dollars a dozen.

Close by on some lower trees were seen several Flying Lizards (*Draco volans*), which similarly have a flying membrane, but in their case supported on extensions of the ribs. The little lizards were seen to spring several times from tree to tree and branch to branch, but they pass through the air so quickly that the extension of their parachute is hardly noticed during the flight. Several of them were kept alive on board the ship for a day or two, where they flew from one leg of the table to another. It was curious to find two animals so widely different in structure, yet provided with such similar means of flight, thus occurring together in the same grove and even on the same tree.

While the ship was absent at Port Isabella coaling, a party of officers and naturalists, with three men, remained at Samboangan and made an excursion to the high land about seven miles distant, where they pitched a tent in a beautifully wooded valley and were engaged during the 2nd, 3rd, and 4th February in various collecting and hunting expeditions.

Monkeys (*Macacus philippensis*) and Hornbills were very numerous in the valleys, and the woods continually resounded with their cries and calls. A large number of specimens were collected. Among twenty-two species of birds preserved were five new

[1] A. R. Wallace, Tropical Nature and other Essays, p. 31, London, 1878.

species,[1] viz.—*Buceros mindanensis*, Tweedd.; *Dicrurus striatus*, Tweedd.; *Phabotreron brevirostris*, Tweedd.; *Batrachostomus septimus*, Tweedd.; and *Dicæum mindanense*, Tweedd. Five new species of Lepidoptera[2] were obtained, viz.—*Zizera oriens*, Butler; *Terias invida*, Butler; *Terias vallivolans*, Butler; *Appias mindanensis*, Butler; *Phyllodes cerasifera*, Butler; and one new species of Hymenoptera,[3] *Bracon trisignatus*, Kirby; and also *Polyrhachis phyllophila* and *Polyrhachis sculpturata*, Smith, not previously recorded from the Philippines.

At Malanipa Island, a very small island, not far from Samboangan, natives had felled a good many large trees to make canoes. The suitable trees are usually at some distance from the water. A straight broad road is cut through the smaller wood direct from the large tree to the sea shore; the smaller trees are felled so as to fall across the road, and across their prostrate trunks the canoe is hauled to the shore. The open avenues were extremely useful in affording an easy road into the interior of the forest for collecting purposes. Among nine species of birds shot on this island by a landing party was a new species of Sun Bird (*Nectarophila juliæ*, Tweedd.), which was very numerous among the tops of the high trees.

Samboangan to Humboldt Bay, New Guinea.

On the 5th February, after having obtained the necessary observations for rating the chronometers, and purchasing a few goats and pigs to land on any uninhabited island which might be visited, the ship left the anchorage at 6 P.M. and was steered to the eastward for the Sarangani Islands at the south end of Mindanao Island.

The course after leaving Samboangan was over comparatively new ground. The main object was to get sufficiently far to the eastward to be able to make a fair wind of the northeast trade to Japan, so that the coals might be expended in sounding and trawling, more especially as this would give a meridional section in the western part of the Pacific Ocean from the Equator to Nipon Island. The secondary object was to visit any unknown islands on the course, and if possible to pay a flying visit to New Guinea. In planning out the track, it was found that, so far as was known, only one navigator had hitherto pursued it, viz., Dampier in the year 1700. His vessel rounded the northwestern extremity of New Guinea on the 5th February, and sailing along the Equator reached the meridian of 150° E. in twenty-one days. It was therefore reasonable to expect to get far enough to the eastward by the end of February to be able to make a fair wind of the northeast trade in proceeding towards Japan. The Expedition was, however, not so fortunate as Dampier, for even occasionally using steam, it took twenty-six days to reach the meridian of 147° E. (or the Admiralty Islands), but after leaving the Admiralty

[1] Zool. Chall. Exp., part viii., 1880.
[2] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xi. pp. 417, &c., 1883.
[3] *Ibid.*, vol. xiii. p. 505, 1884.

Islands a nearly straight course was made for the south part of Nipon Island. Had the winds been favourable, the Expedition would have proceeded east as far as Greenwich Island, and from thence sailed to Hogolu in the Caroline group, thence to Guam in the Ladrones, and afterwards to Yokohama, but the investigation of those interesting places had to be abandoned.

On the 6th February, at daylight, in lat. 6° 38′ N., long. 122° 38′ E., the ship was again swung for the errors of the compass. This additional swinging was rendered necessary in consequence of the pinnace's boiler having been shifted from the quarter deck to the forecastle. At 8 A.M. this operation was completed and sail was made to the eastward, the wind being light and variable.

On the 8th February the ship sounded and trawled in 2050 fathoms in the Celebes Sea in lat. 5° 47′ N., and long. 124° 1′ E. (see Sheet 31), and at 7 P.M. proceeded under easy steam towards the Sarangani Islands.

On the 9th February, at 5 A.M., the Sarangani Islands were sighted, and the ship was steered to pass between them and the island of Mindanao, and as it soon became evident that the chart of this neighbourhood was incorrect, a running survey of the islands and channel was made.

Balat Island has a rounded top 2350 feet high in lat. 5° 28′ N., long. 125° 23½′ E. In shape it is an irregular quadrangle 5¾ miles in length E.N.E. and W.S.W., and about 3 miles in breadth; off its southwest end is a rock about 40 feet high.

Sarangani Island lies in a north and south direction to the eastward of Balat Island, leaving a channel 1½ miles in width between the two islands which appears to be navigable, as Captain Waterman of the "Volunteer" passed through it and reported a shoal running out from one of its sides.[1] Sarangani is 5¾ miles in length and 2 in breadth. Its top, which is comparatively level, is about 500 feet above the level of the sea. Its coast line appeared irregular on the western side, so much so as to cause it to be believed that small bays or coves might there exist in which anchorage could be found. The north part of Sarangani is in lat. 5° 33′ N., long. 125° 29′ E.

Lanibal Island is a small flat cay with trees on it, 60 feet in height, 1 mile N.E. by N. from the north point of Sarangani Island; it is surrounded by a coral reef, between which and that fringing the north point of Sarangani is a narrow channel which appeared navigable.

The southern peninsula of Mindanao is high and has several remarkable peaks on it. The southern hill, 1670 feet high, which is really round-topped, looks somewhat like a pyramid on an E.S.E. or W.N.W. bearing; its summit is in lat. 5° 39′ N., long. 125° 21′ E. Seven miles N.N.E. of this round-topped hill is a saddle peak 3600 feet above the level of the sea, the summit of which is in lat. 5° 46′ N., long. 125° 24′ E., and 8 miles northeast from this saddle mountain there is a high range, the highest peak of which, 4530 feet, has a conical top when viewed from the southward, and is in lat. 5° 51½′ N., long. 125° 30′ E.

Cape Sarangani is a bluff point in lat. 5° 34′ N., long. 125° 21′ E. From it the coast on the west side trends N.W. by W. 3 miles, and on the other side east for 2 miles, after which it turns to E.N.E., and afterwards to N.E. by N., the coast becoming low. A coral reef fringes the shore.

[1] Horsburgh's Directory, 8th ed., vol. ii. p. 563, footnote.

The slopes of the hills on Mindanao Island were cleared in patches, with huts adjacent to the clearings; there were also huts on Balat Island, but none were seen on Sarangani.

The channel between the southern part of Mindanao Island and the Sarangani group is 5 miles across between Lanibal Island and the southwest extremity of Cape Sarangani and 7 miles between that Cape and Balat Island.

These positions may be depended on, as fortunately the meridian altitude of Venus was obtained at 9 A.M., and that of the sun at noon, besides numerous observations for longitude. The longitude depends on the lighthouse at Samboangan, taken for these calculations as 122° 6′ E.

Having passed through Sarangani Passage, an E. by S. course was shaped for Mata Island, and the ship proceeded under steam and fore and aft sails. At 3 P.M. a strong southerly current was experienced, and the ship was hauled up to east, being then in lat. 5° 26′ N., long. 125° 51′ E., or 20 miles from the supposed position of Mata Island. The vessel was steered east until 6 P.M., at which time it was in lat. 5° 29′ N., long. 126° 11′ E., or 6 miles south of the supposed position of Mata Island. The latitude was obtained by a bearing of Balat Island, which could be distinctly seen, and the longitude by D.R. from sights at 5 P.M. No sign of any island was seen from the masthead, which commanded a view of at least 15 miles radius, and it was therefore thought that Mata Island did not exist. In short, reading the accounts given, it is highly probable that Mata, Palmas, and Hunter or Haycock Islands are one and the same island with different localities assigned to it. At 6 P.M. fires were banked, and sail made to a fresh N.N.E. wind, the current running to the southward at the rate of $1\frac{1}{2}$ miles per hour.

On the 10th February, at 4.45 A.M., the Meangis Islands were seen ahead, and the ship was steered to pass to leeward of them, and at 8.30 A.M. sail was shortened, and a sounding and two trawlings obtained in 500 fathoms, the position by astronomical observation being lat. 4° 33′ 10″ N., long. 127° 5′ 45″ E., and by bearings of the islands lat. 4° 32′ N., long. 127° 3′ 45″ E. The islands of the Meangis group appear to be laid down on the chart correctly in relation to each other, with the exception of Central Island, which requires verifying.

Sueste Island, a small peaked islet 266 feet high, is the southernmost of the small islets eastward of Kakarutan Island.

Nanusa Island rises gradually from the shore and is rounded gently at the summit, which appears bare, with the exception of some cocoanut palms along the ridge. The other islands of the group are low and flat, but being densely wooded can be seen at a considerable distance. There are cocoanut trees on each of them.

Karckelang, the largest island of the Tulur group, appeared to be much out in position; from the ship at 9 A.M. its extremities bore N. 87° W. and S. 36° W., which would place it considerably to the northwest, supposing it to be as large as depicted on the chart.

Whilst dredging, a native canoe came alongside from the Meangis Islands, but as the occupants spoke neither Malay, Dutch, nor Spanish, no communication could be opened with them. The boat was 30 feet long, sharp at both ends and without outriggers, of the Ki Island build. The men (twenty-two in number) wore turbans, like the Lutaos of

Samboangan, and were many of them apparently of the same race, but appeared to be a mongrel lot, and were very dirty looking. They brought mats and very pretty blue and red Lories (*Eos indica*) alive for sale, secured to sticks by means of rings made of cocoa-nut shell as at Amboina. The men did not chant or use drums as they paddled; they displayed Dutch colours.

There was a moderate northerly wind all day with fine weather. Whilst dredging, the current ran to the southward at the rate of one mile per hour.

The two hauls of the trawl at this Station (214) proved to be among the most productive of the whole cruise, twenty-two specimens of Teleostean fishes, and over one hundred and fifty specimens of invertebrates belonging almost exclusively to new genera and species of deep-sea animals, being procured. The deposit was a blue mud containing 34 per cent. of carbonate of lime. A new species of deep-sea fish (*Malacosteus indicus*, Günth.) was obtained, which had between the maxilla and the eye on either side two spots, the posterior one round and of a beautiful light yellowish green colour, the anterior one larger, club-shaped (the head of the club pointing back), and of a dull red colour; the specimen was $4\frac{1}{2}$ inches long, entirely black, with minute dots over the surface. A *Lernæa* was attached to its belly.

Crinoids were especially abundant in these trawlings; the following is a list of the species with the Myzostomida attached to them :—*Pentacrinus alternicirrus*, *Pentacrinus naresianus*, *Metacrinus costatus*, *Metacrinus moseleyi*, *Metacrinus murrayi*, *Metacrinus varians*, *Metacrinus wyvillii*, *Antedon* (six species), *Promachocrinus naresi; Myzostoma calycotyle*, *Myzostoma wyville-thomsoni*, *Myzostoma asymmetricum*, *Myzostoma pentacrini*, *Myzostoma deformator*, *Myzostoma tenuispinum*. *Scalpellum album*, *Verruca nitida*, *Gnathophausia calcarata*, *Porocidaris elegans*, five new species of Ophiurids, and a new Cephalopod (*Cirroteuthis meangensis*) belonging to a genus hitherto found only on the coast of Greenland, but discovered by the Challenger also in the Southern Ocean and the South Pacific, were also among the novelties obtained.

The new deep-sea genus and species of Polyzoa (*Bifaxaria lævis*, Busk), was represented in this trawling. As will be seen from the following resumé of his Report[1] on the Polyzoa by George Busk, Esq., F.R.S., the Bifaxariadæ are almost exclusively a deep-sea family :—

[1] Report on the Polyzoa, by Geo. Busk, F.R.S., Zool. Chall. Exp., part xxx. 1884.

The Polyzoa.—"About three hundred to three hundred and twenty species of Marine Polyzoa were collected during the Challenger Expedition, of which by far the largest proportion, or not less than two hundred and eighty, belong to the suborder

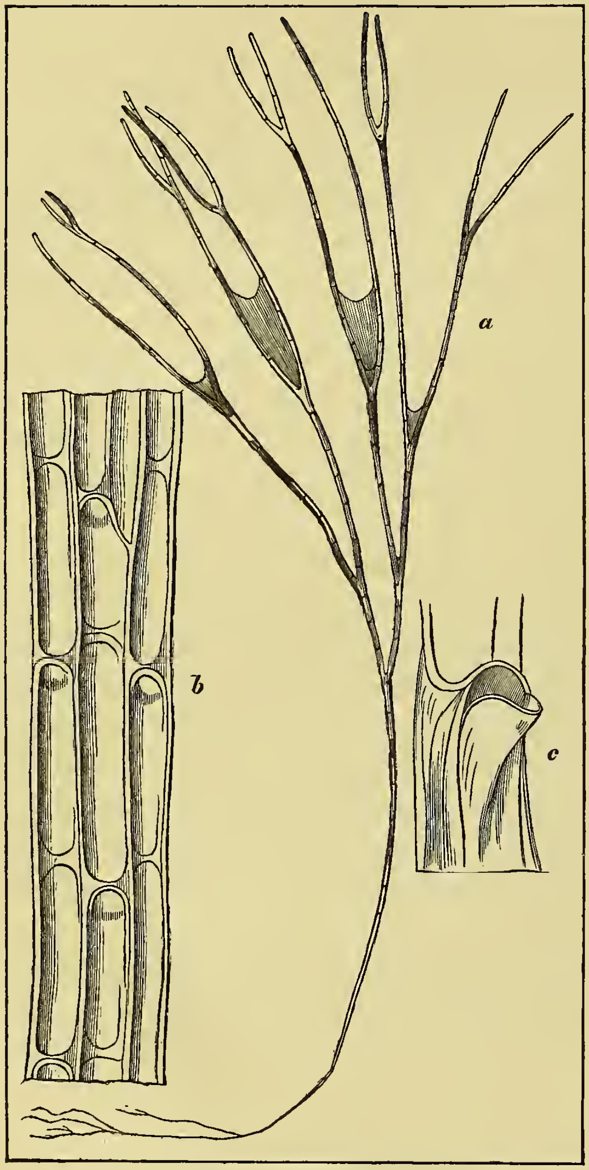


FIG. 223.—*Farciminaria hexagona*, Busk. *a*, natural size; *b*, magnified; *c*, orifice, more highly magnified.

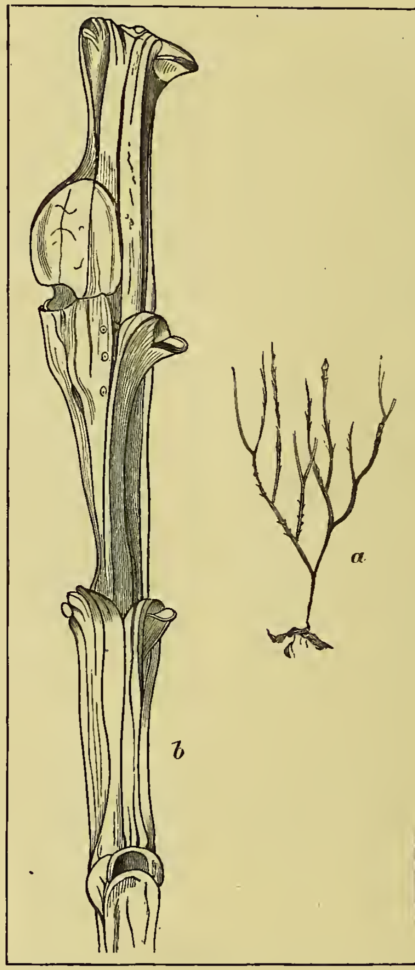


FIG. 224.—*Farciminaria delicatissima*, Busk. *a*, natural size; *b*, magnified.

Cheilostomata, of which about one hundred and seventy appear to have been previously undescribed.

"Belonging to the suborder Cyclostomata the number of species is about thirty, including perhaps ten new forms; whilst the Ctenostomata afford not more than seven of which two are probably as yet undescribed.

"In the Endoproctous division the number of species is still more limited, including only a species of *Loxosoma* not yet positively determined, and two species belonging to a very peculiar and interesting generic type, for which some years since I had provisionally adopted the name *Ascopodaria*,[1] but two species of which have since been described and published by Mr. Hincks, one as *Barentsia bulbosa*,[2] and more recently a second under the appellation of *Pedicellinopsis fruticosa*,[3] the latter being one of the two species in the Challenger collection upon which I had proposed to found the genus *Ascopodaria*.

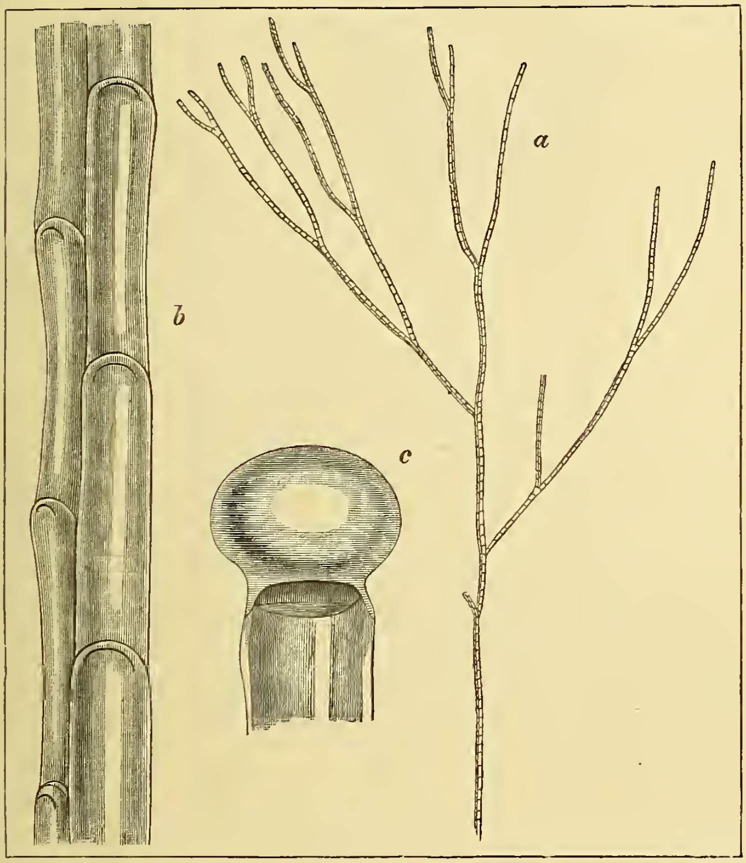


FIG. 225.—*Farciminaria magna*, Busk. *a*, natural size; *b*, magnified; *c*, oœcium, more highly magnified.

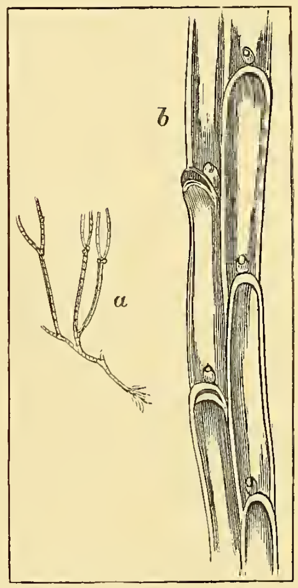


FIG. 226.—*Farciminaria gracilis*, Busk. *a*, natural size; *b*, magnified.

"Besides these the collection contains one or more species of *Rhabdopleura;* and allied to that genus the very remarkable form described by Professor M'Intosh under the name of *Cephalodiscus dodecalophus*.[4]

"The most important and characteristic part of the collection consists in the large number of deep-water or abyssal forms, comprehending under that term only the species

[1] Prof. Allman's Presidential Address, *Journ. Linn. Soc. Lond.* (Zool.), vol. xv. p. 2, 1879.
[2] *Ann. and Mag. Nat. Hist.* ser. 5, vol. vi. p. 285, pl. xv. figs. 12–14, 1880.
[3] *Ibid.*, vol. xiii. p. 363, pl. xiv. figs. 3–3*c*, 1884.
[4] *Ibid.*, vol. x. p. 337, 1882.

which occurred at or below the depth of 1000 fathoms. A list of these, according to their bathymetrical distribution, is subjoined, giving also the geographical region and the nature of the bottom. The list includes about fifty species belonging to twenty

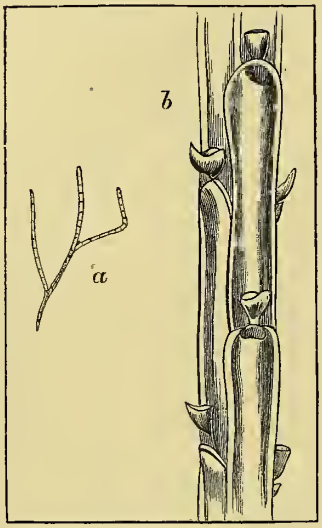


Fig. 227.—*Farciminaria cribraria*, Busk. *a*, one-third the natural size; *b*, magnified.

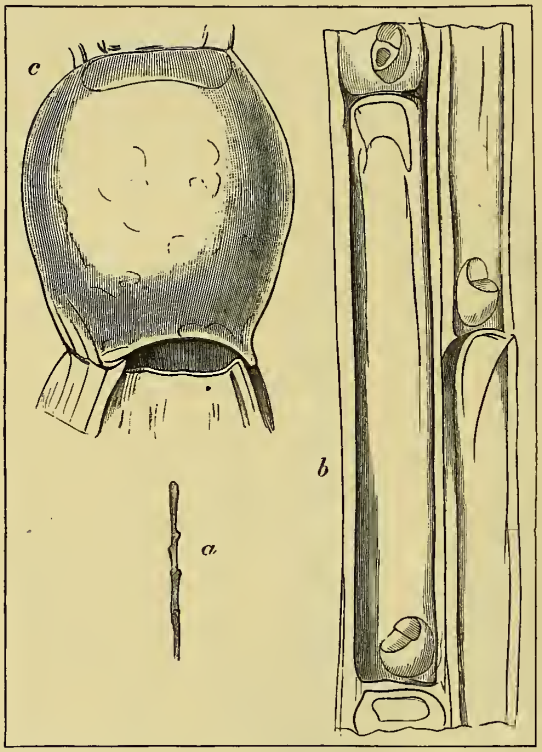


Fig. 228.—*Farciminaria pacific*, Busk. *a*, natural size; *b*, magnified; *c*, oœcium, more highly magnified.

genera in thirteen families, but of these the eighteen marked with an asterisk occur also at depths less than 1000 fathoms, so that the *exclusively* abyssal forms in the collection are reduced to about thirty-four.

Below 3000 *fathoms.*

Family.	Genus and Species.	Station.	Depth.	Bottom.	Region.[1]
Bifaxariadæ, .	*Bifaxaria abyssicola*, ...	253	3125	red clay.	N. Pacific.
Cribrilinidæ, .	**Cribrilina monoceros*, ...	253	3125	„	„
Bicellariadæ, .	*Bugula johnstoniæ*, ...	253	3125	„	„
Escharidæ, . .	*Phylactella*, sp.?	253	3125	„	„

But of these the last two were too fragmentary to admit of certain determination.

[1] For these regions see the map in the Report, Zool. Chall. Exp., part xxx., 1884.

Between 2500 *and* 3000 *fathoms.*

Family.	Genus and Species.	Station.	Depth.	Bottom.	Region.
Bicellariadæ, .	*Kinetoskias cyathus*, . . .	325	2650	bl. m.	S. Atlantic.
,, .	*Bugula reticulata*, var. *unicornis*, .	101	2500	bl. m.	N. Atlantic.
,, .	,, ,, ,, .	104	2500	gl. oz.	,,
Cellulariadæ, .	*Cellularia crateriformis*, . . .	325	2650	bl. m.	S. Atlantic.
Farciminariadæ, .	*Farciminaria delicatissima*, . .	64	(2700)	red clay.	N. Atlantic.
,, .	,, *magna*, . . .	325	2650	bl. m.	S. Atlantic.
Celleporidæ, .	*Cellepora solida*, ...	160	2600	red clay.	Australia.

Between 2000 *and* 2500 *fathoms.*

Family.	Genus and Species.	Station.	Depth.	Bottom.	Region.
Bicellariadæ, .	**Kinetoskias pocillum*, . . .	299	2160	bl. m.	S. Atlantic.
,, .	*Bugula margaritifera*, . . .	332	2200	gl. oz.	,,
,, .	* ,, *reticulata*, ...	299	2160	bl. m.	,,
,, .	,, ,, var. *unicornis*, .	68	2175	gl. oz.	N. Atlantic.
,, .	,, *mirabilis*, ...	89	2400	gl. oz.	,,
,, .	*Bicellaria pectogemma*, . . .	299	2160	bl. m.	S. Atlantic.
,, .	* ,, *navicularis*, . . .	332	2200	gl. oz.	,,
Cellulariadæ, .	*Menipea pateriformis*, . . .	299	2160	bl. m.	,,
Farciminariadæ, .	*Farciminaria delicatissima*, . .	89	2400	gl. oz.	N. Atlantic.
,, .	,, ,, . .	68	2175	gl. oz.	,,
,, .	,, *pacifica*, . . .	241	2300	red clay.	N. Pacific.
Bifaxariadæ, .	*Bifaxaria reticulata*, . . .	68	2175	gl. oz.	N. Atlantic.
Flustridæ, . .	**Flustra biseriata*, ...	299	2160	bl. m.	S. Atlantic.

Between 1500 *and* 2000 *fathoms.*

Family.	Genus and Species.	Station.	Depth.	Bottom.	Region.
Bicellariadæ, .	*Kinetoskias cyathus*, . . .	VI.	1090 to 1525	gl. oz.	N. Atlantic.
„ .	*Bugula reticulata*, var. *unicornis*, .	106	1850	gl. oz.	„
„ .	* „ „	147	1600	di. oz.	S. Indian.
„ .	„ *leontodon*, ...	3	1525	h. gr.	N. Atlantic.
„ .	„ *bicornis*, ...	157	1950	di. oz.	S. Indian.
„ .	„ *margaritifera*, . . .	323	1900	bl. m.	S. Atlantic.
„ .	*Bicellaria infundibulata*, . . .	147	1600	di. oz.	S. Indian.
„ .	„ „ . . .	156	1975	di. oz.	„
Cellulariadæ, .	*Canda simplex*, ...	44	1700	bl. m.	N. Atlantic.
„ .	*Menipea clausa*, ...	70	1675	gl. oz.	„
„ .	*Cellularia crateriformis*, . . .	323	1900	bl. m.	S. Atlantic.
„ .	*Nellia simplex*, ...	87	1675	rock.	N. Atlantic.
Farciminariadæ, .	*Farciminaria delicatissima*, . .	13	1900	gl. oz.	„
„ .	„ „ . .	14	1950	„	„
„ .	„ *gracilis*, . . .	70	1675	„	„
„ .	„ *magna*, . . .	153	1675	bl. m.	S. Indian.
„ .	„ „ var. *armata*, .	323	1900	bl. m.	S. Atlantic.
„ .	„ *cribraria*, . . .	323	1900	„	„
Bifaxariadæ, .	*Bifaxaria reticulata*, . . .	13	1900	gl. oz.	N. Atlantic.
„ .	„ *minuta*, ...	70	1675	„	„
Salicornariadæ, .	* *Salicornaria magnifica*, . . .	13	1900	„	„
„ .	„ „ . . .	323	1900	bl. m.	S. Atlantic.
„ .	„ „ . . .	157	1950	di. oz.	S. Indian.
Membraniporidæ,	*Foveolaria orbicularis*, . . .	147	1600	di. oz.	„
Catenariadæ, .	*Catenaria bicornis*, ...	280	1940	gl. oz.	S. Pacific.
Onchoporidæ, .	* *Onchopora sinclairii*, . . .	157	1950	di. oz.	S. Indian.
Escharidæ, .	* *Tessaradoma boreale*, . . .	13	1900	gl. oz.	N. Atlantic.
Idmoneidæ, .	*Idmonea marionensis*, . . .	147	1600	di. oz.	S. Indian.

Between 1000 *and* 1500 *fathoms.*

Family.	Genus and Species.	Station.	Depth.	Bottom.	Region.
Bicellariadæ, .	*Kinetoskias cyathus*, ...	VI.	1090 to 1525	gl. oz.	N. Atlantic.
" .	**Bugula reticulata*, ...	303	1325	bl. m.	S. Atlantic.
Cellulariadæ, .	**Menipea benemunita*, ...	303	1325	"	"
" .	* " *aculeata*, ...	303	1325	"	"
" .	*Cellularia cirrata*, ...	195	1425	bl. m.	Australian.
" .	**Scrupocellaria macandrei*, . . .	93[1]	1070 to 1150	volc. m.	N. Atlantic.
Farciminariadæ, .	**Farciminaria hexagona*, ...	195	1425	bl. m.	Australian.
Salicornariadæ, .	**Salicornaria malvinensis*, ...	176	1450	gl. oz.	"
Reteporidæ, .	*Retepora margaritacea*, ...	176	1450	"	"
Celleporidæ, .	**Cellepora eatonensis*, ...	303	1325	bl. m.	S. Atlantic.
Flustridæ, . .	**Carbasea ovoidea*, ...	303	1325	"	"
Escharidæ, . .	**Cribrilina monoceros*, ...	303	1325	"	"
Crisiidæ, . .	*Crisia delicatissima*, ...	303	1325	"	"

"The extreme depth from which any Polyzoa were procured was 3125 fathoms, at Station 253 in the North Pacific. In this haul there were four species attached to a manganese nodule, from a bottom of red clay, and associated with them were two or three minute specimens of a species of *Stephanoscyphus*. Of the four species thus living at a depth of about 3½ miles, only one perhaps can be regarded as belonging to a decidedly or almost exclusively deep-water family—the Bifaxariadæ; for although the Bicellariadæ include many abyssal forms, one, *Bugula* (*Halophila*) *johnstoniæ* has usually occurred in comparatively shallow depths, whilst of the other two species, one, *Cribrilina monoceros* is very generally distributed in the southern hemisphere, and apparently occurs at various depths from 5 to 1350 fathoms; the fourth is too fragmentary to admit of complete diagnosis, but it belongs to the family Escharidæ, and probably to only moderately deep water.

"It will be seen that by far the greater number of the deep-sea forms belong to families characterised by having the zoarium of great flexibility, rooted by a dense bundle of extremely delicate radical fibres, most of which are attached to separate *Globigerinæ* or other solid particles in the ooze or mud of which the bottom at these depths is usually formed.

[1] Off St. Vincent, Cape Verde Islands.

"Of all the deep-water genera, *Farciminaria* appears to be the most exclusively abyssal, and the accompanying figures of species belonging to that genus (figs. 225 to 229) are given as types of the delicate and flexible conformation of the forms inhabiting the tranquil depths of the ocean.

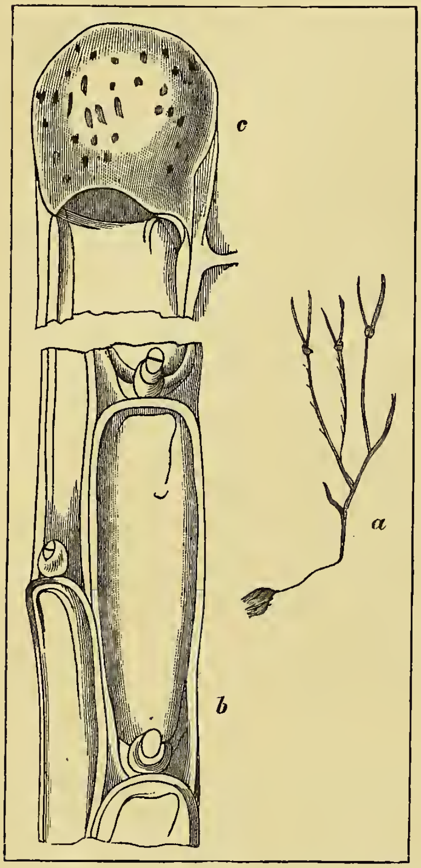


FIG. 229.—*Farciminaria brasiliensis*, Busk. *a*, natural size; *b*, magnified; *c*, oœcium, more highly magnified.

"From the Tables it will be seen that the geographical distribution of the very deep-water forms has no evident relation to the bathymetrical. And in even still less degree is any evidence afforded respecting their distribution in time as might indeed be expected from the exceedingly delicate and fragile structure of all or nearly all the species, excepting one of very peculiar habit, *Cellepora solida*, which bears a very close resemblance to, if it be not identical with, the Miocene *Celleporaria polythele*, Manzoni,[1] (*nec* Reuss)."

Cephalodiscus.—Professor M'Intosh furnishes the following note on this remarkable form :—

"No more interesting or more novel type occurs in the series of discoveries by the Challenger than *Cephalodiscus*, a new Polyzoon allied to Professor Allman's *Rhabdopleura.* This form, which has been termed *Cephalodiscus dodecalophus*,[2] was dredged in the Strait of Magellan in 524 fathoms, and the Polyzoarium at first sight may readily be mistaken for a seaweed, since it is composed of a much branched fucoid tissue tinged of a pale brownish hue, and semi-translucent (fig. 230). It is spinous all over, and moreover has numerous apertures leading into the interior, which is honeycombed by a series of canals through which sea water has constant ingress and egress. This remarkable cœnœcium, which is secreted by the little animals, has probably been found that best adapted for the preservation of the species, by its resemblance on the one hand to other organisms in its neighbourhood, and on the other hand by its affording complete aeration, abundant supply of food, and security to the little polypides and their delicate plumes. The polypides are quite free and in great profusion; moreover, the caudal region has buds, and in addition free ova occur in numbers. Each adult polypide (fig. 231) is about 2 mm. in length, with a bean or kidney-shaped body, from the posterior bulbous part of which a pedicle

[1] I Briozoi Fossili del Miocene d'Austria ed Ungheria, p. 4, pl. i. fig. 3, 1877.
[2] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. x. p. 337, 1882.

comes off. The anterior region of the body curves somewhat suddenly downward so as to form a flattened surface on which the great buccal disk rests. On the ventral surface are two large pigment spots, or eyes, which are covered by the disk. The latter forms a thin plate of a definite shape and marked by pigment, free all round the edge, but fixed by a central pedicle in front of the mouth. Attached to the posterior part of the disk is the basal tissue of the plumes, twelve of which arise from the dorsal edge. Each plume consists of a central stem ornamented by a series of long, slender pinnæ on the ventral surface and sides, the tips in both cases being slightly bulbous. No special

FIG. 230.—Fragment of Polyzoarium of *Cephalodiscus dodecalophus*, M'Intosh.

FIG. 231.—Ventral view of *Cephalodiscus dodecalophus*, M'Intosh.

organs occur in connection with the mouth, which leads by a canal with frilled walls into the ventrally situated stomach. At the posterior end of the latter the intestine turns upward and advances along the dorsum to open on the anterior projection of the body behind the plumes. The body wall is composed from without inwards of hypodermic, elastic and longitudinal muscular layers. There is no trace of a nervous system nor any evidence of perigastric fluid. The ovary lies anteriorly and is generally distended with one or two large and several smaller whitish ova. Posteriorly the ventral surface of the body is continued into a cylindrical pedicle, which in almost every adult bears one or more buds."

On the 12th February, at 9 A.M., a sounding, trawling, and temperatures were obtained in 2550 fathoms (see Sheet 31), this work being completed by 7 P.M., when sail was again made to the eastward. The deposit was a blue mud which did not effervesce with weak acid, and contained no calcareous shells, although pelagic Molluscs and Foraminifera were taken abundantly at the surface. The trawl contained only a few fragments of pumice about the size of hens' eggs. On this occasion the trawl was used without any bag being sewed in at the bottom, and it is possible that delicate organisms, such as Holothurians, deep-sea fish, Umbellulas, and similar animals which live at these depths might be completely destroyed and washed through the netting on being hauled up through such a great depth of water.

During the two previous days the wind had been unsteady, varying from N.W. to E.N.E., its general direction being N. by E. and its velocity 12 to 15 miles per hour; the weather squally and rainy; the current slightly to the north-eastward.

On the 13th February, at 6 P.M., a fresh S.W. breeze was experienced, which continued steady until 4 A.M. on the 14th, when it again became light and variable. The weather overcast and showery.

On the 15th, at 10 P.M., the weather being quite calm, steam was got up and the ship proceeded towards the supposed position of the Carteret Shoal.

At 5 A.M. on the 16th, a sounding was obtained in 1675 fathoms in lat. 2° 46′ N., long. 133° 59′ E., 15 miles southwest of the supposed position of the Carteret Shoal. The deposit was a light grey Globigerina ooze, consisting of immense numbers of the dead shells of pelagic Foraminifera. After obtaining serial temperatures, the ship steamed to the northeast, and at noon, when in lat. 2° 56′ N., long. 134° 11′ E., being exactly on the position of this danger as marked on the chart, a sounding was obtained in 2000 fathoms and the trawl was put over (see Sheet 31). The deposit at this depth contained very much less carbonate of lime than at 1675 fathoms. The trawl brought up a good many pieces of pumice partly coated with manganese, one deep-sea fish, and about thirty specimens belonging to various invertebrate groups.

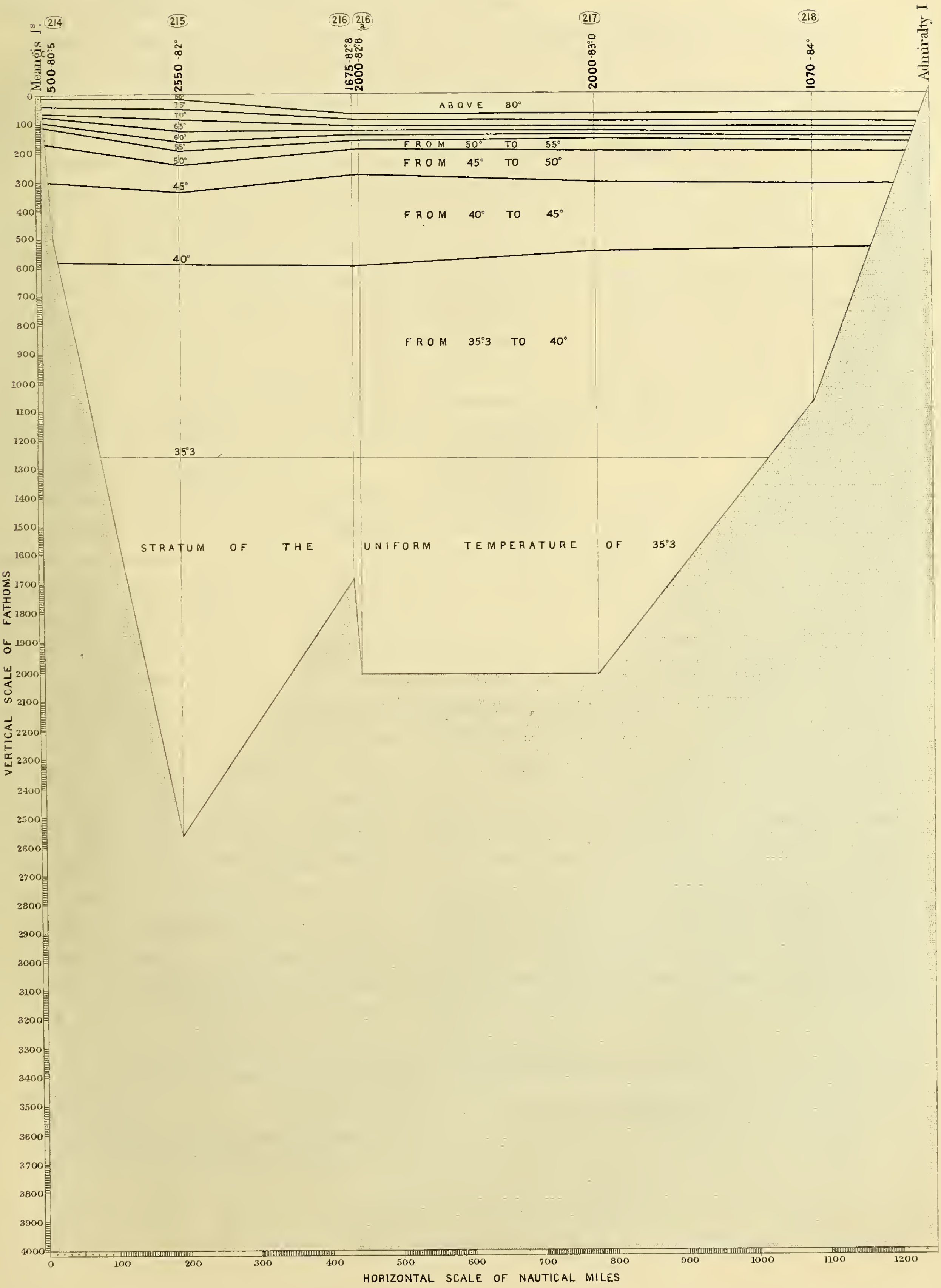
No sign of a shoal was seen, nor of shoal water; indeed no such signs were expected, as from Carteret's account of the reef it could hardly be in the position marked. In the narrative of his voyage[1] he sees the St. David or Freewill Islands on September 25th, 1767, to which he gives a certain position, and three days afterwards he sights the reef named after him, which he places in lat. 2° 53′ N. and long. 1° 41′ W. of the Freewill Islands; this would place the reef N. 53° W. 200 miles from those islands, but in the chart furnished, the reef is marked due north from them. If the Freewill Islands be in their correct position, then the position of the Carteret Shoal, as given by its original discoverer, would be nearly the same as that of the reef at present marked as the Helen Shoal, and

[1] Hawksworth's Voyages, vol. i. pp. 607–610, London, 1773.

PACIFIC OCEAN

Longitudinal Temperature Section. Meangis I^s to Admiralty I^s

For explanation of Symbols see Appendix 1.



Engraved by Malby & Sons

as the description of that danger by Rosser[1] coincides remarkably with Carteret's account, there can be little doubt that the shoals are identical.

Shortly before stopping to sound at noon, a commotion in the water was seen from the deck, which at first resembled the sea breaking over a reef. This, on examination, proved to be a school of whales about thirty in number, who were swimming to the westward. Their black backs appearing above the water looked at first remarkably like the stones on the edge of a reef, and they might easily have been taken for one.

At 6 P.M. the ship proceeded to the eastward under easy steam, the wind being light and variable. The early part of the day was fine, but from 1 P.M. to 6 P.M. rain squalls were experienced. The average velocity of the wind, by the anemometer, was six miles per hour.

From the 16th to the 20th, light breezes varying from north to east were experienced, the average velocity being from 9 to 15 miles per hour, the weather cloudy with passing showers; from the 20th to the 22nd the weather was quite calm, necessitating the use of steam. On the 22nd a sounding and temperatures were taken in 2000 fathoms, and the ship then proceeded for Humboldt Bay. Whilst sounding the ship was in lat. 0° 39′ S., long. 138° 55′ E., about 70 miles northeast of the numerous mouths of the Mámberan,[2] the largest river in New Guinea.

On the 21st and 22nd the specific gravity of the surface water was lower than usual, and the ship was at times surrounded by large quantities of drift wood. Among the surface organisms was *Noctiluca miliaris* and others indicative of shore waters; the Naturalists were away in boats on both days examining the drift wood. As the Mámberan is the only river of any importance on the north coast of New Guinea, there can be little doubt that the drift wood and fresh water were thence derived, especially as similar discharges from its mouths have been met with by other explorers.[3] The river probably rises in the Charles Lewis Mountains on the opposite side of New Guinea, which are said to reach a height of over 16,000 feet. Long lines of drift wood disposed in curves at right angles to the direction in which the river lay were passed through by the ship in her progress. The propeller had to be constantly stopped lest it should be fouled by the wood. The logs had evidently not been very long in the water, being covered only by a few young Barnacles (*Balanus*) and Hydroids. Amongst the logs were many whole uprooted trees, one of which was 2 feet in diameter at its stem. The majority of the pieces of wood were small branches and small stems; the bark was often floating separately. The midribs of the leaves of a pinnate-leaved palm were abundant, and also the stems of a large Cane Grass (*Saccharum*), like that so abundant on the shores of the great river (Wai Levu) in Fiji. One of these cane stems was 14 feet in length,

[1] W. H. Rosser, North Pacific Pilot, part ii. p. 181, London, 1870.

[2] Auszüge aus den auf einer Neu Guinea Reise im Jahre 1873, geführten Tagebüchern, von A. B. Meyer, p. 6, Dresden, 1875.

[3] The mouths of the river were passed by Rosenberg on his way to Humboldt Bay in 1862, *Nat. Tydsch. voor Nederl. Indie*, Deel. xxiv. p. 334, Batavia, 1862.

and from $1\frac{1}{2}$ to 2 inches in diameter. Various fruits of trees and other fragments were abundant, usually floating confined in the midst of the small aggregations into which the floating timber was almost everywhere gathered. Amongst them were the usual littoral seeds, those of two species of *Pandanus*, and of the Puzzle-seed (*Heritiera littoralis*), fruits of a *Barringtonia* and of *Ipomœa pes-capræ*. But besides these fruits of littoral plants, there were seeds of forty or fifty species of more inland plants. Very small seeds were as abundant as large ones, the surface scum being so full of them that they could be scooped up in quantities with a fine net. For a report on the nature of these fruits and seeds see the Report on the Botany.[1] With the seeds occurred one or two flowers, or parts of them. Leaves were absent except those of the palm, on the midribs of which some of the pinnæ were still present. The leaves evidently drop first to the bottom, whilst vegetable drift is floating from a shore; thus, as the débris sinks in the sea water a deposit abounding in leaves, but with few fruits and little or no wood, will be formed near shore, whilst the wood and fruits will sink to the bottom farther off the land. Much of the wood was floating suspended vertically in the water, and most curiously, logs and short branch pieces thus floating, often occurred in separate groups, apart from the horizontally floating timber. The sunken ends of the wood were not weighted by any attached masses of soil or other load of any kind; possibly the water penetrates certain kinds of wood more easily in one direction with regard to its growth than the other, hence one end becomes water-logged before the other.

It is evident that a wide area of the sea off the mouth of the Mámberan River is thus constantly covered with drift wood, for the floating wood is inhabited by various animals, which seem to belong to it as it were. The fruits and wood were covered with the eggs of a Gasteropod Mollusc, and with a Hydroid, and the interstices were filled with Radiolarians washed into them and gathered in masses, just as Diatoms, in the Antarctic Ocean, are gathered together in the honeycombed ice. Two species of crabs inhabit the logs in abundance, and a small Dendrocœle Planarian swarms all over the drift matter and on the living crabs also. A *Lepas* was common on the logs. Enormous quantities of small fish swarmed under the drift wood, and troops of Dolphins (*Coryphæna*) and small Sharks (*Carcharias*), 3 or 4 feet long, were seen feeding on them, dashing in amongst the logs, splashing the water, and showing above the surface, as they darted on their prey. The wood which had been longest in the water was bored by a *Pholas*.

A large flock of the very widely spread Phalarope (*Phalaropus hyperboreus*) was seen flying over the drift wood, no doubt following the timber out from shore, and roosting on it. In England this bird is considered as one of the visitors from the far north, so that it seems strange to meet with it at New Guinea, although it was previously known from the Arrou Islands. Some specimens shot had small surface Crustacea in their stomachs. The various smaller animals no doubt congregate about the drift wood because

[1] Bot. Chall. Exp., part iii., 1885.

it seems to act as a sort of sieve or screen, and to concentrate amongst it the surface animals on which they feed. The drift wood and seeds were also abundant on the surface on the previous day, and a boat which was lowered from the ship captured amongst it a Sea Snake (*Pelamys bicolor*) over 3 feet in length.

On the 23rd, shortly after noon, the Cyclops Mountains were seen ahead, and the vessel steamed towards Point Caillié, which was rounded at 7 P.M., and shortly afterwards anchored in 19 fathoms, with that Point bearing N. 24° W., distant 1½ miles.

There was no difficulty in distinguishing the land. Mount Bougainville on the east side of the entrance is a high solitary peak, and the Cyclops Mountains stand well out. Point Caillié appears like an island. Bonpland Point is at the extremity of a ridge of hills westward of Mount Bougainville, and separated from it by a low neck of land, and at a distance looks like an island in Humboldt Bay, which then appears to extend from Mount Bougainville to Point Caillié.

Rounding Point Caillié at a distance of from 1 to 1½ miles, no soundings were obtained with 40 fathoms of line. The first sounding was 28 fathoms, and the ship was immediately stopped, and when her way through the water was lost, the anchor was let go in 19 fathoms, it being quite dark at the time.

Humboldt Bay, New Guinea.

As the ship entered the bay ("Talok Lintju" of the inhabitants themselves), a light flashed from the Point Caillié shore, glimmered and flashed again, then another flashed, then another, and soon a dozen or more lights close together were flashing and moving to and fro. These signal fires were answered from the south side of the bay, and from another spot higher up on the same side, and the peculiar holloa of warning, "hoa, hoa," was heard coming over the water from many voices, and sounding exactly like the shouts with which the savages at Api in the New Hebrides greeted the ship. The masses of lights glimmered from the very water level, as could be seen from the mode of reflection of the flashes in the water. The villages of pile-dwellings of Ungrau and Tobaddi were giving the alarm, and were being answered by the people of Wawah on the other side of the bay. The bright lights could be seen moving about, and waving to and fro as they were carried by the excited natives along the platforms of the pile-built villages; glimpses of the shadows of the natives' bodies could be caught as they passed between the ship and the light.

Just as the anchor was let go a light appeared on the water close to the ship, and a canoe was evidently reconnoitring it, but the natives were shy and wary, and the light disappeared again for some time. Then it was again seen close at hand, being waved up and down; and a native standing up delivered a volley of his language.

Lights were placed at the gangways and were waved as a token of friendship, and all sorts of encouragements were used, but the canoe kept at a distance, paddling to and fro. The only word caught was "sigor," "sigor"! The canoes had two paddlers, one at either end, apparently boys, and a full-grown savage on the small platform in the centre, who had his huge mop-like head of hair set off by a radiant halo of feathers stuck into it, and decked with a broad fillet of scarlet *Hibiscus* flowers, placed under the edge of the mop, above his forehead. As he blew up his smouldering fire-stick into a blaze, his dark face glowing in the light and set off by the scarlet blossoms, formed a most striking, and at the same time most savage, spectacle.

The canoe at last dropped under the stern, the natives shouting still "sigor" "sigor"! and a gaudy handkerchief was thrown down from the stern boat. It was at once fished out of the water with a four-pronged fish spear, and examined by the glow of the fire-stick, and then another canoe which was approaching, and which contained four natives, was shouted to in the most excited language, expressive evidently of satisfaction.

"Sigor" being supposed to mean "tobacco," a cigar was let down with a line and immediately taken and lighted, more were shouted for, and two cocoanuts neatly husked and tied together with a part of the husk left attached for the purpose, as in the many islands visited by us, were fastened to the line, to be drawn up in exchange. Then by cries of "sigor"! which acted as a loadstone, the canoes were drawn up opposite the gangway, and every attempt was made from the bottom of the ladder to invite the natives on board, but without success; nor would they approach near enough to receive presents from the hand, evidently fearing a trap, but they took a number of cigars, receiving them two at a time, stuck between the prongs of a long fish-spear. The placing of the cigars between the jagged points of the spear was rather trying work, for the ship was rolling somewhat, and the spear thus moved to and fro in a dangerous manner. Another gaudy handkerchief being given to the boat which had received one already, it was passed over to the other boat at once, either according to some agreement as to division of spoil or perhaps because the occupant of the boat was a chief. The use of ship's biscuit was not understood. One native made signs that he wanted a gun, by pretending to load his bow from some implement picked up from the bottom of his canoe to represent a powder flask, then ramming down in pantomime, drawing the bow as if shooting, and saying "boom." The natives seemed frightened to some little extent by a "blue light," and shoved off a bit, shouting something as it was lit. At one time they commenced a sort of song in their canoe, as they lay off the ship hesitating to approach. At last they left for the shore.

At daylight on the 24th the ship was surrounded by canoes, each containing from two to six natives all jabbering together and making the most terrible din one could possibly imagine. The anchorage being rather an uncomfortable one, owing to its being exposed to the full effect of the swell rolling into the bay, which made the ship very uneasy, at 7 A.M. the anchor was weighed and the ship steered in for a small cove under Point Caillié. At the first movement of the screw the natives in the canoes seized their weapons, and it was certainly thought for an instant that the officers on the bridge were going to be favoured with a flight of arrows. Much relief was felt when they were seen pointing to the propeller, which they evidently took at first to be a marine monster of some kind or other. Having satisfied themselves, however, that it was machinery connected in some way with the ship, they put their weapons down and resumed paddling alongside, their canoes forming a wide trailing line as they accompanied the ship. There were in all sixty-seven canoes present, and this was the greatest number seen, a few of them contained five natives, some four, some three, and some only two. In fifty canoes on one side of the vessel there were one hundred and forty-eight natives, or about an average of three to a canoe; in all, therefore, there must have been two hundred natives. From time to time the shout which was heard the night before was raised. When heard close by, it was found to commence with a short quick "wăh wăh," followed by a long "ōh ōh ōh." Some few natives had perforated Conch shells, both a *Triton* perforated on the side of one of the upper whorls, and a large conical *Strombus* perforated at the apex of the spire. They blew these shells, making a booming sound which mingled with the shouts. They evidently prize these trumpet shells highly, and would not part with them, perhaps from the same motives that prevent them parting with their flutes, as described by the officers of the "Etna."[1]

When the ship moved the scene was very fine. In front were the Cyclops Mountains rising to heights of 6000 feet, at the eastern base of which was a sheltered cove with one or two small islets in it, all lit up by the rising sun behind, whilst around were a crowd of canoes filled with naked savages ornamented with frizzled hair, tusks through the septa of their noses, and blackened faces; in the centre was the Challenger, steaming slowly along in search of a secure anchorage, and rolling lazily to the heavy swell. As the ship steamed towards the shore the water grew deeper instead of shallower, and finally it became necessary to anchor in 36 fathoms, with the right extremity of Point Caillié N. 82° E., Observation Islet S., and an island with a village on it S. 43° W. Here the vessel was well protected from the swell.

Many of the natives made a sign of drinking, and pointed to a part of the bay where water was to be procured, evidently thinking that the ship required water. This shows that they are more or less accustomed to ships watering here, and the fact that the utmost endeavours failed to induce any of the natives to come on board the ship, and their extreme caution in their first approach, seemed to show that they must have been frightened or maltreated in some way by recent visitors to the bay. When the Dutch vessel of war "Etna" came into the harbour in 1858, the natives clambered on board before the cable had run out.

[1] Neu Guinea und seine Bewohner, Otto Finsch, p. 144.

As soon as the ship anchored again, the natives crowded round and barter recommenced most briskly, being carried on through the main deck ports, the natives passing up their weapons and ornaments stuck between the points of their four-pronged spears, and receiving the price in the same manner.

The constant cry of the natives was "sigor sigor," often repeated ("sīgōr sīgōr," slowly, "sīgōr sīgōr sīgōr," quickly), which was found to mean iron. Iron tub-hoop, broken into 6 or 8-inch lengths, was the commonest article of barter, but most prized were small trade hatchets, for which the natives parted with anything they had. The iron wherewith to replace the stone blades of their own hatchets, and the miserable ready-made trade hatchets, are to them the most valuable property possible, since they lessen the toil of clearing the rough land for cultivation, and of canoe and house building, which with the stone implements alone must be arduous work indeed. Hence the natives cared hardly for anything except iron; bright handkerchiefs or Turkey red stuff were seldom taken in exchange, and then for very little value; beads, however, were prized. Of their own property, the natives valued most their stone hatchets. Very probably they obtain the stone for making them by barter from a distance, since the rock at Humboldt Bay is a limestone, and the hatchets are made of nephrite or greenstone, or of a slate. The labour involved in grinding down a nephrite hatchet head to the smooth symmetrical surfaces which these native implements show, must be immense. Next in value to the stone implements were the breastplate-like ornaments, each of which has as its components, eight or more pairs of wild boar's tusks, besides quantities of native beads, made of small ground-down *Nerita* shells. These treasures required a trade hatchet at least to purchase them. All other articles, necklaces, armlets, tortoiseshell ear-rings, combs, paddles, daggers of Cassowary bone and such things, could be bought for plain hoop iron, as could also bows and arrows in any quantity, and even the wig-like ornaments of Cassowary feathers, which the men wear over their brows, to eke out their mop-like heads of hair.

The natives often attempted and succeeded in withdrawing an arrow or two from a bundle purchased, just as it was being handed on board, though on the whole they understood the laws of barter thoroughly, and stuck to bargains. They attempted once or twice to keep the articles given beforehand in payment without return, but often returned pieces of hoop iron and other things which had been handed down for inspection and examination, as to whether they were worth the article required for them or not. One or two of these natives tried to fish things out through the lower deck-scuttles from the cabins with their arrows, but were detected and frustrated in their design.

Many of the men wore a pair of wild boar's tusks fastened together in the form of a crescent, and passed through a hole in the septum of the nose, so that the two tusks projected up over their dark cheeks as far as their eyes. Most of them had short pointed beards, apparently cut to that shape; the old ones had whiskers. One old man who was bald, wore a complete but small wig. None of the men were tattooed, but they had large cicatrised marks on the outer sides of the upper arms, and smaller ones on the shoulders.

The fungoid skin disease was common here as at the Arrou and Ki Islands, but only on the adults; the boys and many of the younger men were free from it.

The men attracted attention to barter by the cries of "urh, urh"!; to express astonishment they struck the top of the outer sides of their thighs with their extended palms. Refusal of barter or negation was combined with an expression of disgust, or rather the two ideas are not apparently separated; the refusal was expressed by an extreme pouting of the lips, accompanied by an expiratory sniff from the nostrils. The forehead muscles were very little used in expression, though they were slightly knitted in astonishment. In laughing, the corners of the mouth were excessively drawn back, so that four or five deep folds were formed round the angles of the mouth, the head was lolled back, the mouth opened wide, and the whole of the upper teeth uncovered; the whole expression was most ape-like.

The bows of the Humboldt Bay natives are cut out of solid palm-wood, and require a very hard pull. They taper to a fine point at either end, and in stringing and unstringing them a loop at the end of the string is slipped on and off this point and rests in the extended bow on a boss raised with wicker-work, at some distance from the bow-tip. The bows are strung quickly by their lower ends being placed between the supports of the canoe outriggers as a fulcrum. If an attempt be made to string a bow, by resting one end on the ground, the tapering end snaps off directly pressure is applied. The bowstring is a thick flat band of rattan, and the arrows, like all New Guinea arrows, have no notch, but are flat at the ends, and are also without feathers. The natives have never learnt the improvement of the notch and feather. The men of Api Island, New Hebrides, have most carefully worked notches to their arrows, but still no feather. The Arrou Islanders have both notch and feather.[1] The Humboldt Bay arrows further are excessively long, far too long for the bows, being 5 feet in length, so that not more than half of their length can be drawn, they are rather small spears thrown by a clumsy bow for short distances than arrows. They go with immense force for a certain distance, but only fly straight for ten or a dozen yards, wobbling and turning over after that length of flight.

In the Humboldt Bay stone choppers, the stone blade is mounted in the end of a long wooden socket piece which is fitted into a round hole at the end of the club-like handle. The socket piece can thus be turned round so that the blade can be set to be used like that of either an axe or an adze. The handle and socket piece form nearly a

[1] For the distribution and various forms of bows and arrows, see General Lane Fox, F.R S., On Primitive Warfa *Journ. Roy. United Service Inst.*, 1867–69.

right angle with one another, and the socket piece is so long that the whole seems a most clumsy arrangement, and it is most difficult to strike a blow with it with any precision. The shorter the socket piece the easier it is to direct the blade with certainty in a blow. In Polynesia generally the stone blades are thus fixed close up to the ends of the handles, but in New Guinea this curious long-legged angular handle is in vogue. It is difficult to understand the reason, unless these natives began with a chisel and mallet; and having got so far in improvement as to join them together, have not yet discovered the advantage to be gained by shortening up the socket piece.

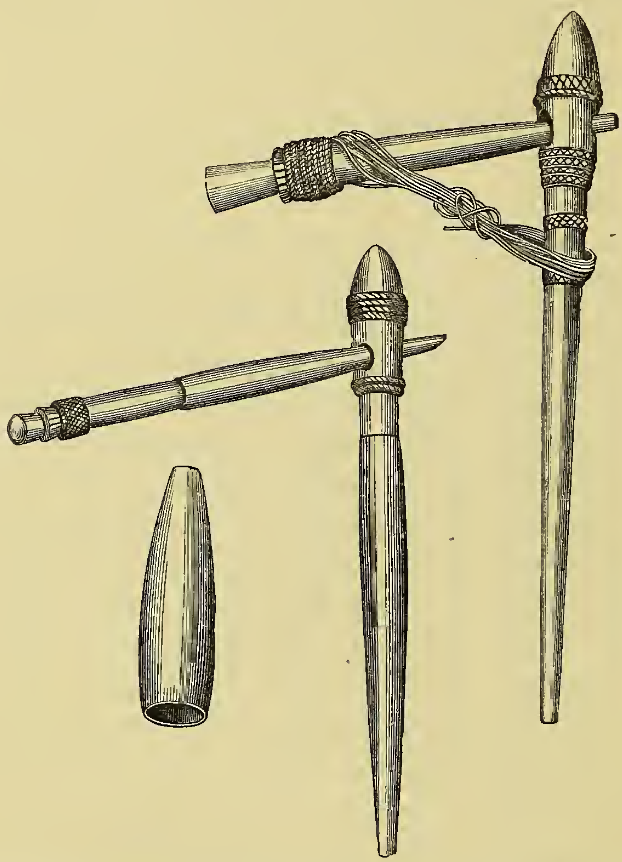


Fig. 232.—Stone-bladed Chopper and Stone-headed Hammer in use at Humboldt Bay, also a larger view of the stone hammer-head removed from its socket.

A curious stone implement, similarly mounted to the chopper, was common in most of the Humboldt Bay canoes. The stone head is cylindrical in form, tapering to fit the socket at one end, and hollowed slightly on the striking face. It is used for pounding sago. The awkwardness of its method of mounting is at once felt on trying to drive a nail with it.

The ethnographical details of the people of Humboldt Bay are, thanks to the investigations of the Dutch commission on board the ship "Etna," better known than those of most savages.[1]

Directly the ship was anchored, the boats were hoisted out and preparations made to survey the bay and explore the country, but although the natives allowed the officers sent to obtain astronomical observations to land on a small uninhabited island, they used threatening gestures towards the other boats, pointing their arrows against the breasts of the naturalists and officers; consequently the exploring and surveying parties returned for orders.

This unwillingness on the part of the natives to allow the parties to land and explore the country rendered it necessary either to pay respect to their wishes, or to proceed in the investigations at the risk of an embroilment with them. Much as it was wished to explore a part of the world so little known as is the district of New Guinea around Humboldt Bay, it was considered unjustifiable to use force for the purpose, or even to land any explorers where a momentary impulse on the part of a savage might possibly lead to the sacrifice of many lives. Conciliation was thus the only resource left, and the boats were kept on board whilst endeavours were made to make friends with the people in the canoes surrounding the ship. All the efforts, however, failed to induce even one of the men to come on board, and the conclusion was reluctantly come to that it would require some days' intercourse with them before they could be taught that the object of the Expedition in visiting their settlement was a friendly one. There was no doubt that by sacrificing a week or ten days in conciliation almost anything might have been done with these people, but devoting so much time to this purpose was out of the question, so it was resolved to leave Humboldt Bay and proceed to the Admiralty Islands, where it was hoped that the intercourse with the natives might be more fortunate.

Before hoisting in the boats the pinnace proceeded towards one of the villages with Captain Thomson, Professor Thomson, Mr. Murray, and Mr. Wild, in order to allow Mr. Wild to make a sketch of the village (see fig. 233). As the pinnace approached the platform on which the houses were built, four or five natives presented themselves with bows and arrows in hand. One of them drew his bow and pointed his arrow towards the pinnace, but offered both immediately for "sigor." When the bow of the pinnace was placed alongside the scaffolding on which the pile-dwellings stand one of the bluejackets got on to it. This was, however, strongly objected to by the natives, who motioned him back to the boat. After a short time one of the natives was induced to take Mr. Murray on shore in his canoe, and Professor Thomson and Captain Thomson followed shortly after in a second canoe. The rock at the point where the party landed was a limestone weathered at the surface into sharp, jagged points, round which the roots of the trees were twined in a most extraordinary manner. Two birds (*Tricho-*

[1] Nieu Guinea Ethnogr. en Natuurkundig onderzoocht in 1858 door een Nederl. Ind. Commissie, *Bijdragen tot de Taal Land en Volkenkunde van Nederlandisch Indie*, Deel v., Amsterdam, 1862. For Von Rosenberg's account of the visit, see *Nat. Tydsch. voor. Nederl. Indie*, Deel xxiv. p. 333 *et seq.*, Batavia, 1862.

glossus cyanogrammus and *Arses insularis*) were shot, and a number of Goura pigeons, cockatoos, and several other birds were noticed. The natives were quite friendly, and took a great interest in pointing out the birds and in watching the result of each shot. They did not seem to be greatly astonished at the report of the gun. As the pinnace returned to the ship a few women with short kilts were observed standing at the door of one of the pile-dwellings.

Humboldt Bay, shaped somewhat like a crescent, is from 4 to 5 miles wide at its entrance between Points Caillié and Bonpland (the extreme points of the crescent), and perhaps 7 miles wide at its broadest part by about 4 or 5 miles deep. The bay

Fig. 233.—The Village of Ungrau in Humboldt Bay, New Guinea.

is open to the northeast, and a heavy swell rolls in, which, whilst the Expedition was there, was breaking on the shores all round, with the exception of a small portion sheltered by Point Caillié. Point Caillié is a promontory about 500 feet high, jutting out to the S.S.E. from the mainland, to which it is joined by a low neck, and forming between it and a point $1\frac{1}{2}$ miles to the southeastward a sheltered cove which was named Challenger Cove. In the southwestern part of Challenger Cove are two small islets; the outer, uninhabited, was named Observation Islet, and the inner, on which is a settlement, Village Islet. Southwestward of these islets are some coral rocks with deep water between them. At the northeast end of Challenger Cove, on Point Caillié, is another village, off which the anchorage appeared to be free from danger. One mile

S. by W. from Observation Islet is another small islet, and on the mainland between them there are a few huts on the beach. At the head of Humboldt Bay is a sharp peak just inside the coast line, from whence to Point Bonpland the coast is low. Point Bonpland is the western extremity of a ridge of hills, about 4 miles long and from 800 to 1000 feet high, which stretches from that point towards Mount Bougainville, ending with a sharp fall over Point Bonpland, off which there are two small islets. Mount Bougainville is wrongly placed on the chart; it bears S. 68° E. (true) 17·5 miles from Point Caillié, and is a sloping mountain 4500 feet above the level of the sea. The Cyclops Mountains consist of a long range with one peak considerably higher than the others, the position and height of which could not be determined.

The deposit at 37 fathoms in Humboldt Bay was a greenish mud, containing a few Pteropod and Foraminifera shells. The surface organisms did not indicate the presence of any large body of river water, being rather pelagic than estuarine.

Humboldt Bay to the Admiralty Islands.

The first two days after leaving Humboldt Bay for the Admiralty Islands, light westerly winds and fine weather were experienced, after which the wind became variable, with squalls, and approaching the Admiralty Islands there was almost continuous rain. Matty Island, the Schouten group, and the Hermit Islands were sighted on the passage, and one sounding of 1070 fathoms was obtained in lat. 2° 33′ S., long. 144° 4′ E.; a trawling and temperatures (see Sheet 31) were also obtained in this position. The deposit was a blue mud with a reddish surface layer, and contained 17 per cent. of carbonate of lime. The trawl brought up a large quantity of mud, large pieces of pumice, fragments of wood and fruits, and nearly two hundred specimens of deep-sea animals. The net was covered with a branching Rhizopod.

The Alcyonaria.—The Pennatulida have been noticed on page 49. The other Alcyonarian collections were sent to Professor E. Perceval Wright, who is engaged in preparing a Report on them; he writes as follows:—"The species of the suborder Alcyonacea, being for the most part inhabitants of shallow water, were not well represented in the collections. Still some interesting species of the genera *Xenia*, *Clavularia*, and *Nephthya* occur, and a few forms of the genus *Spoggodes* were dredged in depths of from 100 to 150 fathoms. A species of *Sarcophyton* found on the reefs off the shores of the Admiralty Islands supplied Professor Moseley[1] with the material for an important memoir on the structure of this form, the heteromorphism of which had already been discovered by Professor Kölliker. Only a few fragments of *Tubipora musica* were collected, and no simple non-colonial forms.

[1] On the Structure of Sarcophyton, *Phil. Trans.*, part i. p. 109, 1876.

"The great mass of the specimens collected belong to the suborder Gorgonacea, the mere enumeration of the names of which would be without interest. Several species of the genus *Primnoa* were dredged in great quantities. A fine specimen of the

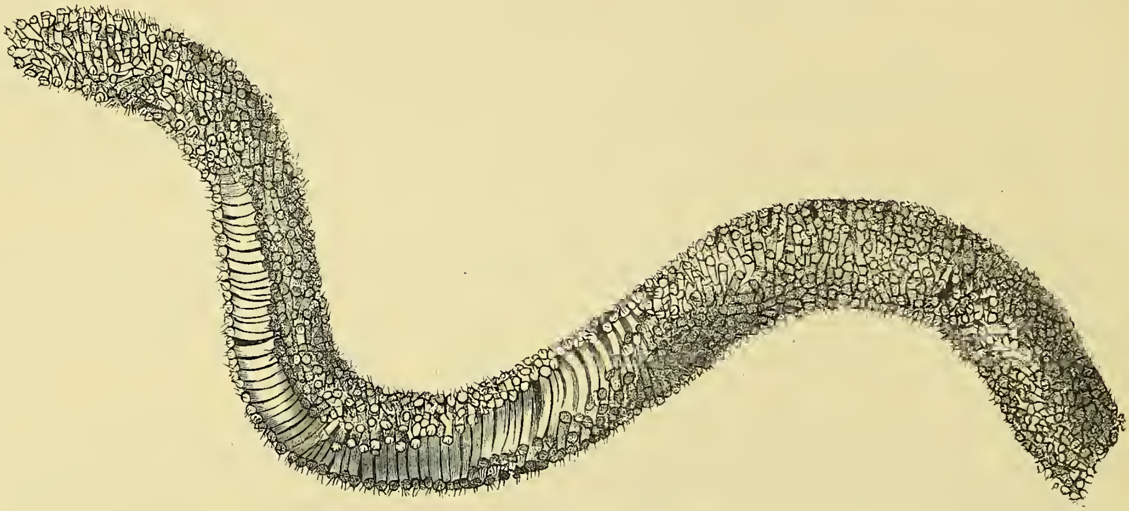


FIG. 234.—*Callozostron mirabile*, n. gen. et sp.; natural size; from 1675 fathoms.

rare *Calytrophora japonica*, in nearly perfect condition, was dredged from a depth of 610 fathoms off the Fiji Islands, while another and smaller species of more rigid growth, and with the verticels of polyps reversed on the stem (*Calytrophora wyvillii*, n. sp.), was taken off the Kermadec Islands from a depth of 600 fathoms. There are numerous species of *Primnoëlla*. In a new species (*Primnoëlla murrayi*) from Station 320, at a depth of 600 fathoms, the verticels of polyps resemble minute cycad cones, from the peculiar imbrication of the large external scale-like spicules.

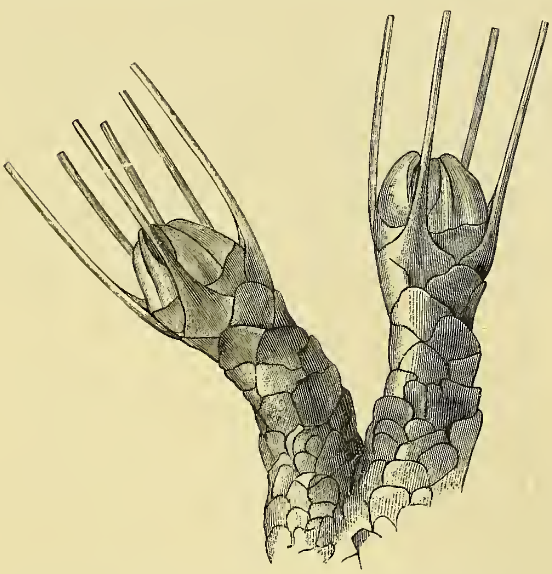


FIG. 235.—*Callozostron mirabile*, n. gen. et sp.; single polyps, enlarged.

"The most remarkable form of Alcyonarian collected, which shows certain affinities to the Primnoads, is the one whose general appearance will be best understood from the accompanying illustration (fig. 234). It was dredged at Station 153, in the Southern Ocean, from a depth of 1675 fathoms. The stem or main axis is flexible and only partially calcareous; around about five-sixths of its surface the large polyps are tightly packed, while the remaining one-sixth is free from polyps, and apparently trailed along the ground. As the basal portion of the main axis or stolon is imperfect, it must remain a matter for conjecture whether, as seems probable, it was attached or remained free and was only anchored in the mud. In either case it seems likely that by the contraction of the polyps, an irregular vermiform movement may have been given to the colony. To this strange form the name *Callozostron mirabile* has been given. Fig. 235 shows two of the polyps, enlarged.

"Next in interest come a number of deep-sea forms, which will necessitate the emendation of Verrill's recently established family Chrysogorgidæ. The species are noted for the elegance of their form, which varies from that of an elongated unbranched axis not thicker than a horse hair to a spirally branched axis forming quite

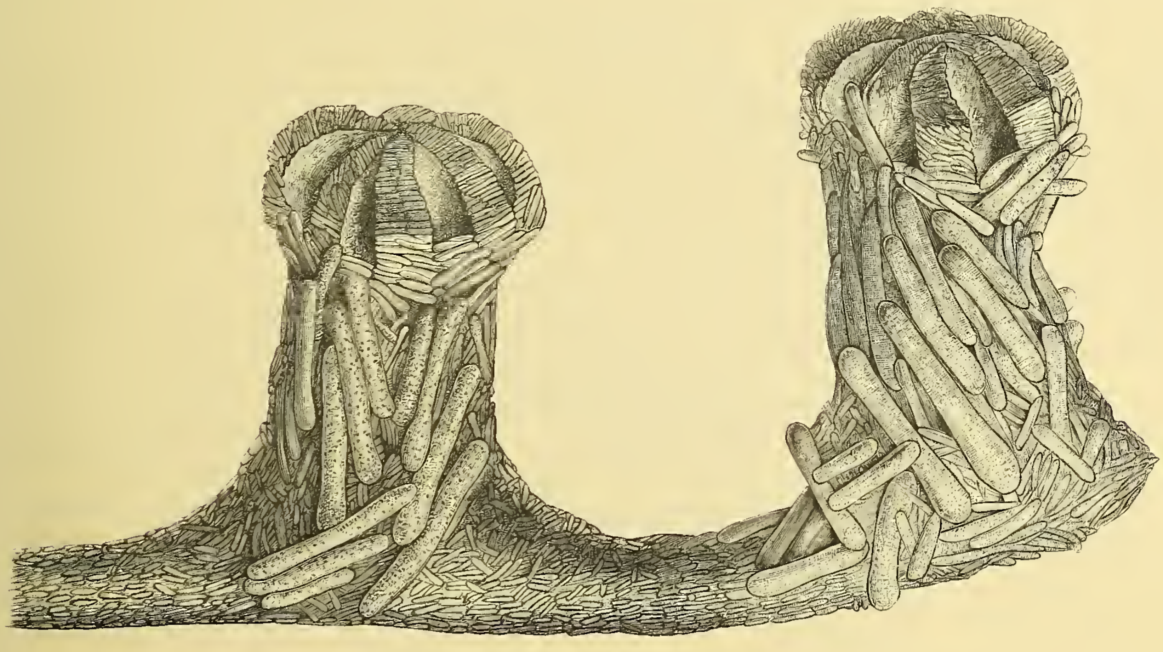


FIG. 236.—*Bathygorgia profunda*, n. gen. et sp.

a shrub-like mass. The axes when denuded are of a most brilliant metallic hue, and markedly iridescent. All the hitherto recorded species have been taken in deep water off the Atlantic shores of the West Indies or North America. Among the new forms in the Challenger collection may be mentioned *Strophogorgia challengeri*, n. gen. and sp., 600 fathoms (off Cape St. Vincent), and *Strophogorgia verrilli*, n. sp., from Station 235 (Japan), at a depth of 565 fathoms. Other species have been taken at Station 70 (Azores), depth 1675 fathoms, and Station 237 (Japan), depth 1875 fathoms. A form (*Bathygorgia profunda*) in which the axis was too feeble to hold the polyps in an erect position is shown in fig. 236; it was dredged at Station 241, from a depth of 2300 fathoms. The spicules are very massive, and are club-shaped. A number of new and interesting forms belonging to the families Muricidæ and Gorgonidæ were taken, and numerous species belonging to the genera *Acanella, Ceratoisis, Sclerisis,* and *Lepidisis* of the family Isidæ.

"But few species of the suborders Briareacea and Melithæacea were collected.

"Coralleacea—No living species of the genus *Corallium* was discovered, but some worn specimens were found at Banda and the Ki Islands,[1] which Mr. S. O. Ridley describes as follows:—

"'One specimen was a large well-branched example, 9 inches high by 5 inches in greatest diameter above, greatest diameter at base 22 mm. The branching is essentially in one plane, while its fundamental plan appears to be dichotomous, it is not strictly adhered to, and the larger branches are more or less regularly pinnate, with marginal twigs of small size. The stem and larger branches have their antero-posterior diameter decidedly larger than the lateral diameter. The longitudinal striæ of the hard axis are delicate and numerous, viz., about 4 to 1 mm. on an average in the larger axes. A transverse section of one of the small pinnæ exhibited the structure characteristic of the axes of members of this family. The section, like the exterior of the corallum itself as seen with the naked eye, is devoid of positive colour; with the exception of a few pale red points in the centre of the section which are evidently embedded spicules, and appear to have the stellate form characteristic of the family, no free spicules could be found. The specimen, which had evidently been dead for some time, as the longitudinal striæ are obliterated in places, and besides being encrusted with Polyzoa, a delicate Sponge, &c., is much excavated, apparently by Worms and boring Sponges, was obtained on the 26th September 1874, in 129 fathoms, off the Ki Islands. The second specimen, which measures only $2\frac{1}{4}$ inches in height and diameter, the greatest diameter of the stem being 10 mm., agrees so closely in all its external characters with the first, that it is unnecessary to describe it further, except by saying that all the clean broken surfaces of the branches exhibit a pure white colour, whereas the first specimen shows a faint pink coloration on the broken surfaces of five small branches. It was obtained off Banda, in 200 fathoms. With regard to the genus and species to which these specimens should be referred, it must be stated that, in the absence of the cortex, a final decision is impossible. In the general external characters (with the exception of the colour) they resemble very closely the only known species to which on distributional grounds it is likely that they would belong, viz., *Corallium* (*Pleurocorallium*) *secundum*, Dana, which is known to inhabit Japanese seas. This species (as shown by the series of specimens exhibited in the Japanese Court at the International Fisheries Exhibition, 1883) varies very greatly in its external coloration, being apparently in some cases wholly white externally, like the present specimens; if therefore it is remembered that their maceration in sea water would probably destroy or alter a bright red surface colour, and that in parts the corallum still retains a red tint, the improbability, founded on colour, of the identifica-

[1] Another specimen of *Corallium* has recently been found by Prof. Moseley in the dredgings off Prince Edward Island.

tion becomes much less. The chief interest of the specimens lies in the fact that no Coralliidæ have ever been recorded from the Malay Archipelago, and that the only localities in the Indo-Pacific area from which species of the family are known are Mauritius (*Corallium stylasteroides*) and Japan (*Pleurocorallium secundum*). Dana's locality of Sandwich Islands for the latter is very uncertain. The fragments (in the fossil state) described by Professor Duncan from New Zealand do not appear to throw light on the present specimens.' "

The Nudibranchiata.—Dr. Rudolph Bergh of Copenhagen, who has prepared the Report[1] on the Nudibranchiate Molluscs collected by the Expedition, has supplied the following note:—"The so-called Nudibranchiate Gasteropoda are distributed over all

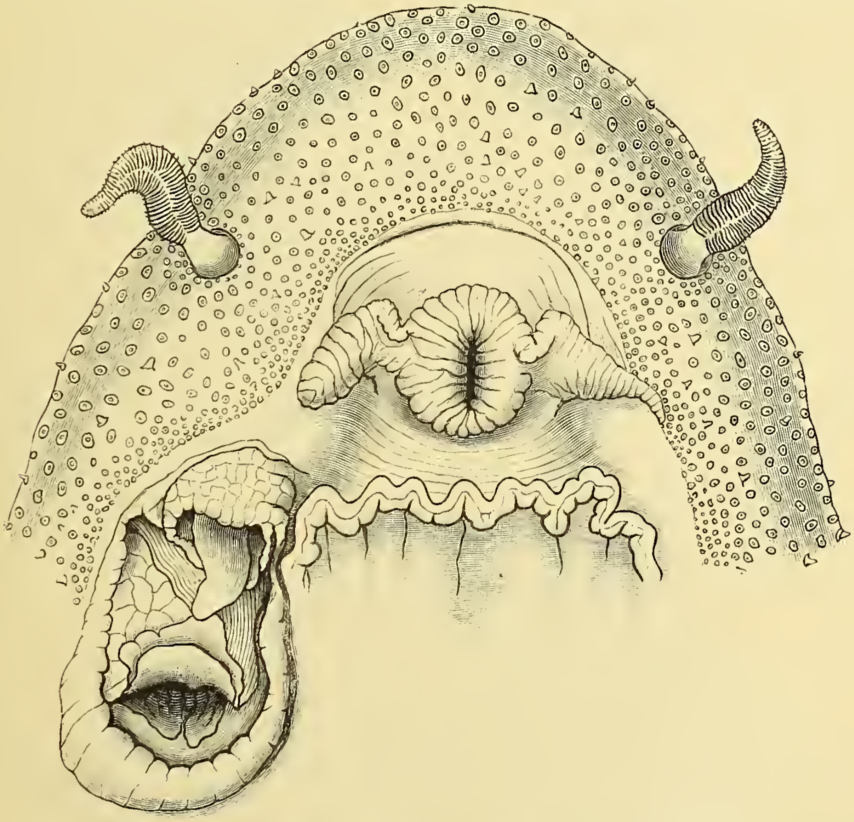


FIG. 237.—Inferior surface of anterior extremity of *Bathydoris abyssorum*, Bergh (natural size), showing the mouth, the two rhinophoria projecting from their sheaths, the two genital openings (from the anterior of which projects the large glans penis), and the anterior margin of the foot.

seas. Judging by the discoveries made by the Polar Expeditions they appear to be least common towards the Poles, while they are most abundant in the tropical and subtropical seas, in which latter there occur species of unusual size and most beautiful colour.

[1] Report on the Nudibranchiata, by Dr Rudolph Bergh, Zool. Chall. Exp., part xxvi., 1884.

"Most of the families belonging to this group are found in all seas; some, however (*e.g.*, the Phyllidiadæ), occur only in the tropics. The largest group, the Dorididæ, is represented by a large number of generic forms especially in tropical regions, whilst the Æolidiadæ, on the other hand, are more conspicuous in more northern seas.

"Most Nudibranchiata live on algæ and coral reefs in the neighbourhood of coasts or on the surface of the open seas; it was therefore not to be expected that the Challenger

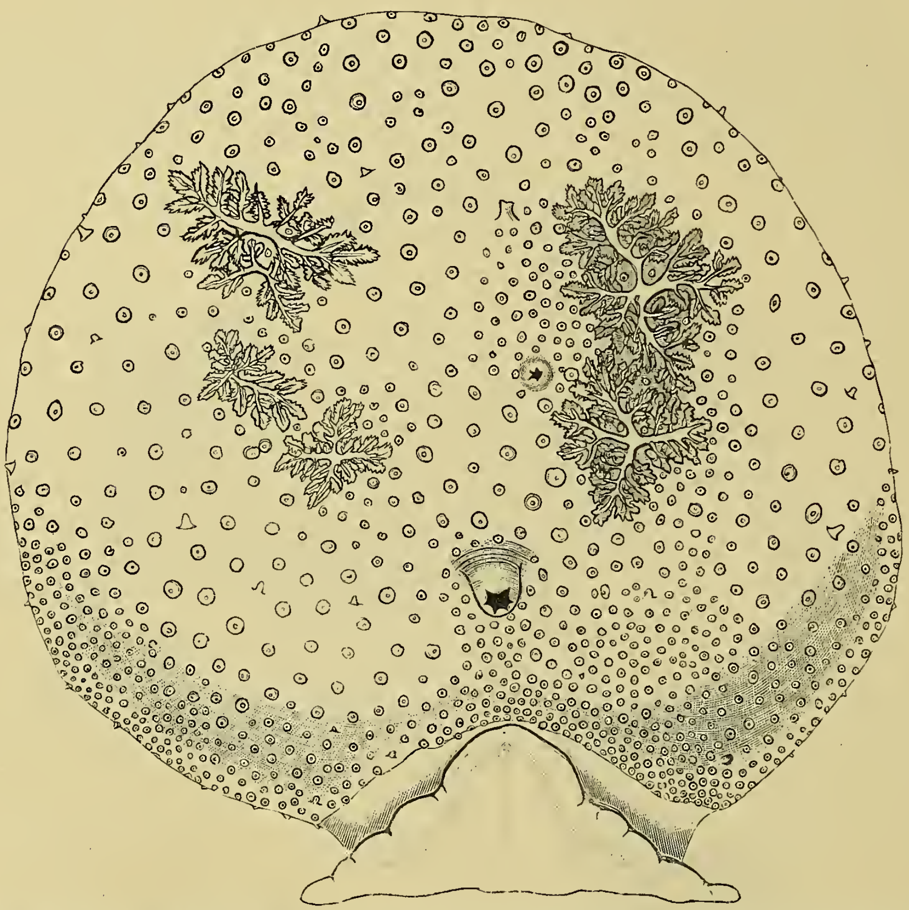


FIG. 238.—Back view of *Bathydoris abyssorum*, Bergh (natural size), showing the five branchial tufts, one having been probably accidentally lost from the right side; close to the branchiæ on the right side is the renal pore, and below in the middle line the anal papilla; at the bottom is the expanded foot.

Expedition, which was chiefly concerned with deep-sea investigation, should bring back a large collection of these animals, nor many new species.

"In fact, only twenty-four (or twenty-five) forms altogether were obtained, of which, however, twelve or thirteen were new species, which give rise to the constitution of four new genera.

"The most remarkable form was dredged from the great depth of 2425 fathoms; the Nudibranchiata called 'deep-sea' by M. Sars came from much shallower water. This form, to which the name *Bathydoris abyssorum* (figs. 237, 238) has been given, is perhaps the largest Nudibranchiate Mollusc hitherto known, measuring 12 cm. in length after long immersion in spirit. When alive it was transparent and gelatinous in consistency; the rhinophoria were brown, the gills and protruding external genital organ orange, and the foot dark purple. In shape it is subglobular, somewhat resembling the genus *Kalinga* of Alder and Hancock. The gigantic bulbus pharyngeus resembles rather that of *Bornella* and other Tritoniadæ; the labial disk is thus unarmed and the powerful mandibles are covered by a thick muscular mass. The radula is not unlike that of the Tritoniadæ, possessing as it does a median tooth and a series of lateral teeth, but the first lateral tooth is quite similar to the rest, whereas in the Tritoniadæ it is different. On the whole *Bathydoris* appears to form a remarkable connecting link between the Tritoniadæ and the Dorididæ. It was taken at Station 271 in the middle of the Pacific from a depth of 2425 fathoms.

"A second form obtained by Mr. Murray in the 'Triton' from 608 fathoms, in the Færöe Channel, has been made the type of a new genus, and has been named *Cuthonella abyssicola*. This novel form, for which I have established the generic name *Cuthonella*, somewhat resembles *Cratena* and *Cuthona*, but differs in some comparatively essential points. The anus, instead of being situated upon the side of the body, is dorsal and slightly lateral. The dorsal papillæ are not inflated; they are set in transverse or oblique rows, which are crowded together so as to form a few larger groups. In the specimen examined the cnidophorous bags were absent. The foot is not very broad, its anterior margin is truncated. The mandibles are somewhat short, the masticatory edge provided with several series of strong denticles. The radula has a single series of rather large teeth, with a denticulate cutting edge. The penis is unarmed."

CHAPTER XVII.

The Admiralty Islands—History of their Discovery—Description of Nares Harbour—General Appearance of the Islands and Botany—Natives—Their Houses, Habits, Customs, Ornaments, Weapons, and Implements—Zoology—Polynesian Races.

On the 3rd March the weather was so thiek and rainy that, being elose to the land without seeing it, it was neeessary to "lay to" for a short time. After noon the weather eleared somewhat, and at 2 P.M., the three northwest islets of the Admiralty group (Buehanan, Murray, and Moseley Islands) were sighted and the ship steered to the eastward towards D'Entreeasteaux and Suhm Islands, after passing whieh a eourse was kept along the edge of the D'Entreeasteaux Reef, rounding its eastern extremity at dusk and anchoring in 18 fathoms.

D'Entreeasteaux's sketch of the north side of the Admiralty Islands was found very correet for a running survey, and no diffieulty was found in distinguishing the points and islands laid down on it.

As the ship approaehed the anchorage several canoes eame off, under sail, from D'Entrecasteaux and Wild Islands, through openings in the reef, though a stiff breeze was blowing. The natives were evidently in great exeitement, and eager to reaeh the vessel; paddles were waved to show friendship, and various artieles of barter exhibited. The eonstant ery was "laban, laban," whieh was found, like the "sigor" of Humboldt Bay, to mean iron, the form of wealth which they also coveted most.

After the ship anehored on the evening of the 3rd Mareh, the ehief ordered all the canoes away, and the vessel was left alone till the morning. On the 4th, at 7 A.M., several eanoes eame off from Wild Island, and, as the natives appeared well disposed and the weather favourable, a party landed on a small coral island (Observatory Islet) to obtain astronomieal observations. After breakfast Captain Thomson landed on Wild Island, and found the inhabitants very friendly, so the boom boats were got out, the Naturalists went away exploring, and every preparation was made for surveying the anehorage, whieh was ealled, in compliment to the late eaptain, "Nares Harbour" (see Sheet 34).

The Expedition remained at Nares Harbour for seven days, until the 10th Mareh, surveying the harbour and exploring the eountry, but the work was much impeded by rain, whieh fell on five days out of the seven, the total fall being 2·81 inehes, the greatest in any one day being 1·21 inches. The wind, the direction of whieh was reeorded bi-hourly, prevailed from the northward, its average veloeity being 7½ miles per hour. The sky was eloudy and the atmosphere damp and oppressive, the mean temperature being 81°, and the relative humidity 97. The mean pressure of the air at a temperature of 32° was 29·83, and the mean temperature of the sea surfaee 83°·8.

The existence of the Admiralty group of islands[1] was first made known to Europeans by Le Maire and Schouten, who sailed along their southern side on the 4th July 1616, and named them the "Twenty-four Islands," but did not anchor or attempt to communicate with the shore; in fact they mistook the largest of the islands for Ceram, so uncertain was the method of obtaining the longitude in those days.

The next account of the group is from the voyage of Captain Philip Carteret in H.M.S. "Swallow," 1767, who sighted the southern side of these islands on the 14th September, and gave them the name by which they have since been distinguished. Twelve or fourteen canoes came off to Carteret's vessel, and the natives at once attacked him by throwing their lances into the midst of his crew, whereupon Carteret replied by firing some muskets and a swivel gun at the canoes, which caused them to disperse. One of the boats was afterwards captured and found to contain six fine fish, a turtle, some yams, and a cocoanut. This canoe, which was rudely made out of a tree and furnished with outriggers, was 50 feet in length.

Bougainville, in August 1768, passed northward of the Admiralty Islands without seeing them, but sighted the Anchorite and l'Echiquier groups.

Francisco Maurelle, captain of the Spanish frigate "Princessa," was the next to sight the Admiralty Islands, on his passage from Manila to San Blas. He appears to have been well acquainted with Bougainville's discovery, but knew nothing of Carteret's, and thought he was the first European to see this group. Having first observed the Hermit Islands on the 8th January 1781, he passed between them and Anchorite Island, and on the 10th, saw the main Admiralty Island, which he named "Bosco." On the 11th some natives came off to his vessel, who, according to his account, were in a most miserable condition, and fought for some biscuits and cocoanuts which he threw amongst them. Steering along the northern shore of the main island, Maurelle gave the name of "Los Negros" to the islets lying off the northeast point, and the names of "San Gabriel," "San Rafael," "Los Reges," "Jesu Maria," and "San Miguel" to those to the east and southeast.

A little confusion of names appears to have arisen regarding these various islands, that at present named "Commerson Island" is in all probability the Anchorite Island of Maurelle, seen by Bougainville from the masthead, whilst the present Anchorite Islands are those which he named "Los Monjos." Again, it is probable that the isle marked Low Island, southeast of Admiralty Island, was the one seen and named "San Miguel" by Maurelle, for the present San Miguel Islands are said to be only 15 feet high, whilst Low Island is marked as being 700 feet high. An account of Maurelle's voyage is given by Espinosa and La Perouse.

The Admiralty Islands appear to have been next sighted by Captain John Hunter of H.M.S. "Sirius," who, having lost his vessel at Norfolk Island in March 1790, took passage

[1] Burney's Voyages, Hawkesworth's Voyages, Bougainville's Voyage, La Perouse's Voyage, Espinosa's Memoires Astronomique.

to England, via Batavia, in the hired transport "Waaksamheyd." Starting from Port Jackson at the end of March 1791, he passed through St. George's Channel (separating New Britain from New Ireland) in May, and after stopping a short time at Port Hunter, Duke of York Island, made the Admiralty Islands on the 31st of that month, and sailed along their northern coasts to the westward. Five large canoes came off to the "Waaksamheyd," with eleven natives in each canoe, who, although anxious to barter, refused to come alongside the ship. One of them made various motions for shaving by holding up something in his hand, with which he frequently scraped his cheek and chin, causing Captain Hunter to infer that they had been visited by La Perouse on his way northward from Botany Bay, in which port Captain Hunter met the French Discovery ships, "La Boussole" and "Astrolabe," in March 1788.[1]

Early in the year 1791 the Parisian Society of Natural History called the attention of the Constituent Assembly to the fact that no information of La Perouse had been received for nearly three years. The hope of recovering at least some wreck of this expedition induced the Assembly to despatch two vessels, the "Recherche" and "Esperance," under the command of Bruny D'Entrecasteaux, to search for intelligence of La Perouse. Arriving at the Cape of Good Hope in January 1792, D'Entrecasteaux received an exaggerated account of the report of Captain Hunter, one statement of which went so far as to say that the crew of the "Waaksamheyd" had distinguished, in the Admiralty Island canoes, Europeans clothed in the uniform of the French Marine, who displayed a white flag as a signal for the English to approach.

This information, evidently incorrect from Captain Hunter's own narrative, induced D'Entrecasteaux to visit the Admiralty group, where he arrived at the end of July 1792. He first proceeded to Jesu Maria Island, which is described as being surrounded by a reef and with apparently but few inhabitants. From Jesu Maria Island he proceeded to Vandola, where he communicated with the natives, but did not land owing to the surf which breaks on the reef surrounding the island. Thence he proceeded towards the Negros Islands on the northeast coast of the main Admiralty Island, and sailing along the north coast, communicated with the natives and made the first running survey of the group, but gained no intelligence of La Perouse, and finally left the islands on the 1st August, without landing on any of them.

In 1843 the islands were visited by the American clipper "Margaret Oakly," whose crew landed at many points on the coast of the main island, which, according to Jacobs' account, was called "Marso" by the natives; they also visited many of the small outlying islands. Jacobs' account[2] is full of interesting details, but evidently not entirely trustworthy; such portions of it as are important will be referred to in the sequel.

From 1843 there is no published account of the visit of any vessel to the Admiralty

[1] Hunter's Journals.

[2] Scenes, Incidents, and Adventures in the Pacific Ocean, &c., by J. T. Jacobs, pp. 164–182, New York, 1844.

Engraved by Malby & Sons.

Islands till the year 1874, although it is known that whaling vessels cruised occasionally in their vicinity, for Captain Abraham Bristow of the "Sir Andrew Hammond" was there in February, March, and April 1871, and specimens of Admiralty Island lances and gourds are to be seen in the Christy and British Museum collections, which had been obtained from Cape York, having doubtless been taken there by tortoiseshell and pearl shell traders, and by the whaling vessels. In 1874 H.M. Schooner "Alacrity," Lieutenant Commander Saunders, visited the south and east coasts of the main Admiralty Island and Jesu Maria Island, and found the inhabitants friendly and well disposed.

Since the visit of the Challenger in March 1875, the Admiralty Islands have been several times visited by the far famed Melanesian explorer Baron N. de Miklucho-Maclay, viz., in 1876, 1879, and January 1883.

The Admiralty group, which may be considered as confined between the parallels of 1° 40′ and 3° 30′ south latitude, and the meridians of 145° 30′ and 148° 30′ east longitude, consists of one large and numerous small islands, amongst which are interspersed many coral reefs.

The main Admiralty Island (named "Bosco" by Maurelle, but which is merely designated Admiralty on the Admiralty charts) is about 60 miles in length by 10 in width, and occupies an area of upwards of 500 square miles. The next largest island in the group is that of Jesu Maria, which is about 12 miles in length by 5 in breadth, with an area of 50 square miles. The remaining islets of the group are small.

Admiralty or Bosco Island consists for the most part of undulating land, which attains a considerable elevation, nearly 3000 feet, in its central parts. The coast is for the most part low, and here and there indented by deep bays and occasionally fringed with mangrove bushes. Off the coast, at varying distances, are a series of coral reefs forming natural breakwaters, and as the water is of a convenient depth between these reefs and the shore, well protected anchorage may be obtained at almost any part of the island. These off-lying reefs do not form a connected barrier such as may be seen off the north-eastern coast of Australia, but are detached from each other, in some cases, by considerable intervals; they are however, in all probability, elevations of the same submarine plateau the extent of which requires to be traced by the lead line.

Besides Admiralty or Bosco Island, four others of the group attain an elevation of from 600 to 800 feet, while the remaining islets are low and more like what in the West Indies are denominated "cays" than islands, and are situated on coral reefs.

The investigations of the Challenger were confined to the northwest corner of the main island, in the immediate neighbourhood of the anchorages.

Nares Harbour, at the western extremity of the north coast of Admiralty Island, is a well sheltered and convenient anchorage, easy of access, but destitute of supplies. It is nearly 8 miles in length from east to west, has an average breadth of 3 miles, and is protected by a reef which, joining some outlying islands lying nearly parallel to Admiralty Island, forms a natural breakwater completely sheltering the space enclosed between it and the coast of that island. This reef has been named after D'Entrecasteaux, who made a running survey of the northern portion of the Admiralty group in 1792, and whose positions and sketch of the land are apparently correct.

The whole of the space enclosed between D'Entrecasteaux Reef and Admiralty Island is not available for anchorage, part of it being occupied by several small islands and shoals; there is, however, sufficient room to afford shelter to several vessels, and if the whole of the harbour were sounded it would probably be found quite large enough for all requirements of trade at this group for many years.

D'Entrecasteaux Reef is 7 miles long W.N.W. and E.S.E., and 6 cables in width at its broadest part. On it are three low, flat, sandy islands (named D'Entrecasteaux, Suhm, and Wild), all of which are thickly wooded, two of them, D'Entrecasteaux and Wild Islands, being inhabited; and close to its eastern extremity is a small sandy cay with a few trees on it, named Observatory Islet, being the observation spot of the Challenger in 1875.[1] The northern or outer edge of the reef is well defined, and has apparently no outlying dangers, none having been seen from the masthead when sailing along it in the Challenger, nor any found by the boats when sounding close to the breakers, which in March are very heavy. At a distance from its edge of $1\frac{1}{4}$ miles, one sounding of 150 fathoms was obtained. The southern or inner edge of the reef is not well defined; it has, as is usual with coral reefs, several mushroom-shaped rocks cropping up close to it, with deep water around, and must therefore be approached with caution. In the centre of the reef is a shallow lagoon, and $2\frac{1}{2}$ miles from its western extremity there is an opening, through which apparently a boat or even a small vessel might pass into smooth water under favourable circumstances, but the sea breaks at times across it.

D'Entrecasteaux Island is the westernmost of the three on the reef of that name, and lies 3 cables from its edge. It is nearly half a mile in length and 2 cables in breadth, low and flat, but covered with trees, which, rising from 80 to 100 feet, can be seen at some distance. The natives live in a village on its north side, which is guarded by a rough stockade. The landing place is on the south side. There is no good water to be found there, nor in fact on any of the small outlying islands visited; the natives use the sea water which filters through the sand into wells dug near their habitations, and is very brackish even in the rainy season.

Suhm Island, a little over a mile to the eastward of D'Entrecasteaux Island, is of nearly the same size and height as that island, but is uninhabited. Four cables to the eastward of it is the break in the reef before mentioned.

The space to the westward of Suhm Island appeared from the masthead of the Challenger, when outside the reef, to be free from danger, and good anchorage will most likely be found there. The west point of D'Entrecasteaux Reef may probably be rounded at a distance of a quarter to half a mile, and anchorage found between the two islands to the southward of the reef; but it must be borne in mind, in entering the harbour by the western passage, that no soundings have as yet been obtained there, and therefore it is imperatively necessary that a good lookout should be kept from aloft for any shoal heads that may exist.

Wild Island lies nearly 4 miles E.S.E. of Suhm Island, is three quarters of a mile in length, and 250 yards in breadth at its widest part, and is low, flat, and covered with trees, like Suhm and D'Entrecasteaux Islands. Wild Island is inhabited, the village being on the south coast, near its

[1] The native names not being procurable, it was considered justifiable to give names to the various islets, &c.

centre. On the two inhabited islands there are numerous cocoanut trees, whereas neither of the other small islands, nor the coast of the larger island in the immediate neighbourhood of the harbour, have any.

Observatory Islet, in lat. 1° 55′ 0″ S., long. 146° 38′ 40″ E., lies E. by N. 8 cables from the east point of Wild Island, and about a quarter of a mile inside the eastern extremity of D'Entrecasteaux Reef, which here comes to a point. It is small and stony, but has a few trees growing on it.

Challenger Shoal, over the west end of which the Challenger passed, lies E. by S. $\frac{3}{4}$ S. 1·4 miles from Observatory Islet. On it are $3\frac{1}{2}$ fathoms, with shallower water apparently to the eastward. When passing over the shoal, Observatory Islet was in line with the north extremity of Suhm Island.

Eastern Channel is a safe and deep channel one mile broad, between Challenger Shoal and the east extremity of D'Entrecasteaux Reef, leading into Nares Harbour.

Wyville Point, the northwest extremity of Admiralty Island and the southwest extremity of Nares Harbour, lies S. $\frac{1}{2}$ W. nearly 5 miles from D'Entrecasteaux Island. The point itself is rocky, and has a coral reef stretching off it a short distance from all parts; from it the coast to the westward trends nearly south to the west point of Admiralty Island, while to the eastward is a large but shallow bay, formed between it and the next point (Moseley Point), which lies N.E. by E. $\frac{1}{2}$ E. a little over 4 miles from it. This bay, named Shallow Bay, was mistaken by D'Entrecasteaux for a strait separating a considerable tract of land from the main island.

Shallow Bay, which is 4 miles wide from Wyville Point to Moseley Point at its entrance, is about 3 miles deep. It has not been sounded, but as the Challenger's pinnace, with an exploring party, grounded several times, ships should not at present attempt to make use of it. There are no inhabitants in the locality, nor could any stream of fresh water be found in or near it. In the centre of the bay are three small islands named Higham, Button, and Ferguson, all of which are low, flat, and thickly wooded.

From Wyville Point the land rises in a gradual slope to a saddle-shaped hill, 500 feet high, S. by E. $2\frac{1}{2}$ miles from the point. This is the highest hill in the vicinity of the harbour, but there is higher land some miles to the eastward of it.

Maclear Island.—Between Wyville Point and D'Entrecasteaux Island is Maclear Island, the summit of which, 200 feet high, lies N. by E. $\frac{1}{2}$ E. nearly 2 miles from Wyville Point. It is thickly wooded, nearly circular in shape, 900 yards long, 750 yards in breadth, and is surrounded by a coral reef, on the western edge of which are two small rocks about 20 feet high, named the Twin Rocks.

Between the coral reefs of Maclear Island and Wyville Point there is apparently a deep passage one mile in width, but it has not been sounded.

Moseley Point, at the eastern entrance of Shallow Bay, is 4 miles N.E. by E. $\frac{1}{2}$ E. from Wyville Point, 5 miles S.E. from D'Entrecasteaux Island, and $3\frac{1}{2}$ miles S.W. by S. from Observatory Islet. Eastward of it the coast trends to the E.S.E. for nearly 3 miles, when it juts out slightly, forming a small promontory, which has a "boat cove" on its western side, and a small islet (Richards Islet) to the eastward of it. From this promontory the coast of Admiralty Island trends more to the south-eastward for a short distance.

Between Moseley Point and D'Entrecasteaux Island are three islands, named Carpenter, Browne, and Tracey, and nearly one mile E. by S. from Moseley Point is a small island, named Pigeon Island from the large number of those birds which frequent it.

The whole of that part of the coast of Admiralty Island which was explored to the eastward of Moseley Point is fringed with a coral reef, extending from 2 to 4 cables from the shore.

Failure Rocks are two small bare rocks about 5 or 6 feet high, on the edge of the reef which fringes the coast of Admiralty Island. They lie S.S.E. a little over 3 miles from Observatory Islet and E. by S. ½ S. nearly 4 miles from Moseley Point, and form a good mark for entering through the east channel into Nares Harbour, as they lead, when bearing S. ¾ E., midway between the east extremity of D'Entrecasteaux Reef and Challenger Shoal.

To the northward of these rocks, at a distance of half a mile, there is a narrow shoal with 4 fathoms on it, and 20 to 28 fathoms just outside.

Carpenter, Browne, and Tracey Islands are connected by a reef. They lie in a N.W. by W. direction from Moseley Point, and between that point and D'Entrecasteaux Island. There is a channel 9 cables in width between the reef surrounding them and the reef off Moseley Point, which appears, so far as explored, to be safe and deep, and there is probably also deep water between D'Entrecasteaux Island and this reef, as well as between it and Maclear Island, where one sounding of 19 fathoms was obtained. The space between these three islands and Maclear Island appears an excellent position to anchor in if the water should be found of a suitable depth, but this has not yet been ascertained. The three islands are all uninhabited, and like most others in the vicinity of the harbour are low, flat, and thickly wooded.

Anchorage.—In that part of Nares Harbour sounded by the Challenger, viz., from Suhm Island eastward to the Challenger Shoal, a distance of 6 miles, and from the inner edge of D'Entrecasteaux Reef to the reef fringing Tracey, Browne, and Carpenter Islands and the coast of Admiralty Island, the depth varies from 10 to 30 fathoms, with patches having less water near the edge of the reefs; and the depth in the channel entering the harbour between D'Entrecasteaux Reef and Challenger Shoal varies from 20 to 40 fathoms. The centre of the harbour is much encumbered by a chain of coral knolls extending from the middle of Carpenter Island northeastward to the edge of D'Entrecasteaux Reef. These knolls have from 1 to 2 fathoms over them, but are separated by channels of deep water 1½ to 3 cables in width, either of which may be used if required; but as there are no good marks for leading through, it is requisite either to buoy the knolls between which it is intended to pass, or to pilot the ship from aloft, when these patches are distinctly visible. To the eastward of these shoal patches is the anchorage, 3 miles long by 1½ miles in width, and the only dangers in it with the exception of Havergal Shoal, are close to the edges of the reef.

Havergal Shoal, a small patch of 4 fathoms, lies on the western side of the eastern channel into Nares Harbour. From it, Observatory Islet bears N.W. by N. 6½ cables, and the east point of Wild Island W. by N. ¾ N. 1¼ miles, and between it and Challenger Shoal the channel is 9 cables in width. Vessels should on no account attempt to pass between Havergal Shoal and D'Entrecasteaux Reef, as some shoal heads may exist there which have not been examined.

Directions for the Eastern Channel.—If bound from the westward, steer along the edge of D'Entrecasteaux Reef at a distance of a mile until Observatory Islet bears south, when haul to the southward and bring Failure Rocks, which may be easily distinguished, to bear S. ¾ E., and steer in with them on that bearing, which will lead mid-way between Challenger Shoal on the east side of the channel, and the point of D'Entrecasteaux Reef and Havergal Shoal on the west side. When the whole of Suhm Island is open to the southward of Wild Island, the ship will be inside Havergal Shoal and should haul to the westward, steering towards Browne Island, until the west point of Wild Island bears from N. to N.N.W.; then steer in slowly towards Wild Island, and anchor as convenient in 18 to 20 fathoms about half a mile from the shore.

If from the northward, steer to make Observatory Islet, and when that is sighted, proceed as before directed.

If from the eastward, steer to make Observatory Islet, which should on no account be brought to the westward of S.W. until Failure Rocks bear S. ¾ E., in order to clear the Challenger Shoal.

Buchanan, Moseley, and Murray Islands.—Five miles west of Maclear Island are three small islets, Buchanan, Moseley, and Murray, connected by a reef which extends some little distance from them. Between this reef and D'Entrecasteaux Island there is a wide and apparently deep channel into Nares Harbour. On Buchanan Island, the southernmost of the three islets, is a conspicuous tree, considerably higher than those surrounding it, and nearly in the centre of the island.

Boudeuse Bay is a small indentation in the north coast of Admiralty Island, 4 miles to the eastward of Nares Harbour. In it is a small village and several streams of fresh water, from which vessels may obtain a supply, but there is no anchorage off it in the northwest monsoon, so that they must despatch their boats from Nares Harbour.

The land surface in the vicinity of Nares Harbour consists of a series of low irregular ridges rising one above another, with wide flat expanses at the heads of bays on the coast, which are scarcely, or not at all, raised above sea level, and thus are in a swampy condition. The mountains appear, from their form, to be volcanic; and it is probable that the obsidian used by the natives for their spear heads is procured from them. A trachytic lava was found to compose one of the outlying islands, and a similar rock was observed on the mainland where it commenced to rise. A platform of coral sand rock forms the coast line of the main island in many places; and a similar rock is the only component of most of the small outlying islands.

From the position of the Admiralty Islands with regard to the Equator, their climate is necessarily damp. Dense clouds of watery vapour hung about the forest-clad ranges, keeping the mountains most frequently concealed; and in the evening mist hung about the lower land, looking like smoke rising from between the densely-packed trees. In a bay some miles to the eastward of the anchorage of the Challenger, the mouth of a small river, apparently the outlet of the drainage of the mountains on this side, was found, and also a very small brook; but running water was not elsewhere observed, and the rain probably drains to a large extent into the swamps.

The main island, as viewed from seawards, is seen to be densely wooded everywhere. Along the summits of the ridges cocoanut palms show out against the sky, accompanied by Areca palms, as can be made out on a nearer view. The general dark green mass of vegetation on the hillside is festooned with creepers, and the smaller outlying islands dotted about in front of the main island are all thickly wooded. Those which are inhabited may be distinguished at once by the large number of cocoanut trees growing upon them, and forming the main feature of their vegetation.

Upon the mainland where the shore is not swampy, the trees overhang the sea with immense horizontal branches. The bases of many of their trunks are constantly washed by the waves, but they nevertheless have large woody fungi growing upon them, sometimes attached so low down that they are frequently immersed in salt water. The overhanging branches are loaded with a thick growth of epiphytes; and it was necessary to wade up to the middle in order to collect specimens of orchids and ferns which hung often only a couple of feet above the water.

In other places the shore is swampy, and is either covered with mangroves or with a dense growth of high trees with tall straight trunks, so closely set that it was very sensibly dark beneath them. In such a grove near Pigeon Island, a small outlier near the anchorage, whilst the ground beneath is bare and muddy and beset with bare roots, the trunks of the trees and fallen logs are covered with a most luxuriant growth of feathery mosses and Jungermannias.

On one of these trunks was found a very curious and rare Fern (*Trichomanes peltatum*), known before only from Samoa and New Caledonia, the fronds of which are circular in form, and, connected by a slender rhizome, adhere in rows to the bark. They are pressed absolutely flat against the bark, so as to look like an adherent crust, and have all the appearance of a *Riccia* or some such liverwort, for which indeed they were mistaken, when gathered by shaving off the bark. A species of Adder's-tongue Fern (*Ophioglossum pendulum*), unlike the humble little English form, grows in abundance attached to tree stems with long pendulous fronds a yard in length.

Before the visit of the Challenger the botany of the Admiralty group was entirely unknown. Amongst the plants collected was a new tree-fern, and an orchid forming a new section of the genus *Dendrobium*.[1]

The morning after the Expedition arrived trade went on briskly, the canoes crowding round the ship, and the natives handing their weapons and ornaments through the main deck ports. The barter given in exchange was principally ordinary hoop iron broken up into pieces about 6 inches in length; but a great quantity of so-called "trade-gear" was also disposed of.

Trade-gear is regularly manufactured for Polynesian trading, and sold by merchants in Sydney and elsewhere. A stock of about £300 worth had been bought for the ship's use. It consisted of a cask of small axes, rather worthless articles with soft iron blades, butcher's knives of all sizes, some with blades 12 to 14 inches in length, Turkey red and navy blue cotton cloth, beads, trade tobacco and pipes, and other similar articles.

The islanders had possibly traded with Europeans shortly before the Challenger's visit, for they brought off their tortoiseshell ready done up in bundles, and knew the relative value of various qualities. The chief had a large European axe, apparently not procured from the ship, and many natives had hoop iron adzes. Nevertheless they must have had very little experience indeed, otherwise they would not have taken old German

[1] Bot. Chall. Exp., part iii., 1885.

newspapers in trade freely as they did at the first, thinking them to be fine cloth, until rain had fallen. They soon took to making trade goods, shell hatchets, and models of canoes, to sell to the Expedition, and these were as badly made as the trade-gear given in exchange. They understood the rules of barter well, and, as in Labillardière's time, seemed anxious to pay their debts. They must trade with one another regularly. They pretended, with many expressive grimaces, to be unable to bend pieces of tortoiseshell which they offered for sale, and of the thickness (*i.e.*, fine quality) of which they wished to impress the purchaser. They often thus pretended to try ineffectually to bend very thin pieces, and fully entered into the joke when the buyers did the same with thin bits of hoop iron. They always required to see the hoop iron tested by bending before accepting it. They made signs that the ore of manganese which they use came in canoes from a distance eastwards. The native canoes are so seaworthy, and the natives so enterprising and fearless, that possibly articles may pass by barter from island to island over wide distances, even to New Hanover and New Britain.

The natives took all the hoop iron they could get from the ship, evidently receiving more than they could use, no doubt intending it for future barter. They were anxious to trade to the very last, and followed the ship to sea from the anchorage with that intent. They were in a highly excited state, especially at first, and the man from whom some of the first obsidian headed spears were procured fairly trembled with excitement as two pieces of hoop iron were handed to him. The natives have no metals of their own. They blacken their bodies with the ore of manganese, which they call "laban," and they have adopted the same term for iron. They appear unable to work iron at all, since they refused any pieces not of a form immediately applicable for use. They preferred a small piece of hoop iron to a conical mass of iron weighing several pounds.

The natives are quieter than the Humboldt Bay men, and there was comparatively little noise and no combined shouting when their canoes were alongside. They are rapacious and greedy, and very jealous of one another, the chief showing all these traits in the highest degree. They were ready enough to thieve, but not so constantly on the lookout for plunder as the Humboldt Bay Papuans.

The native guides who accompanied parties of explorers always went armed, and were much frightened and astonished at first at the sound of a gun. One of the guides, when birds were being shot, stopped his ears at first, and bent down trembling every time the gun went off. The natives were not, however, much scared when on one occasion the ships' guns and some rockets were fired at night, but came off next day to the ship to trade as if nothing had happened.

The natives showed no great astonishment at matches or a burning glass, apparently understanding the latter, and motioning that the operator should wait until the sun came from behind a cloud. Looking glasses were not at all understood; they were tried in all positions, for example, as ornaments on the head and breast, but the men seemed to recognise no advantage in seeing their faces in them; in Labillardière's time, however, they broke them to look for the picture, or man, inside. Tobacco and pipes were not understood. Biscuit was eagerly taken and eaten. Great wonder was expressed at the whiteness of European legs and chests by the natives, and the women at D'Entrecasteaux Island crowded with great curiosity and astonishment to look at a white arm or chest. The natives possibly thought that the hands and faces were only painted white, and took the negroes on board the ship for men who had not got the paint on.

The Humboldt Bay and Admiralty Island natives probably believed that their weapons were purchased in order that they might be used as such, for they frequently, when offering spears and bows, showed by signs how well they would kill.

The following account of the natives of the Admiralty Islands is largely taken from a paper on the subject published in 1877 by Mr. Moseley,[1] to which the reader is referred for further details as to the language and other matters. It must be remembered that the stay of the Challenger at the islands lasted only a week, and that the period during which the natives and their customs could be studied was very short. A most important and full account of the anthropology of the group is to be expected when Baron de Miklucho-Maclay publishes in full the results of his prolonged researches on Melanesian races. Some corrections of erroneous impressions formed at the time of the visit of the ship have been made in the following account from information which has been derived from that illustrious naturalist in conversation.

Nearly all the ornaments, weapons, and utensils figured in the text and plates are deposited in the Christy Collection at the British Museum.

About fifty-five words and the numerals of the islands were obtained, and the results are published in Mr. Moseley's paper above referred to. The numerals are interesting because those for 8 and 9 are expressed as 10 minus 2, and 10 minus 1.[2] In the process of learning the art of counting, a term for the numeral 10 has been reached by the natives, before 8 and 9 have been named. This method of forming the numerals 8 and 9 is known amongst other distant races, such as the Ainos and some North American peoples, but apparently does not occur amongst either Polynesians or other Melanesians. It is, however, found in the language of one Micronesian Island, Yap, in the Caroline group. In counting objects, the natives clap their hands, held with the fingers pointed forwards and closed side by side, once when 10 is reached, twice when 20 is pronounced, thrice for 30, and so on. Up to 10 counting is done on the fingers, and after that, 11, 12, &c., are reckoned on the toes.

[1] *Jour. Anthrop. Inst.*, vol. vi. pp. 379–425, 1877.

[2] Admiralty Island Numerals:—1, Sip. 2, Huap. 3, Taro. 4, Vavu. 5, Lima. 6, Wono. 7, Hetarop. 8, Anda Huap. 9, Anda Sip. 10, Sangop. Jacobs, *loc. cit.*, p. 172 gives See, Maruer, Tollo, Ear, Leme, Ouno, Andru-tollo, Andru-ruer, Andru-see, Songule. Thus, according to him, the numeral for 7 is formed in the same manner as that for 8 and 9. His numerals are no doubt from a different part of the Admiralty group, and the method of spelling adopted by him is very different, still they correspond closely with those obtained.

To express affirmation, the natives jerk the head up, as at Fiji. Negation is expressed by a most extraordinary and peculiar method: the nose is struck on its side by the extended forefinger of the right hand, the motion being as if the tip of the nose were to be cut or knocked off. This sign was invariably used to express refusal of proffered barter, or that a native had not got some article asked for. It is capable of various modifications: the quick decided negative is given by a smart quick stroke on the nose; in the doubtful, hesitating negative, the finger dwells on its way, and is rubbed slowly across the nose.

The men average about 5 feet 5 inches in height, and the women about 5 feet 1 inch. They contrast at once with the natives of Humboldt Bay, in being far thinner and lankier. Three men who were weighed, averaged only nine stone (127 lbs.) in weight. Only one native was observed that was at all fleshy, although such were not uncommon at Humboldt Bay. Food is perhaps not so abundant here as on the New Guinea coast, and the natives have not, like the natives there, the advantage of bows and arrows to kill game with.

MEASUREMENTS in inches of NATIVES of the ADMIRALTY ISLANDS, taken by the late R. VON WILLEMOES SUHM, being of NATIVES of WILD ISLAND, except those of Nos. 6, 7, 8, 9, which were taken on board the ship by R. VON WILLEMOES SUHM and H. N. MOSELEY.

		Height.	Breadth.	Arm Length.	Leg Length.	Foot Length.	Hand Length.	Nose Length.	Forehead Length.	Ear Length.	Breasts Length.	
WOMEN.	1. Old woman; 40 years (*circa*),	60	15	28	...	10	7	...	...	...	7	
	2. Young girl; 15 years (*circa*),	61½	15	25	33	9½	...	1⅞	...	2½	...	
	3. Woman of mean size, older than 2,	60	12	25	...	9	6⅞	2	3	...	6½	
	4. Old woman,	63	...	...	...	10	8	...	...	...	...	
	Mean,	61	14	26	33	9½	7½	2	3	2½	6¾	
											Mouth Width.	Weight in lbs.
MEN.	1. Young man,	67	16	29	37	9½	7	2	2	2¼	2⅝	...
	2. Adult,	63	18	28	35	10½	7	2⅜	3	2⅞	...	...
	3. Adult,	63	17½	27½	34	9½	...	2	...	2½	3⅛	...
	4. Adult,	66	17½	28½	...	...	...	...	...	2⅝	...	...
	5. Oto,[1]	67	17½	...	...	...	...	...	...	...	...	...
	6. Adult,	64¾	...	...	...	...	...	..	...	...	...	...
	7. Adult,	63	...	...	...	9¾	...	...	...	...	...	122
	8. Adult (photographed),	62½	17¼	27½	33½	10¼	8	1⅞	3	3	3	133
	9. Young,	66¾	16	27	34	10	7½	2	3¾	...	...	126
	Mean,	64 7/9	17 1/7	28	34⅗	9⅚	7½	2	3	3	3	127

[1] The Chief of Wild Island.

The usual colour of the natives is a black-brown, often very dark, and darker than that of the natives of Humboldt Bay. As is usually the case with dark races, the young girls and boys appear much lighter as a rule than the adults. Some one or two of the young women were of a quite light yellowish brown, as was also one young man, who came from a distance to the ship to trade. No doubt there is a mixture of blood, and the light coloured natives observed belonged to the light coloured race described by Jacobs as inhabiting the eastern part of the main island, and as constantly being made war upon by the dominant black race.[1]

The hair of the head, which is worn long only by the younger adult males, formed in them a dense mop, projecting in all directions 6 to 8 inches from the head, but appeared less luxuriant in growth than that of the natives of Humboldt Bay. The hair is crisp, glossy, and extremely elastic, and every hair rolls itself up into a spiral of small diameter, thus in general appearance it is fine curly, like that of Fijians. On comparing it with a very small sample of hair of the natives of Humboldt Bay taken from several native combs, the hair of the latter proves to be somewhat coarser, but in other respects the two hairs are closely alike, the diameters of the spirals of the curls being the same. Some hair from a native of Api, New Hebrides, is of about the same coarseness as the Admiralty Island hair, but the curls are of much smaller diameter; the hair of the Api Islanders seems to be remarkable for the fineness of its curls. The fineness of the curl of the hair in various Melanesian races seems to be pretty constant in each race and characteristic. It might be estimated by measuring the diameter of the circles formed by the separate spirally twisted hairs, and taking the average of several measurements. No doubt a certain curve of the hair follicles corresponds with and produces the curl in the hairs, as in the case of the hair follicles of the negro as discovered by Mr. Stewart,[2] but the amount of curve will be peculiar to each race. The hair of both head and body of the Admiralty Islanders is naturally black, that of the head being of a glossy black. The hair of the men's bodies was not at all abundant, nor by any means so plentiful as it is often seen to be on the bodies of Europeans, the hairiness of whom is apt to be underrated. Eyebrows were generally absent in the Admiralty Islanders, having very probably been shaved off; the natives made signs when offered razors that they used obsidian knives for shaving.

It was not noticed that the natives seen at Nares Harbour had excessively large front teeth. This fact was observed by Baron de Miklucho-Maclay[3] on his first visit, and he has since examined most interesting cases of macrodontism on subsequent excursions to the islands.

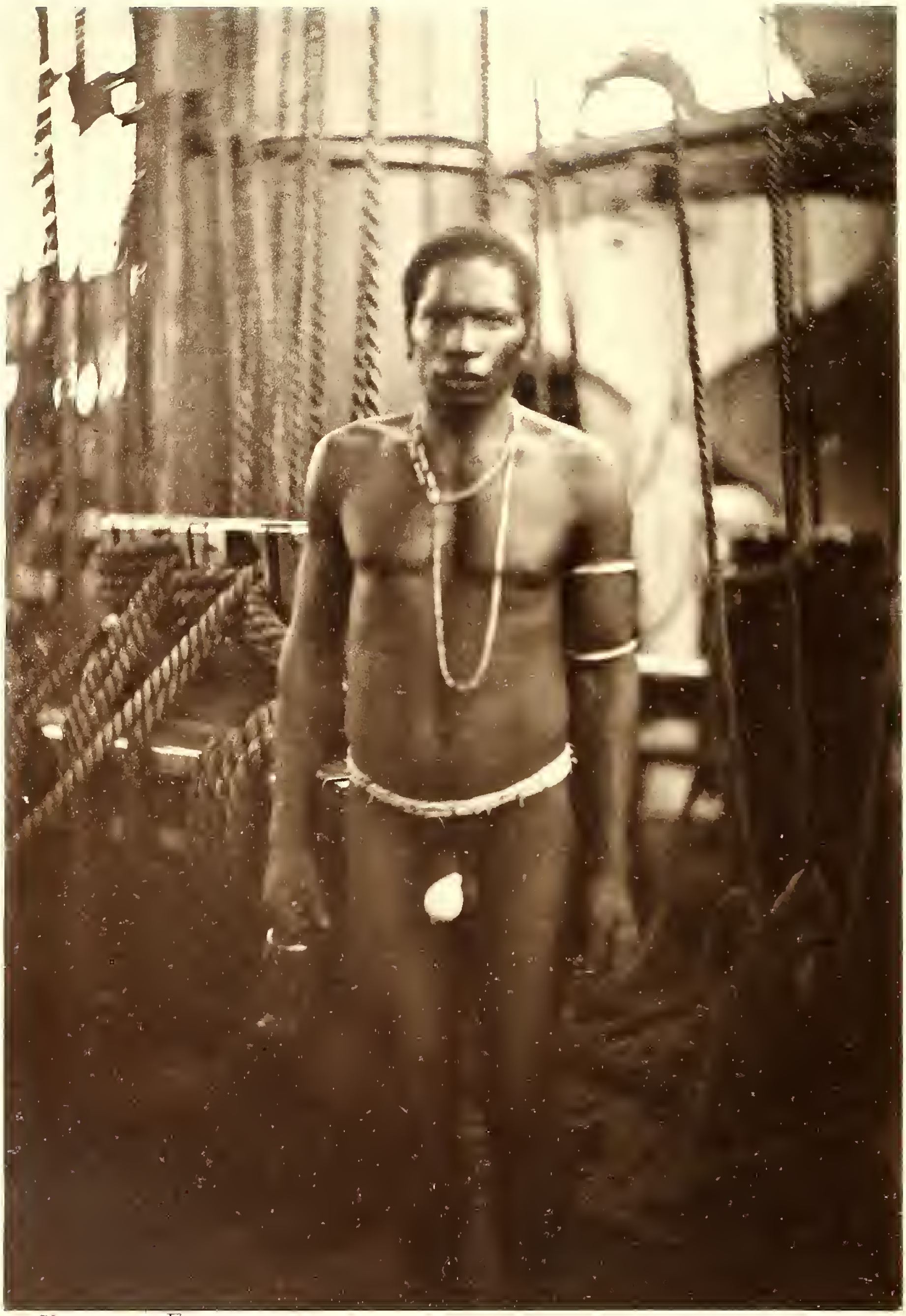
The septum of the nose in all the adult males is perforated, and the lower margin of

[1] Jacobs, *loc. cit.*, p. 176.

[2] Charles Stewart, F.L.S., Note on the Scalp of a Negro, *Microscopical Journal*, vol. ix. p. 54, 1873.

[3] Verhandl. der Berlin Gesellsch. f. Anthrop., *Zeitschr. f. Ethnol.*, Bd. viii., 1876.

Plate XXIX.



Horsburgh, Edinburgh. Permanent Phototype.

NATIVE, ADMIRALTY ISLANDS.

the perforation usually dragged down by the suspension of ornaments, so that in a profile view of the face the large aperture in the septum is looked through by the observer.

Some of the natives (about one in every fifteen or twenty) have most remarkable long Jewish noses, as at Humboldt Bay. It was at first imagined that this form of nose was produced to some extent by long action of excessively heavy nose ornaments, but one youth of only sixteen or seventeen was seen with such a nose very fully developed, and more than one woman with a well-marked arched nose with dependent tip, and the women appear to wear no nose ornaments.

The earlobes of all the men were enlarged, being slit and dragged down into long loops by the weight of suspended ornaments.

The women wear as their only covering two bunches of grass, one in front, the other behind. The dress of the men, besides a white cowry shell (*Ovulum ovum*), consists occasionally of a narrow strip of bark cloth about 5 feet long and 6 or 8 inches in breadth, which is almost white when new and clean (see Pl. XXIX.). The cloth is in the form of a long natural sac, open at both ends, being evidently loosened from the cut limb of the tree from which it is made by beating, and then drawn off entire. This cloth is sometimes reddened by being rubbed with a red earth also used by the natives for smearing their bodies. No better native cloth was seen; and the natives apparently do not know the method of fusing the fibrous material from several pieces of bark together, so as to form tappa, like that of Fiji or Tonga.

The hair in the women, young and old, is cut short all over the head, and worn in this simple fashion, without decoration of any kind. In the boys the hair is short, probably cut short, as in the women, and in the older men the hair is always short. Only the young men of apparently from eighteen to thirty or so wear the hair long and combed out into a mop or bush. The mop of hair in the young men, possibly the warriors (though numbers of adults still in full vigour, had their hair short), is carefully combed out, often reddened, and greased. A triangular comb is usually worn in it (see Pl. I. fig. 4), also cocks' feathers or plumes of the Nicobar Pigeon or the Night Heron, bound together in tufts and fastened on to the ends of short sticks of wood, are worn as hairpins.

It must be remembered that the native ornaments of the Pacific Islands are all made to show on a dark skin. White shell or tusk ornaments look exceedingly well against the dark skins of natives, although when removed and handled by whites they show to little advantage. The young girls at the Admiralty Islands sometimes wear a necklace or two, but they are never decorated to the same extent as are the men, who seem averse to part with any of their finery to the women. The old women have no ornaments. One girl was seen with only a necklace of the beads procured from the ship; and another had one of small unshaped lumps of wood, worn apparently rather as a charm than an ornament.

The men wear armlets (often seven or eight on each arm) of *Trochus niloticus* shell, like those of Fiji, the Carolines, and elsewhere. The rings are neatly engraved with lines forming patterns composed of lozenges, triangles, and transverse bars, the raised lines being blackened so as to form a dark background against which the lozenges show

Fig. 239.—Four Armlets, consisting of horizontal sections of *Trochus niloticus* shells, engraved with various patterns, from the Admiralty Islands.

out in strong relief (see fig. 239). The *Ovulum* shells worn by the men are usually tastefully decorated in a similar manner, and form very effective ornaments indeed.

Long styles of *Tridacna* shell are worn dependent from the nose. They are very like those which, in the Solomon Islands, are worn stuck transversely through the septum

Fig. 240.—Pendent Nose Ornaments from the Admiralty Islands, made of ground *Tridacna* shell, with loops of twine for suspension. One specimen ornamented with engraved rings.

nasi, but are here always worn hanging by loops of plaited twine sometimes ornamented with teeth (see fig. 240). Ear and nose ornaments are also made of the teeth of the *Cuscus* of the islands or of crocodiles' teeth. The ears and nasal septa are always perforated. Pieces of rolled-up leaf are sometimes worn in the ear (perhaps those of *Chavica betel*).

A. T. Hollick del et lith   Hanhart imp

ADMIRALTY ISLANDS.

1 & 2. UNUSUALLY LARGE & HIGHLY DECORATED OBSIDIAN BLADED SPEAR. 3 & 4 OBSIDIAN BLADED SPEARS OF OLD PATTERN HEADS.
5. SPEAR HEAD WITH BLADE OF HARD WOOD PAINTED TO RESEMBLE OBSIDIAN

Necklaces of native beads of shell or cocoanut wood are also worn. Rings of tortoise-shell are commonly worn in the ears as at Humboldt Bay. Both waistbelts and armlets of fine plaited work, with patterns in yellow and black, are common, resembling those of the Arrou Islands and Humboldt Bay (see Pl. H. figs. 2, 3).

The body is seldom decorated with green leaves, as at Humboldt Bay, but leaves are occasionally worn, both hanging down the shoulders and on the arms. Flowers, also, are seldom worn, but a single *Hibiscus rosa-sinensis* flower is sometimes carried in the hair.

The full-grown men are mostly marked with cicatrizations, in the form of circular spots about the size of half a crown, which are sparsely disposed over the upper part of the chest and shoulders in front, and sometimes continued down the back in two lines leading obliquely downwards from the shoulders to meet one another in the middle of the back. One full-grown young man of twenty years or so had the spots fresh and raw; they had apparently been raised by burning.

Tattooing is almost entirely confined to the women, with whom it is universal. Two males, however, were tattooed: one, a small boy, had a simple ring-mark round one eye, the other, an adult, had rings round both eyes; these were, however, exceptional cases. The tattooing is not made up of fine dots or pricks, but of a series of short lines or cuts;[1] the colour is an indigo blue. The women are tattooed with rings round the eyes and all over the face, and in diagonal lines over the upper part of the front of the body, the lines crossing one another so as to form a series of lozenge-shaped spaces. The tattooing is sparse and scarcely visible at a short distance, and nowhere are the marks placed so close to one another as to form coloured patches on the body, as in Fijian women or Samoan men.

The male natives occasionally have their chests and faces coloured with a burnt red clay. Sometimes only one lateral half of the face is reddened. When vermilion was given to the natives they put it on cleverly and symmetrically in curved lines, leading from the nose under each eye, showing that they understood how to use it with effect, but magenta was found useless as an article of trade, for it is too transparent to show on a dark brown skin, and the natives rejected it directly they tried it. No doubt the reason why they do not tattoo themselves is because the tattooing would show so little; perhaps also it is on account of their dark colour that Melanesians generally have so largely adopted cicatrization as a substitute.

It is probable that the natives paint themselves elaborately on festive occasions and in time of war. They were fond of being painted, and two natives who were painted on board all over with engine-room oil-paint, yellow and green, in stripes and various facetious designs, were delighted. They were also often coloured black over the faces

[1] Probably made with obsidian flakes. It is said that the Solomon Islanders are tattooed with short cuts made in this way.

and chests, the colouring matter used being an ore of manganese, which gives their bodies a metallic lustre, like that produced by plumbago or boot-blacking. This mode of decoration was often observed in the old women, and especially in a group engaged in singing an incantation. One man, who was possibly a priest, was always thus smeared over the face, arms, and chest, so that perhaps blackening has a religious signification.

The natives almost universally chew betel, using the pepper leaf, areca nut, and lime together as usual. Some one or two men were observed who did not chew at all and had no lime gourds. The lime is carried in gourds of a different form from those used at Humboldt Bay, but perforated in the same manner at one end with a small hole through which the long spoon-stick is inserted. The lime is conveyed to the mouth by means of the stick.

Most of these spoon-sticks were plain (Pl. K. fig. 2, *b*), but some few were carved at the handle end, the finest obtained having belonged to the chief (see fig. 241), and being adorned with a perforated carved handle of considerable artistic merit cut out of the same piece as the stick. These instruments are all narrow in the blade, and show no tendency to broaden out into the spoon shape of the more highly developed corresponding

$\frac{1}{5}$

Fig. 241.—Lime Spoon-stick with carved handle, from the Admiralty Islands.

implements of some other Melanesian races. The majority of them are in the most primitive form of the simple stick only. At Humboldt Bay the lime gourds are seldom decorated, and are of a simple cucumber-like shape. At the Admiralty Islands they are all decorated, and are of a peculiar form, somewhat like an hourglass, being constricted in the middle (see Pl. K. figs. 2, 2*a*, 3). All have a pattern burnt in on their surfaces, which is very peculiar, and almost exactly alike on all. It has no doubt had its origin in the representation of some natural objects, but it appears impossible to make out the nature of this from the pattern in its present condition. One gourd obtained bears a drawing of a lizard; some bear a series of short parallel lines near the middle, possibly marks of ownership (see Pl. K. figs. 2, 2*a*).

The use of kaava and of tobacco is entirely unknown to the natives, kaava being unknown to all other Melanesians except the Fijians, who probably learnt it from Polynesians.

The principal vegetable foods of the islanders are cocoanuts and sago. This last is prepared into a farina, and preserved in hard cylindrical blocks about a foot in height and 6 or 8 inches in diameter. Specimens of the preparation have been placed in the Kew Museum. Taro (*Caladium esculentum*) is also eaten, and is cultivated in small

A. T. Hollick del et lith.

Hanhart imp.

ADMIRALTY ISLANDS.

1. THE HEAD AND SHAFT OF A SPEAR WITH THE BINDING TWINE CUT OFF TO SHOW THE CONSTRUCTION. *a. a'.* FRONT & BACK OF THE SOCKET. *b. b'.* THE BLADE (BROKEN AT THE POINT.) 2. 3. TWO BELTS OF PLAITED WORK.

enclosures adjoining the houses, but to a limited extent, and there are no large clearings nor indeed any kind of cultivation leaving its mark on the general features of the vegetation of the islands as viewed from the sea, as at Humboldt Bay, Api, or Fiji. Plantains are grown sparingly round the houses ; and a bread-fruit tree also about the villages. Several wild fruits, a Hog-plum (*Spondias*), a small fig, and the fertile fronds of a fern are eaten by the natives, and they have a sugar cane of better quality than that used at Humboldt Bay. Young cocoanut trees are planted about the houses, and carefully protected from injury by means of neatly-woven cylindrical fences ; they are also planted with care on the uninhabited islands. The natives have no Yams (*Dioscorea*) nor sweet potatoes.

The flesh of pigs is roasted by the natives, and served for eating, placed on a quantity of the prepared sago in large wooden bowls, which are often elaborately carved (see Plate M). The Phalanger of the islands (*Cuscus*) is also roasted whole, and is carried about cold, with head, tail, and legs intact, ready to be torn with the teeth and eaten at any moment.

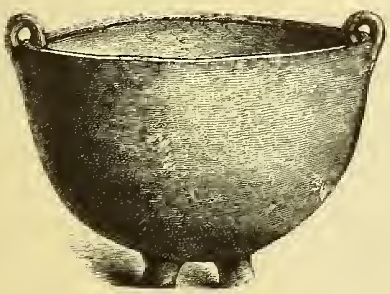


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Fig. 242.—Earthenware pot with two handles, and supported on four feet, from the Admiralty Islands.

$\frac{1}{5}$

Fig. 243.—Spherical earthenware pot, from the Admiralty Islands.

The natives possess pottery, although apparently in small quantity only; it is neither glazed nor ornamented. An earthen pot was obtained from them, represented in the accompanying woodcut (see fig. 242). Like the bowls it is supported on four feet and like them has a pair of lateral inwardly curved handles. Although no proof that this was of their own manufacture was obtained, it is probable that it was made by them, since Melanesians are mostly potters, and the pattern is obviously copied from that of their wooden bowls. The natives have also large, nearly spherical, cooking pots of thin black earthenware with narrow necks (see fig. 243).

There are wells on the inhabited islands at some little distance from the houses; they are shallow holes dug in the coral ground, and are kept covered in with sheets of bark. Cocoanut shell cups are hung up for drinking at each well.

The houses of the natives are built on the ground,[1] and always close to the shore. On Wild Island they are built of a continuous wall and thatch of grass and cocoanut leaves or similar material. They are all of an elongate beehive shape, occupying an oval area of ground, and thus look somewhat like long haycocks (see Pl. XXX.).

In D'Entrecasteaux Island many of the houses have their walls built up neatly of wood cut into billets and piled as firewood s in Europe, and the roofs are similar to those in Wild Island. They are supported on two stout posts rising from the foci of the oval floor of each house, and by a regular framework of rafters. Shorter posts, placed along the walls at intervals, support the roofs at their periphery and the walls. Very often the ground is excavated to the depth of a foot or so beneath the house, so that the wall is partly of earth, and one has to step down to get into the house.

The dwelling houses are mostly about 20 to 25 feet long, 10 to 15 feet in height, and about 10 feet in breadth. They have a low opening at one or both ends. To the main supporting posts of the roof are secured a series of wide horizontal shelves placed one above another, and on these food, implements, and weapons are kept; similar shelves are present in the women's houses. In some of the houses are also bed-places, consisting of rough boards fastened against the side posts of the walls on one side, and supported by short special posts on the other. Arms and implements are suspended from the posts and rafters. The dwelling houses have no further furniture. The posts are sometimes carved and painted, and occasionally a human skull is fastened to one, or placed under the thatch. Everything about the houses is rough, and there is no neatness as in Fijian buildings.

Besides the dwelling houses there are larger ones, supposed at the time to be temples, but in reality, as explained by Baron de Miklucho-Maclay, club houses used for meeting and feasting purposes by certain select and exclusive associations of the natives who construct them in common for the purpose. These club houses are constructed exactly like the dwellings, but larger; some have carved entrance posts of wood, representing male and female figure, and the entrances are closed by a kind of hurdle. The club houses will be further described in the sequel. About the houses in the villages, bright-red *Dracœna* plants are commonly planted as ornaments, representing the flower garden in its most primitive stage.

The canoes have their bows and sterns low, and simply pointed, and not turned up and built so as to form figure-heads, as at Humboldt Bay. Their hulls are formed each of the hollowed trunk of a tree, with a single plank built on above it, and a gunwale-piece as a finish. The hollowed-out portion has slightly and equally rounded sides, and is not flat on one side and rounded on the other, as in the Caroline Islands. The mast is stepped in the bottom of the canoe, just in front of the horizontal outrigger

[1] Jacobs, *loc. cit.*, p. 182, describes as seen by him "several large villages built on piles over the water" on the east coast of the main island. Lieut. Saunders, R.N., also saw some pile-dwellings at the islands.

Plate XXX

HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

NATIVE HUT, ADMIRALTY ISLANDS.

platform. A pole of about similar length, with a natural fork at the top, is stepped against the foremost end of the cross-bar of the horizontal outrigger, and it and the mast being inclined towards one another, the mast is fitted into the fork at the top of the pole, and roused down with a rope-stay so as to remain firm in that position. The bow and stern are ornamented with a simple carved ridge or two and with *Ovulum ovum* shells, a single row of about a dozen being fastened on either side. A horizontal outrigger extends from the middle of the canoe on one side, and is connected with a long canoe-shaped float, and opposite to it is an inclined shelf or deck supported on two or three stout projecting beams. A platform is formed with planks on the horizontal outrigger, and on the outer part of this a large store of spears and the mast and sails are kept. On the inner part the natives sit when not paddling, and stow on it some of their gear, food, and articles for barter, but most of these are kept on the inclined platform, where also some of the crew often sit. These canoes are from 30 to 40 feet in length.

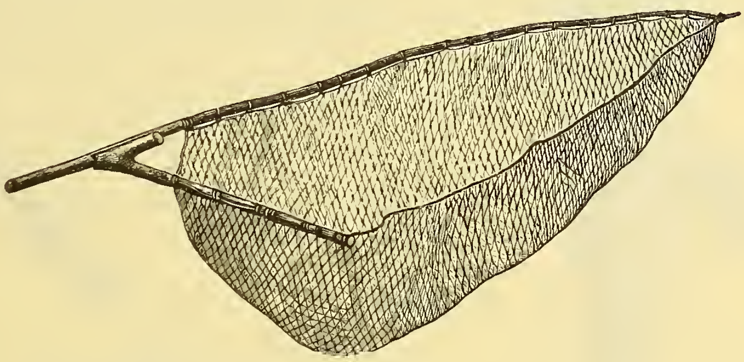

Fig. 244.—Hand Fishing Net supported on an elbow-shaped frame of wood, Admiralty Islands.

The sail is nearly square in form; it is hoisted to the top of the mast and set so that one corner is uppermost. The opposite corner does not nearly reach down to the canoe, hence the square sail, being high above the water, has a very peculiar look when seen over the sea at a distance. As at all Pacific Islands, the outrigger platform is apparently the place of honour, and the seat of the head-man or chief. Oto, the chief of Wild Island, never occupied any other position, and never touched a paddle. Small canoes with single outriggers, holding one or two persons, are used for paddling about the reefs round the islands. The large canoes are manned by from ten to fifteen men.

The natives swim hand over hand; they never take a header in diving, but jump in upright after any object, sinking feet first with the body inclined forwards.

Long seine-like nets are used for fishing. These are probably the property of a club, for they are kept hung up in the club houses. One was seen about a fathom in depth and of very considerable length. Hand-nets fixed on elbow-shaped frames of wood are also used (see fig. 244), and stake nets, lines of stakes for which are conspicuous objects just off the shore near the villages.

The fish-hooks are made of *Trochus* shell, all in one piece, and are of a simple hooked form without a barb (see fig. 245). The natives did not seem to care for steel fish-hooks, and apparently did not, at first at least, understand their use. It is possible that they have never found out the plan of using bait on a hook. Apparently all Polynesian and Melanesian fish-hooks are of the nature of artificial baits of bright nacre, imitating small fry in the water. If the natives did not understand the use of baits, it is no wonder that they despised European fish-hooks.


½

Fig. 245.—Admiralty Island Fish-hook made of *Trochus* shell.

The tool in most constant use by the natives is a small adze, consisting of a natural crook of wood on which is bound a *Terebra maculata* shell ground down until only one lateral half of it remains. Such small shell adzes were abundant enough even at this time, but in most cases the shell had been replaced on the handle


1/5

Fig 246.—Admiralty Island Adze, with blade of *Terebra maculata* shell.


1/5

Fig. 247.—Admiralty Island Adze in which the blade of *Terebra* shell has been replaced by one of hoop iron.

by a piece of hoop iron. Almost every man carried one of these small adzes hung on his left shoulder. From the houses large adze blades made of *Tridacna* and *Hippopus* shells were obtained somewhat resembling those from the Caroline Islands, but very roughly made indeed, only the actual edge being ground (see fig. 248). None were seen

A. T. Hollick del. et lith.   Hanhart imp.

ADMIRALTY ISLANDS.

1. OBSIDIAN KNIFE MADE BY BREAKING OFF THE HEAD OF A SPEAR. 2. KNIFE MADE FOR THAT PURPOSE ONLY. 3. SHEATH OF BANANA LEAF FOR KNIFE OR SPEAR. 4. COMB. 5. BAG.

mounted, and they appeared to have gone out of use. Axes made of hard volcanic rock were also obtained from the houses. They have ground surfaces and are triangular in form, and resemble the stone adzes of the Solomon Islands, but are mounted in an entirely different and very primitive way, as axes, being merely jammed in a slot cut in a club-like billet of hard wood near its end. Only one specimen was obtained thus mounted (see fig. 249). These stone implements did not seem plentiful, and the natives

Fig. 248.—Large Adze Blades of *Tridacna* and *Hippopus* shells, only partly ground, Admiralty Islands.

valued them highly and required a high price for them; and when a Humboldt Bay stone axe was shown to them to try and explain that it was desired to buy such from them, they were immediately anxious to purchase it themselves. The chief had a very fine large one, with which he would not part.

The heads of the obsidian bladed spears, the principal weapon of the natives, serve as knives, being cut off just below the ornamented mounting which acts as a handle.[1] Long

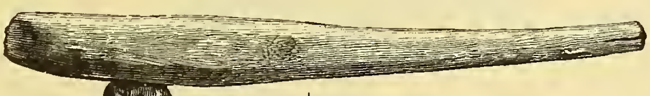

Fig. 249.—Admiralty Island Axe Blade of volcanic rock, mounted in a slot in a billet-like handle of hard wood.

flakes of obsidian are, however, also mounted specially as knives in short handles (see Pl. I. figs. 1, 2). They are exceedingly sharp, and are used even for shaving, but are of course very brittle. Pieces of pearl oyster shell, usually semicircular in shape, ground down

[1] This is an interesting instance of the same instruments serving different purposes in a rude condition of the arts, other cases of which have been dwelt on by General Lane Fox, F.R.S., Lectures on Primitive Warfare, *Journ. Roy. United Service Inst.*, 1867-69.

thin to an edge on the rounded border, are used constantly as knives to cut cordage, and for similar purposes (see fig. 250). Knives are also made of the spine of a Sting Ray (*Trygon*), and large pearl oyster shells ground smooth are used to dig with. Excellent oblong bags made of finely woven grass, and kept open by means of sticks placed inside, are ornamented by long fringes and pendant strings, and have a handle and small mouth-opening (see Pl. I. fig. 5).

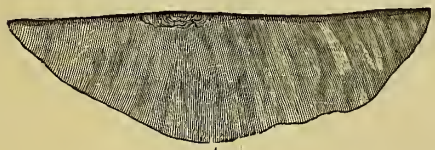

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Fig. 250.—Knife made of a portion of a Pearl Oyster shell, Admiralty Islands.

The Admiralty Islanders have no bows, slings, throwing sticks, ulas (Fiji), nor clubs. Their only weapons are lances or spears of several kinds, which are thrown with the unaided hand, not even with a cord, as in New Caledonia. They have no spears like the Humboldt Bay men, Fijians, and others, to be used at close quarters, and no shields, though Jacobs mentions shields as in use at other parts of the group.

The principal weapon is a lance, formed of a small, usually flexible, shaft of tough wood, often a natural stem, with the bark trimmed off, to the thicker end of which is attached a heavy head of obsidian, which in size appears out of proportion to the light shaft. The obsidian lance heads are usually triangular in outline, but some often irregular (see Pl. G.). They are shaped by bold wide flaking. The points and edges are often slightly rechipped in order to sharpen them, but the original faces and angles are never worked up for the sake of symmetry or balance, but remain rough. Many lances have their edges and points sharp and perfect, though formed entirely by the original flaking. The hinder borders of the lance heads are simply rounded, and secured in a socket of wood attached to the end of the shaft by means of a cement, and by being bound round with fine twine. The socket is hollowed out in a separate piece of wood, and in order to facilitate the scooping-out process two slots are usually cut in its two opposite faces (see Pl. H. fig. 1, *a*, *a′*, *b*, *b′*). The shaft of the lance is spliced into a V-shaped slot in the lower part of the socket-piece. A rounded strengthening piece is retained in the socket-piece, between the actual socket and the narrowed part of it, in which the slot for the shaft is cut. A very hard and solid gum is used to bed the lance head and the shaft in their respective positions, and to mass together the turns of fine twine which secure the whole. In some lances the entire socket-piece and the turns of binding twine are concealed by a thick even layer of the gum, whilst in others the gum is used more sparingly, and the turns of twine and wood of the socket piece are exposed to view. In the former class of lances ornamentation is effected by patterns being incised in the layer of gum, and these have no *Coix lachryma* seeds attached to them (see Pl. I. fig. 1). Lance heads ornamented in this fashion were possibly the only ones made at some former period by the islanders, all the older specimens of Admiralty Island lances in the various continental and British collections obtained before the Challenger's

A. T. Hollick, del. et lith. Hanhart imp.

ADMIRALTY ISLANDS.

1. DECORATED SKULL OF TURTLE HUNG UP IN CLUB HOUSES AS A MEMENTO OF THE FEAST.
2, 2a. VIEWS OF A LIME GOURD FOR CARRYING LIME TO BE CHEWED WITH BETEL. 2b STICK FOR SPOONING OUT THE LIME. 3 A SMALLER GOURD.

visit being of that type. In the other forms, probably of modern make only, the upper turns of twine are arranged in diagonals, separating the areas of different ornamental colours, and the actual wood of the socket-pieces is carved and coloured (see Pl. G.). The gum employed is the same as that used by the islanders for caulking their canoe seams, and is obtained by pounding the brown ovoid fruit of *Parinarium laurinum*, which is about the size of a goose's egg. The efficiency of the fixation of the stone head of the lance evidently depends mainly on this gum, which is excessively hard and firm when set, and is in use for similar purposes in various parts of Polynesia. The wood of which the socket-pieces are made is hard when dry and old, but probably much softer when cut in the fresh condition. Some of the lance heads, owing to the method of manufacture, are extraordinarily long, some curved, and others of various forms. They are most formidable weapons, especially to a naked skin. The shaft is merely an instrument for throwing point first a very heavy, excessively sharp-pointed, stone, which cuts its way through almost anything. The socket-pieces of the lance heads are elaborately decorated. Some lances have a lozenge-shaped perforation in the socket-piece beneath the head (Pl. G. fig. 1); others have small tufts of *Cuscus* hair fastened on to them in the same position. Two obtained had these tufts wet with some oily substance, but apparently not poison. The heads of the lances are kept covered with a conical sheath of dried banana leaf made to fit (Pl. I. fig. 3). The natives possess an enormous store of these weapons, and they have piles of them lying on the outriggers of the canoes. On shore the men commonly carried two or three in their hands. In a dispute alongside the ship one of the lances was instantly snatched up and made ready. They are used for hunting wild pigs as well as for fighting. The natives pointed to the mountains of the mainland as the source of the obsidian. They parted with the lances readily, so that the material must be abundant. They are thrown in the usual manner, grasped by the naked hand, being first poised and made to quiver by a shaking motion of the hand for some seconds. Some of the shafts are made of a light but rigid reed; others have large carefully-cut sharp-pointed heads of hard wood, which is painted of the same colour as the obsidian, and at a short distance looks exactly like it. Some of the wooden heads are longer and larger than any of the stone ones, and these were several times bought under the impression formed at a distance that they were very fine obsidian weapons.

Besides the larger lances, small darts are used, having pliant, very light stems about a yard long, and heads of small sharp chips of obsidian, often of a very irregular form, apparently the refuse chips from the larger weapons. These darts are carried about done up in bundles of a dozen or so. A guide engaged on Wild Island carried such a bundle on his shoulder all the way.

Another kind of dart has the stem made of reed and the head of hard wood of a somewhat conical form, with a knot at the base of the cone. These darts are of the same length as the others, and are likewise carried in bundles. They are thrown overhand, being held by the hinder extremity, and swung round vertically (see fig. 251). The natives have no defensive weapons, such as shields.

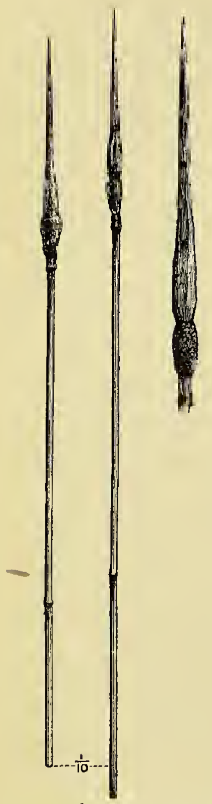

FIG. 251.—Short Darts with reed shafts and heads of hard wood, Admiralty Islands.

Though there is an enormous abundance of wild pigeons on the islands the natives have invented no means of shooting them; they can only climb the trees and catch them roosting, or knock them off the nest.

The natives are extremely expert in wood carving, and show most remarkable taste in their designs. The lance heads are often carved, the carving taking the form mostly of incised patterns, the effect being heightened and beautified by the use of black, white, and red pigments; the white being coral lime, the red burnt clay, and the black possibly charcoal of some kind. The human images carved on the door-posts of the club houses, and the posts of some of the dwelling houses, are also ornamented in the same style (see fig. 257.) These patterns are all modifications of the lozenge or diamond, and without curves. The ornamental patterns woven in the belts are also composed of longitudinal and diagonal elements. They are very tasteful, and approach somewhat in beauty of execution the similar fabrics of the Caroline Islands (see Pl. H. figs. 2, 3).

An entirely different class of carving is that of the large wooden bowls which are used by the natives for eating out of. They resemble those of the Solomon Islanders, although never ornamented by inlaying, but are most remarkable for their graceful forms and delicately carved handles. The bowls are worked with wonderful precision to the circular form, considering the tools available, appearing as true as if turned. They are widely open, and provided with a pair of curved handles, which rise above the level of the brims, and are usually cut in a delicate spiral. The handles are always ornamented with perforated carving, and may include a pair of crocodiles, or roughly executed human figures; sometimes they have no handles (see fig. 252). The bowls stand always on four short legs, like the Fijian kaava bowls. They never have a circular bottom, no doubt because there are no level surfaces for them to rest upon, and because the idea is derived from a four legged stool. Sometimes the perforated handles are further ornamented by pendants of seeds strung on twine (see fig. 253). Their workmanship is of astonishing excellence and great beauty. The finest specimens here figured are in the collection of Mr. J. Y. Buchanan, the others are deposited in the Christy Collection in the British Museum.

Some of the bowls are like some of those made at the Solomon Islands and elsewhere in the form of birds (see Plate M. fig. 2), and a double one was obtained, composed of

A. T. Hollick del. et lith. Hanhart imp.

ADMIRALTY ISLANDS.

1. 1a & 2. BADGES OF DISTINCTION CONSISTING OF A HUMAN HUMERUS DECORATED WITH FEATHERS CARRIED BY WARRIORS
1. 1a FRONT AND BACK VIEWS OF SAME. 3. A SIMILAR BADGE BUT WITHOUT FEATHERS.

two birds joined tail to tail and suspended by strings attached to the bars representing the bases of the wings at their opposite extremities (see fig. 254). The bird bowls retain the four stout feet each; and this is even the case in the double bird bowls, where two pairs might have been dispensed with without the combination becoming unstable. Another bowl is in the form of a crocodile, an animal of which the natives are in dread. Here again the four supporting feet are present, and it has not struck the

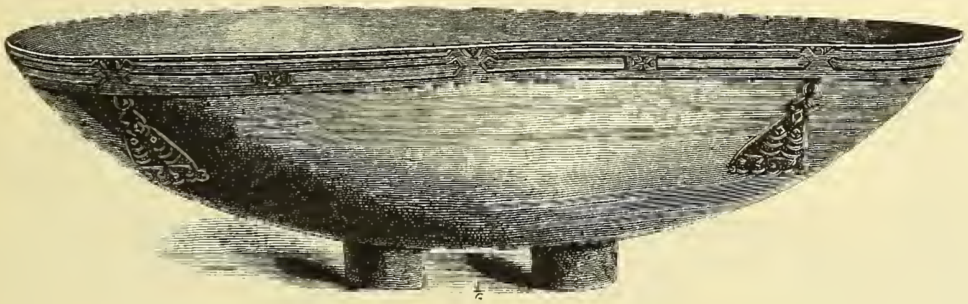

FIG. 252.—Large carved wooden Food Bowl without handles, Admiralty Islands.

artist to make these coincide with the legs of the animal, which are represented separately (see fig. 255).

Some of the bowls are blackened all over, others are of a bright and handsome burnt sienna colour. In some the effect of the carving and fretwork is enhanced by colouring with the usual red and white pigments (see Plate M.).

A remarkable appreciation of symmetry and fertility in design is shown in the patterns

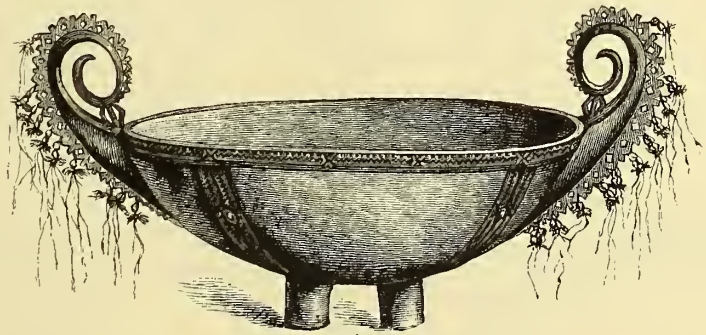

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FIG. 253.—Food Bowl, with spiral, carved, and perforated handles, carved from a single block of wood, Admiralty Islands.

which are cut upon the circular plates worn sometimes on the forehead, oftener on the breast. These consist of circular white plates ground down out of *Tridacna* shells, with a hole in the centre for suspension. On the front of this white ground is fastened a thin plate of tortoiseshell, which is ornamented with fretwork, so that the white ground shows through the apertures. The patterns are of endless variety, *no two being alike*, and show all kinds of combinations of circles, triangles, toothing, and radiate patterns. The shell background is often graved also at its margin. Symmetry is evidently striven after, but with the appliances available the execution falls short here and there of the design, but these ornaments are very beautiful nevertheless. Closely similar ones are worn in the Solomon Islands, and also in New Hanover, and curiously enough in the far-off Marquesas Islands.

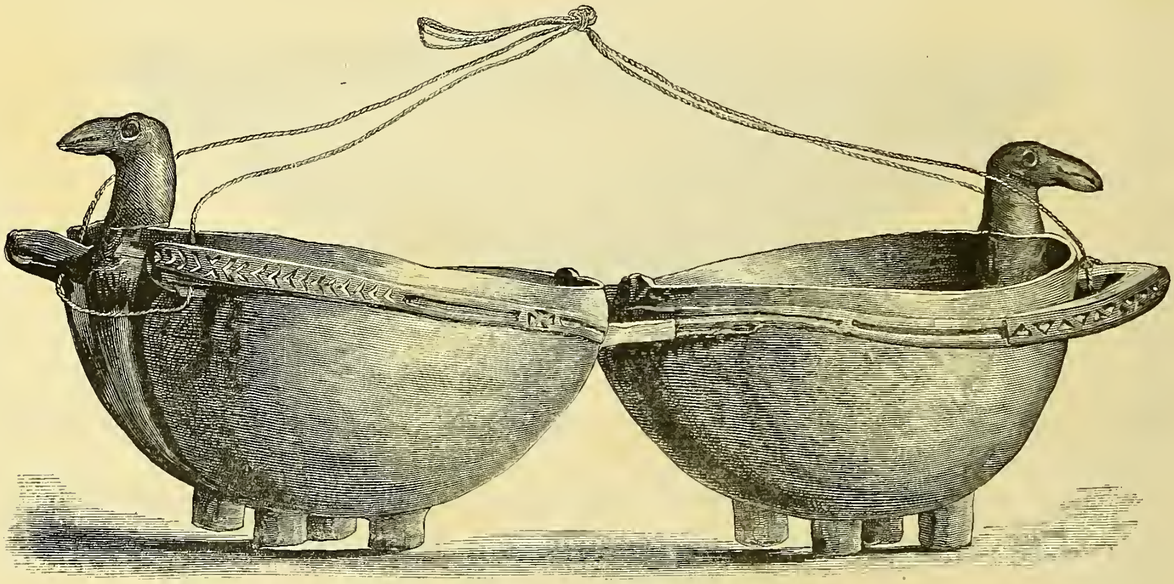

FIG. 254.—Admiralty Island Double Bird Bowls carved in wood, the property of J. Y. Buchanan, Esq.

A regular style of ornamentation is preserved for each class of ornaments, weapons, and implements. Thus no *Ovulum* shells were seen with curved patterns like those on the lime gourds. Both these and the bracelets bore simple patterns of diagonal lines graved and blacked. The spears, moreover, never bore curves.

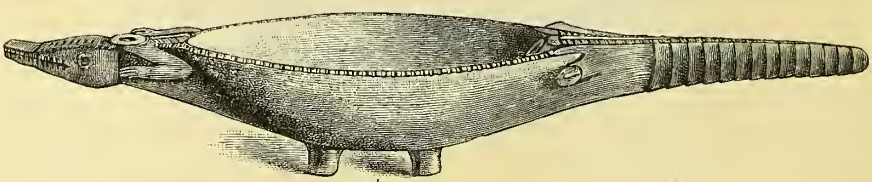

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FIG. 255.—Admiralty Island carved Wooden Bowl representing a Crocodile.

The skulls of turtles suspended in the club houses are ornamented with patterns painted in the three usual colours (Pl. K. fig. 1). The human skulls are likewise decorated, and some have eyes of pearl or *Cardium* shell inserted into the orbits on a background of black clay.[1]

[1] Report on the Human Crania, Zool. Chall. Exp., part xxix., pl. iii., 1884.

J. Robertson del.

G. Waterston & Sons Imp.

ADMIRALTY ISLANDS.

1. 1ª A VERY FINE BOWL WITH LIZARDS ON THE HANDLES.
2, 2ª A BOWL IN THE FORM OF A BIRD. 3. 3ª. A BOWL WITH HUMAN FIGURES SUPPORTING THE SCROLLS.
BELONGING TO J. Y. BUCHANAN Esq.ᴿ

The musical instruments used are the Conch shells (*Triton*), perforated on the side as usual, a very simple Jew's-harp made of bamboo, of the usual Melanesian pattern, Pan-pipes, of three to five pipes of different lengths (the New Hebrides natives have Pan-pipes with three pipes), and lastly, drums. These latter are hollowed out cylinders of wood with only a narrow longitudinal slit opening to the exterior. Some of them are small, a foot and a half or so in length, and are sometimes carried in the canoes. The larger drums, seen only in the club houses, are cylinders, four feet in height and a foot and a half in diameter, and are fixed upright at the entrances of these houses. There were four such at the four corners of one club house. The slit in these is not more than four or five inches broad, and it is difficult to understand how the cylinders are hollowed out by the natives. Very similar drums exist at the New Hebrides, for example at Efate, where they are stuck upright in the ground in circles.[1]

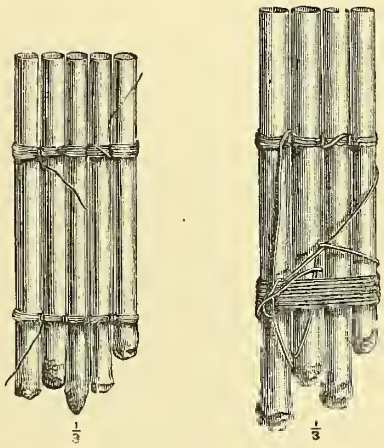

Fig. 256.—Admiralty Island Pan-pipes.

The natives seemed to have no idea of tune, they blew the notes on the Pan-pipes at hap-hazard. The chief of Wild Island blew with evident satisfaction a child's tin trumpet, which he appropriated from one of his subjects, to whom it had been given, and came off to the ship standing on his canoe platform and blowing it with all his might, with three bright coloured cricket belts which he had purchased, put on one above the other round his middle. The drums were frequently sounded on Wild Island, often in the afternoon. Such drums are used in New Guinea as signals.

The women, both old and young, dance, moving round in a ring with a quick step. The men signified that they danced too, but were not seen to do so. Some old women were seen performing a kind of incantation; four of them sat on the ground in the yard of one of the houses, facing one another in a circle, whilst two sat outside the circle; as before mentioned all had their faces and bodies blackened, and uttered at regular intervals a chant, "ai aiai aiai aiai aiai umm." The commencement was shrill, in a high key, and the terminal "umm" was sounded low, with the peculiar humming lingering sound, just as in Fijian chants.

The village at D'Entrecasteaux Island is fortified, a palisade about 10 feet high stretching right across the corner of the island, where the village lies, shutting it off from the landing place. The path to the village led through a gate-like opening in the palisade, which did not seem in very good repair, and was without ditch or embankment. The village itself was surrounded by a second wall, low and crossed by stiles,

[1] F. A. Campbell, A Year in the New Hebrides, p. 111, figure Fili Id Efate, Melbourne, 1873.

whilst at Wild Island there was no fortification. The natives inhabit the small outlying islands, probably for protection from attack. Very few natives were seen living on the mainland, and these few at one spot only, near the mouth of the small river, where there was an apparently temporary hut. Former dwelling places on the mainland appear to have been abandoned. No actual fighting was seen, but in a quarrel about some barter alongside the ship Oto, the chief attempted to strike a native in another canoe from a distant small island, but was prevented by his own men, who held him back. The opposite party at once got their spears ready, and threatened him with them.

There are several club houses in Wild Island; they have already been partially described. One such had as door-posts a male and female figure roughly carved in wood, but elaborately ornamented with incised patterns and colour (see fig. 257). Between the legs of the female figure a fish was represented. There are in the same figure black patches with white spots, which appear to mark out the breasts. The hair in both figures is represented as cut short, the mop of hair of the warrior not being represented in the male figure. No clothes, *i.e.*, T-bandage of bark-cloth, bulla shell, nor ornaments, such as ear-rings, nose ornaments, and breastplates, are indicated on the figures, and the male figure has no weapons. The ears of both figures are, however, slit for ear-rings, and it is possible that a zone of diagonal ornament passing round the body of the male figure represents the plaited waistbelt commonly worn. On the upper part of the chest of the male figure are a series of circular white ring-marks on a black ground, which evidently denote the cicatrizations present in all the male natives. In the female figure the tattooing is possibly indicated by a wide patch of diagonal ornamentation upon the abdomen, as also by lines drawn round the eyes, and not present in the male figure. In the male figure one lateral half of the face is painted white, and the other red. The arrangement of paint in this way is in vogue amongst the natives here as at Fiji. One Admiralty Islander was seen with one side only of his face reddened, and in Fiji at dances it is common to see natives with one lateral half of the face blue, and the other red or black (see Plate E. fig. 4). All the ornamentation on the figures is of the common zig-zag pattern, and formed of a series of lozenge and triangular shaped spaces. The patterns are incised, and stained of three colours, black, red, and white. The parts coloured white and red are cut in, whilst the patches of original surface left in relief are blackened. Careful coloured drawings of the figures were made by Mr. J. J. Wild, artist of the Expedition, and facsimiles of them have been published by him in his work[1] already referred to.

Another club house had no figures, but the four large drums already mentioned. To the rafters and supports of the roofs of these club houses inside are fixed up quantities of skulls of pigs and turtles, all arranged regularly, with the snouts downward; these skulls

[1] Dr. J. J. Wild, At Anchor, p. 138, London, 1878.

were decorated with colours (see Plate K. fig. 1). With them were suspended large quantities of balls of human hair, some evidently old, others of recent date, which were sometimes suspended in networks of string, sometimes in small receptacles of a very open basket-work (see figs. 258 and 259). Both the bunches of hair and the

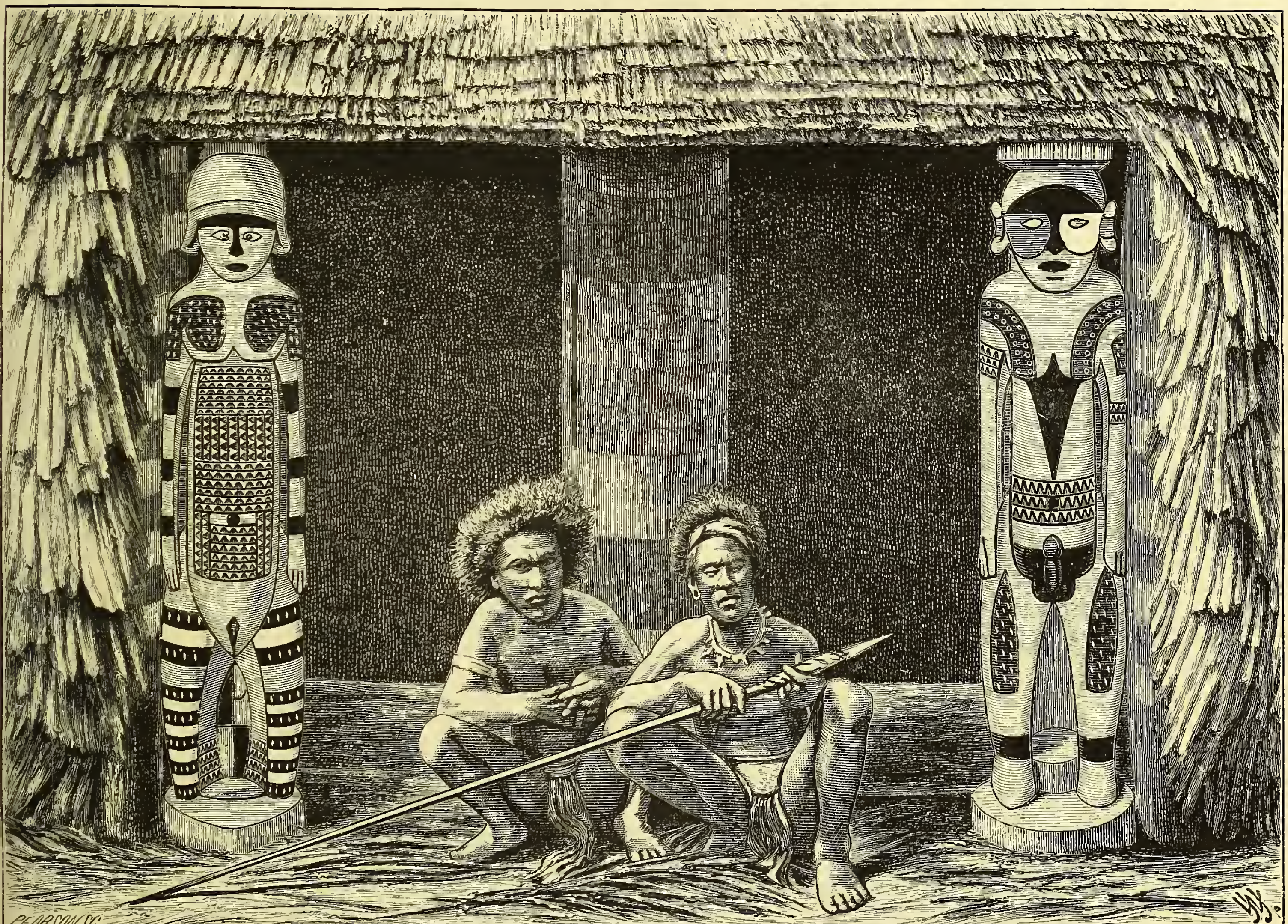

FIG. 257.—Entrance to a Club House, Wild Island, Admiralty Islands, with carved and decorated door-posts.

skulls appeared often to have regular owners, though set up in the club house; the natives parted with both freely for barter.

Skulls of a Dugong and a Porpoise were also produced for barter. As appears from what is published of Baron de Miklucho-Maclay's researches on the Maclay coast of New Guinea and other sources, the club houses, as already stated, belong to certain associations of natives who build them for their common and exclusive use. The skulls with which the roof is decorated inside are mementos of successive feasts, a bone or the skull or some other relic of every animal feasted on being thus preserved and set up. The collection thus formed serves as a kind of chronicle and record of the flight of time, which is thus divided into feasts and intervals of low diet between them. The human skulls and the bunches of hair are equally relics of cannibal feasts, and it is possible, as suggested by Mr. Wilfred Powell, that the male and female carved wooden figures described above as forming the door-posts of one of the club houses represent a man and woman eaten at the inauguration feast of the club house itself. If so, the absence of the mop of hair in the male figure may be accounted for by supposing him to be represented as ready for the feast with his hair already removed for suspension in a net. The absence of ornaments and weapons from the figures may be similarly explained. The fish may represent part of the banquet. The club houses were considered more private than the dwellings. The one with the images for door-posts was frequently closed, and the natives objected to its being entered, though sometimes it was left freely open. When one of the naturalists of the Expedition began sounding the big drums in the other club house, the guides hastily drew him out in terror, and made signs that the consequences would be serious. Human skulls are kept stuck up in the thatch of the houses. At D'Entrecasteaux Island, one having an ornament in the nose was suspended to the front of a house over the doorway by means of a stick thrust through holes in the squamous parts of the temporal bones. This skull the owner could not be induced to part with, but usually skulls were sold pretty freely, and were in considerable abundance about the houses, but often much shattered; about a dozen only were purchased, and their characters have been described and figured by Professor W. Turner.[1] They are all distinctly dolichocephalic. As with the crania of other Melanesians the height of the skull is almost always greater than the breadth, though the hypsistenocephalic character is not so strongly marked as in the mountaineers of Fiji or in the Loyalty Islanders.

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Fig. 258.—Human hair supported in a rough bamboo basket from a club house, Admiralty Islands. A memento of a cannibal feast.

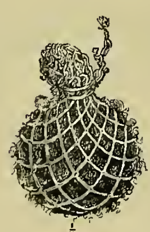

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Fig. 259.—Human hair in a net of string, suspended from the roof of a club house at the Admiralty Islands.

The natives are very apprehensive, for when a group was being photographed, the old women put up two long poles transversely between themselves and the apparatus in order to protect themselves from its evil influence, and they could not be persuaded to sit until Captain Thomson seated himself in the centre of the group, and was taken with them.

[1] Report on the Human Crania, Zool. Chall. Exp., part xxix., 1884.

A very peculiar ornament carried by some of the islanders consists usually of a human humerus bound round with an investment of the wing feathers of a large bird, the vanes of which are notched to heighten their appearance. The whole is bound round with great care with fine twine in an ornamental manner, and sometimes decorated with colour and shell bead-work (Pl. L.). In one instance the humerus was replaced by four human ulnar and radial bones, and in another by the long bones of some large bird, probably the Eagle (*Pandion haliaëtus*); and curiously enough in one specimen the apparent human humerus was found to be an imitation carved in wood. One decorated humerus bound round and reddened, and with pendants of shell beads and seeds (Pl. L. fig. 3), was without any feather dress, but seemed to be of the same significance as the others. From Baron de Miklucho-Maclay it has been ascertained in conversation that these curious objects are badges of hereditary distinction which pass from father to son, corresponding somewhat to crests and coats of arms. It was noticed that one of the foremost men at D'Entrecasteaux Island, when he possibly wished to incite the natives to attack one of the ship's boats or to try and capture a much coveted bag of trade-gear in it, took this badge, usually worn hung round the neck, in his hand and flourished it about, dashed it on the ground and gesticulated with it during a violent harangue to his fellow islanders. Interesting details as to the meaning and use of the badge may be expected when Baron de Miklucho-Maclay's promised book appears.

The dead are buried in the ground. Two different natives, one on D'Entrecasteaux Island, and the other on Wild Island, explained in an unmistakable way that the skulls put up about the houses were obtained by burying bodies in the earth, and afterwards digging them up again. The value set upon the skulls and bones as ornaments, and probably also superstitious motives, are no doubt the reasons why no marks of burial were seen; no mark is made, probably for fear of the bones being stolen. Professor Turner regards four at least of the skulls procured as females.

The fact that some of the men restrain themselves and abstain from the use of betel, seems to be a proof of considerable strength of character. A hatchet was given to a guide at D'Entrecasteaux Island as pay, according to promise; he seemed grateful, presented his own shell adze unasked in return, and made signs that the others had got enough, and that more should not be given away.

The natives delighted in being towed along in their canoes by the steam pinnace, and clapped their hands with delight, but of course did not understand how the boat moved, nor apparently see in the fire the cause of motion. They came up to the cutter when sailing to get a tow for their canoes, and apparently expected to see the boat go off, head to wind, in the same style.

The inhabitants of each small island appeared to be quite independent of each other, and more or less under a chief, whose power seemed to depend on his fighting qualities. The chief of Wild Island had considerable power; he took articles away from men to whom they were given, and made arrangements for each man of a party getting a hatchet. He never paddled himself, and he pushed canoes out of the way when approaching the ship. He, however, clamoured with the rest for presents and trade. No ceremonious respect was paid to him at all, and he here is termed chief merely because he evidently took the lead whenever present.

The natives seemed friendly enough, but they were of course greatly excited at our presence and probably were afraid of us. When a party, which landed with Captain Thomson on D'Entrecasteaux Island, was putting off from shore in a small boat to reach the pinnace, the inhabitants seemed possibly to be meditating an attack, for they suddenly produced their lances and showed intense excitement; the sight of a sack full of trade articles in the boat was possibly almost too tempting for them.

The members of the Expedition were usually on very good terms with them. On one occasion Mr. R. Richards, Paymaster of the Challenger, accompanied a number of natives in the chief's canoe, who were guiding a party to Pigeon Island; he took down the names of the whole crew.

The natives were very much frightened at some goats which were offered to them by Captain Thomson, and refused to let them be landed on the inhabited islands. They were very much scared also by a wooden jointed toy snake which was shown them swaying to and fro, and evidently must be acquainted with poisonous snakes, as they made signs for the thing to be killed lest it should injure some one. A squeaking doll, which kicked its legs and arms about, frightened the chief Oto very much, and he and others made signs at once to have it put out of their sight.

With regard to the population of the islands, it was estimated that the population of Wild Island was about 400 or 500, and that of D'Entrecasteaux Island about 250 or 300.

The Admiralty Islanders, like many other Melanesians, for instance the New Caledonians, Loyalty Islanders, and apparently the New Britain and New Ireland races, have no bows and arrows, and the same is the case with the natives of the southeast of New Guinea; bows and arrows seeming to commence on the coast only about Humboldt Bay, but all seem to have slings or other additional means of defence.

The only domestic animals possessed by the natives of the Admiralty Islands in any abundance are pigs. These are partly kept in enclosures around the houses, and partly run half wild over the inhabited islands. They are small, lean, and black coloured, and never appear to develop large tusks.[1] No ornaments of large pigs' tusks were seen in the

[1] Four skulls of the Admiralty Island Pigs were sent to Oxford to the late Prof. Rolleston, who refers to them in his Memoirs on the Domestic Pig of Prehistoric Times in Britain, *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, vol. i., 1876, reprinted in his collected Scientific Papers and Addresses, edited by Prof. Turner, Oxford, 1884. Dr. Rolleston states that these skulls had an eminence in the middle frontal line over an area homologous with the human glabella. In *Sus papuensis* this eminence is rudimentary.

possession of the natives. If therefore, as is probable, from signs made by the natives, there are wild pigs on the main island of the group, they must be unlike the Papuan pigs in this respect, and resemble more the New Hebrides breeds. Two dogs were seen on Wild Island; one, a puppy, was white, smooth haired, like a fox terrier in appearance, and very like a dog that was in the possession of the natives at Humboldt Bay. These were the only dogs seen amongst the natives. Rats were not observed on any of the islands. No fowls were seen in the possession of the natives, but a plume of cock's feathers worn as a head-dress was obtained from one native. Fowls must therefore exist in the islands somewhere, but are probably scarce, as only this one plume was seen.

The Dugong, a Dolphin, and a Phalanger (*Cuscus*) are killed by the natives. Two species of Fruit Bats (*Pteropus hypomelanus* and *Harpyia cephalotes*) were procured.

Of Reptiles, two species of Turtles are common, *Chelone midas* and *Chelone imbricata*, the latter being the source of the principal article of barter, tortoiseshell. In the swamp-pools is a species of Crocodile. There are also, at least, two species of Snakes (Hydrophidæ), one of which is *Platurus laticaudatus*. A Gecko (*Heteropus*) and two species of blue-tailed Lizards (*Mabouya cyanura* and another), a Skink (*Keneuxia smaragdina*), and a large Monitor (*Varanus indicus*) were procured by the Expedition, the Lizards being very abundant.

Among the birds collected were six new species.[1] The most abundant are the Fruit Pigeons (*Carpophaga rhodinolæma*), which feed upon the wild coffee and nutmegs, and roost in vast numbers upon one of the outlying islands. Small Tree Swifts (*Collocalia*) fly about among the cocoanut trees, and all day flocks of Terns and Noddies (*Sterna lunata*, *Anous*) follow, in the still waters within the reefs, the shoals of Skipjacks (*Caranx*) as they pursue the smaller fish. The shores are inhabited by several species of littoral birds. There was seen on the main island a scarlet and black Parrot or Cockatoo of some kind, which flew out of some high trees on the sea shore, screaming loudly, like a Cockatoo. It was wary, and could not be approached within shooting distance.

Among the fish collected by the Expedition were three new species; one *Lophius* and two Pleuronectids.[2] The only Butterfly obtained on Wild Island was a new species (*Saphara ursula*, Butler), and the only Moth captured was *Damalis alciphron*. Of the twelve species of land and fresh water Mollusca collected nine were previously undescribed.[3]

[1] *Rhipidura semirubra*, Scl.; *Philemon albitorques*, Scl.; *Monarcha infelix*, Scl.; *Myzomela pammelæna*, Scl.; *Carpophaga rhodinolæma*, Scl.; and *Ptilopus johannis*, Scl.

[2] *Lophius naresi*, Günth.; *Pseudorhombus ocellatus*, Günth.; and *Nematops microstoma*, Günth.

[3] *Athoracophorus virgatus*, Smith; *Helix (Geotrochus) moseleyi*, Smith; *Helix (Geotrochus) labillardierei*, Smith; *Helix (Hemiplecta) infrastriata*, Smith; *Helix (Hemiplecta?) cartereti*, Smith; *Helix (Chloritis) dentrecasteauxi*, Smith; *Partula hartmanni*, Smith; *Cyclostoma infans*, Smith; *Helicina ponsonbyi*, Smith, *Proc. Zool. Soc. Lond.*, pp. 263–266, 1884.

On two occasions the pinnace was engaged in dredging in Nares Harbour in 16 to 25 fathoms, the deposit being usually coral mud and sand. Sponges, Alcyonarians, Hydroids, Annelids, Crustaceans, and Echinoderms were abundant, and several of them have proved to be undescribed species.

The Crania of the Admiralty and other Pacific Islanders collected during the voyage have been reported on by Professor Turner, and he has supplied the following resumé of the conclusions embodied in his Report:[1]—"It is generally admitted that at least two well-defined aboriginal races of men occupy the South Sea Islands. The one, named Papuan or Melanesian, inhabits New Guinea, the Admiralty Islands, and other groups to the east, south, north, and west. This race is distinguished by its sooty-brown or black skin, black frizzly hair, and well developed beard. The other, named Polynesian or Mahori, inhabits the islands in the more eastern part of the Pacific, from the Sandwich Islands in the north to New Zealand in the south. This race is distinguished by its light brown or yellowish skin, straight black hair, and scanty beard. The so-called Micronesian race, which occupies the Pelew and other islands in the north-west part of the Pacific, is not a pure race, but apparently a mixture of the Mahoris and Papuans with offshoots of the brachycephalic Negrito and Malay races, whose present home is especially in the islands of the Indian Archipelago. The Malay and Negrito races are also represented in the western parts of New Guinea, on the sea coast of which colonies of Malays have established themselves, whilst the mountains in the northwest are apparently occupied by a Negrito population. If the Australian continent be included in the Pacific area, then its aboriginal inhabitants constitute another ethnic element in this region of the globe.

"New Guinea is the headquarters of the Melanesian race. Their head form is distinctly dolichocephalic, *i.e.*, the skull is long and relatively narrow, and the length-breadth or cephalic index is below 75. But the height of the skull in this race of men is more than the breadth, so that the vertical index is greater than the cephalic. The Admiralty Island crania collected by the Challenger exhibited this type of skull in a characteristic form. In the Loyalty Islands, the New Hebrides, and the mountainous parts of Fiji, the crania of the Melanesian people present in an exaggerated form the characters of length, narrowness, and relative height, so that the term hypsistenocephalic was applied by the late Dr. Barnard Davis to these skulls. These characters are fostered perhaps by tribal interbreeding and hereditary descent amongst people who have little or no intermixture with other races.

"The Samoa and Tonga Islands are apparently the central home of the Mahoris or Polynesians in the Pacific, from which they have diffused themselves in several directions. Their head form is brachycephalic, *i.e.*, the skull is broad and rounded, and the

[1] Report on the Human Skeletons—The Crania, by Professor W. Turner, F.R.S., Zool. Chall. Exp., part xxix., 1884.

length-breadth or cephalic index exceeds 80. In these skulls the height as a rule is below the breadth, so that the vertical index is less than the cephalic. But in comparatively few of the islands of the Pacific are the crania restricted to either a simple dolichocephalic or brachycephalic standard. Both forms do, without doubt, occur in a pure state. Thus all the skulls collected in Wild Island in the Admiralty group were dolichocephalic. But it is not uncommon to obtain skulls of mixed or mesaticephalic proportions, *i.e.*, with the cephalic index ranging from 75 to 80, along with in some islands dolichocephalic, in others brachycephalic, crania. These variations can be sufficiently accounted for on the theory that the two great Pacific races are in some islands pure, in others mixed with each other, either in colonies living side by side in the same island, or by intermarriage. The crania collected by the Challenger in the Sandwich Islands furnished an excellent illustration of different types of skull occurring in one region, for eleven of these skulls were distinctly brachycephalic, fifteen were dolichocephalic, and eleven were mesaticephalic. Amongst the Maoris in New Zealand, also, a good deal of variation occurs in the proportion of the length and breadth of the skull, which points also to a mixture of races in that island. In the Society and the Marquesas groups, as well as in many of the smaller islands in the eastern Pacific, a mixture of dolichocephalic, brachycephalic, and mesaticephalic crania has also been shown to occur by various observers, more especially MM. de Quatrefages and Hamy, Dr. Barnard Davis, and Professor Flower. From the study of the crania in the Polynesian region there is good reason to believe that the Melanesian race had at one time been widely distributed throughout those islands, and that they had been inhabited by Papuans prior to the Mahori colonisation. But even in those more western islands of the Pacific, which are the special habitat of the Melanesian race, colonies of Polynesians have established themselves. The Louisiade Archipelago, the adjacent coast of the main island of New Guinea, some of the Fiji Islands, Tanna and Efaté, or Sandwich Islands, in the New Hebrides, have all received Polynesian immigrants, and crania of brachycephalic and mesaticephalic proportions have been obtained in them.

"The Australian race, again, seems to be confined to that great island continent. The aborigines, although on some parts of the coast line they make rude canoes, are not a seafaring people, and have been unable therefore to spread for any great distance beyond the Australian shores. On the other hand, they do not appear to have been much modified by mixture with other existing races. For although small colonies of Polynesians may have settled on the northeast coast, and the Malays are in the habit of visiting the west and northwest coasts, they seem to have exercised no appreciable effect upon the people. The Papuans have, however, apparently somewhat modified the characters of the tribes on the north coast, as it has been stated by Mr. Paul Foelsche that the hair of the head of the men of those tribes is invariably thick and curly, whilst the general appearance of the hair of the Australians is straight and smooth. The

Australians are a well-marked dolichocephalic race, the men with strongly projecting glabella and supraciliary ridges, and with a deep depression at the root of the nose. The nostrils also are wide, and the index of the nose is platyrhine. From my own measurements, and from an analysis of the measurements of crania recorded by various observers, it has been shown in my Report that the skulls collected to the north of the latitude of the southern boundary of Queensland have almost invariably the vertical index greater than the cephalic, whilst in the skulls from the south of that latitude a large proportion have the height appreciably less than the breadth. The low vertical index has especially been observed in the tribes in the Adelaide district, South Australia, and the crania which possess this character have been called by MM. de Quatrefages and Hamy dolichoplatycephalic. Of twenty-two skulls from this district which have been measured, seventeen had the vertical index less than the cephalic. It is not unlikely that in those tribes an intermixture may at some previous time have taken place with a people in whose crania the height index was below that of the breadth, and that in proportion to the extent of this intermixture did the tendency to a diminution in the vertical index show itself. In the crania of the now extinct Tasmanians the vertical index is much below the cephalic, and it is possible that they may have occupied, at a remote period, the southern part of Australia and been displaced by the Australian race, and the two races may have intermingled along the southern sea board.

"Various theories have been advanced as to the origin of the Mahoris or Polynesians, though none of them is perhaps entirely satisfactory. America has been regarded by some as their original home, from which they diffused themselves over the eastern Pacific in the course of the trade winds. By others Asia and the Malay race have been considered as their progenitor, and the term Malayo-Polynesian is on this view a popular ethnological designation for them. Others again, like Mr. Wallace, have accounted for both Polynesians and Melanesians on the well known theory of Charles Darwin that the Pacific is an area of subsidence, that its coral reefs mark out the position of former continents and islands, and that both races are merely varying forms of one great Oceanic race, the diversities of which are to be accounted for by the certain effects of the varying physical conditions which have resulted in the present state of the surface of the land in Oceania. But it is difficult to understand wherein such varying physical conditions could reside in islands subject to such uniform or closely allied climatic conditions as the tropical islands of the Admiralty, New Hebrides and Tonga groups, even on the supposition that they had at one time been the tops of continental mountains, so as to produce, in the two former, a black-skinned, frizzly haired, dolichocephalic stock, and in the last named a brown-skinned, straight haired, brachycephalic people. The hypothesis also which accounts for the origin of the Melanesians on the supposition that, in prehistoric times, a great south oceanic continent existed which extended from the east of Africa up to the Indian

Ocean, and from which the black race spread into both Africa and the islands of the Pacific, is not satisfactory. For the deep-sea investigations of the Challenger have thrown great doubt upon the possibility of such an extensive continent ever having had any existence in recent geological times either in the Indian or Pacific Oceans. But from the superior civilisation and better physical development of the Polynesians there can be little doubt that they represent a later incursion into the Pacific than either the Melanesian or Australian races.

"It is interesting to observe that not only the Tasmanians and Australians, but the Bush race in South Africa, the Fuegians in the southern part of South America, and the Andamanese and other Negrito tribes in the islands to the south and east of the Asiatic continent, are distinguished by the small capacity of their crania, by their low intellectual development, and, as a rule, by their small stature and feeble physical configuration. It is not unlikely that these races may, in the early unwritten periods of human history, have had in their respective continental areas a much wider range of distribution than at present, and have been gradually pushed southwards into their present comparatively restricted regions by the advance from the northward of the races, more powerful in both intellectual and physical development, which are now to be seen in proximity with and around them."

CHAPTER XVIII.

Admiralty Islands to Japan—The Schizopoda, Cumacea, and Phyllocarida—Japan—The Japan Stream—Japan to the Sandwich Islands—The Hydroida—Honolulu—Hawaii—Sandwich Islands to Tahiti—Dr. Rudolf von Willemoes Suhm—Tahiti—The Corals—Structure of Coral Reefs.

Admiralty Islands to Japan.

On the 10th March 1875, at 3.30 p.m., the Challenger left the Admiralty Islands for Japan. In steaming out of Nares Harbour, the ship suddenly came into shoal water, and before the engines could be stopped, passed over a coral patch of $3\frac{3}{4}$ fathoms, with some very suspicious looking ground to the eastward. When outside the harbour, a sounding and a productive haul of the trawl were obtained in 150 fathoms.

After leaving the Admiralty group, the regular work of sounding and obtaining serial temperatures and dredgings again commenced.

In this section—from the Admiralty Islands to Japan—thirteen soundings, twelve serial temperature soundings, one dredging, and six trawlings were obtained.

During the passage the force of the wind was exceedingly light; on no occasion did it exceed a force of 6, the average being from 2 to 3. Its direction for the first few days after leaving Nares Harbour was variable, shifting gradually from W.N.W. through N. to N.E. The true trade wind was reached in lat. 1° 15′ N., and lasted to the 19th parallel, shifting more and more east as northing was made. From the 19th parallel to Japan, variable breezes were experienced which, commencing at N., shifted gradually to N.E., E., and S.E., finally dying away at S. or S.W.

The currents in the immediate neighbourhood of the Admiralty group, and as far north as the 5th parallel of north latitude, were very strong, running to the westward at rates varying from 14 to 37 miles per day, or at a mean rate of 26 miles per day. Between the 5th and 10th parallels little or no current was experienced, but from thence to the 19th parallel, where the trade wind was lost, an average set of 17 miles per day was experienced, the direction varying from N.W. to W.S.W. From the 19th parallel the currents were variable until the Japan Stream was entered.

On the 23rd March, in lat. 11° 24′ N., long. 143° 16′ E., a sounding of 4475 fathoms was obtained,—the greatest depth observed during the cruise. Such deep water not having been expected, only 3 cwt. of sinkers were put on the rod, which being too light a weight for the depth, the intervals between the 100 fathom marks entering the water were somewhat long. The line was checked at 3000 fathoms, but the accumulators showed unmistakably that the weights had not reached the bottom; at 4575 fathoms the line was again checked, and this time the accumulators showed that the weights had become detached, so the line was hove in, and a little red clay was found in the sounding tube, and one of the thermometers had been broken by the pressure. The depth not having been ascertained with sufficient accuracy, another sounding was taken with 4 cwt. of sinkers attached, and the line was checked at 3000, 3475, 3800, and 4000 fathoms, but on each occasion the accumulators indicated that the weights were still attached; finally the time-intervals increased so rapidly that the moment the rod reached the bottom was known with considerable accuracy; thus, between 4400 and 4425 fathoms the interval was 36 seconds; between 4425 and 4450 fathoms, 38 seconds; between 4450 and 4475 fathoms, 37 seconds; and between 4475 and 4500 fathoms, 52 seconds; showing conclusively that the weights struck the bottom between 4475 and 4500 fathoms.

The two thermometers sent to the bottom the second time were both broken by the pressure. Mixed with the mud brought up in the tube on this occasion was some mercury out of these broken thermometers, which, falling faster than the sinkers, reached the bottom first, and, owing to the perfect stillness of the sea at this great depth, was caught by the rod descending exactly on the spot where the quicksilver had fallen.

A curious circumstance about this sounding was that the time-intervals went on increasing from 0 to 3500 fathoms, after which they remained nearly stationary at 35 seconds for each 25 fathoms until the bottom was reached, which apparently indicates that from 3500 to 4500 fathoms the impetus of the falling sinkers increases in exact proportion to the friction of each additional fathom of line.

On the passage to Japan, the ship passed over the position of Lindsay Island reported by Captain Lindsay of the British schooner "Amelia" to be in lat. 19° 20′ N., long. 141° 15½′ E., four miles in length, of a dark brown colour, very barren, and 40 feet high. On the 29th March, at 5 A.M., the position of the Challenger by star observations was lat. 19° 8′ N., long. 141° 16′ E., and a northward course was shaped until 8 A.M., when being in lat. 19° 24′ N., long. 141° 13′ E., by observations of Venus and the sun, a sounding in 2450 fathoms was taken. The day was fine and clear, and from the masthead a radius of at least 12 miles was commanded, so that Lindsay Island would have been seen did it exist anywhere near the locality assigned it. Either it is much out of position or Captain Lindsay must have mistaken a cloud for land, or, what seems still more improbable although it has been known to occur, the island has now disappeared through some volcanic action.

The bed of the ocean, from the Admiralty Islands to Japan, was, with the exception of the one deep sounding of 4475 fathoms before mentioned, fairly level, the average depth being about 2450 fathoms. At one sounding, however, 100 miles north of the Admiralty group, the bed of the ocean rose to 1850 fathoms in the immediate neighbourhood of the Carolines, indicating that these islands are situated on a large plateau.

The temperature of the water at the bottom in this section was generally the same as that at 1400 fathoms, viz., 35°·3, from which it appears probable that this portion of the Pacific Ocean is cut off from the general circulation by a ridge joining Japan with the Admiralty group through the chain of small islands stretching in an almost continuous line from Japan through the Bonin, Ladrone, and Caroline Islands to the Equator.

The surface temperature, which at the Admiralty Islands was 83°·7, continued above 80° for nearly 1000 miles, and even as far north as the 22nd parallel was over 78°. Between the 22nd and 25th parallel it fell 8°, and continued at an average of 69°·5 to the 30th parallel, after which it varied between 56° and 68° to the coast of Japan, being 55° in Yokohama Bay.

The serial temperatures showed that from the Admiralty Islands to the 14th parallel of north latitude, a mass of warm water above the temperature of 80° extended from the surface to the depth of from 50 to 90 fathoms. Below this warm surface stratum the temperature decreased very rapidly (on one occasion altering 15° in 11 fathoms), until at 300 fathoms it appeared to be very nearly constant at 45°. The isotherm of 45° remained at the depth of 300 fathoms from the Admiralty Islands to the 15th parallel, northward of which it sank to 400 fathoms. Between the 15th and 26th parallels the isotherm of 40° was constant at 500 fathoms; northward of the 26th parallel it rose towards the surface, as did also the isotherm of 45° (see Diagram 16). The isotherm of 45° was also at the depth of 300 fathoms in the Banda, Celebes, and China Seas; and the isotherm of 40° was found at a depth of 500 fathoms in the China Sea in January.

Anemometer observations were taken daily during the passage, from which it appeared that between the 1st and 6th parallels of north latitude, the mean velocity of the trade wind was only 6 miles per hour. North of the 6th parallel the velocity gradually increased, until in 10° N. it was 22 miles per hour, which was the maximum attained; it then gradually decreased to 8 miles per hour in 17° N., and from that parallel to 20° N. only averaged 5 miles per hour. After losing the trade, the velocity of the wind varied considerably, but it never exceeded a rate of 22 miles per hour.

No current observations were taken except the surface set, which was ascertained by frequent astronomical observations.

In April, when nearing Japan, the temperature of the surface water fell from 70° to 64° between 6 P.M. on the 8th and 1 A.M. on the 9th, so the ship having apparently entered the Japan Stream, a sounding was taken at 5.30 A.M. in 2250 fathoms, but little or no current was observed, the position at this time being lat. 31° 8′ N., long. 137° 8′ E.

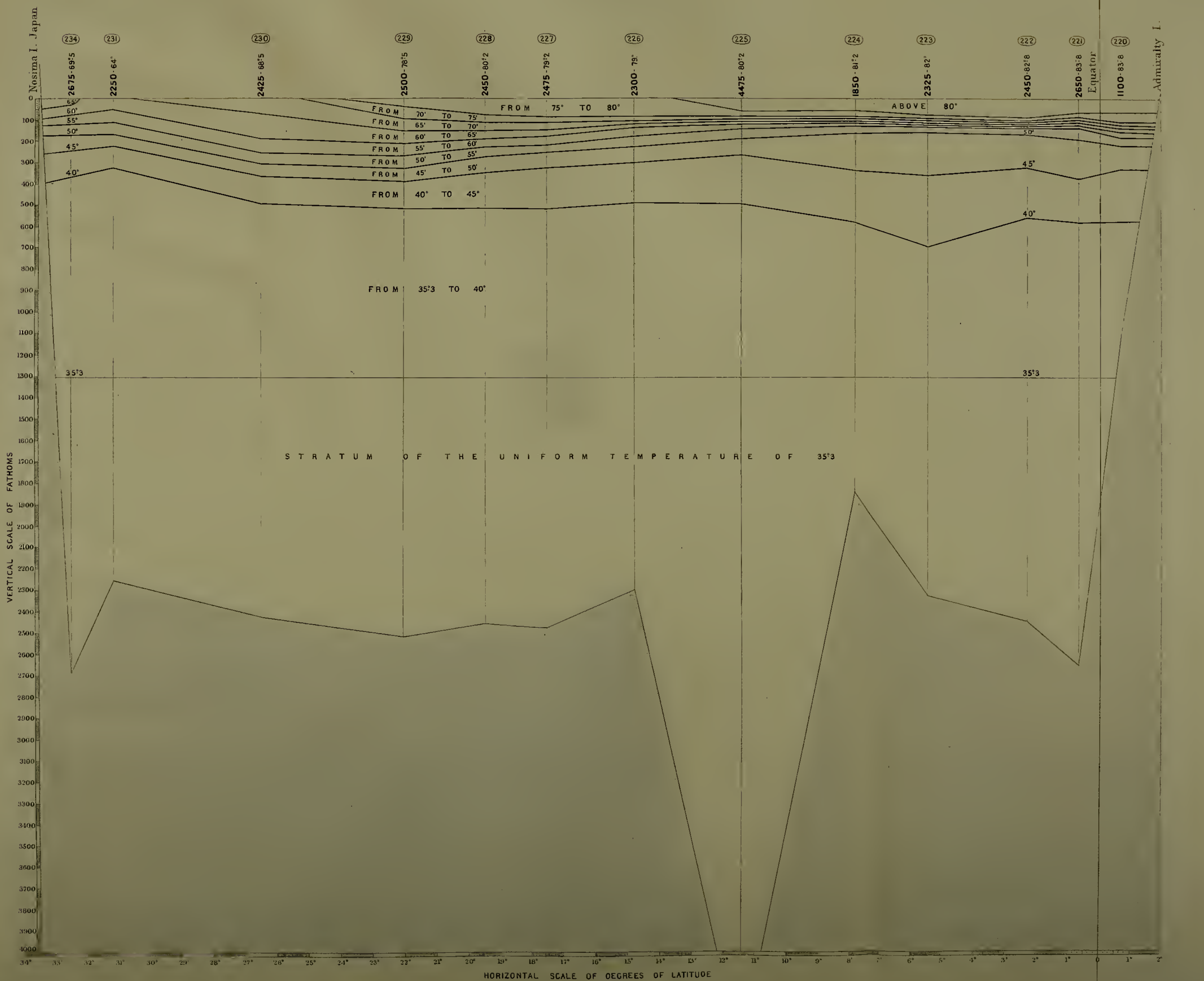
After completing the sounding the vessel proceeded to the northward, the surface temperature varying from 63° to 64½° until 6 A.M. on the 10th April, when in lat. 32° 35′ N., long. 137° 45′ E., it rose suddenly to 68°. At noon the ship's position was lat. 32° 55′ N., long. 138° 25′ E., and a current of 42 miles N. 22° E. (true) had been experienced since noon on the 9th. This position was fixed by meridian altitude, and

DIAGRAM 16

PACIFIC OCEAN

Meridional Temperature Section . Admiralty Island to Japan.

For explanation of Symbols see Appendix 1.



Engraved by Malby & Sons

three sets of sights in the forenoon. The afternoon was cloudy, with little or no wind, and no astronomical observations could be obtained until 9.40 P.M., when, a few stars shining out for a minute or two, and the horizon being lit up by the moon, both the latitude and longitude were obtained, and the ship was found to be in lat. 33° 24′ N., long. 138° 44′ E., or 24 miles northeast of the position by D.R. A moderate westerly breeze having sprung up, the ship was steered due north, this northeasterly set being expected to continue, but it was found at 8 A.M. on the 11th April that a current of only 11 miles due east had been experienced since the sights at 9.40 P.M. on the 10th, and the ship had consequently barely cleared the Redfield Rocks. The surface temperature on the 10th was about 68° from 6 A.M. to 1 P.M. 63° from 1 P.M. to 8 P.M., 68° from 8 to 9 P.M., after which it fell gradually.

On the 11th April, at daylight, the islands of Kosu Sima and To Sima were seen, and a course shaped to pass inside Vries Island with a fresh fair wind, the vessel arriving at Yokohama at 5 P.M.

The deposits between the Admiralty Islands and Japan proved very interesting, chiefly from the large number of Radiolarians present in them, and also from the complete absence of carbonate of lime in all the deeper soundings. In depths greater than 2400 fathoms there was either no carbonate of lime in the deposit or only a small percentage, as for instance in 2450 fathoms in lat. 2° N., where there was 6 per cent., due to the presence of a few broken fragments of pelagic Foraminifera shells. On the other hand, there was 78 per cent. of carbonate of lime in the deposit at 1850 fathoms on the Caroline Islands plateau, which was a Globigerina ooze made up principally of the shells of pelagic Foraminifera, Coccoliths, and Rhabdoliths. The absence of the shells of Pteropods, Heteropods, and other pelagic Molluscs from this deposit is worthy of note, as well as the absence of the Foraminifera shells from all the deeper deposits, as these organisms were very numerous at the surface throughout the whole region. As already stated, siliceous shells and skeletons were especially abundant in all the deposits in this section, more numerous than in any deposits previously met with during the cruise. Sometimes these beautiful little organisms made up more than one half of the deposit, which was in consequence called a "Radiolarian ooze." This was the case in the deepest sounding, viz., 4475 fathoms, the greatest depth from which a specimen of the bottom has yet been obtained. On this occasion the sounding tube had sunk about 3 or 4 inches into the bottom and brought up a section to that extent. The layer, which formed the upper surface at the bottom of the sea, was of a reddish or chocolate colour, and contained, besides the Radiolarian and Diatomaceous remains, numerous small round pellets of manganese peroxide, fragments of pumice, and clayey matter. The deeper layers were of a pale straw colour, and resembled both in appearance and touch the Diatom ooze from the Antarctic Ocean. These deeper layers had a laminated structure, and were very compact and difficult to break up, being composed of felted masses of Radiolarians and frustules of Diatoms.

Pumice was very abundant in all the deposits, the trawl frequently bringing up numerous rounded pieces, many of them partly decomposed and coated with manganese peroxide. The mineral fragments in the deposits appeared to be chiefly derived from the pumice, except in the soundings close to the Japan coast. All the deeper deposits were brown or chocolate coloured, due to the presence of manganese.

The dredgings and trawlings were not very productive. The dredge brought up from 1850 fathoms a large quantity of Globigerina ooze, specimens of *Bathyactis symmetrica, Ophioglypha undulata, Ophiomusium corticosum,* and *Styracaster armatus,* the latter being a new genus and species of Asterids. A specimen of *Hyocrinus* was obtained from 2325 fathoms, some fragments of *Brisinga* from 2300 fathoms, and a *Discina* was found on some pumice stones from 2425 fathoms.

The surface fauna and flora were especially rich and abundant throughout. In the region of the Counter Equatorial Current, between the Equator and the Caroline Islands, pelagic Foraminifera and Mollusca were caught in great numbers in the surface nets, surpassing in this respect anything previously observed. The fact is most probably in relation with another, which may be pointed out. In this region the soundings in 2325 and 2450 fathoms contained respectively 52 and 6 per cent. of carbonate of lime, whereas at 2300 fathoms, in lat. 14° 44′ N., only a few broken fragments of Globigerina shells could be detected on microscopic examination; and at 2450 fathoms, in lat. 19° 24′ N., there was not a trace of carbonate of lime shells in the ooze. This shows apparently that where there are numerous calcareous shells at the surface their remains may be found at greater depths at the bottom than where relatively less abundant at the surface. The pelagic Foraminifera appear to float about in great banks; one day immense numbers of *Pulvinulina* would be taken in the net, the next day *Pullenia* would be most abundant, and *Pulvinulina* nearly or quite absent from the hauls. The heavier shelled specimens were usually taken when the nets were dragged 100 or 150 fathoms beneath the surface. Between latitudes 10° and 20° N., Oscillatoriæ were very numerous at the surface, and Diatoms, especially a large cylindrical *Etmodiscus,* were more abundant than in the tropical waters of the Atlantic far from land. The list of surface animals recorded in the note-book is nearly the same as that given on pp. 216 and 217, but the relatively much greater abundance of Radiolarians and Diatoms is specially noteworthy.

Between the Admiralty Islands and the northern tropic very few birds were observed from the ship. One day, in lat. 5° N., a red-tailed Boatswain Bird (*Phaëthon flavirostris*) alighted on the ship, and the following day a Noddy Tern (*Anous melanogenys*) was procured in a similar manner. As soon as the ship passed out of the tropics, she was daily surrounded by large numbers of the northern Albatross (*Diomedea brachyura*). When about 240 miles westward of the Bonin Islands, five Swallows alighted on the rigging in an exhausted state and were captured; these were *Hirundo gutturalis*, the eastern form of the familiar *Hirundo rustica*. Several Finches and a thrush-like bird were observed at the same time.

Professor G. O. Sars, of Christiania, who is preparing a Report on the Schizopoda, Cumacea, and Phyllocarida, gives the following notes on the collections which were placed in his hands:—

The Schizopoda.—"The collection of Schizopoda procured during the Challenger Expedition is extremely rich and of great interest. The three subdivisions or families hitherto established—Lophogastridæ, Euphausiidæ, and Mysidæ—are all represented, and the late Dr. v. Willemoes Suhm has, in addition, founded a new subdivision for the

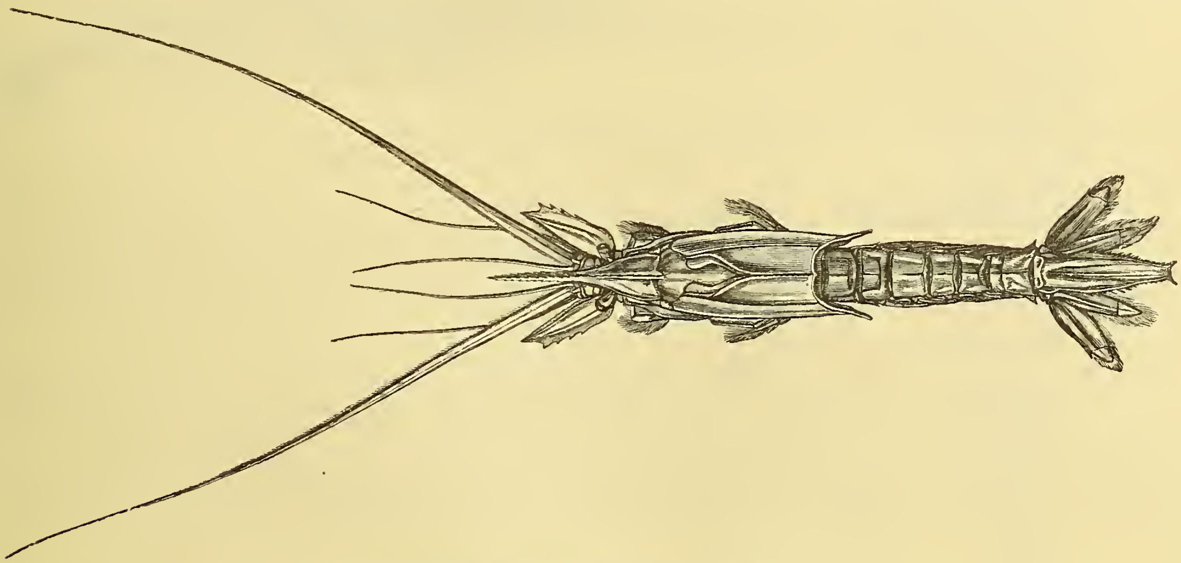


FIG. 260.—*Gnathophausia gigas*, Suhm. Dorsal view.

remarkable genus *Eucopia*, Dana (or *Chalaraspis*, Suhm), also procured during the Expedition.

"Of the Lophogastridæ, specimens of the first established species, *Lophogaster typicus*, M. Sars, hitherto only known from the Norwegian coast and the Shetland Isles, have been obtained in a widely remote locality, viz., south of the Cape of Good Hope. A solitary specimen, representing a new genus, *Ceratolepis*, was caught north of Australia. Exceedingly interesting is the discovery of the remarkable deep-sea Lophogastrid genus *Gnathophausia*, established by the late Dr. v. Willemoes Suhm. Three species have been described by that author, one of which, *Gnathophausia gigas* (see figs. 260, 261), attained dimensions truly gigantic for a Schizopod. A closer examination of the material has shown that no less than nine different species of this interesting genus are in the collection, one of which somewhat exceeds in size even the *Gnathophausia gigas*, the specimen secured being a full-grown female with enormously developed marsupium, and exhibiting a rather striking appearance from its thick-set form and very large, loosely attached carapace. This form, too, has proved to be identical with a peculiar Crustacean described by Professor Dohrn as *Lophogaster ingens*, from a very incomplete specimen sent to him from the museum in Hamburg. The *Gnathophausia zoœa* (see fig. 262) of Suhm, recalls in a most striking manner, by the form of its carapace, the larva (zoœa) of the Brachyura, and seems to be the most widely distributed species, being found on both sides of the Atlantic and also in the Pacific.

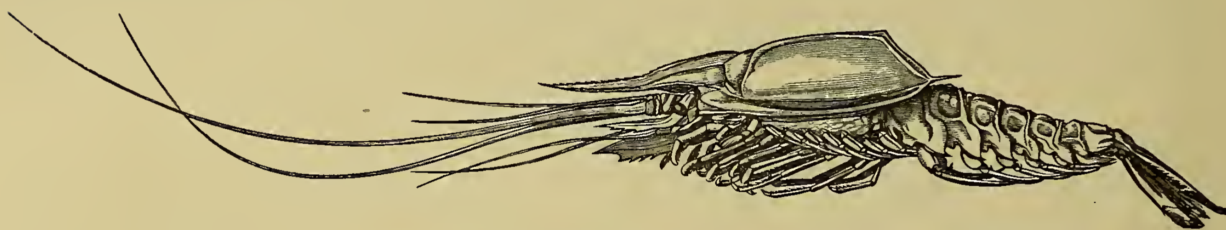


FIG. 261—*Gnathophausia gigas*, Suhm. Lateral view.

"The remarkable form, *Eucopia australis*, Dana (= *Chalaraspis unguifer*, Suhm), seems also to be widely distributed in the great depths of the oceans, but, owing to its remarkably soft integument and fragile limbs, most of the specimens in the collection are in a more or less imperfect state.

"The subdivision Euphausiidæ, in contrast to the Lophogastridæ and Eucopiidæ, seems to consist almost exclusively of true pelagic species, some of them being often found in great profusion swimming about near the surface of the sea, especially at night. As was first stated by Vaughan Thompson, these elegant and pellucid Crustacea are highly

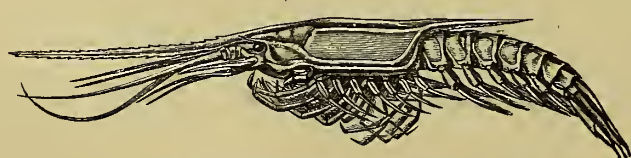


FIG. 262.—*Gnathophausia zoœa*, Suhm.

phosphorescent, the generic denomination, *Noctiluca*, given to them by that author being in fact derived from this peculiarity. The mode by which this phosphorescence is effected does not seem, however, to have been fully ascertained hitherto. It is true several authors have mentioned in these Crustacea a number of peculiar vivid-coloured globules, occurring both on the sides of the trunk and along the ventral face of the tail between the bases of the pleopods; but the structure of these globules generally has suggested the supposition that they were accessory eyes. The re-examination of the said organs in connection with observations made on living specimens at the Norwegian coast has, on the other hand, led me to the conviction that these globules, in spite of their striking similarity to eyes, do not represent visual organs at all, but constitute together a highly complicated luminous apparatus; the lenticular body of the organs, generally described as a true eye-lens, acting as a condenser, which, in connection with the great mobility of the globules, enables the animal to produce at will a very bright flash of light in a given direction. The great majority of the species possess these organs, generally arranged in a perfectly similar manner; but in a large, non-pellucid deep-sea *Euphausia* (not represented in the collection), v. Willemoes Suhm could not detect these globules in their usual place.

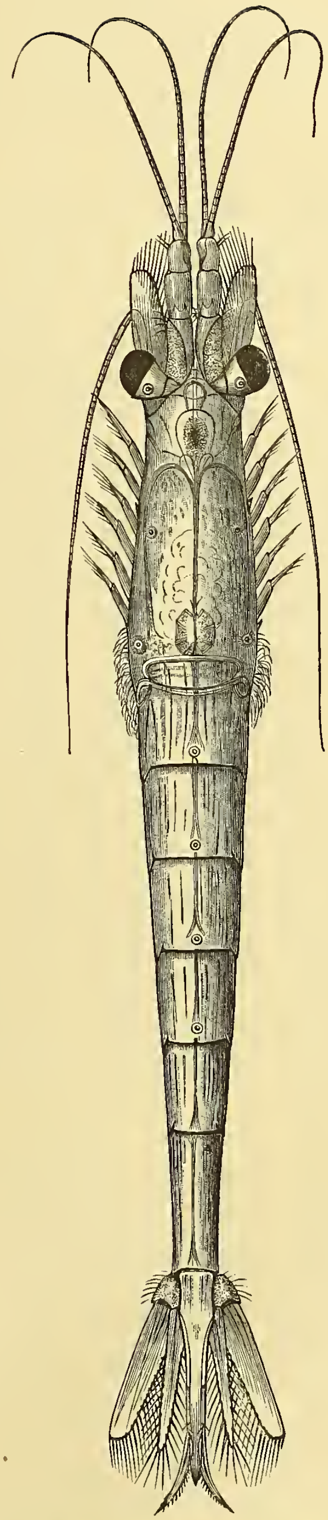


Fig. 263.—*Euphausia pellucida*, Dana.

"The extensive use of the surface net during the Expedition at many different localities, and carried on by day as well as by night, has brought together a very large number of these interesting Schizopoda, both adults and larvæ, and of course our knowledge of this family has been very materially increased. No less than twenty-seven species are represented in the collection, belonging to six different genera, of which four are new. One of these genera, *Nematoscelis*, G. O. Sars, is distinguished by the enormously elongated and slender form of the second pair of pediform appendages (the modified gnathopoda). In another genus, *Stylocheiron*, G. O. Sars, on the other hand, the third pair of legs has been peculiarly modified, being also greatly elongated, the two last joints forming together a kind of imperfect chela. In accordance with their pelagic life the geographical distribution of the species is generally very extensive. By far the most widely distributed is, however, the *Euphausia pellucida*, Dana (fig. 263), ranging from Norway (*Thysanopoda bidentata*, G. O. Sars) and the Mediterranean (*Euphausia mülleri*, Claus), throughout the Atlantic and Pacific up to the coast of Japan. The large number of larvæ caught with the help of the surface net has also enabled me to trace the very interesting and complicated development of several species from the Nauplius stage through all the many successive stages up to the adult form.

"The fourth subdivision of the Schizopoda, the Mysidæ, is represented both by deep-sea forms and pelagic species. Of the first group a very peculiar form, *Petalophthalmus armiger*, has been described by v. Willemoes Suhm, distinguished by the rudimentary leaf-like eyes and more particularly by the very remarkable appearance of the male, in which the antennules, mandibular palps, maxillipedes, and partly also the legs, are very peculiarly modified. Another very large and handsome form from the Subantarctic Sea has been referred by v. Willemoes Suhm to the same genus, but is evidently not congeneric with *Petalophthalmus armiger*, although it exhibits a similar reduction of the visual organs. It has proved to be identical with a form described by Professor Sars as *Boreomysis scyphops* from the depths of the Arctic Sea, thus exhibiting another instance of a very peculiar geographical distribution, the very same species being found in the corresponding region in both hemispheres, without occurring in the wide intermediate space, comprising both the temperate and the tropical zones. Two more Mysidians with imperfectly developed lamelliform eyes have been collected in the southern hemisphere, both of which belong to the boreal genera *Amblyops* and *Pseudomma*, G. O. Sars, differing only very slightly from Norwegian species.

"Of pelagic Mysidæ, five species are represented in the collection. One of these, which has been collected off the Cape of Good Hope, belongs to the genus *Auchialus* of Kröyer, and is apparently identical with the typical species described by that author. Of the genus *Siriella*, Dana (or *Cynthia*, Thompson), the two species *Siriella thompsonii*, Edwards, and *Siriella gracilis*, Dana, seem to have a very wide geographical distribution, being found in nearly all parts of the oceans traversed by the Expedition. The two remaining pelagic species of Mysidæ belong to a new genus, *Euchætomera*, chiefly distinguished by the strongly plumose setæ on the several limbs, as also by the peculiar form of the telson. Both species were caught in the Pacific."

The Cumacea.—"The Cumacea are rather scantily represented in the collection, only eleven species having been secured, which may perhaps be accounted for by their generally small size and inconspicuous colours, causing them easily to be overlooked in the rough examination of the dredged material. Most of the species belong to the genus *Diastylis*, some of which were taken in very considerable depths, viz., down to 2025 fathoms. Perhaps the most striking among the Challenger Cumacea is a very slender form from the coast of Kerguelen Island, *Hemilamprops serrato-costata*, G. O. Sars, of which numerous specimens were collected during the stay of the Expedition at Christmas Harbour. In examining a parcel of dredged mud from this locality (120 fathoms), several more specimens have been picked out, showing that this form occurs there in great profusion. The examination of the mud also yielded a great quantity of other small Crustacea, especially Isopoda and Amphipoda, and the similarity of these species with northern forms is on the whole very striking. A small Cumacean of the genus *Leucon* seems hardly to be distinguishable from the well known northern species, *Leucon nasicus* of Kröyer."

The Phyllocarida.—" Of Phyllocarida a new species of *Nebalia* has been described by v. Willemoes Suhm from the Bermudas (see p. 150). Another large and very interesting deep-sea Phyllocarid, apparently nearly related to *Nebalia*, was met with at two different localities. Of one of the specimens only the carapace and a fragment of the anterior part of the body have been secured. It seems to be this imperfect specimen that the late Dr. v. Willemoes Suhm mentioned in one of his letters to Professor v. Siebold[1] as a gigantic Ostracode. Fortunately another more perfect, though smaller, specimen was afterwards collected in the South Pacific when the dredge had been down to the considerable depth of 2550 fathoms, showing clearly that it is a Phyllocarid, and not, as first suggested, an Ostracode. The most striking characters of this form are the distinctly sculptured carapace, the rudimentary eyes, and the remarkably feeble structure of the branchial legs, distinguishing it from *Nebalia* as a distinct genus, *Nebaliopsis*, G. O. Sars."

The phosphorescent light emitted by the species of the Euphausiidæ was frequently under observation during the cruise. If one of these be taken up by a pair of forceps when newly caught, a pair of bright phosphorescent spots will be observed directly behind the eyes, two other pairs on the trunk, and four other spots situated along the median line of the tail. These can all be quite well seen with the naked eye. The pair close to the eyes are first and most brilliantly illuminated, and then the light, which is bluish white, spreads to the other organs on the trunk and tail. After a brilliant flash has been emitted from the organs they glow for some time with a dull light. The light is given out at will by the animal, and usually, but not always, when irritated. The most brilliant flashes occur when freshly taken from the sea. Subsequent flashes become less and less bright, till the animal appears to lose the power of emitting light. If the organs be removed with the forceps the points will glow brightly for some time, and when the animal is dying the whole body is frequently illuminated by a diffused light. These phosphorescent organs appear under the microscope as pale red spots with a central clear lenticular body. The phosphorescent light comes from the red pigment surrounding the lenticular space. In August 1880 Mr. Murray observed at night on the surface of the sea in the Færöe Channel large patches and long streaks of apparently milky white water. The tow-nets caught in these immense numbers of *Nyctiphanes* (*Thysanopoda*) *norvegica*, M. Sars, and the peculiar appearance of the water seemed to be due to the diffused light emitted from the phosphorescent organs of this species.

[1] Brief II., *Zeitschr. f. wiss. Zool.*, Bd. xxiv. p. xiii., 1874.

JAPAN.

On the 13th April the anchor was weighed early in the forenoon, and the vessel proceeded out of Yokohama Bay for the purpose of swinging ship to ascertain the errors of the compass. The position of the ship at noon was Treaty Point W.N.W. one mile. At 8.30 P.M. she returned to the anchorage, and on the 26th April proceeded to Yokoska Harbour, and the following day was hauled into dock for repairs. On the 3rd May she was hauled out of the dry dock and returned to the former anchorage off Yokohama.

On the 12th May the Challenger left Yedo Bay for a cruise along the southern coast of Japan and into the Inland Sea. Proceeding first round Joka Sima, a day was spent in sounding, dredging, and trawling in the bay next west of Yedo, where the celebrated Japanese siliceous glass rope Sponges (*Hyalonema*) are found. A native fisherman was taken to point out the best spot, which proved to be Double Hill (on the coast on the east side of Yedo Bay) in line with Tree Hill, and a notch in the coast behind Ino Sima shut in by that island. The angles were Peaked Rock 28° 10′ ⋉ Ino Sima 82° 40′ Tree Hill ⌽ Double Hill (see Sheet 35). The depth was 345 fathoms, and the deposit a dark green mud containing a few shells of pelagic and other Foraminifera, fragments of Molluscs, Echinoderms, Polyzoa, Sponge spicules, Radiolarians, and Diatoms. There were a good many glauconitic casts of the calcareous shells.

The ship was surrounded by native fishing boats, and Mr. Murray visited a number of these. They were fishing with long lines on which were attached iron hooks without barbs, about 6 feet apart. On the lines which were being hauled in were Pennatulids, Hyalonemas, Astropectens, Hydrozoa, and Macrurids and other deep-sea fish. It is worthy of remark that while several Hyalonemas were procured from the native lines none were obtained in the dredgings and trawlings from the ship, although most of the other species were captured and many others in addition. The whole fauna had a marked deep-sea character. In the Memoirs already published thirty-two new species are described from this locality.

Dr. A. Günther has the following interesting remarks on the Fish from this Station :—

" A fact to which I have repeatedly drawn attention, and again quite recently,[1] viz., that there exists the greatest similarity between the marine fauna of Japan and that of the Mediterranean, the adjacent parts of the Atlantic, and the West Indies, is fully borne out by the Challenger collections. It is proved not only by a number of species absolutely identical in the seas named, but also by a large proportion of representative species. The similarity becomes still more obvious when we take into consideration species which live at a moderate depth of from 200 to 400 fathoms ; and although I

[1] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. i. p. 485, 1878 ; also *Journ. Linn. Soc. Lond.* (Zool.), vol. xii. pp. 100–109, 1874.

have included the descriptions of those fishes in the deep-sea series, it will be useful to enumerate them here, with an indication of their geographical range. Of the nineteen species obtained at a depth of 345 fathoms, four are identical with Mediterranean species, five are representatives of Mediterranean species, eight belong to genera with a wide range at great depths, and two only must be regarded as peculiar Japanese forms.

"1. *Centrophorus squamulosus*,	Eight species of *Centrophorus* from the coast of Portugal, Madeira, and the Mediterranean.
2. *Centrophorus foliaceus*,	
3. *Beryx decadactylus*,	Madeira and the coast of Portugal.
4. *Polymixia japonica*,	One species of this genus from Madeira and St. Helena. One species from Cuba.
5. *Lepidopus tenuis*,	One species from the Mediterranean and the East Atlantic.
6. *Physiculus dalwigki*,	Madeira and St. Helena.
7. *Haloporphyrus lepidion*,	Mediterranean, Madeira, and the coast of Portugal.
8. *Macrurus japonicus*,	The species of *Macrurus* and *Coryphænoides* are generally distributed over the deep sea.
9. *Macrurus macrochir*,	
10. *Macrurus parallelus*,	
11. *Coryphænoides nasutus*,	
12. *Coryphænoides villosus*,	
13. *Bathythrissa dorsalis*,	Peculiar to the sea off Japan.
14. *Xenodermichthys nodulosus*,	Peculiar to the sea off Japan.
15. *Gonostoma gracile*,	One species from the Mediterranean and Madeira, the other from the deep sea, and generally distributed.
16. *Synaphobranchus pinnatus*,	Madeira, Brazil.
17. *Synaphobranchus affinis*,	Japan.
18. *Nettastoma parviceps*,	One species from the Mediterranean.
19. *Myxine australis*,	Southern coasts of South America."

At 6 P.M. the ship proceeded for the passage between Vries Island and Nipon, which was passed at midnight. The light at Joka Sima was not seen farther than 10 miles.

The temperature of the surface water off Ino Sima was 3° higher than in Yedo Bay, and it gradually rose to 68° between Vries Island and the mainland. Here a current was met with setting northeast at the rate of one mile per hour.

On the 13th at 5 A.M. Rock Island was passed, and the ship was steered to the westward towards Matoya to keep out of the current. At noon the barometer began to fall rapidly and a southerly gale was expected, for it was noticed whilst lying in

Yokohama Bay that the winds appeared to follow a definite course, viz.:—With a high barometer, light southerly winds and fine weather prevailed; when the barometer fell the wind increased rapidly, and the weather became thick and dirty; when the barometer reached its lowest point the wind suddenly shifted to the westward and northwestward, and the sky became clear; the barometer now gradually rose and the wind which at first blew as hard from the N.W. as it had from the southward gradually decreased, shifted to the northward and northeastward, and fell light.

At 4 P.M. Matoya light bore N. 71° W., Kami Sima N. 15° W., Cape Sima, S. 77° W., and the ship was steered to the southwestward and southward and shortly after the land was lost sight of, the weather becoming thick and squally. The wind increased to a gale by midnight and the sea got up rapidly, so that the vessel with all four boilers was only steaming 3 knots against it.

On the 14th, at 4 A.M., the sea had increased so considerably that the engines were eased, and the ship stood off the land on the starboard tack. At 6 A.M. the barometer reached its lowest point, 29·62 inches, the weather cleared, and the wind shifted to the northwestward, the clouds disappearing as if a curtain had been withdrawn from the sky. After a short interval of calm the wind increased to a single-reefed-topsail breeze from the northwest, and there being a good deal of sea on the south of Oosima, the ship made but little headway against the combined influences of sea, wind, and current. At 0.30 P.M. it was considered advisable to bear up for Oosima Harbour, where the vessel anchored at 3 P.M., with Itsino Sima Rock N. 50° E., Wooded Island S. 40° E., and west point of Mioga Sima S. 5° W.

A number of the officers landed in the course of the afternoon at Nasingari village, and proceeded along the beach to the town of Kusimoto, and returned by a beautiful glen. The water in Oosima Harbour contained many Copepods, Ctenophores, Hydromedusæ, larvæ of Annelids, Diatoms, and immense numbers of *Noctiluca miliaris*. These last were very large fine specimens, and in a great many instances they had swallowed several large Diatoms. One specimen was seen to eject the frustule of a Diatom through its cell-wall at a point nearly opposite to the point where the flagellum is inserted. The spot where the frustule was ejected closed immediately, but for a long time remained marked by star-like radiating lines; similar star-like spots were noticed in several specimens, but not in the same position. The animal apparently ejects these frustules through any part of the surface of the body. The nucleus, which became coloured with carmine before treatment with spirit, was very minute and circular.

On the 15th, at 5 A.M., the vessel left Oosima Harbour, going out through the south channel (having previously come in through the east). The day was calm and fine and the water smooth, and the ship proceeded along the land for Isumi Strait and Kobé. The Japan Stream was lost at 8 A.M., the surface temperature having decreased from 67° to 65°·5. At 2 P.M. the ship passed through Isumi Strait, where the temperature of the surface was 61°·5, and at 5 P.M. anchored off Kobé in 5 fathoms, with Hiogo Tower S. 22° W., Kawa Saki Tower S. 50° W., Pier End N. 42° W., and Kobé Point N. 45° E.

The vessel remained at Kobé until the 25th May in order to allow members of the Expedition time for a visit to Kioto (or Miako), the western capital of Japan, and old residence of the Mikados, where an exhibition of Japanese workmanship was then being held.

The steam pinnace was engaged several days dredging in shallow water off Kobé.

On the 25th, at 10.30 A.M., the Challenger left Kobé for a cruise in the Inland Sea. At 1 P.M. Matsu-wo-ga-hana, the north point of Awadji Island, was passed, and a course shaped as requisite to pass through Akashi Strait, keeping the right extremity of End Hill in line with the lighthouse, a most excellent mark. After passing Shika-no-se the ship was steered for the left extremity of Sozu Sima and anchored on the south side of that island at 7 P.M. off Sakate, with Ukado Point 93° 30′ Small Fukube Island 30° 40′ Dyizo Hana.

On the 26th, at 6 A.M., the ship proceeded under steam for Miwara, at 9 A.M. passed Odutsi Island, and at 9.40 A.M. Nabe Sima lighthouse. At 11.20 A.M. a trawling was taken in 15 fathoms, with the left extremity of Sanagi Sima 58° 40′ the right extremity of Nezumi Sima 120° 0′ Akeno Misaki. At 11.45 A.M. the vessel proceeded again towards Miwara, and at 0.40 P.M. a trawling was obtained with Mutsu Sima N. 63° E., Udsi Sima N. 4° W., Ibuki Sima S. 12° E. At 1.30 P.M. the trawl was hove up, and the ship proceeded for Miwara, anchoring there at 4.15 P.M. in 14 fathoms with the following anchorage marks :—

431 feet hill, Iwashi Sima, 58° 0′ apex Sukune Sima in line with Guize Yama, 54° 0′ right extremity Ko Saki Sima.

The following leading marks were found useful in passing through the different channels :—

The south point of Kasiva, in line with the north point of Oki Sima, clears the shoal patch between Oki Sima and Okabula.

Avari Sima, in line with the south point of Kasiva, just clears the Galatea Bank, but a better mark is the south point of Té Sima, in line with the south point of Kasiva.

The south point of Ko Sima in line with the north point of Oki Sima clears the Maka Se.

After passing Nabé Sima light, Ko Sei Sima kept open north of Sanmen Sima until the 10 feet rock is in line with the north point of Takami, clears the Three Rocks spit and the rocky knolls north of Usu Sima. When abreast of the north point of Usu Sima, the 10 feet rock should be kept a little north of Takami to clear the rocks north of Siyako.

The peaks of Odutsi, Nabé Sima, and the north point of Usu Sima in line together and kept in transit, clears the Conqueror Bank, and leads a safe distance south of the 10 feet rock, after passing which it should be brought in line with the clump on Usu Sima, which mark leads between the banks east of Takami on the south side and off Sanagi Sima and Ko Sima on the north side of the channel.

The 27th was spent by the members of the Expedition in visiting the extensive ruins of a Daimios castle at Miwara, and visiting several points in the picturesque vicinity.

Miwara was the terminus of the cruise in the Inland Sea, which, with its variety of islands and forelands, deep bays and inlets, backed by numerous ranges of hills and mountains of every possible shape, justified its reputation for beauty of scenery, which, however, is somewhat marred by the barren appearance of the hills, especially at a distance. On closer inspection almost every sheltered nook in this intricate network of seas and channels is found to be occupied by populous towns and villages, surrounded by well cultivated fields, which at the time of the visit were all yellow with ripening grain. The fields were bordered by clumps of fine old trees, which the Japanese—with that delicate artistic feeling for the beauties of nature which is a striking peculiarity of this remarkable people—take care to leave standing in the midst of their dwellings and fields.

On the 28th May the vessel left Miwara to return to Kobé. At noon a trawling and temperatures were obtained in 12 fathoms, and then the ship proceeded for Sanagi Sima anchoring off that island at 3 P.M. At 8 A.M. on the 29th the vessel left that anchorage and arrived at Kobé at 5 P.M.

Several dredgings and trawlings were taken in the Inland Sea in depths of 15 and 11 fathoms. The deposit was a stiff blue mud containing a great variety of mineral particles and some Foraminifera, fragments of Echinoderms, Molluscs, &c. There were, however, no pelagic Foraminifera shells, nor were any of these organisms found in the surface net gatherings during the cruise in the Inland Sea. In the trawls were Holothurians, Ophiurids, Asterids, Echinids, Annelids, Crabs, Shrimps, several Cephalopods and other Molluscs, and many Teleosteans, some of which have proved to be new species. On the surface there were many Diatoms, *Noctilucæ*, and other Protozoa, larvæ of Lamellibranchs, Gasteropods, Ophiurids, Starfish, Annelids, and Crustacea, *Appendicularia*, Copepods, *Daphnia*, and a small species of *Acanthometra*.

On the 2nd June, at 10 A.M., the Expedition left Kobé for Yokohama, passing through Isumi Strait at 1.40 P.M. At 5 P.M. Miya Saki bore N. 18° E., Hino Misaki E., and Ilibé Saki S. 55° E., and a S. by E. ½ E. course was shaped for a position 50 miles south of Oosima in order that a sounding and dredging might be obtained the next morning. The temperature of the surface water rose gradually from 65° in Isumi Strait to 70°·5 at 10 P.M.

On the 3rd, at 5 A.M., a sounding was taken in 2675 fathoms in lat 32° 31′ N., long. 135° 39′ E. (see Sheet 35), and serial temperatures were obtained to a depth of 300 fathoms, but owing to the dirty looking weather and increasing breeze no attempt was made to dredge. Whilst sounding no current could be detected. The deposit here was a blue mud with a reddish surface layer, and did not contain any carbonate of lime. At 9 A.M. sail was made, and the ship stood to the northeastward, the barometer falling with a fresh S.E. wind and dirty weather which lasted until 8 P.M., when the barometer reached 29·51 inches and the wind shifted to the westward and then to N.N.E., but the weather still remained thick, and after midnight the barometer again fell slightly,

SHEET 35

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reaching its minimum at 4 A.M. on the 4th (29·48 inches), then rising quickly, with a freshening wind from the northeastward.

On the 4th, at 7.30 A.M. the mist cleared, the weather became quite bright, and the land about Matoya was distinguished; astronomical observations were also obtained by which it was ascertained that no current whatever had been experienced since passing Hino Misaki. At 4 P.M., the weather being very fine and calm, a sounding in 565 fathoms, serial temperatures, and a most successful and productive trawling were taken in lat. 34° 7′ N., long. 138° 0′ E., and again no current was found running (see Sheet 35). At 7.30 P.M. the vessel proceeded under steam towards Rock Island.

On the 5th June at 8 A.M. Rock Island lighthouse was passed, and at 1 P.M. a sounding, trawling, and temperatures were taken in depths varying from 775 to 420 fathoms over rocky uneven ground, with the left extremity of Vries Island S. 9° W., the right extremity of Vries Island S. 32° W., and Tree Hill N. 42° W. Considerable difficulty was experienced in recovering the trawl, owing to the rocky nature of the bottom, but eventually it was hove to the surface at 5 P.M. much torn and containing a few stones, after which the ship proceeded for Yokohama, anchoring there at 9 P.M.

The Japan Stream or Kuro Siwo.—The Challenger's observations show that on approaching Japan a belt of water which was running to the northeastward at the rate of three miles per hour was passed through between lat. 32° 30′ N. and 33° 30′ N., on the meridian of 138° 25′ E. from Greenwich. On the southern edge of this belt the stream had a more northerly, and on its northern edge a more easterly, tendency than N.E. When to the northward of this belt of rapidly moving water a set of one mile per hour was experienced.

When in the current the temperature of the surface water varied from 63° to 68°, changing suddenly from the one temperature to the other, giving alternate streams of cold and warm water without any alteration in its rapidity being detected. That this was the case is readily proved by the observations from 7 A.M. to 10 P.M. on the 10th April, which, though taken at different times, all agreed in showing a steady set of three miles per hour, although the temperature of the sea changed suddenly at 1 P.M. from 68° to 64°, and at 7 P.M. from 63° to 68°.

In the month of May a moderate set to the eastward was experienced close to the south coast of Nipon Island. In June there was no current at a distance of 30 to 40 miles from that coast, but to the southeastward of Nipon a stream was found running to the northward at the rate of two miles per hour of the mean temperature of 72°·5.

The rapid stream of alternate belts of warm and cold water south of Nipon Island probably originates in the following manner:—The northern Equatorial Current striking against the eastern side of the Philippine Islands is, as is well known, diverted to the northward, along the eastern side of Formosa, after passing which, it appears gradually to lose its distinctive character. During the northeast monsoon a cold surface current is running to the southward from the Japan and Yellow Seas. It appears therefore highly probable that the Equatorial Current, instead of losing itself as is supposed, when it meets with the cold water from the Japan and Yellow Seas, is diverted to the eastward along with a cold northerly current, the two running together side by side without intermingling their waters. When the northeast monsoon ceases the current from the Japan and Yellow Seas also ceases, which causes the slackness of the Kuro Siwo, south of Nipon Island, in June, as it is then only due to the Equatorial Current. Later on, in July and August, when it is augmented further by the surface drift from the China Sea in the southwest monsoon, it runs again with great rapidity, and is wholly a warm current. These peculiar effects are probably not experienced to the eastward of the meridian of 140° E.; there apparently the stream is always a warm one.

While passing through the Japan Stream the tow-net observations also indicated water from two different sources. When in the colder streams there were very many more small Diatoms, *Noctilucæ*, and Hydromedusæ than in the warmer streams, where the same pelagic animals that were obtained all the way from the Admiralty Islands prevailed. Many similar instances occurred during the cruise, where the approach to land or the presence of shore water was indicated by the contents of the tow-nets.

Japan to the Sandwich Islands.

On the 16th June the Expedition left Yokohama for the Sandwich Islands, with the intention of running a section across the Pacific on the 35th parallel of north latitude as far east as the meridian of Hawaii, and then proceeding southwards. At 10 P.M. Susaki bearing N. ½ E. and No Sima light E.N.E., a course was shaped to the south-eastward for a good position in which to sound (see Sheet 36).

On the 17th, at 4 A.M., a sounding, trawling, and temperatures were taken in 1875 fathoms in lat. 34° 37′ N., long. 140° 32′ E. Whilst the vessel was trawling the Japan Stream was setting to the eastward at the rate of 1½ miles per hour, the temperature of the surface water being 73°.

The deposit at this Station was a blue mud with a thin reddish surface layer, and contained 5 per cent. of carbonate of lime, which consisted chiefly of a few pelagic and other Foraminifera and Coccoliths.

The trawling was a very successful one, for the net contained a large quantity of mud, several large pieces of pumice, a hardened block of the bottom deposit over a foot in diameter, some fragments of plants, and a large number of deep-sea animals. In the washings of a very large quantity of mud one *Ianthina* shell, three or four Pteropod shells, the vertebra of a fish, and the beak of a large Cephalopod were found. The hardened fragment of the deposit contained the same mineral particles and organisms as the soft mud

SHEET 36


YOKOHAMA
to the
SANDWICH ISLANDS
June, July 1875.
For explanation of abbreviations &c. see Appendix I.
Aleutian Is
Kuril Is
Yezo
Nipon
Yokohama
Ladrone Is
Sandwich Is
Honolulu
Hawaii
For soundings and stations in the vicinity of the Sandwich Is see sheet 37.
Vancouver I.
San Francisco
Long. East from Greenwich 180° Long. West from Greenwich
Engraved by Malby & Sons.

Radiolarians and Diatom frustules made up a very large part of the deposit, probably about one fourth of the whole.

It would take up too much space to give the list of new fishes and invertebrates from this trawling; nineteen specimens of the former and about one hundred specimens of the latter were obtained, most of the species being new ones first discovered by the Expedition. Among the most remarkable were the four specimens of *Monocaulus*, referred to by Professor G. J. Allman, F.R.S., in the following notes on the Hydroida collected during the cruise, the first part of whose Report[1] has been published:—

The Hydroida.—"The only group the investigation of which has yet been completed is that of the Plumularidæ, which contains a large number of new forms, no fewer than eight being peculiar types, which have rendered necessary the construction of as many new genera; while the number of species now for the first time determined amounts to thirty-one.

"Among the new genera *Streptocaulus* (fig. 264), dredged off Porto Praya, San Iago, from a depth of 100 fathoms, presents a form of ramification hitherto unknown among the Hydroida, the ultimate ramuli or hydrocladia being thrown by the twisting of the stem into a graceful and beautiful spiral; while in *Diplocheilus*, dredged in Bass Strait from a depth of 30 to 40 fathoms, the curious duplication of the hydrothecal margin is as remarkable as it is unique. Several new forms, the special interest of which consists in their presenting transitional characters between certain well-marked Plumularian groups, have also been obtained.

"A striking feature among the Plumularidæ brought home by the Challenger is the large proportion of species having open phylactocarps, as seen in the types of *Acanthocladium*, *Lytocarpus*, and *Cladocarpus*. These, by the analysis they present of the more usual form of phylactocarp as shown in the corbula of *Aglaophenia*, are of special interest in throwing light on the morphology of the structures which in the phylactocarpal genera are adapted to the protection of the gonangia, and in the confirmation they afford of the conclusion that the essential parts of these structures are to be regarded as greatly developed and peculiarly modified nematophores.

Fig. 264.—*Streptocaulus pulcherrimus*, Allman; nat. size.

[1] Report on the Hydroida—The Plumularidæ, Zool. Chall Exp., part xx., 1883.

"Other Hydroid groups are at present under examination, and have already yielded some interesting results.

"The collection is very rich in the species of *Cryptolaria*, and the specimens it contains have furnished the means of working out in greater detail than had hitherto been done the structure of this curious group. Not only has the essential structure of its trophosome been thus determined and its stem proved to consist of two distinct elements—an axial, with which alone the hydrothecæ are in connexion, and a peripheral, which forms an enveloping sheath for the axial—but we have been made acquainted with its

Fig. 265.—*Monocaulus imperator*, Allman; one half the natural size.

gonosome, which had not previously been detected, and which is present in a species dredged by the Challenger from a depth of 2600 fathoms.

"A new genus, *Perisiphonia*, has been constructed for the reception of some very remarkable species which agree with the *Cryptolariæ* in the presence of an axial and of a peripheral system of tubes in the trophosome, but which differ from these in the very different form and relations of the hydrothecæ, while they are further characterised by the presence of a highly developed system of accessory receptacles analogous to the nematophores of the Plumularidæ.

"The genus *Grammaria* is also well represented, and has been found to agree with *Cryptolaria* and *Perisiphonia* in the essential structure of the hydrocaulus, which consists, as in those genera, of an axial and a peripheral system, but with differences which will not allow *Grammaria* to be generically united with *Cryptolaria* or *Perisiphonia*.

"Among other groups, the Lafoeidæ, Haleciidæ, and Campanularidæ have as yet been the most completely examined. These are represented by some new genera, and by many new and beautiful species. Their investigation has in some instances necessitated the revision of existing definitions, while it has considerably extended our knowledge of Hydroid morphology.

"The number of gymnoblastic Hydroids brought home by the Challenger is but small. Among these, however, has been found an exceedingly interesting form which must be regarded as the type of a new genus, and which is especially remarkable from the peculiarity of its habitat, living as it does parasitically beneath the dorsal plates of an Annelid. It was found in this situation by Professor M'Intosh while engaged in his examination of the Challenger Annelids, and by him sent to me for determination.

"Among the results of the Challenger dredgings must, however, be specially recorded the discovery of a gigantic Tubularian (fig. 265), which was dredged in the North Pacific from depths of 1875 and 2900 fathoms. It is referable to the genus *Monocaulus*, a near ally of *Corymorpha*. One of the specimens whose dimensions were noted by Professor Wyville Thomson and Mr. Moseley immediately after its capture was found to measure 9 inches from tip to tip of the extended tentacles, which form the proximal tentacular circlet; while its stem rose from its point of attachment to a height of 7 feet 4 inches. This great Tubularian affords indeed an example of a Hydroid attaining dimensions far exceeding the maximum which would have been hitherto thought possible in Hydroid life—a character to which the vast depth whence it was obtained gives additional significance."

On the passage across the Pacific on the 35th parallel, the ship was, for the first week after leaving Japan, favoured with fresh southerly and southwesterly winds, and occasionally, as far as the meridian of 165° E., with drizzling rain, the weather being cloudy and foggy. From the meridian of 165° E. to that of 180°, which was reached on July 3rd, light winds from west round south to east were experienced, with moderately fine weather, but the atmosphere continued very damp. After crossing the 180th meridian, light easterly winds necessitated the vessel being steered north to the 38th parallel, in which moderate westerly breezes were experienced to the meridian of 160° W., the weather still continuing damp and cloudy. After passing the 160th meridian in lat. 38° N., winds from the southeastward were experienced, varying from south to east until within a short distance of the Sandwich Islands.

The section across the western portion of the North Pacific, from Japan to Honolulu, has been divided into three parts:—1st, the section from Japan to the 180th meridian on the parallel of 35½° north latitude; 2nd, the section from the 180th meridian to the meridian of 156° 25′ west longitude, on the 38th parallel of north latitude; and 3rd., a meridional section from a position in lat. 38° 9′ N., long. 156° 25′ W., to Oahu Island in the Sandwich group (see Diagrams 17, 18, and 19).

In the first part of the section the bed of the ocean shows, as had been expected from the soundings of the U.S. ship "Tuscarora," a remarkable depression in the immediate neighbourhood of Japan, the depth being nearly 4000 fathoms at a distance of 200 miles east of Nosima, after which a gradual rise takes place to 2300 fathoms at a distance of 900 miles from that headland, then a gradual increase of depth to 2900 fathoms 1500 miles from Japan, and another rise to 2050 fathoms near the end of the section. It is probable that the deepest point of the depression off the Japanese coast was not hit upon, as the "Tuscarora" found depths of 4600 fathoms farther north. In the second part of the section the depths vary from 2530 to 3125 fathoms, the mean being 2900 fathoms; whilst in the third part, south towards the Sandwich Islands, the bottom shows a very gradual rise until within 120 miles of the land, when the gradient becomes steeper.

The temperature at the bottom was remarkably uniform throughout the whole distance traversed, the highest result being 35°·3, the lowest 34°·8, and the mean 35°·1. The mean temperature at a depth of 1500 fathoms was also 35°·1. These results agree with those obtained between the Admiralty Islands and Japan. It is therefore evident that over a very large area of the North Pacific the water is at a uniform temperature from the depth of 1400 or 1500 fathoms to the bottom.

The surface temperature on the parallel of 35½° N. varied from 74° to 64°·5, the mean being 69°·5. The comparatively low surface temperature of 64°·5 was exceptional, this result being obtained at Station 240 on the 21st June, the water remaining at from 64°·5 to 65° during the whole of the time sounding and trawling operations were carried on, although 10 miles on either side of this Station it was 5° higher (see Diagram 17).

On the 38th parallel the mean surface temperature was 65°·3 and the extremes 69°·5 and 62°·2. It would therefore appear that in the month of July a difference of latitude of 150 miles makes a difference of 4°·2 in the surface temperature of the North Pacific on or about the 36th parallel.

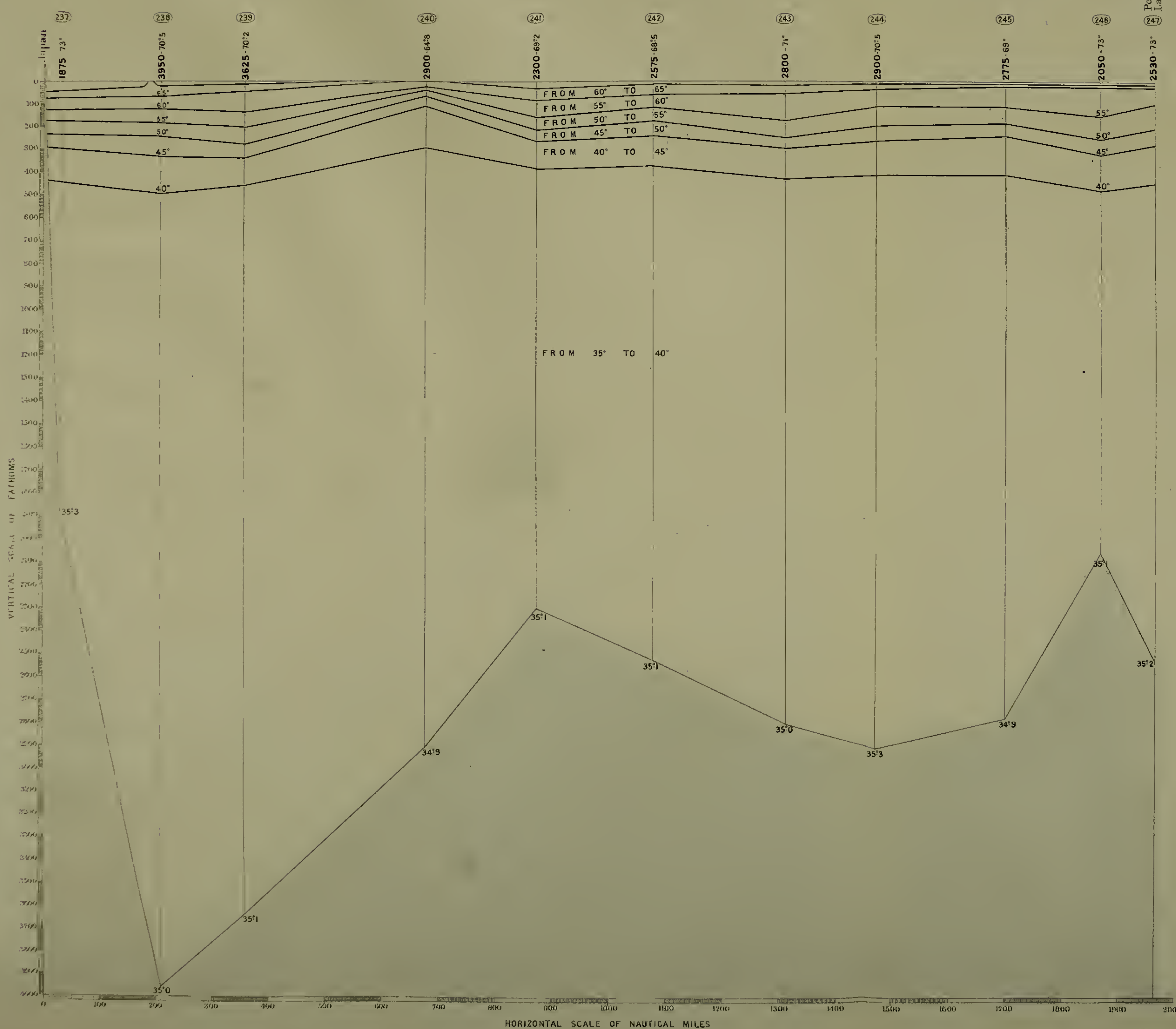
In the third part of the section, from lat. 38° 9′ N., long. 156° 25′ W., to the Sandwich Islands, the surface temperature rose gradually from 68° to 78° at Honolulu.

The serial temperatures show some peculiarities. For instance, the observations taken at Station 240 on the 21st June, in lat. 35° 20′ N., long. 153° 39′ E., where the surface temperature was, as mentioned previously, abnormally low, gave results

PACIFIC OCEAN

Longitudinal Temperature Section. Japan to a position in Lat. 35°49′ N. Long. 180°.

For explanation of Symbols see Appendix I.



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considerably lower than those obtained at corresponding depths at Stations 239 and 241 on either side of Station 240. Thus, at 100 fathoms the temperature at Station 240 was 15° lower than at Station 239, and 12° lower than at Station 241; at 200 fathoms it was 16° lower than at Station 239 and 10°·3 lower than at 241, &c., down to 1500 fathoms, at which depth the same temperature was obtained as at all the other Stations. A further peculiarity here was, that from 200 to 300 fathoms the water was at a temperature of 40°.

The upper isothermal lines between the coast of Japan and Station 240, 650 miles from the coast, occupied greater depths than they did between Station 240 and the 180th meridian, being doubtless influenced by the Japan Current. The isotherms were fairly parallel with the surface (see Diagram 17).

The abnormal condition of the temperature at Station 240 is due in all probability to an outset from the Sea of Okhotsk, or the western part of Behring Sea, as Captain Belknap, in the U.S. ship "Tuscarora," found a belt of cold water opposite the entrance of those seas, which, from the observations of the Challenger, appears to extend to the 35th parallel. Here however it nearly ceases, as the width of the cold stream on the surface did not exceed 20 miles.

The serial temperatures taken on the 38th parallel, between the meridian of 180° and 156° 25′ W., gave nearly the same results, so that the isotherms were fairly parallel with the surface, the isotherm of 40° being at an average depth of 400 fathoms; that of 45°, at an average depth of 250 fathoms; of 50°, at 150 fathoms (see Diagram 18).

In the third part of the section, from a position in lat. 38° 9′ N., long. 156° 25′ W., to the Sandwich Islands, the upper temperatures increased as the vessel proceeded to the southward, causing the isotherms above 50° to descend gradually; the isotherms of 40° and 45°, however, maintained a position nearly parallel with the surface, at depths of 400 and 250 fathoms (see Diagram 19).

No current observations were taken by mooring a boat to the sounding line or trawl rope, but whilst sounding or trawling the direction of the surface set was noted, and its velocity estimated; and the direction and rate of the current were also calculated from frequent astronomical observations. The general direction of the current from the Japanese coast to the meridian of 170° E., was northeast 19 miles per diem, the greatest set in any one day being 37 miles, and the least 10 miles. From the meridian of 170° E. to 156° W. the currents were variable and generally insignificant, and on the southward track to the Sandwich Islands they were variable between the 38th and 30th parallels, and had a general westerly tendency from the 30th parallel to Oahu, the velocity being in no case considerable.

Anemometer observations were taken when favourable opportunities offered, whilst the ship was stationary sounding or trawling; and it was also noticed that the direction of the wind, as registered when under sail, differed considerably from the direction noted when, sail being shortened, the ship was brought head to wind to sound. For instance, on the 24th June, at Station 242, the direction of the wind was noted as south when under sail, the course of the ship being east, and the speed 9 knots per hour, but when brought head to wind, the direction was found to be S.S.W. to S.W. by S. The following table shows the results of the anemometer observations whilst the ship was stationary :—

Date. 1875.	Station.	Velocity of wind in miles per hour.	Force of wind by Beaufort's scale, as noted in log.
June 24	242	19	4 to 5, mean 4½
„ 26	243	8	1 to 2, mean 1½
„ 28	244	8	1 to 2, mean 1½
„ 30	245	10	2
July 2	246	5	1
„ 3	247	7	2
„ 5	248	9	2
„ 7	249	25	5 to 6, mean 5½
„ 9	250	20	4 to 5, mean 4½
„ 10	251	9	2
„ 12	252	7	1 to 2, mean 1½
„ 14	253	11	2 to 3, mean 2½
„ 17	254	6	1 to 2, mean 1½
„ 19	255	6	1
„ 21	256	8	1 to 2, mean 1½
„ 24	258	11	2
„ 26	259	18	3

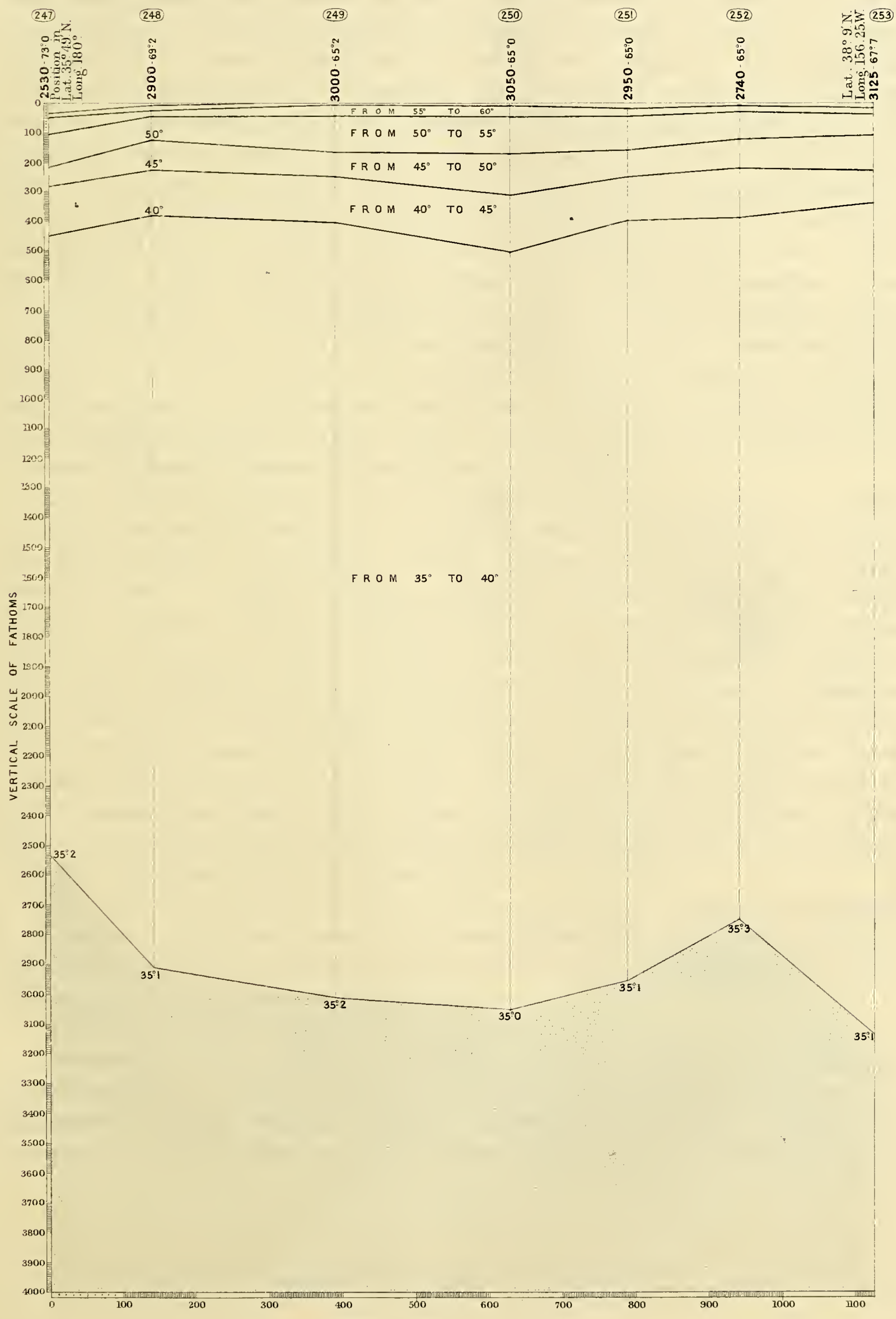
The deposits between Japan and the Sandwich Islands were most interesting. In all the greater depths there was no carbonate of lime in the deposits, but it is instructive to notice that at two Stations where the depth was less than the average, viz., 2300 and 2050 fathoms, there was respectively 17 and 56 per cent. of carbonate of

PACIFIC OCEAN

Longitudinal Temperature Section

From a Position in Lat. 35°49' N. Long. 180° W. to a Position in Lat. 38°9' N. Long. 156°25' W.

For explanation of Symbols see Appendix 1.



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lime, consisting chiefly of the shells of pelagic Foraminifera; this clearly shows, as has been already pointed out, that the amount of lime deposited is in inverse relation to the depth, when as in this instance the surface conditions are the same or nearly so. A sounding (Station 247), where the depth was 2530 fathoms, was remarkable. In the upper part of the section brought up by the sounding tube there was a reddish clay without any carbonate of lime; this layer was about one inch in thickness, and was somewhat sharply marked off from the lower layers, which were of a much lighter colour, and contained about 20 per cent. of carbonate of lime in the form of shells of pelagic Foraminifera. This condition of things might be explained by supposing that after the lower layers had been laid down, a subsidence of the bottom had taken place to the extent of 200 or 300 fathoms. All the deposits from the Japan coast to the 170th meridian of west longitude contained a very large number of the remains of siliceous organisms, chiefly Radiolaria; in fact, five or six of the soundings might have been as consistently called Radiolarian oozes as red clays, for these organisms appeared to make up nearly one half of the deposit. As the Sandwich Islands were approached, the siliceous organisms almost disappeared from the deposits, which were then almost wholly composed of the triturated fragments of pumice and amorphous clayey matter.

There were eleven trawlings and two dredgings during the trip, but on four occasions the line parted and the trawls with a considerable length of line were lost. The others were fairly successful and productive. On all occasions the bag of the trawl contained numerous pieces of pumice and many manganese nodules. Some of the rounded fragments of pumice were quite fresh and unaltered; others had undergone profound alteration, and were frequently coated with successive layers of the peroxide of manganese. These pieces of pumice seem to have formed the centres of most of the manganese nodules taken in the North Pacific, but on several occasions the nuclei were teeth of Sharks—*Oxyrhina*, *Lamna*, and *Carcharodon*—and in one instance a siliceous Sponge (*Farrea*) occupied the centre of the nodule. On the 12th July, from 2740 fathoms, the dredge contained more than a bushel of these dark brown coloured manganese nodules, which, when rolled out on the deck, somewhat resembled in appearance a lot of potatoes, the largest being about the size of cricket balls.

The trawlings were not very productive so far as specimens of animals were concerned. In the shallower depths where there was carbonate of lime in the deposit, viz., at 2050 and 2300 fathoms, there were respectively about sixty and twenty specimens of invertebrates, all belonging to characteristic deep-sea species.

At 2900 fathoms the following were procured:—

Antheomorphe elegans, Hertwig; *Bathyactis symmetrica*, Mosel.; *Antipathes* sp.; *Stephanoscyphus* sp., *Monocaulus imperator*, Allman; *Pourtalesia laguncula*, A. Ag.; *Hymenaster infernalis*, Sladen; *Benthaster wyville-thomsoni*, Sladen; *Brisinga* sp.; *Oneirophanta mutabilis*, Théel; Comatulæ; *Lepas anatifera*, Linn.; *Terebratula wyvillii*, Dav.; *Gonostoma microdon*, Günth.; several Annelids, Shrimps, fragments of siliceous Sponges, and several living Foraminifera. It is of course probable that the *Gonostoma* and Shrimps did not come from the bottom.

To the upper surface of a nodule from 3125 fathoms (12 × 8 × 2 inches), the following were attached:—*Bifaxaria abyssicola*, Busk; *Cribrilina monoceros*, Busk; *Bugula johnstoniæ*, Gray; *Phylactella* sp.?; several Annelids, *Stephanoscyphus* sp., *Actinia* (?), a tubularian Hydroid, and over the whole surface were many branching tubes of *Rhizammina algæformis*, H. B. Brady.

The remarkable fall in the temperature of the surface water on the 21st June (Station 240) has already been referred to, and at the same time there was a marked change in the character of the surface fauna. The ship on that day passed through red and white coloured patches of water. The red colour was due to immense numbers of Copepods (*Calanus propinquus* G. S. Brady) and Hyperids, the contents of the tow-nets resembling very much those taken in the cold water south of Kerguelen and the Crozets. There were also in the tow-nets immense numbers of dead pale white Copepods, a species different from the red ones, and the white coloured patches of water appeared to be due to the presence of these. There were in the tow-nets many other dead animals besides the Copepods, and it seems probable that immense numbers of animals belonging to the warm currents had been killed by the streams of cold water flowing southward and breaking into the warm waters of the Japan Stream. On the second portion of this cruise, between 180° and 156° west on the 38th parallel, where the average temperature was 65°, the surface fauna was considerably different from what it was 2 degrees farther to the south. The large tropical *Etmodiscus rex*, *Pyrocystis*, *Pulvinulina menardii*, some of the tropical species of *Globigerina* and other pelagic Foraminifera peculiar to the warmer waters of the ocean were absent. On the other hand, there were immense numbers of small Diatoms and of *Lepas fascicularis* and its larvæ. For days the ship passed through floating balls of this barnacle, the development of which was made the subject of a special study by Dr. v. Willemoes Suhm.[1] The balls appeared to be mostly formed by the larvæ becoming attached to dead Ianthinas and Velellas, very large numbers of which were found dead floating on the surface, apparently killed by the cold water. A Nudibranch, an Aphroditacean, a *Cymothoa*, and *Halobates* were found attached to or resting on these floating balls of *Lepas*, while very numerous small particles of pumice were taken in the tow-nets, which in some instances had animals attached to them. The stomachs of the zoœas of the *Lepas fascicularis* contained many Coccospheres and Rhabdospheres, and minute Diatoms.

Tow-nets were sent down to 500, 1000, and 2000 fathoms on many occasions in the trip between Japan and the Sandwich Islands, with the result that many organisms were procured which had not hitherto been noticed in the tow-net gatherings down to

[1] *Phil. Trans.*, part i. pp. 131–154, pls. x.–xv., 1876.


PACIFIC OCEAN. Meridional Temperature Section. From the Parallel of 38° N. to the Parallel of 40° S.
For explanation of Symbols see Appendix I.
Equator
Oahu I.
Hawaii I.
Tahiti I.
FROM 75° TO 80°
ABOVE 80°
FROM 70° TO 75°
FROM 65° TO 70°
FROM 60° TO 65°
FROM 55° TO 60°
FROM 50° TO 55°
FROM 45° TO 50°
FROM 40° TO 45°
FROM 35° TO 40°
UNDER 35°
VERTICAL SCALE OF FATHOMS
HORIZONTAL SCALE OF DEGREES OF LATITUDE
Engraved by Malby & Sons

100 fathoms from the surface. The characteristic forms were Radiolaria belonging to the legion Phæodaria (see p. 217). It is impossible to say whether or not these organisms exist all the way from a depth of 100 fathoms to the bottom, but the experiments proved the existence of an intermediate fauna of considerable variety existing between 100 fathoms and the bottom.

The Sandwich Islands.

On the 27th July at daylight the island of Molokai was observed ahead, and Oahu on the starboard bow, and a course was shaped for the passage between them. At 8 A.M. a sounding was taken in 310 fathoms, with the extremities of Molokai Island S. 63° E. and N. 74° E., the island off the right extremity of Oahu N. 56° W., and the left extremity of Oahu S. 88° W.; afterwards serial temperatures and a haul of the trawl were obtained, but the latter operation was difficult on account of the rocky nature of the bottom. At 11 A.M. the ship bore up for Honolulu and was anchored outside the harbour at 2 P.M. At 4 P.M. a pilot was received on board, and the vessel proceeded into the harbour, and was moored head and stern at 5 P.M.

Honolulu (*Honoruru*).—The islands of Oahu and Molokai are most remarkable for the extremely barren aspect which they present as viewed from the sea on their leeward sides. In this respect they differ from all other Pacific Islands which were visited during the voyage of the Challenger; trees or shrubs do not form a conspicuous feature in the view, but the hillslopes are covered with a scanty clothing of grass and low herbage, which in the summer season is yellow and parched. Only one scanty grove of cocoanut trees is to be seen on the shore of Oahu Island, to the east of the town of Honolulu, whilst westwards the barren plains and distant bare hills almost equalled St. Vincent, Cape Verde Islands, in their sterility. There are no thick belts of cocoanut trees fringing the shores as at Tonga, with littoral vegetation overhanging the very surf; no dense forests clothing the mountains from the summits to the shore as at Fiji or the Admiralty Islands. There is little more show of vegetation in the general appearance of the islands, as seen from seawards, than is to be seen on the bleak Marion Island in the Southern Ocean.

The harbour of Honolulu is entered by a narrow channel through a fringing reef which is not very extensive. The town lies on an almost flat expanse immediately adjoining the shore, and is not very conspicuous at a distance. It is composed of streets of very various widths, laid out at right angles to one another, lined on either side by very irregular rows of houses of all kinds, mostly wooden shanties, the greater part of them occupied as general stores.

There is a large shop of Chinese and Japanese curiosities, and two photographers' shops, where corals, imported mostly from the Marquesas Islands, especially large specimens of *Distichopora coccinea*, often mistaken by purchasers for Precious Coral (*Corallium rubrum*), and spurious imitations of native implements manufactured for sale, are disposed of, at exorbitant prices, to passengers by the mail steamers. It is said that a Chinaman is even employed to manufacture facsimiles of the stone gods of the ancient Hawaiians for sale as genuine curiosities; the forged deities being represented as having been dug up in taro fields.

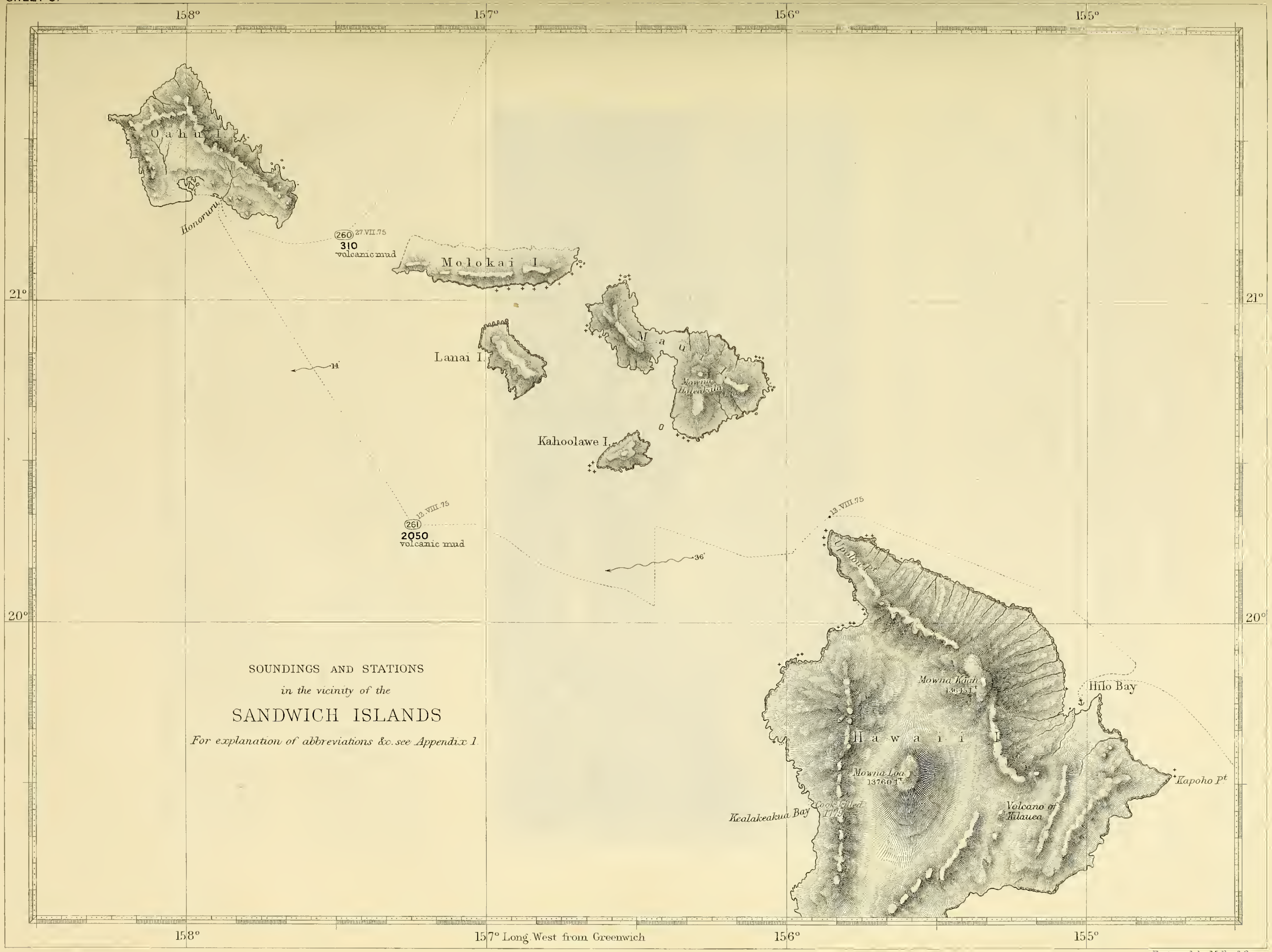
The business streets are very hot and dusty, but around the hotel and villa dwelling houses on the east side of the town are pretty gardens, filled with the usual imported tropical garden plants, shrubs, and trees, which are maintained alive only by constant irrigation, hoses from the town supply-pipes being kept playing on them day and night. Thirty years ago, where these gardens now are, there was not a single tree, and now the gardens form only a small oasis in a dry parched desert, which extends along the coast east and west, and is soon reached on leaving the town in either of these directions.

On this tract the bare volcanic rock shows out everywhere, and the only conspicuous vegetation is a Prickly Pear (*Opuntia*) introduced from America, which has spread far on either side from the town and multiplied exceedingly, so as to form in places a dense impassable growth, and constitute a most conspicuous feature in the landscape. These barren parts of Oahu resemble somewhat the rocky tracts of Tenerife with their growth of *Euphorbia canariensis*. The Guava, another introduced American plant, has spread in all directions, in places forming dense thickets from which it is difficult to drive out the half-wild cattle.

The whole town of Honolulu has a thoroughly American aspect. Americans are supplanting the rapidly decreasing native population; American plants are, as has been said, covering the ground, and American birds have been introduced and bid fair to spread and oust the native fauna, which has no single land bird in common with any other Polynesian island group. The only vigorous opponents of the Americans in the struggle for existence seem to be the Chinese.

Behind Honolulu is the Nuuanu Valley (see fig. 266), with precipitous walls in its upper part, which becomes greener and greener as the ascent is made by the road leading up it. The difference between the rainfall in the valley and in Honolulu is most remarkable. At Waikiki, near Honolulu, at sea level, the rainfall in 1873 was 37·85 inches, whilst in the Nuuanu Valley, $2\frac{3}{4}$ miles inland, and at an elevation of only 550 feet, the fall in the same year was 134·06 inches. Captain Wilkes says that even certain streets in the town of Honolulu are said to be more rainy than others. The leading native trees in the valley are the malvaceous *Hibiscus tiliaceus*, the *Acacia koa*, and the Candle Nut (*Aleurites triloba*). The *Hibiscus* forms curiously tangled impassable thickets, while the *Acacia* grows only high up on the cliff tops. The Candle Nut trees, by the peculiar glaucous colour of their foliage, give a characteristic appearance to the vegetation seen in the far distance, for these bluish green trees appear as rounded bushes, dotted over the high ground above

SHEET 37



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the barren shore region. At the summit of the valley is the "pali," a narrow cleft in the tops of the mountains, which are precipitous on the other side. A beautiful view of the windward side of the island is here suddenly encountered, and a refreshing breeze blows through the gap. The range of cliffs forming the windward side of the mountain range is an ancient coast line, and against the foot of the cliffs the sea used to beat in past ages.

Mr. W. L. Green, the foreign minister of Hawaii, took a deep interest in the Expedition, and arranged several excursions to the chalk beds at Diamond Point, and other places of interest; he presented numerous rock specimens and some skulls to the scientific staff.

A visit was paid to the Challenger by Kalakaua, the King of the Sandwich Islands,

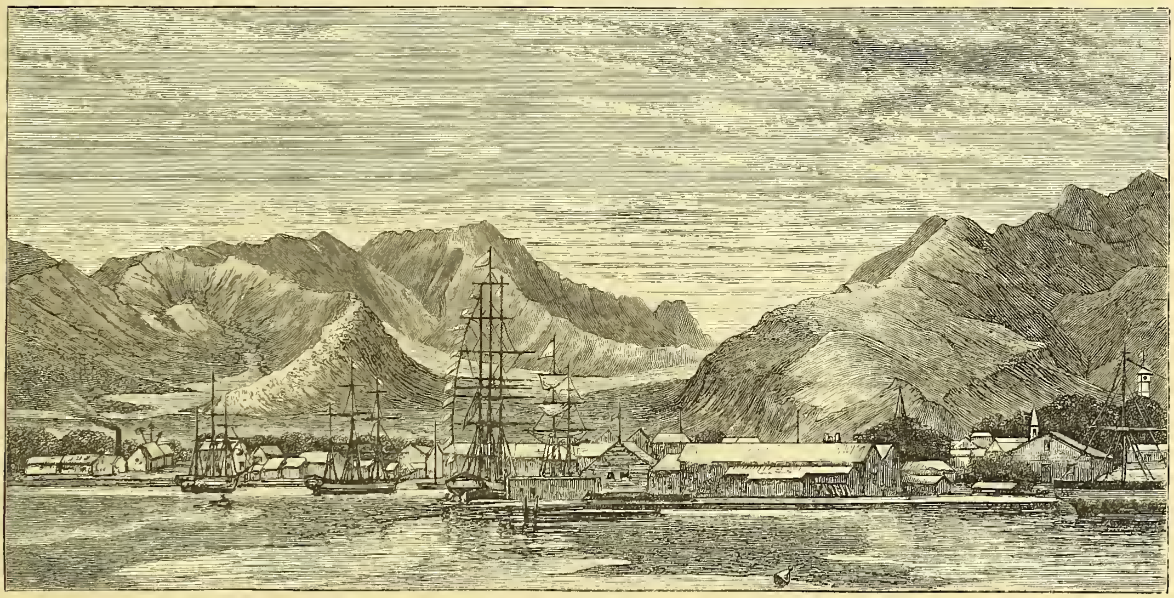


FIG. 266.—Honolulu and the Valley of Nuuanu.

who took the liveliest interest in the special work of the Challenger, and recognised the well-known anchors in the skin of the Holothurian *Synapta* when shown them under the microscope, and named them at first glance. These anchors stood the scientific staff in good stead at all the ports visited, and were described in the colonial newspapers as belonging to the "Admiralty worm," supposed to be the most wonderful of the deep-sea discoveries of the Expedition.

There is a most excellent musical band at Honolulu, composed almost entirely of Hawaiians and numbering twenty or thirty performers, who execute complicated European music with accuracy and most pleasing effect. No one can doubt, after listening to this band, that the Polynesian ear is as capable of appreciating the details of music as the European. It will be interesting to observe in the future whether the Chinese and Japanese, whose music is so very different from that of Europe, and who profess to dislike Western music, and now at least much prefer their own, will develop a similar capacity and changed appreciation in the future.

Whilst the ship was at Honolulu Mr. Moseley visited the northeast side of the island in order to collect a series of native skulls from a deserted burial-place, on the estate of Mr. John Cummins at Waimanalo. The graves are amongst dunes of calcareous sand, lying often on the sides of the gullies between the dunes, and the bones are exposed by the shifting of the sand by the wind. The graves have probably been made in this locality because of the ease with which the sand is excavated; similar burial-places occur at various spots around the coast of Oahu, and there is scarcely any place where more abundant material is ready at hand for the study of the skeletal peculiarities of a savage race, by the examination of long series of crania and skeletons, than here. Other burial-places occur in caves inland, where the bodies are found in a dried mummy-like condition. All those at Waimanalo were buried in a doubled-up posture; one which was exhumed with care *in situ* had been buried with the knees bent up to the chest and the head bent forwards, and was placed resting horizontally on the back. Chips and fragments of basalt were found around all the graves, but no implements of stone. This burying ground has subsequently been visited by Dr. Otto Finsch,[1] who considers that the skeletons found there are pure Hawaiians belonging to a period free from European influence, as this part of the coast has not been disturbed by white people. The skulls obtained have been carefully described by Professor Turner,[2] who states that some are of a well marked brachycephalic type, others are equally well marked dolichocephalic, whilst others again are mesaticephalic in their proportions. His conclusion is that these differences in the cranial characters express the presence in the Sandwich Islands of more than one race of men, and that they have probably been inhabited both by Polynesians and Melanesians, who have doubtless to some extent intermingled with each other.

During the stay of the ship at Honolulu the pinnace was engaged four days in dredging and trawling operations outside the reefs, with the view of ascertaining the bathymetrical limits of the reef-building corals and other organisms.

Honolulu Harbour, although very small, is of considerable importance from the fact of its being the only really well protected port in the Sandwich group. It has a narrow entrance through the outer part of the reef, the harbour and entrance together being somewhat like an ordinary retort in shape. This narrow channel, which originally had a depth of 20 feet, has since been deepened to 22 or 23 feet, and is kept open in all probability by the freshwater streams from the hills. The harbour is so small inside that vessels cannot swing at their anchors but have to moor head and stern, or lie alongside a commodious wharf which has been constructed on the eastern shore. To facilitate

[1] *Zeitschr. f. Ethnologie*, Bd. xi. p. 362, 1879.

[2] Zool. Chall. Exp., part xxix., 1884.

mooring, anchors are buried at suitable distances from each other on the reef on the western side of the harbour, and ships moor by letting go their own anchors as holdfasts in the centre of the anchorage ground, and then secure their sterns by chains to the anchors on the reef. One chain is sufficient in the summer time, but it is advisable to have two in the winter, when southerly winds occasionally blow.

The channel into the harbour is buoyed on each side, and there are two lighthouses which serve as leading marks either by night or day. One of these lighthouses is erected on a point of the reef on the western side of the harbour, and the other, which is very difficult to distinguish, at the corner of a row of houses facing the harbour. These marks, together with the buoys, are sufficient to enable vessels whose draught does not exceed 15 or 16 feet to enter without a pilot, but vessels of larger draught should take pilots, especially if unacquainted with the port, for as the channel is narrow and the buoys are not moored taut, it does not do to keep midway between them, for they may be out in the channel on one side and over on the reefs on the other side. Of course buoys would not be required at all if the water were clear, but as it is frequently turbid the channel cannot be distinctly seen from aloft.

The harbour is said by the local authorities to be silting up slightly. A survey by the Americans, undertaken shortly before the visit of the Expedition, shows a depth of 22 feet on the bar. There appears, however, to be some doubt as to the datum mark to which the soundings have been reduced, for although the rise and fall is very slight, it appears that there is a difference of a foot or so in the mean level of the sea at different seasons of the year; so that a reduction of a sounding obtained to low water does not allow of a comparison between surveys of different dates. The Government of the Sandwich Islands had at the time of the visit established a surveying and land office at Honolulu and commenced a trigonometrical survey of the group, and doubtless they will establish permanent marks to which soundings are in future to be referred.

The harbour of Honolulu is almost deserted in the summer time, but in the winter is much frequented by whaling vessels. At the time of the visit there was regular communication between the Sandwich and Society Islands, the vessels carrying cattle and sheep to the Society group, and bringing back oranges. A quarantine hospital has been established at Honolulu on some reclaimed ground on the western side of the harbour.

Besides Honolulu there are two other harbours on the island of Oahu; one, the Pearl Lochs, 5 miles to the westward, a large inlet with ample water in it for heavy ships, but which is unfortunately barred by shoals having about 12 feet over them; the other, a small harbour on the northeast side of the island, used occasionally by the local schooners, which appears shallow and intricate.

In the Government buildings at Honolulu there is a public library, which is accessible to all visitors from 10 A.M. to 4 P.M., and as it contains numbers of the original editions of the works of the old voyagers in the Pacific, it is well worth a visit.

Supplies at Honolulu are plentiful and very moderate in price. Excellent beef can be procured at 2½d. per pound ; mutton, 3d. per pound ; sheep, 10s. each ; fowls, 20s. per dozen ; potatoes, 1½d. per pound ; turkeys, 5s. 6d. each ; eggs, 2s. per dozen ; &c., besides which a large variety of fruit is cultivated, pine-apples, grapes, the avocado pear, plantains, melons, and oranges.

A meteorological register has been kept at Honolulu by the Harbour Master, from which the following table has been compiled showing the climate of the town :—

Meteorological Table compiled from observations made in the years 1837–8, by Dr. T. C. B. Rooke, and during the years 1869, 1870, 1871, and 1872, by the Harbour Master, Captain Daniel Smith.

Barometer reduced to 32° and sea level. Temperature observations taken at sunrise and at 2 P.M.

MONTH.	Barometer.		Mean Temp. in shade.	Mean Range of Temp.	Max. Temp. in shade registered.	Min. Temp. in shade registered.	Clouds—0 to 10 Mean Amount.	Rain.		Wind.										No. of days Gales.	No. of days Fogs.	Remarks.
	Mean Height	Ext. Range						Total Fall.	No. of days.	Av. Hourly velocity.	No. of days from. N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	C'lm			
	in.	in.	°	°	°	°		in.														
January, .	29·999	0·55	73·8	12·7	85	58		3·66	3		3	15	...	1	7	1	1	...	3	1		
February,	30·044	0·31	73·9	12·6	84	60		3·42	4		2	17	1	...	6	1	...	...	1	2		
March, .	30·045	0·33	75·3	11·0	84	65		3·34	2		...	20	...	1	5	1	...	...	4	2		
April, .	30·071	0·22	76·2	10·9	87	62		2·79	2		1	25	1	1	2	...	...	...	...	...		
May, .	30·071	0·24	78·1	11·5	87	70		1·57	1		1	28	...	...	2	...	...	...	...	...		
June, .	30·054	0·25	79·3	10·8	89	73		1·28	2		...	26	1	...	2	...	...	...	1	...		
July, .	30·037	0·22	80·5	11·8	89	73		2·05	4		...	28	1	...	1	...	...	...	1	..		
August, .	30·013	0·22	81·0	11·6	90	74		1·48	1		...	28	...	...	2	...	...	...	1	...		
September,	30·019	0·35	80·8	11·4	89	72		2·26	2		...	29	1	...	...	...	...	...	...	1		
October, .	30·003	0·32	78·5	12·4	88	70		6·99	4		1	18	2	1	7	...	...	...	2	1		
November,	30·017	0·48	76·1	11·3	86	61		6·39	6		1	18	1	1	6	1	...	2	...	...		
December,	30·021	0·35	74·4	12·0	85	62		4·02	3		1	17	...	...	10	1	1	...	1	1		
Means and Totals,	30·033	0·55	77·3	11·7	90	58		39·25	34		10	269	8	5	50	5	2	2	14	8		

Hawaii.—On the 11th August the Expedition left Honolulu for Hilo Bay in Hawaii Island, in order to allow the Naturalists an opportunity of visiting the celebrated volcano of Kilauea. On leaving, the ship was swung outside Honolulu to ascertain the errors of the compass and dipping needle. The trade wind was fresh from E. by N., necessitating working to windward under steam and fore and aft sails. One sounding of

2050 fathoms was obtained on the passage, in lat. 20° 18′ N., long. 157° 14′ W. (see Sheet 37), and at night the light from the volcano of Mauna Loa was seen quite distinctly. During the passage from Honolulu to Hilo a Petrel, possibly *Procellaria rostrata* which occurs at Tahiti, and a Stormy Petrel (*Oceanites*), were seen about the ship. These birds do not seem to be included in lists of the avi-fauna of the group. The ship anchored in Hilo Bay on the 14th in 6 fathoms, with Green Hill in line with Hilo Church S. 40° W., Red Cliffs N. 16° W., and the left extremity of the rocks off Cocoa Nut Island N. 84° E.

The Americans possess a much better plan of Hilo Bay than is given on the Admiralty Charts, for Captain Wilkes made an elaborate survey of the anchorage when there with the United States Exploring Expedition.

The lighthouse at Hilo is a wooden building 14 feet high on the cliffs. It exhibits a light of very low power, which cannot always be depended on, as the illuminating apparatus consists merely of an ordinary paraffin lamp with a metal reflector.

Whilst at the Sandwich Islands the following information was procured from Captain Chaves, of the brigantine "W. H. Allen," relative to the small islands between the Sandwich and Society groups. At Howland and Baker Islands a severe S.W. gale was experienced in December 1870, which lasted three days, during which the ship "Liebig" of Hamburg was wrecked on Baker Island and another ship was driven to sea from Howland Island. This gale is said to be the only bad weather experienced in the vicinity of these islands for ten years. Howland, Baker, Malden, Flint, and Caroline Islands are frequented by ships wishing to obtain cargoes of guano. At Malden Island there is no anchorage, but moorings are laid down for ships whilst embarking guano, one of the mooring anchors being buried in the reef and the other laid down in a depth of 70 or 80 fathoms off the reef. At Caroline and Flint Islands, moorings are also laid down for the convenience of guano ships. In these two islands the guano is worked by an English company, whose agents, Brander & Co., reside at Tahiti. At Penrhyn Island there is said to be good anchorage, but none has hitherto been found at either Reirson or Humphreys Islands. At Suwarrow Island Captain Chaves resided two years, having been cast on shore there in a whale boat with one native belonging to the Society Islands. They lived on cocoa-nuts and clams the whole period, and were finally taken off by a passing vessel. Captain Chaves reports that at this island there exists an excellent harbour inside the lagoon of the reef, to which there is a deep channel through the reef.

The appearance of the great volcano of Mauna Loa on Hawaii Island is most remarkable. The slope of the mountain, as seen from the sea, is so gradual that it is difficult to believe that it rises to a height of nearly 14,000 feet above the sea level. The cause of the peculiar form is the extreme fluidity of the lava, of successive flows of which the mountain is composed. The other large mountain of the island, Mauna Kea, has a similar form, as will be seen from the accompanying sketch by Dr. Wild (see fig. 267).

During the stay at Hilo several parties visited the well-known Kilauea, which is a secondary crater on the side of the Mauna Loa, at a height of about 4000 feet. The island of Hawaii is much more fully clothed with verdure than Oahu, and has none of the desert appearance of the latter. The journey to Kilauea is a tedious and monotonous ride, the ascent being so gradual that it is hardly perceived. The track leads first through a fine belt of forest near the shore, and then emerges on a weary expanse of open country, entirely devoid of any fine trees, and mostly covered with a scanty, low moorland-looking growth with Screw Pine trees. The track is scarcely marked on the bare surfaces of the lava flows, which look almost as fresh as if the lava had only set the day before. These surfaces are covered in every direction by ropy projections, curved lines of flow, and small rounded ledges, showing where one part of the flow has run over another. The whole looks as if a vast quantity of melted pitch had been suddenly turned out of a mighty pot and allowed to run and set hard.

During the ascent a globular cloud was seen hanging in the air in the distance,

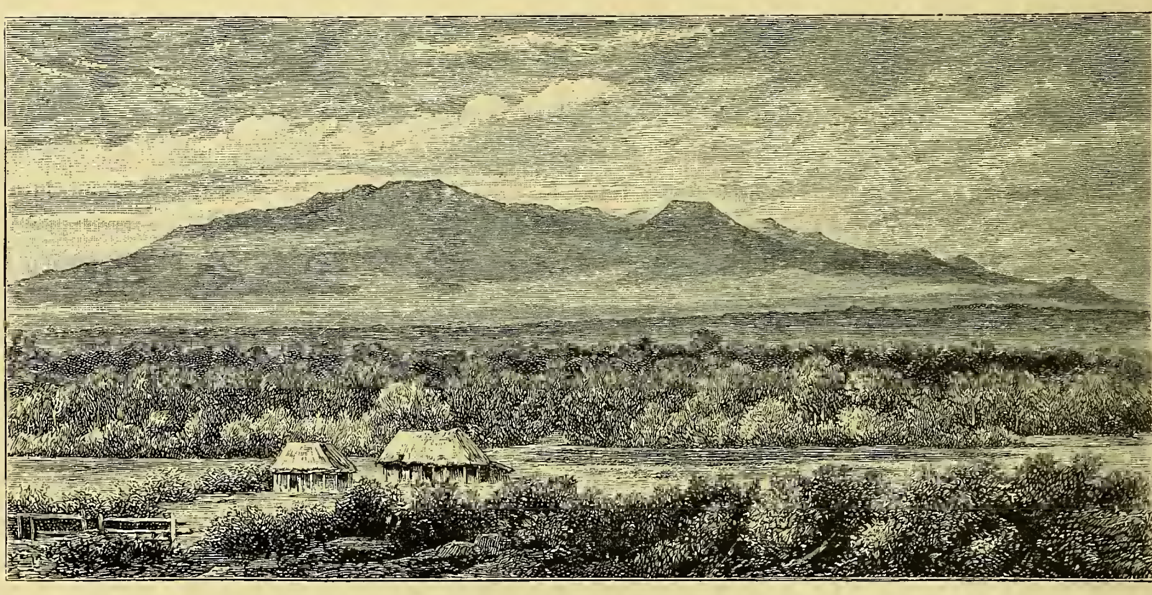
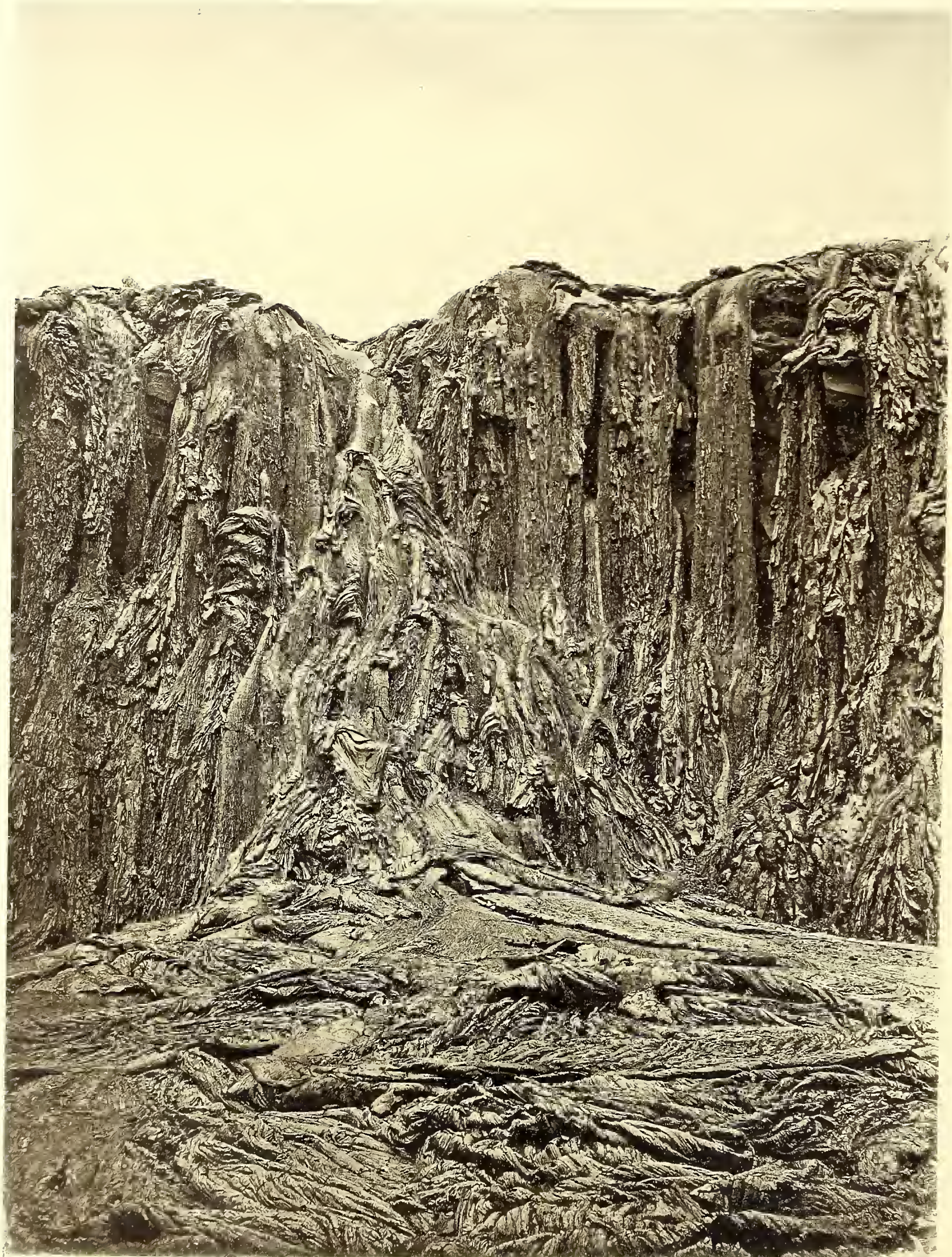


FIG. 267.—Mauna Kea, Hawaii, as seen from the Half-Way House, on the road to the Crater of Kilauea.

which, as the guide explained, hung over the summit of Mauna Loa itself. The fact, however, was not in any way apparent, for the gradient was so slight that there was no appearance of any mountain at all. As night fell this cloud perpetually re-formed by condensation, and was lighted up by a brilliant orange glow reflected from the molten lava in the great terminal crater, and the general effect was just as if a fire were raging in the forest in the distance.

With the evening appeared an Owl, probably *Asio brachyotus*, the Short-eared Owl of England. A Duck also rose from a small marsh, probably *Anas wyvilliana*, which is peculiar to the Hawaiian group, and was named by Dr. Sclater after Sir Wyville Thomson, from specimens collected by the Expedition. Not far from the crater of Kilauea there are abundant woods of *Acacia koa* trees, and plenty of herbage; and no

Plate XXXI.



Horsburgh, Edinburgh. Permanent Phototype

Lava Cascade. Kilauea, Mona Loa.

doubt deer, which have been turned out, will thrive there and multiply rapidly. A few small sandalwood trees remain uncut in the vicinity.

When the crater of Kilauea was reached it appeared in the dark as a wide abyss filled with gloom, but in the distance were seen three or four glowing spots, reminding one of the furnaces seen at night in the Black Country, and every now and then a jet of glowing matter showed itself thrown up from a lava fountain, which happened to be playing at the time.

In the morning the crater was seen to be bounded by a range of cliffs all round, and at the bottom was a wide flat expanse of hardened lava which looked as fresh as if it had only just set (see Frontispiece to Part II.). The crater has evidently been formed by the sudden falling in of vast masses of rock by the fusion and flowing away of the supporting rock below. A succession of smaller secondary cliffs round the inner margin of the crater-bottom mark where this process has been repeated several times, for after the crater has been filled to certain levels, and the lava has hardened, the support has given way on successive occasions over the greater part of the area. The smooth surface of the lava within the crater was very like that traversed on the journey from Hilo; it was cracked by contraction on cooling in all directions, and through all the cracks, at a depth of a foot or so, was seen to be glowing hot.

The well-known molten lake of Kilauea was at the time of the visit rather to be termed a pond, for a stone could have been thrown across it; it occupied a small area on the floor of the main crater. It was possible to stand on a low cliff overhanging it on the side from which the wind drifted away the stifling vapours exhaled from it, and to throw stones into the pond of melted rock below. A low cliff bounded the expanse nearly all round. At the base of this cliff opposite, in three places, a violent surging was constantly taking place, the melted rock being thrown up high above the cliff by violent discharges of gas from below. The melted rock was thrown in waves against the base of the cliff which, as they surged against it, made a noise like that of waves of the sea beating similarly against rocks. There seemed to be no tenacity about the melted lava, it splashed about just like water. As the waves fell back from the bases of the cliffs, pendent coagulations of lava were formed for an instant, and hung in the glowing cavities like icicles, but were re-melted in a moment by the returning waves, which glowed brightly with heat as they were thrown up. The lake itself was covered with a thin black scum of coagulated lava with red-hot cracks in it, and the whole moved slowly round under the influence of the ebullition taking place at one side as above described.

Close by was another but smaller pond, where, however, the churning up of the lava was more violent; it occurred here also, as in the other pond, at the bases of the low bounding cliffs only. The waves dashed against the cliffs, threw their spray high into the air above them, and the wind carried part of this spray over the edges of the cliffs so as to fall on the hard lava platform far above.

The spray masses cooling as they fell, formed in their track the threads known as "Pele's hair," like fine-spun green glass. Many of the threads could be picked up, each with the small mass of hardened lava still attached. These fallen masses are closely like drops thrown out of a pitch-pot. Some were nearly pear-shaped; others, which had reached the ground before setting, or when only partially set, had coiled up into various forms as they fell, but nearly all showed an upright fine point, where a hair had been

FIG. 268.—Falls of Waianuenne, near Hilo.

attached to them. Pele's hair, thus formed, drifts away with the wind and hangs in felted masses about the rocks, and the birds sometimes gather it, and make their nests entirely of it.

Between the two ponds was the lava fountain, which had been seen playing the night before, but was now quiet. A lava fountain is a tall hollow cone, an extinguisher as it were, which is built up of successive jets of lava thrown out of a hole at the summit, and hardened one over the other. The surface of the cone looks as if built up of small masses of pitch thrown on to it hap-hazard one over another. As the mouth of the cone contracts, the jet is thrown higher and higher, and the spray falling all around, covers the lava platform around with congealed drops of a lava rain. Each of these drops forms a Pele's hair, like the spray from the waves.[1]

Over one of the ranges of low cliffs in the crater, a cascade of lava had poured, and cooling and setting as it flowed, had been drawn out into long ropes and rounded ridges which were twisted one over another, and formed a curiously gnarled and contorted mass. Everywhere complex ripple marks were sharply moulded in the rapidly setting melted mass (see Pl. XXXI.). All over the lava surfaces bubbles were to be met with blown in the hot lava by the escaping gases, and now set and covered by convex films of thin transparent lava like thin-blown green bottle glass.[2]

Not far inland from Hilo are the beautiful falls of the Waianuenne, the basins of which are much used as a bathing place by the natives (see fig. 268).

Sandwich Islands to Tahiti.

The Challenger left Hilo for Tahiti on the 19th August at 2 P.M. An excellent meridional section was made between the Sandwich and Society groups; at every Station the temperature of the water was taken at every 10 fathoms from the surface to 200 fathoms, and at every 100 fathoms to 1500 fathoms (see Sheet 38).

Dr. R. von Willemoes Suhm.—During the passage, on the 13th September, the Expedition had the misfortune to lose Dr. Rudolf von Willemoes Suhm, who died after a short illness from erysipelas. This sad circumstance cast a shade of melancholy over the ship, which was not entirely thrown off until the departure from Tahiti, for Dr. von Willemoes Suhm had won the respect of everyone on board by his zealous attention to work, and by his readiness to put up with the many inconveniences inseparable from life on board a ship, where the irksomeness of discipline can never be relaxed.

Rudolf von Willemoes Suhm, son of the Kammerherr Landrath von Willemoes Suhm, a native of Schleswig-Holstein, was born September 11th, 1847. From his earliest years he showed a special aptitude for the study of all branches of Natural History, and during his boyhood he was a frequent contributor to the Zoological Garden Journal of Frankfort.

At eighteen he went to the University of Bonn, where he was a member of the corps "Borussia" and studied law. Though he was not remiss in his attendance on the lectures of the professors of the Legal Faculty, his own study during the three sessions

[1] Mr. H. C. Sorby, F.R.S., had come to the conclusion from the observations on furnace slag that Pele's hair was probably formed in this manner with globules attached, *Nature*, vol. xvi. p. 23, 1877.

[2] For a detailed account of the volcanos from a geological point of view, see W. T. Brigham, Notes on the Volcanic Phenomena of the Hawaiian Islands, *Mem. Boston Soc. Nat. Hist.*, vol. i. pp. 341 and 564.

which he spent at Bonn was devoted to Anatomy and Natural History. At the end of this time he went to Munich to devote himself entirely to the study of zoology under Professor von Siebold, who was always the warm friend and judicious adviser of the young zoologist, and received from him in return a sincere veneration which ended only with his life.

His letters at this period express much contentment; he felt very happy, and worked with ardour to distinguish himself; but although so occupied that he once playfully wrote to his sister—"Alles was ich treibe interessirt mich lebhaft, nur habe ich so unglaublich viel zu thun, dass sich abends, Bindegewebe, Fische, Ammoniten, Krebse, Frösche in wüstem Cancan mir im Kopfe drehen," he yet found leisure to frequent society, which furnished him with a salutary change amidst his incessant studies.

The year 1868 was marked by a visit to Venice, which he afterwards styled his "erste Vernunftreise," and a sojourn at Berchtesgaden in the Bavarian Highlands with the von Siebolds, which furnished him with an opportunity of studying wasps.

At Easter 1869 he left Munich for Göttingen, where he found the same friendly reception as elsewhere. After having continued his studies under Professors Henle, Meissner, Seebach, and Grenacher, he obtained his doctor's degree in February 1870. Before his examination, however, he went during the summer vacation in 1869 for two months to Spezzia and Genoa; a visit which gave him much enjoyment, and rich material for his scientific researches. In Spezzia he made the acquaintance of the Marchese Andreas Doria, known by his travels to Borneo, Sumatra, and Persia. The Marchese was then building a splendid museum at Genoa, and during v. Willemoes Suhm's stay there behaved very kindly towards him, showing him his treasures, and giving him much useful information.

During a temporary residence at Kiel in 1870 he was introduced to Professor Kupffer (now in Munich), for whom Willemoes Suhm always professed the warmest regard and friendship; their intercourse was never interrupted till his death. In October 1871 Willemoes Suhm returned to Munich by the advice of Professor von Siebold, and on the 18th December he was accepted as "Privat Docent," after having pronounced a thesis upon "Die rudimentarischen Organe und deren Bedeutung in der Thierwelt." He then began his lectures, and enjoyed the friendly support of both professors and students. During his sojourn in Munich, though always devoted to science, he spent many happy days in Possenhofen at the house of the Duke Carl Theodor, who then took great interest in zoology.

It was about this period that he felt an earnest longing to quit Europe and travel through foreign countries in order to enlarge his knowledge, and this wish constantly haunted him. In July 1871, he wrote to his mother:—"Ich fühle dass ich hinaus in die Welt muss; eine Museums Existenz wäre auf die Länge für mich unerträglich. Ich muss Bewegung, Veränderung haben; jetzt docire und studire ich nur, eine trockne Beschäftigung die mir auf die Länge ein schlimmeres Nervenfieber zuziehen würde als wie je Indien mir bereiten könnte. Ich hatte viel in mich aufgenommen, dass trug gute Früchte, aber jetzt muss für neue Nahrung gesorgt werden." Von Willemoes Suhm having learned that a museum was to be built in Ceylon, and a curator would be required, applied to Professor Huxley, through the mediation of Professor von Siebold, for advice, but the application came to nothing.

In the summer of 1872 he accompanied a Danish Expedition to the North Sea and the Færöe Islands. On his return the ship put into Leith, and he visited Professor Wyville Thomson in Edinburgh, on whose invitation he agreed to join the Civilian Scientific Staff of the Challenger Expedition.

While engaged on board the Challenger he was an indefatigable worker and a cheerful companion. A few days after leaving the Sandwich Islands he said that as he was now homeward bound he intended to devote several hours every day to the collection and arrangement of the observations which he had made. A few days later he was seized by the deadly disease which removed him on the 13th September 1875.

Professor Wyville Thomson writing from Tahiti, October 1st, 1875, says of him—"Altogether I looked upon R. von Willemoes Suhm as a young man of the very highest promise, perfectly certain, had he lived, to have achieved a distinguished position in his profession, and I regard his untimely death as a serious loss, not only to the Expedition in which he took so important a part, but also to the younger generation of scientific men, among whom he was steadily preparing himself to become a leader."

A tablet to the memory of R. von Willemoes Suhm has been erected in his native place by his colleagues in the Challenger. A list of his contributions to the Zoology of the Expedition will be found in the Bibliography which accompanies this volume.

From Hawaii Island to the parallel of 11° N., the mean direction of the wind was E. by N., gradually decreasing from a force of 4 at Hilo to a calm at that parallel. Light winds were then experienced, varying from south to east to the parallel of 6° N., when the southeast trade was fallen in with, which gradually shifted east as the ship proceeded to the southward, its mean direction at the Equator being S.E. by E., on the parallel of 5° S., east, and of 9° E.N.E.; from the 13th parallel to Tahiti little or no wind was experienced. The northeast trade was squally, with passing showers; the belt from 11° to 6° N. was cloudy, squally, and rainy; the southeast trade was steady and the weather fine.

The bed of the ocean between Hawaii and Tahiti undulates somewhat, the depth varying from 2300 to 3000 fathoms, the mean depth being about 2650 fathoms.

The bottom temperature varied 0°·7, viz., from 35°·2 to 34°·5, the mean being 35°·0, or only 0°·1 lower than the mean north of the Sandwich Islands.

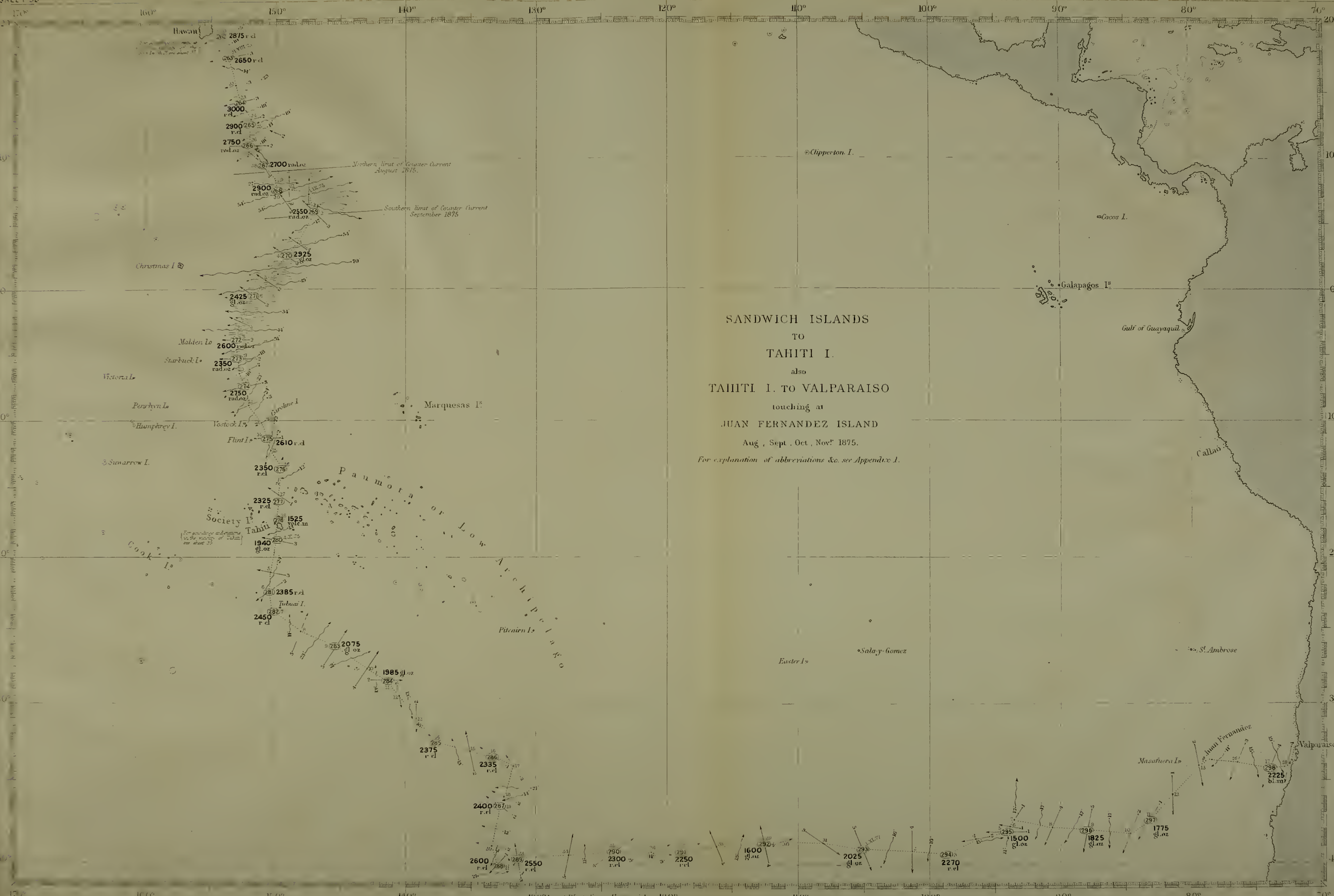
The mean surface temperature north of the 13th parallel was 77°·5, after which it gradually increased to 80° at 10° N., and continued at 80° to 81° to the 6th parallel of north latitude; it then decreased to 77° near the Equator, where the current was running at the rate of 3 miles per hour to the westward, rose to 79° in 6° S., and then gradually decreased to 77° at Tahiti.

The serial temperature soundings show that the isothermal lines above 55° all rise slightly from the Sandwich Islands to the parallel of 9° N., but afterwards all descend steadily to Tahiti. The rise of these isotherms in 9° N. is very remarkable, as they are there considerably higher than either to the north or south. This is probably due to excessive rainfall, for it is known that at this season of the year (August) the northeast trade only extends to 10° N.; from thence to 6° N., where the southeast trade commences, light winds with cloudy weather and much rain are experienced. These heavy rains, combined with the cloudy weather, affect the specific gravity of the surface water to a considerable extent, so that at 9° N. it is only 1·025, whilst on each side of that parallel it is 1·026, hence the surface water does not sink and consequently does not impart its heat to the water beneath. The isotherm of 40°, which is at a depth of 500 fathoms at Hilo, descends to 650 fathoms at 2° N., and then varies from 500 to 600 fathoms to Tahiti. The isotherms of 45° and 50° follow, but not very closely, the curve of that of 40° (see Diagram 19).

The currents between the Sandwich and the Society Islands ran with considerable force. From Hawaii Island to the 10th parallel the direction of the current was N. 60° W., and its average velocity 18 miles per day, ranging from 10 to 23 miles. From the 10th to the 6th parallel its direction was easterly, and its average velocity 31 miles per day, ranging from 7 to 54 miles. From the 6th parallel of north latitude to the 10th parallel of south latitude, the direction was again westerly, and the average velocity 35 miles per day, ranging from 17 to 70 miles per day. From thence to Tahiti the general tendency of the current was westerly, but its velocity was variable. The axis of greatest velocity of the Counter Equatorial Current was between the 7th and 8th parallels of north latitude (see Sheet 38).

The axis of greatest velocity of the Equatorial Current was on the parallel of 2° N., where its speed amounted to 3 miles per hour. Such an exceptional velocity has, so far as is known, only been recorded once before, viz., by the French corvette "Eurydice" in August 1857. The astronomical observations taken at frequent intervals showed even a greater velocity than 3 miles per hour. By those observations it appeared that the vessel was in the still water between the Equatorial and Counter Currents on the 2nd September in lat. 5° 54′ N., long. 147° 2′ W. From this position to lat. 4° 32′ N., long. 147° 38′ W., the velocity of the Equatorial Current was $\frac{3}{4}$ mile per hour S. 53° W.; from thence to lat. 3° 55′ N., long. 148° 10′ W., its velocity was $1\frac{1}{2}$ miles per hour; thence to lat. 3° 32′ N. its velocity was $1\frac{3}{4}$ miles per hour; thence to lat. 2° 34′ N., long.

SHEET 38



Engraved by Malby & Sons

149′ 9′ W., its velocity was 3 miles per hour S. 76° W.; thence to lat. 2° 10′ N., long. 149° 34′ W., its velocity was 4 miles per hour; thence to lat. 1° 0′ N., long. 150° 30′ W., its velocity was 3 miles per hour S. 85° W.; thence to lat. 0° 25′ N., long. 151° W., its velocity was $2\frac{1}{2}$ miles per hour; thence to lat. 0° 33′ S., long. 151° 32′ W., its velocity was $1\frac{3}{4}$ miles per hour S. 81° W.; and then it gradually decreased.

Anemometer observations were taken whenever sounding or trawling operations were in progress, and the following table shows the results obtained :—

Date. 1875.	Station.	Velocity of wind in miles per hour.	Force of wind by Beaufort's scale, as noted in log.
August 20	262	15	2 to 3, mean $2\frac{1}{2}$
„ 21	263	16	2 to 3, mean $2\frac{1}{2}$
„ 23	264	18	3
„ 25	265	6	1 to 2, mean $1\frac{1}{2}$
„ 26	266	10	2 to 3, mean $2\frac{1}{2}$
„ 28	267	5	1
„ 28	267	2	0 to 1, mean $\frac{1}{2}$
„ 30	268	12	3 to 4, mean $3\frac{1}{2}$
September 2	269	17	2 to 3, mean $2\frac{1}{2}$
„ 4	270	20	4 to 5, mean $4\frac{1}{2}$
„ 6	271	11	2 to 3, mean $2\frac{1}{2}$
„ 8	272	17	2 to 3, mean $2\frac{1}{2}$
„ 9	273	11	2
„ 11	274	15	3
„ 14	275	11	1 to 2, mean $1\frac{1}{2}$
„ 17	277	0	0

During the passage from Hawaii to Tahiti the ship was close hauled nearly the whole time; in fact the winds and currents experienced generally between the two groups appear to render it advisable to keep to the wind for the best part of the voyage, notwithstanding an occasional favourable slant, for such a slant is almost certain to be followed by an unfavourable breeze for a time. The master of the brigantine trading between the Sandwich and Society Islands said that he sometimes failed to fetch his port when bound either the one way or the other. Should a doubt of this kind be felt when making the passage, it should be borne in mind that the Counter Equatorial Current affords an opportunity of making easting.

The deposits between Honolulu and Tahiti presented many points of interest. The mineral particles consisted of minute fragments of felspars, augite, hornblende, magnetite, and vitreous particles; magnetic (cosmic) spherules, and crystals of philipsite, together with many pumice stones, palagonite, and manganese nodules. At each Station these minerals varied much as to their relative abundance. Between Hawaii and the 7th parallel of north latitude the depths ranged between 2650 and 3000 fathoms, and the deposits consisted very largely of the remains of Radiolarians and Diatoms, these organisms becoming more numerous as the distance from Hawaii increased. There was hardly a trace of carbonate of lime in these deposits. The next three soundings were between the 6th parallel north and 1st parallel south latitude, the depths being 2550, 2925, and 2425 fathoms, and the deposits contained respectively 21, 71, and 81 per cent. of carbonate of lime, chiefly in the form of the shells of pelagic Foraminifera. The reason why such a relatively high percentage of lime was found in these depths is probably explained by the fact that the pelagic Foraminifera and Molluscs were exceedingly abundant in the Equatorial and Counter Equatorial Currents which occupy the surface at these Stations. In these deposits the Radiolarians and Diatoms were likewise very numerous. The next three soundings, between 3° and 8° S., ranged between 2350 and 2750 fathoms, and were made up largely of Radiolarians and Diatoms, but contained in the surface layers a considerable number of pelagic Foraminifera shells. When the tube penetrated over a foot into the deposit the deeper layers did not show any traces of carbonate of lime. The deposit in lat. 11° 20′ S., long. 150° 30′ W., 2610 fathoms, was a dark chocolate-coloured clay containing an immense number of crystals of philipsite, and together with these many fragments of palagonite and small nodules of manganese peroxide. The crystals of philipsite made up the principal part of the deposit; these had been present in many of the previous deposits, but never in such abundance as in this instance. There was no carbonate of lime; and Radiolarians, which had been so abundant in previous deposits on this section, were only represented by a few specimens. The same remarks as to the nature of the deposits apply to the next two Stations, where the depths were 2350 and 2325 fathoms respectively, with the exception that there was 22 and 10 per. cent. of carbonate of lime, which was due to the presence of calcareous Foraminifera. The deposit in 1525 fathoms was a volcanic mud containing 20 per cent. of carbonate of lime.

In every instance the dredgings and trawlings yielded some manganese nodules and pumice, but on two or three occasions the manganese nodules were in extraordinary abundance. Over a peck of heavy very compact oval nodules was obtained from 2750 fathoms on the 11th September. The largest were 4 inches in diameter and 2 inches thick, the upper surface was smooth while the under one was rough and irregular. Although differing in size, most of them had the same shape, indeed it may be remarked that there is generally a close resemblance both in composition and shape and sometimes in size among the nodules from any single dredging. Along with the nodules were sixteen Sharks' teeth of considerable size, two being those of *Carcharodon*, nine of *Oxyrhina*, and four of *Lamna*; some of these were deeply imbedded in deposits of manganese. There were in addition to the above eight earbones of Cetaceans belonging to the genera *Globiocephalus*, *Mesoplodon*, and species of Delphinidæ.

On the 16th September, from 2350 fathoms, the trawl brought up more than half a ton of manganese nodules which filled two small casks. The great majority were small and nearly round, resembling a number of marbles with a mean diameter of three quarters of an inch. Their nuclei were generally palagonite or other volcanic material, but very frequently small Sharks' teeth or fragments of bone. Among the nodules were counted two hundred and fifty Sharks' teeth, without taking into account those less than half an inch in length. Three of the teeth belonged to *Carcharodon*, being from 2 to 2½ inches across at the base of the dentine. Ten resembled those of *Carcharias*, and the remainder were referred to the genera *Lamna* and *Oxyrhina*. The Cetacean bones among the nodules consisted of two tympano-periotic bones of *Mesoplodon*, eight separate petrous bones, and six tympanic bullæ belonging to *Globiocephalus*, *Delphinus*, and *Kogia* (?).

The dredgings and trawlings in this section did not yield a very large number of deep-sea animals. From 3000 fathoms there were fragments of *Euplectella* and another siliceous Sponge, and a large specimen of a hydroid (*Stephanoscyphus*). From 2750 fathoms there were five specimens of Holothurians belonging to two new genera (*Psycheotrephes exigua*, Théel, and *Benthodytes selenkiana*, Théel), a Starfish belonging to a new genus (*Hyphalaster hyalinus*, Sladen), a Pennatulid, fragments of siliceous Sponges, and two small Actiniæ adhering to the manganese nodules. From 2600 fathoms several siliceous Sponges, two Annelids, and the following Echinoderms:—*Phormosoma tenue*, A. Ag., *Pourtalesia rosea*, A. Ag., and *Aceste bellidifera*, A. Ag., were obtained. The trawling in 2425 fathoms gave three deep-sea fish and twenty-seven deep-sea invertebrates, among which were the following:—*Discina atlantica*, King; *Coryphænoides variabilis*, Günth.; *Scopelus macrostoma*, Günth.; *Homolampas fulva*, A. Ag.; *Culeolus moseleyi*, Herdman; *Peniagone wyvillii*, Théel; *Benthodytes papillifera*, Théel; *Bathydoris abyssorum*, Bergh; and *Arca corpulenta*, Smith. From 2350 fathoms there were an Ophiurid (*Ophiochytra epigrus*, Lyman), several Shrimps, and a *Stephanoscyphus* attached to the manganese nodules. It should of course be remembered that the fish and shrimps above mentioned are probably not from the bottom, but from intermediate depths. The tow-net gatherings were very productive throughout the trip, the abundance of life in the Equatorial and Counter Equatorial Currents being very remarkable, both for the number of species and individuals. Nets were frequently sent down to depths greater than 100 fathoms, and in every case yielded forms not met with in the surface waters.

The Society Islands.

On the 18th September, at daylight, Eimeo Island was seen ahead, and Tahiti on the port bow, and at 6 A.M. the Tetuaroa Islands. At 10 A.M. the ship was stopped and a sounding taken in 1525 fathoms (see Sheet 38), with the extremities of Tahiti S. 52° E. and S. 18° E., and the summit S. 34° E., the extremities of Tetuaroa Islands N. 18° E. and N. 33° E., the extremities of Eimeo S. 7° W. and S. 31° W., and the apex S. 14° W. Shortly after noon, having obtained temperatures to 1000 fathoms, the vessel proceeded towards Papieté Harbour, and having received a pilot at the entrance, anchored at 4.30 P.M. in 11 fathoms, with Point Fareute N. 5° W. and Motu-Uta Island N. 82° W.

Tahiti.—The Expedition remained at Tahiti until the 3rd October, completing with coal, obtaining observations, and preparing for the voyage to Valparaiso, and it is hardly necessary to say received every attention both from the French authorities and the natives.

The French authorities compel the payment of pilotage into the harbour; if a pilot be employed, the full amount is charged, if he be not employed, then half the amount. An excellent chart of Papieté Harbour is published at Paris, and also two good sheets of the coasts of the island; one extending from Papieté Harbour to Punaavia on the west coast, and the other from Point Venus to the Artemise Bank on the north coast. The survey of the island has, it is understood, been completed and will doubtless soon be engraved.

The leading marks into Papieté Harbour are excellent, but as the channel is very narrow and the water on the bar frequently turbid, strangers may with advantage employ a local pilot the first time they enter, but will probably prefer afterwards to dispense with his services. The leading marks into Toanoa Harbour have been removed, but the passage into it, and from it to Papieté, is now well beaconed, and as it is deep and the water clear, the reefs may readily be distinguished, provided the sun be not ahead. The beacons are white on the south side of the channel and red on the north side, and by their aid and a lookout from the foreyard, no difficulty should be experienced in using this passage.

The little island of Motu-Uta is now used as a quarantine ground, and a quarantine and lepers' hospital has been built there; consequently, observations could not be taken on it; this was regretted, as the Austrian frigate "Novara" obtained magnetic observations there in 1859.

The French have established a depôt of coals on Point Fareute and constructed a slight embankment on the eastern side of the point, and as the water is deep, vessels are enabled to haul close enough to the shore to allow a landing brow to be hauled on board. There are plenty of conveniences on shore to which hawsers or chains may be attached, but vessels must use their own anchors as off-fasts, and must keep a good strain on the off-cables, as the trade wind has a tendency to force them against the point.

The island of Eimeo is badly depicted on the Admiralty Chart (Sheet 1382). It is triangular in shape, the base to the northward, the apex to the southward, and has several small harbours inside the barrier reef encircling it, the principal of which are those of Taloo and Avootai. This island has also been surveyed by the French.

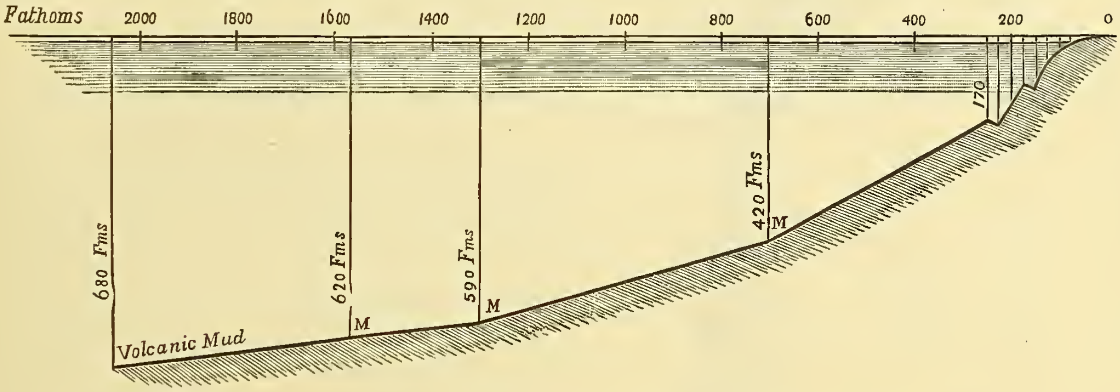


FIG. 269.—Slope of the outer face of the Barrier Reef at Tahiti, from the edge of the reef to two miles seawards.

Foreign vessels are not permitted to trade with any of the islands under the French protectorate, except Tahiti. The master of a British brigantine had some time before the Challenger's visit been imprisoned for twelve months for trading with the inhabitants of the Low Archipelago for pearl shells.

The mails to Tahiti are brought by a fast sailing schooner from San Francisco; there is no steam communication.

Supplies at Tahiti were, at the time of the Expedition's visit, scarce and high in price. Beef, which was brought from the Sandwich Islands, was 10d. per lb.; pork, 6½d. per lb.; sheep, which were occasionally brought from the Sandwich Islands or Easter Island, and which after the voyage weighed when killed and dressed only from 10 to 20 lbs., and were almost uneatable, cost 24s. each; fowls, 2s. 6d. each; and eggs, 2s. per dozen. Vegetables were plentiful and moderate in price; potatoes 16s. per bushel. Fruit was plentiful and cheap, but there was not much variety; the oranges were excellent.

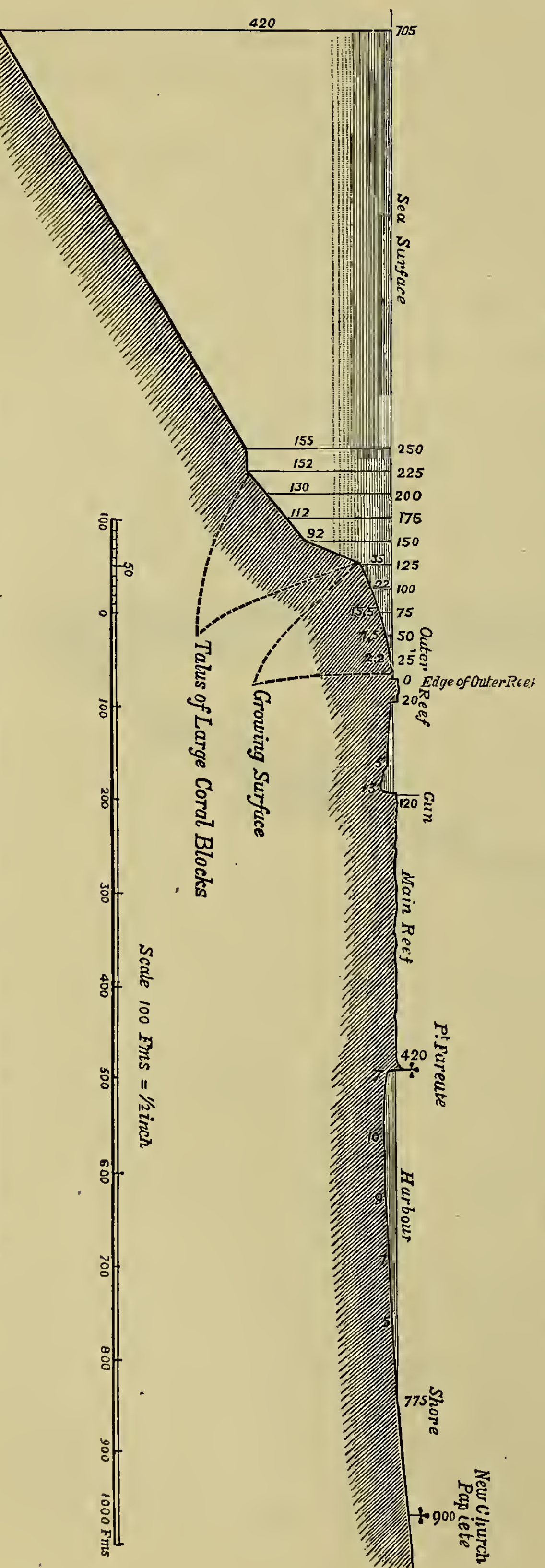


Fig. 270.—Section of the Barrier Reef at Tahiti, from the shore to a depth of 420 fathoms outside the Reef.

During the stay at Tahiti a careful examination was made of the coral reefs, and a survey was specially conducted to ascertain the seaward slope of the barrier, by Lieutenant H. Swire, who writes as follows:—

"I gladly entered into co-operation with Mr. Murray, under whose guidance and general superintendance the examination was conducted, and by his desire made a survey of the seaward face of the reef, carrying the soundings from the water's edge to a depth of 180 fathoms by boat, the lines of soundings being afterwards extended by the ship when under steam, to a depth of 680 fathoms (see fig. 269).

"By sounding to seaward on lines 200 yards apart, and perpendicular to the direction of the reef, taking the depth at equal intervals and carefully fixing each position by angles; and in addition, by fixing the position on each line of certain given depths —as for instance 5, 10, 15, 20, &c., fathoms— it was considered that a good insight into the configuration of the reef would be obtained, whilst by 'arming' the sounding lead with the usual mixture of white lead and tallow in order to ascertain the nature of the bottom at each cast, and by making free use of drag nets, a dredge fitted with tangles, a water telescope, &c., the investigation into the other conditions of the reef could be simultaneously carried on.

"The portion of the reef selected was 1120 yards in length, the greater part being in general direction a straight line, which circumstance somewhat simplified the matter, as a single base line sufficed for the greater portion of the reef.

"In order to obtain soundings at given

Engraved by Malby & Sons.

distances apart, previously calculated angles were used, whereas to fix the position of previously agreed upon depths, it became necessary to observe independent angles. In this manner all the lines of soundings were run to such a depth as was possible in a boat, the coast line of the reef was sketched in, and the ship afterwards extended the lines to a distance of 2055 fathoms from the reef."

The results of these observations are given in the diagrams and following table (see Sheet 39 and figs. 269–271).

Comparative Table of the Six Sections of the Outer Edge of the Barrier Reef at Tahiti.

Distance from Edge of Reef in Fathoms.	No. 1 Section.		No. 2 Section.		No. 3 Section.		No. 4 Section.		No. 5 Section.		No. 6 Section.	
	Depth in Faths.	Angle of Slope.	Depth in Faths.	Angle of Slope.	Depth in Faths.	Angle of Slope.	Depth in Faths.	Angle of Slope.	Depth in Faths.	Angle of Slope.	Depth in Faths.	Angle of Slope.
0	...	10° 12′	...	2° 17′	...	5° 2′	...	5° 15′	...	2° 17′	...	3° 26′
25	4·5	12 24	1·0	2 45	2·2	11 58	2·3	7 58	1·0	2 45	1·5	4 7
50	10·0	12 51	2·2	21 24	7·5	17 45	5·8	15 0	2·2	23 22	3·3	15 0
75	15·7	16 54	12·0	17 45	15·5	16 42	12·5	26 34	13·0	15 38	10·0	15 38
100	23·0	17 45	20·0	25 38	22·0	27 28	25·0	54 28	20·0	37 14	17·0	13 30
125	31·0	43 14	32·0	68 40	35·0	66 19	60·0	59 14	39·0	69 15	23·0	4 34
150	54·5	66 8	96·0	37 14	92·0	38 39	102·0	15 38	105·0	38 39	25·0	72 39
175	111·0	51 44	115·0	30 58	112·0	35 45	95·0	60 57	125·0	45 0	105·0	38 39
200	142·7	...	130·0	37 14	130·0	41 21	140·0	55 13	150·0	30 58	125·0	50 12
225	...	...	149·0	32 37	152·0	6 50	176·0	13 30	165·0	30 58	155·0	45 0
250	...	...	165·0	...	155·0	...	170·0	...	180·0	...	180·0	...

An examination of these sections shows that a depth of 25 to 35 fathoms is met with at 100 to 150 fathoms from the edge of the reef. At about this distance from the reef there is a rapid increase of depth to 160 and 180 fathoms, these latter depths being met with at a distance of 225 to 250 fathoms from the edge of the reef. Between the depths of 35 and 100 fathoms the average slope is about 45°. The slope is about 30° to 200 fathoms or thereabouts, and then becomes less and less until a slope of 6° is met with half a mile from the reef. The whole of the space from the edge of the reef to a depth of 35 fathoms was covered with a most luxuriant growth of corals, with the exception of one or two small spaces where there was white coral sand. The depths were most irregular, the sounding lead at one time falling on a coral boss, and showing a depth of 5 or 6 fathoms, and then close alongside it a depth of 16 fathoms. It could be seen with the water glass that many of these bosses and heads of coral were overhanging and in a most luxuriant state of growth. So irregular was the ground out to 35 fathoms that dredging was almost, if not quite, impossible; still by means of the swabs and tangles some corals were obtained. From 35 or 40 fathoms down to 150 fathoms dredging was equally difficult. Here a number of Sponges, Alcyonarians, Corals, and other invertebrates were obtained. Beyond 150 fathoms the bottom was a coral sand with volcanic minerals and pelagic shells. The soundings taken by the ship at depths of 420, 590, 620, and 680 fathoms showed the presence of a volcanic sand or mud, containing coral débris, fragments of Pteropods, Gasteropods, Coccoliths, with pelagic and other Foraminifera; the deposits at the greater depths contained about 19 per cent. of carbonate of lime.

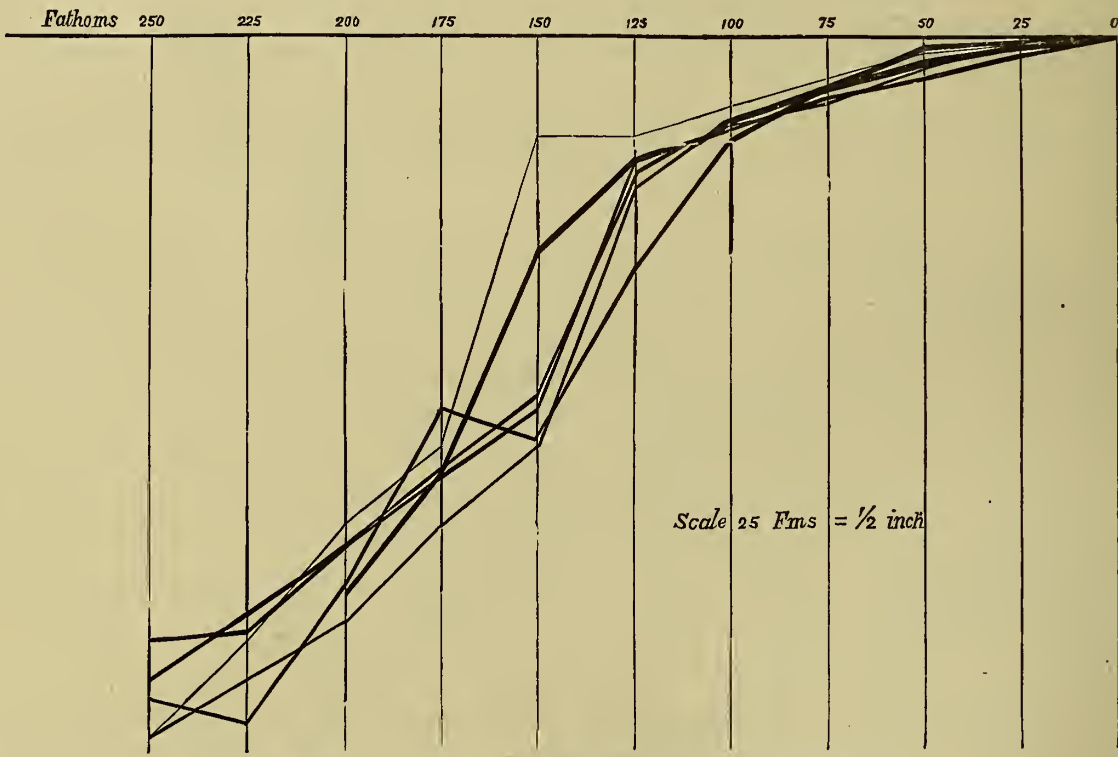


Fig. 271.—Profile of the Reefs on the six lines referred to in the foregoing Table.

Mr. Moseley says that in from 20 to 30 fathoms a *Mycedium* and a *Madrepora* were obtained different from those on the reefs and in shallow water. In from 30 to 70 fathoms were found the same *Mycedium*, a fragment of *Madrepora* (both probably from the former depth), and a small solitary *Balanophyllia*, which from its appearance very probably came from 50, 60, or 70 fathoms. Also in from 30 to 70 fathoms Alcyonarians and Sponges were obtained. One of the Alcyonarians is very hard, and looks like a Coral (*Porites*), but is seen in section not to be one. There were also several pieces of the *Mycedium*, a bit of the *Madrepora*, and several specimens of the *Balanophyllia*. There was also another calcareous organism forming large thin incrustations, and at first sight presenting a fallacious resemblance to a Coral such as *Millepora*.

The margins of the reefs inside the lagoons presented quite a different appearance from those on the seaward face outside. Here they were fringed with living coral, sloped downwards and outwards for a few feet, and then plunged at once to depths of 10 and 16 fathoms. Many of them were overhanging, and in one place a large ledge seemed recently to have fallen away, and to have rendered the water shallower alongside the reef. These overhanging or mushroom-shaped reefs inside lagoons or lagoon-channels have been frequently described by Jukes and others. The deposit in the lagoons was in some places a coral sand and in others a volcanic mud. The reefs at Tahiti have been described both by Darwin and Dana as examples of barrier reefs, but for miles the reefs have quite a fringing character; in other places there is only a small channel across which the natives wade to the edge of the barrier, or there is a boat passage; in other places, as at Papieté, there is a ship channel, or a commodious harbour, while there are some portions of the coast where no reefs exist.

The island of Tahiti is surrounded by a belt of fertile land from 3 to 4 miles wide, and in some places the alluvium rests on portions of the shore reef in such a way as to indicate that the island had been recently elevated.

According to Mr. Murray the observations of the reefs at Tahiti support the view that the reefs have been built from the shore seawards, and that the lagoons have been, and are still being, formed by the removal of the inner and dead portions of the coral reef by the solvent action of sea water. The islands in the harbour and lagoons are regarded as portions of the reef which have been left standing, but will ultimately be removed, and in confirmation of this it is pointed out that on the inner part of the reef there are large and massive specimens of the coral which are now dead, but which probably flourished at the time when the outer edge of the reef was at the position in which they are now found. The steep slope which is found on the outer edge of the reef, between the depths of 35 and 200 fathoms, is believed to be formed by huge masses and heads of coral which have been torn away from the ledge between the edge of the reef and 35 fathoms during storms, or by overhanging masses which have fallen by their own weight. In this way a talus has been formed on which the corals living down to 35 fathoms have found a foundation on which to build further seawards, for this seaward slope is the great growing surface of the reef. The food supply for the masses of living coral on the outer slope of the reef is brought by the oceanic currents sweeping past the islands, a fact in relation with the more vigorous growth of the reef on the windward sides. It is maintained by Mr. Murray[1] that the whole of the phenomena of the Tahiti reefs may be fully explained by reference to the processes at present in action, and without calling

[1] On the Structure and Origin of Coral Reefs and Islands, by John Murray, *Proc. Roy. Soc. Edin.*, vol. x. pp. 505–518, 1880.

in the aid of subsidence as is done by Darwin and Dana, and it is argued further that the form of atoll and barrier reefs generally can be explained on the same principles, when taken in conjunction with what is now known of the bathymetrical distribution of animals, and the mode of formation of deep-sea deposits. The recent discoveries of Dr. Guppy[1] in the upraised coral islands of the Solomon group confirm the view here advanced.

Observations were taken at the lighthouse on Point Venus in order to connect the observing stations with those of Captains Cook, Beechey, Fitzroy, &c.

The following meteorological table shows the climate at Papieté from observations made by the French during three years.

METEOROLOGICAL TABLE compiled from observations made at Papieté, in the island of Tahiti, during the years 1854, 1855, and 1856.

Barometer reduced to 32° and sea level.

MONTH.	Barometer.		Mean Temp. in shade.	Mean Range of Temp.	Max. Temp. in shade registered.	Min. Temp. in shade registered.	Clouds—0 to 10 Mean Amount.	Rain.		Wind.											No. of days Gales.	No. of days Fogs.	Relative Humidity Sat. 100.
	Mean Height.	Ext. Range						Total Fall.	No. of days.	Av. Hourly velocity.	No. of days from											
											N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	C'lm			
	in.		°		°	°		in.														
January,	29·789		78·1		87·8	69·8		6·00	13													82·5
February,	29·840		77·8		87·8	69·8		4·12	11													84·3
March,	29·834		78·0		88·7	68·0		3·71	12													81·6
April,	29·843		77·9		88·9	67·5		3·41	10													82·2
May,	29·864		76·4		86·0	66·2		4·08	8													82·8
June,	29·905		75·1		84·2	61·7		0·90	7						No information.							79·0
July,	29·922		74·4		84·2	60·8		0·65	5													79·7
August,	29·965		73·8		84·2	60·3		0·61	4													80·0
September,	29·968		73·9		86·4	62·6		3·37	5													81·2
October,	29·931		75·3		86·0	66·2		1·68	5													82·9
November,	29·876		76·5		85·3	66·2		5·03	8													86·7
December,	29·858		76·2		87·8	70·0		4·67	11													85·4
Means and Totals,	29·883		76·1		88·9	60·3		38·23	99													82·4

The beauty of Tahiti as seen from the sea cannot be overrated; it forms a most striking contrast to the barren looking Oahu (see fig. 272). During the stay of the ship an excursion to the mountains in search of plants was made by Mr. Moseley, accompanied by Lieutenant

[1] *Nature*, vol. xxix. pp. 214, 215, 1884.

A. Channer and Mr. F. Pearcey, the birdskinner and naturalists' assistant. Mr. Miller, English Consul at Tahiti, kindly procured the guides and otherwise assisted the party.

Some of the mountains of Tahiti rise to a height of over 7000 feet, and it was hoped to be able to reach a considerable altitude in the search of mountain plants. It was settled that at all events the head of a valley in the interior called Papeno should be reached. The party was provided with native guides; one, an old man, supposed to be thoroughly acquainted with the mountains.

The men carried the little baggage on the ends of poles resting on their shoulders

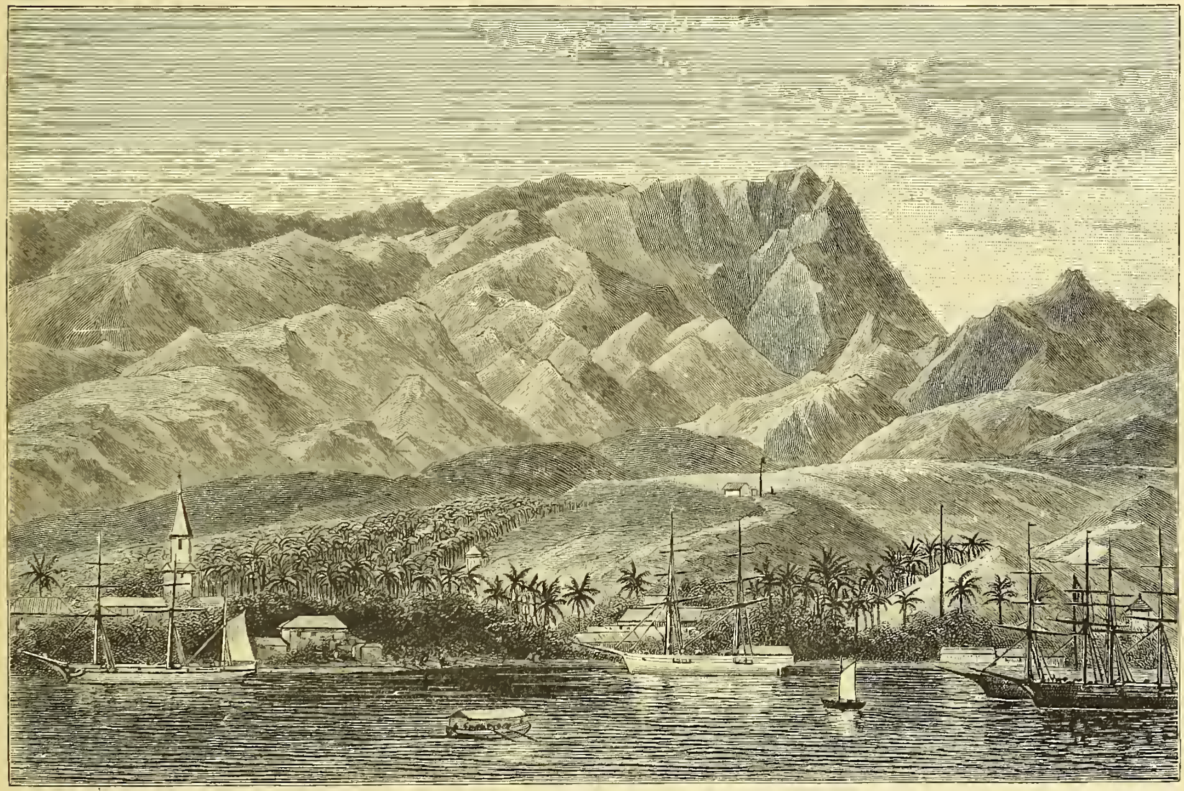


Fig. 272.—Tahiti.

like Chinese coolies. The practice of this method of carrying has been remarked upon as one of the many evidences of the Polynesian affinities of the New Zealanders. The beautiful valley of Fataua, closed at its head by the irregularly peaked outline of the mountain, termed by the French, from its form, the "Diadem," was first traversed.

At some distance from its mouth the valley is barred across by a high cliff over which the stream traversing it falls in a very beautiful waterfall. In the cliff beneath the falling water is a wide hollow, overhung by the rock above, and in this the Tropic Birds (*Phaëthon*) nest, and two or three were constantly to be seen flying about the cliff and across the deep chasm of the valley, conspicuous against the dense green foliage and dark rocks. Excellent strawberries were growing in a garden just above the fall, and the plants were mostly in blossom, only a few fruits being ripe. The Mango trees in the same way were mostly in blossom, or with young green fruit. The orange season was just at its end.

The stream is full of small fish (*Dules malo*), one of the Perch family which have adapted themselves entirely to a fresh water life, and rise to a fly like trout. Captain Thomson and other officers of the Expedition who were anglers, got out their fly rods and whipped the stream, catching a few dozen. The stream falls over the rocks and stones in small runs and stickles just like a trout stream, and the fish thrive in the rapid water.

The first camp of the excursion party was made in the head of Fataua Valley, at a height of about 1600 feet, amongst the "Fei" or Wild Plantain (*Musa troglodytarum*, Linn), a species which occurs also in Fiji and elsewhere in Polynesia according to Seemann, though it is possible that the fruit of the wild plant in other places is not equal in quality to that of Tahiti. The plant is closely similar in appearance to an ordinary large banana tree, but the large bunches of fruit, instead of hanging down, stand up erect from the summit of the stem and are bright yellow when ripe. When a bunch of these is thrown into a fire, the outer skin of the fruits becomes blackened and charred, but when it is peeled off with a pointed stick, a yellow floury interior is reached, which resembles a mealy potato, and is most excellent eating. This is one of the very few plants which, growing spontaneously, and in abundance, affords a really good and sufficient source of food to man. Hardly any improvement could be wished for in the fruits by cultivation. It could not but be most advantageous that the plant should be introduced into many other tropical countries. On the way up the valley numerous natives were met going down to Papieté with loads of "Fei."

Rats live in the mountains, and climb up and devour the ripe plantains, and the groves of the trees are traversed in all directions by the tracks of wild pigs, which likewise feed on the fruit. It is strange that the pig should run wild and thrive, under such widely different conditions as it does, and should be able to exist equally well on wild plantains in the warm Tahiti, and on penguins and petrels in the chilly Crozets. In this power of adaptation it approaches man.

It had been raining heavily during the first day's walk, and was still pouring when the halt was made, and the members of the party were all wet through. The guides soon built a small waterproof hut, with sticks and the huge wild plantain leaves. Then they put up another small roof of leaves, and finding dry dead plantain leaves under the shelter of the freshly fallen ones, soon lighted a fire under the roof, and the clothes of the party were dried in the smoke before nightfall, in the midst of the heavy rain. The banana leaves afforded further excellent waterproof covers for clothes and botanical drying paper. No blankets had been taken by the party, because it was wished to make

Plate XXXII.

Horsburgh, Edinburgh. Permanent Phototype

NATIVE HOUSE, TAHITI.

the utmost attempt to scale the mountains as far as possible, and the baggage had therefore been reduced to a minimum, it not being expected that suffering from cold would be experienced. The thermometer showed, at about half an hour before sunset, 75° F., about an hour later, 68°·5, at midnight 63°·0, at daybreak 60°·5, and in about half an hour after daybreak it rose to 61°·5. The main stream of the valley running past the huts had a temperature at daybreak of 65°·0, having retained throughout the night the heat of the former day, which the air had so rapidly lost. The effect of the stream on the climate here, is thus just the opposite of that of the streams of such an island as Tristan da Cunha.

From this camp, the way led over several steep minor ridges in the head of the valley, and then up to an elevation of 3000 feet, which was reached on one of the extremely narrow ridges, characteristic of Tahiti, situated just to the west of the "Diadem." From the ridge, a descent was made into the Punaru Valley by the aid of ropes fastened to the trees. The precipitous side of the valley which was thus descended, was covered at this elevation, from about 3000 to 2000 feet altitude, with a dense vegetation, composed almost entirely of ferns. A Tree Fern (*Alsophila tahitiensis*) formed a sort of forest almost to the exclusion of other trees, and with this were associated huge clumps of the Giant Fern (*Angiopteris evecta*) and masses of the Birds-nest Fern (*Asplenium nidus*). With these grew a trailing Screw Pine and a *Dracæna*, but the three ferns together formed a remarkably large proportion of the entire vegetation.[1]

The second camp was made at an elevation of about 1800 feet, at a native hut in the upper part of Punaru Valley. The natives have not forgotten their religion since the time of Darwin's visit;[2] the guides said their prayers every evening before sleeping, even when huddled together out of the rain, all repeating the words together, and the native family at the hut did the same. The temperature at the hut sank at daybreak to 59° F. Much suffering from cold was experienced in the night, and still more from mosquitos. An old piece of canvas was lent to the party to lay on the ground to sleep on, but was used as a coverlet for warmth.

In the morning the attempt was made to cross over a high ridge at the head of Punaru Valley, and so to reach the proposed destination, the Papeno Valley, but the attempt failed, for it was found after toiling up to an elevation of about 3000 feet that the guides did not know the way at all. One of them had been over the pass many years before, but all he seemed to know was, that he had been up a stream, so the day was spent in wading through pools and clambering over slippery boulders in its bed, creeping along under the overhanging branches. Attempts were made time after time in various impracticable places, and at last a hurried descent was made in the evening into the valley, and a camp had to be prepared almost entirely in the dark, and in heavy rain, at a height of 2500 feet.

[1] On the significance of this, see A. R. Wallace, Tropical Nature, p. 269, 1878.

[2] C. Darwin, Journal of Researches during the Voyage of H.M.S. "Beagle," p. 411, ed. 1879.

This was above the limit of the growth of the wild plantain in any abundance, so the shelter for the night was made of the fronds of the Birds-nest Fern (*Asplenium nidus*). These are tougher and more durable than the leaves of the plantain, and hence are used for permanent thatching, but from their smaller size require much more time in arrangement.

The members of the party had to put up with a very small hut, which sheltered their bodies as they lay down, but would not cover their legs, and they had to feel in the baggage in the pitch darkness for their food, and eat it by the help of the sense of touch alone. The unfortunate guides, who had constructed the hut first, could find scarcely any more fern leaves in the dark, and they squatted out the night together, sheltered from the rain by a small extinguisher-shaped erection, which looked as if one human body could not be forced into it, much less two. The temperature here at daybreak was 60° F., and the morning being cloudy, and the camp lying in a narrow gorge, it remained the same for an hour and a half after daybreak.

In the morning the party descended again several hundred feet, and sent back to the hut and procured two young men, supposed to be practised mountaineers, and, as was thought, certain to know the way about every pass within 4 or 5 miles of their dwelling. One of them, as a proof of his knowledge, brought with him what appeared to represent the most primitive form of a map. It was a thick stick of wood about a foot and a half long, with two short cross pieces on it at some distance from the ends, and on each of these cross pieces were set up three short uprights of wood. The uprights represented mountain peaks, and the spaces between, the valleys. The new guide held his map in his hand and took a long consultation with his brother, and then explained matters thoroughly to the original guides. He clutched the uprights one after another and dilated upon them, pointing out the peaks to which they corresponded. There seemed no doubt that the right man had been got hold of at last.

The guides now lashed the small baggage on their backs, instead of on poles as before, since this mode of carriage was no longer practicable, owing to the steepness of the ascent, and a start was made up the face of an extremely steep-sided ridge, a spur of Orofena, the highest mountain of Tahiti. At the lower part, each pulled himself up by means of the trailing Screw Pines. These covered the ground with a tangled mass of long serpentine stems so thickly, that in climbing the ground was a yard or more beneath.

Near the summit of the spur, the face of the ridge was almost perpendicular, and one of the men got up by the help of the bushes and let down a rope by which the crest was reached. In order to collect plants, a knotted handkerchief had to be held in the teeth and filled, as it was impossible to get at a vasculum. The crest of the ridge was nowhere more than a yard wide, often less, and there was an almost sheer fall on either hand; if grass and small bushes had not been growing at the edge on each side, it would have been very difficult to walk along without becoming giddy. It was as if one were walking along the top of an immensely high wall.

Here and there small *Metrosideros* trees grew upon the centre of the crest of the ridge, and when these were encountered it was necessary to climb between the branches, often where they overhung a sheer drop below, and once to swing along the steep side of the crest for a short distance past one of these trees under its overhanging branches.

The crest of the ridge was ascended until an altitude of 4000 feet was reached, when the guides found the way barred by a precipice and entirely impracticable. The summit of the ridge was covered with a thick growth of the Fern (*Gleichenia dichotoma*) and a Climbing Fern (*Lygodium*), and amongst the bushes on the ridge a Whortleberry (*Vaccinium*) was very abundant, and also two species of *Metrosideros*. The entire vegetation was different from that below. One of the species of *Metrosideros* was, however, also seen growing much lower down.

Just as the ridge met the face of the mountain, by which the party was brought to a halt, its crest widened out, and here there was a damp hollow with mosses and lichens growing in it in great abundance. Here also grew a tree (*Fitchia nutans*), 20 feet in height, and with a trunk 9 inches in diameter, belonging to the Compositæ, with a large yellow flower. It is allied to the Composite trees of Juan Fernandez and nearly related to the Chicory.

Here in the soft loose soil, amongst the moss, were numerous burrows of a Petrel (*Procellaria rostrata*). The natives call it the "Night Bird," just as the inhabitants of Tristan da Cunha call the Burrowing Petrels there "Night Birds." The Tropic Birds also nest far up in the mountains, and in Hawaii they nest in the cliffs of the crater of Kilauea at an altitude of 4000 feet. Similarly a Puffin (*Puffinus nugax*) nests at the top of the Korovasa Basaga Mountain, in Viti Levu Island, Fiji,[1] and in like manner, a *Procellaria* breeds in the high mountains in Jamaica.

It seems possible that these birds may carry Alpine plants as seeds and spores attached to their feathers from one island to another, for great distances. They make their holes in the ground where it is densely covered with herbage, and often become covered with vegetable mould. The Procellaridæ, widely wandering as they are, have probably had a great deal to do with the wide distribution of much of the Antarctic flora. Grisebach[2] lays stress on the range of the Albatross (*Diomedea*) from Cape Horn to the Kurile Islands, as possibly accounting for the occurrence of northern species of plants amongst the southern flora, and also the wide range of the Antarctic flora. He supposes the seeds, however, to be swallowed by the Albatross, with its food, after being washed down into the sea by rivers, and perhaps swallowed by fish.

[1] Finsch u. Hartlaub, Ornithologie der Viti, Samoa und Tonga Inseln; Einleitung, p. xviii., Halle, 1867. Peale describes the habit in question of *Procellaria rostrata* at Tahiti.

[2] A. Grisebach, Vegetation der Erde, Bd. ii. p. 496.

As the date of the sailing of the ship was uncertain, the party was obliged to give up the attempt to reach Papeno Valley, and therefore returned to the native hut for the night. The sky being remarkably clear, the thermometer sank at daybreak to 55° F. (elevation 1800 feet). The Punaru Valley was followed down to the sea shore, and Papieté reached along the coast.

The orange, lemon, and lime, which grow wild all over Tahiti, do not appear to deteriorate at all in quality nor in quantity of the fruit produced in the feral condition, indeed the fruit almost appears finer and better for running wild. The oranges were unanimously pronounced the best ever eaten. The limes lay in cartloads upon the ground, rotting in the woods. It would pay well to make lime juice for export in Tahiti. Some native insect must have adapted itself completely to the blossoms of the orange tribe as a fertilizer, so abundant is the fruit. Vanilla, which is cultivated in the island with success, requires, as everywhere else away from its home, to be fertilized by hand.

A party consisting of Lieutenant Balfour, Mr. Murray, and Mr. Cox visited Lake Waihirra under the guidance of Mr. Green the English missionary. Lake Waihirra, situated 1700 feet above the level of the sea, is surrounded by perpendicular cliffs, and is distant about 45 miles from Papieté. The party reached the lake without much difficulty as a path had been cut through the wood for the Governor of the island, who had visited the lake just before; one night was passed in a hut at the side of the lake. The lake was said to be unfathomable, but the greatest depth obtained was 10 fathoms. The large "eared animals" which were said to inhabit the lake turned out to be immense Eels 4 and 5 feet in length (*Anguilla mauritiana*, Benn., and *Anguilla aneitensis*, Günth.).

The ground just above the shore near Papieté is everywhere burrowed by large Land Crabs, which are difficult to catch, for they never, in the daytime at least, go far from their holes, but watch a passer-by from near the mouths of their retreats, and bolt in, if suspicious of danger, like rabbits. An old marine, named Leary, who acted as a constant assistant to the Naturalists whilst collecting on shore, invented a plan by which he caught some of the largest and oldest of the crabs. He tied a bit of meat on the end of a string, fastened to a fishing rod, and by dragging the meat slowly enticed the crabs from their holes, and then made a dash forward, put his foot in the hole, and so caught them. The larger crabs were far more difficult to catch than the younger ones.

The Corals.—Mr. Moseley writes as follows:—"A Mushroom Coral (*Fungia*) is very common all over the reefs at Tahiti. After much search, I found one of the nurse-stocks from which the disk-shaped free corals are thrown off as buds, as was originally shown by Stutchbury,[1] and confirmed by Semper, who considers the case to be an instance of

[1] G. Stutchbury, An Account of the Mode of Growth of Young Corals of the Genus Fungia, *Trans. Linn. Soc. Lond.*, vol. xvii. p. 493, 1830.

alternation of generations.[1] Though the free corals were so extremely numerous, I found only one mass bearing nurse-stocks. It consisted, as in Stutchbury's specimen, of a portion of a very large dead *Fungia*, to which numerous nurse-stocks in various stages of growth were attached all over. Some of them had only just developed from the attached larva, and had as yet thrown off no buds. A small cup-like coral is formed, and as it grows the mouth of the cup widens and assumes somewhat the form of the adult disk-shaped free coral, but is still distinctly cup-shaped. A line of separation is formed in the stem, and the bud falls off; a fresh bud then starts from the centre of the scar left by it on the stock, and the process is repeated. The fresh bud in its growth does not spread its attachment over the whole surface of the old scar, the margins of which persist only as a dead zone around its base. The line of separation of the successive buds does not correspond with that of the first, but is a short distance beyond it, hence the nurse stem which has thrown off several buds is transversely jointed in appearance. Some of the stems showed thus three rings (see fig. 273). Stutchbury imagined that

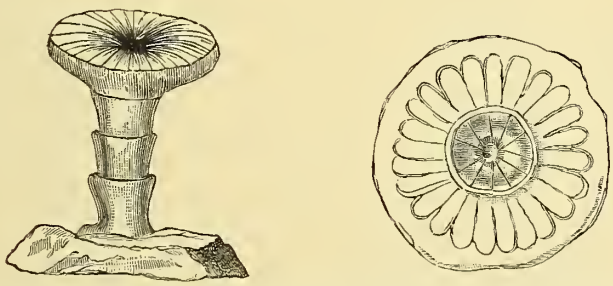


FIG. 273.—Diagram representing a Nurse-Stock of the Mushroom Coral (*Fungia*), and enlarged view of the scar left on the end of the stock when a young coral has become detached; a new one has just commenced to grow in the centre.

each mother-stock threw off only one bud, and then died; Semper showed that this was not the case, he speaks of three or four generations only being produced by each stock. Apparently the number produced is very limited. None of the stocks in my specimens were branched like Semper's specimen. A young coral bud just ripe, $1\frac{1}{6}$th inches in diameter, dropped off one of the stocks as I lifted the specimen from the water. Beneath it on the scar, another very small young *Fungia* had begun to bud out before its predecessor was quite free. The somewhat cup-shaped buds when set free, become by the direction in which future growth takes place, flat and disk-shaped and develop eggs, whence spring free-swimming larvæ, which start fresh stocks. The mass of nurse-stocks which I found was surrounded on the reef by a group of fully-formed Fungias of all sizes; I counted twenty in all. Some of these were small, and still showed the scar of attachment which disappears in the process of subsequent growth.

"A species of *Millepora* (*Millepora nodosa*, Esper) is a very common coral upon the Tahitian reefs. It forms irregular nodular masses usually of small size, and often encrusts

[1] Semper, Ueber Generationswechsel bei Steinkorallen, *Zeitschr. f. wiss. Zool.*, Bd. xxii. p. 271, 1872.

dead corals of other species. The tips of the lobes of the living coral are of a bright gamboge-yellow colour, which shades off into a yellowish brown on either side of the lobes. Mr. Murray succeeded in getting the polyps of the coral to expand under the microscope, and handed them over to me for examination. I found them, as Agassiz had discovered long before, to be Hydroids allied to the Medusæ, and not Actinozoa allied to sea anemones, like the majority of modern stony corals; I studied the structure of the coral minutely.[1]

"The hard part of the coral or calcareous skeleton is finely porous throughout, being excavated by a complex reticulation of fine and tortuous canals which are in the freest possible communication with one another. Within this porous mass at its surface are excavated cylindrical holes or pores of two sizes. The canal spaces in the skeleton are, when the coral is living, filled by a network of living tissue made up of a meshwork of branching and communicating tubes, which form a canal system, by means of which a free circulation can pass from one part of the coral to another.

"Two kinds of polyps inhabit the pores described as existing on the surface of the coral. The larger pores are occupied by short stout cylindrical polyps which have each four tentacles and a mouth and stomach, and which are hence termed 'Gastrozooids,' whilst their pores are termed 'Gastropores.' The smaller pores shelter each a very different kind of polyp, which has a long and slender sinuous body provided with numerous tentacles, and devoid of any mouth or stomach; this latter form of polyp, because its function is merely to catch food, is called a 'Dactylozooid,' and its pore a 'Dactylopore.'

"The dactylozooids catch food for the colony and deliver it to the gastrozooids, which alone are able to swallow and digest it. All the polyps of the colony are in communication at their bases with the canal system already described, and by means of these canals the nutritive fluids derived by the gastrozooids from the food are distributed to the entire colony and nourish it; there is thus a very complete division of labour in the colony.

"In all species of *Millepora* the mouth-bearing polyps are much less numerous than the mouthless ones. In some species the gastropores and dactylopores are scattered irregularly over the surface of the colonies. In the Tahitian species, however, they are for the most part gathered into definite groups or systems, each consisting of a centrally placed gastropore surrounded by a ring of five, six, or seven dactylopores, as shown in the accompanying figure (see fig. 274), where the circular groups of minute pores are seen scattered over the coral surface.

"Fig. 275 shows, much enlarged, a single system of polyps belonging to one of the pore systems, as it appears when the polyps are fully protruded from their pores and expanded. Beneath is seen shaded dark, part of the canal meshwork, which maintains the general circulation of the colony. From this stands up in the centre, the short

[1] For further details see H. N. Moseley, On the Structure of a Species of Millepora occurring at Tahiti, Society Islands, *Phil. Trans.*, vol. clxvii. pp. 117–135, 1877.

and stout gastrozooid with its four tentacles, dark stomach cavity seen through the walls of its body and its mouth at its summit. Around are grouped five dactylozooids, each with many tentacles, but without any mouth or stomach. One of the dactylozooids is seen bending over to feed the gastrozooid of the system.

"By far the most valuable discoveries, from a zoological point of view, with regard to the heterogeneous group which commonly goes under the name of 'corals,' made during the Expedition, were those which proved that the curious *Heliopora*, with its dark blue skeleton, to be an Alcyonarian allied to the precious coral of commerce, and the confirmation of the late Professor Louis Agassiz's results as to the Hydroid nature of *Millepora*. Not only were Agassiz's conclusions amply confirmed, but another family of Hydroid corals was discovered in the Stylasteridæ, until then believed to be allied to the

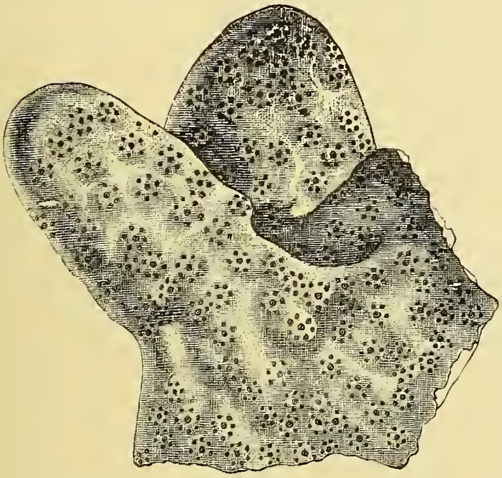


Fig. 274.—Portion of the hard coral skeleton of *Millepora nodosa*; twice natural size.

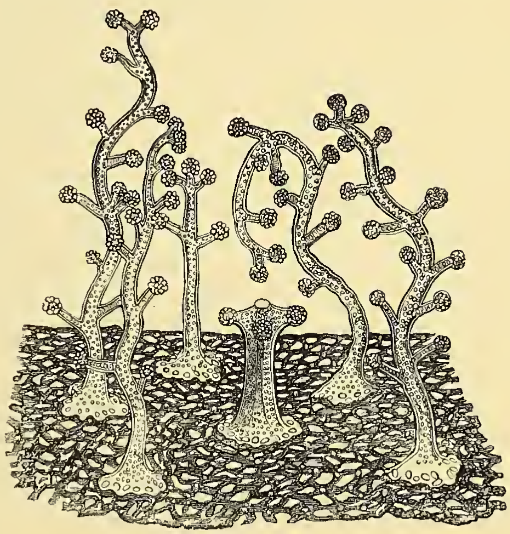


Fig. 275.—System of zooids of *Millepora nodosa* in the expanded condition. Single short gastrozooid in the centre surrounded by five elongate dactylozooids.

Oculinidæ, the members of which exhibit in their structure even more remarkable complexity than the Milleporidæ. *Heliopora*, the blue coral, was, until the voyage of the Challenger, always believed to be essentially similar in structure to ordinary Madreporarian corals, to have its tentacles smooth and non-pinnate, and to bear them in multiples of the number twelve. On examination of the soft tissues, however, it was found that *Heliopora* has eight pinnate tentacles only, and that all its structure conforms throughout with that of other Alcyonarians. *Heliopora* thus proves to be the sole modern survivor of a large series of massive Alcyonarian corals which flourished in the Palæozoic epoch, and its minute structure is of the greatest value, now that it is properly understood, as a guide to the elucidation of complications which occur in its ancestral allies.

"With regard to *Millepora*, some account has just been given of its structure and of the wide differences which separate it as a member of the Hydrozoa from the Aetinozoa. In a dredging off the mouth of the Rio de la Plata in 600 fathoms, six genera of the family Stylasteridæ, which, together with the Milleporidæ, form the group Hydrocorallinæ, were brought up at once in good eondition, and all but one with fully developed generative organs. An examination of this material soon showed that the Stylasteridæ, which had until then been placed amongst the Oculinidæ, are, like the Milleporidæ, Hydroids. In all of them there is an elaborate system of division of labour amongst the members composing the colonies. Some devoid of stomach eatch the food and hand it to

Fig. 276.—*Cryptohelia pudica*, M.-Edw. and Haime; twice the natural size.

others, the sole function of which is digestion for the general good, others again are generative zooids. The aeeompanying figure shows a stem of one these corals, *Cryptohelia pudica*, so called because, as will be seen in the drawing (fig. 276), it has a shield or lid in front of eaeh of the cups in whieh the polyps live conealed. The mouths of the cups are all turned to one faee of the stock. Eaeh of the small cups is notched all round its margin, and in eaeh notch is a grasping zooid (dactylozooid), whilst in the eentre of eaeh ring of dactylozooids is a stomaehzooid or gastrozooid whieh digests the food and distributes the produets all over the eolony by means of an elaborate system of canals. The generative or nursezooids lie embedded in the walls of the cups. In some Stylasteridæ the division of labour is even more complex than here.

"To return again to the Anthozoa, and amongst them to the Madreporaria. A great many beautiful corals new to science were dredged or trawled from great depths during the voyage, but as compared with the yield in the cases of many other animals, the result was but poor. The trawl net is not so well adapted as the dredge for bringing up solitary corals such as occur in the deep sea, and during the greater part of the voyage the trawl was used almost exclusively, because it was found to yield far better results on the whole.

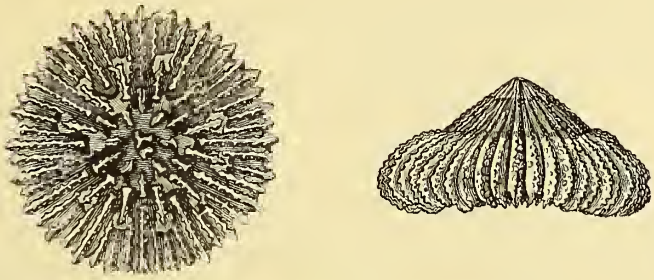


FIG. 277.—*Deltocyathus italicus*, Pourtalès; × 4.

"One of the most markedly beautiful of the deep-sea Madreporaria obtained is a Turbinolid, *Deltocyathus italicus;* it is rather small, and is shown in fig. 277 magnified. It is of special interest as being found as a Tertiary fossil in Italy. It was at first considered by the late Count Pourtalès to be distinct from the fossil form, but the access of abundance of material broke down the distinction relied on. A very curious

FIG. 278.—*Deltocyathus italicus*. Stellate variety of Pourtalès.

stellate or horned variety with a series of prominent spokes (fig. 278) is not uncommon amongst West Indian specimens, but the Challenger procured one only at Bermuda.

"*Deltocyathus magnificus* (fig. 279) is probably the most perfectly symmetrical Madreporarian existing; the interspaces between its radiating septa are almost absolutely equal, and the whole appears as if plotted out with a scale and compasses. It was dredged off the Ki Islands in 129 fathoms. *Odontocyathus coronatus* (fig. 280) is remarkable for having a saucer-shaped base formed by the springing out of root-like prominences below so as to form a support, a contrivance no doubt for preventing the animal being upset in the deep-sea mud; it has three well developed crowns of pali.

"*Stephanotrochus* is another new genus necessitated by the Challenger's discoveries.

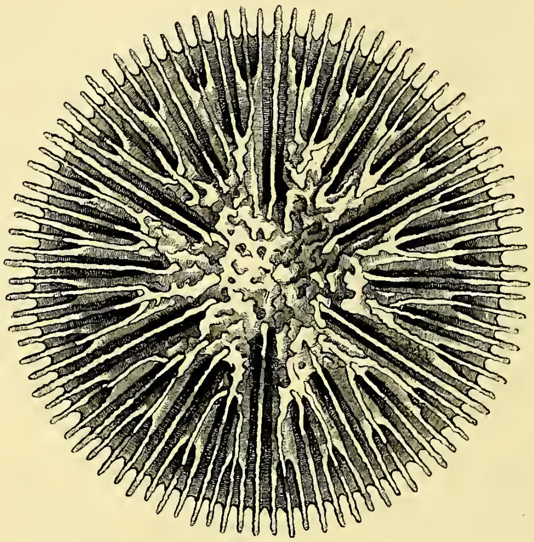


FIG. 279.—*Deltocyathus magnificus*, Moseley; × 2. From 129 fathoms, off the Ki Islands.

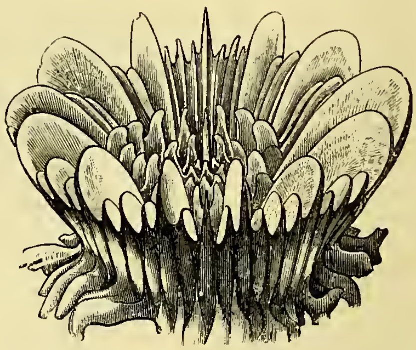


FIG. 280.—*Odontocyathus coronatus*, Moseley; × 2.

Several species were obtained of which two are here figured (figs. 281, 282). It was found to range from near Sydney, New South Wales, all over the Atlantic. Mr. John Murray has dredged it lately off the Scotch coast. *Stephanotrochus diadema* has the most widely patent calicle of the species of the genus, whilst *Stephanotrochus nobilis* has its calicular

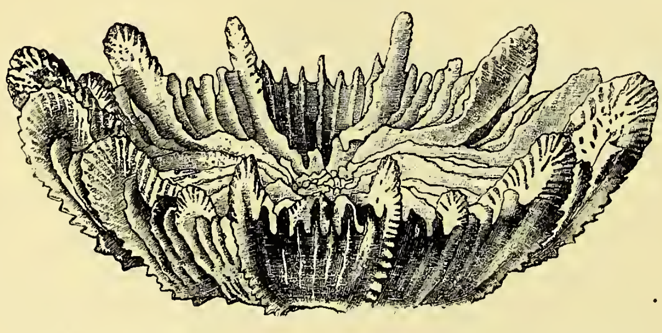


FIG. 281.—*Stephanotrochus diadema*, Moseley. Off Pernambuco, Brazil, 675 fathoms.

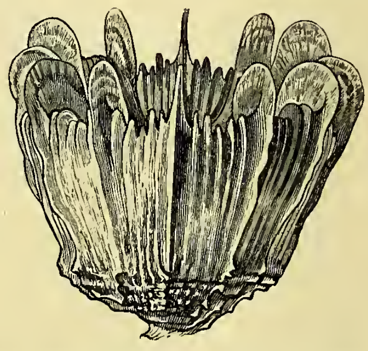


FIG. 282.—*Stephanotrochus nobilis*, Moseley. Off the Azores, 1000 fathoms.

wall most completely folded inwards round the mouth, but the two species are obviously closely connected.

" A great many species of *Flabellum*, a very widely spread genus, were obtained. The most remarkable amongst these, and the finest example of the genus, is *Flābellum* *alabastrum* (fig. 283), dredged off the Azores from 1000 fathoms. It measures when adult 65 mm. in breadth and 50 mm. in height. The coral skeleton is of a beautiful light pink colour, and is very thin and fragile. Two of the adult specimens obtained were alive when brought up, and expanded themselves in sea water, notwithstanding the depth from which they came. They have ninety-six tentacles disposed in cycles with

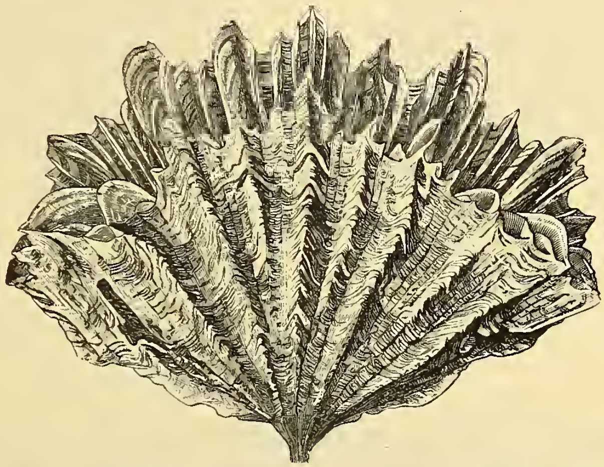


FIG. 283.—*Flabellum alabastrum*, Moseley; slightly enlarged. Off the Azores, 1000 fathoms.

perfect regularity. The colouring is remarkably bright for deep-sea animals: the tentacles are light red, and between their bases are stripes of yellowish red and pale greyish, the inner margin of the disk is of a dark madder colour, and the remainder of the disk pale pink. The madder colouring matter is a peculiar substance, "polyperythrin," which yields three distinct absorption bands in the spectrum, and which is widely

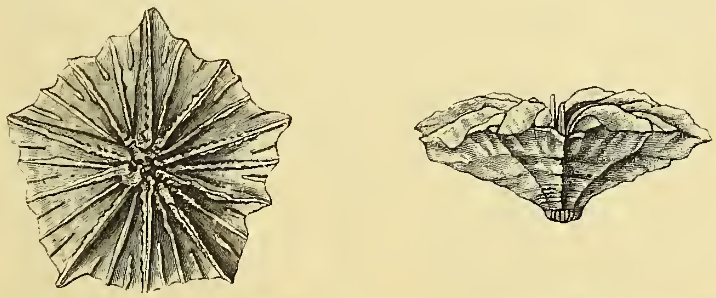


FIG. 284.—*Flabellum angulare*, Moseley; natural size. Off Nova Scotia, 1250 fathoms.

distributed amongst Cœlenterates, being found in many deep-sea Actinias and also in surface-swimming Scyphomedusæ. It is this colouring matter which gives the madder tint to the skeletons of all the Flabellums.

"*Flabellum angulare* (fig. 284) is a remarkable form nearly approaching *Desmophyllum*. It was dredged off Nova Scotia in 1250 fathoms. The specimen figured is obviously abnormal in its arrangement in fives. A specimen with the normal six systems has been dredged by the U.S.S. 'Blake.' *Flabellum apertum* (fig. 285) is interesting because it was dredged at two very distant localities, viz., off Portugal in 900 fathoms, and off Prince Edward Island in 310 fathoms.

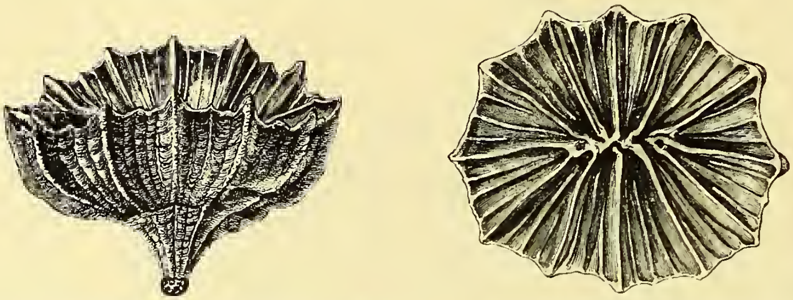


Fig. 285.—*Flabellum apertum*, Moseley; natural size. Off Prince Edward Island, 310 fathoms.

"The most abundant of the very few compound Madreporarian corals which inhabit deep waters is *Lophohelia prolifera* (fig. 286). It varies very much in form and mode of growth, and sometimes forms bushes of considerable size. It occurs in the Mediterranean

Fig. 286.—*Lophohelia prolifera*, M.-Edw. and Haime; three-fourths the natural size.

with Precious Coral (*Corallium rubrum*), off the English and Norwegian coasts in 100 fathoms or so, and all over the Atlantic, off Tristan da Cunha in the south, off

St. Paul's Rocks, off the West Indies in abundance; it is represented in the East Indian region by other allied species. One of the most remarkable instances known of world-wide geographical distribution in a deep-sea animal is the case of *Bathyactis symmetrica* (fig. 287), a solitary discoid coral provisionally placed with the Fungiadæ. This coral varies in the most remarkable manner in size and also greatly in structure. It was obtained of all intermediate sizes from a diameter of 3 mm. only to one of 40 mm., yet the series obtained was so large and complete that there can be no doubt that all the specimens belong to one species. It was further obtained from all depths intermediate between 30 fathoms, off Bermuda, and 2900 fathoms, in the East Pacific Ocean. From the latter locality some of the finest specimens were obtained, and these were crowded with ova and embryos in early stages of development. No relation could be established

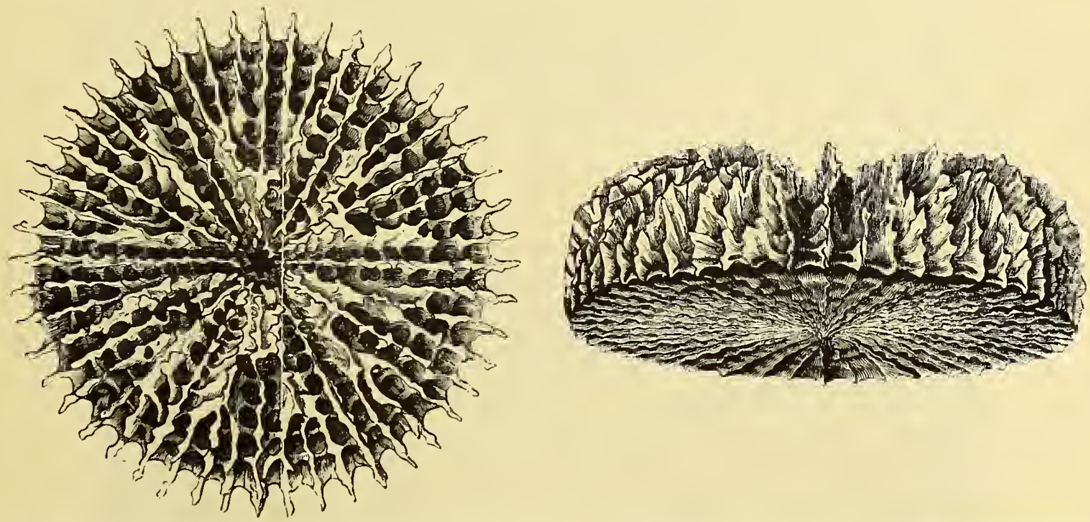


FIG. 287.—*Bathyactis symmetrica*, Moseley; three times the natural size. Dredged west of Tristan da Cunha Island, from 1900 fathoms.

between the temperature, nature of the bottom, or other physical conditions, and the size of the specimens. The coral was obtained frequently in both the North and South Atlantic, the South Indian Ocean, in the Malay Archipelago, in the West and East Pacific, off Japan, and off Juan Fernandez.

"A very interesting form from a palæontological point of view is *Stephanophyllia complicata* (fig. 288), which was dredged off the Ki Islands from 129 fathoms only. This coral is the close ally of the *Stephanophyllia* of the Chalk and Tertiary deposits. It apparently most nearly approaches *Stephanophyllia discoides* of the London Clay. The septa, which are nearly free and straight in the young coral, become most remarkably fused together at intervals laterally in the adult, giving the coral a curious honeycombed appearance. As far as is yet known, the genus *Stephanophyllia* survives only in this remote spot in the East Indies, its present locality being in no way connected with its former one in Europe.

"Probably the most beautiful of all Madreporarian skeletons is that of *Leptopenus hypocœlus* (figs. 289, 290), which was trawled not far from the island of Juan Fernandez

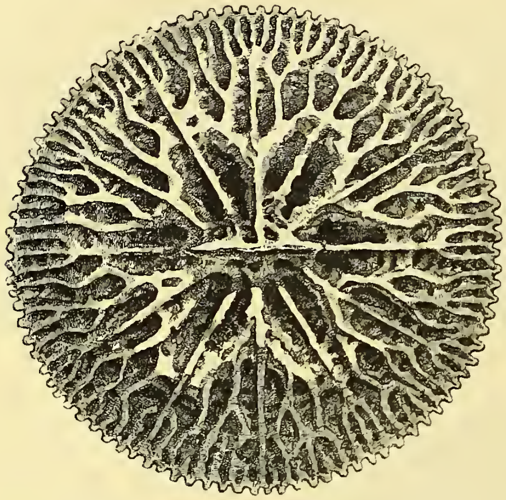


Fig. 288.—*Stephanophyllia complicata*, Moseley; × 3. From 129 fathoms off the Ki Islands.

from 2160 fathoms. The coral, together with another referred to the same genus, *Lepto-*

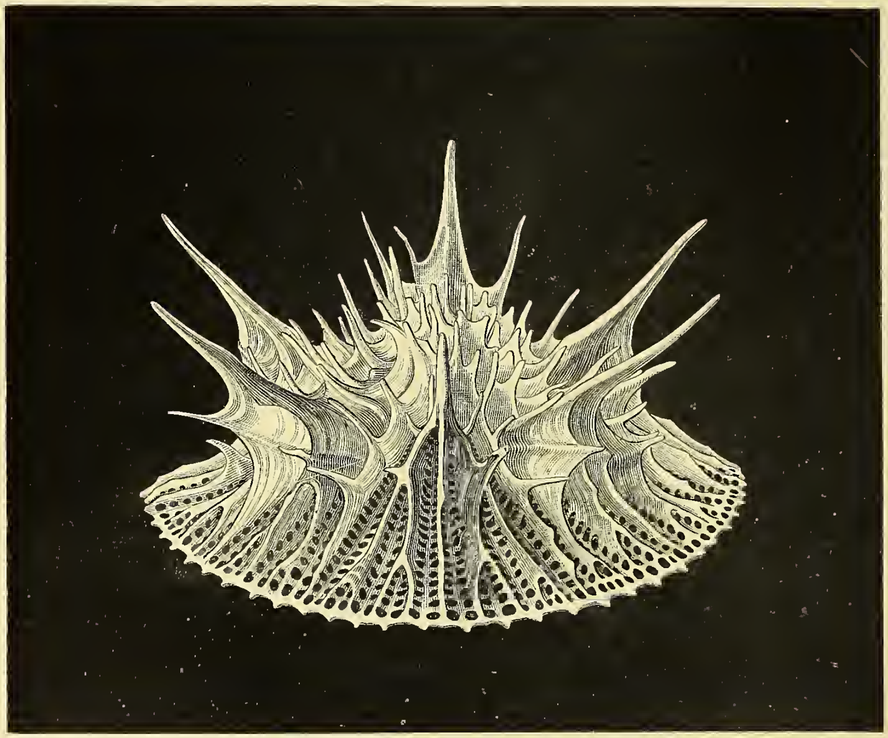


Fig. 289.—*Leptopenus hypocœlus*, Moseley. Off Valparaiso, 2160 fathoms. View from the side.

penus discus, has no living ally nearer than *Stephanophyllia*, and no extinct ally of it is known at all. Very possibly this may be due to the fact that the representatives of the genus *Leptopenus* are so extremely fragile, that only under the most favourable combination of circumstances could they become fossilized. The base of *Leptopenus hypocœlus* is bent upwards below so as to form a hollow cup, and thus rests only on its margin. It is perforated throughout like lace-work by a series of apertures arranged in radiating rows with perfect symmetry. From the margins of the septa a series of septal spines project which probably bore the tentacles in the recent condition of the animal. This,

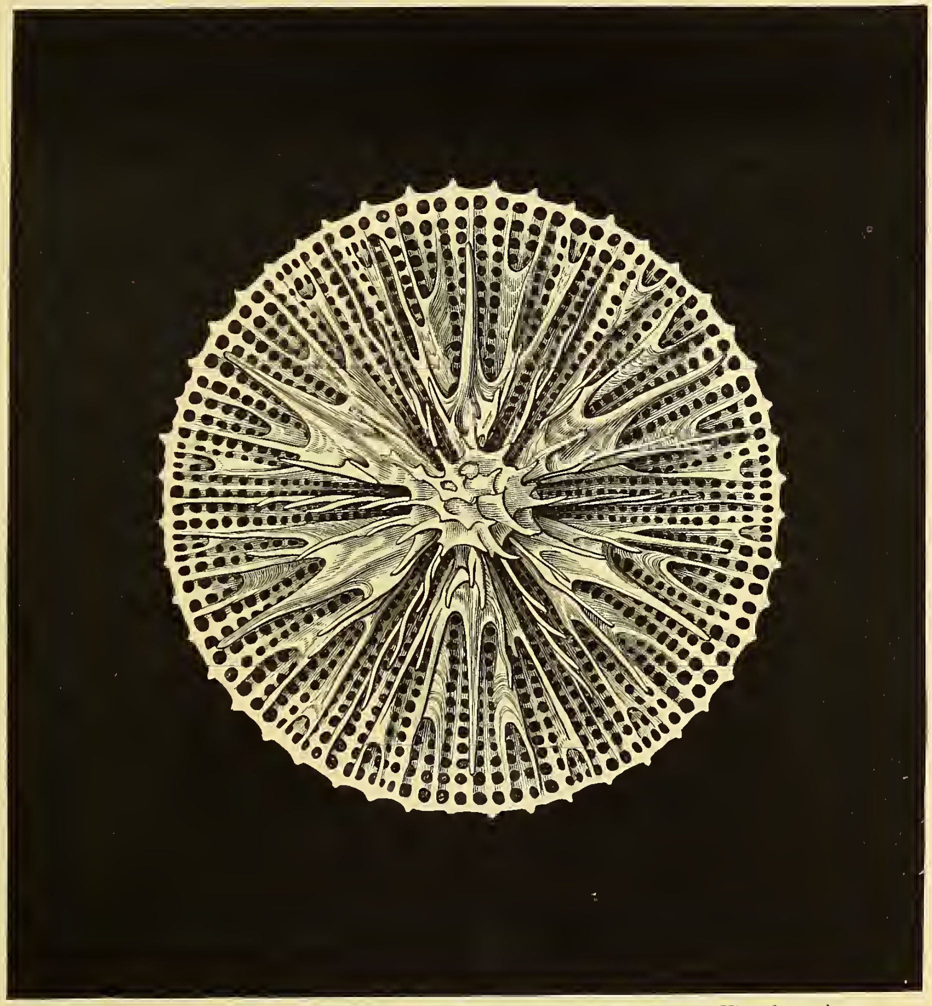


Fig 290.—*Leptopenus hypocœlus*, Moseley. Off Valparaiso, 2160 fathoms. View from above.

however, was not observed to be the case, as only a single specimen of the bare skeleton was obtained. It is most extraordinary that a skeleton of such extreme delicacy should have reached the surface unbroken. It was necessary to secure the coral in a glass box at once to protect it even during scientific examination.

"In some respects the results as to deep-sea corals have been disappointing. No forms of Madreporaria have been obtained which have exhibited any very important peculiarities in their anatomy or thrown any important light on their classification. Results seem to show that ancestral forms such as the Helioporidæ are to be sought rather in shallow water than in the abyssal zones. There are no representatives of the most characteristic of the Palæozoic Corals such as *Zaphrentis*, *Cystiphyllum*, *Stauria*, or *Goniophyllum* in the deep sea. Possible representatives of the Cyathonaxidæ have indeed been obtained in *Guynia*, described by Professor Martin Duncan, and *Haplophyllia* and *Duncania*, described by the late Count Pourtalès, but the Cyathonaxidæ are the least aberrant and characteristic members of the so-called *Rugosa*. Pourtalès justly felt doubtful whether the arrangement of the septa in four systems instead of six could in itself be considered as a criterion of the *Rugosa*, and in the cases of *Haplophyllia* and *Duncania* the septa may be described rather as devoid of any definite numerical arrangement than as exhibiting any tetrameral symmetry. Further, Mr. Moseley has lately examined, by means of sections, the structure of the soft parts of *Duncania* in a specimen provided by Mr. A. Agassiz for the purpose, and finds that with regard to the peculiar arrangement of the longitudinal septal muscles and the demarcation of the directive septa, the coral agrees essentially with the Hexactiniaria such as *Caryophyllia*, and all other modern Madreporaria, the anatomy of which has been adequately investigated."

CHAPTER XIX.

Tahiti to Juan Fernandez—Manganese Nodules, Sharks' Teeth, Zeolites, and Cosmic Spherules in the Deposits of the Central South Pacific—The Stomatopoda—Historical Account of Juan Fernandez—Physical Features—Botany and Zoology—The Nemertea—Juan Fernandez to Valparaiso—The Foraminifera—Valparaiso—The Copepoda and Ostracoda.

Tahiti to Juan Fernandez.

On the 3rd October the anchor was weighed and the ship steamed out of Papieté Harbour, the band playing the Tahitian National Air, a quick and lively jig which is characteristic of the place, and sets the Tahitians dancing at once; it is popular with the French also, and as the Challenger entered Valparaiso Harbour the band on board a French man-of-war struck up this tune as a greeting to recall the gaiety of the beautiful island left behind.

When outside Papieté Harbour the ship was swung to ascertain the errors of the compass and dipping needle, after which a southerly course was shaped to clear the baffling winds between Tahiti and Eimeo Islands, before sail was made. The ship stood to the southward until the trade wind was lost on the parallel of 22° S., when, picking up a fresh S.W. wind for four days, the vessel was steered to the S.E., and on the 10th October lat. 27° 39′ S., long. 142° 47′ W. was reached. The wind then shifted to the westward and northward, and the S.E. course was continued until the 14th, when the ship was in lat. 32° 36′ S., long. 137° 43′ W., from which position light southerly to easterly winds were experienced until the 40th parallel was crossed on the meridian of 133° W. The wind then varied from S.S.E. to S.W. and W. until the 29th October, and the ship stood to the eastward, keeping on the 39th parallel to the meridian of 113° W., when the wind shifted to W. and N.W. and then N.N.E. on the meridian of 100° W. Light easterly winds were then experienced for four days, after which northerly and north-easterly breezes prevailed until the ship arrived at Valparaiso (see Sheet 38). These northerly winds off the coast of South America were quite unexpected and were very unusual, the prevailing wind in the month of November being southerly.

The sounding and temperature observations were uniformly successful. The section has been divided into two parts:—1st, from Tahiti to the parallel of 40° S., and 2nd, from a position in lat. 40° 3′ S., long. 132° 58′ W., towards Mocha Island on the coast of Chili (see Diagrams 19 and 20).

The bed of the ocean from Tahiti to the parallel of 40° S. shows a descent to 2450 fathoms at a distance of 375 miles from Tahiti, then a rise to 2000 fathoms, and afterwards a gradual descent to 2600 fathoms, the mean depth being 2275 fathoms. From a position in lat. 40° 3′ S., long. 133° W., towards the coast of South America the bottom is undulating, varying from 2600 to 1500 fathoms, the mean depth being 2070 fathoms; these soundings seem to indicate the existence of a ridge along the bed of the ocean, stretching away from the South American coast on or about the 40th parallel of south latitude, but whether such a ridge does exist or not can only be ascertained by the slow process of deep-sea sounding.

The bottom temperature on the section from Tahiti to the 40th parallel varied from 34°·7 to 35°·4, the mean being 35°·0 or nearly the same result as between Tahiti and Japan, but from the position in lat. 40° 3′ S., long. 133° W., towards Mocha Island the range in the bottom temperature was 1°·2, notwithstanding which the mean result was 35°·0, or precisely the same as before. The results in the last section appear to confirm the existence of a ridge in this part of the Pacific, for it will be noticed that the temperatures obtained after the shoal cast of 1500 fathoms (see Diagram 20) agree remarkably well (35°·4), whilst between the two shoal casts of 1600 and 1500 fathoms they fall to 34°·5, being again warmer west of the 1600 fathoms sounding, where the temperature was 35°·2, indicating probably that the ship was south of the ridge between the two casts of 1600 and 1500 fathoms, and north of it during the remainder of the section.

In the section from Tahiti to the parallel of 40° S., the surface temperature changed gradually from 78° to 54°·5, and in the section towards Mocha Island remained at a temperature of 54°·5 from the meridian of 133° to that of 101° W., after which it gradually rose to 58°, and was 58° at Juan Fernandez and 59° at Valparaiso.

The serial temperatures show that in the section south from Tahiti, notwithstanding the change in the surface temperature from 78° to 54°·5, the isotherm of 40° remains at about the same depth (550 fathoms), but slightly deeper in the south than in the north. Above the isotherm of 40° the isotherms gradually rise as the surface temperature becomes lower. In the section from a position in lat. 40° 3′ S., long. 133° W., towards Mocha Island the isotherms are nearly parallel with the surface. The surface and consequently the upper temperatures are slightly higher in the eastern than in the western part of this section, but this difference is readily accounted for, not only by the advance of summer, but from the fact that polar winds with a northerly current were experienced in the western, and equatorial winds with a southerly current, in the eastern part.

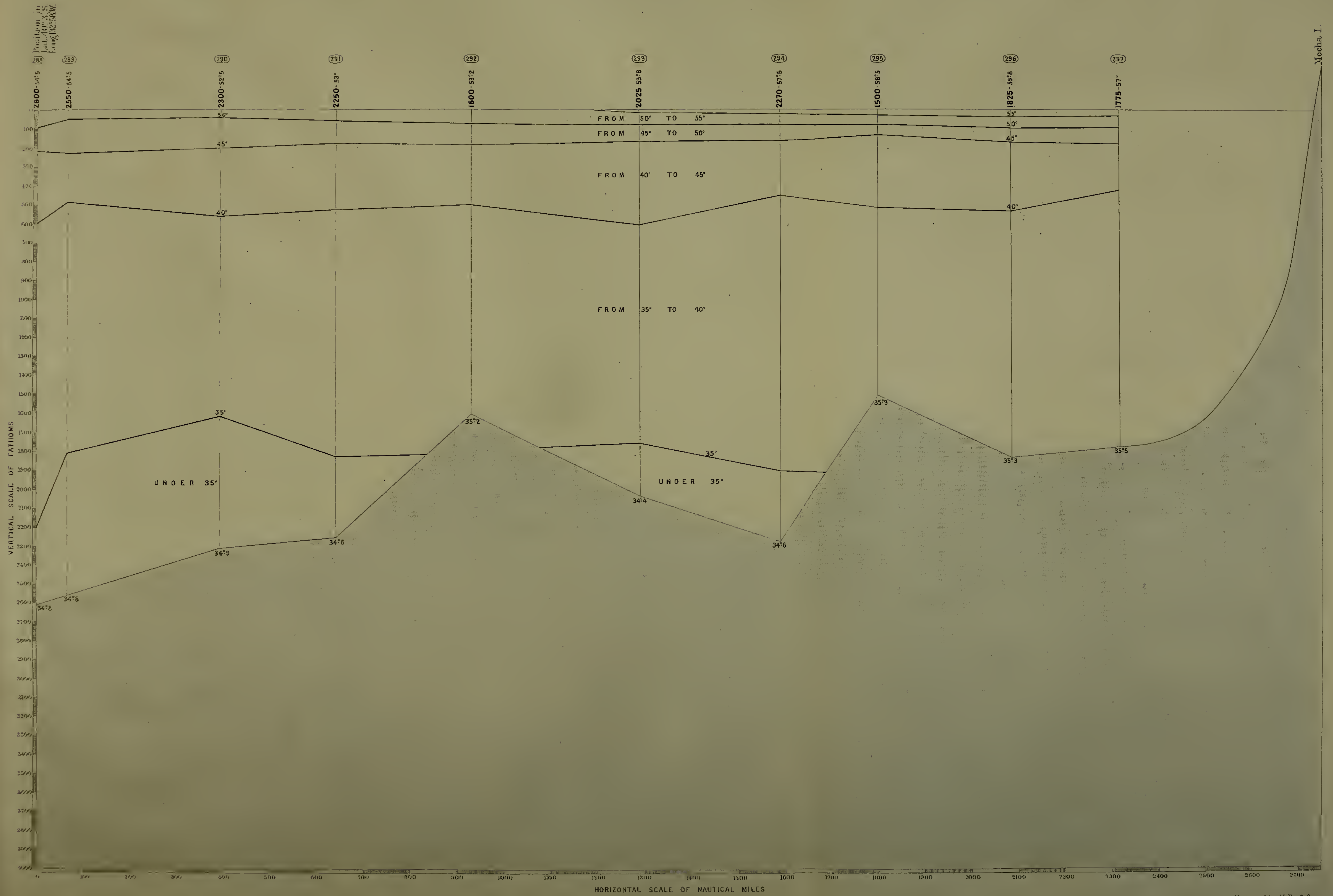
The currents on the passage were moderate, in no case exceeding 24 miles per day, the average rate being 11 miles per day, the direction of the current depending almost invariably on the direction of the wind.

Anemometer observations were taken on any favourable opportunity when the ship was stationary, sounding or dredging. The following table shows the results recorded:—

DIAGRAM 20

PACIFIC OCEAN. Longitudinal Temperature Section. From a Position in Lat. 40° 3'. S. Long. 132° 58'. W. towards Mocha Island.

For explanation of Symbols see Appendix 1.



Engraved by Malby & Sons

Date. 1875.	Station.	Velocity of wind in miles per hour.	Force of wind by Beaufort's scale, as noted in log.
October 6	281	13	2
,, 9	283	25	5
,, 11	284	7	1 to 2, mean 1½
,, 14	285	14	3
,, 19	287	14	2 to 3, mean 2½
,, 21	288	9	1 to 2, mean 1½
,, 25	290	17	3 to 4, mean 3½
,, 27	291	19	6 to 4, mean 5
November 1	293	24	5
,, 1	293	21	4 to 5, mean 4½
,, 5	295	9	1 to 2, mean 1½
,, 5	295	6	1
,, 9	296	22	5 to 6, mean 5½
,, 9	296	24	5
,, 11	297	3	0 to 1, mean 0½
,, 17	298	15	2 to 3, mean 2½

As might be expected from the undulating nature of the bottom, and the varying distance from land, the deposits presented considerable variety during the trip between Tahiti and Valparaiso. In all depths less than 2000 fathoms the deposit was a Globigerina ooze with over 50 per cent. of carbonate of lime, the highest percentage being 84 in 1600 fathoms. As the 40th parallel south was approached the purely tropical species of pelagic Foraminifera—such as *Globigerina conglobata*, *Sphæroidina dehiscens*, *Pulvinulina menardii*, var. *tumida*, *Pullenia obliquiloculata*—disappeared both from the surface waters and from the deposits at the bottom. At the depth of 1600 fathoms above referred to the deposit was chiefly composed of the following species, which were mostly dwarfed:—*Globigerina bulloides*, *Globigerina inflata*, *Globigerina dubia*, *Globigerina æquilateralis*, *Orbulina universa*, *Pulvinulina canariensis*, *Pulvinulina micheliniana*, and *Pulvinulina menardii*. There were a few fragments of Pteropods in one or two of the deposits from the shallower depths, but with this exception the shells of pelagic Mollusca were entirely removed from the bottom.

In depths greater than 2000 fathoms there was less than 50 per cent. of carbonate of lime, viz., 46 per cent. at 2075 fathoms, 26 per cent. at 2375 fathoms, still less in 2400 fathoms, and scarcely a trace in 2600 fathoms, thus showing a gradual diminution in the number of calcareous shells with increasing depth.

At several Stations the sounding tube had penetrated over a foot into the deposit, and on two occasions, viz., at 2025 and 2275 fathoms, there was much less carbonate of lime in the lower layers than in the upper ones, but on another occasion, in 2335 fathoms, the arrangement was the reverse of this, a red clay with only a few calcareous shells occupying the surface, and a Globigerina ooze with very many calcareous shells forming the deeper layers. There were very few remains of siliceous organisms in all these deposits, in which respect they are in marked contrast to the deposits of the Central and West Pacific.

The various dredgings and trawlings were successful with one exception, when the line parted and a trawl with 1600 fathoms of line were lost. The number of animals was not large. From 2550 fathoms there were several siliceous Sponges and Annelids, and two specimens of *Brisinga*, along with some Shrimps and a Scopelid Fish (*Bathypterois longicauda*, Günth.), which probably did not come from the bottom. In several trawlings in depths between 2000 and 2385 fathoms there were again several siliceous Sponges, a Holothurian (*Oneirophanta mutabilis*, Théel), *Hymenaster echinulatus*, Sladen, several Annelids and Hydroids, together with a few Fish and Crustaceans which probably came from intermediate depths. In depths less than 2000 fathoms animals were not much more abundant. The best haul was in 1825 fathoms, when seven specimens of larger animals were taken, including the following:—*Ophiomusium lymani*, Wyv. Thoms.; *Ophiotholia supplicans*, Lyman; *Cystechinus wyvillii*, A. Ag.; and *Polystomidium patens*, Hertwig. In addition to the animals here mentioned there were of course at all the Stations many Foraminifera living on the bottom—some attached to the nodules, some living in the mud, with either arenaceous or calcareous tests. There were many surface animals taken in the tow-nets during each day of the cruise, but the number of forms was much less than in the tropical waters.

By far the most interesting result of these trawlings and dredgings was the great number and variety of Sharks' teeth, bones of Cetaceans, manganese nodules, volcanic lapilli, and zeolitic minerals procured in all the greater depths. In these respects they resemble the trawlings between the Equator and Tahiti (see pp. 774, 775).

On the 6th October, from 2385 fathoms, there were over two bushels of manganese nodules, which were of two kinds, the one round with a concentric arrangement of layers, the other large slabs containing in the centre a volcanic tufa. There would appear to have been at this locality an old sea bottom of red clay, in which round manganese nodules had been formed, and then at a later date a fall of volcanic ashes, covering the bottom in some places to a depth of two inches. This fall of ashes, which was composed of layers made up of different sized particles, the larger particles forming the lower layer, seemed to have consolidated, to have undergone decomposition, and to have been subsequently broken up by some disturbance, after which a deposit of manganese peroxide was formed in the cracks and fissures and on the upper surface. Mixed up with these nodules were one hundred and sixteen Sharks' teeth, eleven referable to the genus *Carcharodon* and the remainder to *Carcharias*, *Oxyrhina*, and *Lamna*. One of the *Carcharodon* teeth was the largest taken during the cruise, and is represented in fig. 291. This tooth is hollow, and has a slight coating of peroxide of manganese on the outer and

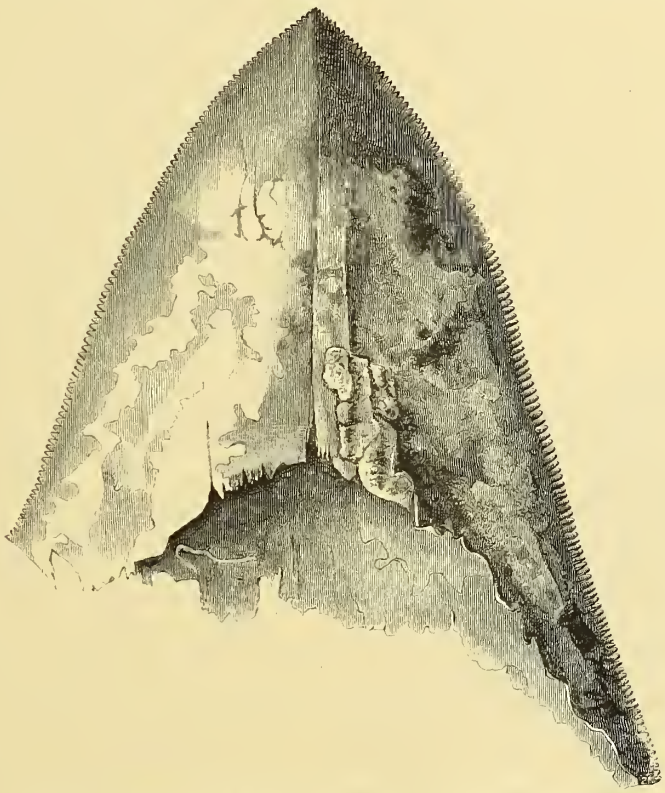


Fig. 291.—*Carcharodon megalodon*. 6th October 1875; 2385 fathoms.

inner surface of the hard dentine, which is indeed all that remains of the tooth. Mr. Murray compared this tooth with many fossil specimens in British and Continental Museums, and could detect no difference of importance between it and specimens of the *Carcharodon megalodon* found in the Tertiary deposits of many parts of the world; it is as large as, if not larger than, any of the fossil specimens preserved in collections. It is to be observed, however, that there is no large base to this tooth, as is usually the case with the fossil specimens. The tooth was covered on one of its surfaces by the branching Rhizopod, *Rhizammina algæformis*, Brady. The bones of Cetaceans consisted of six tympanic bones and three petrous bones, all belonging to the family of Dolphins.

On the 14th October, from 2375 fathoms, there were again over two bushels of manganese nodules, the great majority of which were in form like marbles, from one-fourth of an inch to one inch in diameter. The nuclei of the nodules were either fragments of sharks' teeth or fragments of bones, of palagonite, pumice, or other volcanic fragments. Fifteen hundred specimens of Sharks' teeth were counted from this haul, and in addition to these there were great numbers of small teeth and their fragments in the washings of the trawl and in the substance of the nodules themselves. In all these teeth the hard enamel-like dentine alone remained, the vaso-dentine and osteo-dentine having been removed and their place occupied by depositions of the oxides of manganese and iron mixed with clay. There were also forty-two petrous and tympanic bones, determined by Professor Turner as belonging to *Balænoptera*, *Balæna*, *Megaptera*, *Mesoplodon*, *Delphinus*, and *Globiocephalus*, together with ten or twelve fragments of bones without any definite shape, but apparently belonging to Cetaceans.[1]

On the 16th October, in 2335 fathoms, there was over a bushel of manganese nodules, Sharks' teeth, and bones of Cetaceans. Three hundred and forty Sharks' teeth, over half an inch in length, were counted, some of the largest *Carcharodon* teeth from this haul being over three inches in length. There were about ninety tympanic bullæ, and in addition to these many fragments, coated by, and imbedded in, peroxide of manganese; forty-two detached petrous bones were also obtained. Forty-two specimens also occurred which consisted not only of the petrous, but of a portion of the elongated mastoid element continuous with it. There were also two portions of beaks of a Ziphioid Whale, one being over eight inches in length. A number of fragments of flat bones, most of which were portions of the brain-case, though one or two might have been bits of the shaft of a rib, occurred. An irregular mass of spongy bone, 4 by 8 by 3 inches, consisted apparently of a portion of the expanded wing of a superior maxilla. There were also present many undeterminable fragments of bone, all apparently belonging to Cetaceans.

FIG. 292.—Petrous and tympanic bone of *Ziphius cavirostris*. 16th October 1875; 2335 fathoms.

On the 23rd October, in 2550 fathoms, there was again a large haul of manganese nodules with nuclei of palagonite, Sharks' teeth, and earbones of Whales. Of three large tympanic bones obtained here, one was 4 inches, another 3½ inches, and the third 3 inches in length. These were all thickly covered with nodulated depositions of peroxide of manganese; sufficient of this was removed to show that they were all bullæ of Whales of the genus *Balænoptera*. A large number of the nodules had bony nuclei, but the

[1] Zool. Chall. Exp., part iv. p. 40, 1880.

original characters of the bone had been completely obliterated. The Sharks' teeth in this haul were also deeply imbedded in manganese depositions.

On the 1st November, where the depth was 2025 fathoms and the deposit a Globigerina ooze, there were about a dozen nodules, two small Sharks' teeth, and in one of the nodules a fragment of bone.

On the 11th November, in Globigerina ooze, obtained from 1775 fathoms, there was over a gallon of rounded manganese nodules, the largest being about the size of a hen's egg; but there were no Sharks' teeth nor fragments of Cetacean bones, either separate or occurring as the nuclei of the nodules, which at this Station were formed around hardened portions of the ooze, or around volcanic fragments.

The association of Sharks' teeth, earbones of Cetaceans, manganese nodules, highly altered fragments of volcanic rocks, and cosmic spherules, all in relatively great abundance in the deposits from the greater depths of the Central South Pacific, is a matter of considerable interest, and some of the chief points connected with these materials may be referred to in some detail.

With respect to the earbones or fragments of other Cetacean bones, none were obtained in any of the dredgings north of the Equator either in the Atlantic or Pacific Oceans. In those south of the Equator, only one earbone was found in the blue muds surrounding continental shores, and this was in a depth of 2160 fathoms, over 100 miles from the coast of South America. These Cetacean bones are almost equally rare in the Globigerina oozes: from these deposits one bulla of *Ziphius* was dredged from 2275 fathoms in the South Atlantic; this was the only Cetacean bone procured in the Atlantic. A fragment was also dredged in 1900 fathoms 100 miles off the Cape of Good Hope, and another fragment from 2025 fathoms in the South Pacific.

All the other bones of Cetaceans procured during the Expedition were dredged from red clay or Radiolarian ooze in very deep water far removed from land. If Station 160, in the Indian Ocean, 488 miles southwest of Australia, where there was a depth of 2600 fathoms, and where six earbones were procured, be excepted, all the Stations where these Cetacean remains were found are situated in the South Pacific, in a region the farthest removed from continental land on the surface of the globe, of which Tahiti may be taken as the centre (see Sheet 1).

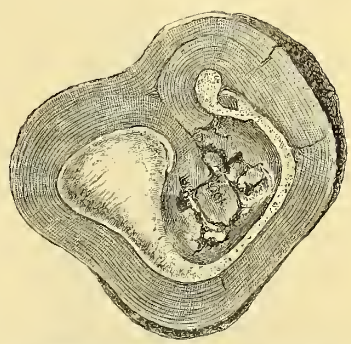


Fig. 293.—Section of a Manganese Nodule, showing a tympanic bone of *Mesoplodon* in the centre. 13th March 1874; 2600 fathoms.

It may be assumed that Whales are not more numerous in the regions where these remains have been dredged from the bottom, than in others where no bones of these animals were obtained by means of the dredge. Mr. Murray has pointed out that the abundance of the bones in some localities and rarity in others is most probably connected with the rate of accumulation of oceanic deposits. In deposits in more or less close proximity to continents and islands, they become covered over and imbedded in the detritus brought down from the land, and hence the chance of taking them in the dredge is small. The same is the case in the regions occupied by Pteropod and Globigerina oozes, where they become covered over and masked by the shells of pelagic Molluscs and Foraminifera. But in those red clay regions far removed from land, where the depth is too great for the calcareous surface shells to reach the bottom, they are not at all, or but slightly, covered up by, or mixed up with, other matters, and hence the dredge takes them in great numbers.

Some of the bones were in a much better state of preservation than others; in some the coating of manganese was very thin, and the Haversian canals and lacunæ were but little impregnated by that substance, so that a fractured surface was greyish white; in others, not only were the bones thickly encrusted, but the canals and lacunæ were nearly all infiltrated with the manganese, so that the fractured surface was brown or black, and the bones very brittle. The great majority of the large cancellated bones of the Whales appeared to have been removed from the deposits through the chemical action of the sea water. The chemical composition of those which remained was entirely altered, and this was more especially the case with the fragments of flat bones and others of a more porous texture (see Appendix V.).

The preservation of the earbones and of the fragments of the beaks of Ziphioid Whales is accounted for by the great density of these portions of the skeleton, and the consequent small amount of surface presented to the action of the sea water when compared with the cancellated bones. Professor Turner points out that he could not identify any of the bones as belonging to the Great Sperm Whale (*Physeter macrocephalus*), although the track of the Challenger, where such hauls of Cetacean bones were made, was through the part of the Pacific frequented by that huge Cetacean.

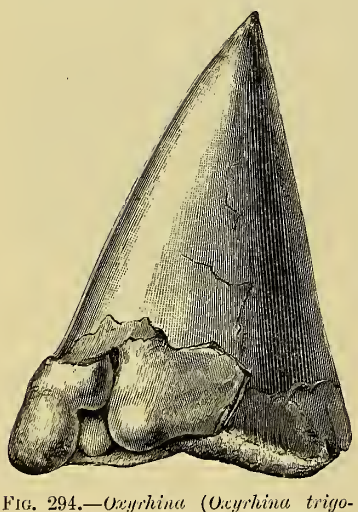


Fig. 294.—*Oxyrhina* (*Oxyrhina trigonodon*, Agass.) tooth. 16th September 1875; 2350 fathoms.

The Sharks' teeth, several hundreds of which, as stated above, were taken in a single dredging, have a distribution in the deposits similar to that of the bones of Cetaceans, although they were dredged more frequently. They are most abundant in the red clay areas far removed from land, and especially in those of the Central South Pacific; they were less frequently taken in the organic oozes of the deep sea, and only in one or two instances in the blue muds, green muds, and volcanic muds surrounding continental land or oceanic islands. As in the case of the bones of Cetaceans, the occurrence of these teeth in greatest abundance in the red clay areas of the abysmal regions, and their rarity in terrigenous deposits, is obviously connected with the more rapid accumulation of the latter, by which the teeth are covered up and the chance of the dredge bringing them up greatly lessened.

The cosmic spherules discovered by Mr. Murray in deep-sea deposits are likewise more numerous in the deposits of the Central Pacific than elsewhere, and their relative abundance in the deposits brought up in the various dredgings and trawlings is the same as in the case of the Cetacean bones and Sharks' teeth, and is to be explained in the same manner. These spherules have been recently more minutely examined by Messrs. Murray and Renard, who write :—

"It is known that the atmosphere holds in suspension an immense number of microscopic particles which are of organic and inorganic origin, and are either dust taken up by aerial currents from the ground or are extra-terrestrial bodies. A large number of scientific men, headed by Ehrenberg, Daubrée, Reichenbach, Nordenskiöld, and Tissandier, have studied this interesting problem, and have brought forward many facts in support of the cosmic origin of some of the metallic particles found in atmospheric precipitations.

"It is certain that serious objections may be raised against the origin of a large number of so-called cosmic dusts. In a great many cases it can be shown that these dusts are composed of the same minerals as the terrestrial rocks which are to be met with at short distances from the spot where the dust had been collected, and a cosmic origin can be attributed only to the metallic iron. It is somewhat astonishing, however, that no trace is ever found in these dusts of meteoric silicates, although in a great many meteorites it might be said that the iron is only accidentally present, while the silicates predominate. On the other hand, having regard to the mineralogical composition of meteorites, it appears strange that the so-called cosmic dusts should present characters so variable, from the point of view of their mineralogical composition, in the different regions where they have been collected. It might also be objected that even the iron, nickel, and cobalt could come from decomposing volcanic rocks in which these bodies are sometimes present, and this objection would seem quite natural, especially in this particular case, where there are numerous volcanic fragments in decomposition on the bottom of the sea. Again, according to numerous researches, native iron is found, although rarely, in various rocks and sedimentary layers of the globe. A reduction of the oxide of iron into metal might also be admitted under the influence of organic substances. It might still further be objected in opposition to the cosmic origin of the fine particles of native iron that they might be carried by aerial currents from furnaces, locomotives, the ashes of grates, and, in the case of the ocean, from steamers. All the materials of combustion furnish considerable quantities of iron dust, and it would not be astonishing to find that this, after having been transported by the winds, should again fall on the surface of the earth at great distances from its source.

"Such are the objections which present themselves when it is proposed to pronounce upon the origin of particles which are regarded as cosmic, and of which a short description will be here given. Many of these doubts will be at once removed by a statement of the circumstances under which cosmic spherules are found in deep-sea deposits, and it will be found also that all the objections are disposed of by showing the association of metallic spherules with the most characteristic bodies of undoubted meteorites.

"In the first place, the considerable distance from land at which cosmic particles are found in greatest abundance in deep-sea deposits, eliminates at once objections which might be raised with respect to metallic particles found in the neighbourhood of inhabited countries. On the other hand, the form and character of the spherules of extra-terrestrial origin are essentially different from those collected near manufacturing centres. These magnetic spherules have never elongated necks or a cracked surface like those derived from furnaces with which they have been carefully compared. Neither are the magnetic spherules with a metallic centre comparable either in their form or structure to those particles of native iron which have been described in the eruptive rocks, especially in the basaltic rocks of the north of Ireland, of Iceland, &c.

"Having referred to the objections, what can now be said in support of the hypothesis that many of the magnetic particles from the bottom of the sea, which are especially abundant in those regions where the rate of accumulation of the deposit is exceedingly slow, are of cosmic origin? If a magnet be plunged into an oceanic deposit, specially a red clay from the central parts of the Pacific, particles are extracted, some of which are magnetite from volcanic rocks, and to which vitreous matters are often attached; others again are quite isolated, and differ in most of their properties from the former. The latter are generally round, measuring hardly 0·2 mm., generally they are smaller, their surface is entirely covered with a brilliant black coating having all the properties of magnetic oxide of iron, often there may be noticed upon them cup-like depressions clearly marked. If these spherules are broken down in an agate mortar, the brilliant black coating easily falls away and reveals white or grey metallic malleable nuclei, which may be beaten out by the pestle into thin lamellæ. This metallic centre, when treated with an acidulated solution of sulphate of copper, immediately assumes a coppery coat, thus showing that it consists of native iron. But there are some malleable metallic nuclei extracted from the spherules which do not give this reaction. Chemical reaction shows that they contain cobalt and nickel; very probably they constitute an alloy of iron and these two metals, such as is often found in meteorites, and the presence of which in large quantities hinders the production of the coppery coating on the iron. G. Rose has shown that this coating of black oxide of iron is found on the periphery of meteorites of native iron, and its presence is readily understood when their cosmic origin is admitted. Indeed, these meteoric particles of native iron in their transit through the air must undergo combustion, and, like small portions of iron from a smith's anvil, be transformed either entirely or at the surface only into magnetic oxide, and in this latter case the nucleus is protected from further oxidation by the coating which thus covers it.

"One may suppose that meteorites in their passage through the atmosphere break into numerous fragments, that incandescent particles of iron are thrown off all round them, and that these eventually fall to the surface of the globe as almost impalpable dust, in the form of magnetic oxide of iron more or less completely fused. The luminous trains of falling stars are probably due to the combustion of these innumerable particles, resembling the sparks which fly from a ribbon of iron burnt in oxygen, or the particles of the same metal thrown off when striking a flint. It is easy to show that these particles in burning take a spherical form, and are surrounded by a layer of black magnetic oxide.

"Among the magnetic grains found in the same conditions as those just described are other spherules, which are referred to the *chondres*, so that if the interpretation of a

Fig. 295.—Black Spherule with Metallic Nucleus ($\frac{60}{1}$). This spherule, covered with a coating of black shining magnetite, represents the most frequent shape. The depression here shown is often found at the surface of these spherules. From 2375 fathoms, South Pacific.

Fig. 296.—Black Spherul. with Metallic Nucleus ($\frac{60}{1}$) The black external coatin of magnetic oxide has been broken away to show the metallic nucleus, represented by the clear part at the centre. From 3150 fathoms, Atlantic.

cosmic origin for the magnetic spherules with a metallic centre were not established in a manner absolutely beyond question, it almost becomes so when their association with the silicate spherules is taken into account. It will be seen by the microscopic details that these spherules have quite the constitution and structure of *chondres* so frequent in meteorites of the most ordinary type, and on the other hand they have never been found, as far as is known, in rocks of a terrestrial origin; in short, the presence of these spherules in the deep-sea deposits, and their association with the metallic spherules, is a matter of prime importance.

"Among the fragments attracted by the magnet in deep-sea deposits granules are distinguished slightly larger than the spherules with the shining black coating above described. These are yellowish brown, with a bronze-like lustre, and under the microscope, it is noticed that the surface, instead of being quite smooth, is grooved by thin lamellæ. In size they never exceed a millimetre, generally they are about 0·5 mm.

in diameter; they are never perfect spheres, as in the case of the black spherules with a metallic centre; and sometimes a depression more or less marked is to be observed in the periphery. When examined by the microscope it is seen that the lamellæ whieh compose them are applied the one against the other, and have a radial eccentric disposition. It is the leafy radial ('radialblättrig') structure, like that of the *chondres* of bronzite, which predominates in the preparations. The granular strueture of the ehondres of olivine is observed much less rarely, and indeed there is some doubt about the indications of thisl ast type of strueture. Fig. 297 shows the charaeters and texture of one of these spherules magnified 25 diameters. On aecount of their small dimensions, as well as of their friability due to their lamellar structure, it is diffieult to polish one of these spherules, and it has been neeessary to study them with reflected light, or to limit the observations to the study of the broken fragments.

"These spherules break up along the lamellæ, which are seen to be extremely fine

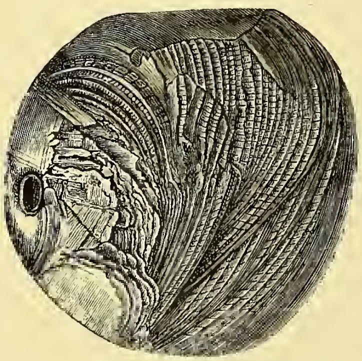


Fig. 297.—Spherule of Bronzite ($\frac{25}{1}$), showing many of the peculiarities belonging to chondres of bronzite or enstatite. From 3500 fathoms Central South Pacific.

Fig. 298.—A Lamella of the Spherule represented in fig. 297, highly magnified.

and perfeetly transparent. In rotating between crossed nicols they have the extinctions of the rhombie system, and in making use of the condenser it is seen that they have one optie axis. It is observed also that when several of these lamellæ are attached, they extinguish exaetly at the same time, so that everything seems to indicate that they form a single individual.

"In studying these transparent and very thin fragments with the aid of a high magnifying power, it is observed that they are dotted with brown-blaek inclusions, disposed with a eertain symmetry, and showing somewhat regular contours; these inclusions are referred to magnetie iron, and their presence explains how these spherules of bronzite are extraeted by the magnet. It is to be observed, however, that they are not so strongly magnetic as those with a metallie nucleus.

"They are designated bronzite rather than enstatite, beeause of the somewhat deep tint whieh they present; they are insoluble in hydrochloric acid. Owing to the small quantity of substance available, only a qualitative analysis could be made, which showed the presence in them of silica, magnesia, and iron.

"These remarks have been limited to these succinct details, but it is believed that enough has been said to show that these spherules in their essential characters are related to the chondres of meteorites, and have the same mode of formation. In conclusion, it may be stated that when the coating of manganese depositions, which surround Sharks' teeth, earbones of Cetaceans, and other nuclei, is broken off and pounded in a mortar to fine dust, and the magnetic particles then extracted by means of a magnet, these latter are found to be composed of silicate spherules, spherules with a metallic centre, and magnetic iron, in all respects similar to those found in the deposits in which the nodules were embedded."

Mr. Murray[1] has pointed out the large part played by volcanic débris and the products arising from its decomposition in the formation of deep-sea deposits, and the microscopic characters of these materials have been described by Messrs. Murray and Renard in more recent papers.[2] Since these volcanic materials were especially abundant in the deep water of the Central Pacific, and as they, owing to the slow accumulation of the deposits, have been long subjected to hydrochemical action, the chief peculiarities of the rocks and minerals brought up by the dredge in this region may be pointed out. At two Stations near the 38th parallel of south latitude, one or two fragments of granite, gneiss, and arkose were obtained, which fact seems to show that a stray iceberg may occasionally reach this low latitude. With the above exception all the rocks and minerals dredged from the Central Pacific were of volcanic origin. Pumice was present in all the dredgings, but the most abundant fragments belonged to the family of the basalts, and the majority of these belonged to the vitreous series of those basic rocks. Rarely some specimens contained hornblende and sanidine. The basaltic, generally vitreous, rocks are represented by fragments rarely exceeding a few centimetres in maximum diameter. From their form, their association with volcanic ash, and their lithological constitution, they cannot be considered as derived from lava flows spread over the sea bottom, but rather as fragmentary materials such as lapilli and volcanic ash, the accumulation of which at some spots on the floor of the Pacific appears to constitute submarine tuffs, which by their mode of origin probably resemble in many respects that attributed by Murchison and Ramsay to certain igneous beds regularly intercalated among the Palæozoic formations of the British Islands.

The fragments are usually incrusted with and infiltrated by peroxide of manganese,

[1] On the Distribution of Volcanic Debris over the Floor of the Ocean, &c., *Proc. Roy. Soc. Edin.*, vol. ix. pp. 247–261, 1877.

[2] On the Nomenclature, Origin, and Distribution of Deep-Sea Deposits, *Ibid.*, vol. xii. pp. 495–529, 1884; On the Microscopical Characters of Volcanic Ashes and Cosmic Dust, and their Distribution in Deep-Sea Deposits, *Ibid.*, pp. 474–495, 1884.

and frequently form the nuclei of manganese nodules. From the closeness of their grain, and the minute dimensions of their constituent elements, it is hardly possible to identify the fragments with the naked eye; a large proportion of the constituent minerals occur also in an advanced state of decomposition. By microscopic examination it is found that the fragments are usually referable to felspathic basalts and kindred rocks; in some olivine is quite absent or a little hornblende is present, or they pass into augite-andesites; in others intercalation of a vitreous base may be observed, these fragments forming a transition to rocks in which such a base is abundantly developed. In all these, two varieties of structure may be distinguished, the one compact, the other porous. Generally the plagioclases are the constituents which have most energetically resisted decomposition; the infiltrated manganese, the altered olivine, and the vitreous base transformed into red spots, render conspicuous the crystals of felspar which stand out glassy and colourless from the matrix in which they are imbedded. The felspars are usually in the form in which they occur in basalts, but sometimes are in the form of rhombic lamellæ.[1] Some sections of the bisilicate are augite, others are seen whose extinctions indicate a pleochroic rhombic pyroxene. The magnetic iron has the same features as this mineral assumes in the basalts. The olivine is the mineral in which the decomposition is most advanced; in some instances the mineral would not be recognisable except for the crystallographic outlines of its sections; generally they are transformed into a reddish brown matter in which the cleavage lines may still be observed, but these sections have lost their optical properties. The vitreous base, when present, is altered to yellowish red irregular spots enclosed between the felspars and augites.

The great majority of the vitreous fragments must be considered as lapilli which have undergone submarine hydrochemical alteration, such as Sartorius von Walterhausen has observed in the palagonitic tuffs of Sicily. These lapilli rarely consist of a homogeneous glass without interposition of crystalline constituents (see Pl. O, fig. 8). The dredged specimens are sometimes composed of single fragments, sometimes of several cemented together by chemical action after their deposition. The aspect of these fragments, when not transformed into palagonite, is a blackish brilliant iridescent homogeneous glass. Thin slices under the microscope show crystallites and crystals of olivine, lamellæ and rhombic plates of plagioclase, crystals of augite, and rarely magnetic iron. The vitreous substance has seldom preserved its original characters; it is almost always transformed into a brownish red matter at the edges. The grains which have undergone this modification are the same as those described by Darwin, Von Walterhausen and Bunsen as forming the incoherent volcanic masses designated palagonitic tuffs. The fracture is resinoid with greasy lustre, and when the specimens were taken from the sea, the palagonitic matter could be cut away with a knife like new cheese. The different phases of decomposition show themselves from the circumference to the centre

[1] *Proc. Roy. Soc. Edin.*, vol. xii. p. 482, 1884.

as concentric zones of different colours frequently giving the fragment the aspect of certain agates. The hydrochemical change has in some instances proceeded so far that the vitreous matter has totally disappeared, but frequently the glass still occupies the centre of the lapilli. The decomposition and disintegration of these vitreous matters result in an argillaceous residue which forms a large part of deep-sea deposits. Wichmann has pointed out that a similar reddish clayey matter results from the decomposition of the vitreous basic rocks of the island of Futuna, one of the Tongu Islands. The hydrochemical action which results in the formation of zeolites at the bottom of the sea is probably the most interesting of all. A very large number of the volcanic fragments present under the microscope remarkable examples of the development of zeolitic minerals. Between the granules of vitreous and basaltic rocks in most of the nodules are colourless bands composed of small prismatic crystals. These cement the lapilli, are attached at one end and arranged in tufts; they protrude to meet those which advance from the next fragment, and at the point of union the heads of the crystals become interlaced, forming a serrated line often distinctly marked by infiltration of manganese. When these crystals fill the vesicular pores of a rock fragment the terminal faces are always turned towards the inside of the cavities; frequently the crystals are not fixed directly to the wall of the pore or fissure, but are separated from it by one or two zones of reddish brown or yellow-green matter (see Plate O, fig. 12).

In addition to the zeolitic crystals found in the fragments of altered rock, there are microscopic crystals and zeolitic spherules in the clay itself. The spherules are fibro-radiated, appear to the naked eye like whitish vitreous granules covered with manganese and iron oxides; their diameter is about 0·5 mm., under the microscope their surfaces are seen by reflected light to be crowded with the extremities of the crystals, the faces of which are exactly the same as those of philipsite, faces of a rectangular prism terminating in a summit with four lozenge-shaped faces which rest on the edges of the prism. Chemical analysis shows that these spherules have the composition of philipsite. Although the greater number of the crystal spherules are formed by the irregular grouping of prisms diverging from a centre, they are sometimes composed of a smaller number of crystals which cross each other with such regularity that they must be looked upon as twin-crossed crystals, so common in the case of philipsite. Associated with the spherules and cross-twinned crystals are smaller crystals of the same species; some are so small that even with the highest magnifying power they appear as small lines; the crystals are often obscured by particles of manganiferous clay, but when these are removed by hydrochloric acid the form of the crystal becomes more apparent since a siliceous skeleton remains. At a few Stations these crystals and crystal balls make up nearly a third of the deposit.

It may be stated generally, that the manganese-iron nodules, which have been so frequently referred to in the course of this Narrative, occur more frequently and abundantly in the deep deposits of the Central South Pacific than elsewhere, a fact which appears to be associated with the larger quantity of volcanic débris belonging to the basic series of rocks, which is in this region spread out on the floor of the ocean, and

Explanation of Plate O.

Fig. 1. Crystals of philipsite seen by reflected light ($\frac{20}{1}$). These spherules are the most frequent form in which zeolites are formed in the deep-sea clays of the Central Pacific. The crystals are irregularly grouped, and have a fibro-radiate arrangement. At the periphery the four faces of the octahedron surmounting the prism are seen; this is more clearly shown in fig. 3. South Pacific, 2350 fathoms.

Fig. 2. Section of pumice showing the infiltration of manganese in all the pores of the rock; at the lower part of the figure sections of augite and plagioclase are seen. South Pacific, 1350 fathoms.

Fig. 3. Twinned crystal of philipsite ($\frac{20}{1}$), frequently found in the deposits, and characteristic of this species of zeolite, as seen by reflected light. South Pacific, 2350 fathoms.

Fig. 4. Volcanic ashes, composed of fragments of hornblende, plagioclase, grains of magnetite, vitreous particles, cemented by infiltration of manganese ($\frac{220}{1}$). The mass formed the centre of a manganese nodule. South Pacific, 2385 fathoms.

Fig. 5. Nodule of manganese formed on the tooth of a Shark (*Carcharodon*), half natural size. South Pacific, 2750 fathoms.

Fig. 6. Section of a zeolitic spherule resembling that represented in fig. 1, showing the fibro-radiate disposition and termination of the heads of the crystals, as well as the zones of increase ($\frac{112}{1}$). The reddish matter which colours the spherule at the periphery is due to the oxides of iron and manganese. The spherule is surrounded by argillaceous matter.

Fig. 7. Section of a lapillus of sideromelan ($\frac{112}{1}$). The brown portion is a volcanic glass with numerous crystals of felspar, augite, and hornblende, which is not yet decomposed. The reddish brown portions which contain the same crystals as the brown glass are decomposed and present the resinous characters of palagonite. The sideromelan is perfectly isotropic, while the palagonite affects the light between crossed Nicols. South Indian Ocean, 2600 fathoms.

Fig. 8. Microscopic section of a nodule of manganese ($\frac{24}{1}$). The figure shows several concretionary centres; in the upper part the iron-manganiferous matter is seen disposed in irregular zones around a fish tooth; a second centre is a decomposed fragment of basaltic rock. The figure also shows the usual concretionary zones present in the nodules. South Pacific, 2375 fathoms.

Fig. 9. Fragment of rounded pumice such as is usually present in the deposits, cut so as to show the zone of decomposition which surrounds the specimen; the vitreous matter at the periphery becomes very friable and impregnated with peroxide of manganese. South Pacific, 2050 fathoms.

Fig. 10. Section of a lapilli of augite-andesite, composed of lamellæ of plagioclase, augite, and magnetic iron ($\frac{60}{1}$). The external zone is covered with a coating of manganese. South Pacific, 2350 fathoms.

Fig. 11. Nodule of manganese formed round a Shark's tooth; the upper part is removed to show the situation of the tooth, one-half natural size. South Pacific, 2385 fathoms.

Fig. 12. Section of palagonitic lapilli cemented by bands of crystals of philipsite and manganese-iron infiltration ($\frac{112}{1}$). South Pacific, 2350 fathoms.

Fig. 13. The figure shows the two halves of a manganese nodule. The one to the right has been treated with hydrochloric acid to eliminate the oxides of iron and manganese, and shows the framework of the nodule, consisting chiefly of clayey matter; the one to the left shows the ordinary appearance of the nodule in section. South Pacific, 2900 fathoms.

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Deep Sea Deposits.

has undergone profound alteration from the long time it has been exposed to the hydrochemical action of sea water. For analyses of these manganese nodules see Appendix V.

It appears then that Shark's teeth, bones of Cetaceans, cosmic metallic spherules and chondres, highly altered volcanic fragments, manganese nodules, and zeolites occur in greatest abundance in the abysmal red clay regions of the Central South Pacific, at that part of the earth's surface farthest removed from continental land. All these substances occur in the other deposits, but owing to the abundance of other materials present in the more rapidly forming deposits, they are covered up and masked, and the chance of obtaining them in the dredge is greatly reduced; they are probably also in some degree protected in these latter deposits, from the hydrochemical action of sea water. They are less abundant in the Radiolarian oozes than in the red clays, are still less so in Globigerina, Diatom, and Pteropod oozes, and have been dredged in only a few instances in the terrigenous deposits which surround the shores of continents and islands. A few analyses of the bones, teeth, nodules, and deposits referred to above, are given in Appendix V., and fuller details will be given in the forthcoming Report on Deep-Sea Deposits.

The Stomatopoda.—Professor W. K. Brooks of Baltimore, who is engaged in the preparation of a Report on the Stomatopoda collected by the Expedition, contributes the following note:—"The general collection of adult specimens is of very little interest, as it contains nothing except well known species, but the surface collections of larvæ are of great value, and they are sufficiently complete to furnish the material for a very exhaustive account of the metamorphoses, although it is impossible to give an intelligible description of them without illustrations.

"The group Stomatopoda is a very compact one, and the adults are almost exactly alike in general structure, differing from each other only in minor points. Contrary to the general rule, however, the larvæ are much more different from each other than the adults. Instead of closely resembling each other at first and gradually changing as they approach maturity, the various species hatched from the egg as larvæ differ from each other in many important features, and become more and more alike as they develop.

"All the Stomatopod larvæ are pelagic animals, and many of them have been collected by explorers, and have received distinct generic names, as adults.

"The Challenger surface collections contain hundreds of specimens of these larvæ, at all stages of growth, and thus furnish the material for a thorough revision of this subject, showing that there are four quite distinct types of larval development, each of which is represented by several hundred specimens.

"I have at present been able to make a thorough study of only one of these, the Erichthus type. This is very fully represented in the collections, from a stage younger than the youngest figured by Claus and Faxon, up to a free-swimming animal with very nearly the structure of the adult. The youngest larva is a little Nauplius-like form, with sessile eyes, and a rounded body, but with rostrum and spines and five pairs of schizopod feet, in addition to the mouth parts and antennæ. This passes into a form like the youngest Erichthus figured by Faxon, and from this point onwards there are two quite distinct lines of development, each of which is represented in the collections by larvæ of two or more species. One line leads through the Erichthus, Erichthoidina, and Squillerichthus stages to the adult, and is, in all probability, the primitive or ancestral mode of development, while the other line presents a much more accelerated history, and leads from the Erichthus stage to a Squilla-like form, very similar to the Alima larva.

"The Alima type of development is also represented by two series, each of which is represented in the collections by the larvæ of several species. I have not yet been able to study this type thoroughly, but one series is much more accelerated, and less like the Erichthus type than the other; and the collections seem to show that the abridged metamorphosis has been produced by modification of the more primitive and ancestral Erichthus series.

"I think too that the collections prove that the Squilla larva is a modified Protozoœa, and that the Stomatopods and Decapods have had a common origin. They also furnish several examples of the disappearance and subsequent re-development of appendages in the course of the metamorphosis."

Juan Fernandez.

On the 13th November, at 9 A.M., the island of Juan Fernandez was sighted ahead, and the vessel passed round its east point at 4.30 P.M., anchoring in Cumberland Bay at 6 P.M. in 30 fathoms, with the point on the N.W. side of the bay N. 36° W., Fort Flag S. 70° W., and the left extremity of the land N. 80° E.

The island of Juan Fernandez,[1] sometimes called "Mas-a-tierra" by the Spaniards, was discovered by a Spanish pilot of that name in 1563, as was also the island of Mas-a-fuera, 90 miles to the westward. The discoverer obtained from his Government a grant of the island, on which he resided some time importing goats and pigs, but he afterwards abandoned his possession. It was however frequented by Spanish fishermen from the coast of Peru shortly after its discovery, as the sea in its neighbourhood was found to be well stocked with fish of all kinds.

In 1616 Le Maire and Schouten called at Juan Fernandez on their voyage round the world, and laying to off its west side, watered their ships and caught numerous fish, principally Bream. At this time there were both goats and pigs on the island.

On April 4th, 1624, the Nassau fleet, under the command of Admiral Jacob

[1] Burney's Voyages, vol. i. p. 274, London, 1803; *Proc. Geogr. Soc.*; *Naut. Mag.*; Voyage of Capts. Edward Cooke and Woodes Rogers; Ulloa's Voyage to South America; Noticia Secretas de America; Morrell's Voyage; History of Chili, by Ignatius Molina, &c.

l'Heremite, anchored in a bay on the northeast side of Juan Fernandez, probably in Cumberland Bay. The anchorage was on a steep bank of rock and sand, and the depth was so great that it was necessary to approach the shore within half musket shot to obtain soundings of 30 to 34 fathoms. Some of the vessels anchored first in 80 to 90 fathoms, and then warped closer in. The valleys adjacent to the anchorage were covered with herbage, and the fresh water was excellent. Fish, Fur Seals, and Elephant Seals (*Morunga elephantina*), the latter being called "Sea Lions" by all the voyagers, including Anson, who figures them, were abundant, and many were killed. The flesh of the Elephant Seals when roasted and with the fat cut off was considered by some of the men equal to mutton, but others would not eat it. Goats were seen, but were difficult to approach. Sandalwood was growing in great quantity, and near the anchorage were some wild quince trees. Three soldiers and three gunners of the Vice-Admiral's ship remained behind when the fleet left on April 13th. What became of them is not known, as from 1624 to 1680 little or nothing is known of the island.

On Christmas day 1680, the buccaneer Sharp anchored in a bay on the south side of Juan Fernandez Island, but finding that the winds at that season of the year prevailed from the southward, he shifted round to a bay on the north side of the island, where he moored his vessel with one anchor in 14 fathoms and a hawser fast to the trees on shore, the land extending from E.S.E. round by S. and W. to N. by W. Sharp must therefore have anchored in Cumberland Bay. Owing to the strong gusts from the hills the vessel parted from her moorings twice and was forced to sea, but each time recovered the anchorage without difficulty. At the time of Sharp's visit the island was much frequented by Fur Seals and Elephant Seals, whose noise and company were troublesome to the men employed in watering. Fish were plentiful, and innumerable Sea Birds had their nests on shore. Cray-fish (a large *Palinurus*) were abundant, and Wild Goats so numerous that a hundred were salted down in addition to those killed for present use. Whilst employed refitting his ship, Sharp was surprised by three armed Spanish vessels approaching the island, upon which all the men employed on shore were recalled, the cable slipped, and they put to sea, but in the hurry of quitting the island one of the Mosquito Indians, named William, was left on shore, and circumstances prevented his being rescued. William remained on the island until March 1684, when another buccaneer named Cook called in for refreshments, in whose vessel were several men who had formerly served with Sharp. Anxious to discover whether their old shipmate yet survived, a boat was quickly despatched to the shore, in which were Dampier and a countryman of William's named Robin, and as they drew near the land they had the satisfaction of seeing William standing on the beach. The interview between the two Indians was very affectionate, and his old shipmates were glad to welcome William again after his long residence in solitude, for although in the interval several Spanish vessels had visited Juan Fernandez, William had always concealed himself. When first left on the island, William had a musket, a knife, a small horn of powder, and a few shot. When his ammunition was expended, he contrived by notching his knife to saw the barrel of his gun into small pieces, which he made into harpoons, lances, hooks, and a long knife by heating the iron and hammering it out with stones. His clothes were soon worn out, and he clad himself with a skin about the waist. From the skins of Seals he manufactured fishing lines, and built himself a hut half a mile from the shore which he lined with goat skins.

At the time of Cook's visit in 1684, the buccaneers found a good supply of provisions, consisting of wild vegetables, Goats, Fur Seals, Elephant Seals, and Fish. Pigs are not mentioned.

At the end of 1687 five men voluntarily remained at Juan Fernandez from another buccaneer ship commanded by Captain Edward Davis. A canoe, arms, ammunition, and various implements were furnished them, together with a stock of maize, and each buccaneer had a negro attendant landed with him. They remained on the island until October 1690, when the English ship "Welfare," Captain John Strong, anchored there and took them off. Nothing is said of the manner in which they employed themselves, except that they lived in subterranean places and had tamed a large number of goats. When they landed first, dogs are reported to have been placed on the island by the Spaniards with a view of destroying the goats, but as mention is made by Dampier in 1704 that there were then no dogs, it is probable that these five buccaneers had managed to exterminate them.

In February 1704 Dampier called at Juan Fernandez, and whilst there, Captain Stradling of the "Cinque Ports Galley" quarrelled with his men, forty-two of whom deserted, but were afterwards reconciled by Dampier; five seamen however remained on shore. In October 1704 the "Cinque Ports Galley" returned to Juan Fernandez and found two of these men, the others having apparently been captured by the French.

During this visit, Captain Stradling had some disagreement with the master of his ship, Alexander Selkirk, who in the first heat of his dissatisfaction demanded to be landed, preferring to be left on a desert island rather than remain any longer under the command of Stradling. His desire was complied with and he was sent on shore with his clothes, bedding, a firelock, one pound of gunpowder, a hatchet, cooking utensils, some tobacco, and his books. Before the ship departed Selkirk changed his mind and desired to return on board, but was refused admittance into the ship. Selkirk remained at Juan Fernandez until February 1709, when Captain Woodes Rogers in the ship "Duke" called at the island and found him there. Captain Rogers was accompanied by another vessel named the "Duchess," commanded by Captain Edward Cook, and they both wrote accounts of their voyage, and gave a description of Selkirk's residence on shore.

During Selkirk's stay of four years and four months, several ships passed by the island but only two anchored, and these being Spanish, their crews shot at him and pursued him into the woods, where he managed to conceal himself in a tree. When first left on shore by Stradling, Selkirk was successful in providing food and lodging for himself, and built two huts which he covered with long grass and lined with goat skins, one of which was used as a kitchen, and the other to sleep in. When his gunpowder failed, he was obliged to catch the goats by speed of foot, and this he was soon enabled to do, for his mode of living and continual exercise in running and walking, kept him in such an excellent state of health that he could outstrip the goat in swiftness, and was quite as surefooted. His agility in this pursuit once nearly cost him his life, as he ran with so much eagerness that he caught hold of the animal on the brink of a precipice, which was hidden by bushes, and fell with the goat from a great height, being so stunned and bruised with the fall that he lay prostrate twenty-four hours before he could crawl back to his hut, and probably would have been killed outright had he not fallen on the goat. Besides goats, he had in the season plenty of good turnips, which were sown there by Captain Dampier, and cabbage from the Cabbage Tree. His meat he seasoned with the fruit of the Pimento[1] and with a black pepper called "malagueta," which he found an excellent stomachic.

At first Selkirk was much distressed by the want of bread and salt, but at length grew accustomed to do without them. Salt he might easily have procured had he wished, for the buccaneers in 1687 supplied themselves with that condiment by making salt pans near the seaside, and it is surprising that Selkirk did not follow their example. He soon wore out his shoes and clothes, and after a time, by being accustomed to shift without the former, his feet became so hard that he felt no inconvenience from their absence. Goat skins furnished him with clothes, the pimento wood with fire by friction, and taming some kids with amusement. He describes the climate as excellent. The winter lasts but two months (June and July), and the trees and grass are verdant throughout the year. The residence of Selkirk on the island, together with the accounts of the Mosquito Indians and buccaneers, furnished Daniel Defoe with materials for the construction of his celebrated tale of Robinson Crusoe, the scene of which was, however, transferred to the West Indies.

In 1712 it appears that some Frenchmen, under the direction of a person named Apreanat, established a fishery at Juan Fernandez, and that a Spanish ship, the "St. Charles," going there for a cargo of salt fish, was wrecked on the island, but all the crew were saved.

In 1718 Clipperton called at Juan Fernandez. In January 1719 Shelvocke in the "Speedwell" visited the island, remaining four days on this occasion, but he returned in May 1720, and having only one anchor left, foolishly anchored, and was caught in a gale on a lee shore when, his cable parting, he was obliged to beach his vessel;

[1] The true Pimento is not found in Juan Fernandez; it was probably one of the species of *Myrtus*.

fortunately the whole crew, seventy-one persons in all, were saved. The shipwrecked people built huts, which they thatched or covered with the skins of Elephant Seals and Fur Seals, on the flesh of which, and on fish, they were obliged chiefly to subsist, as notwithstanding the plenteousness of the goats, they were difficult to procure, and they had little powder or shot to spare for this purpose; cats, however, were plentiful, and they varied their diet with these animals, which were thought good food. Their vegetable diet consisted of turnips, the cabbage palm, water cresses, and wild sorrel. This crew remained on the island until October, during which time they managed to construct, from the remains of the wreck of their ship, a schooner of about 20 tons burthen, in which forty-seven of them embarked and left the island, eleven English-

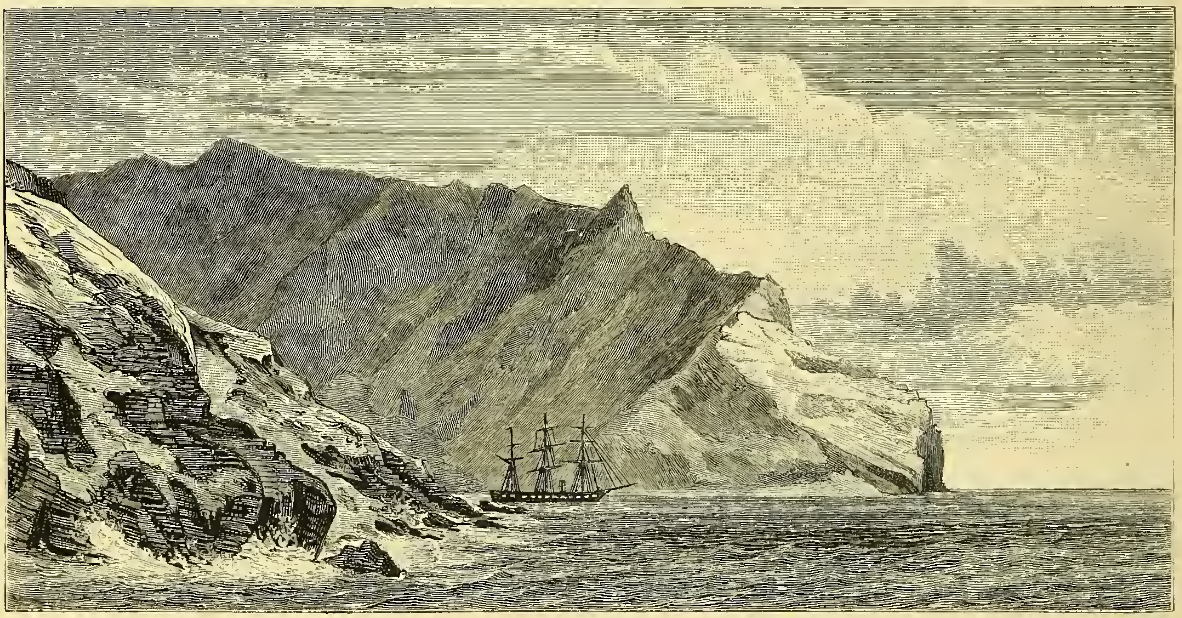


Fig. 299.—Cumberland Bay, Juan Fernandez.

men and thirteen Indians remaining. In this schooner they captured a ship at Pisco and abandoned their crazy vessel to the crew of their prize, but did not return for the rest of their shipmates on Juan Fernandez. These, however, were apparently soon after taken off, for when Roggewein called at the island in March 1722, he makes no mention of any people being there, but merely says that they salted down a number of fish, and that one of the officers fell over a precipice and was killed.

The next account of Juan Fernandez Island is from the voyage of Commodore Anson, who touched there in 1741 and landed his crew, then suffering dreadfully from the scurvy. He anchored in Cumberland Bay in June in the "Centurion," and was joined there by the "Trial," the "Gloucester," and the "Anna." At this time the productions of the island were much as formerly, the vegetables consisting of the cabbage palm, celery, water cresses, sorrel, parsley, turnips, and radishes. Commodore Anson added to these productions by sowing garden seeds and fruit stones, viz., lettuces, carrots, plums, and peaches, some of which prospered well. Some goats were captured whose ears had been slit by Selkirk thirty years previously. Anson remained at anchor in Cumberland Bay until September, when the health of the people having been restored, he continued his voyage. During their stay at Juan Fernandez the "Trial" visited Mas-a-fuera Island, and found there numerous goats, for, the anchorage being more exposed than at Juan Fernandez, the Spaniards had not landed dogs on that island with a view of destroying the goats.

In 1743, two Spanish frigates commanded by Don George Juan and Don Antonio Ulloa visited Juan Fernandez, and Ulloa has given a description of the island. During their stay they visited the valley where Anson had erected his tents, to search for any instructions that might have been left behind, but found only some tent poles and small wooden bridges for crossing the ravine. Ulloa gives an account of a fish caught here, possessing a spur or bone which is an infallible remedy for toothache. This fish, he says, "resembles the Tollo in shape; from the fore part of each of the two fins on its back grows a kind of triangular spur a little bent, but round near the back and terminating in a point. It has a fine gloss and the hardness of a bone. At the root of it is a soft spongy substance." Ulloa asserts that he himself and several of his friends tried this remedy with complete success, and that soon after the application of this spur or bone to the tooth, a drowsiness succeeded and the patient awoke free from pain. The dogs on Juan Fernandez in Ulloa's time were a species of greyhound sent thither by the Viceroy of Peru to exterminate the goats, so that the island might no longer furnish supplies to piratical vessels. The goats, however, being more nimble and surefooted than the dogs, the latter fed on the Fur Seals and Elephant Seals.

On a second visit to the island in the same year, Ulloa saw on the top of one of the mountains a bright light, which was at first very small, but increased so as to form a flame like that of a flambeau; the full vigour of the light lasted three or four minutes, when it diminished, and was not seen afterwards. Subsequently it was discovered that the ground in the vicinity of the spot where this flame was seen was full of fissures still hot, and much burnt, from which Ulloa concluded that he had seen a small volcanic outburst.

After the return of Anson, a question arose as to the advantage of forming a colony on Juan Fernandez, but the Spanish Government, obtaining intelligence that this project was under consideration in England, sent orders at once to take possession of all the outlying islands off the coast of South America, and in conformity with these orders a settlement was established at Juan Fernandez in 1750, consisting of a company of infantry and the necessary staff, with 22 prisoners. In all, 171 persons of both sexes were safely landed, with cattle, mules, sheep, and a variety of poultry, as well as a suitable supply of seed and agricultural implements. A fort mounting 18 guns was also constructed. But this little colony had not been long settled when it was almost totally destroyed by the same dreadful earthquake which in 1751 overthrew the city of Concepcion in Chili. With this earthquake the sea rose and overwhelmed the houses, part of which were built on the seashore; 35 persons perished, amongst whom were the Governor with his wife and family. The settlement was afterwards rebuilt in a safer position farther inshore. The expenses of this settlement in 1753 were 12,640 dollars.

Carteret was the first English navigator who noticed this settlement. He sighted Juan Fernandez in May 1767, and was greatly surprised to see a considerable number of men about the beach, with a house and four pieces of cannon near the water side, and a fort 300 yards inland on the brow of a hill with Spanish colours flying. Twenty-five or thirty houses were scattered round the fort, and many cattle were seen feeding, and the land also appeared to be cultivated. Carteret hoisted no colours but stood on for Mas-a-fuera Island. It may appear strange that Carteret, whose crew were much in want of water and refreshment, should leave an island on which he saw a settlement, cattle, &c., and prefer to proceed towards an uninhabited island, where the anchorage was bad, and the water could only be procured at considerable risk; but it must be borne in mind that the Spaniards in those days were most inhospitable, and it is related in Captain Basil Hall's "South America" that when (between the years 1784 and 1790) an American vessel from Boston touched at Juan Fernandez, having lost one of her masts, sprung her rudder, and being short of water and wood, the Viceroy of Peru and Chili reprimanded the Governor of the island for permitting the ship to repair damages and leave the port, instead of taking possession both of her and the crew, and giving an account of his having done so to his immediate superior the President of Chili. The Viceroy expressed his surprise that the Governor of an island should not know that every strange vessel which anchored in these seas, without a license from Spanish authorities, ought to be treated as an enemy, even though the nation to which she belonged should be an ally of Spain, and gave orders, should the distressed vessel appear again, that she was to be seized immediately and her crew imprisoned. Such conduct fully explains the reluctance exhibited by the old voyagers to placing themselves in the power or under the guns of a Spanish fortress, and also accounts for the meagre knowledge of the island available from the date of its first settlement by the Spaniards in 1750. In 1792 Lieutenant John Ross, R.N., then in command of a whaling vessel called the "William," visited Juan Fernandez and found forty settlers and six soldiers on the island, occupying a village in Cumberland Bay, every house having a garden attached, with arbours of vines. Figs, cherries, plums, and almonds were abundant, as also were potatoes, cabbages, onions, and other vegetables.

In 1814, during the revolutionary wars on the South American continent, the Spaniards withdrew the garrison from Juan Fernandez, destroying, when they left, all the valuable trees, such as sandalwood,[1] &c. In a moment of victory during these wars, the Spanish royalist Osorio banished to the island a number of Chilian patriots, who were afterwards, when fortune favoured their side, brought back to Chili with much triumph and exultation.

Shortly after 1818 Juan Fernandez was utilised as a state prison, and the Chilian Government sent such convicts there as were condemned to hard labour. In 1824 there appear to have been three hundred convicts on the island, guarded by one hundred regular troops. In that year the valleys of the island were swarming with wild cattle, horses, hogs, sheep, and goats, and vegetables and fruit were abundant, consisting of radishes, water cresses, parsley, turnips, purslain, apples, pears, peaches, plums, apricots, figs, cherries, and strawberries; but the Fur Seals and the Elephant Seals found formerly in such abundance had almost wholly disappeared. Fish was, however, as plentiful as ever.

In 1830, when Juan Fernandez was visited by H.M.S. "Adventure," Captain P. P. King, there were no convicts, but the island was rented from the Chilian Government by Don Joachim Larrain for fishing purposes. His establishment consisted of forty persons, who caught and dried the fish for the Chilian market, particularly the rock lobsters, the tails of which when cured are much esteemed and fetch a high price in Chili. At the time of Captain King's visit no supplies could be procured except wild goats, wild peaches, figs, and fish, the cattle so abundant in 1824 having entirely disappeared, but in what manner does not appear to be known. As vessels frequently touched at the island, particularly whalers, the establishment of forty persons might naturally have been expected to cultivate the land, grow vegetables and fruit, &c., but their first effort to raise potatoes having been defeated by the destructive ravages of a worm, they discontinued their agricultural pursuits.

In 1833 Juan Fernandez was again utilised as a convict station by the Chilian Government, and in that year a number of prisoners took possession, during the night, of a French brig that had called at the island for supplies, and compelled the crew to take them to Chiloe.

In 1835 the island appears to have been governed by a Mr. T. Sutcliffe, an Englishman in the Chilian service. He was present when the earthquake took place on the 20th February of that year, of which he gives the following account:—"At 11.30 A.M. the sea rose over the mole and afterwards retired, leaving the greater part of Cumberland Bay dry, so much so that old anchors on the bottom became visible; the earth then began to shake violently, and a tremendous explosion was heard, the sea still receding in immense rollers, which afterwards returned violently, rising to such a height that the

[1] See Bot. Chall. Exp., part iii. pp. 11 *et seq.*, 1885.

settlement was literally covered and washed away, when the sea again receded. This phenomenon occurred four times, causing much destruction, uprooting trees and drowning cattle. Shortly after the explosion, a large column somewhat resembling a water-spout was seen ascending from the sea off Point Bacalao, which proved to be smoke, but at 7 P.M. volcanic flames were visible through the smoke, which lasted until 2 A.M. on the 21st. The depth of water on the spot where these eruptions took place was from 50 to 80 fathoms, and no alteration in the depth was detected the day after the eruption had subsided."

In this year there appear to have been 200 persons on the island altogether, including a detachment of sixty-eight soldiers. In August of the same year an insurrection amongst the convicts took place, and the Governor was deposed by the Commandant of troops. At this time there were again both cattle and pigs on the island, and portions of land were distributed amongst the convicts for cultivation. In November 1835 a Captain Masters called in at Cumberland Bay on a voyage to Mazatlan, and purchased sheep for four dollars each, and bullocks for fourteen dollars. In this month there were seventy soldiers and 319 prisoners on the island, a small number of the latter being women. Shortly after 1835 Juan Fernandez was abandoned as a convict settlement, and since that time has been rented by the Chilian Government to such persons as cared to occupy it for the benefit of fishing and supplying the whalers (about twenty-five annually) that call in with fresh provisions.

In 1866, when H.M.S. "Topaze" called at the island, there were only ten inhabitants, and the Challenger found about forty or fifty under the control of a Chilian who paid £200 a year rent to the Chilian Government, and who had a few men also at Mas-a-fuera Island; he was engaged principally with the hunting of the Fur Seals.

The island of Juan Fernandez is thirteen miles in length and four in breadth, with a total area of 28 square miles, and has off its southwest point an islet named "Santa Clara," or "Goat," one mile and a half in length by one mile in breadth, between which and Juan Fernandez is a channel one mile across, with a depth of 19 fathoms in its centre. It is rugged and mountainous, the highest mountain, named "El Yunque," or "the Anvil," being 3000 feet above the level of the sea. This mountain is almost if not quite inaccessible, and appears never to have been ascended, although a reward was at one time offered to the convict who should succeed in arriving at its summit, but the steep nature of the narrow spurs that descend from it has hitherto rendered them impassable, notwithstanding the trees that abound. The trees in Juan Fernandez are in fact no aid to the explorer, for the soil is so light and shallow, that large trees soon perish for want of root and are easily overturned, several people having lost their lives by trusting to them for support; it should therefore be impressed on all explorers that they should here carefully abstain from trusting to the foliage in dangerous places. There is a beaten path from Cumberland Bay to Mount Portezuela, 1800 feet high, west of El Yunque, and this ridge was visited several times by the officers of H.M.S. "Adventure." It was here that Alexander Selkirk had his lookout, as from this point both sides of the island can be seen, and in its vicinity Commodore Powell of H.M.S. "Topaze" has placed a tablet with the following inscription :—

In Memory of
Alexander Selkirk, Mariner,
A native of Largo in the County of Fife, Scotland,
Who was on this island in complete solitude
for four years and four months.
He was landed from the Cinque ports Galley, 96 tons,
16 guns, A.D. 1704, and was taken off in the
"Duke" privateer, 12 February 1709.
He died Lieutenant of the "Weymouth," A.D. 1723,
Aged 47 years.

This tablet is erected near Selkirk's look-out by
Commodore Powell and officers of
H.M.S. "Topaze," A.D. 1868.

On the coast of Juan Fernandez are some small indentations, and vessels have anchored on all sides of the island; but Cumberland Bay on the north shore is the only good place, and even here the great depth of water and the squalls from the hills render it sometimes insecure, for the interval of calm between the squalls renders a ship liable, by surging ahead after having had a taut cable, to overrun her anchor and foul it so that eventually she drifts off the bank. To guard against such an accident it is advisable to lay out a small anchor to the northward.

In the valleys the soil is of some depth, and fit for the production of any vegetable, and wheat might possibly be grown, but the hillsides, as before mentioned, are very steep, and the soil there is shallow and soon washed away by the rains. The tops of the hills are frequently capped, and from this circumstance there is never any want of fresh water on the island, every valley apparently possessing a small stream or rivulet, by the sides of which the early navigators planted water cresses, which still flourish. There are upwards of twenty-four species of ferns growing in this small island of Juan Fernandez, and in any general view the ferns form a large proportion of the main mass of vegetation. Amongst them are two tree ferns, of which only one was seen amongst the rocks in the distance, but could not be reached. The preponderance of ferns, especially the tree ferns, gives a pleasant yellow tinge to the general foliage. Curiously enough the almost cosmopolitan common Brake Fern (*Pteris aquilina*) does not occur in the island. Four species of the ferns out of the twenty-four present are peculiar to the island, and one (*Thyrsopteris elegans*) belongs to a genus which occurs only here; its appearance is very remarkable, for the cup-shaped sori hang down from the fronds in masses, looking just like bunches of millet seed.

Everywhere for the first few hundred feet trees are absent, the wood having been all felled. In 1830 a large quantity of dry old sandalwood still remained in the valleys; but even then there were no growing sandalwood trees remaining.[1] No doubt the general appearance of the vegetation is very different now from what it was when the island was first visited. In ascending the steep path leading directly from Cumberland Bay to Selkirk's Monument, the first tree was met with at about 700 feet altitude, all below had been cut down. The way led through a hollow overgrown by a dense growth of the gigantic rhubarb-like *Gunnera peltata*[2] (see Pl. XXXIII.). Darwin remarked on the large size of the leaves of this plant and height of its stalks as seen by him in Chili.[3] The stalks of the plants he saw were not much more than 3 feet in height, whilst in this hollow the stalks must have been 7 feet in height. The size attained by the *Gunnera* varies with its situation. A narrow passage was cut in a thicket of them, and the huge circular leaves were elevated far above a man's head. The leaves catch and hold a large quantity of rain water; in many places the leaves are very conspicuous on the hillslopes, crowding closely as an undergrowth, and not rising high above the ground.

The Challenger's visit was in spring, when most excellent strawberries were growing wild about the lower slopes of the island, and especially well on banks beneath the cliffs close to the seashore. The strawberries are large and fine, but white in colour, being a cultivated variety; they have not at all reverted to the parent wild form, either in colour or size; a few only were just beginning to ripen.

At this time of the year the foliage of the Myrtles, though evergreen, looks half dead, and these trees thus show out conspicuously amongst the rest. Here and there the Magnoliaceous trees "Winter's Bark" (*Drimys confertifolia*), common in the Strait of Magellan, were covered with showy white flowers, and large patches of a small species of Dock (*Rumex*) in full flower showed out red amongst the general green, whilst a white-flowered *Libertia* (*Libertia formosa*), growing socially, formed well-marked patches of white. A tall Verbenaceous Shrub (*Rhaphithamnus longiflorus*), which was very common, was covered with dark blue tubular flowers.

The common Sow-thistle (*Sonchus oleraceus*), the ubiquitous weed, has climbed up the pass, and grows by the monument. The endemic Palm (*Juania australis*) has been almost exterminated, except in almost inaccessible places, as on a rock above the monument, where a group of the trees can be seen, but not reached. The terminal shoot, especially when

[1] Narrative of the Surveying Voyages of H.M.S. "Adventure" and "Beagle," vol. i. p. 302, London, 1839. Visit of Capt. King, H.M.S. "Adventure," accompanied by Signor Bertero, the Botanist, February 1833.

[2] *Gunnera bracteata* and *Gunnera insularis* also occur in the island.

[3] C. Darwin, Journal of Researches during the Voyage of H.M.S. "Beagle," p. 279, ed. 1879.

Plate XXXIII

Horsburgh, Edinburgh. Permanent Phototype.

VEGETATION, JUAN FERNANDEZ, (*Gunnera peltata*)

cut just before the tree flowers, is excellent to eat; the developing leaf buds being quite white, and tasting somewhat like a fresh filbert. It seemed more delicate than the shoot of the Cocoanut. The guide knew where there was a tree remaining in the woods not far above sea level, and it was at once inspected in the hopes that it might be found in flower. As it was not, it was cut down for eating, for the guide was only waiting to let it develop further before felling it for that purpose himself. A few seedling Palms grew near by. Palms of the same genus occur in the tropical Andes.

Most remarkable in appearance amongst composite endemic trees are the species of the genus *Dendroseris,* allied to the Chicory. The specimens seen in flower were large straggling shrubs rather than trees, but with thick woody stems and branches from 10 to 15 feet in height. The leaves are very like those of a dandelion in appearance, and the stem, which, when split open, has a curiously jointed pith, has just the smell of a dandelion-root, and would, no doubt, yield chicory. It pours out, like the dandelion and allied plants, a milky juice when cut.

Hovering over the flowering bushes and trees, were everywhere to be seen two species of Humming Bird, one of which (*Eustephanus fernandensis*) is peculiar to the island, whilst the other (*Eustephanus galeritus*), belonging to the same genus, occurs also on the mainland. A further closely allied but peculiar species occurs in Mas-a-fuera. In the species peculiar to the island of Juan Fernandez the male is very different in plumage from the female, being of a chocolate colour, with an iridescent golden-brown patch on the head, whilst the female is green. So different are the two sexes that they were formerly supposed to represent two distinct species, as has happened in the case of so many other birds. This endemic humming bird seemed more abundant than the continental one.

In skinning some of the birds killed, it was noticed that the feathers at the base of the bill and on the front of the head were clogged and coloured yellow with pollen. The birds, no doubt, in common with other species of humming birds, and other flower-frequenting birds, such as the Myzomelidæ, are active agents in the fertilization of plants. Pollen was noticed attached in a similar manner to the head of a bird at Cape York. Mr. Wallace concludes that the presence of these birds, as fertilizers, accounts for the abundance of conspicuous flowers in Juan Fernandez.[1] Ten species of land and fresh-water Mollusca were found by the Expedition, of which only one, *Helix* (*Stepsanoda*) *selkirki*, is new to science.[2]

The flesh of the wild goats of the island is most excellent eating, no doubt because of the abundance of food; in some parts of the island, especially to the southwest, there are open stretches covered with long grass. Pigeons (*Columba œnas*), which are said to have been imported into the island, are common, and feed on the hillsides in flocks.

[1] A. R. Wallace, Tropical Nature, pp. 270, 271, London, 1878.
[2] E. A. Smith, *Proc. Zool. Soc. Lond.*, p. 279, 1884.

Fish are very abundant and easily caught, as are also Rock Lobsters (*Palinurus frontalis*), called "Cray-fish" by the early navigators, which are very large, and very good to eat. More than sixty were taken by means of a baited hoop-net put over the ship's side at the anchorage, and hauled up at short intervals.

Juan Fernandez is so small that from Selkirk's Monument nearly the entire area of the island can be overlooked. Yet this tiny spot of land contains birds, land shells, trees, and ferns which occur nowhere else in the vast expanse of the universe, but here or in the neighbouring Mas-a-fuera. One could almost count the number of trees of the endemic Palm and estimate the number of pairs of the endemic Humming Bird existent at a bird for every bush. Two of the species of land birds, and all the twenty species of land shells of the island are endemic.[1] A small bat, possibly disturbed by the sound of the guns, was seen to fly past.

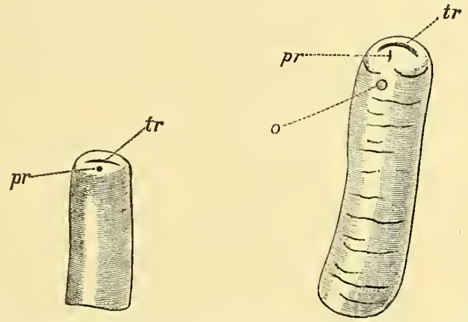
The temperature at the monument at 11 A.M. was 65° F. Close to the farmhouse at the bay still remains a row of old caves dug out in the hillside by the buccaneers. All the rocks collected at Juan Fernandez were typical felspathic basalts.

The Nemertea.—Professor Hubrecht of Utrecht, who is engaged on a Report on the Anatomy and Histology of the Nemertea, has supplied the following notes:—"The Nemertea of the collection, although in several respects highly interesting, are very defective in outward appearance. The immersion in spirit has not only destroyed the natural colours—sometimes so beautiful—of all the specimens, but has at the same time reduced the size and altered the shape of the several individuals to a very uniform cylindrical or flattened pattern. Moreover, the habit of the Nemertea of often breaking themselves into pieces on being placed in any preserving fluid has reduced several other specimens to fragments. Fortunately the state of preservation of all these fragments is most satisfactory, and by applying the modern methods of staining and section cutting they can be successfully transferred into the more useful state of microscopic preparations, the whole animal being in this way both durably preserved and yet fit for delicate histological and anatomical investigations. Not one section need be lost, and the entire reconstruction of all the internal parts thus remains possible at any time.

"This method has already brought to light the presence amongst the Challenger Nemertea of a new genus, represented by two fragments, which fortunately contained all the more important organs. I propose to call it *Carinina*, because it is most nearly allied to the most important and primitively organized genus *Carinella;* it differs from this in certain important points, which will be treated at length in the forthcoming Memoir. Further, it is an unmistakable representative of the interesting group of the Palæonemertea. Both the specimens were dredged between Bermuda and Halifax (Stations 45 and 47), at depths of 1240 and 1340 fathoms. They measure only

[1] For an account of the land birds of Juan Fernandez, see an article by Dr. P. L. Sclater, *Ibis*, p. 178, 1871.

a few millimetres in length. The accompanying woodcuts (figs. 300 and 301) represent these fragments, about four times enlarged; these figures have very few points of interest, giving only the general shape together with the rounded anterior portion of the body, and the openings of the mouth and the proboscis, but there is sufficient reason for their insertion in this place, since they bring vividly before the mind of collectors of marine zoological specimens the desirability of carefully preserving even the smallest and most unpromising fragments that come up in the dredge. As in this case it may often prove possible to distinguish such fragments, specifically and generically, and to obtain most valuable anatomical information by cutting them up into sections.



FIGS. 300, 301.—*Carinina*, n. gen.; four times the natural size. *o*, mouth; *pr*, opening for the proboscis; *tr*, shallow transverse furrow, strongly ciliated.

"Nemertines were obtained at more than twenty different Stations, some of them yielding more than one species. The most striking capture was that of the beautiful pelagic species (*Pelagonemertes rollestoni*), already so carefully described by Mr. Moseley[1] shortly after he had discovered and examined the specimens in the fresh state. They were taken on two occasions; one, an apparently adult specimen, near the southern verge of the South Australian Current, the other off Japan. This animal is most beautifully transparent, the different internal organs standing out very clearly, especially the digestive system, which is of a deep burnt-sienna colour. The lateral cæca of the intestine are branched in the adult. The lateral nerve-cords are united by a commissure which is situated *above* the posterior part of the rectum, the mouth being also situated below the brain. Mr. Moseley suggests that the animal, although essentially pelagic in all its characters, occurs only in deep water, and does not often come to the surface.

"The woodcut (fig. 302) is taken from Mr. Moseley's figure, representing the young specimen, which was better preserved when captured, but which has since perished. The larger specimen, although incomplete, has been preserved in spirit, and will allow of being cut into sections. In this way it may be possible to decide whether I am right in supposing that although Mr. Moseley found the proboscis to be unarmed, it must nevertheless find its place in that group of Nemertea in which the more specialized genera, those having an armature in the proboscis, are arranged. Its position there would not be altogether exceptional, the parasitic *Malacobdella* probably finding its place there also, although in this genus the proboscis is unarmed as in *Pelagonemertes*.

"Mr. Moseley has little doubt that the *Pterosoma plana*, described and figured by

[1] *Ann. and Mag. Nat. Hist.*, ser. 4, vol. xv. pp. 165–168, pl. xv., 1875; *Ibid.*, vol. xvi. pp. 377–383, pl. xi., 1875.

Lesson in his Voyage de la 'Coquille' as a Mollusc,[1] and captured in great abundance between the Moluccas and New Guinea, was another species of *Pelagonemertes*. The genus appearing thus to have a wide distribution, and often to occur in considerable numbers, we may look forward with interest to further specimens being captured and more closely investigated by naturalists residing in that part of the world.

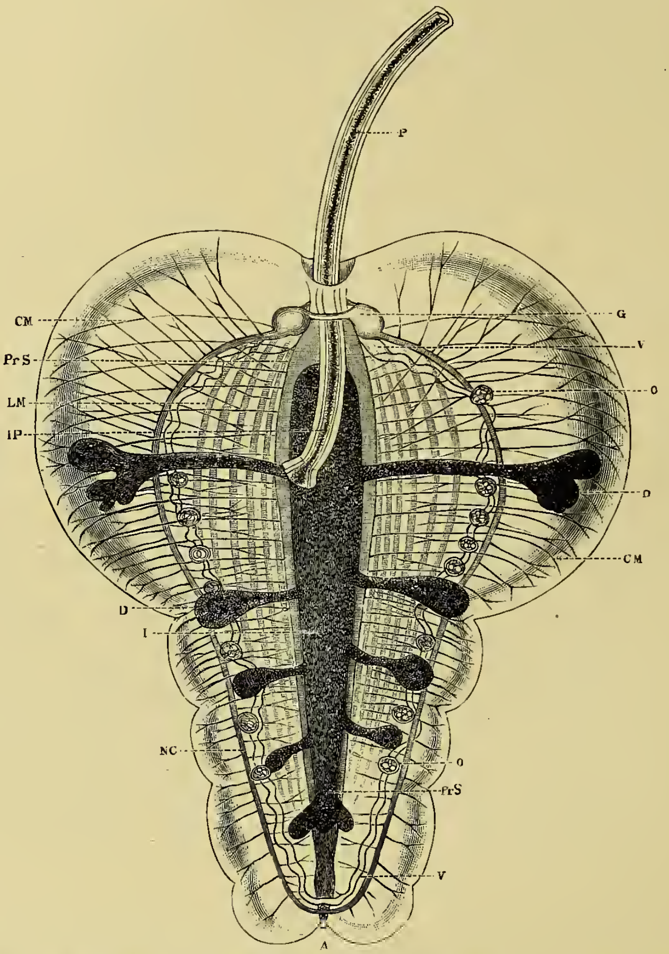


FIG. 302.—*Pelagonemertes rollestoni*, Moseley, enlarged, viewed from the dorsal surface; the proboscis is partly extruded.

P, proboscis; PrS, sac of proboscis; IP, invaginated portion of proboscis within the proboscis-sac; G, superior nerve-ganglion; NC, nerve-cords; V, vascular trunk (the upper V points to an enlargement of the vessel lying just posteriorly to the superior nerve-ganglion); I, intestine; D, diverticula of intestine; O,O. ovaries; CM, circular muscles; LM, longitudinal muscles.

"In looking at the map for the Stations where Nemertea, with the exception of *Pelagonemertes*, were taken by the Challenger, it immediately strikes one that they are all in close proximity to the land. Not one Nemertine was taken at any of the numerous Stations in the open ocean. Even the deep-sea forms above alluded to were found at a compara-

[1] Lesson, M., Voyage de la "Coquille," Zoologie, p. 254, pl. iii. fig. 3, Paris, 1830.

tively short distance from the North American continent. This apparently strict limitation of the Nemertea to the coast dredgings and at the same time their presence in this zone all over the globe is not without importance when attempts are made to estimate the ultimate phylogenetic significance of the group."

Juan Fernandez to Valparaiso.

The Expedition left Juan Fernandez on the 15th November, but the wind persistently hanging to the northward, the American coast was made at Topocalma Point, 70 miles south of Valparaiso, and the ship steamed to the northward along the land. The weather was thick between Juan Fernandez and the coast of Chili, and the swell was from the westward. One sounding, temperatures, and a haul of the trawl were obtained between the two places in lat. 34° 7′ S., long. 73° 56′ W., in 2225 fathoms (see Sheet 38).

The deposit at this Station was a blue mud, with a thin surface layer of a reddish colour, and contained 6 per cent. of carbonate of lime, which consisted chiefly of the shells of Globigerinas, and Orbulinas, and Coccoliths. The mineral particles consisted of quartz, mica, felspars, augite, hornblende, and glauconite. It is worthy of note that this was the first deposit in which glauconite was noticed since leaving the coast of Japan.

In the trawl there were about fifty specimens of deep-sea animals, among which were the following, all of them new species, and five belonging to genera first discovered by the Expedition :—*Ophiacantha sentosa*, Lyman ; *Ophiacantha cosmica*, Lyman ; *Pourtalesia carinata*, A. Ag. ; *Pourtalesia ceratopyga*, A. Ag. ; *Cystechinus vesica*, A. Ag. ; *Aspidodiadema microtuberculatum*, A. Ag. ; *Nymphon longicollum*, Hoek ; *Colossendeis media*, Hoek ; *Parelpidia cylindrica*, Théel ; *Psychropotes longicauda*, Théel ; *Benthodytes mamillifera*, Théel ; *Benthodytes sordida*, Théel ; *Benthodytes sanguinolenta*, Théel ; *Benthodytes abyssicola*, Théel ; *Porcellanaster gracilis*, Sladen.

It was noticed that between Juan Fernandez and Valparaiso the water was of a greenish colour as the continent was approached, contrasting strongly with the deep blue colour which had been constant since leaving the coast of Japan. There was a corresponding change in the general character of the surface animals, Diatoms, Infusoria, and Hydromedusæ becoming very abundant, and the pelagic Foraminifera disappearing from the surface gatherings.

The Foraminifera.—The reader is referred to the Report on the Foraminifera, by Mr. H. B. Brady, F.R.S.,[1] for details concerning these organisms, some species of which are so abundant on the surface, and play so large a part in the formation of deep-sea

[1] Report on the Foraminifera, by H. B. Brady, F.R.S., Zool. Chall. Exp., part. xxii., 1884.

deposits. Mr. Brady remarks—"Notwithstanding the wide geographical range of most of the recent species, a large number of new forms have been brought to light by the examination of the material collected by means of the dredge and tow-net; and the results, taken in conjunction with those of the 'Porcupine' expedition of 1869, have furnished a basis for the systematic treatment of one extensive group of forms, previously but little understood, namely, those which construct composite or arenaceous tests in

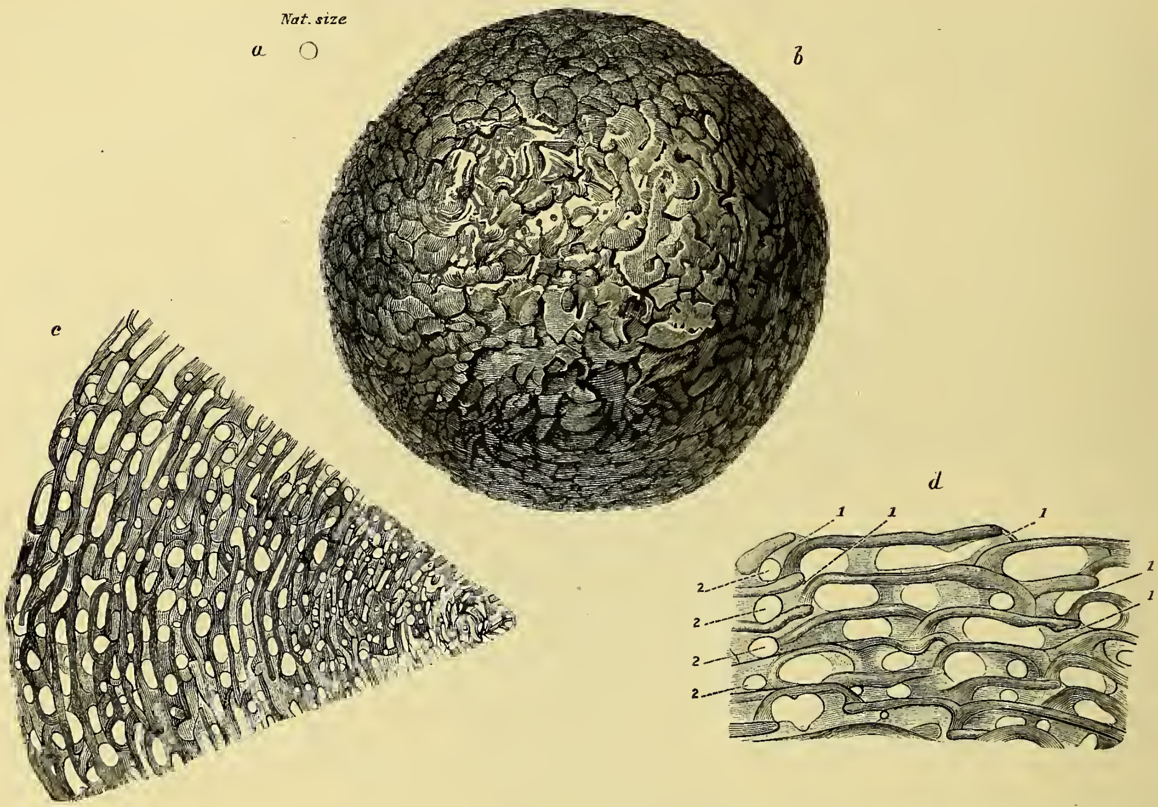


FIG. 303.—*Keramosphæra murrayi*, Brady.

a. Natural size; *b*, magnified 25 diameters.
c. Portion of a nearly central section of the same specimen, magnified 50 diameters.
d. A smaller portion of the same, magnified 100 diameters, showing 1, 1, 1, 1, the orifices communicating between the chamberlets of the successive layers; 2, 2, 2, 2, lateral orifices communicating between the chamberlets of the same layer.

place of the more usual calcareous skeleton. Much light has also been thrown on the range of morphological variation dependent upon local conditions; and the extent of the area over which the collections were made has furnished data for a large reduction in the number of 'species' or of the varieties which amongst the Foraminifera are accepted as species.

"The relation of the pelagic Rhizopod-fauna of the ocean to that of the sea bottom, foreshadowed by the researches of Major Owen and others, has been placed on a broader and more intelligible footing by the discovery of numerous species in the surface water which were previously supposed to inhabit exclusively the bottom ooze. Furthermore, the whole subject of recent oceanic deposits and the organisms concerned in their production, of which the Foraminifera are amongst the most important, may almost be said to owe its initiation to data collected during the Challenger cruise.

"All the larger groups of Foraminifera have been enriched to a greater or less degree by the results of the Expedition. Amongst the *Porcellanea*, or those forms which are provided with an imperforate calcareous skeleton, the most noteworthy acquisitions, so far as the simpler types are concerned, are certain species referrible to Seguenza's genus *Planispirina*. This genus, which was first fully described by Steinmann under the name *Nummoloculina*, is characterised by the laminated structure of the shell, caused by the extension of the umbilical margins of the chamber-walls over the lateral

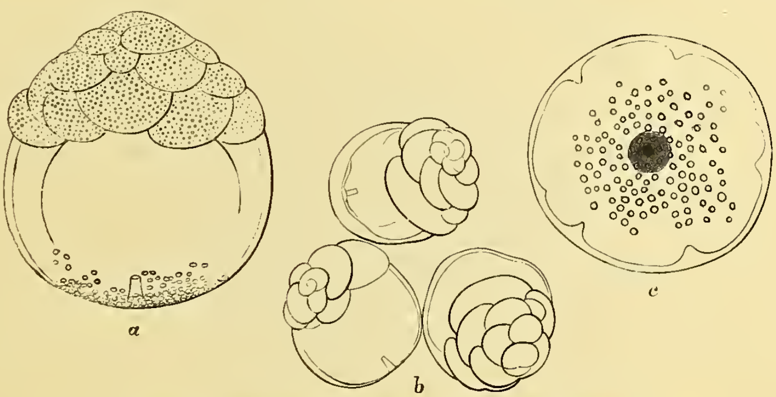


FIG. 304.—*Cymbalopora* (*Tretomphalus*) *bulloides* (d'Orbigny).

a, Large surface-specimen; *b*, small (young?) specimens from the same gathering; *c*, distal face of the balloon-like chamber, showing the entosolenian orifice, seated in a slight depression. All magnified 60 diameters.

faces of the test, a feature which it possesses in common with the much more highly organised type, *Nummulites*. The specimens of the genus *Orbitolites*, collected chiefly on the reefs of the Fiji and the Friendly Islands, have afforded ample groundwork for the revision of the structural and geological relations of that somewhat complex generic group.[1]

"Of even greater interest and importance is the discovery of the new porcellanous type *Keramosphæra*, in a Diatom ooze obtained from deep water in the Southern Ocean. This organism, the structure and position of which have been made the subject of a special 'Note' by Mr. Brady,[2] is closely allied to *Orbitolites*, and, in a less marked degree, to *Alveolina*. The shell is spherical and composed of a multitude of chamberlets

[1] Report on the specimens of the genus Orbitolites, by W. B. Carpenter, C.B., F.R.S., Zool. Chall. Exp., part xxi., 1883.

[2] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. x. p. 242, pl. xiii., 1882.

arranged in more or less distinct layers; but the individual chamberlets are irregular both as to size and shape, and the layers in which they are combined lack the evenness and symmetry which is an invariable feature of the kindred porcellanous forms.

"But little was known of the arenaceous Rhizopoda constituting the families Astrorhizidæ and Lituolidæ before the 'Porcupine' expedition of 1869, and the variety of form which they exhibit, their diversity of structure, and the extent of their

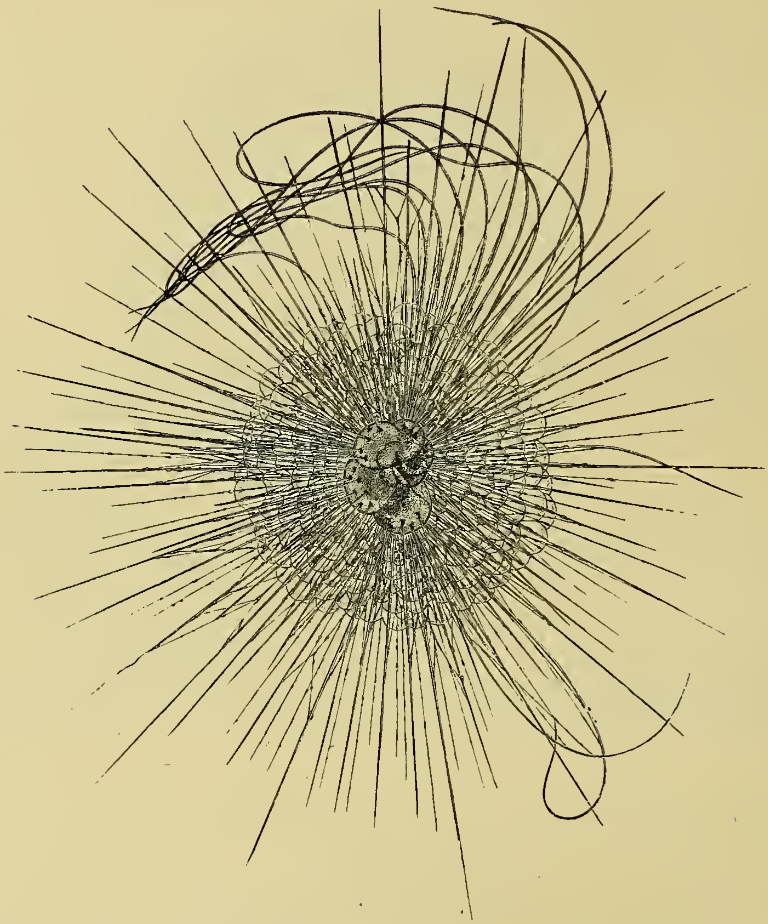


FIG. 305.—*Hastigerina pelagica* (d'Orb.) (*murrayi*, Wyv. Thoms.), with floating apparatus and pseudopodia extended, as found floating on the surface.

geographical distribution, were previously not so much as suspected. The fine series of Arenacea obtained by the 'Porcupine' has been enriched at every point by the Challenger dredgings. To the 'Porcupine' genera *Botellina*, *Marsipella*, *Pilulina*, and *Cyclammina*, the Challenger has added the curiously fashioned *Aschemonella*, the flexible weed-like *Rhizammina*, and the adherent branching *Sagenella*, together with a long array of fresh species of previously known genera.

"Of the Lagenidæ, apart from some of the minute varieties of *Lagena* found in the red clay deposits of abyssal depths, displaying superficial ornament of extraordinary delicacy and beauty, the most interesting of the new forms are certain modifications of *Lagena* and *Nodosaria,* in which a cellulated wall takes the place of the usual solid or porous calcareous film. Such forms have their origin doubtless in costate and reticulate varieties, and the cellulated structure is due to the closing in of the furrows or angular depressions by a thin external wall.

"The singular type *Ramulina,* only known before by the small fragments not uncommon in the Chalk, was found for the first time as a recent organism amongst the

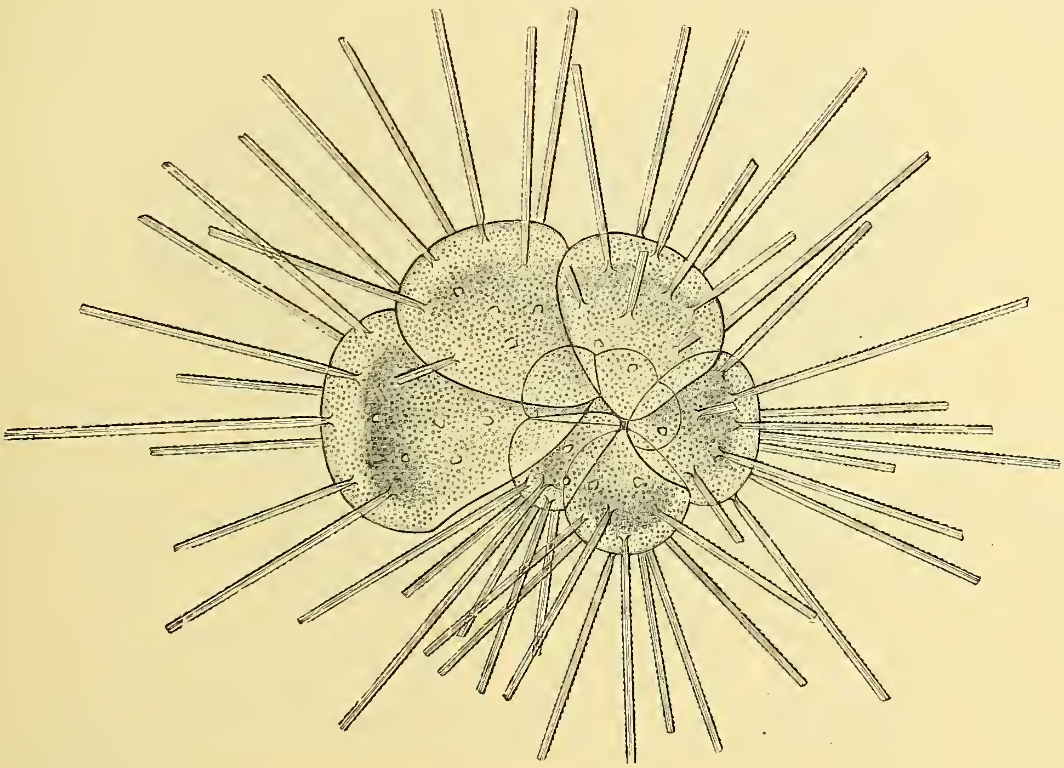


FIG. 306.—*Hastigerina pelagica* (d'Orb.) (*murrayi*, Wyv. Thoms.), from the surface.

coral sands of the Pacific. The shell is rarely obtained even approximately complete, owing to its branching habit and the slenderness of its stoloniferous connections. It consists of a number of spheres connected by narrow tubes of greater or less length, several tubes issuing from a single chamber, and each producing a fresh sphere, usually of smaller size. The chambers, though normally spherical, sometimes take less regular forms.

"Of the Globigerinidæ, the genus *Globigerina* has been found to possess a far wider range of morphological variation than was previously supposed; and the Challenger collections, in addition to a number of new forms, have furnished material for a complete revision of the species and varieties. *Sphæroidina*, *Pullenia*, and *Candeina*, aforetime believed, under all circumstances, to inhabit the bottom ooze alone, are now known to have pelagic representatives.

"There is but little that calls for remark in connection with the Rotalidæ and Nummulinidæ. One or two species of *Pulvinulina* have been added to the pelagic list; and *Cymbalopora bulloides*, with its large balloon-like final segment, has also been taken at the surface. But in connection with these families, the gain to science has been chiefly in the direction of new species and varieties, and in facts illustrative of the geographical distribution of forms already known."

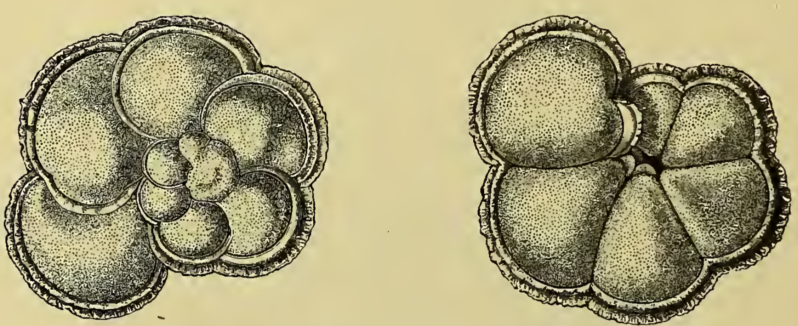


Fig. 307.—*Pulvinulina menardii* (d'Orbigny), from the tropical deposits.

The pelagic Foraminifera were under almost daily observation during the cruise, and have been frequently referred to in the preceding chapters. Among the species recognised by Mr. Brady in his Report, the following have a pelagic habitat:—

Globigerina bulloides, d'Orb.
,, ,, var. *triloba*, Reuss.
,, *dubia*, Egger.
,, *inflata*, d'Orb.
,, *rubra*, d'Orb.
,, *sacculifera*, Brady.
,, *conglobata*, Brady.
,, *æquilateralis*, Brady.
Orbulina universa, d'Orb.
Hastigerina pelagica (d'Orb.).
Pullenia obliquiloculata, P. & J.
Sphæroidina dehiscens, P. & J.
Candeina nitida, d'Orb.
Pulvinulina menardii (d'Orb.).
,, ,, var. *tumida*, Brady.
,, *canariensis* (d'Orb.).
,, *crassa* (d'Orb.).
,, *micheliniana* (d'Orb.).
,, *patagonica ?* (d'Orb.).
Cymbalopora bulloides (d'Orb.).

The last mentioned species (*Cymbalopora bulloides*) was only found when in the neighbourhood of coral reefs, when it was sometimes very abundant in the surface gatherings. There were usually two sizes, as represented in fig. 304, the smaller ones being united into groups of four by a gelatinous matter. Another peculiarity of this species is that these surface specimens did not contain sarcode like that usually found in pelagic species, but were always filled with minute swarm spores about 0·005 mm. in diameter. When a specimen was placed on a slide and crushed with a cover glass, then examined by a high power, a cloud of these minute bodies, with a flagellum at one end and a pellucid spot at the other, spread over the field of the microscope; there was a bubble of air or gas in each shell. A similar condition was observed once in *Globigerina sacculifera* and once in *Pullenia obliquiloculata.*

The colour of the sarcode in the pelagic Foraminifera is sometimes bright red, as in *Hastigerina* and *Pullenia;* in *Globigerina* it is yellow, orange, or of a delicate rose colour; in *Pulvinulina micheliniana* it has occasionally a decidedly greenish tinge.

When observed floating on the surface, the larger part of the sarcode is usually outside the shell, so that the latter may not be noticed owing to the dense mass of

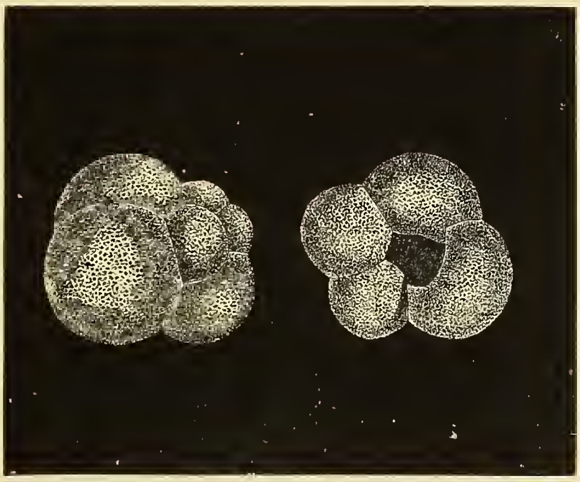


Fig. 308.—*Globigerina bulloides* (d'Orbigny), from the deposits. Tropical regions of the Atlantic.

protoplasmic matter with which it is enveloped. The pseudopodia ramify to a great distance from the shell, and balloon-like expansions of the sarcode are thrown out between the spines of a shell like *Hastigerina;* over these and along the spines, the pseudopodia move freely and rapidly (fig. 305). In the species without spines, this float-like arrangement was never observed fully expanded; the contact of the tow-net having evidently caused a collapse and a contraction of the sarcode close about the shell. On one or two occasions, however, the floats of *Pulvinulina* and *Pullenia* were seen partially expanded.

In *Orbulina* there are almost always a great number of yellow cells similar to those found in the Radiolaria; they are oval and about 0·01 mm. in the longest diameter, and have a nucleus which colours quickly with carmine, before treatment with spirit. On several occasions they were seen to flow out from the interior of the shell with the pseudopodia through the pores, and mount a considerable distance up the spines; when expanded in this way an *Orbulina* or *Globigerina* looks exceedingly like many of the Radiolaria. The yellow cells appeared to have an independent motion, as they

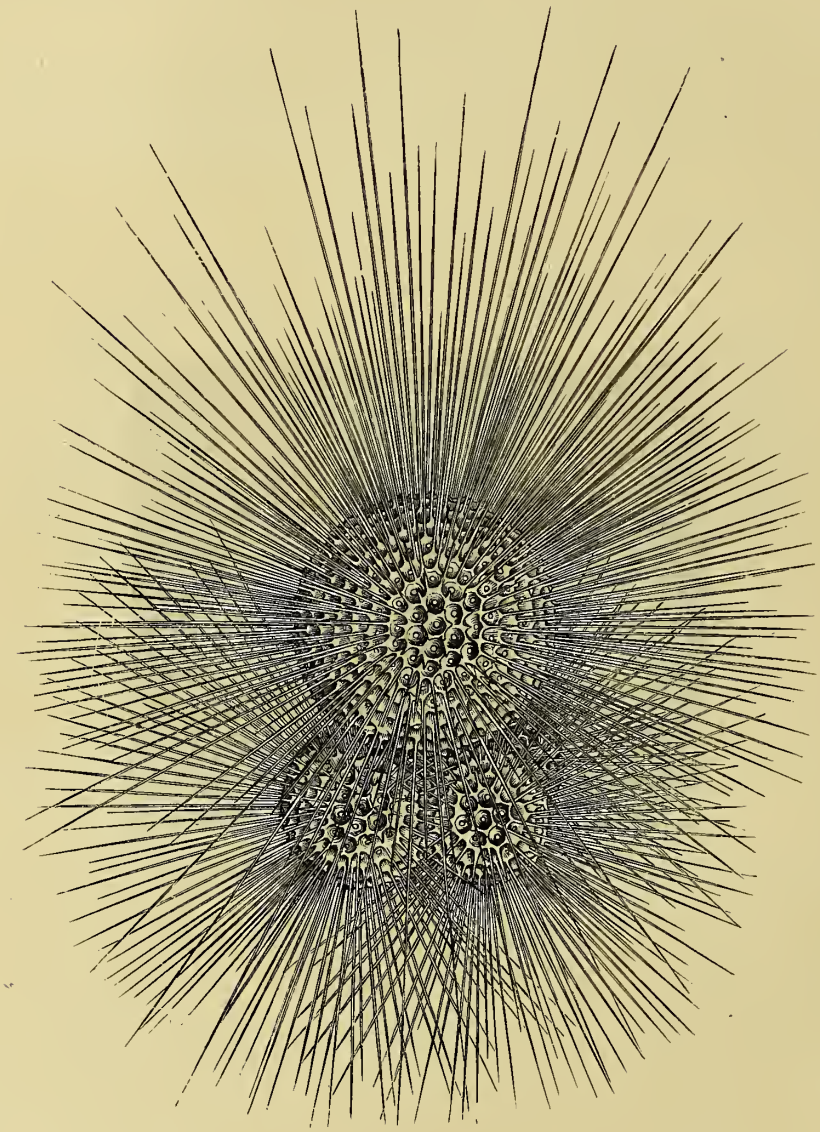


Fig. 309.—*Globigerina bulloides*, var. *triloba* (Reuss), from the surface.

were frequently observed turning about in the sarcode. Yellow cells are also present in *Globigerina bulloides*, var. *triloba*, *Globigerina sacculifera*, and *Globigerina conglobata*, but were not observed in *Hastigerina*, *Pullenia*, nor *Pulvinulina*.

In all the pelagic Foraminifera there is a large nucleus which colours with carmine, both before and after being treated with spirit or glycerin. It appears to occupy no definite position in the chambers, being sometimes found in the larger and sometimes in the smaller ones. Cells about 0·05 mm. in diameter, having in the interior minute vibrating particles, were frequently observed, but whether these were connected with the reproduction of the animal or not it is impossible to say.

Pelagic Foraminifera swarm in the surface and subsurface waters of the tropics, where the greatest number of species and largest and thickest shelled specimens are found; in the colder waters north and south, the specimens become smaller, till in the Arctic and Antarctic only dwarfed specimens of *Globigerina bulloides* are met with. The distribution of the dead shells on the bottom of the ocean corresponds with the distribution of the living ones on the surface, and is governed by surface temperature; on the other hand those species of Foraminifera which live on the bottom attached to Zoophytes and other animals or substances have a distribution quite independent of surface temperature. Independently of the evidence afforded by the distribution of the shells above referred to, it is most unlikely that the same animals should live on the bright sunny surface waters at a temperature of from 60° to 80° and also at the bottom at a temperature of from 32° to 40°, where there is a pressure of two or three miles of water and an absence of sunlight, and no living specimen of these pelagic species was taken on the bottom.

Fig. 310.—*Orbulina universa* (d'Orbigny), from the deposits.

These Foraminifera appear to be truly pelagic animals, and to flourish in the open sea far from land. It is a remarkable fact that they generally disappeared from the tow-net gatherings as land was approached and where river water entered the sea. They were very rarely taken in any of the bays or estuaries. About the British coasts, or even in the North Sea, they are very rarely observed, yet they are taken in great numbers on the surface 100 miles west of the Outer Hebrides.

The same species inhabit the tropical waters of the Atlantic, Pacific, and Indian Oceans, but some species are relatively more abundant in one ocean than in another. For instance, *Pullenia obliquiloculata* is much more abundant in the Pacific than in the Atlantic, while *Pulvinulina menardii* and *Sphæroidina dehiscens* predominate in the latter ocean.

The sarcode of the bottom-living Foraminifera was frequently examined; that in the arenaceous forms, such as *Reophax*, *Hyperammina*, *Haplophragmium*, had always a dark brown-coloured pigment, similar to the phæodium of the Phæodaria.

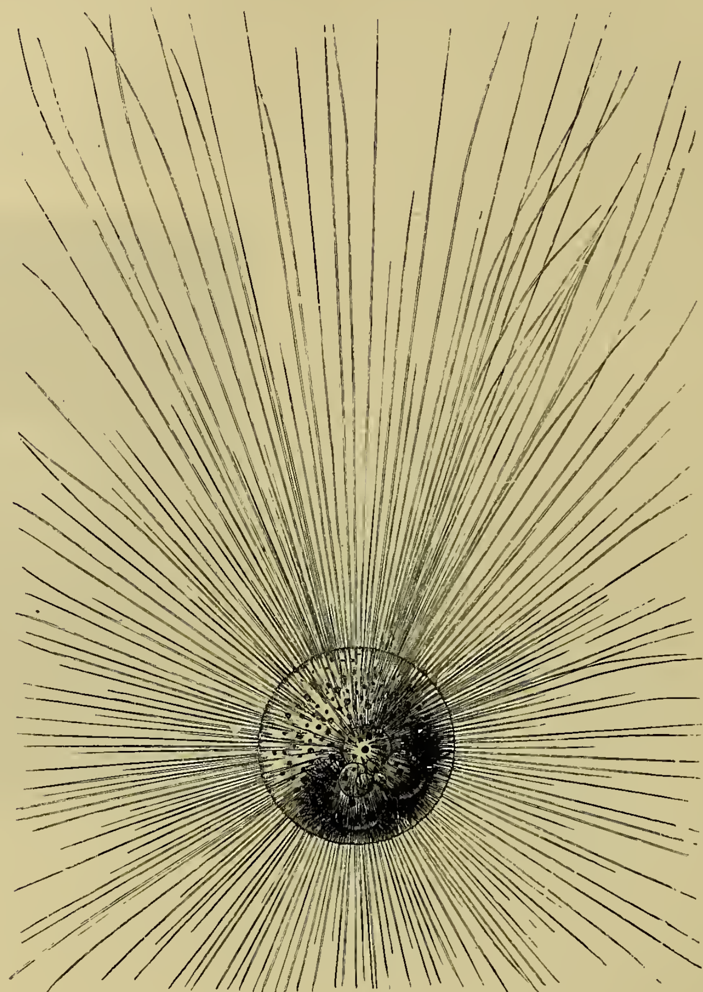


Fig. 311.—*Orbulina universa* (d'Orbigny), from the surface.

The sarcode of *Biloculina*, *Truncatulina*, and *Discorbina* was yellowish in colour, and resembled that of the pelagic species.

Valparaiso.

On the 19th November, at 6.45 A.M., Curamilla Point was sighted, and steering to the northeastward the ship was anchored in Valparaiso Bay at 10.30 A.M.

Merchant ships at Valparaiso are moored head and stern in regular lines or tiers with two anchors ahead and one astern. In the summer months they are placed with their heads to the southward and in the winter months with their heads to the northward. A steam tug is always ready to tow them into their proper berths and lay out their anchors for them, weighing them again when they are ready to proceed to sea. On all ships calling here a hospital charge of ten cents per ton is levied, and should they remain to receive or discharge cargo a charge of ten cents per ton is levied as light dues.

Fort San Antonio, the observing station of Fitzroy, no longer exists, and as a road runs over its former site, observations could not be taken there, so the observations were taken at the battery immediately over the custom house, about 200 yards N.W. of Fitzroy's station.

Supplies of every description are plentiful in this port, and it possesses two floating docks capable of lifting almost any vessel; they are moored at the head of the west side of the bay close to the landing place.

The ship remained at Valparaiso from the 19th November until the 11th December, the crew being occupied in refitting the ship, fitting a new set of sails, and making other repairs; and during this time the members of the Expedition visited Santiago and other places of interest in Chili. During the stay the temperature of the air varied from 53° to 78°, but the sea surface was from 54° to 60°·5, the coldest temperature being registered after a strong southerly wind. The general temperature of the surface water was from 56° to 59°.

The Reports on the Copepoda[1] and Ostracoda,[2] by Dr. George S. Brady, F.R.S., have already been published, and from them the following notes have been prepared :—

The Copepoda.—The Copepoda are almost universal in their distribution, and include both free-swimming and parasitic forms. The sea, from the Equator to the Poles, supports such vast numbers of them, that it is often coloured by wide bands for distances of many miles. But the appearance of these minute creatures at the surface depends upon conditions, the nature of which is scarcely at all understood. In confirmation of this, the Naturalists of the Expedition noted an extraordinary profusion of *Corycæus pellucidus* for two days in the surface water, but after that no more could be seen. Night on the whole seems more favourable than daytime for their approach to the surface, but it would appear that there is no very great difference between the nocturnal and diurnal species in this group. In the Polar Seas some species, especially *Calanus finmarchicus*, are present at times in such great abundance as to constitute an important item in the food of Penguins and Whales. As regards number and size of individuals, the cold water of the Arctic and Antarctic Oceans is even more favourable to the growth of the Copepoda than the warmer seas of the tropics. In the cold Polar Seas, *Calanus*

[1] Report on the Copepoda, by Geo. S. Brady, F.R.S., Zool. Chall. Exp., part xxiii., 1883.
[2] Report on the Ostracoda, by Geo. S. Brady, F.R.S., Zool. Chall. Exp., part iii., 1880.

finmarchicus, and nearly allied forms, are the most characteristic members of the surface fauna; while, judging by the results of the Challenger Expedition, the warm equatorial and subtropical areas present a much greater variety of species. *Undina darwinii* and *Euchæta prestandreæ* may be regarded as holding the same position in the tropical and warm temperate seas as *Calanus finmarchicus* in the cold zones; but there are several other species which follow close upon these.

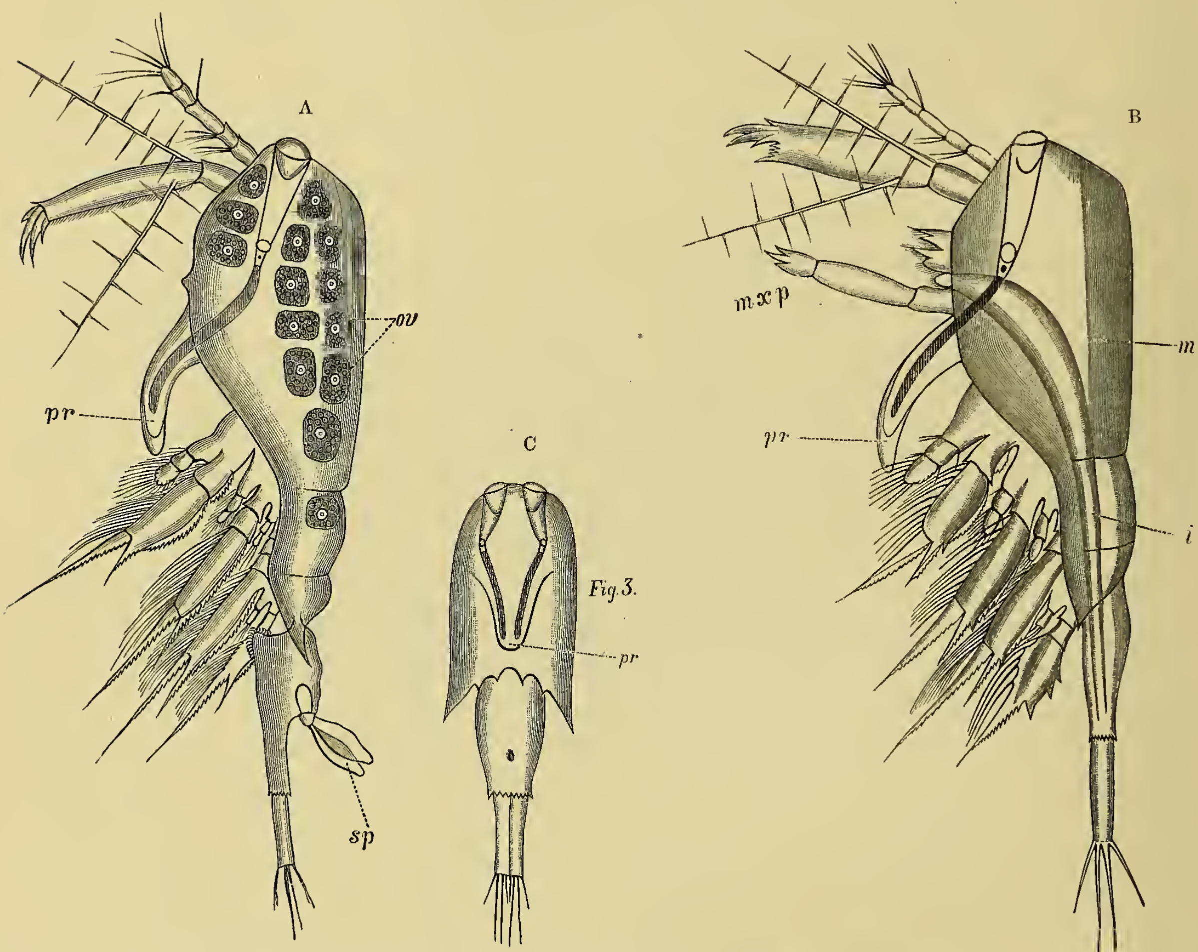


FIG. 312.—*Corycæus pellucidus*, Dana (from Dr. von Willemoes Suhm's drawings).
A, female, seen from the left side; B, male, seen from the left side; C, female, seen from the dorsal surface. *pr*, ocular process; *ov*, ova; *sp*, spermatophores; *mxp*, posterior foot-jaw; *i*, intestine; *m*, dorsal muscles.

As in the case of many purely pelagic or aquatic animals, the range of distribution of many of the marine Copepoda is extremely wide; and one point of paramount interest is the relation of natatory forms of extremely wide distribution, and as an interesting illustration may be mentioned *Zaus spinatus* and *Harpacticus fulvus;* these two species inhabiting precisely the same kind of places respectively in Northern

Europe and the far-off Kerguelen Island. Again, it is a rare exception to find a free-swimming species ranging over a very small district, and the probability is that where this appears to be the case, further research will usually reveal its presence throughout a larger area; as illustrative of this fact, *Copilia mirabilis* was captured in two widely distant areas, viz., Polynesia and the Malay Archipelago, and the North Atlantic, off the west coast of Africa. Only one free-swimming species (*Euchæta prestandreæ*) was found in all the areas explored by the Challenger, although not a few occurred very frequently. The largest numbers of species, leaving out of consideration the fish-parasites, were obtained from the North Atlantic, South Atlantic, Eastern Asiatic, and Australasian Seas, the numbers from these areas being forty-eight, forty-eight, forty-five, and forty-two respectively.

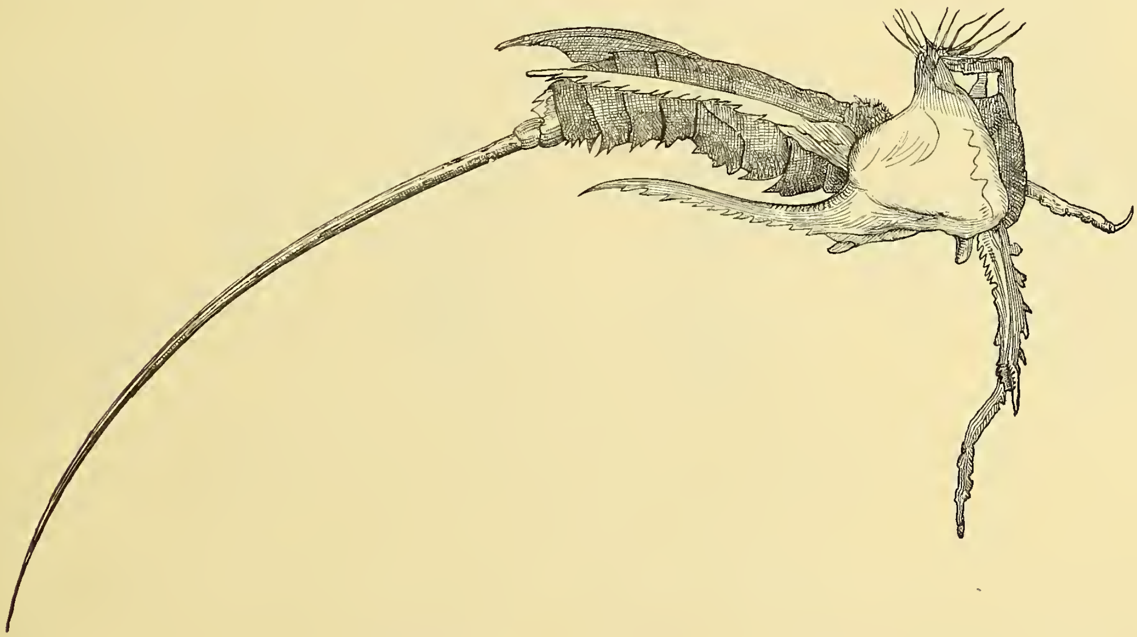


Fig. 313.—*Pontostratiotes abyssicola*, G. S. Brady, seen from the left side; magnified 40 diameters.

The only undoubted deep-sea species, and on the whole the most remarkable Copepod known, is *Pontostratiotes abyssicola*, the single specimen of which was picked from the dried mud, dredged from a depth of 2200 fathoms, having unfortunately lost many of its characters in the drying process; however, it has been minutely described and carefully figured,[1] and is represented in the annexed woodcut (fig. 313). Not only is it peculiar in being an abyssal form, but also in its extraordinary spinous armature, a feature quite unprecedented in the group. Possibly *Hemicalanus aculeatus*, *Phyllopus bidentatus*, and one or two species of *Euchæta* might be reckoned as abyssal species,

[1] Zool. Chall. Exp., part xxiii. pp. 105, 106, pl. xliv. figs. 1–11, 1883.

but it is by no means certain that these specimens came from the bottom. It was frequently noticed that some of the Copepods in the tow-nets sent down to great depths were of a bright red colour, similar to the Shrimps brought up in the trawlings in deep water.

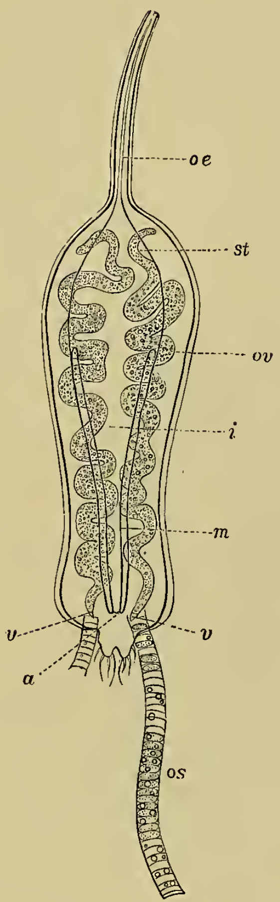


FIG. 314.—*Lernæa abyssicola*, G. S. Brady, parasitic on *Ceratias* (from a drawing by the late R. v. Willemoes Suhm). *oe*, œsophagus; *st*, stomach; *i*, intestine; *m*, muscular portion of intestine; *ov*, ovary; *v*, vulva; *a*, anus; *os*, ovisac.

Remarkably few fish-parasites were brought home by the Expedition. One of the most remarkable of these is *Lernæa abyssicola*, an undoubted deep-sea form, seeing that it was attached to a specimen of the curious abyssal Lophioid genus *Ceratias*. The peculiarity in which it differs from all other parasitic Copepoda is its transparency, its colour during life being of a reddish brown. It is represented in fig. 314.

Altogether one hundred and six species have been enumerated in the Report, forty-three of which are new, and for their reception thirteen new genera have been constituted. This number is inconsiderable relatively to the large number of genera and species previously known, but nevertheless the collection has enabled Dr. Brady to make valuable additions to the knowledge of this group.

The Ostracoda.—The Ostracoda are small laterally compressed Crustaceans whose bodies are completely enclosed in a bivalve shell. They exist, although in very limited numbers, in the most profound depths of the sea, and the number of abyssal genera and species has been greatly increased by the Challenger Expedition.

In those large abyssal areas where, as commonly happens, the ocean-bed consists of pure Globigerina ooze or of red clay, one usually finds a small number of Ostracoda; the specimens consisting of detached valves, frequently much worn and broken, or, more rarely, of perfect though empty shells. These shells evidently belong to animals which lived at the depths where they were found.

A peculiar interest attaches to the Ostracoda from the fact that they alone of all the higher Microzoa are found in fossil strata in sufficient numbers to afford grounds for an exact comparison between the fauna of the present and those of bygone geological epochs. However, as a whole, the results of the Challenger's work in this department are not very important or novel. Very few new and remarkable variations of structural type were found. The Ostracode shells of the present age present different features according as they are found in salt, estuarine, or fresh water, so that the specialist in coming upon a geological stratum containing these shells can at once infer from an examination of them whether it was of marine, estuarine, or inland origin.

The marine Ostracoda of the British Islands consist of at least thirty genera, of which twenty-eight are represented in the Challenger collection; but it must be remembered that during the cruise of the Challenger very few collections were made in the neighbourhood of the shore, which region usually swarms with these small animals. The genus *Paradoxostoma* in British seas, is almost exclusively a littoral one, and it is in this zone that many members of other genera attain their highest development, and there is no doubt that shore-collecting in the tropical and subtropical seas would yield rich results to a student of Ostracoda.

Only two natatory pelagic species have been found by the Challenger to exist in all the areas explored, viz., *Halocypris atlantica* and *Halocypris brevirostris*. These were sometimes captured in great numbers when the tow-net was dragged about

Fig. 315.—*Cythere dictyon*, G. S. Brady.
Male; A, from the side; B, from the front; C, from below.

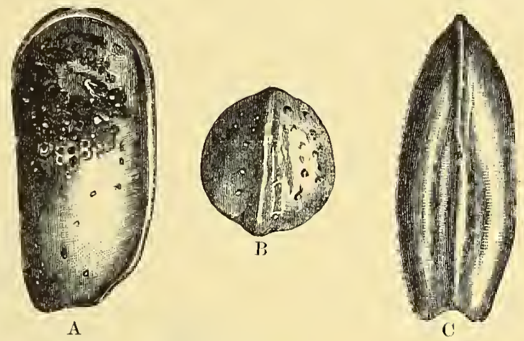


Fig. 316.—*Krithe producta*, G. S. Brady.
A, male, left side; B, female, from the front; C, male, from below.

50 fathoms beneath the surface. The reason of this wide distribution is sufficiently clear if it be remembered that as regards animals living for the most part near the surface of the sea, and dependent, probably, upon no restricted or specially localised supplies of food, the only impediments to universal distribution are conditions of temperature. So far as yet appears, the limit of endurance in these species is reached at about 50° S. and 35° N. latitude.

The species which are most nearly cosmopolitan in their distribution are *Cythere dictyon* (see fig. 315), *Cythere dasyderma*, and *Cythere acanthoderma*. This statement, however, by no means expresses their ubiquitous distribution in the deep sea, a fact which only becomes apparent when it is observed that amongst the forty-five dredgings exceeding 100 fathoms at which Ostracoda were taken, *Cythere dictyon* is noted twenty-three times, *Cythere dasyderma* nineteen times, and *Cythere acanthoderma* seven times.

One of the most common of deep-sea Ostracoda is *Krithe producta* (see fig. 316).

which occurred in most of the regions explored, but the greater number of the examples grouped under this name consisted only of separate valves, varying largely in form and size. The difficulty of dealing with imperfect specimens of shells which possess no distinctive character of sculpture or surface ornament is insuperable.

It may be noted that the affinity of the Kerguelen Ostracoda with the European fauna is much closer than that of any other locality investigated by the Challenger.

CHAPTER XX.

Valparaiso to Cape Tres Montes—The Cirripedia and Pycnogonida—Through the Messier Channel, Sarmiento Channel, and the Strait of Magellan to the Falkland Islands—The Isopoda—The Falkland Islands—Fossils—The Scaphopoda and Gasteropoda—The Anomura.

Valparaiso to Cape Tres Montes.

On the 11th December, at daylight, the Challenger proceeded outside the ships at anchor in Valparaiso Harbour, and was swung to ascertain the errors of the compass and dipping needle. At 1.30 P.M. this operation was completed and all sail was made on the port tack to a fresh southerly breeze. The day was fine and the atmosphere so remarkably clear, that Mount Aconcagua was seen at sunset quite distinctly.

During the whole passage from Valparaiso to the Gulf of Penas steady southerly winds were experienced, never exceeding a force of 5, with fine although somewhat cloudy weather, and a smooth sea. This necessitated beating down the coast to Cape Tres Montes, which occupied twenty days (see Sheet 40). On the passage Juan Fernandez Island was sighted, but the vessel did not touch there; four soundings, five serial temperature soundings, and three trawlings were obtained.

The soundings obtained were made into a meridional section in order to show the temperatures, but as they were taken at varying distances from the coast, no conclusion as to the contour of the bottom can be formed (see Diagram 21).

The surface temperature was 62° at Valparaiso and 59° at Juan Fernandez, from whence it gradually decreased to 55° in the Gulf of Penas.

The serial temperatures show that the isotherm of 40° is almost parallel with the surface, and that the higher isotherms gradually rise as the surface temperature cools.

The surface current experienced always had a northerly tendency, although the daily calculations showed its direction to be sometimes east and sometimes west of north. The total current experienced was north 8 miles per day, the easterly and westerly deflections almost counterbalancing each other; the last three days, however, when close to the Peninsula of Tres Montes, little or no set was felt, the true rate of the northerly current along the coast by the observations being about 9 miles per day.

The following anemometer observations were taken :—

Date. 1875.	Station.	Velocity of wind in miles per hour.	Force of wind by Beaufort's scale, as noted in log.
December 14	299	12	2
„ 17	300	12	2
„ 28	302	16	3
„ 30	303	14	3 to 4, mean $3\frac{1}{2}$

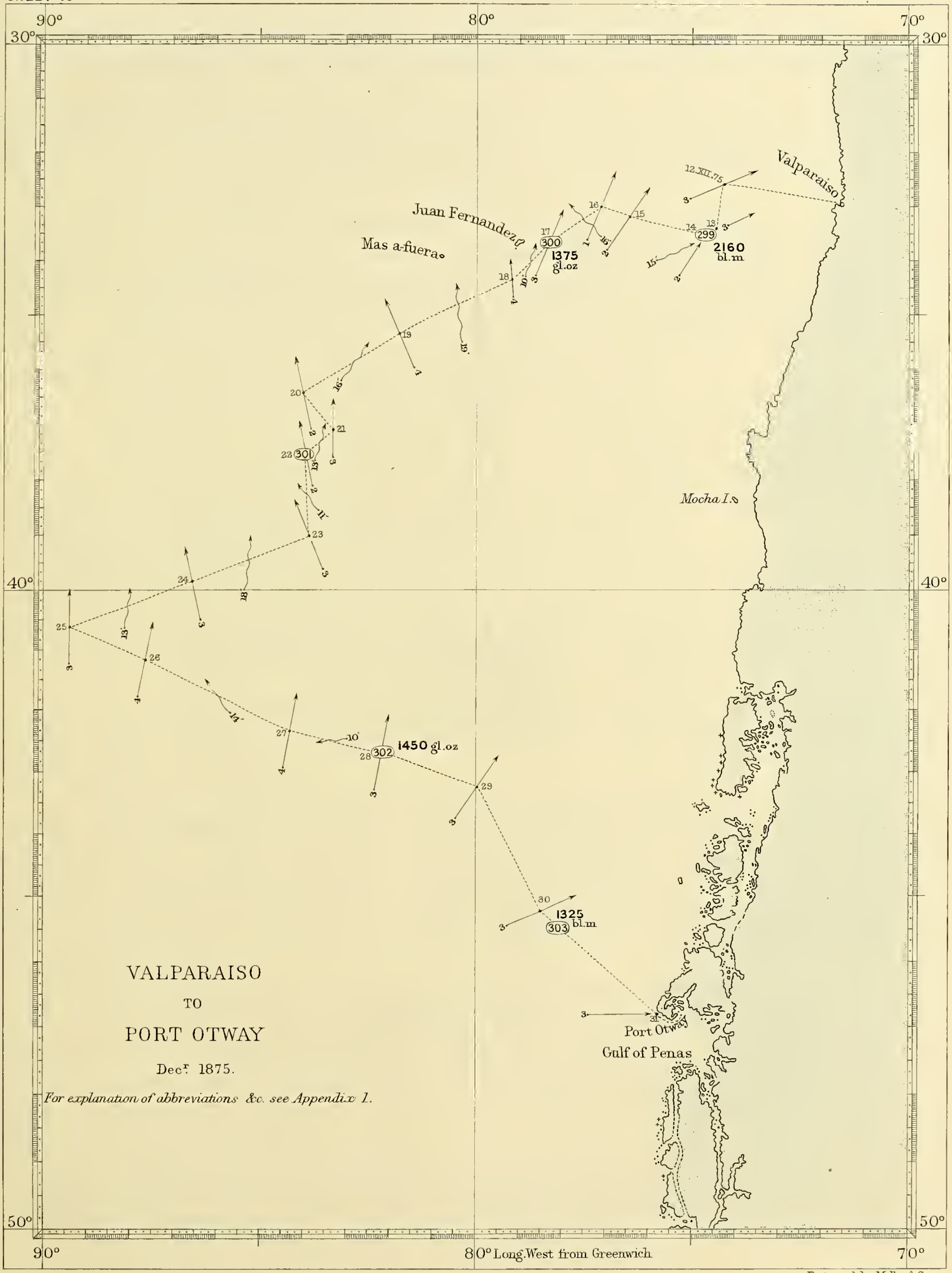
The deposit at 2160 fathoms off Valparaiso contained 16 per cent. of carbonate of lime, and was a blue mud, in all essential respects similar to that in 2225 fathoms at the Station before entering Valparaiso on the 17th November. The trawling was even more productive than on that occasion, for besides some pumice stones and a few manganese nodules, over one hundred specimens of invertebrates and a few fish were obtained. In the special Reports already published, forty-two new species of deep-sea animals are recorded from this Station.

As far as can be judged at present, the trawlings and dredgings on the blue muds near continental coasts are much more productive than those at similar depths on other kinds of deposits far removed from continents. For instance, although many dredgings and trawlings were taken during the cruise between Japan and Chili in depths of about 2000 fathoms or less, none of them can be compared in productiveness either with respect to number of individuals or species with the hauls in 1875 and 2300 fathoms off Japan, or 2225 and 2160 fathoms off the coast of Chili. This fact was noted so often during the cruise that it is difficult to believe it to be a mere accident. It is probably connected with the fact that food is more abundant near continental shores where large rivers enter the sea, and possibly also with proximity to the shallow waters of continental land, whence it may be supposed deep-sea forms have been originally derived. Whether or not animals from trawlings farther removed from shallow water are on the whole more abnormal than those from similar depths near shore, cannot with any certainty be stated until the whole of the groups have been fully worked out, but there are indications that such is the case.

The deposit at 1375 fathoms, 20 miles to the eastward of Juan Fernandez, was a Globigerina ooze containing 54 per cent. of carbonate of lime, which consisted of the shells of Foraminifera, a few fragments of Pteropods, Echinoderms, and Polyzoa. The mineral particles were chiefly of volcanic origin, and among them were very many fragments of palagonite.

The trawl contained over one hundred deep-sea animals and fragments of palagonite, pumice, and tufa. The trawl appeared to have caught in something at the bottom, for

SHEET 40



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the accumulators were stretched to their utmost before it was finally got free. When it came to the surface the net was not torn, but the beam was scored and marked with streaks of black manganese peroxide. The fragments of tufa in the trawl were coated with manganese on one side, and appeared to have been torn away from larger masses, so that here as well as at several other Stations there were indications that the bed of the ocean was uneven, probably from volcanic disturbance.

At 1450 fathoms, 330 miles westward from Chiloe Island, the deposit was again a Globigerina ooze containing 82 per cent. of carbonate of lime. The mineral particles were chiefly minute fragments of sideromelan and palagonite, and peroxide of manganese. The pelagic Foraminifera in the deposit were chiefly *Globigerina* with a few *Orbulina* and *Pulvinulina*, and all these were very small and dwarfed, in this respect agreeing with those taken on the surface by means of the tow-nets.

The trawl again brought up a large number of animals and some manganese nodules. Some of these latter appeared to have been fragments torn from larger masses, and some had nuclei which seemed originally to have been portions of the ooze itself. This association of manganese nodules with altered volcanic fragments in a Globigerina ooze was frequently observed during the Expedition.

The deposit in 1325 fathoms was a blue mud containing 25 per cent. of carbonate of lime made up of pelagic and other Foraminifera, fragments of Polyzoa, Echinoderms, Ostracode shells, and fragments of other calcareous organisms. The mineral particles consisted chiefly of quartz and fragments of rocks and minerals derived from the continent.

Dr. P. P. C. Hoek's Reports on the Cirripedia[1] and Pycnogonida[2] collected by the Expedition form parts of the zoological series; he has prepared the following abstracts of his Reports :—

The Cirripedia.—"A very valuable collection of Cirripedia was made during the cruise of H.M.S. Challenger. It numbers about seventy-five species, eighteen of which were already known, fifty-seven being described in the Report as new to science. The great value of the collection, however, does not exclusively consist in the number of species or of the new ones alone; the objects themselves are highly important from different points of view.

"What a Cirripede Crustacean is, how it develops, grows, and lives, Darwin has taught us with great skill; his monographs, moreover, contain such excellent descriptions of all the genera and species known to him, that they must necessarily be considered as the foundation for all future investigators to build upon. To erect a superstructure on that foundation has, to a certain extent at least, been possible by the aid of the Challenger collection.

[1] Report on the Cirripedia (Systematic Part), by Dr. P. P. C. Hoek, Zool. Chall. Exp., part xxv., 1883. Report on the Cirripedia (Anatomical Part), by Dr. P. P. C. Hoek, Zool. Chall. Exp., part xxviii., 1884.

[2] Report on the Pycnogonida, by Dr. P. P. C. Hoek, Zool. Chall. Exp., part x., 1881.

"The species have been distributed among thirteen genera, of which only one is new to science. This is the genus *Megalasma;* the only species which represents it has a very characteristic shape, though it is doubtless nearly related to the genus *Pœcilasma*, Darwin, and belongs with the latter genus to that group of pedunculated Cirripedia which contains also the genera *Dichelaspis* and *Lepas.* In all these genera the capitulum has the same number of valves (five), the structure of the body being also much the same, and showing only secondary differences. Whereas, however, the species of *Lepas* live only at the surface, those of the nearly related genera were taken at various and sometimes considerable depths. One of the species of *Dichelaspis* ranges even as far down as 1000 fathoms. The surface animals as well as those attached to rocks and stones within

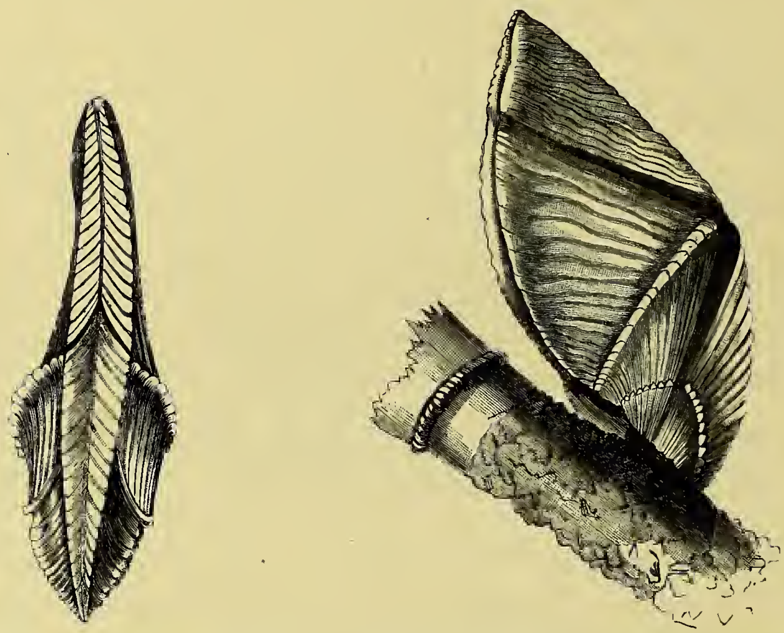


FIG. 317.—*Megalasma striatum*, Hoek. Station 204, off the Philippines, 100 and 115 fathoms.

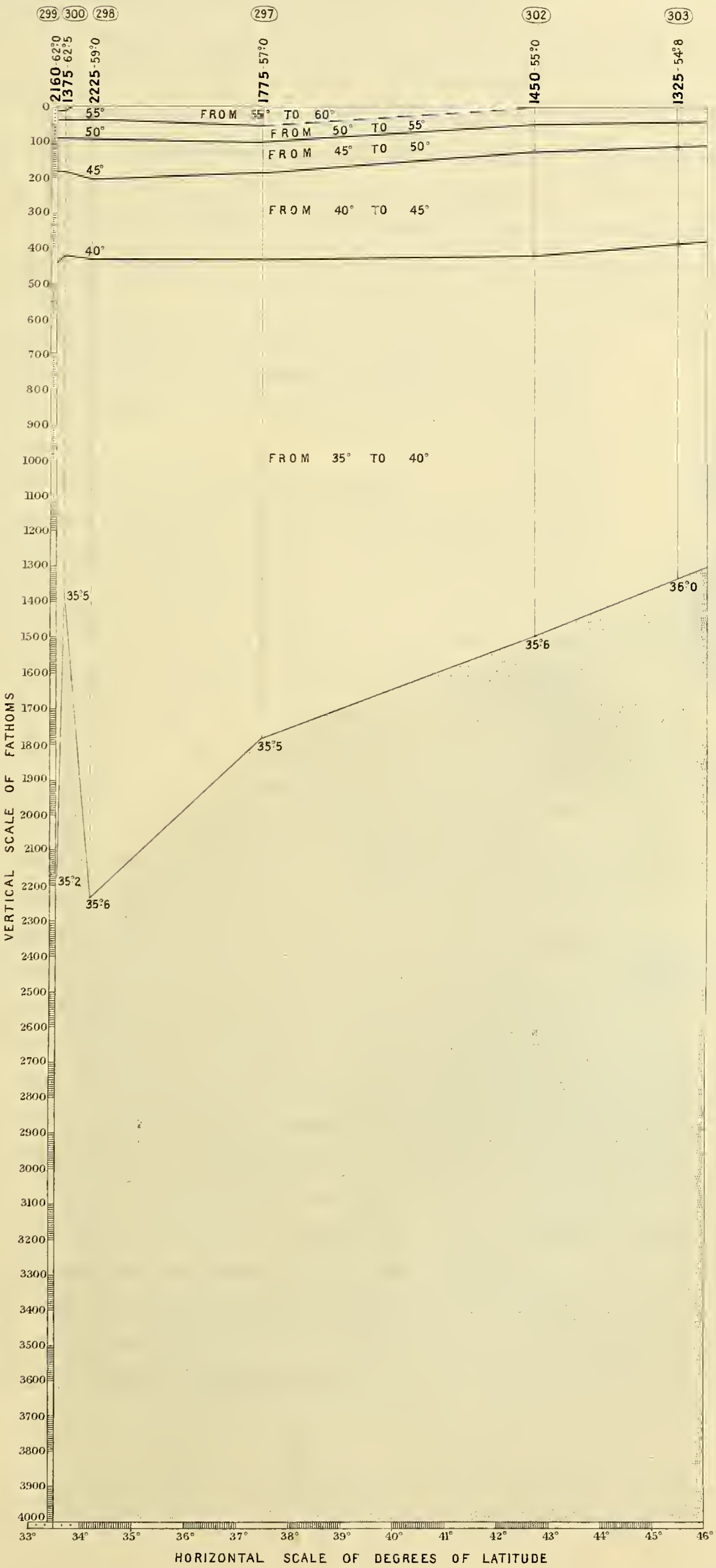
the tide marks live as a rule in numerous assemblies close to one another; in the deep sea, however, the Cirripedia seem to live rather solitarily. And this assertion must not be considered hazardous, for, though the contents of the dredge or trawl do not necessarily show the exact number of specimens living together at one spot, one naturally arrives at the conclusion, as it was found that by far the greater part of the deep-sea species are represented by single or very few specimens only.

"The genera *Conchoderma* and *Alepas* represent a second family of pedunculated Cirripedia. In this family the capitulum shows rudimentary valves only, or sometimes even no valves at all. In the Challenger collection the genus *Conchoderma* is represented by well-known species which live at the surface; of *Alepas*, on the other hand, there

PACIFIC OCEAN

Meridional Temperature Section off the West coast of South America between the 33rd and 46th Parallels.

For explanation of Symbols see Appendix 1.



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was a new species taken at a depth of 410 fathoms living attached to the spines of a deep-sea Echinid, *Phormosoma hoplacantha,* A. Ag.

"By far the most remarkable feature is the extension of the family of pedunculated Cirripedia containing the genus *Scalpellum.* As far as I could make out, only eleven species of that genus were previously known, and the number of new species which had to be described amounts to forty-three. The same family of Cirripedia embraces the genus *Pollicipes* also, seven species of which are known to inhabit tropical seas all over the world. Of this latter genus, however, the Challenger did not collect a single representative, so it would seem we must conclude that this genus does not occur in the deep sea. Yet the hitherto known (shallow water) species of the two genera live exactly under the same circumstances, and, what is also of some importance, both genera (*Scalpellum* as well as *Pollicipes*) very commonly occur in fossil deposits, especially in Secondary strata.

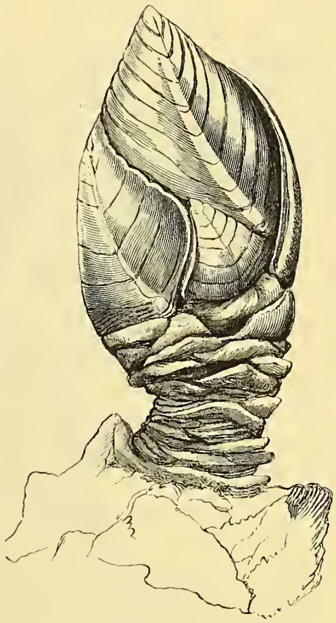


Fig. 318.—*Scalpellum eximium,* Hoek. Station 135, off Tristan da Cunha, 1000 fathoms.

"Thirty-five out of the forty-three species of the genus *Scalpellum* dredged during the cruise of the Challenger inhabit depths of 500 down to 2850 fathoms. Nine of these correspond with the fossil *Scalpellum maximum* in the shape of the valves of the capitulum, and especially of the carinal latus; twenty-six, on the other hand, have this valve of the same shape as the recent forms known to Darwin. We see, therefore, that in the case of the genus *Scalpellum* the abyssal fauna consists partly of forms resembling fossil species, but contains many more species of a true shallow-water type.

"A remarkable observation from a biological point of view was made in one of the specimens of *Scalpellum stroemii,* Sars. It contained rather large eggs, and these had passed the Nauplius-stage and had arrived at the Cypris-stage; so it is quite clear that at least some of the species of the genus *Scalpellum,* for it is highly improbable that *Scalpellum stroemii* should stand alone in this respect, have lost the Nauplius as a free-swimming larval stage. Nor are the results of the study of the 'complemental' males of *Scalpellum,* discovered by Darwin more than thirty years ago, devoid of importance. It was not only possible to prove that their organisation is highly degenerated, but also to demonstrate in what this degeneration consists, and how much it affects some of the organs, whilst others suffer less, or not at all from it. Though very common in the genus *Scalpellum,* the occurrence of little males does not seem to be a rule without exceptions; there are species which probably are hermaphrodite as other Cirripedia are, and in which no complemental males have been observed; there are other hermaphrodite species to which little complemental males are found attached, and, finally, there are true unisexual species, in which small males live attached to very large females.

"Six genera of sessile Cirripedia have representatives in the collection made during the cruise of the Challenger. *Acasta* and *Coronula* are represented by one species each, *Tetraclita* and *Chthamalus* by two each, and one of the species of the latter genus has been described as new; far more interesting, however, are the species of *Verruca* and *Balanus* brought home by the Challenger.

"*Verruca* was collected at six different Stations, and, though not without hesitation, the specimens from each Station have been considered as representing a different species, although perhaps it will hereafter be possible to show that two or more of them belong to one and the same species. These species are especially interesting, because they form together a very distinct and characteristic division of the genus, showing affinity to *Verruca nexa* as far as regards the perpendicularity of the walls and the presence of a distinct third articular ridge on the outer surface of the scutum, a peculiarity which is also observed in the fossil *Verruca prisca*, Bosquet. At the same time these new forms have shown that the genus has a truly world-wide range, and that in the case of *Verruca*, as in that of *Scalpellum*, there is coincidence of great antiquity with the occurrence at a considerable depth. For, whereas the greatest depth from which Darwin got specimens of *Verruca* was only 90 fathoms, the range in depth of the Challenger species is from 500 to 1900 fathoms.

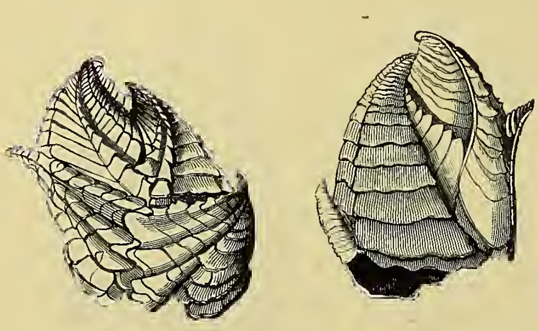


Fig. 319.—*Verruca sulcata*, Hoek. Station 170, off the Kermadecs, 520 and 630 fathoms.

"The genus *Balanus* has twelve representatives among the Challenger species. Of these five are new; three of them, however, are probably nearly related to species described by Darwin; the remaining two, *Balanus corolliformis* and *Balanus hirsutus*, on the other hand, representing two closely allied species, scarcely admit of comparison with any species Darwin knew. They belong to the deep-sea fauna, one being found at a depth of 180 fathoms, the other of even 516 fathoms, and some of the peculiarities of their structure must be regarded as standing in near relation to their living at so considerable a depth. These peculiarities are the absence of radii and the solidity of the parietes; the former causes the compartments to adhere so feebly as almost to separate on being manipulated. For an animal living near the surface the violent beating of the waves would soon prove fatal, if its walls showed the structure of the present species. As, moreover, the compartments are solid (not permeated by pores), they have by no means the strength of those of other species of the genus.

"So we see that though the genus *Scalpellum* is by far the most remarkable of the collection, the representatives of some of the other genera are not devoid of importance either.

The study of the material from a morphological point of view has also yielded some results, and these have been brought together in a supplementary Report. A detailed description of the little male of *Scalpellum regium*, and a comparison of its structure with that of the other species of *Scalpellum*, form the first chapter of this supplement. Some of the more general results of the investigations in this department have been given already. The second chapter is devoted to the description of those problematic organs

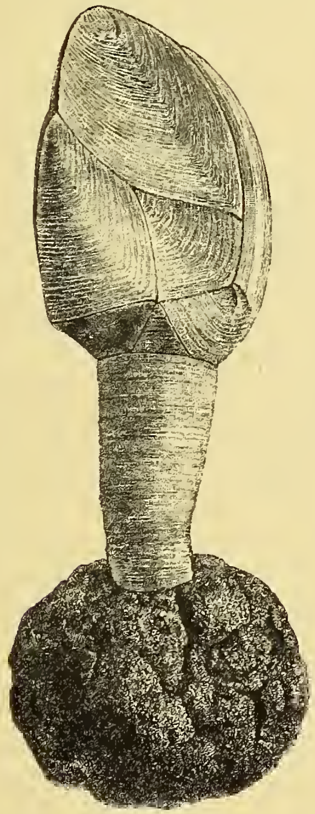


Fig. 320.—*Scalpellum darwinii*, Hoek, attached to a manganese nodule. Station 299, 2160 fathoms. Natural size.

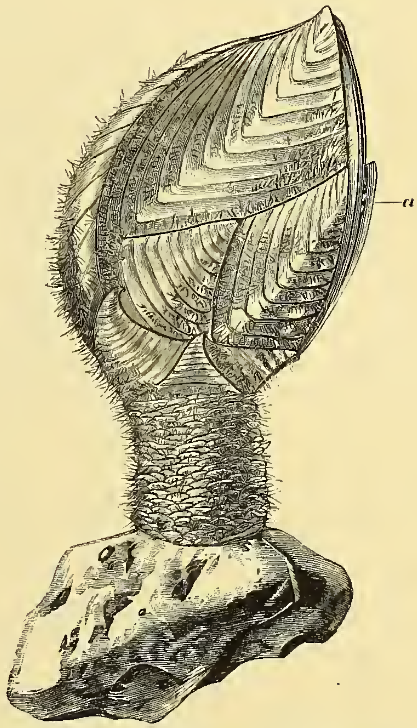


Fig. 321.—*Scalpellum regium* (Wyv. Thoms.), Hoek. *a*, the male. Stations 61 and 63, 2850 and 2750 fathoms. Natural size.

of Cirripedia which Darwin observed in the outer maxillæ, and to which he ascribed an olfactory function. They were found to constitute an open communication of the body-cavity with the exterior, and shown to be comparable with the segmental organs of the Annelida.

"A rather detailed description of the cement-apparatus is given in the third chapter. The structural differences in the various genera do not lack importance; however, their importance would no doubt be much greater still, if the question of the morphological significance of the apparatus were more decided.

"Darwin's 'true ovaria,' which Cuvier thought to be salivary glands, were also subjected to a close inspection, and were shown to be digestive glands pouring their secretions into the alimentary canal. The body of these glands is composed of one kind of cell only, belonging apparently rather to the pancreatic than to the hepatic cells, which are found in the digestive glands of the higher Crustaceans (Weber). To the same category of problematic organs, in which Cirripedia always were very rich, no doubt belongs the small organ of vision discovered by Leidy; it is attached to the surface of the stomach and covered by the ligament between the two scuta, and by the muscles placed between this ligament and the widened stomach. Leidy's observation is quite in accordance with the facts, and these beautifully illustrate the persistence of an old larval structure which can hardly be considered to be of any use to the animal.

"Though in general Krohn and Kossmann had a correct notion of the structure of the female genital apparatus, our knowledge, as far as details are concerned, has been considerably augmented by the investigation of the Challenger material. The results of the researches with respect to this apparatus have been published in the last chapter of the Supplementary Report. The discovery of the occurrence of the segmental organ communicating with the exterior by means of the openings in the outer maxillæ, perhaps casts light on the peculiar place of the female genital openings of Cirripedia. These would appear to be nothing but the openings of a second pair of segmental organs; thus the first pair of segmental organs furnishes a direct communication of the body-cavity with the surrounding medium, whereas the second serves for the evacuation of the female genital products."

The Pycnogonida.—"The Pycnogonids form together a little group of Arthropodous animals. Though they are often met with by zoologists studying the marine fauna, they have hitherto, with a few exceptions only, been but superficially investigated. The naturalists who paid more special attention to the group had but few specimens at their disposal, and these belonged to a couple of species only; thus it happened that though the number of papers treating of these animals had grown rather large, and though a considerable number of new species had from time to time been described, our knowledge of the group was but little increased. By far the greater number of the species were described so inaccurately as not to admit of comparison with one another, and so far as the morphology of the group is concerned, we have till recently been almost entirely in the dark. The papers of Dohrn (1869) and Semper (1874) are among the first that tried to shed light on this question, and it is well known that they have arrived at very different conclusions. Dohrn's conclusion was that the Pycnogonids, though not Crustaceans, appear by the presence of a Nauplius-larva in their ontogenetical development to be nearly related to Crustaceans; Semper, on the contrary, tried to demonstrate the truly Arachnid nature of these animals.

"Species were recorded from different coasts and seas, but the incompleteness of the descriptions made it almost impossible to arrive by their aid at any general result as far as geographical distribution was concerned. With a few exceptions only, the species were all littoral, and these few were chiefly those dredged in the North Atlantic, and investigated by G. O. Sars,[1] and those taken off New England and described by E. B. Wilson.[2]

"The study of the material collected during the cruise of H.M.S. Challenger has added to our knowledge of the group in many respects. On twenty-six occasions out of two hundred and eighty-two on which the dredge or trawl was let down during the

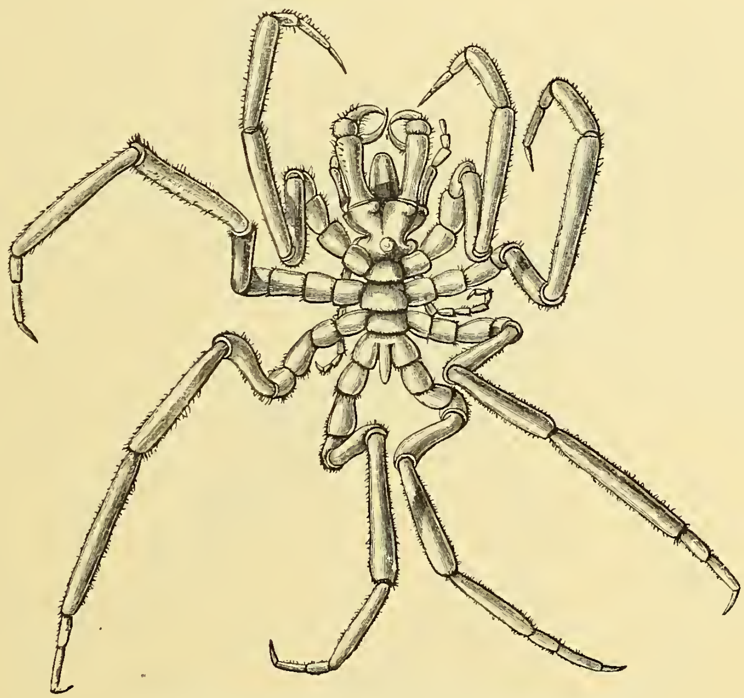


Fig. 322.—*Nymphon robustum*, Bell. 375 and 540 fathoms.

cruise, Pycnogonids were taken; a collection was made numbering about one hundred and twenty specimens, belonging to thirty-six species, thirty-three of which had to be described as new to science. These thirty-three species belong to nine[3] genera, three of which are new. Five of these nine genera contain species which may truly be called inhabitants of the deep sea. They are the genera *Nymphon, Ascorhynchus, Oorhynchus, Colossendeis,* and *Pallenopsis.* However, with one exception only (*Oorhynchus*), these

[1] *Archiv f. Math. og Naturvid.*, Bd. ii., 1877, and Bd. iv., 1879.

[2] Report U.S. Commission of Fish and Fisheries, part vi. for 1878, Appendix xv., 1880.

[3] In the Report only eight genera are recorded as represented; the ninth is the genus *Pallenopsis*, Wilson. The species which belong to this genus were considered in the Report as belonging to *Phoxichilidium*. (*Vide* Hoek, Pycnogonids of the "Triton" Cruise, *Trans. Roy. Soc. Edin.*, vol. xxxii. p. 9, 1883.)

genera contain also species which are true littoral or shallow-water forms. *Nymphon* is represented by fifteen species, ten of which belong to the deep sea. Of the three species of *Ascorhynchus*, one was taken in shallow water and two in deep water; *Colossendeis* has eight deep-sea species and one shallow-water form; *Pallenopsis* is represented by five species, three of which are true deep-sea animals. The new genus *Oorhynchus*, which I have been obliged to introduce into science, is the only one which, as far as our present knowledge goes, contains no shallow-water but only deep-sea species. As the single species it contains is represented by one specimen only, we can hardly call it an exception, and we arrive at the conclusion that, though there are numerous deep-sea species, there exist no true deep-sea genera. At the same time it is worthy of note that, though some of the genera of Pycnogonids have a very great range in depth, this is only in a slight degree the case with the species. The most striking instances of species ranging through different depths are those of *Nymphon grossipes*, Oth. Fabr. (taken at 83 and also at 540 fathoms), *Colossendeis leptorhynchus*, Hoek (from 400 and 1600 fathoms), and *Pallenopsis patagonica* (Hoek), taken at 45 and 175 fathoms.

"With regard to the geographical distribution, no general results of any particular importance or novelty have been arrived at by the study of the Challenger Pycnogonida. The deep-sea genera are world-wide in their distribution in this group of animals as well as in most others that have been studied of late in this respect. The shallow water in the neighbourhood of the coasts is much richer in different forms of Pycnogonids than seems to be the case in the deep sea. Very interesting in this respect is a comparison between the results of the study of the Challenger Pycnogonida and those arrived at by Dohrn from the study of the Pycnogonida of the Gulf of Naples. As I mentioned above, of the thirty-three new species collected by the Challenger thirty belong to genera already described and only three belong each to a new genus. Two of these (*Hannonia* and *Discoarachne*) were taken on the shore (at Sea Point near Cape Town); so only one can be added to the genera known as deep-sea inhabitants. Dohrn, on the contrary, enumerates twenty-five species as inhabiting the shores of the Gulf of Naples; these he divides into ten genera, five of which are described as new to science. So the study of the Pycnogonids of a range so very limited as the Gulf of Naples brought to light more new forms, in the real sense of the word, than that of the Challenger dredgings in various parts of the world.[1]

"Deep sea conditions of life have not dwarfed the Pycnogonids; on the contrary, many of them there attained such proportions as they never do in the shallow water near the coast. The size of *Colossendeis gigas*, Hoek, and *Colossendeis robusta*, Hoek, is indeed gigantic (the body of *Colossendeis gigas* has a length of 80 mm., the leg of

[1] "When Dohrn's elaborate monograph was published, the Challenger Report on the Pycnogonida was printed and ready to appear, as it did a few weeks later. For a comparison of Dohrn's results with mine I beg to refer the reader to a paper which I published in the *Archives de Zool. expér.*, t. ix. pp. 525–539, 1881."

301 mm.), and the deep-sea species *Ascorhynchus glaber*, Hoek, *Pallenopsis mollissima*, (Hoek), and *Nymphon hamatum*, Hoek, are also remarkable for their dimensions, especially when they are compared with species of the same genera inhabiting shallow water.

"It has not been possible to demonstrate by the aid of the deep-sea material any relationship of the Pycnogonida either with the Arachnida or with the Crustacea. It is necessary, therefore, to consider them, provisionally at least, as a distinct group (Class)

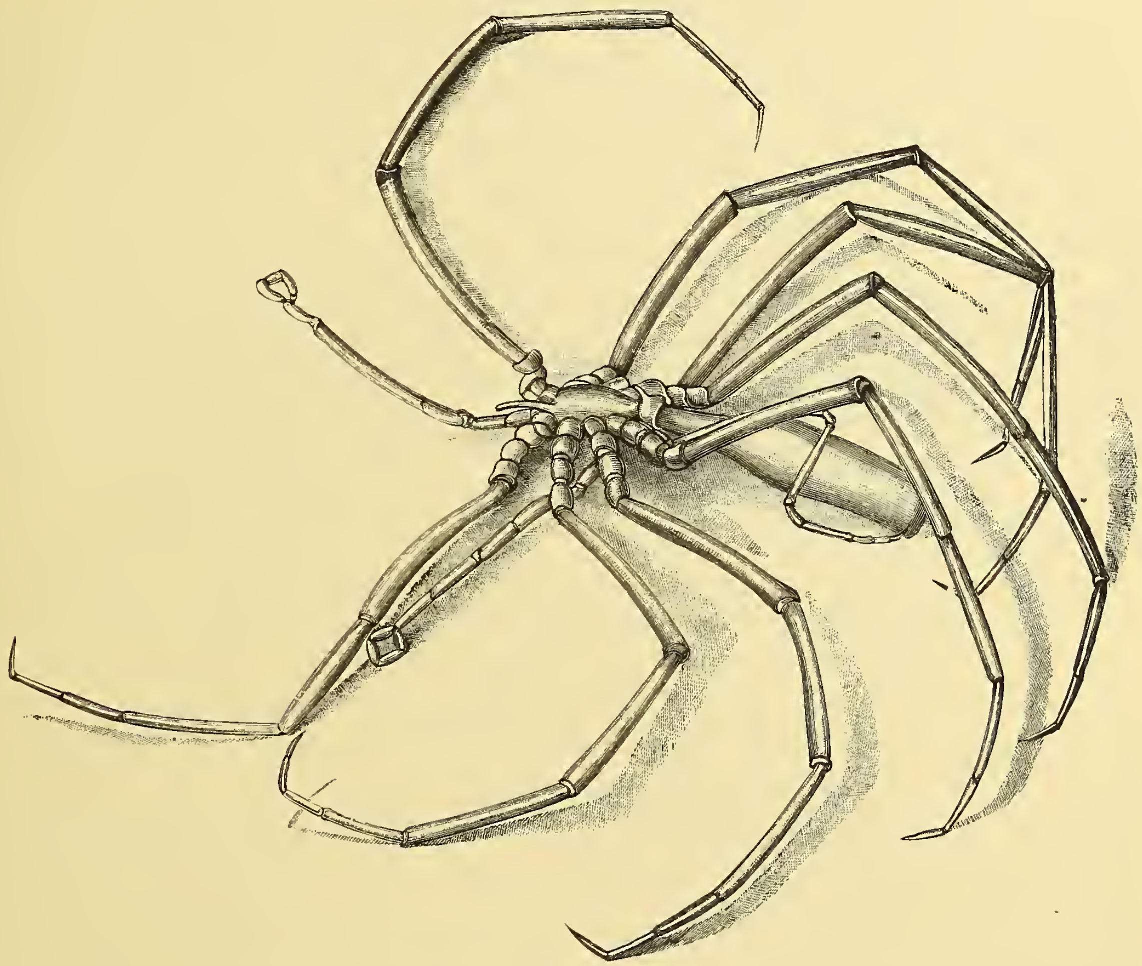


Fig. 323.—*Colossendeis proboscidea*, (Sabine). 540 fathoms. Natural size.

of Arthropodous animals. Their body consists of a cephalon, a thorax, and a rudimentary abdomen. The cephalon is united with the first segment of the thorax, and three free thoracic segments follow behind this coalesced segment. When comparing different genera of Pycnogonida a great diversity is shown with regard to the number of cephalic appendages; sometimes there are three pairs of them, sometimes only two, sometimes one, and occasionally they are all wanting. This last circumstance, however, is never met with in the full-grown animals of both sexes; the third pair of appendages at least, the so-called 'ovigerous legs,' are always developed in the full-grown males. The other two pairs may each or both of them be either represented or wanting in the full-grown animals; however, there is not a genus and not even a single species of Pycnogonids in which the three pairs of cephalic appendages, or only one of them, have totally disappeared; they always show themselves during at least one of the first stages of the ontogenetical development.

"I therefore believe that these three pairs of cephalic appendages are an inheritance from the common progenitor of all living Pycnogonids; and so are probably the four pairs of long eight-jointed legs which in all full-grown Pycnogonids are attached to the four thoracic segments. As the rudimentary abdomen never shows traces of appendages, it is best, I think, to admit that the body of the hypothetical ancestor of this group was composed of the above mentioned seven segments.

"The study of the nervous system tended in general to confirm this suggestion; with regard to its structure, special attention was paid to the innervation of the proboscis. A complex nervous apparatus serving for the innervation of the muscles of the proboscis was discovered and described; it probably is not of any primary morphological significance, yet its structure seems highly important, as it beautifully illustrates the great amount of complication which even the nervous system may undergo, when it serves for an organ fulfilling a special and rather important function.

"Except the organs of touch, which are spread all over the body, the eyes are the only organs of sense certainly known to exist in the Pycnogonids. With regard to their occurrence in the specimens inhabiting great depths, I found as a rule that they had either no eyes at all or rudimentary ones without pigment. However, even those which must be called rudimentary, from their want of pigment, often show distinct lenses as rounded spots conspicuous by their brightness. Nor is the want of pigment in the eyes of the deep-sea species a rule without exceptions: *Nymphon macronyx*, G. O. Sars, from 840 fathoms, has distinctly pigmented eyes; *Oorhynchus aucklandiæ*, Hoek, from 700 fathoms, has them with pigment also; and even *Nymphon meridionale*, Hoek, from 1675 fathoms, has distinctly pigmented eyes. In the case of Pycnogonids we have no reason to doubt that the animal really lived at the depth from which the net in which it was found was drawn up. The fact is also quite in accordance with the occurrence of eyes in deep-sea Crustaceans, fishes, and other animals. Though we do not understand the nature of the light present in the deep sea, it is hardly possible to accept any longer the supposition of the absolute darkness of the abysses.[1]

[1] The result of the earliest deep-sea dredgings carried on in H.M.S. "Lightning" in 1869 was to convince Dr Carpenter, Mr Gwyn Jeffreys, and Prof. Wyville Thomson, who conducted them, of the existence of light in the ocean abysses. They write in their Report: "That there *is* light there can be no doubt (*Proc. Roy. Soc. Lond.*, vol. xviii. p. 431, 1870), and every extension of deep-sea exploration since that time has confirmed the truth of this assumption.—J. M.

"A very characteristic feature in the life-history of the Pycnogonids is afforded by the circumstance that the males fulfil the duty of bearing the eggs on the so-called ovigerous legs. However, I have been able to ascertain that this rule, which was discovered by G. Cavanna about 1874, admits of an exception in the case of *Nymphon brevicaudatum*, Miers. A specimen with egg-masses on the ovigerous legs had considerably swollen thighs and large genital pores such as are characteristic of the females. On investigating the thighs of this specimen, I found them filled up with well-developed ovaries. Moreover, from the great resemblance of the ovigerous legs of the males and females, I hazarded the supposition that the Pycnogonids of the genus *Colossendeis* would deal with their eggs in a way differing from that of the species of other genera.

"Finally, a few words on the metamorphosis of the Pycnogonids. As a rule the

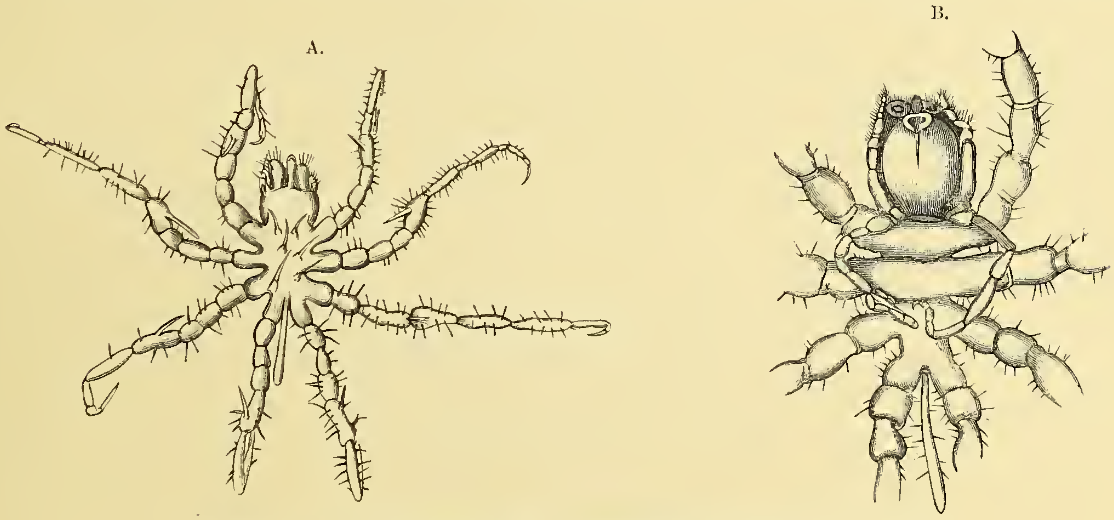


FIG. 324.—*Oorhynchus aucklandiæ*, Hoek. Station 169, off New Zealand, 700 fathoms.
A. Magnified $7\frac{1}{2}$ times. B. Magnified 15 times.

larva creeping out of the egg is a little creature with only three pairs of appendages (which become later on the cephalic ones); still in some cases the degree of development which the larva has reached, when leaving the egg, is different even for two Pycnogonids belonging to the same genus. For example, the larva of *Nymphon gallicum*, Hoek, from the French coast, is a true Protonymphon with three pairs of appendages only; the young *Nymphon macrum*, Wilson, as well as the young *Nymphon brevicaudatum*, Miers, when hatching, is furnished not only with the three pairs of cephalic, but also with one or two pairs of thoracic appendages. The cephalic appendages in these latter larvæ, moreover, have grown rather weak; their bodies are much more elongate than is the case in the other larvæ."

Through the Messier Channel, Sarmiento Channel, and Strait of Magellan to the Falkland Islands.

The Messier and Sarmiento Channels.—On the 31st December, at 9.15 A.M., the Peninsula of Tres Montes was seen through the mist, and at 10.45 A.M. Cape Raper was observed ahead. A fine westerly breeze was blowing, but the weather was cloudy and misty, with passing showers of drizzle until noon, at which time Cape Gallegos bore north and Cape Raper N.E. by E. ¼ E. The afternoon was fine, especially after Cape Tres Montes was passed at 2 P.M., and there was a remarkably fine view of this iron-bound coast, off which, fortunately, there is no outlying danger, or it would probably have been the scene of many a shipwreck besides that of H.M.S. "Wager" in 1741. At 3 P.M. Cape Stokes was rounded, and shortly afterwards a sounding and dredging obtained in 40 fathoms, with the rock off the left extremity of the Peninsula of Tres Montes 17° 20′ Cape Stokes 75° 20′ right extremity of Entrance Isles. At 5 P.M. the ship proceeded towards Port Otway, anchoring there at 6.30 P.M. A party from the ship landed for a short time; the rock at the landing place was a dolomitic limestone.

On the 1st January 1876, at 5 A.M., the Expedition left Port Otway, and proceeded across the Gulf of Penas towards the Messier Channel, in order to pass through the Inner Straits from the Gulf of Penas to the Strait of Magellan. The morning was bright and fine, though misty. At 6 A.M. Cape Stokes was passed and a S.E. ½ S. course shaped for the Ayantau Islands. The rock off Cape Stokes is about 3 feet high and flat, but that off the point next west of Cape Stokes is about 60 feet high. At 10 A.M. the Ayantau Islands were seen and they were passed shortly after noon. By a good meridian altitude the peak of the largest island of this group was found to be in lat. 47° 35′ 30″ S. instead of lat. 47° 38′ S., as marked in the chart supplied. At 2 P.M. a sounding was obtained in 165 fathoms, blue mud, with Sombrero Peak S. 82° E., Ayantau Peak N. 12° W., Mount Anson west, Southeast Hill S. 67° W., the left extremity of Penguin Island S. 27½° E., and Mount Baker S. 59° E. Proceeding towards Penguin Island, the ship was stopped at 2.45 P.M., and exploring parties were sent on shore, together with an officer to obtain a few angles, but the weather becoming cloudy with a drizzling rain, no angles could be taken. In the meantime the ship sounded and trawled in 125 fathoms, with Sombrero Island Peak N. 65° E., Ayantau Peak N. 12° W., Pedro Island N. 57° W., and Mount Baker N. 69° E., and afterwards in 160 fathoms, with Ayantau Island N. 14° W. and Sombrero Island N. 72° E. On Penguin Island the rocks were an altered diabase and amphibolic granite. At 4 P.M. the exploring and surveying parties returned, the trawl was hove up, and at 4.30 P.M. the ship proceeded for Hale Cove, the weather still rainy and thick. At 5 P.M., however, the rain ceased, and at 6 P.M. the weather was again bright and clear. The vessel passed close along the west sides of Baker, Scout, Scylla, and Alert Islands, and the kelp reported by the "Alert" was

SHEET 41

PORT OTWAY
through
MAGELLAN STRAIT
touching at
HALE COVE, GRAY Hr., PORT GRAPPLER, TOM BAY, PUERTA BUENO, ISTHMUS BAY, PORT CHURRUCA, PORT FAMINE, SANDY POINT AND ELIZABETH I.
Jany. 1876.
For explanation of abbreviations &c. see Appendix 1.
Peninsula of Tres Montes
P. Otway
304
45
green sand
Gulf of Penas
Ayantau Is.
165 bl.m
305
P. Barbara
Hale Cove
305a 305 b. bl.m 125 & 160
565 bl.m
345
306
306a bl.m
Messier Chl.
WELLINGTON I.
Gray Hr.
English Narrows
Indian Reach
140 bl.m
307
P. Grappler
Trinidad Chl.
Wide Chanl.
Tom Bay
308
175 bl.m
Concepcion Ch.
Scout Rks.
Guia Narrows
Hanover
Puerta Bueno
309 & 309a
40 & 140
R. Sta. Cruz
77° 76° 75° 74° 73° 72° 71° 70° 69° 68° 67°
46° 47° 48° 49° 50° 51°


Plain of Diana
Last Hope Inlet
C. Sta Lucia
Nelson Strait
Queen
Adelaide
Archipelago
Evangelists
Mt. Burney (5800ft.)
Smyth Ch.
Icy Sound
Skyring Water
Otway Water
C. Pillar
Sea Reach
P. Churruca
Cordova Pena.
Long Reach
Landfall I.
Brunswick Pena.
P. Gallant
C. Froward
P. Famine
Sandy Pt.
Froward Reach
Sta. Ines I.
Charles Is.
Noir I.
Camden Is.
Stewart Is.
First Narrows
Second Narrows
C. Virgins
Catherine Pt.
Elizabeth I.
Broad Reach
San Sebastian Bay
Useless Bay
TIERRA DEL FUEGO
Mt. Sarmiento 6800ft.
Mt. Darwin 7000ft.
Beagle Channel
Hoste I.
Navarin I.
Nassau B.
York Minster
Christmas Sd.
Ildefonso Ids.
C. Horn
52°
53°
54°
55°
56°
77° 76° 75° 74° 73° Long. West 72° from Greenwich 71° 70° 69° 68° 67°
Engraved by Malby & Sons

carefully looked for, but was not seen. At 6.15 P.M. the ship rounded the south extremity of Alert Island and was steered for Hale Cove, anchoring there at 6.45 P.M., with the right extremity of Billard Island S.S.W. $\frac{3}{4}$ W., Point Boulard S.E., and Point Pillot W.N.W.

Hale Cove is a very good anchorage for vessels entering the Messier Channel and being nearer the Gulf of Penas, will probably be preferred also by vessels bound northward. Island Harbour, 10 miles farther south, is smaller and much more confined.

In making the Messier Channel, the bearings taken from the ship to the various conspicuous points on shore were found not to agree, and there can be no doubt that the chart is somewhat incorrect. However, with the fine weather experienced, there was no difficulty in distinguishing the land or in steering towards the port it was intended to anchor in for the night; it might have been otherwise had the hills been capped, or only visible at intervals through the rain. The great difficulty of pilotage is in first making out the land; when the various objects on a coast have been once distinguished, and the vessel's position assured, then little difficulty is experienced in proceeding along the coast or into the port of destination, for as the vessel proceeds, the various objects which from time to time are sighted may readily be recognised by an occasional judicious angle from previously known points. If however the chart be incorrect, considerable difficulty is experienced in recognising the various objects delineated, more especially if a continuous view of the land cannot be obtained owing to rain or thick weather; and as this appears to be the general condition of things in the Gulf of Penas, there can be no doubt that a correct survey of its southern coasts is a great desideratum. When once in the Messier Channel the water is so deep and the coast so steep that little danger need be apprehended; besides which, vessels are well protected from the gales which prevail in the Pacific on this parallel.

On the 2nd January the ship left Hale Cove and proceeded to the southward through the Messier Channel for Gray Harbour at the northern end of the English Narrows. At 9 A.M. a sounding was obtained in 565 fathoms, with Scout Peak N. 30$\frac{1}{2}$° W., Mount Millar N. 39$\frac{1}{2}$° W., Mount Black N. 49$\frac{1}{2}$° W., Middle Island Summit S. 39° E., and Cock's Head N. 16$\frac{1}{2}$° W. Black Island Peak is the easternmost of the two marked on the chart, and is higher than the one delineated, being 2000 feet above the level of the sea. At 9.20 A.M. the vessel again proceeded to the southward, and at 11.10 A.M. stopped off Middle Island, to land surveying and exploring parties. Here a latitude was obtained on the west extremity of the island, and a rough true bearing and a few angles taken. The latitude was 48° 28′ 3″ S., the true bearing of Scout Peak N. 11° 22′ W., and of the summit of Thornton Island S. 8° 25′ E. Whilst the exploring parties were on shore the ship sounded, trawled, and took temperatures in 345 fathoms, Middle Island Peak bearing N. 85° E. and Thornton Island Peak S. 31° 40′ E. The temperature at the surface was 57°·5, and from 100 fathoms to the bottom was 46°. At 2 P.M. the ship again proceeded to the southward towards Gray Harbour. At 4 P.M., when off the Direction Islands and abreast of Iceberg Sound, several small pieces of ice were passed and it was found that the surface temperature had decreased from 57° to 44°, and the specific gravity to 1·004. Soon after passing Iceberg Sound, the temperature again increased to 56°. At 6.30 P.M. the ship anchored in Gray Harbour in 17 fathoms; in entering, a cast of 7 fathoms was obtained on the 9 fathom patch in the centre. The day was very fine throughout, with an almost perfect calm, and the scenery as the vessel steamed through the Messier Channel was magnificent.

The ship remained at anchor in Gray Harbour until 10.30 A.M. on the 4th, parties exploring the neighbourhood and obtaining observations. The shooting parties were not very successful, but at the head of the harbour is a large lake where plenty of small fish having the general appearance of a Trout (*Haplochiton zebra*), and belonging to a family representing the Salmonoids in the Southern Hemisphere, were caught. The weather being remarkably fine on the 3rd,—the black bulb thermometer exposed to the sun recorded 111°,—the ship's company were landed to wash their clothes and have a run on shore, but they lit fires all over the harbour, which spreading, set fire to the woods. Unfortunately, Dr Wild, one of the civilian staff, did not return with the boats at 6 P.M., and as it was feared that he would get lost or burned, searching parties were sent after him; however, he turned up all right at 8 P.M.

On the 4th January, at 10.30 A.M., the ship left Gray Harbour and proceeded through the English Narrows to the southward for Port Grappler. The vessel took the channel west of Mid-channel Island, rounding that island just before noon, being abreast of Zealous Island at noon. No difficulty was experienced in twisting the Challenger through the narrow part, it being slack tide, but there is no doubt the mail steamers, some of which are 400 feet in length, would find it difficult even at slack water, and almost impossible with the stream against them. At 1 P.M. the ship passed Olland Island, and at 1.30 P.M. the Gorgon Rock, which was then showing about three feet above water. At 2 P.M. Toro Island was passed, and at 2.20 P.M. Crossover Island; there were numerous Fur Seals round the ship, and also on the rocks south of the Covadonga Islets. At 3 P.M. the vessel stopped in the fork at the north end of Saumarez Island, and a sounding and trawling were obtained in 147 fathoms, with the left extremity of Foot Island N. 5° W., the left extremity of Broome Island N. 33° W., the left extremity of Escape Reach S. 2° E., the left extremity of Stony Bill Point S. 66° E., and Hayman Point S. 76° E. From these bearings it appears that the chart is considerably in error, although of course there is no difficulty in determining which route to take or in fixing roughly the position of the ship. At 4.30 P.M. the trawl was hove up and the ship proceeded for Port Grappler, anchoring there at 5.40 P.M. The first part of the day was fine, but the afternoon was cloudy and the evening rainy, the wind being light.

The steam pinnace left Gray Harbour at 4 A.M. with several naturalists and officers, and joined the ship in the evening at Port Grappler. On the way landing was effected at several spots and a number of birds were procured; a very large number of Fur Seals *Arctocephalus* were seen and six were shot, the skins and skeletons of which were preserved.

In Port Grappler a derelict German steamer was found in possession of four Englishmen, part of the crew of a Chilian steamer. It appears that the German vessel was bound from Valparaiso to Hamburg, and that in passing through Indian Reach she struck on the Vaudreuil Rock and knocked a hole in her bottom, so her Captain took her into Port Grappler and abandoned her, taking passage to Sandy Point in a passing vessel. The derelict vessel's name was the "Karnach," and being laden with silver ore, copper, hides, and sugar, doubtless proved a valuable prize for the salvors.

In passing Eden Harbour the kelp patch reported by H.M.S. "Zealous" was carefully looked for, but nothing was seen of it. Several patches of detached kelp were, however, passed; had there been a rock off Eden Harbour marked by kelp, it could hardly have escaped the notice of the surveyors in the "Nassau."

On the 5th January, at 4.30 A.M., the ship left Port Grappler for Tom Bay, at 6.25 A.M. rounded Bold Point, and at 7.30 A.M. Hamilton Shoulder. At this time a fresh breeze sprang up from the southward, making it necessary to use the third boiler. At 2 P.M. the vessel stopped off the northeast end of Madré Island, and a sounding was taken in 175 fathoms, with the right extremity of Clanricarde Point S. 58° E., the right extremity of Topar Island N. 19° E., and the left extremity N. 26° W. Afterwards the trawl was put over, and a boat sent in shore to look for an anchorage close to the Trinidad Channel, but although there was a good inlet, the water was too deep for anchoring, so that at 4 P.M. the ship proceeded for Tom Bay, in order to lay there whilst repairing a steam-pipe which had become damaged, and anchored at 5.45 P.M. in 17 fathoms, with Centre Island S. 60° W., East David Island S. 45° E., and Robert Point N. 61° E. There was a fresh southerly wind all day, with passing rain squalls, between which the weather was bright and pleasant.

On the 6th January, at 4 A.M., the survey of Tom Bay was commenced, and the weather being fine, equal altitudes, circummeridian altitudes, and a true bearing were obtained, and several trigonometrical stations taken up, the boats sounding the outer part of the bay. Towards evening the sky became overcast and gloomy, and shortly after midnight the wind freshened and blew in squalls from the northward, so the cable was veered to five shackles, when finding the stern close to a rock awash between Centre and One Tree Islands, steam was got up in three boilers. At 8 A.M. on the 7th, the wind still continuing from the northward with dirty squally weather, the vessel was shifted to the northeast side of the bay, and brought up in 28 fathoms, with 90 fathoms of cable. In the afternoon the wind shifted to the northwestward and the squalls became lighter, but the weather was so thick and rainy all day that the survey could not be proceeded with.

On the 8th January, at 4 A.M., the breeze having moderated and the weather become fine, the anchor was weighed and the ship steamed towards Trinidad Channel, with the intention of looking for an anchorage in the vicinity of Cape Candelaria, but after rounding Brazo Ancho Point at 6 A.M. the wind increased rapidly from the westward, and the weather became so thick and dirty that at 8 A.M. the ship bore up, it being considered unadvisable to pursue surveying investigations in such weather, and then proceeded for Puerto Bueno. The rock marked by kelp was seen between Medio and Topar Islands. At 8.48 A.M. the ship again rounded Brazo Ancho Point and was steered for Inocentes Island, the rain squalls very heavy, completely obscuring the land at times. At 11 A.M. Inocentes Island was passed and the ship steered for the Guia Narrows, and at 11.30 A.M. a very heavy squall of wind was experienced, which cleared off the rain for a time. At noon the ship was abreast of Juan Island, at 0.30 P.M. the Guia Narrows were passed, and shortly after another deluge of rain experienced, so that one could not see more than half a mile in any direction; however, by keeping the east coast on board, the ship passed Cape Charles all right, and shortly afterwards there was another break in the weather which allowed a sounding and trawling to be taken in 140 fathoms off the south end of Bonduca Island. The first trawling was in 40 fathoms, with the south end of Bonduca Island W. by N. distant two cables, the second in 140 fathoms with the north point of Bonduca Island N.W. by W. ½ W., and Cape San Antonio N.N.E. At 3.45 P.M. the trawl was hove up, and at 4.30 P.M. the ship anchored at Puerto Bueno, with the left extremity of Hoskyn Island W. by S., the centre of Pounds Island S.S.E., and the right extremity of Paynter Island E.N.E.

The vessel remained at anchor at Puerto Bueno on the 9th to allow a chance of the country in the neighbourhood of the port being explored. The day was squally and rainy. Some of the Trout-like fish already mentioned (*Haplochiton zebra*) were caught in the lake at the head of the harbour, and a few birds and an Otter shot.

On the 10th, at 4.30 A.M., the Expedition left Puerto Bueno. At 8.30 A.M. the ship stopped in the opening from Sarmiento Channel into Nelson Strait, and sounded and trawled in 400 fathoms, with the left peak of Double Island N. 37° E., the left extremity of Evans Island N. 34° W., Cape Kendall S. 86° W., High Lobos Island S. 43° W., the right extremity of Carrington Island S. 40° E., and the left extremity of the islands north of Piazzi Island S. 26° W. These bearings would place Double Island considerably to the southward of the position it now occupies on the charts; there can be no doubt that here the survey has been very loosely made. Cape St. Vincente is about 900 feet high; the islands north of Piazzi Island are all low. At 10.45 A.M. the trawl was hove up and the ship then proceeded through the Sarmiento Channel for Farquhar Pass, which was cleared at 1.30 P.M. From here the vessel was steered for the Victory Pass, which was cleared at 3.45 P.M., and then for Isthmus Bay, anchoring there at 4.40 P.M., with Harlow Island N. by W. and Selpo Point S.W., in 25 fathoms. The rocks collected at Isthmus Bay, where a party landed, were decomposed diabase and micaceous quartzite.

The day was cloudy and drizzly, not much wind in the inner passage, but apparently a fresh breeze outside in Nelson Strait. The rain was never sufficiently heavy to hide the land for any distance, but it was enough to prevent surveying operations.

On the 11th January, at 4 A.M., the vessel left Isthmus Bay for Port Churruca. No difficulty was experienced in proceeding through Smyth Channel and Mayne Passage. Bradbury Rock, the height of which is not given on the chart, is low, about 6 feet above the level of the sea. At 10.30 A.M., having cleared Smyth Channel, a sounding and trawling were obtained in 245 fathoms, with the left extremity of Fairway Island north, St. Agnes Peak N. 15° W., St. Anne's Peak N. 33° W., the left extremity of the islands in Parker Bay N. 71° W., and the right extremity of Tamar Island S. 30° E. The temperature at the surface was 50°, and at the bottom 46°. At 0.30 P.M. the trawl was hove up, and the ship proceeded for Port Churruca, anchoring in Nassau Bay at 2.45 P.M., with Digby Point N. 10° E., Holland Point N. 34° W., and the entrance of Lobo Arm N.E. by E. ½ E. The early part of the day was rainy and thick, but this cleared off about 9 A.M., and the rest of the day was fine, with a moderate breeze. The Challenger had then steamed 300 miles through the Inner Channels from the Gulf of Penas to the Strait of Magellan, thus avoiding the chances of bad weather on the tempestuous coast of Western Patagonia.

The existence of these channels was first made known by Pedro Sarmiento. He entered the Gulf of Trinidad in November 1579, and anchored in 20 fathoms, rocky bottom, near the south shore, 15 miles within the outer capes, but being there exposed to northwest winds, afterwards anchored in 5 fathoms in a narrow port, which he named "Rosario," just west of Cape Candelaria. The first anchorage was named "Puerto Peligroso" by Sarmiento, but by the seamen "Cache Diablo." From Port Rosario the ships proceeded to the eastward into Concepcion Channel, and then anchored in Port Bermejo at the southeast extremity of Madré Island. Leaving his ships at anchor in Port Bermejo, Sarmiento proceeded in boats first along the western coast of Hanover Island, which he traced as far south as Cape Santa Lucia, and rejoined his vessel again on December 24th. Leaving Port Bermejo again on the 29th, Sarmiento proceeded in his boats to the southeastward, past Inocentes Island and through the Guia Narrows into the channel now bearing his name, which he traced to the southward to the parallel of 52° 15′ S., but missing the passage by which he might have entered the Strait of Magellan, returned to his ship January 12th, 1580. Giving up hopes of being able to enter Magellan Strait by the inner channels, Sarmiento took his ships outside through the Concepcion Channel. It is worthy of note that by observations made at Port Bermejo, there was in 1580 no variation of the needle.

From the time of Sarmiento no account was given by any Europeans of the Gulf of of Trinidad or the inner passages, until the two surveying ships "Adventure" and

"Beagle" left England in 1826 to survey the Strait of Magellan, although it was known that the whalers employed in the south-sea fishery visited the outer coast of Patagonia, and anchored in a port in lat. 51° 30′ S., for Mr. Arrowsmith in 1806 had a plan of this port which he had received from a vessel employed in this fishery.

The "Adventure" and "Beagle," with the schooner "Adelaide," between the years 1826–30, traced the Inner Channels from the Strait of Magellan to the Gulf of Penas, and a most interesting narrative of their proceedings was published by the late Admiral Robert Fitz Roy, the officer who commanded the "Beagle;" but it was not until 1848 that these channels were used, the first vessel to pass through them being H.M.S. "Gorgon" in September of that year. She left Sholl Bay at the southern end of Smyth Channel on the 28th August, and reached the Gulf of Penas on the 12th September. A few of H.M. ships, and also an occasional Chilian steamer took the inner passages after the successful trip of the "Gorgon," and H.M.S. "Nassau" surveyed on a large scale their narrowest parts, viz., Smyth Channel and the English Narrows in 1868. The Peninsular Steam Navigation Company sent their vessels by this route in 1870, but discontinued doing so in 1872 owing to numerous accidents, as their ships, being 380 feet in length on the keel, were very unhandy to turn in the narrow harbours or the English Narrows. Since 1872 the mail steamers pass into the Pacific from Sea Reach, unless circumstances make it unadvisable to face a gale, when they use Smyth Channel and enter the Pacific by the Gulf of Trinidad.

The chief difficulty in using the Inner Channels from the Strait of Magellan to the Gulf of Penas is the want of anchorages suitable for large vessels. The first anchorage after passing through Smyth Channel is Isthmus Bay, at its northern end, but even here the largest swinging scope is but one and a half cables. From Isthmus Bay to Puerto Bueno (a harbour rather larger and better than Isthmus Bay), a distance of 75 miles, no place is at present known where a large vessel could find shelter, although there are a few anchorages fit for small craft, viz., Columbine Cove, Mayne Harbour, &c. Again, from Puerto Bueno to Port Grappler, a distance of 115 miles, the knowledge of the channels does not permit at present of positive assertion as to whether there are suitable anchorages for large vessels or not, although it appears probable that there may be some good harbours in Madré Island; Port Grappler itself is but two cables in width. From Port Grappler to the English Narrows the distance is 35 miles, but on each side of the Narrows is a fair anchorage. From the Narrows to the Gulf of Penas the distance is 80 miles, and here again the anchorages are deficient, although either of the three known, viz., Connor Cove, Island Harbour, and Hale Cove may be used if necessary; Hale Cove, however, is probably the best.

Although the chief difficulty in using the Inner Channels is the want of harbours, there is another and very serious difficulty in two parts of these otherwise safe passages, viz., the sharp turn a vessel has to take both in Smyth Channel and in the

English Narrows. In Smyth Channel this difficulty can be much more readily overcome than in the English Narrows, for the depth of water at the turning point there being equal to the depth on each side, the tidal stream is never very violent. In the English Narrows the depth of water north and south of the turning point exceeds 100 fathoms, whilst at the turning point it shoals to less than a third of that depth; consequently the tidal undulation produces here a rapid stream of from 3 to 6 knots per hour, and it would be the height of folly to attempt passing this spot in a vessel over 300 feet in length, except at slack tide, for the stream catching the ship at the moment of turning would in all probability put her on shore. Fortunately, as previously mentioned, there is a fair harbour on each side of these Narrows in which a ship may drop her anchor whilst waiting for the turn of the stream.

A glance at the published sheets of these various channels will show conclusively how much they are indented, and how very little is known of these indentations, which have merely been sketched in by the "Adelaide" or "Nassau" as they passed from the Gulf of Penas to the Strait of Magellan, and it may therefore be hoped that a full exploration will add to the anchorages, even if it do not, by opening up the Fallos and other channels, enable long vessels to escape the English Narrows.

So far as the mail steamers are concerned, it is improbable they will ever again use the Inner Channels north of the Gulf of Trinidad, but between that Gulf and the entrance of the Strait of Magellan the knowledge is so imperfect that little more is known about some parts than was known in Sarmiento's time in 1580, and a full exploration would doubtless not only be of advantage to ships in general and the mail steamers in particular, but would add considerably to the scientific knowledge of the maze of islands lying off the western coast of Patagonia, besides probably opening up new Seal and other fisheries.

To explore these numerous channels and to venture outside along the weather coasts of the islands would require a small vessel with good steam power, and an officer in command of indomitable energy combined with perfect patience, the latter quality being probably more called into play than the former whilst waiting for perhaps days together in some little harbour for the weather to clear up sufficiently to enable him to proceed with his surveying work. Since the Challenger's visit regular surveying operations have been in progress in these localities in H.M. Ships "Alert" and "Sylvia," commanded by Captains Sir George Nares, K.C.B., Maclear, and Wharton.

Strait of Magellan.—The Expedition remained at Port Churruca on the 12th January to give the Naturalists an opportunity of exploring in its vicinity. Early in the morning of that day, during a slight squall off the land, it was found that the ship was drifting and the second anchor was immediately let go. By the time the ship was brought up the shore was so close that steam was got up in two boilers to shift berth. When the first anchor was weighed the shank was found broken two feet below the stock. This probably took place when the anchor was let go, as the ground was rocky, and it was fortunate that there was little or no wind during the night, or the ship might have been drifted on shore. After weighing both anchors the berth was shifted to Oldfield Anchorage, and the vessel came to in 18 fathoms, veering 50 fathoms, but keeping the fires banked. The wind inside was from the northward all day, and kept the ship swung across the anchorage, but outside the port a westerly gale was blowing, as indicated by the movements of the clouds. The force of the wind was not felt much at Oldfield Anchorage, and the squalls were not nearly so severe there as in other parts of Port Churruca, still, lying across the Oldfield arm, with the anchor in the centre and 50 fathoms of cable out, the stern was unpleasantly close to the shore, and had the anchor dragged or the cable parted, the ship would probably have grounded; steam was however kept in readiness to guard against such a contingency. The anchorage in Port Churruca was decidedly the worst experienced since entering the Messier Channel, being confined as to space, with rocky bottom and deep water (see Pl. XXXIV.).

On the 13th January, at 4 A.M., the anchor was weighed and the ship left Port Churruca. Outside, in Sea Reach, a westerly gale was found blowing, with a considerable sea and thick dirty weather, so that the ship had to be steered along the land by patent log. From the entrance to Port Churruca the vessel was steered N.E. 2 miles, then E. by N. 1½ miles, and then east, which latter course took the ship about 1½ miles northward of a number of islets two-thirds the distance from Port Churruca to Cape Upright. At 6.30 A.M. Cape Providence was seen N.E. ½ N. and Cape Upright S.E. by E., after which there was no difficulty in running for and through Long Reach, at a speed averaging 10 to 12 knots per hour under double-reefed topsails and foresail aided by steam. After rounding Cape Monday there was smooth water. In Glacier Bay, Snowy Sound, and Snowy Channel there were magnificent glaciers extending to the water's edge. From Cape Upright to Port Churruca and between Cape Providence and St. Anne Island the chart appeared to be much in error, but there was no opportunity of correcting it. At 4 P.M. Cape Froward was rounded, and at 6.30 P.M. the ship anchored in Port Famine with St. Anne Point N.E. by E., Tablet Mound north.

On the 14th, at 4.30 A.M., the vessel left Port Famine and steamed towards the Chilian settlement at Sandy Point, anchoring there at 8.30 A.M. in 10 fathoms, with the Cemetery Cross S. 82° W., Block House N. 56° W., and Sandy Point N. 8° E. The day was fine and clear, with a moderate breeze.

The Chilian settlement at Sandy Point was founded in 1850 after a trial of a few years of Port Famine. It is built on the summit of a bank about 35 feet high, in front of which is a large flat formed by the deposit of a river which runs past it on the north side. A raised road has been constructed from the village to the water's edge where a pier runs out. The first pier was washed away in 1867, but another has since been built;

Plate XXXIV

Horsburgh, Edinburgh. Permanent Phototype.

Glacier, Port Churruca.

this also, however, was so rickety that it probably will not last long. From the pier a tramway runs to the coal mines to facilitate the transport of that mineral, which can be brought right down in trucks and discharged into barges alongside the pier. The price was $6 a ton, but as the coal is of inferior quality and gives but little heat, there was not much sale for it.

The Chilians originally established the colony at Port Famine, and afterwards at Sandy Point as a penal settlement, but in consequence of the increase of steam traffic through the Strait of Magellan, grants of land and other advantages were promised to immigrants, and in January 1869 a new Governor arrived in a vessel of war with some 300 settlers. In 1876 the colony appeared to be thriving; some of the land in the vicinity of Sandy Point was being cleared, vegetables were being cultivated, and in Freshwater Bay corn had been successfully grown. Bullocks and sheep were fairly plentiful, and beef and mutton could be procured at 7d. per pound. Mushrooms were plentiful in the vicinity of Sandy Point, and large quantities were gathered and fully appreciated by all on board, as were also the ducks and snipes brought back by the shooting parties.

Several members of the Expedition visited the coal mines; six different seams of coal were counted in riding up the valley, some of them being 7 feet in thickness. There are gold mines in the same locality, but they hardly paid the expense of working.

The Governor of the colony, Don Diego Dublé Almeida, presented some Fuegian skulls to the Expedition, and received the officers with great hospitality. Some time after the visit of the Expedition this little settlement was the scene of a terrible massacre. On the 11th November 1877 the artillerymen mutinied and liberated the convicts; a massacre of the inhabitants and destruction of the greater part of the town followed. The Governor, who behaved with great bravery, barely escaped with his life, after being severely wounded and suffering great hardships.

On the 18th January the vessel left Sandy Point for Elizabeth Island, anchoring off that island at 11 A.M. in $5\frac{1}{2}$ fathoms, with its west point S. 52° W., Sylvester Point S. 46° E., Quoin Hill N. 58° W., left extremity Santa Marta S. 72° E., and Sweepstakes Foreland N. 56° E.

Exploring parties landed on the island, which is without trees but covered with grass, and since the Expedition's visit has been occupied as a sheep and cattle run. The island is the breeding place of large numbers of wild Geese (*Chloephaga patagonica*), which were very abundant. Wild-goose shooting in Elizabeth Island is a very different matter from what it is at home, for when the sportsman has shot nine geese he finds that he has no light task before him in carrying them to the boat at the end of the island, over the soft and yielding soil. In the Falkland Islands similarly the sportsman finds himself early in the day with a heavier bag than he can stagger under. The geese at Elizabeth Island showed some wariness, and some little trouble had to be taken in order to get within shot of them, unless they were met with in long grass. When on the alert they settled on the summits of the hillocks and ridges, in order to have a wide view of the enemy. One had to creep up under cover of the hillslopes, and make a final rush towards the flock; the birds are startled by this, and it is some time before they make up their minds to fly. Doubtless the wariness of these geese is due to their progenitors having been hunted for generations by natives in old times. The geese at the Falkland Islands are far tamer than those at Elizabeth Island, and do not seem to understand a gun, though they have been shot at now for a long period. The Falkland Islands, however, were never inhabited by any savage race, and the birds have not had time to learn. The other birds, as for example the Loggerhead Ducks, in Magellan Strait, which also occur at the Falklands, show the same contrast in their wildness. The young geese at Elizabeth Island, whilst still covered with black down, run amongst the grass with astonishing quickness, and are as difficult to shoot as rabbits; it is no easy task to catch them by running. A brood when met with separates, every gosling running off in a different direction; the young birds dodge behind a tuft of grass, and squatting closely under it are at once safe, for it is quite impossible to find them, and a brood of ten or twelve goslings, as large almost as full-grown fowls, disappears as if by magic. It was astonishing to find that even goslings are able to secure their safety so completely. They can only be caught by the pursuer keeping his eye on one bird only, and running after it at the utmost possible speed. They are far better to eat than the full-grown geese. At Sylvester Point there was an immense rookery of the small Black Headed Tern (*Sterna hirundinacea*).

On the southeast shore there were some large kitchen middens resting on a bed of fine sand, into which the sea had cut and exposed long sections of the middens. There were bones of Guanacos, of a small Rodent, of Fur Seals, Whales, Porpoises, Penguins, Rheas, Terns, and Shags. Some of the bones were charred, some were split, and some fashioned into awls and needles. Arrow and spear heads, and knives made of chert, were found, also rounded stone sinkers with a groove cut in them for a string. In some places the middens were covered by over 6 inches of soil, and appeared to be of great antiquity—possibly prior to the separation of Elizabeth Island from the mainland. In other places they appeared to be of recent origin; the island was inhabited at the time of the early Dutch voyages.

On the 20th January, at 4.50 A.M., the ship left Elizabeth Island for the Falkland Islands under steam and sail, having a fair tide till noon. The day was fine and clear, and no difficulty was experienced in fixing the position of the ship so as to ensure passing in the centre of the channels. The ship had the strength of the ebb stream in the first narrows, and for half an hour was going at the rate of 18 miles per hour over the ground (11 through the water). At 2 P.M. Mount Dinero was in line with the beacon on Dungeness Point, and a course was shaped to cross the Sarmiento Bank. which was cleared at 3 P.M., and then the ship was steered for the West Jason Cay. At 4.40 P.M. the vessel stopped, and sounded and trawled in 55 fathoms in lat. 55° 20′ S., long. 67° 39′ W., after which sail was made for the Falkland Islands.

The deposit at 55 fathoms, as well as at two other soundings, 70 and 110 fathoms, was a coarse sand, the grains about one millimetre in diameter, consisting of quartz, jasper, felspars, mica, hornblende, augite, glauconite, pumice, and particles of crystalline and schistose rocks.

The deposits in the Messier and Sarmiento Channels and Magellan Strait were in all cases blue muds containing very little carbonate of lime, and consisting mostly of débris from the neighbouring mountains. Pelagic Foraminifera were only represented by a few stray specimens of *Globigerina*, and on the surface only a few of these shells were noticed, the deposits and surface gatherings in these enclosed channels thus being in marked contrast to those found in the open sea, at some distance from land. The dredgings were moderately productive, and in depths between 60 and 400 fathoms a good many new species were procured, including one new genus and five new species of fish. The parties landed at the various points where the ship anchored made extensive collections of plants, birds, fish, and other animals.

In passing through the eastern part of the Strait of Magellan, a red beacon, which had been recently erected by the Chilian Government, was observed on Cape Gregory. Arrangements had also been made, it was understood, to buoy the Triton Bank. In the first narrows a buoy was seen adrift, and after passing them, the Chilian vessel of war "O'Higgins" was observed at anchor on the Nassau Bank, so that the buoy passed was probably the one off that shoal.

The Strait of Magellan was discovered by Fernão de Magalhães in October 1520, during that celebrated voyage when for the first time the globe was circumnavigated. Entering the Strait from the Atlantic on October 21st, he reached the Pacific on the 27th November, 37 days after passing Cape Virgins.

Magellan's great discovery being made known on the return of his ship to Spain, other navigators turned their attention towards this route, and followed it with varying fortune. Thus, Don Garcia Jofre de Loyasa, a native of Ciudad Real, passed through in April and May 1526 in 48 days, having previously failed in January of that year. Simon de Alcazora attempted it in January 1535, but failed; Alonso de Camargo succeeded in January 1540; Sir Francis Drake, the first Englishman who used the Strait, passed through it in 17 days in August and September 1578; and Sarmiento, after discovering the Gulf of Trinidad, navigated it from west to east in January and February 1580, occupying 31 days in the transit from one ocean to the other; a great part of this time was, however, spent at anchor, waiting for his consort.

Sarmiento, on his arrival in Spain, represented to the King (Philip II.) the advantages of fortifying narrow parts of the Strait in order to prevent vessels of any other nation than their own passing into the Pacific, as at this time it was not known that a passage existed round Cape Horn. The King approved of Sarmiento's plans, and despatched a fleet of twenty-three ships, on board of which were numerous artificers, and large stores of ammunition and ordnance, to colonize and fortify commanding situations in the Strait. Owing to various mishaps on the voyage, Sarmiento did not arrive off Cape Virgins until the 1st February 1584, and then with only five vessels. Directly they anchored, the men were landed to form a colony, but one of the vessels being wrecked and three driven off by westerly gales, Sarmiento was left with 400 men and 30 women, with provisions for only eight months. Leaving 150 men under the command of Andres de Viedrua to found the City of Jesus, Sarmiento proceeded with the remainder overland to the bay now known as Port Famine, where he founded the city of San Felipe. The exact situation of the City of Jesus appears doubtful; Burney says that in the chart of Olmedilla it is placed near Cape Possession, but Captain King thinks it was about half way between the first and second narrows.

On the 25th May, Sarmiento left the town of San Felipe in charge of Juan Suarez and sailed in the "Maria," the only vessel remaining, for the Settlement of Jesus, off which he anchored; but a violent tempest drove him out to sea and forced him to bear up for Brazil, from whence he endeavoured to despatch supplies to his colony, but failed owing to a series of misfortunes. Nothing more was heard of either of the two settlements until January 1587, when Cavendish entered the strait and found fifteen men and three women remaining of the inhabitants of the town of San Felipe. Whilst these Spaniards were considering whether they should trust themselves on board an English ship, a fair wind arose, with which Cavendish proceeded through the strait.

Cavendish gave the name of Port Famine to the bay in which the town of San Felipe was situated, a name which it bears to this day. He rescued one man, Tomé Hernandez, from starvation, and another was rescued by Merick in 1590; these were the only two survivors of the 400 men and 30 women landed in 1584.

Cavendish passed through the strait in 49 days in January and February 1587. Merick in January 1590 failed to get far beyond Cape Froward, the southern point of America, and Cavendish in his second voyage also failed to get farther than that Cape in April and May 1592; but Captain John Davis, who discovered the Falkland Islands in that year, succeeded in passing through the Strait of Magellan in September. Westerly gales, however, forced him back from the Pacific again, and he eventually returned to Port Desire, being thus the second navigator to pass through from west to east. The next Englishman to pass was Sir John Hawkins in February and March 1594; he took 39 days in sailing from the Atlantic to the Pacific. In 1599 De Cordes, the first Dutchman who attempted this route, wintered in the strait, remaining there from April to September, finally passing into the Pacific on the 3rd of the latter month. On November 4th of the same year, Oliver van Nooit, another Dutchman, anchored off Cape Virgins, and after struggling for 117 days against gales and bad weather, reached the Pacific on the 29th February 1600. On April 3rd 1615, Joris Spilbergen, also a Dutchman, entered the strait and reached the Pacific on the 6th May, occupying 33 days in transit. In this voyage the first good chart of the route taken was constructed by Cornelius May.

In January 1616 Le Maire and Schouten discovered the passage round Cape Horn, and the Strait of Magellan lost its importance directly it was known that another route existed by which ships could reach the South Sea. Information of this discovery reaching Spain, the Spanish Government despatched two small vessels to verify it, under the command of Bartolomé Garcia de Nodel and his brother Gonçalo. They rounded Cape Horn and returned to the Atlantic through Magellan Strait in February and March 1619, having circumnavigated Tierra del Fuego.

After 1616, vessels bound to the South Sea appear to have more generally preferred the route round Cape Horn to that through the Strait of Magellan. Some adventurous captains, however, tried the latter route. Sir John Narborough took 25 days to make the passage in October and November 1670. He constructed a very good plan of the channels, and after visiting the coast of Chili, returned through the strait in January 1671. Captain John Strong in 1690 took 100 days to reach the Pacific in the months February to May. M. de Gennes failed to get through in 1696. M. de Beauchesne in 1699 passed Cape Virgins on June 24th, but did not succeed in reaching the South Sea until January 21st 1700, being thus 211 days in the strait. Commodore Byron in 1765 took 58 days, sailing through in February to April, and Captain Wallis in 1767 occupied 116 days in transit from December 1766 to April 1767. Cook did not use this route, preferring the passage round Cape Horn, nor is there much other information respecting it until H.M. ships "Adventure" and "Beagle" were despatched to explore it in 1826. They traced all the channels in the vicinity of the strait, ascertained the position and extent of the anchorages described by the older navigators, and constructed an excellent chart of the whole southern part of America. It would however be a mistake to suppose that in the six years occupied by these surveying ships on this work, the various channels had been surveyed with that minuteness which is characteristic of the present style; such accuracy could not possibly have been attained in five times the number of years occupied by Captains King and Fitz Roy on these inclement coasts. Theirs was essentially a preliminary work, which requires to be followed by detailed surveys, such as that of H.M.S. "Nassau" in 1866–69 of the eastern half of the strait; but considered only as preliminary, it deserves great praise, and their chart has enabled navigators to steer with the utmost confidence from the Atlantic to the Pacific, as, although in many parts capable of much improvement in detail, the general run of the channels is laid down with accuracy.

The first large sailing vessel which used Magellan Strait after the survey of the "Adventure" and "Beagle" was H.M.S. "Fisgard" in 1842. She occupied 17 days in the transit from east to west in October, and was followed in 1851 by a Swedish frigate, and in the same year H.M.S. "Havannah," homeward bound, passed through from west to east, as also did H.M.S. "Calypso" in 1862. The first steamer that adopted this route was the "Peru," commanded by Captain George Peacock, formerly a Master in H.M. Navy. She was followed by H.M. steamships "Salamander," "Cormorant," "Gorgon," "Vixen," "Virago," &c., and it is now the practice for all steamers to take this passage in preference to the route round Cape Horn, a practice which is likely to continue, unless in the course of time a canal is cut through the Isthmus of Panama.

From this it appears that the shortest time taken by sailing vessels to pass through the Strait of Magellan is 17 days, and that two men have performed this feat, viz., Sir Francis Drake in 1578, and Captain Duntze of the "Fisgard" in 1842.

The navigation of the Strait of Magellan is difficult owing to a variety of causes: in the eastern part there are numerous shoals and rapid tides, but the weather is fairly clear and little rain falls, whereas in the western part the depths are so great that although there are few dangers and but little tide, there are few places where large vessels can anchor, and the rainfall is abundant. The weather is boisterous in all parts of the strait and at all seasons of the year, and the rain which is so abundant on the Pacific seaboard, gradually decreases in copiousness from the western to the eastern end.

The scenery of the western Patagonian fjords is very beautiful. The successive ranges of mountains are capped here and there by snow, and glaciers, the dwindled representatives of those that scooped out the main features of the region, fill some of the valleys. The fjords remind one somewhat of those in Norway; they branch and send offsets on either hand. Thus, as these long sounds are traversed constant glimpses are obtained down the communicating channels bounded by successions of mountain ridges, fading gradually out of sight one behind the other. In some parts of the Messier Channel the mountains are covered by a dense forest of small trees, and one peculiarity of the scenery is due to the fact that these forests come down to the seashore and overhang the beds of mussels growing on the rocks. In some harbours it is impossible to get away from the shore, so dense is the barrier of forest undergrowth everywhere. On the eastern side, about Sandy Point, the country is more open, and there are wide stretches of grass-land.

From a register kept for a period of nearly ten years at Sandy Point, it appears that the mean temperature there in July is 35°·4, or 2°·9 colder than the mean temperature for January at Greenwich, whilst the mean temperature at Sandy Point in January is 54°·8, or 7°·4 colder than the mean temperature at Greenwich in July. The following table will enable an opinion to be formed of the climate.

Table of the Mean Monthly Temperature at Greenwich and Sandy Point.

Month.	Greenwich.	Corresponding Month.	Sandy Point.
January	38°·3	July	35°·4
February	39·3	August	37·4
March	41·6	September	42·4
April	47·1	October	47·3
May	52·9	November	50·7
June	59·0	December	53·2
July	62·2	January	54·8
August	61·4	February	54·4
September	57·2	March	48·0
October	50·2	April	44·1
November	43·6	May	40·4
December	40·3	June	35·4

From this table it will be seen that the winter is very little colder than the winter at Greenwich, but that the summer months are considerably colder, and that the range of mean monthly temperature which at Greenwich is 23°·9 is at Sandy Point 19°·4. The climate of Sandy Point is, like that of the whole southern oceanic region, therefore a very equable one, of uniformly low temperature, and this is doubtless due to the uniform temperature of the sea water, the mean range of which does not exceed 10°, or from 42°·5 in winter to 52°·5 in summer. The mean annual temperature of Sandy Point is 45°·3, and as the temperature of the deep water in the strait is 46°, there appears to be some connection between them, as this deep water is cut off both from the Atlantic and Pacific by ridges not exceeding 50 fathoms in depth. What the extreme depression of the bed of the channels in Magellan Strait and the inner passages may be, has not as yet been determined. One sounding of 565 fathoms was obtained in the Messier Channel, one of 400 fathoms in Sarmiento Channel, and one of 240 fathoms in Sea Reach; and Sir John Narborough did not obtain bottom anywhere at 200 fathoms in the main strait, which is sufficient to show that the lower waters here form an inland sea the temperature of which in all probability depends on the temperature of the Pacific in this latitude at the depth of the ridge separating that ocean from the basin, or basins, of the strait; and this again, there is reason to think, renders the climate so equable, and helps to keep the surface temperature in winter so much higher than the temperature of the air.

The route through the Strait of Magellan has been much facilitated by the excellent survey of the eastern portion by H.M.S. "Nassau," and by the beacons which have been erected by the Chilian Government, but the charts of its western entrance are capable of much improvement; a great part of the coast line there is still unexplored, and it is possible that harbours may exist of which nothing is now known; besides which a vessel employed on this service would, by keeping a careful meteorological register, enable the condition of the climate of the western side of Patagonia to be ascertained, which there is every reason to believe differs greatly from the climate of Sandy Point and the eastern coast.[1]

The Isopoda.—Mr. F. E. Beddard, the first part of whose Report on the Challenger collection of Isopoda is published,[2] writes:—"Among the specimens of Isopoda collected by the Expedition, those belonging to the genus *Serolis* are the most noteworthy. This genus, originally founded by Leach for the reception of *Oniscus paradoxus*, Fabricius, is chiefly interesting on account of its peculiar geographical distribution. For a long time it was only known to occur on the shores of Patagonia and the South Shetland Islands; the Challenger, however, discovered many species in other parts of the southern hemisphere. During the Transit of Venus Expedition and the voyage of the German ship 'Gazelle' several of these species were dredged off the coasts of Kerguelen subsequently to the Challenger's visit, and have already been described. New Zealand appears to be another locality of the genus, since the British Museum contains a single specimen each of the Patagonian *Serolis schythei* and *Serolis paradoxa* from that locality; and *Serolis latifrons*, a characteristic Kerguelen species, was obtained during the voyage of the 'Erebus' and 'Terror' at the Auckland Islands, south of New Zealand. The genus is therefore more particularly characteristic of the southern hemisphere, and, until quite recently, was believed to be entirely confined to that portion of the globe; within the last few years, however, a single species, *Serolis carinata*, has been met with as far north as San Diego in California. During the Challenger Expedition a large number of examples of several Patagonian species and of all the known Kerguelen species were dredged, but none of these were obtained from any new localities except in so far as regards the Crozets and Marion Island. These islands, as might be expected, are inhabited by species identical with those found at Kerguelen. On the shores of Southern and Eastern Australia six species were obtained, of which five prove to be new; it is an interesting fact that these Australian species form a well marked section of the genus, agreeing with each other and differing from their Patagonian and Kerguelen representatives in a number of small but

[1] H.M.S. "Sylvia," under Captain Wharton, was employed surveying here in 1882 and 1883.

[2] Report on the Isopoda—The Genus Serolis, by F. E. Beddard, Zool. Chall. Exp., part xxxiii., 1884.

quite definite characters; on the other hand, it is quite impossible to detect any such differences between the species of the genus which range from Patagonia through Kerguelen to New Zealand, and in some cases, as already pointed out, there is an absolute identity. It would be rather premature to draw any wide conclusions from the distribution of a single genus, but the facts recorded here seem to favour the division of the southern hemisphere into two regions—(1) an Australian, (2) an Antarctic extending from Patagonia to New Zealand. Other observers have commented on the close relationship that subsists between the littoral faunas of Patagonia and New Zealand.

"The most interesting species of the genus *Serolis* that were dredged by the Challenger are four from deep water, all of which are new to science. The genus was not known to range into deep water until the publication of Dr. v. Willemoes Suhm's notes on the Crustacea observed during the voyage.[1]

"It is a remarkable fact that none of these deep-sea species were dredged north of the Equator; it will be interesting to note whether further dredgings show that, in common with the majority of deep-sea animals, they are comparatively unrestricted in their range.

"*Serolis bromleyana*, the largest of the deep-sea species, is figured, natural size, in the accompanying woodcut (fig. 325); the drawing represents the male specimen dredged at Station 156, near the Antarctic Ice Barrier, in 1975 fathoms. This species was met with again considerably to the north, off the east and west coasts of New Zealand, in 400, 700, and 1100 fathoms; it has already been pointed out by Dr. Gerstaecker[2] that this species, as well as *Serolis antarctica*, which ranges from off the coast of South America just under the Equator (400 fathoms) to the neighbourhood of the Crozets (1600 fathoms) appears to inhabit deeper water in the more southern latitudes; and there are other instances adduced to show that certain species which are widely distributed are found in shallower water towards the Equator, and in deeper water towards the poles.

"It is worthy of note that in the two instances just mentioned the examples from deeper water and more southern latitudes are larger than those from shallower water and nearer the Equator.

"The third deep-sea species, *Serolis neæra*, was dredged at Stations 320 and 318; at the latter from a depth of 2040 fathoms, the greatest which the genus is known to inhabit. The remaining deep-sea species, *Serolis gracilis*, was dredged at Station 120 in 675 fathoms. None of the deep-sea species were found to inhabit shallow water also, nor do any of the shallow-water species of the genus pass the 300 fathom limit; the *Serolis*-faunas of deep and shallow water are quite distinct, but it is impossible to distinguish the former by any definite characters which would serve to unite them into

[1] Suhm, *Proc. Roy. Soc. Lond.*, vol. xxiv. p. 590, 1876.

[2] Gerstaecker, Bronn's Klassen u. Ord. d. Thierreichs, Bd. v. Abth. 2, p. 247, 1883.

a special subgenus; they all present considerable differences from the shallow-water species, but these appear to be due to modifications produced by some unknown causes which affect the inhabitants of the deep sea, and not to be a mark of near affinity; for example, the epimera of *Serolis bromleyana*, *Serolis neæra*, and to a less degree of *Serolis gracilis*, are enormously elongated, and terminate in sharp spine-like points; this, however, is not necessarily an indication of near affinity, because the same thing is met with in other deep-sea Isopoda; moreover, *Serolis neæra*, in the disposition of the spines and carinæ of the caudal shield, most nearly resembles *Serolis schythei* among the shallow-water species, while *Serolis bromleyana* is unlike this or any other shallow-water species that has been yet described. *Serolis antarctica* is conspicuous for the extensive sculpturing of the dorsal surface of the body, and eyes are quite absent—a condition obviously correlated with the great depth at which it exists; in the other species the eyes are large but whitish in colour from the partial or entire absence of pigment, as in many deep-sea fishes, Pycnogonids and Crustacea.

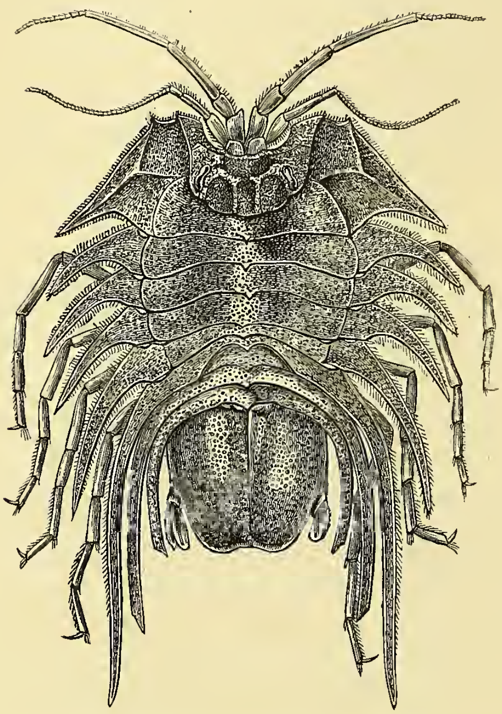


Fig. 325.—*Serolis bromleyana*, Suhm. Antarctic Ocean, 1975 fathoms.

"The large size of *Serolis neæra* and *Serolis bromleyana* is all the more remarkable since it does not appear to be a general rule that the deep-sea Isopoda are conspicuously larger than their shallow-water allies, though there are certain exceptions, such as *Bathynomus giganteus* of Milne-Edwards, which is no less than 9 inches in length.

"Nearly all the families of the Isopoda are represented by deep-sea forms, but in very different proportions; the most characteristic are the Munnopsidæ and the Arcturidæ, and of both these a great number of new species were obtained during the voyage. The Munnopsidæ are indeed typical inhabitants of the deep sea, as has been already made known by the results of Professor Sars' dredgings off the coast of Norway; very few of the forms described by him were got in water shallower than 120 fathoms, and the majority range beyond the 300 fathom limit. The Munnopsidæ collected by the Challenger were invariably dredged in very deep water, one species having been obtained from 2600 fathoms. At Station 68, in 2175 fathoms, a very remarkable example of the Munnopsidæ was dredged; this specimen is of considerable size, upwards of an inch in length (the majority of the group do not exceed half an inch or so), and the integument, instead of being firm and opaque like other Crustacea, appeared to be almost entirely uncalcified; indeed the only parts of the body at all hard and resistant are the mouth appendages and, though to a considerably less extent, the ambulatory limbs; the integument is naturally extremely transparent; it might perhaps be imagined that this specimen has but just shed its skin, but the presence of a colony of well developed Hydroids attached to the body seems to negative this possibility; the floor of the ocean at the locality where this specimen was dredged is composed of Globigerina ooze, and there is therefore no lack of calcareous salts which might otherwise explain the anomalous condition of the integument in this Isopod. At another Station in the Antarctic a somewhat similar Munnopsid was dredged, but in this species it is the abdomen only that is clear and transparent, and but little calcified; the rest of the body is comparatively hard and opaque.

"Several species are remarkable for the great development of spines, and one example dredged at Station 157 (1950 fathoms) especially so; the anterior part of the body (the abdomen is unfortunately lost) is furnished with a ring of long slender spines upon each segment a quarter of an inch or so in length. The excessive development of spines appears to be commonly met with among the deep-sea Isopoda; the long spine-like epimera of the deep-sea *Serolis* have been already referred to, and in many of the Arcturids the tubercles on the surface of the body are prolonged into sharp spiniform processes, attaining in many cases a considerable length, while one species at least, allied to the Munnopsidæ, has comparatively long and spiniform epimera analogous to those of *Serolis*. None of the Munnopsidæ possess eyes, but the deep-sea Arcturidæ in every case have well-developed eyes, strongly pigmented.

"Of the Cymothoadæ one example was dredged in deep water (Station 218, 1070 fathoms) which is of some interest; this Isopod is remarkable for the fact that *all* the abdominal appendages are modified into foliaceous gill lamellæ; the terminal pair are in no way different from the five preceding pairs, whereas in other Isopoda it is the general rule that this pair of appendages does not form branchial organs but swimming feet. Eyes are quite absent; the anterior antennæ are short and broad, consisting of two joints only; the second pair of antennæ have four joints and a terminal filament, and are much more slender; the first pair of thoracic appendages are clawed. The specimen measures about 70 mm. in length. The Challenger collection contains only one other species belonging to this family from deep water.

"The Sphæromidæ, judging from what is known at present, are but poorly represented in deep water; only two examples, apparently a male and a female of the same species, were dredged at Station 218, 1070 fathoms. This species is evidently closely allied to the genus *Næsa*, but is probably distinct; the most noticeable peculiarity is that the eyes are nearly abortive; there is no pigment present, and the cornea is not clearly facetted. Of the Anthuridæ one or two specimens were dredged in deep water.

"Several species of *Tanais* were obtained from deep water, one of these at Station 248 in 2900 fathoms; this is the greatest depth at which any Isopod is known to exist; all the deep-sea species of *Tanais*, without exception, are entirely blind, but this fact is the less noteworthy since several species from shallow water are also blind.

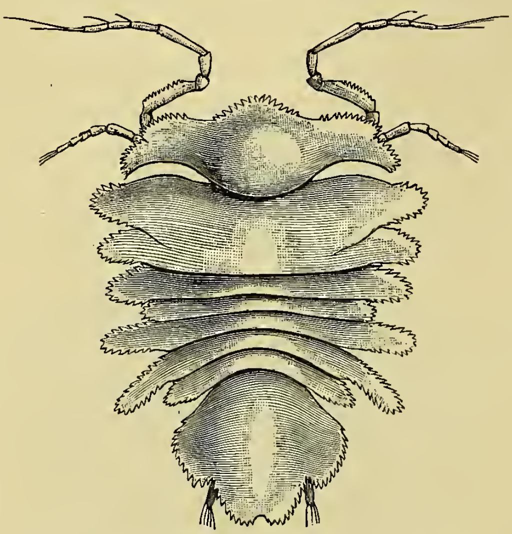


Fig. 326.—*Neasellus kerguelenensis*, n. gen. and sp.

"The long stay of the Challenger at Kerguelen naturally resulted in the collection of a large number of new forms of Isopoda from this little explored region; several of these, however, have been since described from the collections made during the cruise of the German ship 'Gazelle.'[1] The Isopoda appear to form a more important element in the fauna of this region than anywhere else. According to Dr. v. Willemoes Suhm about 20 per cent. of the Kerguelen Crustacea belong to this order.[2]

"An abundant species is *Tanais willemoesii*, Studer. This Isopod is remarkable for the fact that the females carry their eggs in two sacs attached between the fourth and fifth pairs of legs. Dr. v. Willemoes Suhm has already referred to this peculiarity; even in the youngest females the sacs are present, and with the normal shape and position, so that it is impossible to state whether they are entirely new and anomalous structures, or whether they result from the modification of the ordinary ovigerous lamellæ that are met with in other Isopoda.

"The accompanying woodcut (fig. 326) is a representation of a very curious little Isopod, of which only a single example was got; the figure is greatly enlarged, since the specimen itself does not measure more than one-tenth of an inch in length, it is remarkable for the great lateral elongation of the head, so that the antennæ come to be placed quite at the side of the body instead of being close to the median line. The epimera of all the segments as well as the fore part of the head and the caudal shield are fringed with a dense series of leaf-shaped processes; the eyes are completely aborted. This Isopod evidently belongs to the family of the Asellina, and I have called it *Neasellus kerguelenensis*.

"Other characteristic Kerguelen Isopoda represented by specimens in the Challenger collection have been already described by Studer."

[1] Th. Studer, *Archiv f. Naturgesch.*, Jahrg. xlv. Bd. i. p. 19, 1879; *Abhandl. d. k. Akad. d. Wiss. Berlin*, pp. 1–28, 1883.

[2] *Proc. Roy. Soc. Lond.*, vol. xxiv. p. 590, 1876.

Falkland Islands.

The ship had a fairly fine passage across from Magellan Strait to the Falkland Islands, although the early part of the 22nd January was so thick that the land was not seen until close to the Jason Cays. The ship rounded the East Jason Cay at 4 P.M. on that day, and was steered along the north side of the islands, rounding Cape Carysfort at 8.30 A.M. on the 23rd, and anchoring in Port Stanley at 3 P.M. the same day.

A question having arisen as to whether the sea level at the Falkland Islands was not becoming gradually lowered, or, what comes to the same thing, whether the islands were not being gradually elevated, instructions had been received to investigate the matter.

On the ship's arrival at Stanley a tide-pole was set up at once, and a party was landed to register the tide night and day. Inquiries were then made respecting the

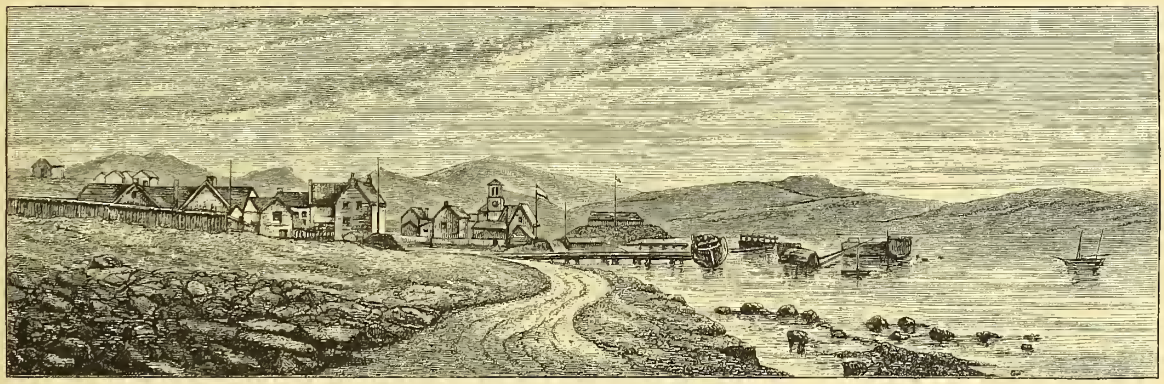


Fig. 327.—Stanley, Falkland Islands.

reasons which had induced the residents to assert that an alteration in the sea level was in progress. On this point no satisfactory information could be obtained, nor indeed any precise reason as to why they had come to such a conclusion,—except that as usual that mythical personage the oldest inhabitant had stated that the tides now-a-days were quite different from those he remembered when first he came to the island, just as old sailors are never tired of asserting that the storms now experienced are by no means so violent as they were when they first went to sea in that fine old clipper the "Three Grandmothers" of Shields. It therefore seemed that the inhabitants of Stanley had reported an alteration of sea level without having taken any pains to investigate the matter even in the roughest manner, for they could show no difference in the tidal marks on the beach, nor any alteration of the sea level with reference to the many rocks in the neighbourhood of the harbour, some of which being covered at high water, and others a foot or two above high water, afford excellent standard marks for testing a statement which only rests on assertion without corroborative observation. No alteration could be detected by the eye in the heights of these numerous pinnacles, which appeared to be in exactly the same state as when this group was surveyed by Captains Fitz Roy and Sulivan in 1834–39.

The assertion that no alteration could be detected by the eye was of course of no more value than that of the residents, who said that an alteration had taken place; fortunately, however, Sir James Clark Ross, during his stay at the group in 1842 to refit the "Erebus" and "Terror" for another cruise to the southward, had taken tidal observations and left permanent marks on the rocks immediately adjacent to his observation spot. These marks, two in number, were made, one by levelling the top of a rock and the other by cutting a ledge in the face of a cliff, both 5 feet 8 inches above the mean level of the sea as deduced from five months observations. They are situated on the coast immediately to the westward of the small stream west of the entrance to the careenage basin of Port Louis, Berkeley Sound, so that a comparison could be made, with some degree of accuracy, of the state of the sea level now with that as determined by Sir James Ross thirty-four years previously.

It was of course known that to make a really accurate comparison of the tidal wave and mean level of the sea now with the result deduced from the observations of Sir James Ross, a considerable time would be required; for the whole question is so complex that observations extending over only a few tides are but of little value, and had it been requisite to investigate the point scientifically, arrangements should have been made for an accurate tidal and barometric register for a period which should embrace the months devoted by Sir James Ross to these observations at Port Louis. But when it is only necessary to ascertain within a few inches whether any alteration has taken place, the mean sea-level deduced from two or three successive tides, when the barometer is near its normal condition, is all that is requisite, and was all that was found necessary, for the mean result of two high and two low waters at Port Louis, during which time the barometer was steady at an average of 0·1 of an inch above its mean height for the year, gave the mean level of the sea within an inch of Sir James Ross's result, and just an inch less than his, corresponding precisely with the amount which should be allowed for the extra pressure of 0·1 of an inch of the mercurial column.

It may therefore be safely asserted that the inhabitants of Stanley were in error in supposing that they had detected an alteration in the level of the sea, for if any alteration had taken place it must have been far too slight to be noticed by casual observers. The fact is, that the observations of Sir James Ross at Port Louis, as well as those of the Challenger at Port Stanley, show certain irregularities of the tide which may easily be mistaken for alterations of sea level. Firstly, the diurnal inequality is considerable; on one occasion it amounted to $1\frac{1}{2}$ feet at Port Stanley, that is, a difference of 3 feet in the range of the two tides, and the inequality disappears at neaps, for as far as the present observations extend, the maximum inequality occurs from two to three days after the moon has attained its extreme north or south declination, and entirely disappears two or three days after the moon crosses the Equator. During the summer months the day tides are highest and have the greatest range, and during the winter months the night tides. Secondly, the atmospheric pressure, the range of which is very considerable in this locality, exerts a great influence on the mean sea level at the Falkland group, for it was found to rise and fall inversely as the barometric column, allowing a foot of water to be equivalent to an inch of mercury. It is therefore not at all improbable that occasionally during the winter months the residents at Stanley might observe, during the period of spring tides, a high water that barely reached the ordinary mean level of the sea ; for if during this time of the year, when the day tides at springs have but a small range, a high barometer coincide with the period of greatest diurnal inequality, such a case would doubtless arise, and this has in all probability led the inhabitants to infer that a gradual alteration was taking place in the mean sea level.

During the stay at the Falkland Islands from January 23rd to February 6th, the mean temperature of the sea was 51° and of the air 48°·8. During Ross's stay, from April to December 1842, the mean temperature of the sea was also invariably higher than that of the air, as the following table will show :—

Comparative Temperature of the Air and Sea for 1842.

Month.	Mean Temp. of Air.	Mean Temp. of Sea.	Difference.
May	40°·8	43°·5	2°·7
June	34·1	38·9	4·8
July	33·8	38·7	4·9
August	34·1	38·1	4·0
September	38·9	41·8	2·9
October	...	...	...
November	45·9	47·4	1·5

In March 1833, Captain Fitz Roy in H.M.S. " Beagle " made the mean temperature of the air for the month 46°·7 and of the sea 48°·7, and in March 1834, 46°·9 and 48°·2, but in both these cases the temperature of the air is only given, as a rule, for noon of each day, so that this mean is higher than it should be.[1]

[1] See Voyages of the "Adventure" and "Beagle," Appendix, London, 1839.

It appears, then, that at the Falkland Islands the temperature of the sea is, as a rule, higher than the temperature of the air, and this seems the more extraordinary, because it is well known that the current in the vicinity comes from the southward, for on all parts of the southern shores of this group the beaches or rocks are covered with trees which have drifted from Staten Island or Tierra del Fuego; and at sea, northward of the Falklands, great quantities of drift-kelp are seen, besides water-worn trunks and branches of trees, near which there are generally fish and numbers of birds.

The fact appears to be that on the western coast of South America the surface drift, impelled by the westerly winds, strikes against the shore and there accumulating somewhat, runs off along the coast, or, in short, bifurcates somewhere between Chiloe Island and Valparaiso, one part running into warm latitudes and consequently cooling the temperature of the air along the whole seaboard of Chili and Peru, whilst the other part running southwards into colder latitudes warms the seaboard of Patagonia, and rounding Cape Horn, affects the climate of Tierra del Fuego and extends its influence even as far north as the Falkland Islands.

That such a current exists, and that it is warmer than the sea in its neighbourhood, is evident from the temperatures obtained in the vicinity of Cape Horn, for a comparison of the results registered in the Appendix to the voyages of the "Adventure" and "Beagle," with the temperatures published in pamphlet No. 11 of the Meteorological Committee, shows first, that in the vicinity of the western coast of Patagonia the mean temperature of the sea is almost invariably warmer than that of the air throughout the year; and secondly, that the temperature of the sea is decidedly warmer in the immediate vicinity of Cape Horn in the months of January, February, and March than it is a few miles south of it; for a reference to Fitz Roy's observations shows that in St. Martin's Cove, in December 1832, the mean temperature of the surface water was about 47°, and that this temperature extended to the Diego Ramirez Islands, whereas 30 miles to the southward in the same month it was 42°. Again, in January and February 1833, whilst the "Beagle" was employed surveying the anchorages surrounding Nassau Bay, the temperature of the sea surface ranged from 48°·5 to 55°·5, whilst in those months, in the square in which Cape Horn is situated, the mean temperature is 43° to 45°.[1]

Unfortunately, comparisons cannot be drawn between the temperature of the sea in the immediate neighbourhood of the south coast of Tierra del Fuego and at a distance of from 40 to 50 miles southward in any other season of the year, for so far as is known there have been no observations taken except those of the "Chanticleer" at corresponding times. The one observation of the "Chanticleer" in March 1829 agrees with the theory of a warm current inshore, for on approaching Cape Horn the temperature of the sea increased 4° in 43 miles. The want of observations off Cape Horn is to some extent compensated by the observations of Sir James Ross at Port Louis, Falkland Islands, in

[1] No. 11 pamphlet of the Meteorological Committee.

1842, a reference to which will show, as previously mentioned, that the mean temperature of the sea is invariably warmer than that of the air during the winter months. Now, as it is a fact well ascertained that the current in the vicinity of the Falkland group sets from the southwest towards the northeast, and as this current is warmer than the air, there can be but one way of accounting for its heat; that is, by supposing it to derive this warmth from lower latitudes in the Pacific, and to be carried by the prevailing winds and configuration of the land round Cape Horn and northeastward to the Falklands.

That this agrees with the temperatures recorded on the western coast of Patagonia will be seen by referring to No. 11 pamphlet of the Meteorological Committee, as the mean temperature of the sea in the squares adjacent to the coast is from 2° to 4° higher than that of the air during the months of May, June, and July. On leaving the Falkland Islands and standing to the eastward, vessels generally obtain colder surface temperatures than those at the group. In the Challenger a decrease of 3° was registered to the northeastward of Port Stanley.

What the width of this warm portion of the Cape Horn Current is, remains to be determined, and also whether its speed is greater than that of the drift current farther south. The available evidence points to a considerable velocity at times, for the "Chanticleer" registered a speed of 54 miles in 23 hours between Cape Horn and Staten Island in May. During the "Beagle's" stay in the vicinity of Tierra del Fuego, surveying, the current was always found running to the eastward, but its velocity varied with the tidal wave, being at its maximum with a rising and at its minimum with a falling tide.

A series of charts, showing the surface temperatures of the Atlantic, Indian, and Pacific Oceans, has recently been published by the authority of the Meteorological Council, in which many more observations are given off Cape Horn.[1] These observations confirm this conclusion, but observations closer to the shore than those on the charts would probably show a still higher temperature of the surface waters. As there is very considerable interest attached to this current around Cape Horn, it is to be hoped that further observations will soon be made.

The following table will give a fair idea of the climate of the settlement at Port Stanley, but as the observations extend over one year only, the means will be subject to modification from future observations. The barometer used in taking the observations was a standard, and its indications agreed precisely with those of the instruments on board the Challenger, which were verified at Kew at the termination as well as at the commencement of the voyage.

[1] Charts showing the Surface Temperature of the Atlantic, Indian, and Pacific Oceans. London, 1884.

Stanley, Falkland Islands.

Meteorological Table compiled from Observations taken at 9 a.m. daily by Mr. Cobb during the year 1875.

Barometer reduced to 32° and sea level. Position of Observatory lat. 51° 41′ S., long. 57° 51′ W.; Height of Barometric Cistern 21·5 feet. The mean temperature is the mean of the maximum and minimum Self Registering Thermometers read at 9 a.m.

MONTH.	Barometer.		Mean Temp. in shade.	Mean Range of Temp.	Max. Temp. in shade registered.	Min. Temp. in shade registered.	Clouds—0 to 10. Mean Amount.	Rain.		Wind.										No. of days Gales.	No. of days Fogs.	Relative Humidity Sat.=100.	REMARKS.
	Mean Height.	Ext. Range.						Total Fall.	No. of days.	Av. Hourly velocity.	No. of days from												
											N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	C'lm				
	in.	in.	°	°	°	°		in.															
January, .	29·514	0·99	49·0	12·9	64·0	36·0	7·4	3·27	21		2	...	...	...	6	8	10	5	...	4	...	67	
February, .	29·543	1·02	48·6	13·4	64·1	37·1	7·6	3·32	18		3	...	...	...	6	3	9	7	...	3	1	77	
March, .	29·654	1·01	49·3	12·2	67·0	32·8	5·6	1·76	17		3	...	1	...	...	7	13	7	...	5	2	79	
April, .	29·458	1·28	43·4	10·2	58·0	32·9	5·1	2·40	24		2	...	1	...	2	4	17	2	2	5	2	82	
May, .	29·551	0·82	42·3	8·4	51·0	24·0	6·6	1·45	15		5	2	6	...	...	...	14	4	...	1	5	91	
June, .	29·756	0·95	38·4	6·0	45·7	29·1	7·4	1·43	18		2	...	3	2	5	...	14	3	1	2	2	89	Max.—Black bulb in Sun 150°·5. Min.—On Grass 19°·7.
July, .	29·581	1·34	37·0	8·3	48·1	27·2	6·9	1·18	17		4	.	...	1	5	4	14	1	2	...	2	90	
August, .	29·653	1·16	38·5	9·9	51·9	23·7	6·3	0·91	16		2	...	...	...	4	1	16	5	3	6	2	88	
September,	29·762	1·15	41·6	11·1	53·8	28·7	4·9	0·84	14		2	...	...	2	1	4	17	3	1	5	2	75	
October, .	29·708	1·30	42·1	14·8	58·9	29·7	7·4	1·07	20		3	...	...	...	7	8	11	1	1	1	1	81	
November,	29·750	1·13	46·2	11·8	68·2	33·0	6·9	1·24	14		1	1	1	1	12	5	9	...	...	3	1	72	
December,	29·486	0·70	45·8	12·1	64·4	30·5	7·2	2·92	25		4	3	3	3	5	4	8	1	...	3	2	76	
Means, Totals, and Extremes,	29·618	...	43·5	10·8	68·2	24·0	6·6	21·79	219		33	6	15	9	53	48	152	39	10	38	22	80	

The Falklands are a treeless expanse of moorland and bog, and bare and barren rock. Though it was summer at the time of the visit, and the islands are in about a corresponding latitude to London, a bitterly cold hail-storm was pelting down as the first boat was rowed to the shore. The islands are occupied as sheep and cattle runs, and since sheep are found to pay best, they are to a large extent supplanting the cattle, formerly so numerous. The mutton is most excellent, but the supply is so far in excess of the small demand that the Falkland Island Company have a large establishment where their sheep are boiled down for tallow.

At the request of the Governor, Mr. Moseley rode with Lieutenant Channer 60 miles across the large island, on which the town of Stanley is situated, to Port Darwin, in order

HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

BALSAM BOG (*Bolax glebaria.*) FALKLAND ISLANDS.

to examine some reported coal beds. The route lay over the dreary moorland, and wound and turned about in order to avoid the treacherous bogs. A "pass" in the Falkland Islands means not a practicable cleft in the mountains but a track by which it is possible to ride across a bog. The horses born and bred in the island know full well when they are approaching dangerous ground, and tremble all over when forced to step on it. A most interesting plant, the Bog Balsam (*Bolax glebaria*), occurs all over the moors, closely simulating in appearance the *Azorella selago* described in Chapter IX. as covering the surface of the ground in Kerguelen Island with elastic cushions. The *Bolax* forms closely similar springy compact rounded lumps of dark green on the Falkland soil (see Pl. XXXV.).

At every 10 miles or so a shepherd's cottage was met with, otherwise the entire route was uninhabited. Usually the shepherd was a Scotchman in the employ of the Falkland Company; some of the shepherds are married, and seem well off and were very hospitable. These Scotchmen have almost entirely supplanted the "gauchos" from the mainland, who did all the cattle work at the time of Darwin's visit to the islands; they come out from home usually entirely unaccustomed to riding, but very soon become most expert with the lasso and bolas, and can ride and break in the wildest horses. There were only two Spanish gauchos in the employ of the Company at the time of the ship's visit. The Company's shepherds are allowed each eight horses, a fresh one for every day of the week and a pack horse, which feed together on the moorland near the shepherd's cottage, and keep together in a band though quite free. An old broken down mare which cannot roam far is usually kept with each band, and is generally one in which the hoofs, as occurs quite commonly in the Falklands from the softness of the soil, are grown out and turned up somewhat like rams' horns. Though the gauchos themselves are matters of the past in the Falklands, their Spanish terms for all things connected with cattle and horses survive and are in full use among the Scotch shepherds. Such a maimed animal as above described is accordingly called a "chapina" (*chapina*, a woman's clog); the band of horses, which is called a "tropija," never deserts its chapina.

A man after riding 30 or 40 miles and about to change horses merely takes the saddle off his horse, gives the animal's back a rub with his fingers, to set the hair free where the saddle cloth pressed, and lets the horse go, when it never fails to return to its tropija and feeding ground. Horses were changed several times on the route, since the party were the guests of the Company, and were treated most hospitably; the tired horses were always simply turned loose, to find their own way back for 20 miles or so

The progress on the trip was mostly slow, because of the bogginess of the ground, and it was dark by the time the party reached the end of the 60 miles' ride.

An experienced guide is required in order to traverse the Falkland Island wastes and find the passes. To a stranger every hill and mountain appears alike, and many persons have lost their way and their lives on the moors. The most experienced "camp" men (Spanish, *campo*) lose themselves sometimes, especially when a thick fog comes on, and then they trust entirely to their horses, which when left to themselves make their way back to their accustomed feeding ground.

Mr. Fell, the head man of the Company at Darwin Harbour, said that a band of horses will always stay with a mare that has a foal. Mr. Darwin has described a degeneration in the size and strength of the horses which have run wild in the Falkland Islands,[1] ascribing the degeneration to the action of the climate on successive generations. Mr. Fell, and other persons brought into constant relation with the horses, hold the opinion that it is only the wild horses, occupying a particular district in the neighbourhood of Port Stanley, which are small and pony-like; further, they believe that the reason why these particular wild horses are small is that they are sprung from a stock originally inferior in size when imported. The wild horses, which are abundant in the large peninsula known as Lafonia, were said to be of full size and vigour, and to show no signs of degeneration, and to be preferred for all purposes to those bred in domestication. Several of these horses which had been wild were seen, and one was ridden by a member of the party; they were not at all undersized. The guide rode a sturdy pony, which he said was one of the smaller wild breed.

Mr. Fell has watched the habits of the wild horses in Lafonia closely. The strong and active horses each guard a herd of mares; they keep the closest watch over them, and if one strays at all, drive her back into the herd by kicking her. The young horses live in herds apart, but the more vigorous ones are always on the lookout to pick up a mare from the herds of the older ones, and drive her off with them, and they sometimes gather a few mares and hold them for a short time, till they are recaptured from them. When they think they are strong enough, they try the strength of the old horses in battle, and eventually each old horse is beaten by some rival and displaced; the fighting is done mainly with the tusks, front to front, and not with the heels. Thus the most active and strongest males are naturally selected for the continuation of the herds.

The wild horses, as well as others, are often broken in by tying them with a raw hide halter to a post, and leaving them for several days without food or water. After long ineffectual struggles to break loose, the animals become convinced of the absolute power of the halter over them, and in future become cowed and docile directly a halter or lasso is over their heads. The wild horses when broken in are very tame and quiet to ride, and obey the rein with astonishing facility. There is no necessity, as a rule, to make them feel the bit at all in order to turn them; merely laying the part of the reins close to the hand against that side of the neck from which they are wanted to turn is sufficient; well-broken horses can be turned round and round in a circle by this means, by a gentle touch on the neck only.

The wild cattle in Lafonia will probably all be killed off in order that sheep may be

[1] Journal of Researches during the voyage of H.M.S. "Beagle, p. 192, ed. 1879; Animals and Plants under Domestication, vol. i. p. 52, 1868.

substituted. At present the Company pays men to kill the wild cattle for their hides. They are thrown with the lasso or bolas, ham-strung, or "cut down" as the term is, and then killed and skinned at leisure. Two thousand had been thus killed in Lafonia in the year of the visit.

The boys at the Falkland Islands have invented a small bolas in which the large knuckle-bones of cattle are used as the larger balls, and a smaller bone from the foreleg as the small ball for the hand; they use the bone bolas for catching wild geese, creeping up to a flock and throwing the bolas at the birds on the wing as they rise. They constantly succeed in thus entangling them, and bringing them to the ground, and their mothers always send out their boys when they want a goose, so that the birds are seldom shot at around Darwin Harbour. The bone bolas comes curiously near that of the Esquimaux in structure, the latter, used also for catching birds, has however more than three balls, and these are made of ivory. Flocks of the geese were to be seen feeding on the grass close to the houses, looking just like farmyard geese. The birds take no notice of a gun, but are very quick at seeing a bolas brought near them, well knowing that they are going to be molested.

Near Darwin Harbour Mr. Moseley found some Dipterous insects with rudimentary wings, of which specimens have been sent to Mr. W. F. Kirby of the British Museum, who writes as follows:—"One is a Gnat allied to *Limnobia* (Tipulidæ). Another species has considerable resemblance to some of the subapterous Kerguelen insects, with one of which some dipterologists of my acquaintance regard it as identical; my own view is that it is totally distinct, but I should not like to express any opinion as to its affinities in the absence of better preserved specimens."

The Wingless Flies of Kerguelen have hitherto been found nowhere else but there and in Marion Island, and it would be of great interest to find further connections between Fuegia and the distant Kerguelen Island, the connections between the floras of which were so long ago demonstrated by Sir Joseph Hooker.

The Gnat cannot fly, having even smaller rudiments of wings than the other insect. It was found crawling on rocks, on the shore in sheltered places, and also on the sunny sheltered face of a peat-bank, which formed the cattle fence across the narrow neck of the promontory of Lafonia. It runs quickly, and when in danger draws up its legs and drops amongst the grass in order to escape. A Gnat with rudimentary wings occurs also in Kerguelen Island. Some species of Flies and Gnats with rudimentary wings are known in Europe and elsewhere, and an Apterous Fly (*Borborus apterus*) occurs in England. A Wingless Beetle, and another with perfect wings, were also found near Darwin Harbour.

The other species was found near Darwin Harbour, only on the sea coast, in hollows under overhanging slabs of the sandstone rocks, and sheltering in crevices. It springs nimbly like a Flea or small Grasshopper, and is a little difficult to catch, but cannot fly at all. According to the Rev. H. C. Lory, late Colonial Chaplain in the Falkland Islands, these insects inhabit in immense numbers dried matted seaweed which is to be found on the beaches. He says that they escape in hundreds from the seaweed masses when they are broken up, and that the masses are full of the pupæ.

One new land Mollusc (*Succinea falklandica*, E. A. Smith) was obtained from a hill near the lighthouse, Pembroke Point.[1]

From the head of Port Sussex, not far off, was obtained the skeleton of a Ziphioid Whale, measuring exactly 14 feet in length, complete except the paddles, which had been dragged away tied to the ends of lassos in order to get the oil out of them. It was given to the Expedition by Mr. John Bonner, a farmer in the neighbourhood. Professor Turner, who has described this skeleton, regards it as a young example of *Mesoplodon layardi*.[2] The skeleton was lashed on a pack-horse, by no means an easy matter in the case of so unusual a load. The party rode at a good pace, but during the long ride the lashings were constantly getting loose, and the party almost lost the way near the end of the journey, night having overtaken it before it reached Stanley with the skeleton.

Mr. Murray visited, with Mr. Mansel, the manager of one of the large estates on the island, Fitzroy Island Harbour and Fox Point, places distant about 40 miles from Stanley. At Fitzroy Island Harbour there are several hills of blown calcareous sand, composed chiefly of broken fragments of Molluscs, at other places the sand was of very pure quartz. All along the coast there were many bones of Seals and Whales. The clastic sedimentary rocks of the island are volcanic grit, arkose, graphitic and other shales. Where the shales are inclined at a high angle the ground is much drier than at other places, and is known as "dry camp." The well known "stone rivers" have been described and their origin discussed by Sir Wyville Thomson.[3] A large block brought home from one of these rivers is a diorite containing some crystals of augite.

Mr. Robert Etheridge, jun., who has examined the fossils collected by the Expedition, has supplied the following notes :—"Mr. Darwin remarked upon the general close resemblance the organic remains bore to those of the Silurian rocks of Murchison, with, at the same time, a tendency towards a Devonian facies.

"Sir Wyville Thomson, in his account of the Falkland Islands, noticed the similarity between the lithological character of the Falkland fossiliferous sandstones and the ferruginous sandstones of May Hill and Girvan. He regarded the fossils as indicating a horizon near the base of the Devonian formation.

"The only publication bearing directly on the purely palæontological aspect of the Falkland group is that by Professor J. Morris and the late Mr. D. Sharpe.[4] They

[1] *Proc. Zool. Soc. Lond.*, p. 280, 1884.

[2] Report on the Bones of Cetacea, Zool. Chall. Exp., part iv., 1880.

[3] The Atlantic, vol. ii. p. 245, 1877.

[4] Description of Eight Species of Brachiopodous Shells from the Palæozoic Rocks of the Falkland Islands, *Quart. Journ. Geol. Soc.*, vol. ii. pp. 274–278, pls. x. and xi., 1846.

described the following eight new forms :—*Chonetes falklandica, Orthis sulivani, Orthis tenuis, Orthis concinna, Atrypa palmata, Spirifera hawkinsii, Spirifera antarctica,* and *Spirifera orbignii,* with an *Orbicula,* which is figured but not specifically named, numerous traces of Crinoid stems, an *Avicula,* and fragments of a Trilobite.

"The individuals of the genus *Spirifera* were few in number, those of *Orthis, Chonetes,* and *Atrypa* abundant. The alæform outline and paucity of ribs of the Spirifers allied them to those of the Palæozoic rocks of New South Wales, and some Devonian forms of the Gifel. The Orthidæ they considered to be more nearly allied to some Lower Silurian species of the northern hemisphere.

"Messrs. Morris and Sharpe say :—'We cannot attempt to place the beds in the Falkland Islands, which have supplied these specimens, on the level of any particular portion of the European scale of formations, but must be contented with saying that they belong to a part of the Palæozoic series of which the position is still undetermined.'

"The fossiliferous specimens brought by the Challenger Expedition from Port Louis in the Falkland Islands consist of medium sized blocks and hand specimens of a fine liver-coloured micaceous sandstone. These are traversed by thin layers of internal casts and external impressions of shells, chiefly Brachiopoda, and fragments of Crinoid stems. The only other recognisable fossil is a broken internal cast of a Gasteropod. Pieces of buff-coloured mudstone, apparently quite a different deposit to the fossiliferous sandstone, contained a few body rings (also casts) of a Trilobite, but quite past all recognition. Another block of the same material contains the internal cast of a large *Spirifera,* in all probability *Spirifera antarctica,* M. and S. No trace of the *Orbicula* figured by Morris and Sharpe was observed."[1]

[1] *Notes on the Species.*—"Numerous examples exist of a very large *Spirifera,* possessing a series of simple broad ribs, crossed by numerous prominent lamellæ, which may be referred to the *Spirifera antarctica,* M. and S. It bears strong resemblance to the *Spirifera cultrijugata,* F. A. Römer, found in the Devonian beds of the Gifel and Ardennes.

"Several other examples of a second species of *Spirifera* recall the *Spirifera orbignii,* M. and S., but the radiating ribs of the shell are smaller, more numerous, and more closely set. They are however in all probability only a variety of this species. A third species is present in some of the blocks, having a long hinge line, a simple fold, with on each side some nine ribs, crossed by fine concentric wavy laminæ. Near the extremities of the wings there are indications of spaces devoid of ribs, as in *Spirifera speciosa,* Schlotheim, of the European Devonian, and of which it may probably be only a variety. It might have been referred to the *Spirifera hawkinsii,* M. and S., had it not been for the increased number of ribs.

"There are a few examples of a small cast with the general form and area of *Cyrtina heteroclyta* (a well known Devonian Brachiopod), but without the sinus of the ventral valve, and an ill-defined fissure. It may be only a *Spirifera* with a large area, but it certainly possesses a very *Cyrtina*-like appearance. It is quite different from any of the figures given by Messrs. Morris and Sharpe.

"Large numbers of the *Atrypa palmata,* M. and S., are scattered about the fossiliferous layers of the blocks from Port Louis, and the mass from Macbride's Head, East Falklands. This species is about the best marked of the Falkland fossils, and is easily recognisable. The whole internal characters are well shown, and they appear to indicate that the species is not an *Atrypa,* but should more properly be referred to Prof. James Hall's genus *Leptocœlia.* The description of the parts, and lengthy arguments for this change, cannot be entered on here, but the whole structure of this shell would well repay detailed study. Messrs. Morris and Sharpe alluded to the resemblance between their *Atrypa palmata* and the well known shell *Atrypa hemispherica,* which it is quite possible may itself be a *Leptocœlia.*

"The genus *Orthis* is represented by fragments of a very finely striated shell which may perhaps be referred to the

Many of the seamen living at Stanley constantly visit the Strait of Magellan, and very often bring back with them Fuegian bows and arrows for their children to play with. The boys shoot at a mark with the stone-tipped arrows, and the tips are soon broken off and lost. The stone arrow-heads thus become scattered about the moor anywhere near a habitation, and before long they are sure to be picked up, being indestructible. It must then be remembered that they are not proofs that the Falkland Islands were once inhabited by a savage race. Difficulties of this kind are constantly occurring; for example, part of a New Zealand mere of nephrite has been found in Yorkshire, and ancient Chinese seals have been turned up in the ground in Ireland.

Not far from Stanley Harbour there are rookeries of the Magellan Jackass Penguin (*Spheniscus demersus*, var. *magellanicus*). The birds make large and deep burrows in the peat-banks on the seashore in such numbers that the ground is hollowed out in all directions. The edges of the birds' bills are excessively sharp, and can cut a strip out of a man's finger as cleanly as a razor. Round the mouths of their burrows and on the even surface of the banks, between the holes, the birds lay out pebbles which they must carry up from the seashore for the purpose. The pebbles are of various colours, and the birds seem to collect them from curiosity, at least there appears to be no other explanation of the fact.

Many stones, pebbles, and fish bones were found in the stomachs of some of these birds. The sealers said that they vomited up the stones and shells found at the mouths of their burrows when they came up from the sea, and in going to sea again take in the very same stones as "ballast." Fur Seals were said to take in "ballast" in the same way as Penguins.

The Scaphopoda and Gasteropoda.—The Rev. R. B. Watson, on the return of the Expedition, undertook the description of the Mollusca at the request of the late Sir C. Wyville Thomson. However, after separating out the different species, and labelling the known species of the greater part of the collection, Mr. Watson decided to limit his investigations to the Scaphopoda and Gasteropoda. Mr. Watson says:—"The Challenger collected belonging to these groups between 940 and 1000 recognisable

Orthis tenuis, M. and S. More and better preserved specimens of this, however, are requisite before a definite opinion can be passed.

"*Orthis sulivani*, M. and S., is present on almost every block of sandstone, and is by far the commonest species represented in the Challenger collection. It occurs in every state of preservation but one, viz., with the shell on. The fringed internal edge of the shell is a particularly well marked and typical character in *Orthis sulivani*. The depressions between the ribs on the surface of the valves were intersected by concentric striæ, which in all probability likewise passed over the ribs. The latter appear also to have been ornamented with small scattered spines. This species should with greater propriety be referred to the genus *Streptorhynchus*, King (or more properly *Orthotetes*, Fischer). An elongated mesial septum existed, and short strong brachial processes, more in accord with the structure of *Streptorhynchus* than *Orthis*. Accompanying *Orthis sulivani* are smaller casts which may represent the *Orthis concinna*, M. and S. The chief point of separation between the two species appears to be the width of the hinge area, and the internal edge-striation of *Orthis sulivani*. It is possible likewise, that a few faint impressions visible on some of the blocks may represent *Chonetes falklandica*, M. and S., but their state of preservation forbids a positive opinion."

species new and old, with some 400 more indistinguishable forms, that is 1300 to 1400 in all.

"At thirty-nine places not reckoned as Stations, but where gatherings were made on the shore, in harbour, or in quite shallow water outside, 338 old species, 91 new, and 155 indistinguishable forms were found, or 584 in all, on an average 15 forms from each place.

"At fifty-seven Stations from 0 to 400 fathoms, 314 old species, 309 new species, and 196 indistinguishable forms were found, or 819 in all, an average of 14 forms from each Station.

"At thirty-seven Stations from 400 down to 2650 fathoms there were found 81 old species, 127 new, and 39 indistinguishable forms, or in all 247, rather less than 7 from each Station. The greatest depth from which any Gasteropod was obtained was 2650 fathoms, in the South Atlantic. The solitary specimen of *Stylifer brychius*, Watson, dredged at that depth was preserved in spirit, but I failed to extract the animal, owing to the shell being so delicate that no force could be used. The colour is that pale uniform buff so common in deep-sea Mollusca. With nearly, though not absolutely, uniform constancy the deeper the water the rarer were the specimens.

"The absolute number of species is thus obviously considerable, but as a representation of the whole sea bottom reached by the Expedition the result is very small.

"The cause of this fact is of course deserving of careful inquiry. The Mediterranean depths and the Sargasso Sea bottom are certainly poor in all life, but the 'Blake' dredgings by the United States Government in the Gulf of Mexico and up the course of the Gulf Stream seem to indicate an immense wealth of Molluscan life at very considerable depths, and the French Government dredgings in the North Atlantic, and especially along the west coast of Africa, point on the whole in the same direction, though there are indications of individual spots of great poverty; but to what the poverty of these spots is due—whether to stagnation of the water, nature of the ground, volcanic agencies, or currents—is not obvious.

"As regards the shells themselves, some forms of singular beauty have been found. Such are *Cassis wyvillei* from the Philippines in 115 fathoms (like, but quite distinct from, a very rare West Indian species), *Fusus pagodoïdes* from 410 fathoms off Sydney, *Provocator pulcher*, a new Volute from Kerguelen, and *Guivillea alabastrina*,[1] the latter, a pure white alabaster Volute of exceptional form, from a depth of 1600 fathoms in the Southern Ocean. Of all the Molluscs got by the Expedition, *Guivillea alabastrina* (see fig. 328) is certainly the most valuable. It is large; the shell is singularly beautiful in form and colour; it comes from a great depth, and its generic features are very peculiar. It is unfortunate that it is somewhat broken. In the act of its capture, or in the extraction of the animal, the shell must have been slightly crushed, and the fragments lost. To me it came most carefully packed in cotton-wadding; but one or two small pieces of

[1] Originally described under the generic name "*Wyvillea*," which was afterwards found to be preoccupied.

shell were found loose in the box, and these I could replace. Under my care, however, in spite of the most extreme solicitude, it met with sore disaster. The breaking

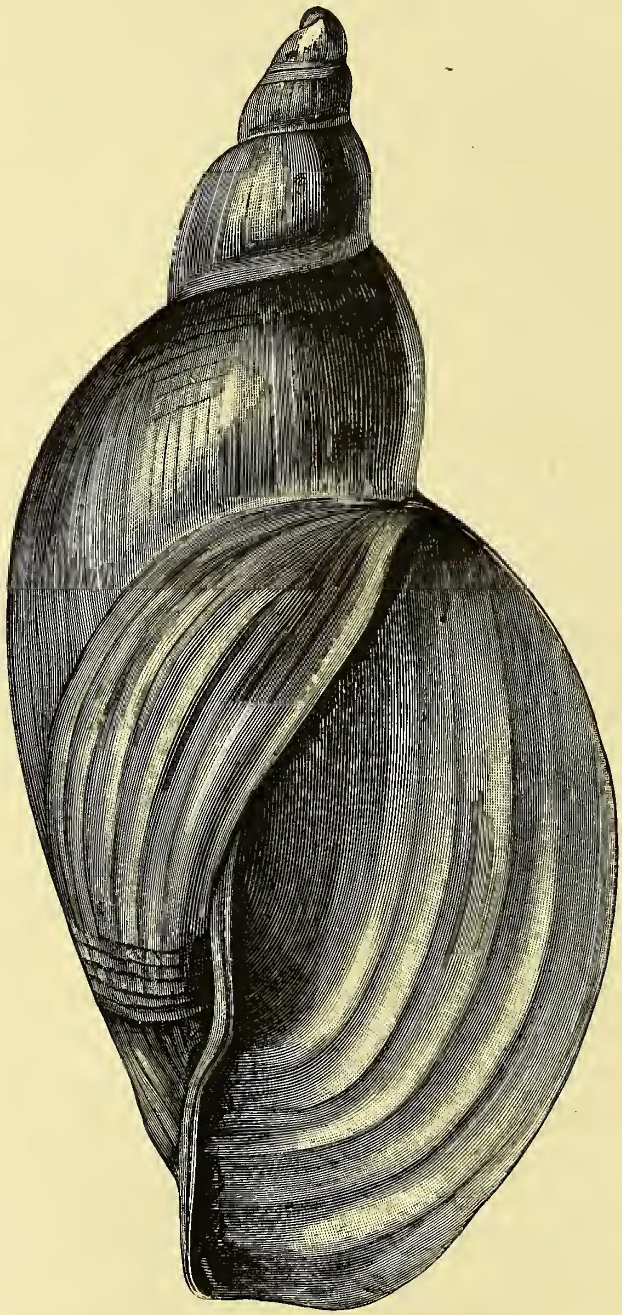


FIG. 328.—*Guivillea alabastrina*, Watson; natural size. From the Southern Ocean, depth 1600 fathoms.

was so bad that the shell looked like a wreck; the bits, however, were got into their places and fixed with cement, and some professional restorer may finish the work more delicately than I could do. In any case this unique treasure is not lost. From the same neighbourhood there were some very beautiful Trochuses of the *Margarita* group, such as *Trochus* (*Margarita*) *brychius* from 1260 fathoms, far to the southeast of Kerguelen. Full-grown shells of *Voluta* (*Volutilithes*) *abyssicola*, H. and A. Ad., a species that has long been an object of interest from its connection with Eocene forms, but which was hitherto known only in one very young specimen, have been brought from near the Cape of Good Hope. *Turbo transenna*, a remarkable new form, comes from 565 fathoms near Japan. *Gaza dædala*, a new and very beautiful *Trochus*, was got in 610 fathoms off Fiji. The great group of the Pleurotomas is largely represented in species, and coming, as many do, from very deep water, they are of great interest, but in the main the specimens are few and poor.

"The presence of the fossil genus *Acteonina*, though in its least characteristic form, and distinguishable indeed from *Actæon* only by the absence of pillar teeth, is not without interest. Two of the Scaphanders, *Scaphander mundus* and *Scaphander niveus*, from the neighbourhood of the Philippines in 800 and 500 fathoms respectively, are very fine.

"That no addition either of species or of specimens should have accrued to the very limited number of living Pleurotomarias—distinctively a deep-water and very ancient genus—is a disappointment.

"As regards distribution, the habitat, hitherto unknown, of some littoral species has been determined. One or two almost forgotten species, such as *Trochus* (*Diloma*) *porciter*, A. Ad., have been recovered in their own home ; but what is probably of highest interest is the proof obtained, though hardly for the first time, (1) of the existence of species such as *Puncturella noachina*, Linn., *Dentalium entalis*, Linn., *Scissurella crispata*, Flem., and *Homalogyra atomus*, Phil., in both Arctic and Antarctic waters ; and (2) of the wide extension in the ocean of still surviving fossil species such as *Dentalium dentalis*, Linn., *Puncturella noachina*, *Puncturella* (*Cranopsis*) *granulata*, Seg., and *Puncturella* (*Fissurisepta*) *rostrata*, Seg., Italian Miocene fossils with others from the Pliocene.

"In a general way the facies of the deep-sea Molluscan fauna may be said to be paleness and fragility. If the number of new species and genera is larger proportionally in the deep than in the shallow water Stations, the fact can only be taken as indicating that a hitherto unexplored field has been entered on."

The Anomura.—Mr. J. R. Henderson, M.B., C.M., who has undertaken the preparation of a Report on those families of Crustacea frequently grouped under this name, writes:—"The Challenger collection of Anomura has only recently been placed in my hands, and I have not yet had time to make a detailed examination of all the specimens. The collection, which is an extensive one, contains many new forms of great interest, and it is also of value for the additional light it throws on the geographical and bathymetrical distribution of these Crustaceans. The Anomura are represented at great depths in the ocean, specimens having been taken by the Challenger beyond 2000 fathoms; in this respect as in general organisation they apparently occupy an intermediate position between the Brachyura and the Macrura. At more than half of the Stations where Anomura occurred, the depth exceeded 300 fathoms, and the groups containing the largest number of new species (Paguridea and Galatheadea) appear to have the greatest vertical distribution.

"The Dromidea are represented by nine species taken at various Stations, from shallow water to 150 fathoms; at the latter depth (Station 142, Agulhas Bank) were taken specimens of *Dromidia bicornis*, Studer, and another species apparently new. Several of the Dromids are protected by Sponges, or Ascidians, which partly envelop them, and to which they appear to be firmly fixed.

"Few species of Homoladea occur in the collection, but at Station 196 a curious form, allied to *Homola* (perhaps referable to *Homolopsis*, A. M.-E.), was dredged at a depth of 825 fathoms. The single specimen taken is characterised by a prominent rostral spine, well-marked supra-orbital spines, and long slender limbs. Examples of the genus *Latreillia* occurred off Zebu, and at two Stations on the Australian coast at depths varying from 30 to 150 fathoms.

"The Raninidea and Hippidea are represented by numerous species taken principally in shallow water. In the former group occur several rare or little known species. The Japanese *Lyreidus tridentatus*, De Haan, was taken off Port Jackson, Sydney (30 to 35 fathoms), also off Kandavu, Fiji (210 fathoms); in the latter locality only a single specimen was obtained, remarkable in having the spine on the fourth abdominal segment very pronounced. An interesting form, allied to *Lyreidus*, was taken off Bahia (7 to 20 fathoms), in which the carapace has a peculiar eroded appearance in the anterior half, due to the presence of numerous pits and depressions; there is a prominent tridentate front, projecting considerably beyond the eyes, which are very minute, and the ambulatory limbs are furnished with uncinate dactyli.

"Of the five species of Lithodidea taken by the Expedition, the best known is *Paralomis verrucosus*, Dana, which occurred at several shallow water Stations in the Strait of Magellan. Two fine and distinct species of *Lithodes* were obtained at Station 145 (310 fathoms), between the Cape and Kerguelen Island; the larger of these is allied to *Lithodes maia*, but has the carapace furnished with several large spines. Very few Anomuran Crustacea appear to have been taken by the Challenger in the North Atlantic, but the collection contains two young specimens of *Lithodes agassizi*, Smith, from Station 78, near the Azores (1000 fathoms).

"The great majority of the Porcellanidea, of which there are numerous examples, belong to species already described and well known, and it is of interest to note that, with a single exception, none were obtained beyond a depth of 30 fathoms. The exception referred to is a species of *Porcellana*, apparently very closely allied to the common European *Porcellana platycheles*, Pennant, from Station 24 (390 fathoms). Numerous specimens of *Polyonyx obesulus*, Miers, were taken in the interior of a Sponge (*Hippospongia anomala*, Poléjaeff), at Station 186 (8 fathoms), and the same species appears also to have occurred in a free condition at this Station.

"The Paguridea are well represented in the collection, and a number of new species are present, especially from deep water. As indicating one feature of this group, it

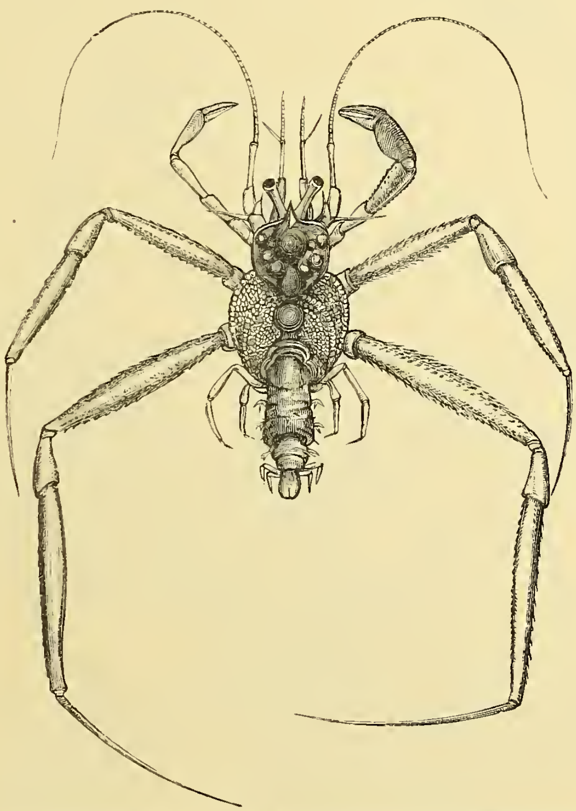


FIG. 329.—*Tylaspis anomala*, n. gen. et sp.; twice natural size. South Pacific Ocean, 2375 fathoms.

may be stated that Pagurids were taken at twelve Stations, where the depth registered was over 1000 fathoms, and two species occurred at depths beyond 2000 fathoms. The majority of these deep-water species are characterised by long and slender limbs, but the eyes—organs in the higher Crustacea perhaps most subject to variation at great depths—appear to have undergone very slight modification. It is also to be noted that, almost without exception, the species taken at great depths inhabit shells to which one or more Actiniæ are attached. Some of the shells bore on them the well known colonial *Epizoanthus parasiticus*, which had as usual removed all their calcareous matter. Some of the Paguridea appear to have a very wide geographical range ; thus, a species apparently identical with the well-known *Pagurus striatus*, Latr., of the Mediterranean, was taken at two Stations off the Philippines, and *Petrochirus granulatus*, Olivi, a native of the West Indies, was dredged at Simon's Bay, Cape of Good Hope. The collection contains several specimens of an interesting species, with a regularly segmented and calcified abdomen, showing a transition between the Paguridea and the Thalassinidea, trawled at Station 163A,

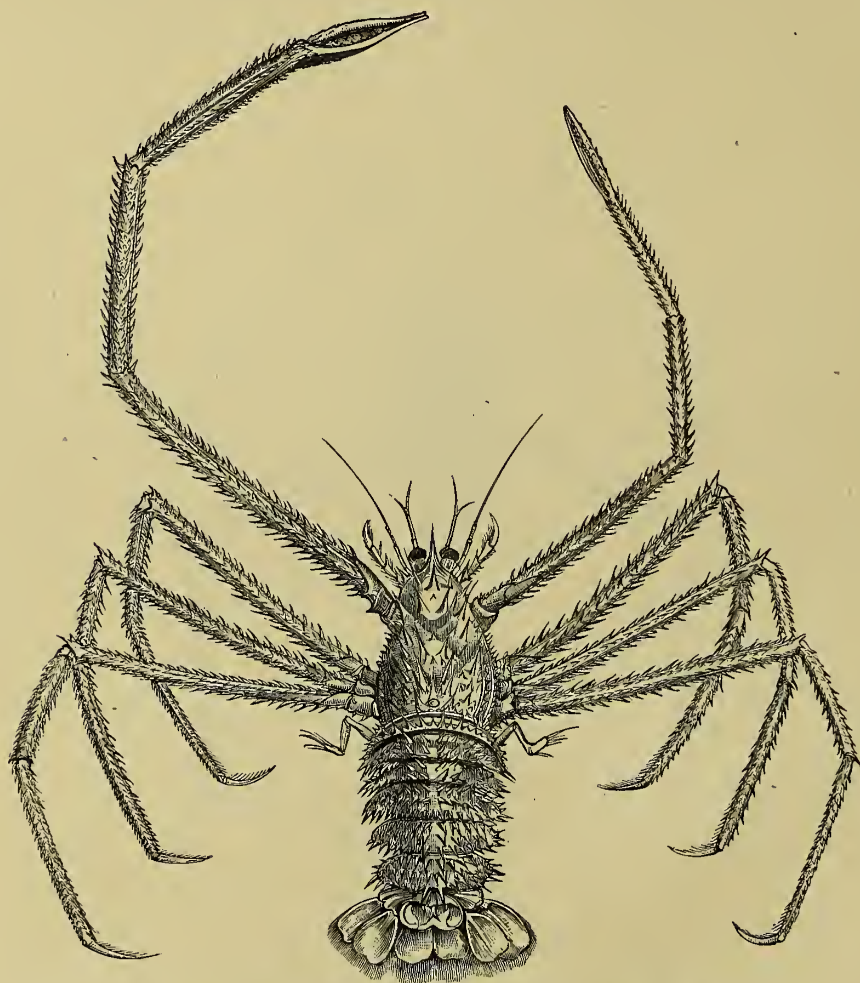
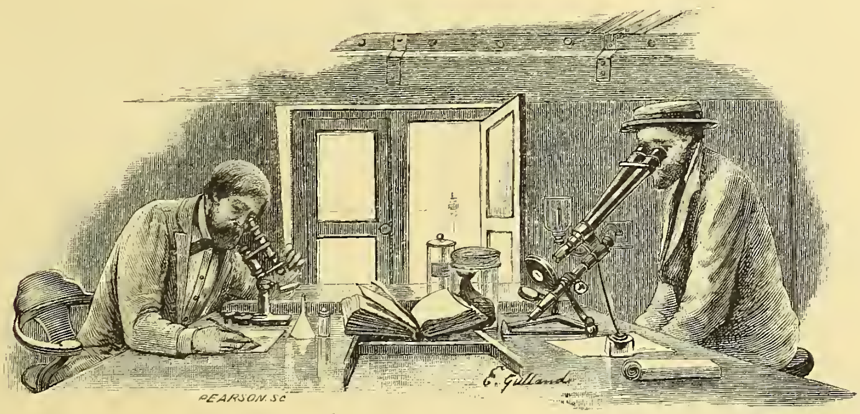


FIG. 330.—*Ptychogaster milne-edwardsi*, n. sp.; natural size. Magellan Strait, 400 fathoms.

off Twofold Bay, Australia (120 fathoms). In many respects this singular Crustacean agrees with the description of A. Milne-Edwards' recently established genus *Pylocheles*, from the 'Blake' expedition, but differs strikingly in habit, as all the Challenger specimens occurred in a free condition. At Station 285, in the South Pacific, at a depth of 2375 fathoms, one of the most interesting forms in the collection was taken. The single specimen, type of a new genus and species (*Tylaspis anomala*) is essentially a Pagurid with a completely calcified cephalo-thorax; the short abdomen exhibits only traces of segmentation, and the ultimate appendages are symmetrical and well developed (see fig. 329).

"The Galatheadea form a large and interesting portion of the collection, and several species extended to great depths. Examples of the genus *Munida*, many of which are new to science, were taken at various depths from shallow water to 600 fathoms, in all the great oceans explored; the occurrence of a species at Station 113A, off the Brazilian coast (7 to 20 fathoms), with the rostral spine distinctly serrated, is of interest. The genus *Galathea* appears to be confined to comparatively shallow water, reaching its limit at 100 fathoms, but specimens of the allied *Diptychus*, apparently a deep-sea representative of *Galathea*, were got from considerable depths down to 600 fathoms. The deep-water forms present many points of interest, and several of them belong to genera lately described by the naturalists of the recent American and French deep-sea expeditions. The eyes are almost invariably devoid of pigment, and are apparently functionless; in some cases the ocular peduncle is prolonged into a spine, while the convex cornea still remains on its outer surface. In a single specimen from Station 196 (825 fathoms), the eyes are represented only by a single spine on either side, in front of the peduncle of the external antenna. The beautiful Galatheid figured (*Ptychogaster milne-edwardsi*, fig. 330) was dredged at Station 310 (400 fathoms); it differs from the only other known species, *Ptychogaster spinifer*, A. M.-E., and *Ptychogaster formosus*, A. M.-E., in having all the abdominal segments furnished with spines on the dorsal aspect."



CHAPTER XXI.

Falkland Islands to Monte Video—The Deep-Sea Fishes—Monte Video—The Gephyrea—Monte Video to Ascension—Description of the Deposits—On Deep-Sea Deposits in General—Ascension—Ascension to Porto Praya—Pelagic Diatoms—Infusoria—Pyrocystis—Coccospheres and Rhabdospheres—Bathybius—Cape Verde Islands to England—Synoptical Table of the Voyage—The Botany of the Expedition—Challenger Collections and Publications.

The Falkland Islands to Monte Video.

On the 6th February, at 4 p.m., the ship left Port Stanley for Monte Video, arriving there on the 15th at 4 p.m.

The wind, as the vessel left the Falkland Islands, was blowing fresh with a falling barometer, but no bad weather ensued. On the 8th a strong breeze was experienced from the northward for four hours; a gale from the westward lasted from 10 p.m. on the 9th until 4 a.m. on the 11th; and on the 12th a strong breeze from the northwestward lasted ten hours. The weather was, on the whole, fine and dry.

In making the Rio de la Plata, it was noticed that the hill named Pan Azucar only looked like a sugar loaf when viewed from the southwest or northeast, for from the northwest or southeast it appears rounded.

In entering the estuary of the river several casts of 10 fathoms were obtained over a muddy bottom, with Maldonado Island N. 6° E., Lobos Island N. 46° E., and Cerro Chico N. 51° W.

In the section from the Falkland Islands to Lobos Island, four soundings, four serial temperature soundings, and three trawlings were obtained (see Sheet 42).

The bottom showed a descent to 2400 fathoms in the centre of the section, and a gradual rise on the one side to the Falkland Islands and on the other side to the River Plate.

The temperature at the bottom varied with the depth, falling to 32°·7 at the 2400 fathom sounding.

The surface temperature, which at the Falkland Islands was about 50°, fell to 46° just outside that group, after which it rose gradually, as the ship proceeded north, to 71° at Monte Video.

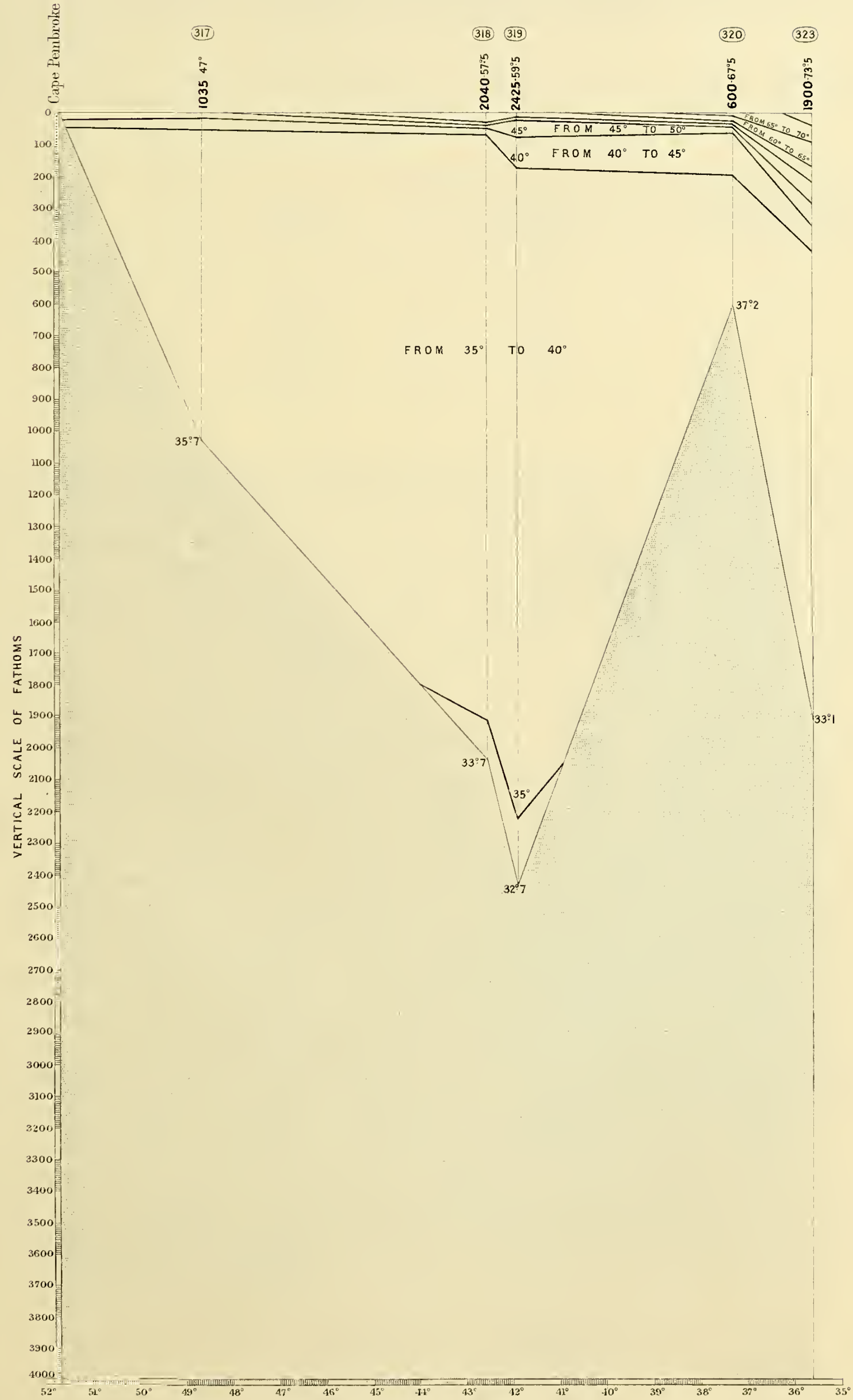
The serial temperature soundings showed a considerable change in the depth occupied by the upper isothermal lines, for whereas on the western side of the South American continent, between the same parallels, the isotherm of 40° maintained an average depth of 380 fathoms, only varying from 320 to 420 fathoms, it was found that between the Falkland Islands and Monte Video it varied from 50 to 430 fathoms in depth.

ATLANTIC OCEAN

Meridional Temperature Section

Falkland Islands to the Parallel of 35°40′ S.

For explanation of Symbols see Appendix 1.



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The surface currents, as ascertained by the difference between the position of the ship deduced from astronomical observations and the ship's reckoning, were N. 79° E. (true) 8 miles per day.

The following anemometer observations were taken when the ship was sounding or trawling :—

Date. 1876.	Station.	Velocity of Wind in Miles per Hour.	Force of Wind by Beaufort's Scale, as noted in Log.
February 8	317	22	4·5
„ 11	318	18	3
„ 12	319	36	7

The deposit in 1035 fathoms in this section was a sandy gravel. The trawl line carried away and the trawl was lost, but the tow-net attached to the line at the weights contained some of the gravel. The larger particles were from 1 to 2 cm. in diameter, brown coloured, flattened, ellipsoidal, derived from ancient continental formations, such as schist, gneiss, arkose, and sandstone, together with milky and hyaline quartz, felspar, augite, magnetite, microclin, hornblende, and glauconite. The glauconite was globular, ovoid, elongated, or vaguely triangular, with rounded angles ; many of the particles were not so homogeneous as true glauconite, and appeared as aggregates of minerals cemented by a green matter. Sometimes they showed a schistoid structure, and often it was difficult to say whether the fragments were glauconite or pieces of rocks strongly impregnated with a chloritic substance. Mixed up with the above mentioned sandy particles were calcareous Foraminifera, fragments of Molluscs, Brachiopods, Echinoderms, and Polyzoans.

In 2040 fathoms the deposit was a blue mud containing 33 per cent. of carbonate of lime. The trawl was put over at this Station, and although it was over for seven hours, it never seemed to have touched the bottom. Two tow-nets were attached to the beam of the trawl, and one at the weights in front of the trawl, and it seems almost impossible that the trawl could have touched on the mud without these fine nets bringing up some traces of it. The trawl, however, contained a specimen of a new genus of Salmonid Fish (*Bathylagus atlanticus*, Günth.), several large Medusæ (*Atolla wyvillei*, Haeckel), and several bright scarlet Shrimps. In the tow-nets attached to the weights and trawl there were also eighteen species of Phæodaria, identical with those obtained in the deep water of the Pacific, several bright red Copepods, and red *Sagittæ* over 2 inches in length. It is impossible to say how near the trawl may have been to the bottom, but Mr. Murray considers it quite certain that most, if not all, of the animals above mentioned were captured in the intermediate water, between a depth of 100 fathoms from the surface and a short distance from the bottom.

At 2425 fathoms there was a blue mud containing about 75 per cent. of mineral particles, the remainder of the deposit being composed of the remains of siliceous organisms and clayey matter; there was no trace of calcareous organisms.

In 600 fathoms the deposit was a green sand, containing 3 per cent. of carbonate of lime. In the sounding tube and in the trawl there were several small concretions, from 1 to 3 cm. in diameter, nodular, more or less elliptical, and varying in colour from grey-green to yellow-green. They were agglutinations of the clastic materials forming the deposit, and cemented together by a clayey matter united with a chloritic mineral, but were not very coherent. Cut into thin sections, they were seen to be formed of angular fragments of quartz (1·0 to 0·5 mm. in diameter), of felspars, some of which were triclinic, of hornblende, of glauconite, and of garnet. The argillaceous matter cementing this sand was finely granular, and impregnated with a green or yellowish chloritic substance, with vague outlines and non-birefringent, the same as that observed upon the isolated grains of the mud. With these sandy agglutinations were associated rounded elliptical fragments with a diameter of from 1 to 2 cm.; they were green, fine grained, could be scratched with steel, and at first sight appeared to have the grain and structure of glauconite. Examined with the microscope, they presented a greenish fundamental mass, with scattered colourless and irregular particles (0·05 mm. in diameter), and black and brown points which appeared to be organic. With polarized light the colourless particles with vague contours were seen to be crystalline, and were probably felspar or quartz. Other fragments with a coarser grain were seen under the microscope to be composed of felspar and quartz perfectly discernible, cemented and surrounded by chlorite.

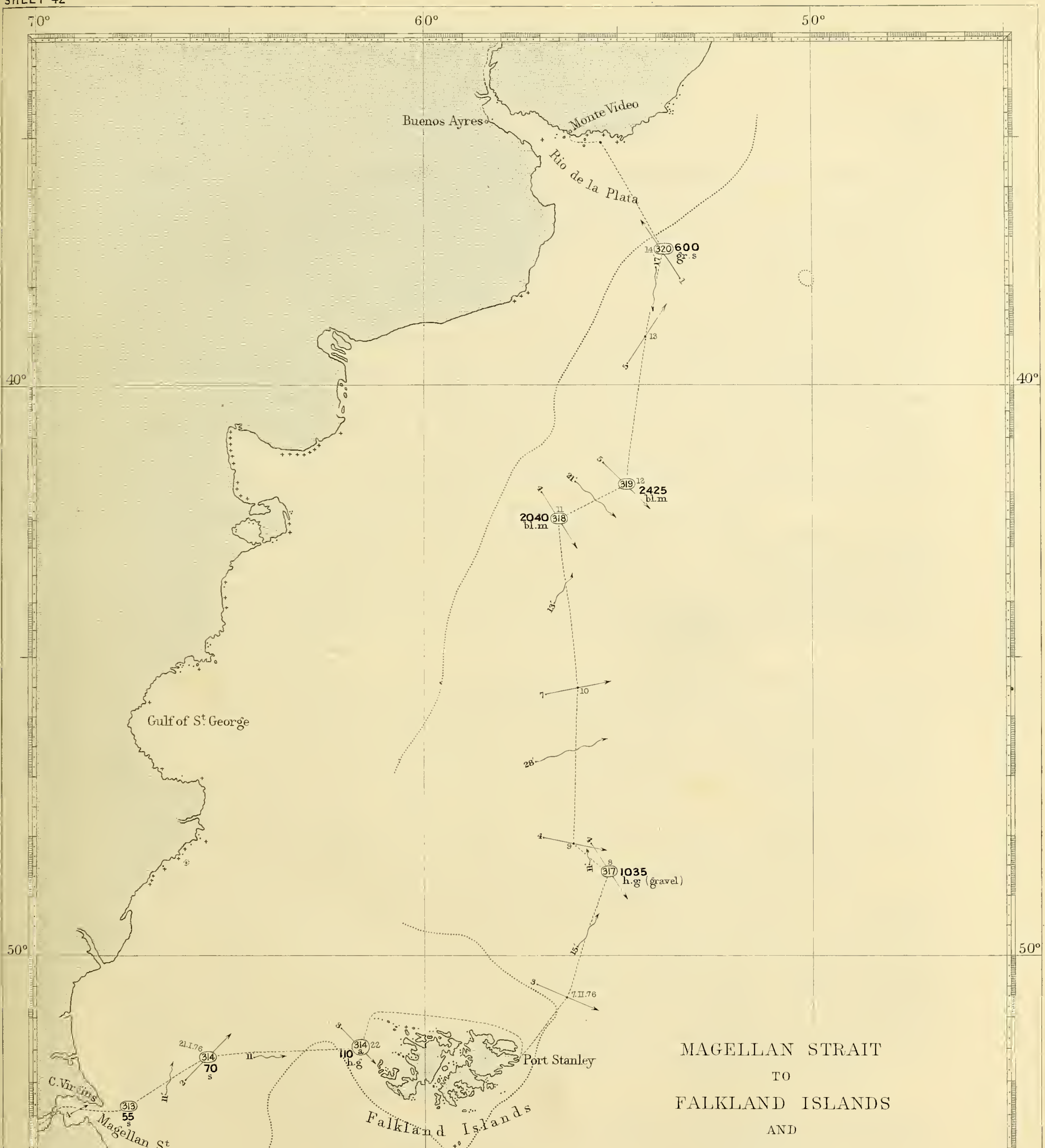
The trawling on this occasion was one of the most productive of the whole cruise, there being in the net four fish and over two hundred specimens of invertebrates, chiefly belonging to the new genera and species first discovered by the Expedition.

The Deep-Sea Fishes.—Dr. A. Günther, F.R.S., is engaged in the preparation of a Report on these fishes, and the following general observations on their characteristic features are extracted chiefly from his recent Introduction to the Study of Fishes:[1]—

Nothing was positively known as to the exact depths inhabited by deep-sea fishes until observations were made during the voyage of the Challenger. The results obtained by the Expedition afford a surer and more extended basis for the knowledge of deep-sea fishes.

The most striking characteristic found in many deep-sea fishes is in relation to the tremendous pressure under which they live. Their osseous and muscular systems are, as compared with the same parts of surface fishes, very feebly developed. The bones have a fibrous, fissured, and cavernous texture, are light, with scarcely any calcareous matter,

[1] An Introduction to the Study of Fishes, Edinburgh, 1880.



MAGELLAN STRAIT
TO
FALKLAND ISLANDS
AND
MONTEVIDEO

Jan^y, Feb^y, 1876.

For explanation of abbreviations &c. see Appendix 1.

Engraved by Malby & Sons.

so that the point of a needle will readily penetrate them without breaking. The bones, especially the vertebræ, appear to be most loosely connected with one another, and it requires the most careful handling to prevent the breaking of the connective ligaments. The muscles, especially the great lateral muscles of the trunk and tail, are thin, the fascicles being readily separated from one another or torn, the connective tissue being extremely loose, feeble, or apparently absent. Some of the deep-sea fishes being most rapacious creatures, must be able to execute rapid and powerful movements in catching and overpowering their prey; and for that object their muscular system, thin as its layers may be, must be as firm, and the chain of the segments of their vertebral column as firmly linked together as in surface fishes. Therefore, it is evident that the change which the body of these fishes has undergone on their withdrawal from the pressure under which they live is a much aggravated form of the affection experienced by persons reaching great altitudes in their ascent of a mountain or in a balloon.

In fishes inhabiting depths of 1000 fathoms or more, the whole muciferous system is dilated, and it is especially the surface of the skull which is occupied by large cavities, while the whole body seems to be covered with a layer of mucus. The physiological use of this secretion is unknown; it has been observed to have phosphorescent properties in perfectly fresh specimens.

The organ of sight is the first to be affected by a sojourn in deep water. In the greatest depths blind fishes occur with rudimentary eyes and without special organs of touch. A very remarkable modification of the eye is found in *Ipnops murrayi* (see p. 239). Whenever a fish has long delicate filaments, developed in connection with the fins or the extremity of the tail, it may be concluded that it is an inhabitant of still water and of quiet habits. Many deep-sea fishes are provided with such filamentous prolongations, the development of which is perfectly in accordance with their sojourn in the absolutely quiet waters of abyssal depths (see *Bathypterois longipes*, p. 217).

Many fishes of the deep sea are provided with more or less numerous, round, shining mother-of-pearl-coloured bodies imbedded in the skin. These so-called phosphorescent or luminous organs are either larger bodies of an oval or irregularly elliptical shape placed on the head, in the vicinity of the eye, or smaller round globular bodies arranged symmetrically in series along the side of the body and tail, especially near the abdominal profile, less frequently along the back (see *Echiostoma micripnus*, p. 412). These organs are all supposed to be producers of light, and they have been observed to be phosphorescent in two species of Sternoptychidæ.

Some of the raptatorial deep-sea fishes have a stomach so distensible and capacious that it can receive a fish of twice or thrice the bulk of the destroyer, as for example *Chiasmodus niger*. Deglutition is performed in them not by means of the muscles of the pharnyx, as in other fishes, but by the independent and alternate action of the jaws.

Before the voyage of H.M.S. Challenger, scarcely thirty deep-sea fishes were known;

this number is now much increased by the discovery of many new species and genera. Modifications of certain organs, perfectly novel, and of the greatest interest were found, but the most important results of this voyage are, that the general character of the abyssal fish-fauna, the abundance of fishes, and the exact depths to which they may descend, have been ascertained. The depths at which the fishes collected by the Challenger were taken cannot be received without some critical examination of each individual species; seeing that no precaution was taken to keep the mouth of the dredge or trawl closed during its descent or ascent, the fishes may have been captured in various strata between the surface and bottom. The Naturalists have simply recorded the greatest depth reached by the dredge or trawl on each occasion, therefore before anything like a division into bathymetrical zones can be attempted, the observations of the Challenger Expedition must be confirmed and supplemented by other series of similar systematic observations. One of the most startling conclusions that would have to be drawn from the Challenger observations, if the greatest depths be taken as those at which the fishes lived, is, that some of the species of deep-sea fishes would range from a depth of some 300 fathoms down to one of 2000 fathoms, or, in other words, that a fish which has once attained that modification of its organisation which will enable it to exist under the pressure of half a ton, can easily accommodate itself to a pressure of two tons or more, a conclusion which requires to be confirmed by other observations.

The greatest depth reached hitherto by a dredge in which fishes were collected is 2900 fathoms. But the specimens thus obtained belong to a species (*Gonostoma microdon*) which seems to be extremely abundant in the upper strata of the Atlantic and Pacific, and were therefore most likely caught by the dredge in its ascent. The next greatest depth, viz., 2750 fathoms, must be accepted as one at which fishes undoubtedly do live; the fish obtained from this depth in the Atlantic, *Bathyophis ferox*, showing by its whole habit that it is a form living on the bottom of the ocean.

The fish fauna of the deep sea is composed chiefly of forms or modifications of forms which are found represented at the surface in the cold and temperate zones, or which appear as nocturnal pelagic forms.

The Chondropterygians are few in number, not descending to a depth of more than 600 fathoms. The Acanthopterygians, which form a majority of the coast and surface faunas, are also scantily represented; genera identical with surface types are confined to the same inconsiderable depths as the Chondropterygians, whilst those Acanthopterygians which are so specialised for the life in the deep sea as to deserve generic separation, range from 200 to 2400 fathoms. Three distinct families of Acanthopterygians belong to the deep-sea fauna, viz., Trachypteridæ, Lophotidæ, and Notacanthidæ. They consist respectively of three, one, and two genera only.

Gadidæ, Ophidiidæ, and Macruridæ are very numerous, ranging through all depths; they constitute about one-fourth of the whole deep-sea fauna.

Of Physostomi, the families of Sternoptychidæ, Scopelidæ, Stomiatidæ, Salmonidæ, Bathythrissidæ, Alepocephalidæ, Halosauridæ, and Murænidæ are represented. Of these the Scopeloids are the most numerous, constituting nearly another fourth of the fauna. Salmonidæ are scarce, with three small genera only. Bathythrissidæ include one species only, which is probably confined in its vertical as well as horizontal range; it occurs at a depth of about 350 fathoms in the Sea of Japan. The Alepocephalidæ and Halosauridæ, known before the Challenger Expedition from isolated examples only, prove to be true, widely-spread, deep-sea types; Eels are well represented, and seem to descend to the greatest depths. *Myxine* has been obtained from a depth of 345 fathoms.

Monte Video.

The Expedition remained at Monte Video ten days, refitting the ship and obtaining the necessary magnetic and other observations, and during this time several members of the Expedition visited Buenos Ayres.

Fitz-Roy's observing station could not be used, as Rat Island was appropriated for quarantine purposes. The surveyors therefore took observations on Point Lobos by the chimney of the pumping engine of the graving dock, and, as the ground thereabouts was rock, they found it to be a very convenient place.

At Point Lobos a fine graving dock was in course of construction, 425 feet in length, 56 feet in breadth, and with 20 feet over the sill at high water (16 at low), which will be sufficiently large for all the Monte Video traffic and trade up the river for some years.

Supplies at this port were plentiful and cheap, beef 2d. to 3d. per lb., sheep 8s. each, potatoes 1d. per lb., coals £2, 10s. per ton. Fruit (especially pears) was also cheap and of excellent quality.

There was at the time of the visit of the Expedition no settled coinage in the Uruguay Republic. The nominal standard was a fictitious dollar with which the coins of other countries are compared. Thus an English sovereign was valued as $4 70 cents, an English florin as only 36 cents, a Peruvian dollar as 80 cents, a French five franc piece 96 cents, and an American eagle $9 66 cents, &c. It was therefore necessary to be acquainted with the value allotted to the different coins here, especially in receiving change.

The Gephyrea.—Professor Emil Selenka, who is engaged in the preparation of a Report on the Gephyrea collected during the Expedition, has forwarded the following note:—

"The number of Gephyrea collected and observed during the Challenger Expedition (including a few from the 'Porcupine' expedition) amounts to about thirty species, which may all be referred to known genera as follows:—

"A new species of *Sternaspis*, *Echiurus unicinctus*, v. Drasche, two species of *Thalassema*, one new, a new *Bonellia*, four new and four previously known species of *Phascolosoma*, *Dendrostoma blandum*, Selenka and de Man, two previously known and three new species of *Phascolion*, two species of the genus *Aspidosiphon*, one of which is new, only two known species of *Phymosoma* and two of the genus *Sipunculus*. There were several forms which it was impossible to determine with certainty, and which will therefore not be described, for they had been much damaged by the dredge; and another form, described as a new genus in the notes of the late Dr. v. Willemoes Suhm, must also be excluded from the descriptions, since the single specimen was quite torn to pieces.

"The Gephyrea of the Challenger Expedition form an interesting contribution to our knowledge of the geographical distribution of this group; a variety of *Phascolosoma vulgare*, Blv., hitherto known only from the Mediterranean and the west coast of France, was discovered by H.M.S. 'Porcupine' to the north of Scotland (I have named it *Phascolosoma vulgare*, var. *astutum*); and the Challenger found a similarly varying form near Kerguelen Island at a depth of 120 fathoms. A new species of this genus (*Phascolosoma flagriferum*) was dredged in the Pacific Ocean and also off the east coast of North America; while several Sipunculids, which have hitherto been known only from shallow water, were obtained from great depths; such was the case, for instance, with *Sipunculus nudus*, Linn."

Monte Video to Ascension.

On the 25th February, at 5 A.M., the vessel left Monte Video for the island of Ascension. A course was shaped first of all for the Tristan da Cunha group, as it was desirable to run a section from Monte Video along the 36th or 37th parallel to those islands to join the section from them to the Cape of Good Hope, after which a meridional section from Tristan da Cunha to Ascension was obtained. In leaving the Rio de la Plata two hauls of the trawl were obtained in 13 and 21 fathoms. The deposits were a blue tenacious mud containing large fragments of Molluscs and plants, and many sandy particles. The trawls contained a large number of *Renilla mülleri*, with Crustaceans, Nemerteans, Annelids, Cephalopods, Molluscs, and a large number of fish, among which were five hitherto undescribed species.

During the passage the wind was at first light and variable to the meridian of 42° W., with the exception of one day when for a few hours a strong S.W. wind was experienced, after which moderately fresh winds from N. to W. were encountered to the meridian of 15° W. Turning up north towards Ascension, a fresh westerly breeze was experienced, which shifted round S. to S.E. and ran the ship into the trade wind, the direction of which was E. to E. by S. The weather on the whole was fine though somewhat cloudy; lightning was common until the vessel was east of the 42nd meridian.

The soundings &c. obtained were divided into two sections—1st, from Monte Video to Tristan da Cunha; 2nd, from Tristan da Cunha to Ascension (see Diagrams 6 and 7).

Between Monte Video and Tristan da Cunha twelve soundings, eleven temperature soundings, and seven trawlings were obtained.

In the western part of the Monte Video–Tristan da Cunha section, the depth varied from 2900 to 2440 fathoms, and in the eastern part from 1715 to 2200 fathoms.

The temperature at the bottom in this section was peculiar. In the western part temperatures of from 32°·3 to 33°·1 were registered, a colder result than any previously obtained except in the immediate neighbourhood of the Antarctic regions. In the eastern or shallower part of the section the bottom temperature varied from 34° to 35°·8. In order to ascertain the exact thickness of this cold stratum, five or six thermometers were on each occasion attached to the sounding line at intervals of 200 fathoms from each other and from the bottom thermometer. From their readings it appears that there is, in the western or deeper part of the section, a stratum of water below the temperature of 33°, the average thickness, or height above the bottom, of which is 400 fathoms. Above 400 fathoms the temperature increases until the isotherm of 35° is reached at an average depth of 600 fathoms from the bottom, an increase of 2° in 200 fathoms. Between the isotherms of 35° and 40° the average distance is 1500 fathoms across the whole section; that is, only a change of 5° per 1500 fathoms.

The surface temperature varied from 73° to 64° across the section.

The serial temperature soundings showed that the isotherm of 40° was on an average 400 fathoms from, and fairly parallel with, the surface, except in the neighbourhood of the coast of South America. The isotherms above 40° were parallel with that isotherm. At Station 333 temperature observations were obtained within a few miles of those previously obtained on the voyage from Bahia to the Cape of Good Hope, in October 1873, at Station 133, and the results at 75 and 100 fathoms were found to be identical on both occasions, notwithstanding a difference of 10° in the temperature of the surface owing to the different seasons in which the observations were made. Below 100 fathoms a good comparison could not be made, as in October 1873 serial temperatures were only obtained to that depth at Station 133, but from a comparison made with the results then registered on each side of that Station, it appears that the calculated results agree fairly well with those actually obtained.

The general direction of the surface current was southeasterly.

In the section from Tristan da Cunha to Ascension, nine soundings, nine serial temperature observations, and four dredgings were obtained.

The soundings in this section show that a ridge extends between Tristan and Ascension Islands separating the deep water of the western part of the South Atlantic from that of the eastern part. The shallowest sounding obtained on this ridge was 1240 fathoms, but it s quite possible that less depths may be found in other places. The deepest cast, 2050 fathoms, was obtained in October 1873, 50 miles north of Tristan Island.

The bottom temperature in this section varied with the depth from 36° at 2050 fathoms to 40°·3 at 425 fathoms. The surface temperature increased from 64° on the 38th parallel to 80° at Ascension.

The serial temperatures showed that the isotherm of 40° occupied a mean depth of 450 fathoms, whilst those of 45°, 50°, and 55° were all lower 200 to 300 miles north of Tristan Island than they were at Ascension.

The general direction of the surface current was W.S.W. 14 miles per day.

The following anemometer observations were taken between Monte Video and Ascension :—

Date. 1876.	Station.	Velocity of Wind in Miles per Hour.	Force of Wind by Beaufort's Scale, as noted in Log.
March 9	331	23	4·5
„ 16	335	20	4·5
„ 24	340	16·5	3·4

The albatross and other southern birds followed the ship till the 16th March when in lat. 32° 24′ S., after which they were not again seen.[1]

In 1900 fathoms, off the mouth of the Rio de la Plata, the deposit was a blue mud containing about 5 per cent. of carbonate of lime, which consisted chiefly of a few shells of pelagic Foraminifera. The six following soundings showed depths ranging between 2650 and 2900 fathoms. In none of these did the deposit contain any carbonate of lime, and no remains of calcareous organisms were observed. The remains of siliceous organisms made up from 15 to 20 per cent. of the deposits. The mineral particles had a mean diameter of 0·1 mm. or less, and consisted of fragments of quartz, plagioclase, augite, grains of magnetite, mica, and a very large number of fragments of pumice and volcanic scoriæ. The fragments making up these deposits appear to have been mostly derived from the Rio de la Plata, whose influence on the deposits could be distinctly traced several hundred miles seawards.

When the depth diminished as the Tristan plateau was reached, the character of

[1] A number of external parasites obtained from *Diomedea exulans* in the South Atlantic and South Pacific Oceans were sent to Mr. W. F. Kirby of the British Museum for determination ; he found the following species among them :— *Docophorus dentatus*, Gieb., Atlantic and Pacific ; *Docophoroides brevis*, Burm., Atlantic and Pacific (a very widely ranging species, and one of the largest of the Mallophaga) ; *Lipeurus clypeatus*, Gieb., Atlantic ; *Nirmus angulicollis*, Gieb., Pacific *Colpocephalum* sp. (?), Atlantic.

the deposits likewise changed. A sounding in 2440 fathoms gave 10 per cent. of carbonate of lime. All the other soundings were on the plateau surrounding Tristan da Cunha, and extending north to the Island of Ascension, and ranged from 2200 to 1240 fathoms. The percentage of carbonate of lime ranged from 66 to 95 per cent., the proportion being greater the less the depth. In depths less than 1500 fathoms the deposits appeared to be very largely, if not mainly, made up of the dead shells of pelagic Molluscs, such as Pteropods, Heteropods, and pelagic Gasteropods, and these deposits have in consequence been called "Pteropod ooze." In depths of 2000 fathoms these shells were almost completely removed from the deposits, which then consisted chiefly of pelagic Foraminifera.

It is not improbable that very much shallower depths occur on this plateau, cones probably rising nearly to the surface, similar to those recently discovered by the telegraph ship "Dacia" off the west coast of Africa. It would have been very interesting had the Expedition had time to take a series of soundings close to the places where the shallowest depths were obtained, as much interest is attached to the deposits forming in shallower water far removed from coasts.

The various trawlings and dredgings were on the whole productive and successful. Those in 1900 and 2650 fathoms off the River Plate yielded a greater number of individuals and species than those in the shallower water in the centre of the Atlantic.

A detailed description is here given of the deposit from 1990 fathoms on this plateau:—

Station 338, 21st March 1876; lat. 21° 15′ S., long. 14° 2′ W.; 1990 fathoms; surface temperature 76°·5, bottom temperature 36°·3.

GLOBIGERINA OOZE, with a reddish tinge when wet, and a slight rose colour when dry, granular, pulverulent.

CARBONATE OF CALCIUM, 90·38 per cent., consists of Coccoliths and Rhabdoliths, pelagic and other Foraminifera, Ostracodes, fragments of Echinoderms and Pteropods.

RESIDUE, 9·62 per cent., colour reddish brown, consists of—

Mineral particles [2·00 per cent.], *m. di.* 0·05 mm., fragments of felspar, hornblende, magnetic particles, and a few small grains of manganese.

Siliceous Organisms [2·00 per cent.], Radiolarians, a few Diatoms, and one or two imperfect casts of Foraminifera.

Fine Washings [5·62 per cent.], argillaceous matter with minute mineral particles and small fragments of Diatoms and Radiolarians.

Remarks.—A dredge was used. The tow-net at the weights did not seem to have touched the bottom, as there was no ooze or undoubted bottom-living organisms in it. The tow-nets attached to the dredge itself each contained a little of the ooze, or rather a large number of pelagic Foraminifera, all dead. These shells were all quite empty and transparent, containing neither sarcode nor clayey matter; *Hastigerina* and *Orbulina* were very numerous, much more so than in the sounding tube or dredge. The dredge contained a very large quantity of a light brown or red coloured ooze, which when dried became white, with a delicate rose tinge. A quantity of this ooze was passed through fine sieves, and the remainder was placed in bottles and brought home for further and more careful examination than could be made on board ship. There remained from the quantity passed through the sieves on board three small pieces of pumice and a few fragments of a Gasteropod shell. The pieces of pumice were about 5 mm. in diameter, rounded, white, areolar, and containing small crystals of sanidine, hornblende, and magnetite. During the cruise it frequently happened that no particles of pumice, of sufficient size to be perfectly determinable, were found in the specimen of a Globigerina ooze brought up in the sounding tube, yet when a large quantity of the ooze was obtained by the dredge or trawl at the same place, and passed through sieves, a few pieces of pumice were obtained, as in this instance. It is important to bear this fact in mind when judging of the role played by pumice in the formation of deep-sea deposits.

In the examination of the large quantity of this ooze brought home the following organisms were observed :—

Fragments of Echinoderms, Ostracodes (*Cythere dictyon* and *Cythere dasyderma*), a small Lamellibranch, a fragment of a Polyzoon, otoliths and small teeth of fish, fragments of *Lepas* valves, fragments of Pteropods and Heteropods (*Hyalea*, *Cleodora*, *Cuvieria*, and *Atlanta*), Rhabdoliths and Coccoliths, a few Radiolarians, a few Sponge spicules, one or two fragments of Diatoms (?), and the following Foraminifera :—

Biloculina depressa.
Spiroloculina tenuis.
Miliolina seminulum.
Hyperammina vagans.
Reophax scorpiurus.
Thurammina papillata.
Cyclammina cancellata.
Verneuilina pygmæa.
Virgulina schreibersiana.
Lagena globosa.
Lagena gracilis.
Lagena lævigata.
Lagena lævis.
Lagena lagenoides.
Lagena lagenoides var. *tenuistriata.*
Lagena lucida.
Lagena seminiformis.
Lagena squamosa.
Lagena striata.
Nodosaria calomorpha.
Cristellaria obtusata.
Cristellaria rotulata.
Polymorphina angusta.
Polymorphina lactea.
Polymorphina longicollis.
Globigerina æquilateralis.
Globigerina bulloides.
Globigerina conglobata.
Globigerina digitata.
Globigerina dubia.
Globigerina helicina.
Globigerina inflata.
Globigerina rubra.
Globigerina sacculifera.
Orbulina universa.
Hastigerina pelagica.
Pullenia obliquiloculata.
Sphæroidina dehiscens.
Candeina nitida.
Truncatulina haidingerii.
Truncatulina wuellerstorfi.
Pulvinulina menardii.
Pulvinulina micheliniana.
Pulvinulina patagonica.
Pulvinulina pauperata.
Pulvinulina tumida.
Rotalia soldanii.
Nonionina umbilicatula.

This deposit is one of the purest Globigerina oozes obtained during the cruise, and is almost wholly composed of the dead shells of surface organisms. The carbonate of lime present is estimated to be made up as follows :—

Pelagic Foraminifera,	65·00	per cent.
Pelagic Mollusca,	2·00	„
Coccoliths and Rhabdoliths,	15·00	„
Fragments of Echinids, Ostracodes, Polyzoa, otoliths, teeth, valves of *Lepas*, fragments of bottom-living Mollusca and bottom-living Foraminifera,	8·38	„
	90·38	per cent.

The bottom-living Foraminifera do not appear to make up more than 1 per cent. of this deposit. The great majority of the finest portions are made up of Coccoliths, Rhabdoliths, primordial chambers and very young specimens of pelagic Foraminifera.

On comparing this deposit with one nearer the Equator it is noticed that the majority of the shells of pelagic Foraminifera are much smaller and thinner shelled in the former than in the latter, the younger specimens are much more numerous, and the predominating species are also different. The same remarks hold good for the specimens taken on the surface.

More than two litres of this ooze were dissolved in hydrochloric acid, and in this way a relatively large quantity of the residue was obtained. The magnetic particles were in the first place extracted by means of a magnet; the larger mineral particles and siliceous organisms were afterwards separated by decantation. The mineral particles and siliceous organisms thus obtained formed but a small portion of the residue, the greater part of which consisted of what are denominated "fine washings" (see Pl. N, fig. 5).

These fine washings are deep brown or maroon in colour, greasy, and do not contain particles sensible to the touch. The material is but slightly plastic, when dried it becomes yellowish brown, forming lumps which break easily and absorb water quickly without breaking up; the streak is lustrous. It reddens with heat, and melts easily before the blow-pipe into shining beads, which are black and magnetic. These globules examined by the microscope appear as a brownish glass, filled with gas cavities. Some of these characters apply to what is usually called a clay, but some of the properties, especially the pyrognostic properties, show that it is not a pure clay, but a mixture of different materials. An examination of the wet preparations of these fine washings with a power of 450 diameters shows that they are composed of an amorphous matter, fragments of minerals and rocks, the remains of siliceous organisms, and of colouring substances.

The amorphous matter, which may be considered as properly the argillaceous matter, presents characters essentially vague. It appears as a colloid substance without definite contours, generally colourless, perfectly isotropic, and forms a mass which agglutinates and connects the other particles of the washings. As these physical characters are very indefinite it is difficult to estimate, even approximately, the quantity present in a deposit. However, it augments in proportion as the deposit becomes more clayey, but only a small quantity of this substance is necessary to give a clayey character to a deposit. That which predominates in this fundamental base, are irregular fragments of minerals, vitreous rocks, and remains of siliceous organisms. These particles probably make up about 50 per cent. of the whole mass, and this large percentage of foreign matters must necessarily mask the character of the clayey matter in which they are imbedded.

The mineral particles are seldom larger than 0·01 mm. in diameter, but descend from this size to the merest specks. It is impossible on account of their size to say to what mineral species they belong, their thickness not being sufficient to be distinguished by polarised light, their outlines too irregular, and all special coloration having likewise disappeared. All that can reasonably be said is that these minute mineral particles probably belong to the same species as the larger particles in the same deposit, such as felspar, hornblende, magnetite. In the case of the pumice and siliceous organisms the fragments can be recognised when of a much less size than in the case of the above minerals. Here the structure and fracture of the pumice, and form and markings of the organisms, enable very minute particles to be detected. However, some particles of pumice are so small as to have lost entirely their fibrous structure, the bulbs of air, and the peculiar fracture with frequent semicircular contours, and are therefore indistinguishable from the minute fragments of minerals which are likewise isotropic. In the same way extremely minute fragments of siliceous organisms cannot be distinguished from minerals and pumice fragments of about the same size.

The colouring substances are the hydrated oxides of iron and manganese. The former is scattered through all the mass in a state of very fine division. In some points, however, it is more localised, the argillaceous matter appearing with a brown tinge, but these spots are noticed gradually to disappear in the surrounding mass. The coloration given by the manganese is much more distinct. There are small, rounded, brown-coloured spots, with a diameter of less than 0·01 mm., which disappear under the action of hydrochloric acid with disengagement of chlorine. Among the magnetic particles, which consisted of small fragments of magnetite and small spherules, there was one spherule of bronzite (see p. 812).

The mineral particles collected after dissolving away a very large quantity of the ooze were the same as to size and species as those indicated in the description of the deposit. A quantity of the ooze was taken from the dredge, and divided into three portions by decantations. The finest portion gave 88·15 per cent. of carbonate of lime, the second gave 98·84 per cent., and the third 98·56 per cent. The finest portion consisted chiefly of Coccoliths, Rhabdoliths, primordial chambers of Foraminifera, and amorphous clayey and calcareous particles, thus showing that most of the clayey matter passed away with the finest matter. The second contained the smaller and the third the larger Foraminifera. This difference in the quantity of carbonate of lime in the decantations shows how two samples of the same ooze may vary when it is allowed to settle after being shaken by carriage in bottles or by the action of the dredge or trawl during collection. For these reasons an average sample of the deposit was generally carefully selected for analysis, and this has usually been taken from the specimen obtained in the sounding tube, where this sorting is much less likely to have taken place.

The following analysis by Professor Brazier is from an average sample from the dredge :—

Loss on ignition after washing and drying at 230° F.,		1·40
Portion soluble in Hydrochloric Acid = 97·11, =	Alumina,	0·65
	Ferric Oxide,	0·60
	Calcium Phosphate,	0·90
	Manganese Oxide,	trace
	Calcium Sulphate,	0·19
	Calcium Carbonate,	92·54
	Magnesium Carbonate,	0·87
	Silica,	1·36
Portion insoluble in Hydrochloric Acid = 1·49, =	Consisting of Alumina and Ferric Oxide, with Silica,	1·49
		100·00

It will be seen that this deposit has a high percentage of carbonate of calcium, and a small residue. The slightly higher percentage of the carbonate of lime in this analysis than that given above (90·38) may be owing partly to the sorting of the materials of the ooze, and partly to the prolonged action of the hydrochloric acid in the complete analysis.

On Deep-Sea Deposits in General.—The foregoing example will serve to show the method adopted by Messrs. Murray and Renard in the examination of the deep-sea deposits. The description commences by indicating the kind of deposit (red clay, blue mud, Globigerina ooze, &c.), with the macroscopic characters when wet or dry. When a complete chemical analysis has not been made the amount of carbonate of calcium has always been determined.

This determination was generally made by estimating the carbonic acid; a gramme of a mean sample of the substance was taken for this purpose, using dilute and cold hydrochloric acid. However, as the deposits often contain carbonates of magnesia and iron as well, the results calculated by associating the carbonic acid with the lime are not perfectly exact, but these carbonates of magnesia and iron are almost always in very small proportion, and the process is sufficiently accurate, for, owing to the sorting of the elements which goes on during collection and carriage, no two samples from the same Station give exactly the same percentage. The number which follows the words "carbonate of calcium" indicates the percentage of $CaCO_3$; the general designations of the principal calcareous organisms in the deposit are then given.

The part insoluble in the hydrochloric acid, after the determination of the carbonic acid, is designated "residue." The number placed after this word indicates its percentage in the deposit; then follow the colour and principal physical properties. This residue is washed and submitted to decantations, which separate the several constituents according to their density into three groups—(1) *Minerals,* (2) *Siliceous Organisms,* (3) *Fine Washings.*

1. *Minerals.*—The number within brackets indicates the percentage of particular minerals and fragments of rocks, and is the result of an approximate evaluation. As it is important to know the dimensions of the grains of minerals which constitute the deposit, their mean diameter in millimetres is given after the contraction *m. di.*; then the species of minerals and rocks are enumerated. In this enumeration the minerals are placed in the order of the importance of the role which they play in the deposit. The specific determinations have been made with the mineralogical microscope in parallel or convergent polarised light.

2. *Siliceous Organisms.*—The number between brackets indicates the percentage of siliceous organic remains which, as in the case of the minerals, is an approximate evaluation. Under this heading the glauconitic casts of the Foraminifera and other calcareous organisms are also placed.

3. *Fine Washings.*—The particles which, resting in suspension, pass with the first decantation, are thus designated. The number within brackets which follows the words "fine washings" is obtained in the same manner as those placed after "minerals" and "siliceous organisms." The "fine washings" are fully described above (see pp. 913, 914).

The various kinds of deposits referred to in the descriptions of the deposits throughout this volume have been arranged as follows by Messrs. Murray and Renard:—

Terrigenous deposits.	Shore formations, Blue mud, Green mud and sand, Red mud,	Found in inland seas and along the shores of continents.
	Volcanic mud and sand, Coral mud and sand, Coralline mud and sand,	Found around oceanic islands and along the shores of continents.
Abysmal deposits.	Globigerina ooze, Pteropod ooze, Diatom ooze, Radiolarian ooze, Red clay,	Found in the abysmal regions of the ocean basins.

The *shore formations* which are being laid down on the coast or in very shallow water need not be here referred to, as they were somewhat carefully described prior to the recent deep-sea explorations, but very little attention had been paid to deposits of the same order, and largely of the same origin, which differ from the sands and gravels of the shores and shallow waters only by a lesser size of the grains, and by the fact that they are laid down in deeper water and at a greater distance from the land. These are termed terrigenous deposits, and their chief characteristics may be pointed out.

Blue Mud is the most extensive deposit now forming around the great continents and continental islands, and in all enclosed or partially enclosed seas. It is characterised by a slaty colour which passes in most cases into a thin layer of a reddish colour at the upper surface. These deposits are coloured blue by organic matter in a state of decomposition, or by iron pyrites finely divided, and frequently give off an odour of sulphuretted hydrogen. When dried, a blue mud is greyish in colour, and rarely or never has the plasticity and compactness of a true clay. It is finely granular, and occasionally contains fragments of rocks 2 centimetres in diameter; generally, however, the minerals, which are derived from the continents and are found mixed up with the muddy matter in these deposits, have a diameter of 0·5 mm. and less. Quartz particles, often rounded, play the principal part, next come mica, felspar, augite, hornblende, and all the mineral species derived from the disintegration of the neighbouring lands, or the lands traversed by rivers which enter the sea near the place where the specimens have been collected. These minerals make up the principal and characteristic portion of blue muds, sometimes forming 80 per cent. of the whole deposit. Glauconite, though generally present, is never abundant in blue mud. The remains of calcareous organisms are at times quite absent, but occasionally they form over 50 per cent.; the latter is the case when the specimen is taken at a considerable distance from the coast and at a moderate depth, less than 1500 fathoms. These calcareous fragments consist of bottom-living and pelagic Foraminifera, Molluscs, Polyzoa, *Serpulæ*, Echinoderms, Alcyonarian spicules, Corals, &c. The remains of Diatoms and Radiolarians are usually present. Generally speaking, as the land is approached the pelagic organisms disappear, and on the contrary, proceeding seawards the size of the mineral grains diminishes, and the remains of shore and coast organisms give place to pelagic ones, till finally a blue mud passes into a true deep-sea deposit. In those regions of the ocean affected by floating ice the colour of these deposits becomes grey rather than blue at great distances from land, and is further modified by the presence of a greater or less abundance of glaciated blocks and fragments of quartz.

Green Muds and Sands.—As regards their origin, composition, and distribution near the shores of continental land, these muds and sands resemble the blue muds, and are largely composed of argillaceous matter and mineral particles of the same size and nature. Their chief characteristic is the presence of a considerable quantity of glauconitic grains, either isolated or united into concretions, which last are very frequently phosphatic. In the latter case the grains are cemented together by a brown argillaceous matter, and include besides quartz, felspars, phosphate of lime, and other minerals, more or less altered. The Foraminifera and fragments of Echinoderms and other organisms in these muds are frequently filled with glauconitic substance, and beautiful casts of these organisms remain after treatment with dilute acid. At times there are few calcareous organisms in these deposits, and at other times the remains of Diatoms and Radiolarians are abundant. When dried these muds become earthy and of a grey-green colour, and they frequently give out a sulphuretted hydrogen odour. The green sands differ from the muds only in the comparative absence of the argillaceous and other amorphous matter, and by the more important part played by the grains of glauconite, to which the green colour is chiefly due, although it appears sometimes to be due to the presence of organic matter, probably of vegetable origin, and to the reduction of peroxide of iron to protoxide under its influence.

Red Muds.—In some localities, as for instance off the Brazilian coast of America, the deposits differ from blue muds by the large quantity of ochreous matter brought down by the rivers and deposited along the coast; the ferruginous particles when mixed up with the argillaceous matter give the whole deposit a reddish colour. These deposits, which are very rich in limonite, do not appear to contain any traces of glauconite, and have relatively few remains of siliceous organisms.

Volcanic Muds and Sands.—The muds and sands around volcanic islands are black or grey; when dried they are rarely coherent. The mineral particles are generally fragmentary, and consist of lapilli of the basic and acid series of modern volcanic rocks, which are scoriaceous or compact, vitreous or crystalline, and usually present traces of alteration. The minerals are sometimes isolated, sometimes surrounded by their matrix, and consist principally of plagioclases, sanidine, amphibole, pyroxene, biotite, olivine, and magnetic iron; the size of the particles diminishes with distance from the shore, but the mean diameter is generally 0·5 mm. Glauconite does not appear to be present in these deposits, and quartz is also very rare or absent. The fragments of shells and rocks are frequently covered with a coating of peroxide of manganese. Shells of calcareous organisms are often present in great abundance, rendering the deposit of a lighter colour, and the remains of Diatoms and Radiolarians are usually present.

Coral Muds and Sands.—These muds frequently contain as much as 95 per cent. of carbonate of lime, which consists of fragments of Corals, calcareous Algæ, Foraminifera, *Serpulæ*, Molluscs, and remains of other lime-secreting organisms. There is a large amount of amorphous calcareous matter, which gives the deposit a sticky and chalky character. The particles may be of all sizes according to the distance from the reefs, the mean diameter being 1 to 2 mm., but occasionally there are large blocks of coral and large calcareous concretions; the particles are white and red. Remains of siliceous organisms seldom make up over 2 or 3 per cent. of a typical coral mud. The residue consists usually of a small amount of argillaceous matter, with a few fragments of felspar and other volcanic minerals, but off barrier and fringing reefs facing continents there may be a great variety of rocks and minerals. Beyond a depth of 1000 fathoms off coral islands the débris of the reefs begins to diminish, and the remains of pelagic organisms to increase; the deposit becomes more argillaceous, of a reddish or rose colour, and gradually passes into a Globigerina ooze or a red clay. Coral sands contain much less amorphous matter than coral muds, but in other respects they are similar, the sands being usually found nearer the reefs and in shallower water than the muds, except inside lagoons. In some regions the remains of calcareous algæ predominate, and in these cases the name *coralline mud* or *sand* is employed to point out the distinction. These deposits have a much greater resemblance to the White Chalk than has a Globigerina ooze.

Beyond an average distance of about 200 miles from land, the deposits are characterised by the great abundance of fragmentary volcanic materials which have usually undergone great alteration, and by the enormous abundance of the shells and skeletons of minute pelagic organisms which have fallen to the bottom from the surface waters. These true deep-sea or abysmal deposits may be divided into those in which the organic elements predominate, and those in which the mineral constituents play the chief part.

Globigerina Ooze.—Thus are designated all those truly pelagic deposits containing over 40 per cent. of carbonate of lime, which consists principally of the dead shells of pelagic Foraminifera—*Globigerina*, *Orbulina*, *Pulvinulina*, *Pullenia*, *Sphæroidina*, &c.; in the tropics some of the Foraminifera shells are visible to the naked eye. In some localities this deposit contains 95 per cent. of carbonate of lime. The colour is milky white, yellow, brown, or rose, these variations depending principally on the relative abundance in the deposit of the oxides of iron and manganese. This ooze is fine grained; when dried it is pulverulent. Analysis shows that the sediment contains, in addition to carbonate of lime, phosphate and sulphate of lime, carbonate of magnesia, oxides of iron and manganese, and argillaceous matters. The residue is of a reddish brown tinge. Lapilli, pumice, and glassy fragments, often altered into palagonite, seem always to be present, and are frequently very abundant. The mineral particles are generally angular, and rarely exceed 0·08 mm. in diameter; monoclinic and triclinic felspars, augite, olivine, hornblende, and magnetite are the most frequent. When quartz is present, it is in the form of minute, rounded, probably wind-borne grains, often partially covered with oxide of iron. More rarely white and black mica, bronzite, actinolite, chromite, glauconite, and cosmic dust are found. Siliceous organisms are probably never absent, sometimes forming 20 per cent. of the deposit, at other times they are only recognisable after careful microscopic examination. In some regions the frustules of Diatoms predominate, in others the skeletons of Radiolarians.

Pteropod Ooze.—This deposit differs in no way from a Globigerina ooze except in the presence of a greater number and variety of pelagic organisms, and especially in the presence of Pteropod and Heteropod shells, such as *Diacria*, *Atlanta*, *Styliola*, *Carinaria*.

The shells of the more delicate species, and young shells of pelagic Foraminifera, are also more abundant in these deposits than in a Globigerina ooze. It must be remembered that the name "Pteropod ooze" is not intended to indicate that the deposit is chiefly composed of the shells of these Molluscs, but, as their presence in any great abundance in a deposit is characteristic and has an important bearing on geographical and bathymetrical distribution, it is desirable to emphasise the fact. It may here be pointed out that there is a very considerable difference between a Globigerina ooze or a Pteropod ooze situated near continental shores, and deposits bearing the same names situated towards the centre of oceanic areas, both with respect to the general character of the mineral particles and the variety of the remains of organisms.

Diatom Ooze.—This ooze is of a pale straw colour, and is composed principally of the frustules of Diatoms. When dry it is a dirty white siliceous flour, soft to the touch, taking the impression of the fingers, and contains gritty particles which can be recognised by the touch. It contains on an average about 25 per cent. of carbonate of lime, in the form of small *Globigerina* shells, fragments of Echinoderms, and other organisms. The residue is pale white and slightly plastic; minerals and fragments of rocks are in some cases abundant; these are volcanic, or, more frequently, fragments and minerals coming from continental rocks and transported by glaciers. The fine washings consist essentially of particles of Diatoms along with argillaceous and other amorphous matter. It is estimated that the frustules of Diatoms and skeletons of siliceous organisms make up more than 50 per cent. of this deposit.

Radiolarian Ooze.—It was stated, when describing a Globigerina ooze, that Radiolarians were seldom, if ever, quite absent from marine deposits. In some regions they make up a considerable portion of a Globigerina ooze, and are also found in Diatom ooze and in the terrigenous deposits of the deeper water surrounding the land. In some regions of the Pacific, the skeletons of these organisms make up the principal part of the deposits, and these have been named "Radiolarian ooze." The colour is reddish or deep brown, due to the presence of the oxides of iron and manganese. The mineral particles consist of fragments of pumice, lapilli, and volcanic minerals, rarely exceeding 0·07 mm. in diameter. There is not a trace of carbonate of lime in the form of shells in some samples of Radiolarian ooze, but other specimens contain 20 per cent. derived from the shells of pelagic Foraminifera. The clayey matter and mineral particles in this ooze are the same as those found in the red clays.

Red Clay.—Of all the deep-sea deposits this is the one which is distributed over the largest areas in the modern oceans. It might be said that it exists everywhere in the abysmal regions of the ocean basins, for the residue in the organic deposits (Globigerina, Pteropod, and Radiolarian oozes) is neither more nor less than red clay. However, this deposit only appears in its characteristic form in those areas where the terrigenous minerals and calcareous and siliceous organisms disappear to a greater or less extent from the bottom. It is in the central regions of the Pacific that the typical examples are met with. Like other marine deposits, this one passes laterally, according to position and depth, into the adjacent kinds of deep-sea ooze or mud.

The argillaceous matters are of a more or less deep brown tint from the presence of the oxides of iron and manganese. In the typical examples no mineralogical species can be distinguished by the naked eye, for the grains are exceedingly fine and of nearly uniform dimensions, rarely exceeding 0·05 mm. in diameter. It is plastic and greasy to the touch; when dried it coagulates into lumps so coherent that considerable force must be employed to break them. It gives the brilliant streak of clay, and breaks down in water. The pyrognostic properties show that it is not a pure clay, for it fuses easily before the blow-pipe into a magnetic bead.

Under the term red clay are comprised those deposits which do not conspicuously exhibit the characters of clay, but are mainly composed of minute particles of pumice and other volcanic materials that have not undergone great alteration owing to their relatively recent deposition. If the analyses of red clay be calculated, it will be seen, moreover, that the silicate of alumina present as clay ($2SiO_2,Al_2O_3+2H_2O$) comprises only a relatively small portion of the sediment; the calculation shows always an excess of free silica, which is attributed chiefly to the presence of siliceous organisms.

Microscopic examination shows that a red clay consists of argillaceous matter, minute mineral particles, and fragments of siliceous organisms; in a word, it is in nearly all respects identical with the residue of the organic oozes. The mineral particles are for the greater part of volcanic origin, except in those cases where continental matters are transported by floating ice, or where the sand of deserts has been carried to great distances by winds. These volcanic minerals are the same constituent minerals of modern cruptive rocks, enumerated in the description of volcanic muds and sands; in the great majority of cases they are accompanied by fragments of lapilli and of pumice more or less altered. Vitreous volcanic matters belonging to the acid and basic series of rocks predominate in the regions where the red clay has its greatest development, and the most characteristic decompositions which there take place are associated with pyroxenic lavas.

Calcareous organisms are so generally absent in the red clay that they cannot be regarded as characteristic; when present they are chiefly the shells of pelagic Foraminifera, and are usually met with in greater numbers in the surface layers of the deposit, to which they give a lighter colour. On the other hand, the remains of Diatoms, Radiolarians, and Sponge spicules are generally present, and are sometimes very abundant.

The description of the fine washings of a Globigerina ooze (pp. 913, 914) applies in all respects to the finer parts of a typical red clay. The bones of Cetaceans, Sharks' teeth, cosmic dust, manganese nodules, and zeolites, associated together in typical red clays, are referred to on p. 807.

Messrs. Murray and Renard arrive at the following conclusions as the result of their investigations of the deep-sea deposits :—" Muds and sands are situated at various depths at no great distance from the land, while the organic oozes and red clays occupy the abysmal regions of the ocean basins far from land. Leaving out of view the coral and volcanic muds and sands which are found principally around oceanic islands, blue muds, green muds and sands, and red muds, together with all the coast and shore formations, are situated along the margins of the continents and in enclosed and partially enclosed seas. The chief characteristic of these deposits is the presence in them of continental débris. The blue muds are found in all the deeper parts of the regions just indicated, and typically near the embouchures of rivers. Red muds do not differ much from blue muds except in colour, due to the presence of ferruginous matter in great abundance, and occur under the same conditions as the blue muds. The green muds and sands occupy, as a rule, portions of the coast where detrital matter from rivers is not apparently accumulating at a rapid rate, viz., on such places as the Agulhas Bank, off the east coast of Australia, off the coast of Spain, and at various points along the coast of America.

" The region occupied by terrigenous deposits extends from high water mark down, it may be, to a depth of over four miles, and in a horizontal direction from 60 to perhaps 200 miles seawards, and includes all inland seas, such as the North Sea, Norwegian Sea, Mediterranean Sea, Red Sea, China Sea, Japan Sea, Caribbean Sea, and many others. It is the region of change and of variety with respect to light, temperature, motion, and biological conditions. In the surface waters the temperature ranges from 80° in the tropics to 28° in the polar regions. Below the surface, down to the ice-cold water found in some places at the lower limits of the region in the deep sea, there is in the tropics an equally great range of temperature. Plants and animals are abundant near the shore, and animals extend in relatively great abundance down to the lower limits of this region, which is now covered by these terrigenous deposits. The specific gravity of the water varies much, owing to mixture with river water or great local evaporation, and this variation in its turn affects the fauna and flora. In the terrigenous region tides and currents produce their maximum effect, and these influences can in some instances be traced to a depth of 300 fathoms, or nearly 2000 feet. The upper or continental margin of the region is clearly defined by the high water mark of the coast line, which is constantly changing through breaker action, elevation, and subsidence. The lower or abysmal margin is less clearly marked out; it passes in most cases insensibly into the abysmal region, but may be regarded as ending when the mineral particles from the neighbouring continents begin to disappear from the deposits, which then pass into an organic ooze or a red clay.

" A Pteropod ooze is met with in tropical and subtropical regions in depths less than 1500 fathoms and a Globigerina ooze in the same regions between the depths of 500 and 2800 fathoms. These two deposits occupy about 110° of latitude between the two polar zones, at depths where the action of the waves is not felt, and in areas to which the terrigenous materials are rarely transported, forming vast accumulations of *Globigerina* and other pelagic Foraminifera, Coccoliths, Rhabdoliths, shells of pelagic Molluscs, and remains of other organisms. These deposits may perhaps be called the sediments of median depths and of warmer zones, because they diminish in great depths and tend to disappear towards the poles. This fact is evidently in relation with the surface temperature of the ocean, and shows that pelagic Foraminifera and Molluscs live chiefly in the warm superficial waters of the sea, whence their dead shells fall to the bottom. Globigerina ooze is not found in enclosed seas nor in polar latitudes. In the southern hemisphere it has not been met with beyond the 50th parallel. In the Atlantic it is deposited upon the bottom at a very high latitude below the warm waters of the Gulf Stream, but is not observed under the cold descending polar current which runs south in the same latitude. These facts are readily explained, when it is remembered that this ooze is formed chiefly by the shells of surface organisms, which require an elevated temperature and a wide expanse of sea. But as long as the conditions of the surface are the same, one would expect the deposits at the bottom also to remain the same; such is not the case. Globigerina ooze is rarely found in the tropical zone at depths exceeding 2400 fathoms; when depths of 3000 fathoms are explored in this zone of the Atlantic and Pacific, there is found an argillaceous deposit without, in many instances, any trace of calcareous organisms. In descending from the "submarine plateaux" to depths which exceed 2250 fathoms, the Globigerina ooze gradually disappears, passing into a greyish marl, and finally is wholly replaced by an argillaceous material which covers the bottom at all depths greater than 2900 fathoms.

The transition between the calcareous formations and the argillaceous ones takes place by almost insensible degrees. The thinner and more delicate shells disappear first. The thicker and larger shells lose little by little the sharpness of their contours, and appear to undergo a profound alteration; they assume a brownish colour, and break up in proportion as the calcareous constituent disappears. The red clay predominates more and more as the calcareous element diminishes in the deposit.

It has been noted that when the sounding rod brings up a graduated series of sediments from a declivity descending into deep water, among the calcareous shells those of the Pteropods and Heteropods disappear first in proportion as the depth increases. At depths less than 1400 fathoms in the tropics a Pteropod ooze is found with abundant remains of Heteropods and Pteropods; deeper soundings then give a Globigerina ooze without these Molluscan remains; and in still greater depths, as before mentioned, there is a red clay in which calcareous organisms are nearly, if not quite, absent. At first it would be expected that the Foraminiferal shells, being smaller, would disappear from a deposit before the Pteropod shells; but if it be remembered that the latter are very thin and delicate, and, for the quantity of carbonate of lime present, offer a larger surface to the action of the solvent than the thicker though smaller, Globigerina shells, this apparent anomaly will be explained. The agent concerned in the removal of these calcareous shells is believed to be sea water itself, and the carbonic acid dissolved in it. This question is discussed in Chapter XXII. (see p. 981).

"The action which suffices to dissolve the calcareous matter has little or no effect upon the silica, and so the siliceous shells accumulate and form a Radiolarian ooze in the central portions of the Pacific. A Diatom ooze has been found only in the Southern Ocean south of lat. 45° S.

"Red clay may be found anywhere within lats. 45° N. and S., and at depths greater than 2200 fathoms. It passes at its margins into the organic calcareous or siliceous oozes, found in the lesser depths of the abysmal regions, or into the terrigenous deposits. In its typical form the red clay occupies a larger area than any of the other true deep-sea deposits, covering the bottom in vast regions of the North and South Pacific, Atlantic, and Indian Oceans. As above remarked, this clay may be said to be universally distributed over the floor of the oceanic basins; but it only appears as a characteristic deposit at points where the siliceous and calcareous organisms do not conceal its proper characters.

"The abysmal region in which occur the organic oozes and red clay consists of vast undulating plains from two to five miles beneath the surface of the sea, the average being about three miles, here and there interrupted by huge volcanic cones (the oceanic islands). No sunlight ever reaches these deep cold tracts; the range of temperature over them is not more than 7°, viz., from 31° to 38°, and is apparently constant throughout the whole year in each locality. Plant life is absent, and although animals belonging to all the great invertebrate types are present, there is no great variety of form nor abundance of individuals. Change of any kind is exceedingly slow.

"The abysmal region occupied by the organic oozes and red clay is estimated to occupy about three-eighths of the earth's surface, or an area equal to that of the continents, while the region between the abysmal areas and the continents,—that covered by the terrigenous deposits, is estimated to occupy the remaining two-eighths of the surface of the globe.

"The terrigenous deposits of lakes, shallow seas, enclosed seas, and the shores of the continents, reveal the equivalents of chalks, green sands, sandstones, conglomerates, shales, marls, and other sedimentary formations. Such formations as certain Tertiary deposits of Italy, Radiolarian earth from Barbados, and portions of the Chalk where pelagic conditions are indicated, must be regarded as having been laid down rather along the border of a continent than in a true oceanic area. The argillaceous and calcareous rocks, recently discovered by Dr. Guppy, in the upraised coral islands in the Solomon group, are nearly identical with the volcanic muds, the Pteropod and Globigerina oozes of the Pacific are, however, also represented.

" Regions situated similarly to enclosed and shallow seas and the borders of the present continents appear to have been, throughout all geological ages, the theatre of the greatest and most remarkable changes; in short, all, or nearly all, the sedimentary rocks of the continents would seem to have been built up in areas like those now occupied by the terrigenous deposits. During each era of the earth's history, the borders of some lands have sunk beneath the sea and been covered by marine sediments; while in other parts the terrigenous deposits have been elevated into dry land, and have carried with them a record of the organisms which flourished in the sea of the time. In this transitional or critical area there has been throughout a continuity of geological and biological phenomena.

" The small extent occupied by littoral formations, especially those of an arenaceous nature, shown by deep-sea investigations, is important. In the present state of things there does not appear to be anything to account for the enormous thickness of the clastic sediments making up certain geological formations, unless the exceptional cases of erosion which are brought into play when a coast is undergoing constant elevation or subsidence are taken into consideration. Great movements of the land are doubtless necessary for the formation of thick beds of transported matter like sandstones and conlomerates.

"The débris carried away from the land accumulates at the bottom of the sea before reaching the abysmal regions of the ocean. It is only in exceptional cases that the finest terrigenous materials are transported several hundred miles from the shores. In place of layers formed of pebbles and clastic elements with grains of considerable dimensions, which play so large a part in the composition of emerged lands, the great areas of the ocean basins are covered by the microscopic remains of pelagic organisms, or by the deposits resulting from the alteration of volcanic products. The distinctive elements that appear in the river and coast sediments are, properly speaking, wanting in the great depths far distant from the coasts. To such a degree is this the case that in a great number of soundings, from the centre of the Pacific for example, mineral particles on which the mechanical action of water has left its imprint cannot be distinguished, and quartz is so rare that it may be said to be absent. It is sufficient to indicate these facts in order to make apparent the profound differences which separate the deposits of the abysmal areas of the ocean basins from the series of rocks in the geological formations.

"The continental geological formations, when compared with marine deposits of modern seas and oceans, appear to present no analogues to the red clays, Radiolarian, Globigerina, Pteropod, and Diatom oozes. If it do not follow from this that deep and extended oceans like those of the present day cannot formerly have occupied the areas of the present continents, and as a corollary that the great lines of the ocean basins and continents must have been marked out from the earliest geological ages, it is, nevertheless, a fact, proved by the evidence derived from a study of the pelagic sediments, that these areas are of extreme antiquity. It is indeed almost beyond question that the red clay regions of the Central Pacific contain accumulations belonging to geological ages different from the present. In order to account for the accumulation of all these substances in such relatively great adundance in the areas where they were dredged, it is necessary to suppose the oceanic basins to have remained the same for a vast period of time."

Explanation of Plate N.

Fig. 1. Diatom ooze seen by transmitted light. Lat. 53° 55′ S., long. 108° 35′ E.; 1950 fathoms; $\frac{200}{1}$.

Fig. 2. Radiolarian ooze seen by transmitted light. Lat. 11° 24′ N., long. 143° 16′ E.; 4475 fathoms; $\frac{100}{1}$.

Fig. 3. The finer portions of a Globigerina ooze, showing Coccospheres, Coccoliths, and Rhabdoliths. Lat. 38° 50′ S., long. 169° 20′ E.; 275 fathoms; $\frac{500}{1}$.

Fig. 4. The finer portions of a Globigerina ooze, showing Coccoliths and Rhabdoliths. Lat. 21° 15′ S., long. 14° 2′ W.; 1990 fathoms; $\frac{1500}{1}$.

Fig. 5. "Fine washings" of a Globigerina ooze after removal of the carbonate of lime by dilute hydrochloric acid, formed of exceedingly minute particles of argillaceous matter, along with fragments of organisms and minerals, coloured brown by oxide of iron and manganese. The drawing shows the ordinary characters of the "fine washings," which are nearly identical with the great mass of the red clay. Lat. 21° 15′ S., long. 14° 2′ W.; 1990 fathoms; $\frac{1500}{1}$.

Fig. 6. Ordinary characters of the minerals in a deep-sea deposit. All are of volcanic origin, being volcanic ashes, microscopic fragments of pumice, and vitreous fragments transformed into palagonite. Associated with these are fragments of felspars and augite. Lat. 27° 54′ S., long. 13° 13′ W.; 1890 fathoms; $\frac{220}{1}$.

Fig. 7. Glauconitic casts of Foraminifera and other organisms from a green mud seen by reflected light, after removal of the carbonate of lime in the deposit by dilute hydrochloric acid. East coast of Australia; 410 fathoms; $\frac{35}{1}$.

Fig. 8. The ordinary characters of the mineral particles of a terrigenous deposit; rounded fragments of quartz predominate, being sometimes coated with limonite; there are besides fragments of glauconite, felspars, and other minerals. Compared with fig. 6, the differences between the mineral particles in a deep-sea and a terrigenous deposit will be observed. Blue mud, coast of Scotland; 540 fathoms; $\frac{20}{1}$.

Fig. 9. Pteropod ooze seen by reflected light. Lat. 18° 24′ N., long. 63° 28′ W.; 450 fathoms; $\frac{5}{1}$.

Fig. 10. Globigerina ooze seen by reflected light. Lat. 21° 38′ N., long. 44° 39′ W.; 1900 fathoms; $\frac{25}{2}$.

Ascension.

On the 27th March, at 5 P.M. the ship anchored at Ascension. Early in the morning of that day, at 10 A.M., the wind suddenly shifted to the westward in a heavy rain squall, with quite a tropical downpour, lasting an hour and a half, during which it was necessary to "lay to." The rain did considerable damage on shore, washing away some of the roads, &c., and the sea was quite discoloured for at least a mile to the northwest of the island.

Geo. West del ad Nat.

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Deep Sea Deposits

The sea is usually so rough around Ascension that a sort of crane is provided at the landing steps with a hanging rope, by which those wishing to land can swing themselves on shore from a boat when it is too rough for the boat to come close to the steps.

Land Crabs swarm all over this barren and parched volcanic islet. They go down to the sea in the breeding season ; they climb up to the top of Green Mountain, and the larger ones steal the young Rabbits from their holes and devour them. It always seems strange to an English naturalist to see Crabs walking about at their ease high up in the mountains, although the occurrence is common enough and not confined to the tropics : in Japan a Crab is to be met with walking about on the mountain highroads far inland, at a height of several thousand feet, as much at home there as a Beetle or a Spider, and Crabs of the same genus (*Thelphusa*) live inland on the borders of streams in Greece and Italy.

Fig. 331.—The Green Mountain and Extinct Craters, Ascension Island.

Close to the dockyard is the Turtle Pond, in which there were over a hundred Turtles at the time of the ship's visit. At the side of the pond an enclosed area of sand is provided, in which the Turtles dig great holes, large enough to bury themselves in, laying their eggs at the bottom of them ; some were still laying, but a good many lots of eggs were beginning to hatch out. The eggs have a flexible leathery shell, and are rather smaller than a billiard ball, and of the same shape. The fresh-laid egg is never quite full so that there is always a slight fold or wrinkle in the yielding shell, and the seamen sometimes puzzle themselves by trying to squeeze the egg so as to get the dint out, but it always forms in a fresh place notwithstanding their efforts. When the eggs are near the time of hatching the depression has quite disappeared from the shell, which has become tense, no doubt, from the development of small quantities of gas within.

The sand in which the eggs are hatched does not feel warm to the hand, but rather, in the daytime at least, cool, and it is always moist. Several sets of eggs were gathered, placed in large vessels full of sand, and taken on board the ship, under the impression that it would be easy to succeed in hatching them artificially, and obtain eggs in all stages of development. It was found, however, that all the eggs perished within a couple of days. No doubt a certain definite amount of moisture must necessarily be maintained in the sand as well as a certain constant temperature in order to keep the eggs alive and develop them. The sand, in which the eggs were, was exposed to the sun in the daytime and covered up at night. Turtles' eggs are, however, apparently not hatched by the direct daily heating by the sun of the sand in which they are buried; what appears to be the case is, that the eggs are buried at such a depth that the sand there maintains a constant mean temperature, never hot and never cold. The eggs of a species of Mound Bird (*Megapodius*) are hatched under closely similar conditions in the Philippine Islands (see p. 535).

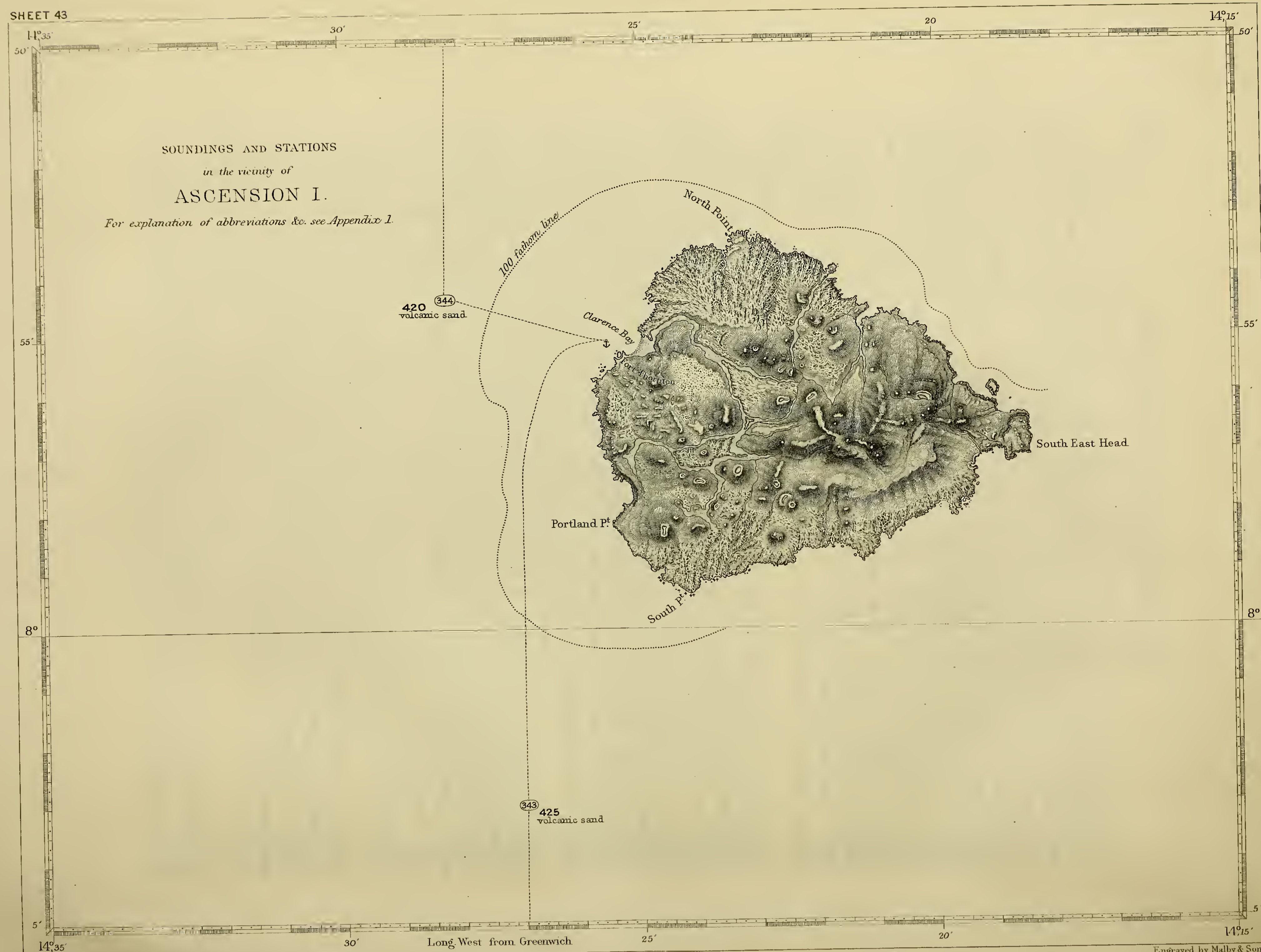
The young Turtles fresh from the eggs are kept as pets by the seamen at Ascension in buckets of sea water. They eat chopped-up raw meat ravenously, using their fore-fins to assist their beak-like jaws in tearing the morsels. Turtle-meat is served out twice a week as rations to the inhabitants of Ascension, who are all naval employés. A series of embryo Turtles in various stages of development were removed from the eggs and carefully preserved, and formed the material, together with a series sent home by Staff-Surgeon Maclean of the Challenger, who was stationed on the island in 1877, for the excellent Monograph by Professor W. K. Parker on the Development of the Green Turtle, which has been published in the Zoological Series of Reports.[1]

A visit was paid in the small steam vessel which is employed in collecting Turtles from the various bays of the island to Boatswain Bird Island, a breeding place of various sea birds. As the vessel steamed along the shore of the main island large flying Gurnets (*Dactylopterus*) rose, scared by the vessel, and skimmed rapidly away in front of the bows. The attempt was made to shoot them on the wing, a novel experiment, but quite without success. The flight was rapid and the boat was in constant motion, pitching and rolling; no doubt in calm weather the thing might be done.

Boatswain Bird Island is a high rock separated from the main island by a narrow channel. The sides of the rock are precipitous, but a sailor had managed to climb up and fix a rope at the summit, so that it hung down the cliff. The cliff surface was covered with guano hanging everywhere upon it in large projecting masses and formations resembling stalactites. The party clambered up the cliff by means of the rope, being half blinded and half choked by the guano dust on the way.

In holes on the sides of the cliff, burrowed in the accumulated guano, nest two kinds of Tropic Birds (*Phaëthon æthereus* and *Phaëthon flavirostris*). In bracket-like nests, as at St.

[1] Zool. Chall. Exp., part v., 1880.



Engraved by Malby & Sons

Paul's Rocks, fixed against the lower parts of the cliffs, breeds a species of Noddy (*Anous*), and together with it a beautiful small snow white Tern with black eyes (*Gygis candida*), called by the seamen the "White Noddy," to distinguish it from the "Black Noddy."

The summit of the rock is flat, and the plateau is covered with guano; in hollows nest the Booby (*Sula leucogastra*), a Gannet (*Sula piscator*), and the Frigate Bird (*Tachypetes aquila*). The throat of the Frigate Bird hangs in the form of a sort of pouch in front, which is bare of feathers and of a brilliant vermilion colour, as if rubbed over with some bright red powder; this gives the bird a very handsome appearance.

When the plateau was first reached all the birds allowed themselves to be knocked over with sticks on their nests or when near them, but they soon became generally alarmed and took to flight. The Frigate Birds were on the lookout whenever the Gannets were molested, and snatched up the small fish which they disgorged, thus profiting by the general disaster. A single "Wideawake," the name given to the Tern (*Sterna fuliginosa*), which breeds in millions gregariously at "Wideawake Fair" on the main island, was found on the plateau; the bird was nesting amongst the Gannets for some reason or other.

It was striking to find breeding thus in the middle of the Atlantic, on the top of a steep volcanic rock, the same assemblage of birds which had been seen breeding together on a coral island at sea level off the northeast coast of Australia. At Raine Island there is a third species of Gannet and a Frigate Bird but no *Gygis*; the same Noddy, the same two Gannets, and the Wideawake breed there together as at Ascension; and also one of the species of Tropic Birds of Ascension.

The whole island is a series of extinct volcanic cones (fig. 331); the rocks collected being augite-andesite, basalt, phonolite, trachyte, liparite (?), obsidian, pumice, volcanic tufa; one ejected specimen was a granite.

The Expedition remained at Ascension from the 27th March to the 3rd April, coaling and provisioning the ship, and obtaining astronomical and magnetical observations. During this time the members of the Expedition visited all the chief points of interest, and received the greatest attention and assistance from the resident naval authorities.

Ascension to Porto Praya.

At 5 A.M. on the 3rd April the voyage to England was resumed. After sounding and dredging in 420 fathoms close to the island, a line of soundings was carried northwards to the Equator to join a line of soundings which had been obtained in August 1873 from the Cape Verde Islands south to the parallel of 3° N. At a position in lat. 3° 10′ N., long. 14° 51′ W., a dredging was taken in 2450 fathoms on the same spot where a sounding was obtained on the 21st August 1873. The ship then proceeded northwards along the coast of Africa to Porto Praya, San Iago.

Between Ascension and the Cape Verde Islands the southeast trade only extended to the Equator; from thence northwards, light variable winds were experienced to the 10th parallel, but north of that parallel a fresh N.N.W. breeze was experienced, which obliged the vessel to stand off on the starboard tack. As the distance from the shore increased, the direction of the wind altered to the northward and N.N.E., which enabled the ship to fetch Porto Praya on the 16th April. On the 10th a very fine water-spout was observed some miles from the ship.

On this trip three dredgings, four soundings, and eight serial temperatures were obtained. The depths ranged from 2010 fathoms to 2450 fathoms, and the deposit in each case was a Globigerina ooze, containing 94 per cent. of carbonate of lime in the former and 65 per cent. in the latter depth. Only one or two small fragments of Pteropod shells were observed in these deposits, in which the carbonate of lime consisted chiefly of the shells of pelagic Foraminifera, Coccoliths, and Rhabdoliths. The remains of siliceous organisms did not make up more than 1 per cent. of the whole deposit. The mineral particles were exceedingly minute, and consisted of fragments of felspars, hornblende, augite, and magnetite.

During a few days when the weather was calm there was an extraordinary abundance of life on the surface. Oscillatoriæ covered the sea for miles, and vast numbers of Radiolaria, belonging to the genus *Collozoum*, which contains all the skeletonless Radiolarian colonies, were taken in the nets. The Foraminifera, belonging to the genera *Pulvinulina*, *Pullenia*, *Sphæroidina*, and *Globigerina*, were very large and very numerous on the surface, and their dead shells made up the principal part of the deposit at the bottom.

Pelagic Diatoms.—Conte Abate Francesco Castracane, who is engaged in the preparation of a Report on the pelagic Diatoms collected by the Expedition, writes:—

"Although the study of the pelagic Diatoms collected by the surface net during the voyage of the Challenger has not led me to any noteworthy general deductions, nevertheless I have made a large number of observations which will greatly increase our knowledge of the biology and morphology of these interesting forms.

"I tried to ascertain whether there existed any laws governing the geographical distribution of Diatoms, but the result was almost *nil.* I found not a few forms common to gatherings made in portions of the sea separated by enormous distances from each other, and these I regard as cosmopolitan; nor is this to be wondered at when it is remembered that the different oceans communicate with each other, and that the action of currents constantly tends to mix the various floras.

"The Antarctic flora has, however, yielded forms of Diatoms, for which new genera must be constituted, such as *Dactyliosolen*, related to *Rhizosolenia*, and *Coretron*, a new type of *Chætoceros*, which have not been found hitherto either in the Arctic waters or in any other seas. But do we know the Arctic and Antarctic floras with sufficient accuracy to be able to speak with authority upon their differences?

"The study of the surface collections has established the distinction between the pelagic and littoral floras, in the former I have never detected frustules of *Achnanthes*, *Rhabdonema*, *Grammatophora*, or of *Cocconeis* and other genera which resemble these in being stipitate, adnate, or attached to each other in some other manner.

"Another observation, made during the examination of these surface gatherings, is that when the net yielded an abundance of different forms of microscopic animals, Diatoms were extremely rare; for this I have been unable to suggest any explanation other than that the Diatoms serve as food to the animals, so that where the latter are abundant the former are few in number.

"The dredgings in the Antarctic Ocean, and especially that south of Heard Island, were very anomalous, showing frustules of freshwater Diatoms, such as *Asterionella formosa* and *Ceratoneis arcus*, along with forms which are entirely marine. This anomaly is, I believe, to be explained by regarding these terrestrial Diatoms, and especially *Ceratoneis* (which grows only at upwards of 300 feet above sea level), as the remnants of icebergs, which slowly melted and deposited their delicate load of Diatoms which grew upon them whilst they formed part of the virgin ice.

"Although I have been obliged to make large additions to the number of genera and species, my observations of the surface gatherings have, at the same time, led me to recognise the variability of certain genera such as *Goniothecium*, *Dicladia*, and by analogy *Syndendrium*. This is also the case with the sporangial forms of different species of *Chætoceros*, and also *Euodia* and *Coscinodiscus*, in which I have observed two different valves of the same frustule, one being provided with a 'pseudo-nodulated' margin, the other without. In the same way I have noticed marked differences in the two valves of the same *Coscinodiscus*, which, if they had been found apart, would certainly have been referred to two different species.

"In these collections I have had the pleasure of recognising certain new types, which I discovered some years ago in the Adriatic, but of which I have hitherto deferred the publication. One of these is *Rhizosolenia* (?) *flaccida*, which, however, I hesitate to refer to that genus, not having been able to observe the terminal calyptra; the other is the type upon which Grunow founded the genus *Thalassiothrix*, a name which I retain out of respect to the author, although I must somewhat alter the account of it, having observed it several times alive and in different conditions.

"In conclusion, we are indebted to the Naturalists on board the Challenger for the knowledge of several new discoidal forms remarkable for their size (sometimes as much as several millimetres in diameter), for the extreme tenuity of their walls and the delicacy of their sculpturing. The size of the frustules and the tenuity of the walls interfere with the possibility of recognizing such organisms even though they be of frequent occurrence; and in fact in many of the soundings entrusted to me, as well as in many marine deposits from America, I have recognised large fragments of finely granulated silica, which I now believe to have belonged to large discoidal Diatoms, similar to those which I have seen in preparations made at the moment of capture (see fig. 333). I have thus been able to determine four specific types of these gigantic Diatoms, which together with smaller forms, to which, however, they are not so closely related, constitute a new genus, which it will perhaps be necessary to divide into two.

"The discovery of forms so remarkable for their size and the tenuity of their walls may well lead us to wonder what new forms may be discovered in the order of the Diatomaceæ, during the prosecution of researches into the unlimited extent of seas, in which such a noble example has been set by the British Government."

For the extremely large and delicately sculptured forms just alluded to, Count Castracane has proposed the generic name of *Etmodiscus*. In addition to the general features already quoted, this genus is characterised by a well-defined convexity of its valves, and, in some cases, by a great development of the connecting zone, which may proceed so far as to cause the axial line of the frustule to exceed the transverse diameter in length.

Delicate radiating striations occur on the valves of several species, such as *Etmodiscus radiatus*, *Etmodiscus coronatus*, *Etmodiscus humilis*, &c., and a corona of great beauty and regularity is found in the form of distinct submarginal points in *Etmodiscus punctiger*, as radiating small lines in *Etmodiscus japonicus*, or as two alternate rows of granules in *Etmodiscus coronatus*. Sometimes, as in *Etmodiscus punctiger*, the entire surface of the valves present a finely punctated appearance, but in other cases granules of small size are to be met with only on subcentral and submarginal regions, the intermediate space being devoid of such markings as in *Etmodiscus periachantinos*, or on the submarginal area alone, as in *Etmodiscus coronatus*. In *Etmodiscus convexus* the large discoidal convex frustule exhibits an almost invisible striation "seminated with very minute thorns," and provided near the margin with a row of delicate "denticules" which differ from the corresponding submarginal circle of points found in *Etmodiscus punctiger* by being at once more numerous and more minute.

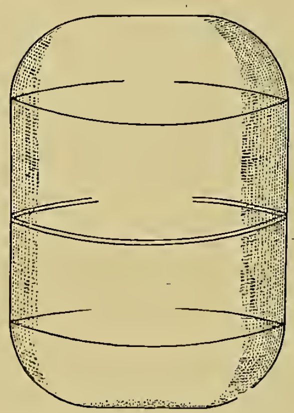


Fig. 332.—Frustule of *Etmodiscus wyvilleanus*, n. gen. et. sp., $\frac{50}{1}$.

The valves of *Etmodiscus radiatus* present a sculpturing of singular beauty, and one which recalls the appearance presented by the medullary rays of an ordinary dicotyledonous tree. Thus its submarginal region forms a belt of small irregularly disposed granules, from which several rows of different lengths proceed towards the centre. Of these rows none reach that point however, the shortest being about one-half, and the intermediate about three-fourths of the length of the longest series. The disposition of these rays on the surface of the valve is perfectly regular and symmetrical. From the central point very delicate striæ proceed towards the periphery, but run across only about three-fourths of the diameter of the valve, the border of which is also striated.

The size of the frustules of this genus varies very greatly. *Etmodiscus humilis* and *Etmodiscus obovatus* are among the smallest forms hitherto recorded, *Etmodiscus convexus* measures 123 μ,[1] *Etmodiscus punctiger* 143 μ, while *Etmodiscus gigas* reaches 1633 μ, and *Etmodiscus spheroidalis* 1882 μ.

The general shape of the frustule varies with the development of the connecting zone, and the degree of convexity of the valves. Four leading forms, however, may be recognised, namely, the discoid, as in *Etmodiscus convexus*, *Etmodiscus radiatus*, &c.; the oval, as in *Etmodiscus obovatus;* the cylindrical, as in *Etmodiscus wyvilleanus* (see fig. 332) and *Etmodiscus tympanum;* and the compressed spheroidal, as in *Etmodiscus spheroidalis.* In *Etmodiscus tympanum* a noteworthy superposition of a belt to the two hoops of the valves occurs, as in the genus *Biddulphia*, and in *Etmodiscus spheroidalis* the belt exhibits a small sutural line in its middle part, recalling in some measure that of *Melosira* and of *Podosira*.

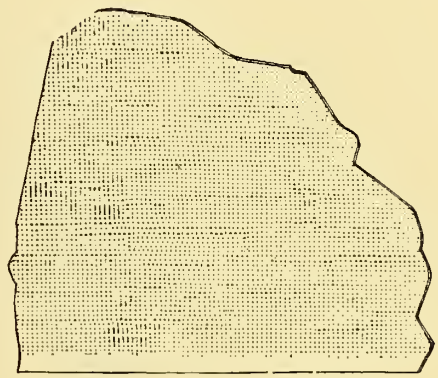


Fig. 333.—Fragment of frustule of *Etmodiscus* sp. $\frac{440}{1}$.

The geographical range of the genus *Etmodiscus* is very extensive. Species occur in the Arafura Sea (*e.g.*, *Etmodiscus convexus*) and the Sea of Japan (*e.g.*, *Etmodiscus japonicus*). *Etmodiscus humilis* was found in mud procured from a sounding of 1950 fathoms near the ice barrier of the Antarctic Ocean, and *Etmodiscus diadema* was also obtained in the same ocean to the south of Heard Island. On the other hand, *Etmodiscus gigas*, *Etmodiscus wyvilleanus*, and *Etmodiscus spheroidalis* are Atlantic and Pacific species, and occur everywhere at the surface of the ocean within the tropics.

Infusoria.—Noctiluca miliaris was observed in great numbers in the water of harbours, but was rarely met with in the open sea far from land. It was abundant at Vigo in Spain, at the Cape of Good Hope, in several parts of the Philippines, at Hong Kong, at Japan, and off the coast of South America. On only two occasions were specimens taken at a great distance from the coast—once in the Japan Stream and once off the north coast of New Guinea—and in both instances the water was of low specific gravity and gave other evidences of being coast water; the specimens were also contracted and shrivelled up.

Species of *Carchesium*, *Vorticella*, *Acineta*, *Podophrya*, *Tintinnus*, and *Ceratium* are all much more abundant in the waters of harbours, enclosed seas, and coast waters generally than in the open ocean. Latterly, indeed, when many representatives of these genera, together with *Noctiluca*, certain other Infusoria, Hydromedusæ, and numerous

[1] μ=0·001 millimetre.

Diatoms were taken in the tow-nets, this was regarded as indicating the presence of coast water. A few species of Infusoria belonging to the above-mentioned genera are, however, constantly met with far from land attached to Diatoms, Radiolaria, Copepods, dead shells of *Spirula*, and other organisms.

Ceratium (*Peridinium*) *tripos* was very frequently observed in chains, from two to twenty-one being attached together, as shown in the annexed woodcut (fig. 334). Although

FIG. 334.—*Ceratium* (*Peridinium*) *tripos in catenâ*, after Murray.

Ceratium tripos occurs in great abundance in shore waters, occasionally filling the tow-nets with a yellow coloured slime, it was only observed *in catenâ* in the open ocean far from land. Neither flagellum nor cilia were observed in the chains of *Ceratium tripos;* a similar observation is recorded by Pouchet.[1] There appear to be good reasons for regarding these organisms as unicellular Algæ rather than Infusoria.[2]

[1] Sur l'evolution des Peridiinens, &c., *Comptes rendus*, t. xcv. p. 794, 1882; Contribution à l'histoire des Cilio-flagellés, *Journ. de l'anat. et phys.*, t. xix., No. 4, 1883.

[2] Mr. J. T. Cunningham, who has recently been making observations on these organisms at the Scottish Marine Station, writes :—"The possession of greatly developed horns, or arms, of a flattened triangular body, and of a large aperture in the case interrupting the equatorial groove, distinguishes the genus *Ceratium* from other Peridiniidæ. The genus was instituted by F. von Paula Schrank. *Ceratium tripos*, the most conspicuous species, was first described by O. F. Müller under the name *Cercaria tripos.* C. L. Nitsch first gave it its present name.

"Dr. R. S. Bergh* has recently published investigations on the nature and affinities of the Cilio-flagellata, and gives a complete discussion of the species of *Ceratium.* He treats the question from a morphological point of view, and believes

* Der Organismus der Cilioflagellaten eine phylogenetische Studie, *Morphol. Jahrb.*, Bd. vii. pp. 177–288, 1882.

Pyrocystis noctiluca.—Mr. Murray says:—"This organism is always present, and often in enormous abundance, at the surface of the open ocean in tropical and subtropical

that forms phylogenetically closely allied may live some as plants others as animals. He proposes the theory that the Flagellata are a primitive group from which the Noctilucidæ, Rhizopoda, and Cilio-flagellata are derived, and that from the last come the Peritricha, and from these the other Ciliata.

"Since the appearance of this paper, George Klebs* in 1883 published some observations on the freshwater forms, and more recently has given an account of the marine Peridiniidæ.†

"Claparède and Lachmann considered Cilio-flagellata as unicellular animals, intermediate between Ciliata and Flagellata. Warming,‡ however, in 1875, expressed the opinion that the Peridiniidæ were plants and ought to be classified as intermediate between the Diatoms and Desmids. Nearly all observers, including Prof. Allman, agree in ascribing to them a long flagellum and a row or two rows of cilia in the equatorial groove. There seems to be some reason to doubt the existence of the equatorial cilia, at least in some species. *Polykrikos auricularia*, Bütschli, certainly possesses eight rows of cilia, but according to Klebs it is a true ciliate Infusorian and not a Peridinean at all. As to the existence of the posterior flagellum in *Ceratium* there is no doubt, though often it cannot be observed; it arises from the protoplasm of the body within the aperture of the case, and I have myself seen it in active motion. I have not been able to detect any cilia, and Klebs up till a short time ago had been unable to discover any locomotive organ except a single flagellum. In the account of his recent studies of the marine Peridiniidæ, Klebs makes the following statements concerning the locomotive organs. Upon the long flagellum which projects backwards in *Ceratium* he has nothing new to communicate; it is as described by earlier writers. But several times he observed in *Ceratium tripos* a second flagellum, arising like the first from the ventral longitudinal cleft, and he believes that in the normal condition this second flagellum vibrates in the equatorial furrow, like the furrow-flagellum which he observed in freshwater forms. He has not been able to find the opening by means of which the flagella and internal protoplasm are continuous. With regard to this point I see no difficulty; in my own observation referred to above, although I could not make out the actual junction of the flagellum with the protoplasm, it was perfectly obvious that the flagellum arose within the area on the ventral surface of the body where the protoplasm was nude. As described and figured by Bergh, the case is wanting over this area and the protoplasm is uncovered. Klebs also says that he has never seen a specimen of *Ceratium tripos* in locomotion. The specimen which I was able to observe at my leisure for some time moved across the field of the microscope with considerable rapidity, so that I had some difficulty in keeping it in view until I fixed it by means of a cover-glass.

"Concerning the internal organisation, Klebs extends what he said of freshwater forms to those of the sea. Usually the protoplasm is coloured yellow by diatomin, which is not diffused but confined to definite bodies like chlorophyll corpuscles. He also found starch and colourless oil in the cytoplasm. He observed a process in *Ceratium fusus* which seemed like spore formation. Copulation he had never seen. The chain forms, observed first by Mr. Murray and afterwards by Pouchet, he regards as connected with a pelagic mode of life; this I do not understand; chains of pelagic organisms such as Diatoms, *Salpa*, &c., are produced by budding or division, and therefore the same is probably the case in *Ceratium tripos.*

"Physiologically the species of *Ceratium* are certainly plants. The substance of which the case consists is closely allied to cellulose, and contains no inorganic matter; unlike cellulose, it is not dissolved by ammoniacal oxide of copper. The body contains a single oval nucleus, deeply stained by the action of carmine.

"Although some Flagellata undoubtedly live as animals, it has not yet been absolutely proved that any of the Peridiniidæ digest. Stein and Bergh affirm the fact in *Gymnodinium*, but Klebs does not accept their conclusion.

"Unless the occurrence of *Ceratium tripos* in chains be due to a process of division, nothing is known of the multiplication or reproduction of *Ceratium.* In allied freshwater forms division has been known to occur for some time. In *Peridinium tabulatum* and *Glenodinium cinctum*, according to Klebs, the old case is burst during division into two halves at the transverse furrow and thrown off, each of the new cells forming a new case for itself.

"Klebs decided from his studies of freshwater forms, that the Peridiniidæ were a group of unicellular plants to be classed with the Thallophytes, their immediate affinities being uncertain. From his study of the marine forms he comes to the conclusion that *Exuviœlla marina*, Cienkowski, is a true Peridinean, and that this organism shows affinities on the one hand with the yellow cells of Radiolarians, on the other with the Cryptomonads, the central group of the Flagellata.

"*Ceratium* may be therefore considered as a genus of unicellular Algæ. Three species of *Ceratium* (*Ceratium tripos*, *Ceratium furca*, and *Ceratium fusus*) are extremely abundant in the waters of the Firth of Forth and neighbouring seas at all seasons."

* *Untersuchungen aus dem botanischen Institut zu Tübingen*, Bd. i. p. 346, 1883.
† *Botanische Zeitung*, Nos. 46 and 47, 1884.
‡ *Vidensk. Meddel. f. d. nat. Foren. i Kjøbenhavn*, Aaret 1875.

regions, where the temperature is over 68° or 70°, and the specific gravity of the water is not lowered by the presence of coast and river water.

"The shape is spherical, from 0·6 to 0·8 mm. in diameter, the colour of the protoplasmic matter is brownish, like that of Diatoms and *Ceratium*. The external capsule is composed of a resistant organic matter containing cellulose. The internal ball or protoplasmic body (cytode) is sometimes separated by a considerable interval from the external capsule, as shown in figs. 336–337; sometimes, however, it is closely applied, and protoplasmic threads ramify over the inner surface of the capsule, or through the internal cavity (fig. 335). In the fresh state the internal ball colours slightly with osmic acid. The nucleus stains easily with carmine solution. Very frequently a number of small pellucid dots are observed over the surface of the external capsule, generally aggregated toward one portion of the sphere. If a little magenta solution be added to the sea water these dots instantly colour, and the organism then presents a very beautiful appearance. The cytode is very often observed in simple division beginning with the nucleus. Sometimes the internal ball divides into four; the outer capsule eventually bursts. The external capsule will persist for days in cold strong nitric acid and caustic potash, but disappears by boiling in the former. When treated with sulphuric acid and iodine solution it becomes blue.

FIG. 335.—*Pyrocystis noctiluca*, Murray; 100 times the natural size.

FIG. 336.—*Pyrocystis noctiluca*, Murray; 100 times the natural size.

"*Pyrocystis* is strongly phosphorescent, the light proceeding from the nucleus, and it is the chief source of the diffused phosphorescence of the sea in equatorial regions. It is especially abundant in the warmest waters of the tropics, the most brilliant displays of phosphorescence observed during the cruise being due to its presence in great numbers at the surface of the sea after calm weather. It has often been mistaken for *Noctiluca*.[1]

FIG. 337.—*Pyrocystis noctiluca*, Murray; 100 times the natural size.

"A second species, *Pyrocystis fusiformis*, is represented in fig. 338. It is not nearly so abundant as *Pyrocystis noctiluca*, but is nearly always present with it, and has the same

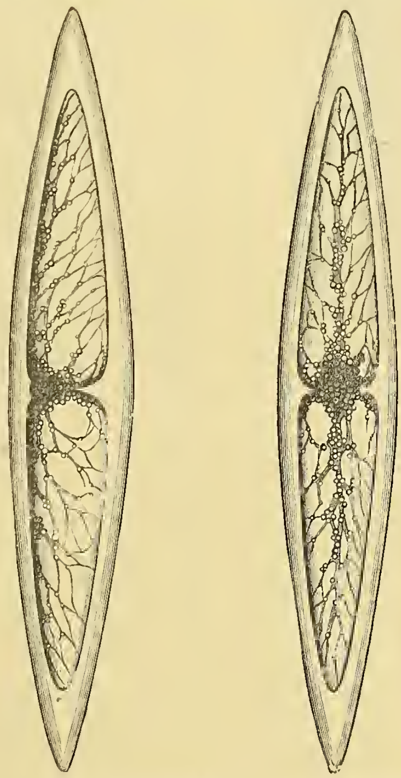


FIG. 338.—*Pyrocystis fusiformis*, Murray; 100 times the natural size.

[1] Prof. Langerhans says :—"*Pyrocystis noctiluca* is observed on the surface in the Bay of Funchal all the year round. From September to December many are in simple division. Having seen your drawings with the interval between inner ball and external capsule, I do not doubt for a moment the identity of the forms observed by us. In case you have not finished your Report you will oblige by mentioning its occurrence here, as I do not see the necessity for writing about it specially. I have never seen *Noctiluca* itself here."—*Letter to Mr. Murray.*

distribution. On one occasion in the Western Pacific a dozen of each of these species were separated out by means of pipettes and put into separate globes of pure filtered sea water. In the evening, when the water was disturbed, about a dozen spots of very brilliant phosphorescence were observed in each of the globes; no difference could be observed in the light from the two species. They ceased to give out light when disturbed three or four times in succession, but after an hour's rest light was given off as brilliantly as at first."[1]

Coccospheres and Rhabdospheres.—The nature of these organisms is very obscure, as from their minute size accurate observations are extremely difficult. They are abundant in all surface and subsurface waters of tropical and subtropical regions away from the influence of coast waters, and are most frequently observed entangled in the protoplasmic matter of pelagic Foraminifera and Radiolarians, in the stomachs of *Salpæ*, of Crustaceans, and other pelagic animals; they can, however, with difficulty be collected floating free in the water. They were not observed in the Southern Ocean south of the latitude of Kerguelen, nor were their broken down parts found in the deposits south of that latitude. Rhabdospheres are almost exclusively met with in water above a temperature of 65°, while Coccospheres are frequently found in water as low as 45°; indeed the Coccospheres are larger and more numerous outside of the tropics. Rhabdospheres are never

FIG. 339.—A Coccosphere; 1000 times the natural size.

[1] Mr. J. T. Cunningham says:—"The specimens of *Pyrocystis noctiluca* preserved in glycerin were mostly collapsed, the membrane or outer capsule being wrinkled, but on the addition of water they at once became spherical. Addition of iodine dissolved in potassium iodide on a slide produces no effect either on the membrane or cell contents beyond tinging them slightly yellow. When a drop of sulphuric acid has been added previously, dilute iodine solution produces a very marked effect; a number of the cells become a beautiful deep transparent blue, but some become reddish purple. Occasionally one specimen is partly blue and partly purple. When strong sulphuric acid is added to some specimens on a slide, they remain unchanged for some time, then gradually the membrane becomes thinner and to a great extent is dissolved away. Even after twenty-four hours there was left a residue of the membrane very small in quantity, retaining to a slight extent the shape of the membrane, and consisting of very minute granules. After boiling a large number of specimens in a watch-glass with nitric acid for some minutes I could find no residue at all of any kind. When burned on platinum each specimen leaves a circular stain.

"As compared with the capsule of *Ceratium*, the membrane behaves under the influence of iodine in exactly the same way, but it resists to a much greater degree the action of strong sulphuric acid. The capsule of *Ceratium* in the acid breaks up into pieces and disappears in less than a minute. The complete disappearance of the membrane of *Pyrocystis* in boiling nitric acid makes it improbable that there is any silica present; if there be any it must be in very small quantity; it certainly does not form a continuous skeleton. It is most probable that the membrane is composed of a peculiarly resistant form of cellulose, closely similar to the modification which forms the capsule in *Ceratium*."

found in the deposits, but their broken down parts, the Rhabdoliths, are very numerous in all the Globigerina oozes of the tropics; Coccospheres are found in the deposits of subtropical regions, even at very great depths, and their broken down parts, the Coccoliths, frequently make up a considerable percentage of some Globigerina oozes. There is a considerable variety both in the form and size of Coccospheres and Rhabdospheres, some varieties having the component parts (Coccoliths and Rhabdoliths), much

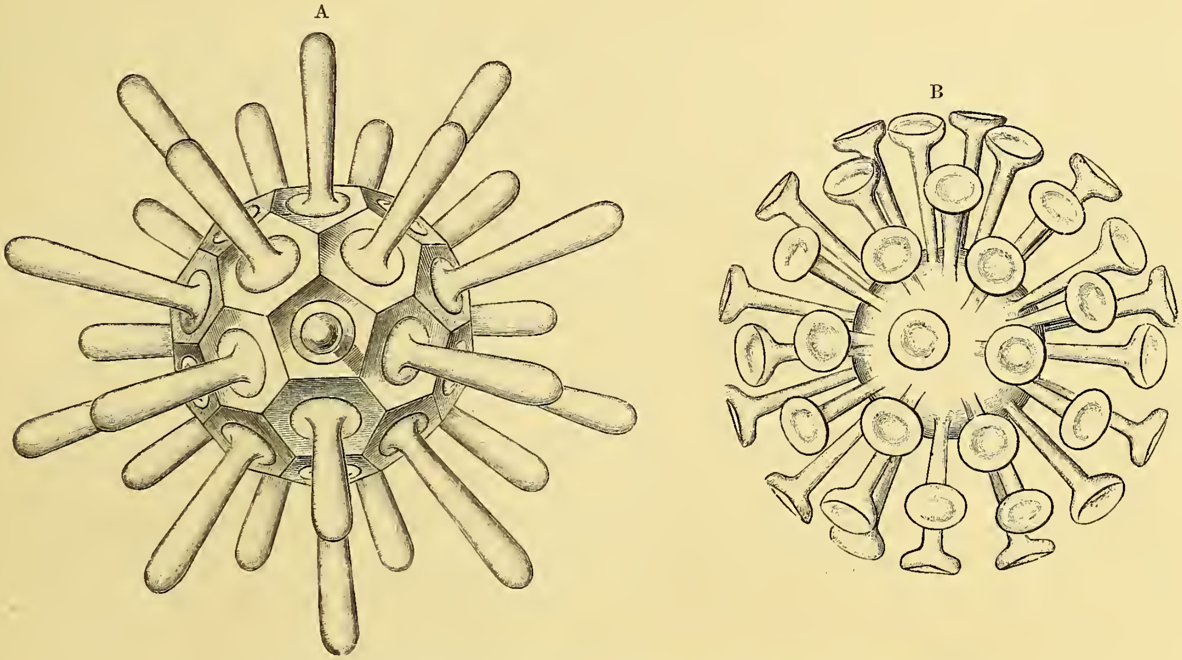


FIG. 340.—Rhabdospheres, from the surface. A, 500 times; B, 2000 times, natural size.

more compactly united into a sphere than others. The interior of the spheres is perfectly clear when examined fresh from the surface, and becomes coloured brown with iodine solution, but with iodine and sulphuric acid no blue colour was observed. They were never observed to colour with carmine solution. When the calcareous parts are removed by dilute acids a small gelatinous sphere remains, in the outer layer of which the Coccoliths or Rhabdoliths were embedded.

Bathybius.—Mr. Murray writes:—"During the first two and a half years of the cruise the muds, oozes, and clays procured by the sounding tube, dredge, and small townets were carefully examined for *Bathybius.* The thin watery surface layer of the deposit was carefully removed as soon as it arrived on board ship, placed under the microscope, and examined for hours at a time, but no protoplasmic movements were observed. On treatment with iodine and carmine solutions the appearances described by Huxley and Haeckel were not observed.

"It was noticed, however, after a considerable time, that specimens of the deposits preserved in bottles with abundance of spirit had (on the upper surface of the mud, as seen in the bottles) a very mobile jelly-like aspect, while similar specimens kept in sea water or fresh water had no such appearance. When the spirit preserved specimens above referred to were treated with the various staining solutions, the appearances so minutely described by Huxley and figured by Haeckel were at once seen. It was further observed that when a small quantity of pure sea water was treated with different quantities of spirit of wine, that precipitates of different characters were obtained; a mixture of one ounce of sea water with one of spirits of wine gives a precipitate which falls to the bottom of the glass and consists of minute crystals, but when three or four ounces of alcohol are mixed with one-quarter or one-half ounce of sea water there is a very bulky gelatinous precipitate which retains its jelly-like character for years. Mr. Buchanan examined these precipitates from pure sea water and found that they consisted wholly of sulphate of lime. When the soundings were being made for the first Atlantic telegraph cables, the naturalists, in their anxiety to get the specimens of the ooze in the best condition for examination, gave instructions that the samples should at once be placed in bottles, and the bottles then filled up with strong spirit. Since the ooze, when freshly collected, has always a quantity of sea water associated with it, the sulphate of lime in it was thrown down as a gelatinous precipitate on the addition of the large quantity of spirit, and it was this precipitate mixed up with the ooze that was described under the name *Bathybius*. Since the analysis of the ooze showed the presence of organic matter, and as the gelatinous precipitate of the sulphate of lime gives reactions with colouring solutions resembling those of protoplasm, the conclusion that the precipitate was protoplasmic in its nature was a very reasonable one."[1]

Cape Verde Islands.

On the 17th April the Challenger left Porto Praya, San Iago, and the following day anchored off Porto Grande, St. Vincent, remaining there till the 26th. While at Porto Grande the steam pinnace was engaged two days in dredging in depths of 7 to 15 fathoms.

Cape Verde Islands to England.

On leaving Porto Grande the trade wind was found very light and well to the northward, as far as the 18th parallel, after which it shifted more to the eastward and

[1] Preliminary Report, by Mr. John Murray, *Proc. Roy. Soc. Lond.*, vol. xxiv. p. 530, 1876; Preliminary Report, by Mr. J. Y. Buchanan, *Ibid.*, p. 635, 1876.

freshened somewhat. The trade was finally lost on the 30th parallel, and then a westerly breeze was experienced for two days, but after that the wind hung persistently to the northward, so that the coast of Spain was made in the latitude of Vigo on the 20th May, and the ship put in there to replenish the stock of fuel.

On the 3rd May, in lat. 26° 21′ N., long. 33° 37′ W., a sounding was obtained in 2965 fathoms, the bottom being a red clay containing in the surface layers 12 per cent. of carbonate of lime, which consisted of a few shells of the larger pelagic Foraminifera and their broken fragments. The mineral particles did not exceed 0·1 mm. in diameter, and consisted of a few grains of felspar, quartz, hornblende, magnetite, volcanic glass, and manganese peroxide. The principal part of the deposit consisted of flocculent clayey matter with exceedingly minute fragments of minerals, Radiolarians and Diatoms.

On the 6th May, in lat. 32° 41′ N., long. 36° 6′ W., another sounding was obtained in 1675 fathoms, the deposit being a Globigerina ooze containing 91 per cent. of carbonate of lime, which consisted of pelagic Foraminifera, Coccoliths, Rhabdoliths, and a few fragments of Pteropods and Echinoderms. The residue, after the removal of the carbonate of lime by weak acid, resembled in most respects the red clay found at greater depths in the same region of the Atlantic.

The Challenger left Vigo on the 21st May, experiencing N.W. winds across the Bay of Biscay, and reached Spithead at 9 P.M. on the 24th May. On the 25th the ship proceeded to Sheerness, was carefully swung to ascertain the errors of the compass and dipping needle, and the difference between her magnetic character after the voyage and that recorded previous to starting three and a half years before. Finally the crew was paid off at Chatham on the 6th June 1876.

Sir C. Wyville Thomson says:—"Writing now after the Commission has come to a close, I think I am justified in saying that the objects of the Expedition have been fully and faithfully carried out. The instructions of the Lords Commissioners of the Admiralty, founded upon the recommendations of a committee of the Royal Society, were followed so far as circumstances would permit. We always kept in view that to explore the conditions of the deep sea was the primary object of our mission, and throughout the voyage we took every possible opportunity of making a deep-sea observation. We dredged from time to time in shallow water in the most remote regions, and we have in this way acquired many undescribed animal forms; and collections of land animals and plants were likewise made on every available occasion; but I rather discouraged such work, which in our case could only be done imperfectly, if it seemed likely to divert our attention from our special object.

"Between our departure from Sheerness on the 7th December 1872, and our arrival at Spithead on the 24th May 1876, we traversed a distance of 68,890 nautical miles, and at intervals as nearly uniform as possible, we established 362 observing Stations."

The accompanying synoptical table of the voyage may prove useful for reference.

From	To	Date of Leaving Port.	Date of Arrival in Port.	Distance sailed in Miles.	Coals expended.	Number of days at Sea.	Number of days in Harbour at Port left.	Number of Deep-sea Soundings obtained.	Number of Serial Temp.	Number of Dredgings.	Number of Trawlings.
					Tons. cwt.						
Sheerness	Portsmouth	Sat. 7th Dec. 1872	Wed. 11th Dec. 1872	200	87 1½	5	22	...	...	...	...
Portsmouth	Lisbon	Sat. 21st Dec. ,,	Fri. 3rd Jan. 1873	1091	207 5½	13	10	5	...	3	...
Lisbon	Gibraltar	Sun. 12th Jan. 1873	Sat. 18th Jan. ,,	340	68 13½	6	9	13	1	5	1
Gibraltar	Madeira	Sun. 26th Jan. ,,	Mon. 3rd Feb. ,,	655	100 0½	8	8	13	1	...	4
Madeira	Tenerife	Wed. 5th Feb. ,,	Fri. 7th Feb. ,,	255	15 9½	2	2	1	...	...	...
Cruising amongst the	Canary Islands	Mon. 10th Feb. ,,	Thur. 13th Feb. ,,	230	45 5½	3	3	12	2	2	...
Tenerife	St. Thomas	Fri. 14th Feb. ,,	Sun. 16th Mar. ,,	2879	122 18	30	1	25	13	15	2
St. Thomas	Bermuda	Mon. 24th Mar. ,,	Fri. 4th April ,,	870	79 18½	11	8	18	4	8	...
Bermuda	Halifax, *via* New York	Mon. 21st April ,,	Fri. 9th May ,,	1261	127 9½	18	17	18	8	8	...
Halifax	Bermuda	Mon. 19th May ,,	Sat. 31st May ,,	796	158 19½	12	10	14	9	6	2
Bermuda	San Miguel Id., Azores	Fri. 13th June ,,	Fri. 4th July ,,	2031	109 13½	21	13	19	13	4	7
San Miguel Id., Azores	Madeira	Wed. 9th July ,,	Wed. 16th July ,,	528	34 10½	7	5	6	4	3	...
Madeira	Porto Grande, St. Vincent	Thur. 17th July ,,	Sun. 27th July ,,	1066	46 1½	10	1	12	7	3	1
Porto Grande	Porto Praya	Tues. 5th Aug. ,,	Thur. 7th Aug. ,,	170	12 15½	2	9	5	...	...	...
Porto Praya	St. Paul's Rocks	Sat. 9th Aug. ,,	Wed. 27th Aug. ,,	1955	101 10	18	2	12	12	1	4
St. Paul's Rocks	Fernando Noronha	Fri. 29th Aug. ,,	Mon. 1st Sept. ,,	342	18 13	3	2	10	2	1	...
Fernando Noronha	Bahia	Wed. 3rd Sept. ,,	Sun. 14th Sept. ,,	815	87 5	11	2	22	2	...	9
Bahia	Cape of Good Hope	Thur. 25th Sept. ,,	Tues. 28th Oct. ,,	3883	173 15½	33	11	19	12	10	3
Cape of Good Hope	Melbourne	Wed. 17th Dec. ,,	Tues. 17th Mar. 1874	7637	247 16	90	50	34	14	23	8
Melbourne	Sydney	Wed. 1st April 1874	Mon. 6th April ,,	550	58 18½	5	15	4	1	2	1
Sydney	Wellington	Mon. 8th June ,,	Sun. 28th June ,,	1432	177 16	20	63	21	6	4	3
Wellington	Tongatabu	Tues. 7th July ,,	Sun. 19th July ,,	1547	73 8	12	9	6	4	...	5
Tongatabu	Ngaloa	Wed. 22nd July ,,	Sat. 25th July ,,	400	13 18	3	3	4	...	3	1
Ngaloa	Levuka	Mon. 27th July ,,	Tues. 28th July ,,	120	7 0½	1	2	.	...	...	...
Levuka	Ngaloa	Sat. 1st Aug. ,,	Mon. 3rd Aug. ,,	120	33 14	2	4	5	1	1	2
Ngaloa	Port Albany, Cape York	Mon. 10th Aug. ,,	Tues. 1st Sept. ,,	2250	71 6½	22	7	13	8	4	3
Port Albany	Dobbo, Arrou Ids.	Tues. 8th Sept. ,,	Wed. 16th Sept. ,,	656	24 6	8	7	5	...	3	3
Dobbo	Ki Doulan	Wed. 23rd Sept. ,,	Thur. 24th Sept. ,,	100	17 9½	1	7	2	2	...	1
Ki Doulan	Banda	Sat. 26th Sept. ,,	Tues. 29th Sept. ,,	200	38 4	3	2	4	1	1	2
Banda	Amboina	Fri. 2nd Oct. ,,	Sun. 4th Oct. ,,	115	17 10½	2	3	1	...	...	1
Amboina	Ternate	Sat. 10th Oct. ,,	Wed. 14th Oct. ,,	300	30 2½	4	6	2	1	...	1
Ternate	Samboangan	Sat. 17th Oct. ,,	Fri. 23d Oct. ,,	511	48 10½	6	3	3	2	...	2
Samboangan	Ilo Ilo	Mon. 26th Oct. ,,	Wed. 28th Oct. ,,	220	21 12½	2	3	2	1	...	1
Ilo Ilo	Manila	Sat. 31st Oct. ,,	Wed. 4th Nov. ,,	350	38 0½	4	3	4	...	...	3
Manila	Hong Kong	Wed. 11th Nov. ,,	Mon. 16th Nov. ,,	650	24 5	5	7	1	1	...	1
Hong Kong	Manila	Wed. 6th Jan. 1875	Mon. 11th Jan. 1875	650	35 17	5	51	1	1	...	1
Manila	Zebu	Thur. 14th Jan. ,,	Mon. 18th Jan. ,,	380	45 14½	4	3	2	1	...	2
Zebu	Camiguin Island	Sun. 24th Jan. ,,	Tues. 26th Jan. ,,	110	29 16 (both runs)	2	6	3	1	2	2
Camiguin Island	Samboangan	Tues. 26th Jan. ,,	Fri. 29th Jan. ,,	250		3	...	1	1	...	...
Samboangan	Humboldt Bay	Fri. 5th Feb. ,,	Tues. 23rd Feb. ,,	1333	108 18½	18	7	7	5	1	5
Humboldt Bay	Nares Harbour	Wed. 24th Feb. ,,	Wed. 3rd Mar. ,,	403	42 2	7	1	1	1	...	1
Nares Harbour	Yokohama	Wed. 10th Mar. ,,	Sun. 11th April ,,	2533	106 0½	32	7	13	12	1	6
Yokohama	Kobé	Tues. 11th May ,,	Sat. 15th May ,,	350	72 19½	4	30	1	1	1	1
Kobé	Miwara	Tues. 25th May ,,	Wed. 26th May ,,	120	20 8½	1	10	3	...	2	1
Miwara	Kobé	Fri. 28th May ,,	Sat. 29th May ,,	120	19 5	1	2	1	1	...	1
Kobé	Yokohama	Wed. 2nd June ,,	Sat. 5th June ,,	400	80 13	3	4	4	3	...	3
Yokohama	Honolulu	Wed. 16th June ,,	Tues. 27th July ,,	4302	279 3	42	11	24	24	2	11
Honolulu	Hilo	Wed. 11th Aug. ,,	Sat. 14th Aug. ,,	200	60 4	3	15	1	1	...	...
Hilo	Tahiti	Thur. 19th Aug. ,,	Sat. 18th Sept. ,,	2630	189 9	30	5	17	17	2	6
Tahiti	Juan Fernandez	Sun. 3rd Oct. ,,	Sat. 13th Nov. ,,	4643	222 19	41	15	22	19	...	13
Juan Fernandez	Valparaiso	Mon. 15th Nov. ,,	Fri. 19th Nov. ,,	400	17 3	4	2	1	1	...	1
Valparaiso	Messier Channel	Sat. 11th Dec. ,,	Sat. 1st Jan. 1876	2033	88 9½	21	22	8	5	1	5
Through the Strait of	Magellan	Sun. 2nd Jan. 1876	Wed. 19th Jan. ,,	700	76 6½	17	1	9	1	1	6
Magellan Strait	Port Stanley, Falkland Ids.	Thur. 20th Jan. ,,	Sun. 23rd Jan. ,,	400	52 11	3	1	3	1	...	3
Port Stanley	Monte Video	Sun. 6th Feb. ,,	Tues. 15th Feb. ,,	1173	80 15	9	14	6	4	2	3
Monte Video	Ascension	Fri. 25th Feb. ,,	Mon. 27th Mar. ,,	3729	177 13½	31	10	23	20	4	9
Ascension	Porto Grande, St. Vincent	Mon. 3rd April ,,	Tues. 18th April ,,	1800	181 15½	15	7	4	8	3	...
St. Vincent	Vigo Bay	Wed. 26th April ,,	Sat. 20th May ,,	2926	141 10	24	8	2	2	...	...
Vigo Bay	Portsmouth	Sun. 21st May ,,	Wed. 24th May ,,	630	122 1	3	1	...	...	...	...
Portsmouth	Sheerness	Thur. 25th May ,,	Fri. 26th May ,,	150	30 18	1	1	...	...	...	...
			Totals,	68,890	4823 17	727	563	492	263	133	151

Botany of the Expedition.—The notes on the Botanical Observations (see p. 27) issued to the Naturalists of the Expedition in the instructions of the Circumnavigation Committee of the Royal Society, were prepared at the Royal Gardens, Kew. During the cruise the botanical collections were made by Mr. Moseley, who despatched them direct to Kew from various ports. Preliminary notices of these collections by various specialists, and notes by Mr. Moseley on the general aspects of the vegetation of many of the places visited, have from time to time been published in the Journal of the Linnean Society.[1] Setting aside the necessarily fragmentary continental collections, it was decided to limit the Botanical Reports to a review of Insular floras which came within the range of the Expedition, combining for this purpose the materials already in existence at Kew with the new facts brought to light by the Challenger collections. The task of preparing these Reports was entrusted to Mr. W. B. Hemsley, A.L.S., who had at all times the assistance of Sir Joseph Hooker, Professor Oliver, and Mr. Thiselton Dyer.

Mr. Hemsley writes:—"Each island or group of islands is treated separately, and complete lists are given of all the indigenous plants known, together with their synonymy, distribution, and other particulars of interest. The islands whose vegetation is thus dealt with are:—The Bermudas, St. Paul's Rocks, Fernando Noronha, Ascension, St. Helena, South Trinidad, Tristan da Cunha group, Prince Edward and Marion, the Crozets, Kerguelen, the M'Donald group, St. Paul, Amsterdam, Juan Fernandez, Mas-a-fuera, San Ambrosio, San Felix, the Southeastern Moluccas, and the Admiralty Islands. For purposes of comparison, and to render the work more useful, two or three islands not visited by the Expedition are included.

"The results of the investigation of the floras of these oceanic islands are important and interesting, especially in relation to the means and agencies which have operated to effect the present geographical distribution of plants. Many facts and theories bearing upon this subject are touched upon in the foregoing Narrative; but some of the more striking features of these Insular floras are brought together here. Beginning with the flora of the Bermudas, this is evidently of comparatively recent derivation, and is almost wholly composed of species either inhabiting the opposite coast of North America or the West Indian Islands, or both. A very small number of the species have not been absolutely identified with others, but they are so closely allied to others from the regions named that there can be no doubt as to their origin. Associated with a large number of undoubtedly introduced plants there are about one hundred and fifty species which probably reached the islands independently of man, and are hence said to be indigenous. Of this number upwards of one hundred also inhabit Southeastern North America, and about as many the West Indies, while between eighty and ninety are found in all three localities. The only really arboreous species are the Palmetto (*Sabal blackburniana*)

[1] For a list of these publications, see Bibliography, Appendix VI.

and the Cedar (*Juniperus bermudiana*), both of which are tenacious of life, and possess remarkable reproductive capacity; neglected ground being soon overrun by seedlings, especially of the latter.

"Passing by St. Paul's Rocks, where neither flowering plants nor ferns exist, the flora of Fernando Noronha, as far as it is known, exhibits the same affinities to that of the nearest mainland as the flora of the Bermudas. Fifty-five species of flowering plants were collected, five of which appear sufficiently different from any described ones to rank as new; all the rest are quite common plants. The apparently total absence of ferns in this flora is remarkable.

"The indigenous vegetation of Ascension is of the scantiest description imaginable; even littoral plants, on account of the nature of the beach, are unable to obtain a footing on the island. Ferns, of which eleven species have been collected, are in the ascendant. There are, however, two flowering plants (*Hedyotis adscensionis* and *Euphorbia origanoides*), which have not been found elsewhere; altogether there are not more than half a dozen indigenous species.

"The flora of St. Helena is very singular in its composition. There are thirty-eight certainly indigenous flowering plants, and twenty-five ferns, besides about twenty-five other species of flowering plants which may have reached the island independently of direct or indirect human agency. With few exceptions the indigenous flowering plants are shrubs or small trees, and a considerable proportion of them belong to genera restricted to the island, whilst some of the species of genera having a wider range are so very distinct from their congeners as not to be generically recognisable as such at first sight. Arboreous Compositæ preponderated, and there is abundant evidence that they formerly constituted the principal element of the woods which covered the island. Disregarding these Compositæ, some of which are resiniferous, like those of Juan Fernandez, the affinities of the native flora are essentially South African; and structurally, if not in habit, the Compositæ are as nearly related to South African forms as to any others.

"The natural history of South Trinidad is still almost unknown. Not a dozen flowering plants and ferns have been collected in the islands, and the most interesting of these is a Fern (*Asplenium compressum*), previously known only from St. Helena. The latest accounts of the vegetation of the island describe the whole of the arboreous plants, except a tree fern, as prostrate and dead, as if all had been killed at one time by some great volcanic disturbance.

"Next in order is the Tristan da Cunha group, where the vegetation consists entirely of types characteristic of temperate regions. In the three islands, Tristan da Cunha, Inaccessible, and Nightingale, fifty-five species of vascular plants have been collected by various travellers, and of this number no fewer than twenty-four are ferns and two club-mosses, leaving twenty-nine flowering plants. There is no endemic genus of plants, but fifteen of the species of flowering plants appear to be restricted to these islands. Several of the plants are quite rare, and the greater bulk of the vegetation consists of very few species, most prominent among which are *Phylicanitida* and *Spartina arundinacea*. The latter is a stout reed, which covers large areas, and the former is the only tree, and is oftener shrubby than arboreous in dimensions. The flora of the islands of Amsterdam and St. Paul, which lie in about the same latitude as the Tristan da Cunha group, though separated therefrom by nearly ninety degrees of longitude, is essentially the same as that of Tristan da Cunha; yet nine of the thirty-three species of flowering plants are apparently endemic. *Phylica nitida* constitutes the whole of the woody vegetation of Amsterdam Island, but it is wanting in St. Paul; and *Spartina arundinacea* is exceedingly abundant in both islands. Here, as in Tristan da Cunha, there is no endemic generic element; and all the genera except *Phylica*, which is African, are represented both in New Zealand and temperate South America.

"The vegetation of the remainder of the Southern Islands dealt with, namely, Marion, the Crozets, Kerguelen, and Heard, is a fragment of a flora characteristic of the detached regions, generally, of the coldest southern zone inhabited by flowering plants, with two endemic monotypic genera. These are: *Lyallia*, restricted, as far as known, to Kerguelen Island, and *Pringlea*, the Kerguelen Cabbage, which is found in all the islands. Out of a total of thirty vascular plants, six, or one-fifth, are endemic; seven are American, and not found in New Zealand or any of the neighbouring small islands, though two of them also occur in Amsterdam Island; two are found in New Zealand or the neighbouring islands, but not in South America or any of the islands adjacent thereto; while fifteen are common to the New Zealand and American regions.

"Juan Fernandez and Mas-a-fuera, like St. Helena, possess a large generic endemic element in their flora, associated, however, with a relatively larger number of endemic species of other genera. There are about one hundred species of flowering plants, probably indigenous, and between forty and fifty species of ferns. Seventy species, belonging to forty genera and twenty-six natural orders, are endemic, and they are remarkable for the large proportion of trees and shrubs they include. Thus, deducting the grasses and sedges, of which there are nine species, out of the remaining sixty-one species, forty-six, or more than two-thirds, are shrubby or arboreous. Out of the forty-six genera of flowering plants represented in Juan Fernandez, twenty are so generally diffused as not to be specially characteristic of any particular region; ten are endemic; seven are otherwise restricted to South America, or do not extend farther north than Mexico; five are represented both in the New Zealand and South American regions; two are represented in the New Zealand but not in the South American region; and two have a wide range in the northern hemisphere, extending southward, however, only in America.

"The botanical collections from the Southeastern Moluccas and the Admiralty Islands consist, as far as the flowering plants are concerned, almost entirely of littoral species of very wide distribution, associated with a small number of endemic species of

Asiatic or Australian genera. But it should be mentioned that the time and means at the disposal of the Naturalists of the Expedition were quite inadequate for a full investigation of the flora of these groups. This part of the botany deals more especially with facts bearing upon the influence of oceanic currents on the dispersion of plants. And the drift seeds and seed-vessels collected by Mr. Moseley off the coast of New Guinea, together with stranded seeds from various parts of the world, are the subject of an Appendix."[1]

It has been stated (p. 930) that the Diatomaceæ, collected in the tow-nets at the surface of the sea and procured from the deep-sea deposits by means of the dredge and trawl, will be described by Count Castracane in his Report.

The Challenger Collections and Publications.—When, in 1872, Professor C. Wyville Thomson was invited by the Government to take the post of Director of the Civilian Scientific Staff of the Challenger Expedition, the Senatus Academicus and the Court of the University of Edinburgh granted him leave of absence from the duties of his chair for three years, and when the Expedition did not return within that time they extended the leave for another year.

With the consent of the Lords Commissioners of the Admiralty, it was arranged that the collections sent home during the voyage should be lodged in the University of Edinburgh till the return of the Expedition. Professor William Turner, F.R.S., undertook the temporary custody of these collections, and on the arrival of the consignments from the Cape of Good Hope, Australia, China, and Japan, personally superintended their examination for breakages. The boxes containing preserved specimens in spirit were opened, examined, and then replaced in the original boxes according to the catalogues. The Botanical collections made during the voyage were, however, on their arrival in England, sent direct to the Royal Gardens, Kew.

On the arrival of the Expedition in England, the collections brought home in the ship were also transported to Edinburgh, and then the whole of the collections were unpacked and temporarily arranged in a large house belonging to the University.

These extensive collections arrived in England without any mishap, and, generally speaking, in an excellent state of preservation. Among the thousands of bottles of all sizes, only three were broken. There had been very little evaporation of the spirit, and not a single specimen was missing according to the catalogues when they were unpacked in Edinburgh.

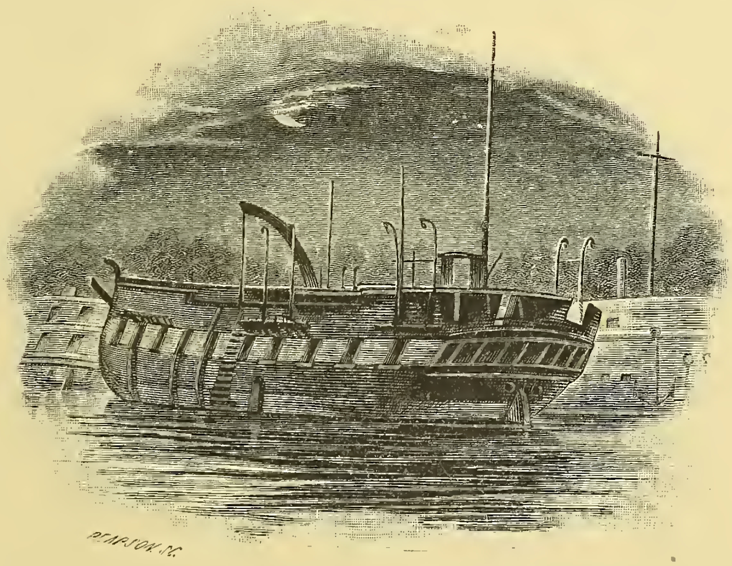
After a correspondence between Her Majesty's Treasury, the Council of the Royal Society, and the late Sir C. Wyville Thomson, it was arranged early in 1877 that the incidental or occasional collections made on shore during the Expedition, such as Mammals, Reptiles, Insects, should be sent at once *in globo* to the British Museum. The great bulk

[1] Appendix on the Dispersal of Plants by Oceanic Currents and Birds, Bot. Chall. Exp., part iii. p. 277, *et seq.*, 1885.

of the collections, and the observations illustrating the physical and biological conditions of the ocean basins, it was arranged, should be worked out on a uniform and well considered plan, with a constant reference to the bearing of the facts upon the objects of the Expedition. The work was to be carried out under the guidance of the Director of the Scientific Staff, whose residence in Edinburgh rendered it necessary that the collections should remain temporarily in that city. Mr. John Murray was at this time appointed chief assistant on the staff to be employed in the preparation for publication of the Scientific Results of the Expedition.

In 1881 Sir C. Wyville Thomson's health had become very much impaired, and in January 1882 the Lords Commissioners of Her Majesty's Treasury, in order to give him relief from the pressure of work, and to enable him to give his undivided attention to the completion of the Narrative of the Cruise, desired Mr. Murray to undertake the editorial work connected with the Special Reports. On the death of Sir C. Wyville Thomson in March of the same year, Mr. Murray was charged with the direction of the whole of the work connected with the official publications.

The collections have now been for some time in the hands of specialists, and where Reports have not already been published, the work is well advanced towards completion. A list of the Reports now published, as well as of those in progress, with the names of the authors, is given in Appendix VII. at the end of this volume. The type specimens referred to in the published Memoirs have nearly all been placed in the British Museum, and ultimately all types will be deposited there. It is estimated that the whole of the Reports will be issued before the end of the year 1887.



CHAPTER XXII.

Density of Sea Water—Composition of Ocean Water Salts—Geographical and Bathymetrical Distribution of Specific Gravity—Carbonic Acid, Nitrogen, and Oxygen in Sea Water—Discussion of Meteorological Observations as bearing on Oceanic Circulation.

During the whole of the voyage very particular attention was paid to the determination of the density of the water and the study of its variations. In a freshwater lake the variations of density depend only on the temperature and pressure of the water, in the sea they depend also on the saline matter held in solution. The effects of change of temperature and of salinity on the density of water have formed the subject of many investigations, and have been ably and exhaustively reported on by Professor Dittmar in his Memoir.[1] The effect of pressure on sea water had been studied occasionally by Perkin, Aimé, Regnault, and others. A number of experiments on the subject were made by Mr. Buchanan in the compression apparatus supplied to the ship, and also in instruments directly attached to the sounding line. Professor Tait has been, for some time, engaged in determining the compressibility of fresh and sea water at different temperatures and pressures, and the effect of pressure on the maximum density point of fresh water. Preliminary results have been published by him from time to time in the Proceedings of the Royal Society of Edinburgh. When these experiments are completed, as it is hoped they will soon be, when a new form of apparatus expressly devised for the purpose is delivered by the makers, the application to the Challenger observations will be made. It is impossible, without such preliminary work, to attack with any hope of success the problem of oceanic circulation.

If the effect of change of salinity, of temperature, and of pressure on the density of the water be known, it is possible from a determination of its density at any temperature and pressure to deduce its salinity, and further to deduce the density of the same water at any other temperature and pressure. The method and instruments employed in the determination of the density of the water have been fully described in Mr. Buchanan's Report.[2] The instrument used was a glass hydrometer weighing about 160 grammes (see p. 109). Its stem was 100 millimetres long and 3 millimetres thick, and was divided into millimetres; the volume of the divided portion of the stem was 0·85 cubic centimetres. The weight of the instrument could be increased by attaching small weights to the top of the stem, and the variations in the volume of the instrument with changes of temperature were very carefully determined. When the hydrometer was

[1] Report on Researches into the Composition of Ocean-Water, Phys. Chem. Chall. Exp., part i., 1884.

[2] Report on the Specific Gravity of Samples of Ocean-Water, Phys. Chem. Chall. Exp., part ii., 1884.

immersed in a liquid and was found to float freely in it, the surface of the liquid reaching to any division on the stem, the volume of the instrument thus immersed could be readily ascertained by reference to the calibration tables of the instrument, regard being had to the temperature of the liquid. But the volume of the immersed portion of the hydrometer is equal to that of the displaced portion of the liquid, and the weight of this displaced volume of liquid is equal to that of the hydrometer which displaces it. By dividing this weight by the volume of displaced liquid, the density of the liquid is obtained. The unit of weight (the gramme) being the weight of the unit volume (cubic centimetre) of distilled water at the temperature of its maximum density at atmospheric pressure (4° C.), the *density* so found is identical with the *specific gravity*, referred to that of distilled water at 4° C. as unity.

In using a hydrometer so delicate as that described, it is necessary that the liquid experimented on should have as nearly as possible the temperature of the atmosphere, otherwise convection currents are set up which interfere with the accuracy of the observations. In practice, therefore, all the observations were made at the temperature of the laboratory, which was that of the atmosphere, and usually very approximately that of the surface water. Waters brought from the bottom or from intermediate depths were always stored in stoppered bottles until they had taken the temperature of the air. Two advantages were gained by this—first, the observations themselves were trustworthy, disturbing causes being eliminated; and second, the variations in the density of waters from different depths at the same Station could be depended on when all the determinations were made under exactly the same conditions. This was of the more importance as the variations in question were comparatively small. The results thus obtained give the density of the water at the temperature at which it was observed, which necessarily varied with the locality. In order that the density may furnish an indication of the salinity of the water, it is advisable to reduce it to its value at one standard temperature. The only tables which were available for this purpose at the time of the voyage were those of Professor Hubbard, published in Maury's Sailing Directions.[1] As they were drawn up with a view to reducing the results to their value at 60° F. (15°·56 C.), this temperature was chosen as the constant temperature to which all the densities should be reduced, in order that they might be comparable as indices of salinity. Later experiments have shown that Hubbard's table is not quite accurate when applied in the reduction of observations made at high temperatures (25° to 30° C.), and the reduced values have been corrected accordingly. Besides reducing the observed densities to their value at 15°·56 C., they have been reduced to their value at the temperature which the water had when in its place in the ocean. In the case of waters from the bottom or intermediate depths, a further reduction for pressure due to depth would give the actual density of the deeper waters as it is in the ocean. In the tables published in Mr. Buchanan's Report[2]

[1] Maury's Sailing Directions, vol. i. p. 237, 1858.

[2] Phys. Chem. Chall. Exp., part ii., 1884.

this reduction has not been carried out. According to Grassi, the increase of density in a water of 1·026 at one atmosphere is 0·00079 per 100 fathoms. From Mr. Buchanan's observations on the compressibility of distilled water, of sea water, and of glass, it was found that sea water was compressed approximately in the ratio 0·0009 for every hundred fathoms of depth in sea water, so that if the density of a water at the surface is 1·027, at 1000 fathoms it is 1·036, at 2000 fathoms 1·045, at 3000 fathoms 1·054, and at 4000 fathoms it is 1·063.

In Table I. the density of sea water of average concentration is given for every whole centigrade degree from 0° C. to 31° C. It will be observed that its density at 15°·56 C.

TABLE I.[1]—*Density of Standard Sea Water* ($D_{15\cdot56}$ = 1·026) *at different Temperatures.*

Temperature, t° C.	Density at t° C., D_t.	$\phi(t) = \frac{D_t}{D_{15\cdot56}}$.	$\frac{1}{\phi(t)} = \frac{D_{15\cdot56}}{D_t}$.	Temperature, t° C.	Density at t° C., D_t.	$\phi(t) = \frac{D_t}{D_{15\cdot56}}$.	$\frac{1}{\phi(t)} = \frac{D_{15\cdot56}}{D_t}$.
0	1·02818	1·0514	0·9511	16	1·02590	0·9989	1·0011
1	813	468	553	17	567	966	034
2	807	422	595	18	542	944	056
3	799	382	632	19	516	922	079
4	790	343	669	20	490	905	096
5	779	309	700	21	463	884	117
6	768	271	737	22	436	869	132
7	755	238	768	23	408	849	153
8	741	205	799	24	380	834	168
9	726	173	830	25	351	815	188
10	710	142	860	26	321	802	202
11	692	116	885	27	290	784	221
12	674	086	915	28	259	766	240
13	654	061	940	29	227	749	258
14	634	037	964	30	195	726	282
15	613	013	987	31	163	705	304

[1] Abridged from the Report on Researches into the Composition of Ocean-Water, Phys. Chem. Chall. Exp., part i. p. 70, 1884.

is 1·026, which approximates to that of average ocean water. In the table, which is taken from Professor Dittmar's Report, the first column t° gives the temperature, the second D_t the density at t° C., the third $\phi(t)$ gives the value of the ratio $\frac{D_t}{D_{15\cdot56}} = \frac{D_t}{1\cdot026}$, and the fourth column gives the values of the reciprocal of $\phi(t)$. The following examples will show the method of using this table.

The density of a water is 1·02734 at 15°·56, what is it at 18°·3 C.? Answer: At 15°·56 the water is heavier than the standard water quoted in the tables by 0·00134, hence at 18°·3 it is heavier than the latter by $0\cdot00134 \times \phi(t)$ = by table to $0\cdot00134 \times$

TABLE II.

Temperature, °C.	Density of Water.			Temperature, °C.	Density of Water.		
	A.	B.	C.		A.	B.	C.
0	1·02713	1·02818	1·02923	16	1·02490	1·02590	1·02690
1	708	813	918	17	467	567	667
2	703	807	911	18	443	542	641
3	695	799	903	19	417	516	615
4	687	790	893	20	391	490	589
5	676	779	882	21	364	463	562
6	665	768	871	22	337	436	535
7	653	755	857	23	310	408	506
8	639	741	843	24	282	380	478
9	624	726	828	25	253	351	449
10	609	710	811	26	223	321	419
11	591	692	793	27	192	290	388
12	573	674	775	28	161	259	357
13	555	654	755	29	130	227	324
14	534	634	734	30	098	195	292
15	513	613	713	31	066	163	260
15·56	1·02500	1·02600	1·02700				

Table III.

Temperature, ° Fahr.	Density of Water.			Temperature, ° Fahr.	Density of Water.		
	A.	B.	C.		A.	B.	C.
32	1·02713	1·02818	1·02923	61	1·02488	1·02588	1·02688
33	710	815	920	62	475	575	675
34	708	813	918	63	462	562	662
35	705	809	913	64	449	548	647
36	701	805	909	65	434	533	632
37	696	800	904	66	420	519	618
38	692	796	900	67	406	505	604
39	688	791	895	68	391	490	589
40	682	785	888	69	376	475	574
41	676	779	882	70	362	461	560
42	669	772	875	71	346	445	543
43	663	766	869	72	330	429	528
44	657	759	862	73	315	414	513
45	650	752	865	74	301	399	497
46	642	744	847	75	285	383	481
47	634	736	838	76	269	367	465
48	626	728	830	77	253	351	449
49	618	720	822	78	236	334	432
50	609	710	811	79	220	318	416
51	598	699	800	80	202	300	398
52	590	691	792	81	186	284	382
53	579	680	781	82	168	266	364
54	569	670	771	83	150	248	346
55	558	659	760	84	133	231	329
56	546	647	748	85	116	213	310
57	536	636	736	86	098	195	292
58	524	624	724	87	080	177	274
59	513	613	713	88	062	159	256
60	500	600	700				

0·9937 = 0·001332; but standard water, by table, at 18°·3 has the density 1·02534, and 1·02534 + 0·00133 = 1·02667, which is the required density at 18°·3.

Second example—Given the density at 18°·3 C. as 1·02667, find that at 15°·56 C. Answer: At 18°·3 C. the density of the given water is 1·02667 − 1·02534 = 0·00133 heavier than the standard; hence the corresponding difference at 15°·56 C. is $0·00133 + \frac{1}{\phi(18·3)}$ = by table to 0·00133 × 1·0063 = 0·00134, hence the result sought = 1·02600 + 0·00134 = 1·02734.

Making use of Table I., Table II. has been compiled; it gives the densities of three waters, A, B, and C, for every whole degree Centigrade. B is the standard water of Table I., and its density at 15°·56 C. is 1·026. The density of water A is 1·025 and that of C is 1·027. Table III. is identical with Table II., with this difference that the values are given for every degree of Fahrenheit's scale between 32° and 88°.

By means of one or other of these tables a density observed at any temperature can be reduced to its value at the standard temperature of 60° F. (15°·56 C.).

The following table has been compiled from Professor Dittmar's Memoir, giving the percentage of chlorine, or rather of halogen calculated as chlorine, in a kilogramme of water of different densities, and his coefficient (180·584) for the proportion of *total salts* to 100 parts of halogen calculated as chlorine. The results for chlorine have been reduced to their values in grammes per litre measured at 60° F., and those for the total salts to grammes per litre and ounces per gallon, both measured at 60° F.

Density at 60° F. (15°·56 C.).	Halogen calculated as Chlorine.		Total Salts.		
	Grammes per Kilogramme.	Grammes per Litre at 60° F.	Grammes per Kilogramme.	Grammes per Litre at 60° F.	Ounces per Gallon at 60° F.
1·02200	16·51	16·87	29·814	30·469	4·865
300	17·23	17·62	31·114	31·829	5·085
400	17·95	18·36	32·414	33·191	5·305
500	18·67	19·13	33·713	34·555	5·526
600	19·39	19·88	35·015	35·925	5·746
700	20·11	20·65	36·315	37·295	5·966
800	20·83	21·40	37·616	38·668	6·187

One of the most interesting results of the analyses by Professor Dittmar of a very large number of the samples brought from different localities passed over during the cruise was that, however much the proportion of total salts to water might vary, the composition of the saline mixture was very constant. From his analyses he has calculated the following numbers for the average composition of ocean water salts.

TABLE IV.—*Average Composition of Ocean Water Salts.*

	Per 100 parts of Total Salts.	Per 100 of Halogen calculated as Chlorine.
Chlorine,	55·292 } [1]	99·848
Bromine,	0·1884 }	0·3402
Sulphuric acid (SO_3),	6·410	11·576
Carbonic acid (CO_2),	0·152	0·2742
Lime (CaO),	1·676	3·026
Magnesia (MgO),	6·209	11·212
Potash (K_2O),	1·332	2·405
Soda (Na_2O),	41·234	74·462
Oxygen equivalent of halogen,	– 12·493	– 22·559
Total Salts,	100·000	180·584

"Combining acids and bases, we have the following average composition of sea salt :—

Chloride of sodium,	77·758
Chloride of magnesium,	10·878
Sulphate of magnesium,	4·737
Sulphate of lime,	3·600
Sulphate of potash,	2·465
Bromide of magnesium,	0·217
Carbonate of lime,	0·345
	100·000"

With these tables the results of observations of density can be interpreted so as to give a very accurate indication of the chemical composition of the water.[2]

[1] Equal conjointly to 55·376 parts of chlorine, which accordingly is the percentage of "halogen reckoned as chlorine" in the *real* total solids.

[2] Prof. Dittmar says :—"From my experiments, hitherto unpublished, on the dissociation of sea water carbonates I conclude that, supposing at a certain time all oceanic carbonates had been of the general formula $R''O.1\frac{1}{2}CO_2$, it could not have sunk below this state of saturation anywhere, *i.e.*, it could not, even in the tropics, have arrived at the composition $R''O.nCO_2$ where $n < 1\frac{1}{2}$; and supposing, secondly, all oceanic carbonates had been of the formula $R''O.1\frac{3}{4}CO_2$, it would not probably have lost carbonic acid, even if the temperature were 32° C. All this rests on the tacit

The source of the salts existing in sea water is rock-substance which has been disintegrated and decomposed by atmospheric influences. The soluble components or products washed out by the rain, and collected in the streams and rivers, are eventually carried into the sea. Here the water is subjected to the action of the sun and winds, which causes it to evaporate, leaving the salts behind. A great quantity of the vapour so formed is carried inland, and condensed on the mountains, washing out the rock and taking up a fresh charge of solid matter which it carries down into the sea, which is thus the great receptacle of degraded land. As it is known that all rivers, at present, hold more or less solid matter in solution, the sea must be continually becoming salter, and must have been always doing so, unless the organic and physical processes by which salts are removed from the ocean should be so active as to counteract the tendency to

TABLE V.—*Showing the Total Saline Contents of Waters of different Densities.*

Density at 60° F.	Total Salts in Grammes per Kilogramme.	Density at 60° F.	Total Salts in Grammes per Kilogramme.	Density at 60° F.	Total Salts in Grammes per Kilogramme.
1·02500	33·713	1·02600	35·015	1·02700	36·315
510	·843	610	·145	710	·445
520	·973	620	·275	720	·575
530	34·103	630	·405	730	·705
540	·234	640	·535	740	·835
550	·364	650	·665	750	·965
560	·494	660	·795	760	37·096
570	·624	670	·925	770	·226
580	·754	680	36·055	780	·356
590	·884	690	·185	790	·485

assumption that the atmosphere is the only active agent, and has always contained 0·0003 of its volume of carbonic acid. From Herschel's estimate of the total mass of the atmosphere, I calculate that the total carbonic acid of the atmosphere amounts to $2·277 \times 10^{12}$ tons (1 ton = 1000 kilogrammes).

"From the oceanometric data of Boguslawski, on the other hand, I calculate that the total *loose* base is equivalent to 160×10^{12} tons of carbonate of lime. Hence, assuming (1) the present oceanic carbonate to be on the average $R''O.1\frac{1}{2}CO_2$, the total *loose* CO_2 in the ocean amounts to $35·2 \times 10^{12}$ tons, or to 15·5 times that contained in the atmosphere. And, assuming (2) the present oceanic carbonates to be on the average $R''O.1\frac{3}{4}CO_2$, its total *loose* carbonic acid amounts to $52·8 \times 10^{12}$ tons, or to 23·2 times that contained in the atmosphere.

"I am, on the whole, inclined to think that of the two numbers, 15·5 and 23·2, the latter comes nearer to the actual value, and, pending further experiments and observations, I assume that, taking the carbonic acid of the atmosphere = 1, that of the ocean is (not far removed from) $\frac{(15·5 \times 23·2)}{2} = 19·4$."

concentration. Although the ocean is the receptacle of the drainage of all the land, it is by no means uniform in saltness; there are variations due to the different meteorological conditions which obtain in the different regions of the earth.

The causes which are effective in altering the specific gravity of the sea are those which influence the formation of vapour and of ice; and as these are found at the surface, it is there that the greatest variations in saltness are observed. The effect of freezing may be taken to apply only to the polar regions. Between these the globe may be divided, or that part of it covered by sea, into five zones, namely—two corresponding to the areas of prevalence of the northeast and the southeast trade winds, in which evaporation goes on actively, and a zone between them corresponding to the equatorial calms, where an immense amount of rain falls; and two to the north and the south of the trade wind districts, where on the whole there is a tolerable balance between rain and evaporation. At both poles there are areas of concentration due to the formation of ice.

But the salinity of the sea is affected by the removal of dissolved mineral matter as well as of water, whether in form of vapour or ice, and any agency which removes solid matter from the water will alter its density. Sea water contains much lime in solution. Immense numbers of animals living in it secrete calcareous coverings, drawing on the water for the lime and possibly for the carbonic acid necessary for the formation of their shells. Let it be assumed that the shell is formed by the direct transference of carbonate of lime from the water to the animals. When they die, their shells sink to the bottom, or are dissolved before they get to the bottom, thus returning either the whole or a part of the carbonate to the water from which it had been taken. Where the conditions are such that the shells reach the bottom, a deposit will be formed which will constitute a continual drain on the supply of carbonates in the water. In this way the composition of the water is altered by precipitation through organic agency. In the same way siliceous deposits are formed by animals secreting siliceous skeletons. But this cause, though it produces in the course of time very important effects, does not affect the composition of the water very sensibly, because the amount of earthy carbonate, or of silica, which is held in solution at any one time is, although sufficient for the support of this extensive process of transmigration of mineral matter, comparatively small; moreover, these very substances, silica and earthy carbonates, form important solid ingredients in solution in river water, and the supply is being continuously kept up, consequently variations in the amount of them would not be expected to produce a marked effect on the density of the water. It is not improbable that in the case of carbonate of lime the comparatively high density of bottom water as compared with intermediate water is due in part to the fact discovered by Professor Dittmar, that the amount of lime in bottom waters is distinctly though slightly greater than in intermediate waters, although this surplus in itself would not affect the most exact specific gravity determinations.

At the surface of the sea in all latitudes there is a constant exchange going on between the atmosphere and the sea. The sea gives up portions of its water as vapour, and the atmosphere in its turn gives up portions of its vapour as water; and climates are dry or moist according as the balance is in favour of the one or the other side of this exchange. Were there no currents in the atmosphere or the ocean, there would be a constant distribution of moisture in the air and concentration in the sea water depending on the temperature, subject to diurnal and annual oscillations. This stationary state of things, however, is by no means what is observed: both in the ocean and the atmosphere there are currents of vast dimensions. The great concentrating agency is the trade winds, which, by virtue of their dryness, remove water from the surface of the ocean over which they blow, while, by virtue of their momentum, they mechanically drive the concentrated water into the equatorial area of dilution.

The same remarks refer in a great measure also to alterations produced by changes from the liquid to the solid state, and *vice versa.* Removal of water, whether as ice or vapour, causes concentration; restoration of it causes dilution. Whether the removal is caused by evaporation or congelation, it is to a certain extent localised so as to produce areas of concentration and of dilution.

The cruise of the Challenger lasted three years and a half, and three years of this time were spent between lats. 40° N. and 40° S., therefore the majority of the observations apply to this region. From the surface observations which were made daily when at sea, and from those of other observers, the accompanying coloured map has been constructed. In it the density of the water at 60°F. (15°·56 C. is represented by various colours, as follows:—

Colour.	Density at 60° F.		Salinity in Grammes per Kilogramme.	
	From	To	From	To
Purple, ...	...	Below 1·0250	...	Below 33·713
Light blue, . . .	1·0250	255	33·713	34·364
Dark blue, . . .	255	260	34·364	35·015
Light green, . . .	260	265	35·015	35·665
Dark green, . . .	265	270	35·665	36·315
Light red, . . .	270	275	36·315	36·965
Dark red, . .	275	280	36·965	37·615
Yellow, ...	...	Above 280	...	Above 37·615

The first glance at this Chart shows the coincidence of the regions of concentration in the sea with those of the trade winds in the atmosphere, which in their turn coincide closely with the areas of maximum barometric pressure. On both sides of each of these regions the concentration diminishes and passes into areas of decided dilution, and also of diminished barometric pressure.

As the concentration of the sea water depends on the climate to which it is exposed, and as that is subject to certain variations, so the areas occupied by the various colours on the map will be subject to oscillations; hence properly there should be similar charts for every month of the year; for this purpose, however, many more observations are required than are at present available. The colours on the Chart will probably not differ very greatly from the mean positions of the regions which they indicate. To take only one instance, it is quite certain that the equatorial area of dilution will have a yearly oscillation corresponding to that of the equatorial calms; in the eastern seas too, where for one half of the year a dry trade wind is blowing, and for the other a moist monsoon, the state of the sea water may be expected to show great variations, and these variations are shown in a very marked manner in the observations made in the China Sea and neighbouring seas, which were traversed in one direction at the end of the southwest monsoon when the water was comparatively fresh, and in the other direction after the northeast monsoon, or true trade, had been blowing for some time. The average density observed in the China Sea in the beginning of November was 1·02510, while in the month of January it was 1·02534.

Taking the surface observations, it will be found that in the North Atlantic the specific gravity increases from all sides up to a maximum about lat. 22° N. and long. 40° W. In this they agree with those of Lenz and the German ship "Gazelle." It is an opinion, expressed by Lenz and by other travellers and navigators, that the specific gravity of the surface water of the North Atlantic is greater on the west and less on the east side; and this opinion is derived from a consideration of the observations on outward-bound and homeward-bound ships. The former keep close to the eastern margin of the North Atlantic, whereas the latter keep well out, passing usually to the westward of the Azores; and it is true that the water in the *centre* of the North Atlantic, between the parallels of 15° and 30°, is denser than on the eastern side, but it is also denser than on the western side.

	East.		Middle.		West.
	Buchanan.	Lenz.	Buchanan.	Lenz.	Buchanan.
Maximum, . . .	1·02755	1·02720	1·02778	1·02776	1·02739
Latitude of Maximum, .	24°	31°	23°	20°	27°

On his outward voyage, Lenz's course lay farther to the eastward than that of the Challenger, and, consequently, he did not observe the same high specific gravity. From the 40th to the 18th parallels his observations show a very constant mean specific gravity of 1·0270. In the centre the two sets of observations agree very closely, and in the west there is only the one.

A comparatively high density prevails in the Atlantic up to very high northern latitudes. The Norwegians in their expeditions of 1876–1878 found the water of the sea surface to have a very uniform density of 1·0262 to 1·0264 up to latitude 75° N. Farther to the west this warm salt water is displaced by the cold fresh water coming down from polar regions and creeping along the American shore as the so-called "cold wall" down to comparatively low latitudes. The waters of the Gulf Stream belong to the warm and salt waters of the Atlantic; consequently, when it is entered from the west or south, no apparent or marked change is observed in the colour, temperature, or saltness of the water. When, however, it is approached from the other side, as by ships leaving American ports, the change is very marked from the green, turbid, cold, and fresh polar waters of the "cold wall" to the transparent deep blue waters of the warmer ocean. The Gulf Stream was crossed twice by the Challenger, once off Sandy Hook and the second time off Halifax. The specific gravity on the latter occasion was 1·0271, which is identical with the mean specific gravity of the water derived from all the observations made between St. Thomas, Bermuda, and the Azores.

What is most remarkable on approaching or leaving the Atlantic shores of North America is not the warm blue water in more or less rapid motion in a northeasterly direction, which does not materially differ from the water of the Atlantic farther to seaward, but the green cold polar water which intrudes itself down along the coast and has such a powerful influence on the climate of the eastern States of America. On the other hand, by following the direction of the green zone on the Chart, it will be seen that the warm and dense water of the Atlantic penetrates far into Arctic regions in the direction of Spitzbergen, where it in its turn may be held to be an intruder, but a beneficent one. It fills the whole of the deep basin of the Norwegian Sea with dense Atlantic water, thrusting the Arctic water farther into polar regions, from whence it overflows down the east coast of Greenland and the western side of Davis Strait. It is the open character of the sea, that is, the freedom from large masses of land, that enables the water to get away towards the polar regions in the direction of Spitzbergen, and thus to benefit the countries which, like Great Britain, are situated on the edge of the stream or drift. On the other hand, the supply of warm water is much increased, as pointed out by Mr. Croll, by the configuration of the American continent, which diverts a large portion of the water impelled by the southeast trade winds into the North Atlantic, so that with an excessive supply of warm water and a ready means of getting rid of it, the circulation in it is active and far reaching.

The equatorial minima observed in the Challenger were 1·0259 in 3° N. on the outward, and 1·0258 on the homeward voyage; by Lenz 1·0251 in 7° 30′ N. outward, and 1·02575 in 2° N. homeward-bound. On the outward voyage he appears to have crossed two streams or layers of remarkably fresh water, separated by a narrow stratum of water of the ordinary specific gravity of 1·0261. It is worthy of remark, that wherever the Counter Equatorial Currents, including the Guinea Current among them, are entered, fresher water is found than outside of them. On the outward voyage the Challenger sailed along the Equator from the meridian of 14° W. to that of 30° W. in the course of the south Equatorial Current; the density was found to rise from 1·0259 in the east to 1·0267 in the west, where the dense water of the southeast trade wind region was crossed as it entered the North Atlantic.

In the South Atlantic, as in the North, the maximum is in the heart of the trade wind region, but it is situated considerably nearer the Equator than is the case in the North. It is also lower on the east side than it is on the west, the absolute maximum on the west side being 1·02775 off the Abrolhos Islands. The very high specific gravity which was observed on the Brazilian coast from Cape St. Roque to the Abrolhos Islands is very remarkable, considering the size of the rivers which empty themselves into the ocean in the neighbourhood. It is no doubt explained by the potency of the southeast trade driving the water concentrated by its action constantly against the American coast, part of the stream going into the North Atlantic as the Equatorial Current, and part running along the Brazilian coast as the Brazilian Current, carrying its saltness even beyond the mouth of the River Plate.

Immediately to the south of the Cape of Good Hope there is much variation in the density as well as in the temperature of the surface water. On the Atlantic side both temperature and density are as a rule lower than on the eastern side, where the Agulhas Current brings the warm and dense waters of the tropical parts of the Indian Ocean. In this current the density of the surface water was as high as 1·0266, and in proceeding to the southward it fell rapidly to 1·0260 in 40° S. lat., and 1·0250 in 46° S. From this latitude to the edge of the pack ice this density is maintained with great uniformity (see p. 422).

Icebergs were not found to affect the density of the water much, principally because the temperature of the water was always close to 32° F., and possessed therefore very little melting power. Amongst pack ice, however, the melting point of which is considerably lower than that of freshwater ice, the sea was, as might have been expected, colder and fresher. In fact, seawater ice is a perfect preservative, and possibly, also, to some extent a restorative, of freshwater ice. Hence icebergs, as long as they remain in Antarctic regions, that is, amongst saltwater ice, have little or no tendency to decrease in size; what is melted by the direct rays of the sun being probably much more than made up by the snow falling on the top. It is true that the temperature observations showed the existence of warmer water below the surface, and icebergs floating with any part of their mass in this stratum would have a greater tendency to decay than those less deeply immersed.

In the Pacific the distribution of the salinity differs considerably from that in the Atlantic. The latter ocean is divided sharply into two basins of concentration corresponding to the North and South Atlantic. In the Pacific only the southern concentration area is well marked; in the northern part of the ocean the variations in salinity are slight, and the mean saltness low. In no part of the North Pacific was the specific gravity observed above 1·0265, while in the southern part, in the region of the trade wind, it exceeds 1·0270, and the mean specific gravity is comparatively high. The maximum in the North Pacific is 1·02644 in lat. 30° 22′ N., and in the south it is 1·02714 in 17° S. The equatorial minimum was 1·02475 in 7° 26′ N. lat. in the Counter Equatorial Current.

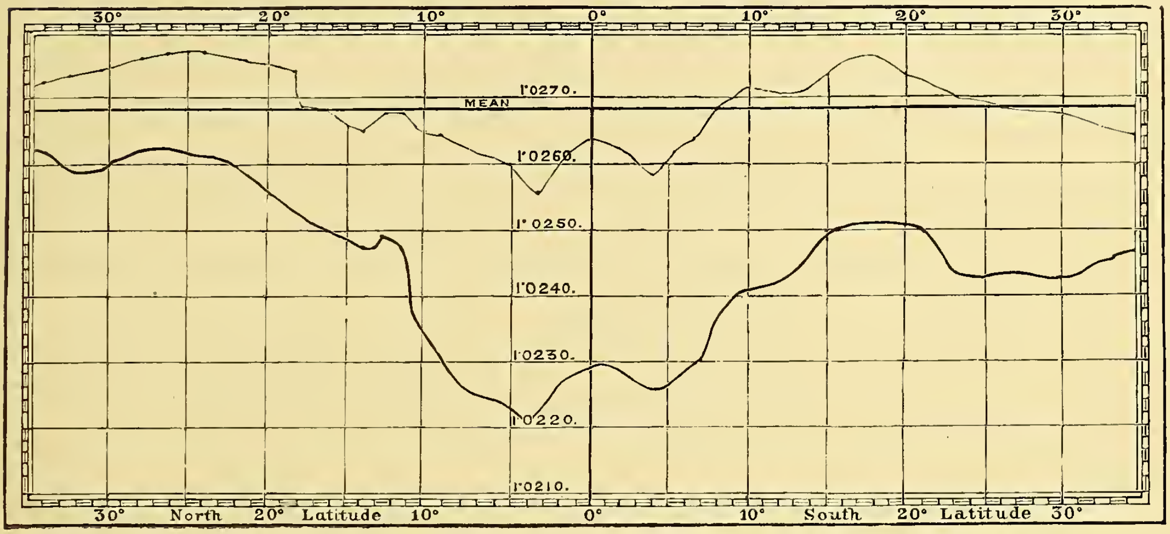
If a line be drawn from Hong Kong to the east coast of Australia, and from Madras one to the west coast of Australia, a region will be enclosed which consists of land and water in nearly equal proportions. Many of the islands are almost continental in size, rise to a great height, and bear on their surface the most luxuriant vegetation of the world. The seas are generally of great depth, and cut off into remarkable separate basins. The amount of upheaval which would be required to transform what is now a sea studded with large and lofty islands into a continent enclosing extensive and deep lakes, would by the majority of geologists be considered quite insignificant. The physical conditions of these masked lakes are also peculiar, more especially as regards temperature. The density of the water, which may be looked on as at one season forming part of the Pacific, and at another part of the Indian Ocean, is remarkably low; and the reason of this is easily found. Lying, as these seas do, on and in the immediate neighbourhood of the Equator, they receive a large amount of rain falling directly on their surface, and in addition, the drainage of the islands in their neighbourhood. The air also above them is always in a state bordering on saturation with moisture, so that notwithstanding the very high temperature frequently attained by their surface waters, the amount of concentration possible is very small. The specific gravity of the greater part of this sea is under 1·0255; and a large area round the islands of Java and Sumatra is under 1·0250. Water so fresh as this is never met with elsewhere, except at the mouths of rivers, or in the neighbourhood of melting ice, although it is of local occurrence in the open sea after heavy rains in the equatorial regions. The saltness of these seas varies considerably at different seasons of the year; at least in the northern part of the China Sea this is remarkably the case. During the prevalence of the southwest monsoon, which is a wetting wind, the water was observed to have a much lower specific gravity than during the dry northeast monsoon; and in these seas there is a regular annual flux and reflux of waters between the Equator and temperate regions—a tide of long period due to the winds. The effect of this tide is shown by its effect on the Japan Stream, which varies much in position, strength, and temperature, and doubtless also in density, according to the season of the year.

It is thus easy to see how a variety of circumstances conspire to equalise and keep down the density of the waters of the Pacific, and especially of the North Pacific. Its form, that of a huge bay, the length or depth of which is about equal to the width of its mouth where it communicates with the great Southern Ocean, affords no facilities for the localisation of the effects of particular climatic conditions. Again, the large amount of fresh water supplied to the seas around the islands which form its western boundary in equatorial regions has been referred to. For half of the year a violent southwest wind blows through these channels, itself heavily charged with moisture, indeed always supersaturated, and driving before it the diluted waters from its source far into the North Pacific, and it is in the North Pacific that the density of the surface water is found to be lowest and most uniform. Also, unlike the Atlantic, there is no facility for the water to get away, consequently the Arctic regions receive no benefit from the tropical heat of either the Pacific or the Indian Oceans. Again, though the eastern shore of Australia resembles that of South America, the warm water driven by the southeast trade wind is not accumulated so as to form a *head* as in the Gulf of Mexico, but leaks into the Indian Ocean through the numberless channels among the islands. Were there a continuous land connection between Australia and the Malay Peninsula, and it is probable that there has been such a connection, the effect on the climate of the northern parts of Asia and America, and probably also of the Arctic regions, would no doubt be very marked, especially as the heating area available in the Pacific is many times larger than that in the Atlantic. On the other hand, however, the much more marked character of the monsoon on the West Pacific coast than on the corresponding Atlantic one, would to a great extent counteract the effect of the southeast trade wind as a furnisher of heated water.

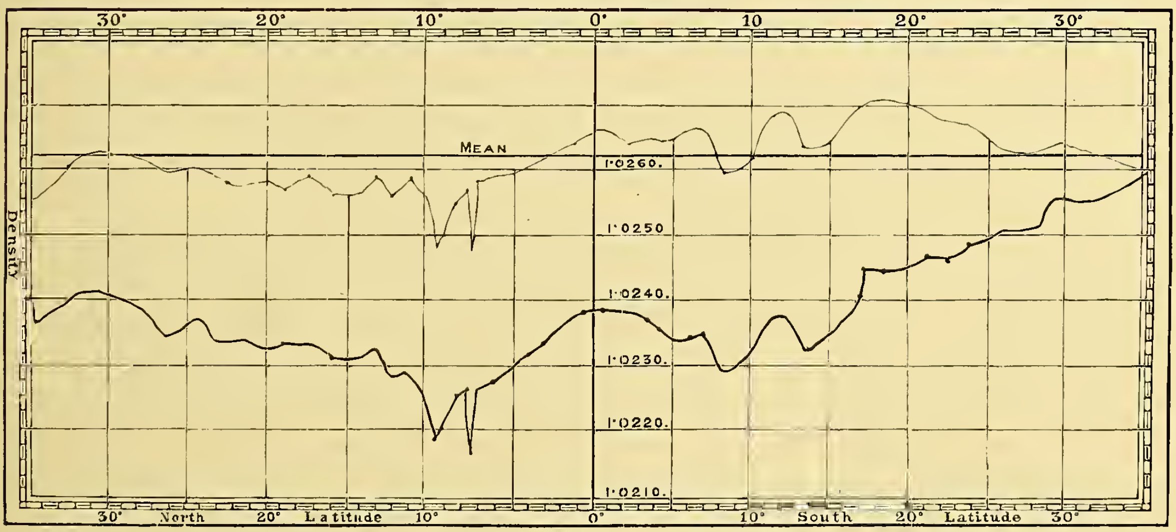
In the Indian Ocean there are few observations with delicate instruments, but to judge from those of Lenz and the "Gazelle," the concentration area due to the southeast trade is not more pronounced than in the West Pacific, with which ocean its waters have a double communication. To the north of the Equator the local influence of the immense continent, which forms its northern boundary, renders the state of its waters very different from what is found either in the North Pacific or North Atlantic. It appears from the observations available, that the water is comparatively fresh all over this area; and this fact must have an important bearing on the conditions of the Red Sea, where the rainfall is almost *nil* and evaporation takes place with such energy that its waters are the saltest that occur in any sea in free communication with the ocean.

The following diagrams represent in a graphic form the densities of the surface water as observed in the Atlantic on the voyage home in March and April 1876 from a position in lat. 35° S., and long. 13° W., touching at Ascension and the Cape Verde Islands to a position in lat. 35° N. and long. 31° W. The light line represents the densities reduced to the constant temperature 60° F. (15°·56 C.). The black line represents the density of the

ATLANTIC OCEAN



PACIFIC OCEAN.



same water at the temperature *in situ*. In the Pacific the figure represents the densities as observed in August and September 1875 on the voyage from a position in lat. 35° N., long. 156° W., touching at the Sandwich Islands and Tahiti to a position in lat. 35° S., long. 132° W. As in the other figure the light line represents densities at 60° F. and the black line densities at the temperature *in situ*.

The course traced by the light line in the Atlantic shows very markedly the great concentration in the trade wind regions and the corresponding dilution in equatorial regions. In the Pacific evidence is seen of materially different conditions. In the South Pacific the trade wind region is clearly marked, though the concentration produced is not nearly so great as in the South Atlantic. In the North Pacific the water between lats. 20° and 30° N. is hardly more concentrated than the average of the equatorial water. Between lats. 7° and 9° N. two very remarkable dips will be observed in the curve. The water here had the abnormally low density of 1·02475. It was in the middle of the Counter Equatorial Current, which was running to the eastward at the rate of 54 miles per day. In lat. 3° N. the Equatorial Current was crossed running 70 miles per day to the westward, and its waters were comparatively dense.

From these curves the following Table (VI.) has been compiled, showing the mean densities at 60° F. and corresponding salinities in grammes per kilogramme of the surface waters in the two oceans as observed along these routes, and computed for every 5 degrees of latitude.

When the densities are reduced to their values at the temperature of the water *in situ*, it is found that, excluding regions affected by ice, the density of the water at the surface decreases with the latitude, and, broadly, the lightest water (1·022 to 1·023) is found at the Equator and the heaviest (1·026 to 1·027) in colder temperate regions. In water below the surface it is found that the apparent anomaly of denser water overlying less dense water disappears. Where the concentrated water of the trade wind region overlies less salt water its higher temperature makes it *in situ* really less dense than the fresher water below. So that if a series of waters be taken at any Station from the surface to the bottom, their densities *in situ* will be found to increase with the depth. Occasional exceptions to this rule are found.

The greatest changes of salinity per fathom of depth occur in tropical regions where vigorous concentration takes place at the surface, and in the first 200 or 300 fathoms from the surface. Here also the temperature falls sufficiently rapidly to counterbalance the effect of decreasing salinity. As the depth increases the changes in salinity become smaller and smaller, and the rate of decrease of temperature with increase of depth diminishes, and the actual density of the water *in situ* is affected chiefly by the pressure of the water above it. The composition, however, of the deeper water of all the oceans is so nearly identical that it may be assumed that their coefficients of compressibility are identical; so that, except for the purpose of actually estimating the weight of a column of water, for all comparative purposes the effect of pressure may be neglected, as it affects equally all waters at the same depth. Experiments made with piezometers on the sounding line showed that the compressibility of water decreases slightly but sensibly with increase of pressure, and this has since been confirmed by experiments made by Professor Tait.

Around the Society Islands the saltest water of the Pacific is found; it is here only that the density exceeds 1·0270, and nowhere does it reach 1·0275. The great bulk of the water in this Ocean has a density under 1·0260. The very low surface specific gravity observed in lat. 9° N. is purely superficial, and is characteristic of the Counter Equatorial Current. As in the Atlantic, the minimum specific gravity is found usually at a depth of about 1000 fathoms, but in the Pacific light water approaches the Equator from *both* sides at the bottom, whilst in the Atlantic it comes in a marked degree only from the south; and consequently in the North Pacific the mean specific

Table VI.

Interval of Latitude.		Atlantic.		Pacific.	
From	To	Density at 60° F. (15°·56 C.).	Salt in Grammes per Kilogramme.	Density at 60° F.	Salt in Grammes per Kilogramme.
35° N.	30° N.	1·02724	36·65	1·02586	34·83
30	25	755	37·03	614	35·20
25	20	766	37·17	589	34·87
20	15	713	36·48	579	34·74
15	10	669	53·91	572	34·65
10	5	635	35·47	552	34·39
5	0	585	34·82	612	35·17
0	5 S.	628	35·38	654	35·72
5 S.	10	649	35·65	642	35·56
10	15	711	36·46	655	35·73
15	20	765	37·16	679	36·04
20	25	728	36·55	690	36·19
25	30	693	36·22	640	35·54
30	35	674	35·98	629	35·39
35 N.	0	1·026924	36·216	1·025863	34·836
0	35 S.	6926	36·218	6554	35·735
35 N.	35 S.	6925	36·217	6209	35·288

gravity is lower than in the south, the contrary being the case in the Atlantic, and no doubt the configuration of these two oceans is the chief cause of their diverging conditions, the North Pacific being, as already stated, a wide open bay, whereas the North Atlantic is more like a lake.

Generally speaking, the density diminishes from the surface down to a depth of 800 or 1000 fathoms, and then increases towards the bottom, where, in the Pacific, the density varies from 1·0254 to 1·0257. In the South Atlantic the bottom density is 1·0258 to 1·0260, and increases to as much as 1·0265 in the North Atlantic. Here, however, is found the greatest collection of dense water to be found in any open ocean, and the basin of the eastern portion of the North Atlantic receives the overflow of very dense water from the Mediterranean, which finds its way out along the bottom of the Strait of Gibraltar. This water having a high temperature (55° F.) and high density (1·028 to 1·029) affects the temperature as well as the density of the bottom water.

In the trade wind regions, the density decreases from a maximum at the surface to a minimum about 1000 fathoms, and then slowly increases again. In the regions of the equatorial calms and rains the specific gravity most commonly increases from a minimum at the surface to a maximum at a depth of from 50 to 150 fathoms, from which point, downwards, it follows the same law as in the trade winds. The existence of the subsurface maximum is probably due to the fact that the water, concentrated on both sides of the Equator, is driven by the wind towards the Equator, where there is a constant supply of fresh water of high temperature, beneath which it is forced to dip. Starting from the source of the trade wind, it is found that while it is concentrating the surface water it is always forcing it farther into warmer latitudes, where, owing to the rise of temperature, the water, though it has become salter, has at the same time become lighter. As the Equator, however, is approached, the rise of temperature with decreasing latitude diminishes, and the water thus becomes liable to sink of itself, even although it were not covered over by the tropical rains. A large quantity of water forced northwards towards the Equator passes into the North Atlantic, owing to the preponderating force of the southeast trade. Here it follows the course of the Equatorial Current into the Caribbean Sea, reappearing as the Gulf Stream, and ultimately forming part of the great lake of warm and dense water which occupies the basin of the North Atlantic. The only outlet for this water is into polar regions, and a portion of the water is driven in this direction and keeps the sea free from ice far into Arctic latitudes. The bulk of it, however, remains in the lake-like basin of the ocean, the central portion of which is known as the Sargasso Sea. In the centre of the northeast trade wind, the evaporation which goes on is very great, whilst at the same time a not insignificant yearly oscillation of temperature takes place; these two causes combined materially assist the propagation downwards both of heat and saltness, and in point of fact in both these respects the waters of this region exceed those of any other part of the ocean. This is particularly well shown by comparing the North Atlantic with the North Pacific. The mean specific gravity of the water between the surface and a depth of 1500 fathoms, at lat. 30° 22′ N. and long. 154° 56′ W., in the Pacific, as determined from observations made at nine different depths on the 21st July 1875, was 1·02534, the depth being 2950 fathoms; at lat. 26° 21′ N. and long. 33° 37′ W., in the Atlantic, the mean specific gravity of the same stratum was 1·02659, from observations at nine different depths on the 3rd May 1876, the depth being 2700 fathoms. The mean temperature of the water down to 1500 fathoms, for the Pacific Station was 40°·16, and for the Atlantic one 45°·53. From observations made in the "Porcupine," in lat. 48° N. a mean temperature of 43°·51 was found down to 1500 fathoms, and in lat. 55° 40′ N. a mean temperature of 43°·11 down to the same depth; it is, therefore, in every way likely that a high specific gravity prevails also down to the bottom. In treating of the concentration of the North Atlantic, it has already been mentioned that that ocean is the recipient of all the brine from the Mediterranean, where evaporation goes on with great vigour. Notwithstanding the great supply of fresh water from the numerous European rivers and the Nile, which is constantly pouring into it, and the rain which falls on itself, there is a constant deficiency in the amount of water present in its basin. That this is so, is evident from the existence of a constant inflow through the Strait of Gibraltar at the surface and southern side, and outflow at the bottom and northern side of very salt water, both streams being, however, modified by tidal currents. The Mediterranean and Red Seas furnish instructive examples of what ocean water tends to become when subjected in the first case to an average climate similar to what prevails in the trade wind regions of the North Atlantic, and in the case of the Red Sea to a climate of almost perfect dryness and great heat, both being connected with the open ocean, so as to admit of interchange of water. The Baltic and Black Seas afford examples of similar seas in colder and damper climates, while the Dead Sea and the depression in which it lies show the result of completely isolating a drainage area in a very dry climate. The water of the Dead Sea is saturated, containing as much as 28 per cent. of salt. The water of the Red Sea contains 4 per cent. of salt, and that of the Mediterranean 3·6 to 3·9 per cent., thus showing the freshening effect of communication with the ocean.

It is worthy of remark that in the Norwegian Sea, which stretches from the Færöe Islands to Spitzbergen, and attains a depth of 2500 fathoms, the deep water was found to be distinctly of Atlantic origin, both on account of its high salinity and of the small amount of dissolved nitrogen which it contained. The comparatively very salt water of the Atlantic is rendered less dense by its high temperature, and is thus able to penetrate into the Arctic regions, where, on being cooled by the winter climate, it sinks down, raising the salinity of the Arctic water with which it mixes, and at the same time carrying down to the bottom approximately the temperature of freezing sea water. The distribution of temperature and salinity in this remarkable basin, which has been so thoroughly studied by the Norwegians in their yearly expeditions, affords the strongest proof of the efficacy of high surface salinity, and a considerable difference of winter and summer temperature in cooling the deeper waters of the sea.

The portion of the Equatorial Current which is diverted southwards on striking the Brazilian coast carries warm and concentrated water far to the southward, and similarly from the Indian Ocean the Agulhas Current brings warm and dense water into the colder regions of the Southern Ocean. The observations made in the South Atlantic on the 28th February 1876, in lat. 35° 39′ S., long. 50° 47′ W., depth 1900 fathoms, show the existence of the dense water from tropical regions penetrating to a great depth. The density (at 60° F.) of the bottom water was found to be 1·02650, and the trustworthiness of this observation is confirmed by the fact that the "Gazelle," in a sounding close to the spot (lat. 34° 36′ N., long. 49° 46′ W.), found the density of the bottom water to be 1·02654 in 1875 fathoms. In a sounding in 1900 fathoms, just off the Agulhas Bank, the bottom water had a specific gravity of 1·02607, which could only have come from the Indian Ocean. The surface water of this ocean is not remarkable for saltness; indeed, in the equatorial part it is very much below the average of Pacific equatorial water. There is, however, one region in the northern part of this ocean, in which concentration goes on with very great vigour, namely, in the Red Sea; and just as the evaporation of the water in the Mediterranean affects the specific gravity of the deep water of the North Atlantic, so may the Red Sea furnish concentrated water to the depths of the Indian Ocean. An objection might be raised to this source of the heavy water observed by the "Gazelle" between Mauritius and Australia, from the fact that the temperature of the bottom water was not above the normal, whereas water coming from the Red Sea must enter the Indian Ocean with a temperature of 70°. Taking the density of the bottom water of the Antarctic Ocean to be 1·0255, and that of the deep water of the Red Sea to be 1·0300, it will be seen that to produce water of the density 1·0261 it is necessary to mix six volumes of Red Sea water with thirty-nine volumes of Antarctic water. If the temperature of the Red Sea water be 70° F., and that of the Antarctic water 33°·5, the temperature of the mixture would be 38°·3. The bottom temperature in the Agulhas Current as determined on December 18th, 1874, was 36°·4. It is therefore probable that the overflow from the Red Sea has a considerable influence on the temperature and density of the deep water of the western Indian Ocean. The effect of concentration in raising the temperature in the subsurface water of this ocean is very evident; in lat. 24° 41′ S. the mean temperature of the water down to 1500 fathoms was 46°·4 F.

To compensate for the warm water flowing from tropical to polar regions, there are cold currents flowing in the reverse direction. One of the most remarkable is that which comes down Baffin Bay, and hugging the American coast penetrates as far south as the latitude of Washington before it is absorbed into the body of the ocean, to the cold of the deeper waters of which it very materially contributes. Another equally remarkable current is that which brings the cold water from the south polar regions up along the South American coast at the bottom as far as the Equator. The bottom water in the corresponding situations in the Pacific and Indian Oceans is found to be much warmer, and it is probable from this fact that the depth between Cape Horn and the south polar land is much shallower than that between either Africa or Australia and the same land. In any case it is certain that facilities must exist here for promoting the flow of cold water at the bottom from high Antarctic latitudes into the lower latitudes of the South Atlantic Ocean. The South American continent extends to the parallel of 56° S. The depth of the sea to the south is unknown, but from the edge of the bank south of the Falkland Islands to the South Shetland Islands is only 380 miles, so that there is some reason in dealing with water at depths of 1500 fathoms and upwards, for assuming a direct connection between the American continent and these islands. Farther to the eastward there are three groups of islands, namely, South Orkneys in 61° S., the Sandwich group in lat. 59° to 56° S., and South Georgia in 54° S. All of these are covered with eternal snow, and are exposed to a glacial climate. Of Georgia, which lies 2° farther north than Cape Horn, the bays are terminated by ice cliffs of considerable height, and according to Cook the country in the very height of summer is in a manner wholly covered many fathoms deep with frozen snow, but more especially on the southwest coast.[1] In the ice chart of the Southern Ocean the line "freezing point in air in January and February" passes through the Sandwich and South Shetland groups, and the northern limit of icebergs reaches the very low latitude of 40° S. The dense water of the tropics, which has been diverted in a southerly direction by the South American continent, is brought directly into this very cold climate, and by virtue of its great salinity affords the means of promptly conveying the surface cold to the bottom. If this cold water have a tendency to flow from the poles, it will in these high latitudes experience a strong thrust towards the westward, due to the increasing rotational velocity of the earth's surface. That this does take place is shown by the low bottom temperatures observed at every Station along the western side of the South Atlantic almost to the Equator, and that there is here a sensible current of cold water along the bottom is shown by the sudden change in the rate of decrease of temperature with increasing depth which is observed at depths of from 2000 to 2200 fathoms. It shows that the water between the bottom and 2000 fathoms is nearly as distinct from the water above it as the water of the "cold wall" on the North American coast is from the Gulf Stream outside it. The temperature observations on the 28th and 29th February 1876 show that the surface of this cold stratum is not level, but rises towards the American shores. On the 28th February the Station (323) was in lat. 35° 39′ S., long. 50° 47′ W., depth 1900 fathoms, and therefore on the continental declivity forming the western containing

[1] See Darwin, Journal of Researches during the Voyage of H.M.S. "Beagle," p. 248, ed. 1879.

boundary of the ocean; on the 29th, 120 miles to the eastward, the bottom of the basin had been reached in 2800 fathoms. On the 28th the "dip" in the temperature took place at 1700 to 1900 fathoms, while on the 29th it was found at 2100 to 2300 fathoms.

The temperature of the water from 2400 fathoms to the bottom was uniform, the mean result of six observations being 32°·43. This water underruns the body of the Atlantic water, which at 1500 to 2000 fathoms has here a temperature of 37°, producing a temperature gradient of about 1°·3 per hundred fathoms at the steepest. For the preservation of this gradient a considerable supply of cold water is requisite, and it must be drawn from higher latitudes. But any motion of the water towards the Equator will be accompanied by a strong deflection to the westward (proportional to the change of the cosine of the latitude). A measure of this deflecting force is furnished by the rise of this cold water at the more inshore Station on the 28th, where the maximum gradient is at about 1750 fathoms, while on the 29th, at a distance of 120 miles, it is at about 2100 fathoms. Hence the average incline produced on the surface of the cold water by this tangential force is 350 fathoms in 120 miles, or approximately a gradient of 1 in 350. Between latitudes 36° and 35° the tangential force increases in the proportion of 81 : 82. In the northern hemisphere there is no polar current at the bottom which can be compared with this one. The North Atlantic water which penetrates into Arctic regions is cooled, and fills up the whole of the deep basin of the Norwegian Sea with cold but dense water, but its passage southward is barred by the ridge stretching from Greenland by Iceland, Færöe, and the Shetlands to Norway, the greatest depth of water on which does not exceed 300 fathoms. The northward drift at the surface is largely influenced by tidal currents which stir up the water to the very bottom, keeping the summit of the ridge clear of mud.[1] Were it not for this ridge there would doubtless be a similar current occupying the deep water along the edge of the continental plateaus of Europe and Africa.

A very remarkable current exists in the North Atlantic close to the shores of Morocco, and extends from Cape Bojador to Cape Spartel and even through the Strait of Gibraltar along the African coast into the Mediterranean. This current, which flows in a northerly direction, is confined to the immediate neighbourhood of the coast, not extending more than 20 miles out to sea. Its waters are characterised by their low density and temperature as compared with the water immediately outside, and by their deep olive-green colour. In October 1883 the S.S. "Dacia" found the temperature of the water out at sea to be very constantly 69° F.; when the African coast in the neighbourhood of the town of Mogador was approached the temperature and the density began to fall perceptibly and close in within a couple of miles of the shore, and in less than 50 fathoms, the temperature fell to 61° in water of a pure olive-green colour, and the density (at 60° F.), which had been 1·0268 outside, fell to 1·0264. When it is remembered that the trade

[1] See Encycl. Brit. Article, Norwegian Sea, vol. xvii. p. 592, 9th ed., 1884.

winds drive the surface water of the Atlantic bodily to the westward, thus drawing the water away from the eastern side of the ocean, it is evident that while it pushes the water westward it must drag water from some other direction to supply its place. No doubt much of it is supplied by surface drift from the southward and eastward, but if the temperature curves of the water off the coast of Guinea be studied, it will be seen that much of the water which is brought into the eastern part of the Atlantic to supply that drained away by the Equatorial Current and other westerly streams is supplied from the deeper, colder, and less dense strata of southern seas. On the 11th August 1873, in the Guinea Current the surface temperature was 78°·7, and at 50 fathoms it was only 54°·2, the decrease being at the average rate of 0°·5 F. per fathom. The latitude of this Station was 12° 5′ N. If this be accepted as an indication of the deep water of the southern hemisphere penetrating to the northward of the Equator, it follows necessarily that as it goes farther north it will experience a thrust to the eastward, and will therefore be thrown up against the western shores of Africa, and the observed cold current coming from the south and entering the Strait of Gibraltar would be satisfactorily explained. It must be remembered that to produce and sustain the observed temperature gradient of 7° F. in less than 20 miles, and a difference of 5° F. between the temperature of the surface water and that of the air above it, a considerable and active supply of cold water is absolutely necessary, and it is observed to have a motion from the southward.

It is difficult to make an accurate estimate either of the mean depth or the mean salinity of the ocean, but taking the one at 2000 fathoms (3660 metres) and the other at 35·5 grammes per litre, there would be an average of 1300 kilogrammes of salt dissolved per square decimetre of sea surface. Taking the specific gravity of sea salt at 2·5, this would give the amount of salt dissolved as equivalent to a layer of it 52 metres, or 170 feet thick over the whole area of the ocean.

It may be pointed out that organisms which secrete silica are much more abundant in the Pacific, where the specific gravity of the water is relatively low; and, on the other hand, organisms which secrete carbonate of lime are relatively more abundant where the specific gravity of the water is high, as, for instance, in the tropical regions of the Atlantic.

The ratio of total salts to water has been discussed when treating of the density of the water at constant temperature. During the cruise samples of sea water from very various depths and localities were collected and preserved in glass-stoppered bottles, and from time to time sent home. After the return of the Expedition a large number of these were handed over to Professor Dittmar for analysis. On his analyses of a portion of these, and his work in connection with the subject, Professor Dittmar has furnished an exceedingly valuable Report,[1]

[1] Report on the Composition of Ocean-Water, Phys. Chem. Chall. Exp., part i., 1884.

which will be quoted liberally. With reference to the composition of the salt mixture dissolved in sea water, Professor Dittmar says :—

"*A priori*, we should say that this composition cannot be subject to any great variation; because, if there were no chemical changes going on in the ocean, and no gain or loss of dissolved individual salts, this composition would now, after thousands of years' constant intermixture, be absolutely the same everywhere; and what is going on in the shape of reactions and importation or exportation of individual salts, really amounts only to an extremely minute fraction of the whole, even in the course of a century. This conclusion is confirmed by the analyses of several hundred samples of surface waters, which were carried out by Forchhammer in connection with a great research which he published in 1864.[1] According to his results, if we confine ourselves to the open ocean, we find that everywhere the ratios to one another of the quantities of chlorine, sulphuric acid, lime, magnesia, and total salts exhibit practically constant values. With the view chiefly of supplementing Forchhammer's work, I have made exact determinations of the chlorine, sulphuric acid, lime, magnesia, potash, and soda in 77 samples of water collected by the Challenger from very different parts of the ocean :—

12 from the surface.
10 from depths of 25 to 100 fathoms.
21 from depths of over 100 to 1000 fathoms.
34 from greater depths.

"The results, while fairly agreeing with Forchhammer's, were in still closer accordance with one another, and thus showed that Forchhammer's proposition may be extended from surface waters to ocean waters obtained from all depths.

"The solid matter dissolved in sea water, though strictly speaking, and we may add necessarily, of a very complex composition, consists substantially of the muriates and sulphates of soda, magnesia, lime, and potash. Forchhammer, after having satisfied himself that all the other constituents taken conjointly amount to only a small fraction of one per cent. of the total solids, in his individual analyses limited himself to exact determinations of the chlorine, sulphuric acid, lime, and magnesia. The potash he determined only in a comparatively small number of samples; and where he reports the soda this component is calculated by difference, on the assumption that the acids and bases present exactly neutralise each other. But this assumption had never been proved to be correct, and *à priori* is improbable, because it leaves out of reckoning the carbonate of lime which many animals need for forming their shells. I therefore in my analyses made it a special point, in addition to the other bases, to determine also the soda by a method independent of the assumption quoted; and on calculating my first set of (21)

[1] *Phil. Trans.*, vol. clv. p. 203, 1865.

Challenger water analyses, had the satisfaction of finding that they had all given a small surplus of base, amounting on an average to 86 equivalents per 10,000 equivalents of acid present, corresponding (if we assume the excess of base to be present as normal carbonate) to about 0·11 gramme of carbonic acid, equivalent to 0·25 gramme of carbonate of lime per 1000 grammes of sea water analysed. While recognising the importance of this result, I was keenly alive to the possibility of its having been brought about by a constant positive error in my sum total of base determinations, and accordingly sought for an exact direct method for the determination of the surplus base in a given sea water."

That sea water has an alkaline reaction was observed early in the cruise by Mr. Buchanan. On the 29th September 1873 it was first remarked, and on that day the alkalinity in the cold of the surface water was repeatedly determined in samples of 500 c.c. each by means of tenth normal hydrochloric acid, using rosolic acid as an index. It was found that 3·5 c.c. 0·1HCl was required to neutralise 500 c.c. sea water, or that 1 litre of sea water is sufficiently alkaline to neutralise 7 c.c. of tenth normal acid, neutrality being indicated by rosolic acid. In other words, the alkalinity is equal to what would be produced by dissolving 28 mgrm. caustic soda (NaHO) in a litre of water. It was found that the water so neutralised recovered its alkaline reaction on standing, and that its alkalinity was increased by boiling.

Mr. Buchanan's observation of the alkalinity of sea water, though original, was not new. It had already been observed by v. Bibra. Its true significance was not seized until the discovery was again made independently by Tornøe on the Norwegian expedition. By working it out he showed that the whole of the carbonic acid in the sea waters experimented on by him must be taken as combined with base, and the average of his experiments gave for carbonic acid forming carbonates 52·78 mgrm. per litre and for carbonic acid forming bicarbonates 43·64 mgrm. per litre, that is, that in the average of the waters examined by him there were bicarbonates and neutral carbonates dissolved in the proportions of 43 : 9. It is evident that in these waters there was no carbonic acid which could be called "free," and the deficiency in the amount required to form bicarbonate goes to explain the alkaline reaction of freshly drawn sea water in the cold.

Professor Dittmar in his Report treats the subject of the alkalinity of sea water and its dependance on dissolved carbonates in an elaborate and exhaustive manner.

The average composition of ocean water salts, as the result of 77 complete analyses, has been given on p. 954. Commenting on these results, Professor Dittmar says :[1]— "As a general result of Forchhammer's and my own analyses, *the above numbers may be taken as holding approximately for any sample of ocean water.* Of the degree of approximation we can form an idea by comparing my numbers for the percentages of chlorine, sulphuric acid, magnesia, and potash, with the corresponding entries in the 77 reports tabulated on pages 23 to 25, and the numbers for the lime there with

[1] Phys. Chem. Chall. Exp., part i. p. 204, 1884.

one another. The percentages of soda being too largely affected by the cumulative error of the other determinations, had better be left out of consideration. But even if we do so, we often meet with fluctuations which are too great to be taken as arising from analytical errors, and consequently must correspond to differences in the actual composition. I have taken great pains in trying to explain these differences by natural causes, but have not been very successful. The final results of my inquiries may be summed up as follows:—

"From my analyses (which I do not pretend exhaust the subject) it would appear that the composition of sea water salt is independent of the latitude and longitude whence the sample is taken. Nor can we trace any influence of the depth from which the sample comes, if we confine ourselves to the ratio to one another of chlorine, sulphuric acid, magnesia, potash, and *bromine.* I emphasise the bromine because, while present in very small proportion, it is taken up preferably by sea plants, and consequently must be presumed to be more liable than any of the major components to at least temporary local diminution. And yet my analyses of the three mixtures of Challenger waters, and of the Arran water referred to, gave identical values for the bromine present per 100 of chlorine. But the determinations of the lime in the same set of waters make it most highly probable that the proportion of this component increases with the depth. Referring to 100 parts of halogen calculated as chlorine, we find for the quantity of lime :—

In deep-sea waters—	
Mixture III., ...	3·0307
In surface waters—	
Mixture I., ...	3·0175
Difference, ...	0·0132
In medium depth waters—	
Mixture II., ...	3·0300
In surface waters, ...	3·0175
Difference, . . .	0·0125

and either of the two differences is five to six times as great as even the absolute sum of the probable errors of the respective two terms. A discussion of the quantities of lime brought out by the 77 analyses had given a similar result, but exaggerated the difference between deep-sea on the one hand and shallow or medium depth on the other.

"But there can be no doubt that, if I had applied even as exact a method in the 77 analyses as I did subsequently in the special investigation on the lime, I should have arrived at a greater difference than 0·013 between certain individual samples.

"The result under discussion received a valuable confirmation from the alkalinity determinations to which I had occasion to refer above. Following the example of the Norwegian chemists, I measured the surplus base (*i.e.* the base left unsaturated by the sulphuric and hydrochloric acid) by the weight of carbonic acid (CO_2) which it would need to convert it into normal carbonate, and referred it to 1 litre of water analysed. But it struck me that in discussing any series of such determinations, they must be referred to a constant salinity, and I accordingly reduced all my numbers to 100 parts of total salts or 55·42 of halogen counted as chlorine ; so that with me 'alkalinity,' as designating a quantity, means 'the weight of carbonic acid (CO_2) present as normal carbonate (*i.e.*, in forms similar to carbonate of lime) in every 100 parts of total salts,' which, on an average of 130 cases, and if the number of parts by weight of carbonic acid be taken in grammes, corresponds to 2·78 litres. Omitting a number of abnormally high or low values, and a few suspected analyses, which left 130 cases for discussion, I found the alkalinity in the whole set to range substantially from 0·140 to 0·164, and then, confining myself to 'surface' waters (meaning waters from depths not exceeding 100 fathoms) and bottom waters, and referring on both sides to 100 samples, I found that alkalinities from 0·140 to 0·148 occur preferably in surface waters, while from 0·148 to 0·160 the bottom waters were in the majority. From a graphic representation[1] showing the frequency of occurrence of certain narrow ranges of alkalinity, I concluded that the most frequently occurring value is

For surface waters, ...	$0·146 \pm 0·002$
For bottom waters, ...	$0·152 \pm 0·003$

which values may be adopted *provisionally*, for the two kinds of ocean water. In fifteen cases I was in a position to compare with one another the alkalinity of a surface water and the bottom water at the same Station. In two cases the balance was in favour of the surface water, the numbers being 0·015 and 0·010 respectively; in one case the difference was *nil;* in the remaining twelve cases it was in favour of the bottom water, the differences ranging from 0·002 to 0·019. According to the above two averages the alkalinity of bottom water exceeds that of surface water by 0·006, meaning of course 0·006 grammes of carbonic acid per 100 grammes of total salts, or 0·014 grammes of lime CaO per 100 of chlorine, if we assume the increase in alkalinity to be owing to additional lime. My determinations of the lime, as stated, had shown the presence of 0·013 grammes of extra lime in deep-sea as compared with shallow waters. The *closeness* of the agreement is of course accidental. That the surplus base in a sea water is not owing entirely to carbonate of lime is too obvious to be specially pointed out. In sea water (as in any mixed salt solution) each base is combined with each acid, and as there are four acids and four bases there must be sixteen salts, the individual percentages of which we have no means of determining. But there are reasons for assuming that the carbonic acid

[1] See Diagram, Phys. Chem. Chall. Exp., part i. p. 136, 1884.

being a feeble acid, is combined chiefly with the weakest bases, and consequently chiefly with the magnesia, and in the second instance with the lime. So we should say, if the arrangement of the bases and acids into salts were a mere matter of tendency to form simple salts. But magnesium has a characteristic tendency to form double chlorides with potassium and sodium, and there is superabundance of chloride of sodium in sea water. Hence, probably, most of the magnesium is not there as carbonate but as double sodio-chloride, and the lime takes the greater share of the carbonic acid. The alkalinity in any case represents the potential, and may fairly be presumed to measure approximately the actual, carbonate of lime. This is the only answer to that often raised question about the presence of ready-formed carbonate of lime in sea water, which some chemists, who at the time must have deliberately shut their eyes to the established propositions of chemistry, have endeavoured to solve by direct experiment. Supposing actual carbonate of lime could be extracted from sea water without the co-operation of external matter (I greatly doubt whether this has ever been done), the weight of such extracted carbonate of lime could not reasonably be assumed to be equal to that which was originally present in the water. Sea water is alkaline, all the alkalinity must be owing to carbonates, and of these carbonate of lime must be one. This is, and for a time is likely to be, the sum total of our knowledge on this point."

At the time when the Challenger Expedition was decided on, and the nature of the work to be done in the different departments was being considered, the chemist's attention was principally directed to the gaseous contents of the water, understanding these to mean the oxygen, nitrogen, and carbonic acid.

Dr. Jacobsen, who had been engaged as chemist on board the German ship "Pommerania" in her cruise in the North Sea, had found that the method boiling *in vacuo*, which was sufficient for the extraction of the oxygen and nitrogen, was useless for extracting the carbonic acid. He found that, to obtain concordant results, it was necessary to distil the water sample almost to dryness and collect the carbonic acid which came away with the steam in baryta water or similar absorbent, and determine it thus directly. The amount of carbonic acid which Jacobsen thus found (about 88 mgrm. per litre) was enormously in excess of what pure water could hold in solution when exposed to the atmosphere under similar conditions. At the same time he was unable to find in the residue when the water was evaporated to dryness an amount of carbonate in any way sufficient to account for the retention of the carbonic acid as bicarbonate. Jacobsen was inclined to ascribe to the chloride of magnesium, which is present in large quantity in sea water, the property of retaining the carbonic acid. When the "Pommerania" touched at Leith on her homeward voyage in August 1872, Jacobsen very kindly communicated to Mr. Buchanan all the facts which he had observed, and his views as to their possible explanation.

Believing that in whatever combination the carbonic acid might be present it would be liberated by boiling the water with excess of acid, Mr. Buchanan proposed to determine the total carbonic acid by boiling the acidified water and determining the eliminated carbonic acid. This method was met by the sufficient objection that the carbonic acid so determined would include any that might be present as neutral carbonate, that is, it would include both the molecules of carbonic acid of any bicarbonate which might be present. The sufficiency of this objection lies in the fact that in 1872 the object of determining the carbonic acid in the water was to furnish precise data as to the state of the atmospheric contents of the water or the amount to which the atmosphere available for the creatures living in the water was vitiated, and it was felt that the so-called half-bound carbonic acid of a bicarbonate might be considered as belonging to the atmosphere, but that this was impossible with the other and more closely combined portion.

This being so, Mr. Buchanan lost no time in making such investigations as the short time available would admit of into what might be the cause of the retention of the carbonic acid. It was, of course, well known that if carbonates were present they would account for some portion of the retained carbonic acid, but in view of the negative results which had attended the labours of some chemists who had sought for them, it was evidently important to experiment on other ingredients known to be present in quantity in sea water, and of these the sulphates of lime and magnesia and the chlorides of magnesium and sodium claimed chief attention.

Solutions of these salts were saturated with carbonic acid and distilled either immediately or after an interval of time, and it was found that, as compared with the behaviour of distilled water when similarly treated, solution of sulphate of magnesium exhibited the property of retaining carbonic acid in a marked way like sea water. This being so, Mr. Buchanan drew the practical conclusion that if the carbonic acid is retained whether in whole or in part by the sulphates it will be more easily extracted if these are eliminated. For this purpose, in all the determinations made on board the Challenger, a sufficient quantity (10 c.c.) of a saturated solution of chloride of barium was added to the sample before boiling. The immediately apparent effect of this was that the carbonic acid came away easily and abundantly the moment the water boiled, and passed principally in the first fifth of the distillate; also the liquid boiled down to dryness without any bumping.

As has been mentioned above, one great result of Tornøe's work in connection with the Norwegian expedition was to show that in the waters examined by him the amount of carbonic acid present was insufficient to form bicarbonate with the neutral carbonate which he so easily and accurately estimates by his alkalinity method. It is probable that this holds in the majority of cases, so that the retention of the carbonic acid is accounted for by the dissolved carbonate without the necessity of calling in the assistance of the sulphates. How was it then that the precipitation of the sulphates as baryta sulphate undoubtedly facilitated the liberation of the carbonic acid, and at the same time the amount of carbonic acid eliminated from sea water by this method was never more than about one half of what Jacobsen found in water of the North Sea under similar conditions? These effects were due to the fact that when chloride of barium is added to a solution containing sulphates and carbonates in suitable proportion, a double salt of carbonate and sulphate of baryta is precipitated, and this salt, as was observed by Rose, is only very slowly attacked even by strong acids. The effect then of the addition of the chloride of barium was, besides removing the sulphates, to remove the carbonate from the carbonic acid with which it was combined, and in this way facilitate its escape, and to preserve the carbonate from attack by the saline solution by transforming it into the more refractory double baryta salt. This result was not foreseen by Mr. Buchanan at the time, but it justifies the presumption that the amounts of carbonic acid found by him in the numerous samples of water examined really do give with considerable accuracy the factor which was sought, namely, the carbonic acid which is present in the water, otherwise than as carbonate. As Professor Dittmar has found that this can be in a great measure eliminated by simple shaking with air at ordinary temperatures, this carbonic acid is rightly looked on as atmospheric.

When the carbonate has been precipitated as double salt by means of chloride of barium, the half-bound carbonic acid thus set free would, if sea water from which the carbonates have been removed, behaved like pure water, be completely eliminated on distilling over about one-eighth of the liquid. Now, although the bulk of it does come over with the first portions of the distillate, a number of experiments made for the purpose of testing the matter showed that, even after 70 per cent. of the liquid had passed, traces of carbonic acid were evolved. This may be due either to the retaining action of chlorides, as was supposed by Jacobsen, or to a slight decomposition of the precipitated carbonate by the boiling saline solution. If the former be the case, then the results require no correction, for they give what was sought, namely, all the carbonic acid not united to base in the form of normal carbonate (R_2CO_3); if the latter supposition be true, then all the results are in excess of the truth. Considering the absolute uniformity with which the determinations were made, this error in excess would probably be a constant very small amount which would fall to be deducted from all the results. The results then, as copied from Mr. Buchanan's journal in Professor Dittmar's Report (p. 119), give a maximum value for the loose and half-bound carbonic acid. Any correction which may have to be applied will be subtractive, and probably insignificant.

On looking at the results as tabulated, one is struck at once by their want of uniformity. The great variations in values under similar conditions are certainly real, and not to be explained by defects in the method. Confining the attention for a moment to the quantity found in surface water, and assuming, with Professor Dittmar, the amount of carbonic acid present as neutral carbonate to be 55 mgrm. per litre, it will be seen that, out of seventy-two surface waters examined, only seven contained more than the amount of carbonic acid eliminable by this method. Of these seven cases, three were waters at temperatures above 70° F., and three at temperatures below 35° F. On the whole, less carbonic acid was found in warm than in cold latitudes. Omitting two abnormally high but not incorrect results obtained in the tropical sea between Fiji and Torres Strait, the following table shows the mean amount of carbonic acid per litre in all the surface waters arranged according to the temperature of the water *in situ*:—

Number of Cases taken Account of.	Temperature Interval, ° C.	Carbonic Acid, Milligrammes per Litre.
20	25°·0 to 28°·7	35·88
15	20·0 ,, 25·0	37·18
10	15·0 ,, 20·0	42·68
8	10·0 ,, 15·0	43·50
8	5·0 ,, 10·0	47·21
9	−1·4 ,, +3·2	53·31

The observations made on waters from different depths are averaged in the following Table:—

Depth in Fathoms.	Carbonic Acid. Grammes per Litre.	No. of Determinations of CO_2.	Average Temperature of Water.
			° C.
Surface.	0·0426	73	...
25	0·0337	2	...
50	0·0488	10	...
100	0·0436	5	14·6
200	0·0446	8	13·0
300	0 0440	4	6·9
400	0·0411	10	5·1
800	0·0422	7	2·5
over 800	0·0446	7	1·5
Bottom	0·0474	54	...

Taking 45 mgrm. as a mean amount of carbonic acid, and 2000 fathoms (3660 metres) as the mean depth of the ocean, this corresponds to a layer of carbon 3·45 cm. thick over the area of the ocean.[1] It is right to observe here in connection with the determination of lime and of carbonic acid in sea water, that the freshly collected sample undoubtedly contains in almost all cases a certain amount of carbonate of lime suspended as living organisms, which, owing to their minuteness and transparency, do not produce any apparent turbidity in the water. The distribution of these organisms is subject to local concentration, so that samples of water taken from neighbouring localities may, and usually do, contain very different amounts of this suspended matter. When these organisms consist, as regards mineral constituent, of carbonate of lime, this carbonate of lime will not be affected by the chloride of barium, but will be subject to the decomposing influence of the boiling solution of chloride of magnesium during the distillation of the sea water, and would account, at least in part, for the continued evolution of carbonic acid during the whole distillation, and for the want of uniformity in the results. Quantitative experiments made by Mr. Murray with the tow-net have shown that as much as 16 tons of carbonate of lime may be suspended in this form in a mass of sea water one mile square by 100 fathoms in depth. These organisms die, the

[1] In a lecture on his Challenger work delivered to the Glasgow Philosophical Society, Professor Dittmar submitted a diagram showing the absolute composition of ocean salts.

Unit = 1 billion tons = $10^{12} \times 1000$ kilogrammes.

Chloride of sodium,	35,990	From Prof. W. Dittmar's analyses and oceanometric data given by Boguslawski.
Chloride of magnesium,	5,034	
Sulphates,	2,192	
Sulphate of zinc,	1,666	
Sulphate of potash,	1,141	
Bromide of magnesium,	100	
Carbonate of lime,	160	
	46,283	
Total bromine (Dittmar),		87·2
Total iodine (Köbbstorffer),		0·03
Total chloride of rubidium (from C. Schmidt's analyses, as reported by Robb, Chemische Geologie),		26·6
Total mass of the ocean,		= 1322355 units.

Prof. Dittmar in the same lecture utilised certain data regarding the solids introduced into the ocean by rivers, which he found in Boguslawski's Ozeanographie, for forming an estimate, however rough, of the rate at which these add to the amount of carbonate of lime. According to Boguslawski's statement of the total water introduced by the thirteen principal rivers per annum on the one hand, and their average content of solids according to Bischoff on the other, it appears that these thirteen rivers contribute about $1·3375 \times 10^9$ tons of solids per annum, of which about one half may be said to be carbonate of lime. Assuming the carbonate of lime contributed by all rivers to amount to just so much, and comparing this with the 160×10^{12} tons of the same substances which are contained in the present ocean, it would take $\frac{160 \times 10^{12}}{1·3375 \times 10^9} = 119400$ years to bring up the total oceanic carbonate of lime to double its present amount; or 1194 years to increase it by 1 per cent. of its present value.

lime passes into solution in the water, and their bodies use up the oxygen of the water to form carbonic acid.

One of the most important discoveries made during the voyage was that the occurrence of carbonate of lime on the bottom depends mainly on the depth of the sea above it. "Pteropod ooze" is not found in depths greater than 1500 fathoms, or Globigerina ooze, as a rule, in greater depths than 2500 fathoms. The animals, the shells of which, when dead, form these deposits, live almost exclusively at or near the surface; when they die they sink to the bottom, and it appears that the time which a Pteropod takes to sink through 1500 fathoms of average sea water is such that the water is able to dissolve it completely; the larger and thicker shelled pelagic Foraminifera are able to last till they reach 2500 fathoms. If, as appears to be generally the case, all the carbonic acid is already united to base either as neutral carbonate or bicarbonate, it is evident that it can have no part in assisting the solution of more carbonate of lime. It has been found, however, that sea water even without excess of carbonic acid has the power of dissolving carbonate of lime, though the presence of free carbonic acid renders it a much more energetic solvent. Professor Dittmar thinks the cause of the disappearance of the surface shells from the deeper deposits is not that deep water contains any abnormal proportion of loose or free carbonic acid, but the fact that even alkaline sea water, if given sufficient time, will take up carbonate of lime in addition to what it already contains.[1] It is probable, however, that carbonic acid does play an important part in the solution of the shells of animals sinking through the water. The organic matter of the animal on being oxidised produces carbonic acid, which being itself a liquid at all depths over 200 fathoms, will form a locally concentrated acid solution inside the shell, which it will attack with vigour.

The presence of carbonic acid in sea water was shown in a remarkable way by its presence in the drinking water. Except during prolonged stay in harbour the fresh water used on board the ship was supplied entirely by distillation from sea water. The steam was taken from the ship's boilers and entered at the bottom of the condenser, forcing by its pressure the condensed water up into the so-called aerating tank from which it went to the store tanks in the hold. There was thus no escape for the carbonic acid except through the distilled water. Freshly distilled water was frequently taken hot from the condenser and tested immediately. The amounts of carbonic acid per litre are given in the following table. They were determined by adding excess of baryta water and titrating with acid.

[1] Phys. Chem. Chall. Exp., part i. p. 222, 1884.

Temperature, °C.	CO_2 Milli-grammes per Litre.	Remarks.
54°·0	63·9	
54·0	80·0	Freshly drawn.
26·0	14·5	Allowed to stand till the temperature fell from 54° to 26° C.
22·0	0·0	Allowed to stand two hours outside of port, while temperature fell to 22° C.
31·5	48·5	From hold tank.
22·0 (?)	0·0	The same allowed to stand some time outside of port.
53·0	65·7	Fresh from condenser.
29·2	80·0	Fresh from hold tank.
18·3	0·0	The same allowed to stand outside port.

The amount of carbonic acid in the freshly collected distilled water is thus very large, notwithstanding the high temperature of the water. The unstable condition of the mixture is shown by the rapidity and completeness with which the carbonic acid disappears when exposed to the air. The results show also in a very evident way that in sea water there can be no appreciable amount of really free carbonic acid. If much more be found than is required for the formation of bicarbonate, then it is retained by some other agency than the absorptive power of the water itself.

With regard to the dissociation tension of carbonic acid in sea water, Professor Dittmar writes:[1]—

"Considering that at a temperature of 18° to 21° C. the dissociation tension of the bicarbonates in sea water is 5 ten-thousandths of an atmosphere, at temperatures not differing by more than one or two degrees from 0° C., such as prevail in the Arctic and Antarctic Regions, it is far more likely than not to fall below 3 ten-thousandths, which is about the partial tension of the carbonic acid in the atmosphere. Admitting this, and assuming that at a given time the ocean everywhere contained its surplus base as sesqui-carbonate, then the water of the tropics would constantly give out carbonic acid to the atmosphere, and tend to raise its 0·0003 atmosphere of carbonic acid pressure to the dissociation tension corresponding to the temperature. Passing now from the Equator, either way, to colder and colder latitudes, this carbonic acid emission becomes less and less intense, until, in a certain belt of temperature which prescribes to the dissociation tension the value 0·0003, this emission becomes *nil*,

[1] Phys. Chem. Chall. Exp., part i. p. 212, 1884.

and proceeding towards the pole to colder and colder latitudes, the water will take in carbonic acid at a greater and greater rate, and tend to convert its surplus base into fully saturated bicarbonate, which stage of saturation is the more likely to be reached the nearer we come to either pole. The number of equivalents of carbonic acid present for every one equivalent of surplus base would, in fact, be a function of the temperature of the water, or approximately of the latitude. But the actual relations are far more complicated: the excess of carbonic acid taken up in the polar regions is constantly being conveyed to warmer latitudes by the polar currents, to make up for loss of carbonic acid constantly suffered by the water there. It may be pointed out that, assuming (as we have tacitly done so far) there were no other source of carbonic acid than the atmosphere, the sea water even in the Arctic and Antarctic Regions could not contain more than traces of actually free carbonic acid in addition to fully saturated bicarbonate. According to Bunsen, one volume of even pure water of 0° C., when shaken with excess of pure carbonic acid of 760 mms. dry gas pressure, absorbs only 1·8 volumes of the gas (measured dry at 0° C. and 760 mm.). Even in the polar regions, the temperature of liquid sea water never sinks by more than 2 or 3 degrees below 0° C., hence the maximum proportion of carbonic acid which such polar sea water could possibly take up from the atmosphere may be roughly estimated at 0·0003 × 1800, or to ·54 c.c., or about 1 milligramme per litre of water. And supposing at a given place a larger proportion were produced by an influx of gas from below, this excess of carbonic acid, over and above the 0·5 c.c., would speedily diffuse out into the atmosphere."

Besides making determinations of the carbonic acid, Mr. Buchanan boiled out the atmospheric gases, oxygen and nitrogen, with a portion of the carbonic acid, from a large number of samples of water, and preserved them till the Expedition came home, when a certain proportion of them were analysed by himself and the remainder by Professor Dittmar.

The atmosphere may be taken as consisting of 21 per cent. oxygen and 79 per cent. nitrogen. Professor Dittmar says[1]:—

"As the pressure of the atmosphere at the sea level does not differ very greatly from 760 mm., the two gases may be assumed everywhere to press on the ocean, the oxygen with a force equivalent to 0·21 times $(760-p)$, the nitrogen with a force equivalent to 0·79 times $(760-p)$ millimetres of mercury, where p stands for the tension of the vapour of water, which of course is very little in the polar regions, while in the tropics it may assume greater values up to some 33 mm. (the tension of steam saturated at 30° C.). According to the law of gas absorption, a given volume of sea water, when shaken up with a given volume of air at a given temperature, takes up both gases, the dissolved quantity of each being proportional to the product of its coefficient of absorption

[1] Phys. Chem. Chall. Exp., part i. p. 223, 1884.

into its partial pressure in the undissolved residue, and as the coefficient of absorption of oxygen is greater than that of nitrogen, the percentage of oxygen in the dissolved air is greater, and that in the undissolved residue is less, than that prevailing in the natural air. The ratio of the two percentages obviously depends on the relative volume of air used, but we need not trouble ourselves with the somewhat complex general formula, because for our purpose it is sufficient to consider the special case which applies to the ocean surface, and which presents itself when the shaking is repeated with constantly renewed air until the last instalment of air remains unchanged. In this case (which for us is the general case) the volume of air dissolved at a given temperature t by one litre of sea water is a quantity λ, which is a function only of t and the pressure of the atmosphere, and every c.c. of dissolved gas contains n_1 c.c. of oxygen and n_2 c.c. of nitrogen, where n_1 and n_2 depend only on t, but change very slowly with the latter.

"According to my own determinations, as fully reported in the Memoir,

"*One litre of Sea Water when saturated with (constantly renewed) air at t° and a pressure of* 760 *mm.* (*plus the tension of vapour of water at t°*) *takes up the following volumes* (*measured dry at* 0° *and* 760 *mm. pressure*) *of the two gases*:—

Temperature, Centigrade.	Dissolved Nitrogen and Oxygen in Cubic Centimetres.		Percentage of Oxygen in dissolved Gas.
	Nitrogen.	Oxygen.	
0°	15·60	8·18	34·40
5	13·86	7·22	34·24
10	12·47	6·45	34·09
15	11·34	5·83	33·93
20	10·41	5·31	33·78
25	9·62	4·87	33·62
30	8·94	4·50	33·47
35	8·36	4·17	33·31

"The temperature of the surface water of the ocean never falls very far below 0° C., even in the polar regions (the Challenger registered 27° F. in the Antarctic Ocean), while even in the tropics it rarely rises above 30° C. The corresponding tensions of aqueous vapour are 4·6 and 33·2 mm. respectively. Now the sea, as far as we know, derives all its absorbed oxygen and nitrogen from the atmosphere,—neither gas can come in from any other source, apart *perhaps* from a small quantity of nitrogen produced in the putrefaction of the bodies of marine animals and plants, which may, however, be safely neglected. Hence, we should say the ocean can nowhere contain more than 15·6 c.c. of nitrogen and 8·18 c.c. of oxygen gas per litre, and the quantity of nitrogen per litre will never fall below $\frac{760-33}{760} \times 8{\cdot}94 = 8{\cdot}55$ c.c. We cannot make a similar assertion in regard to the oxygen, and for it put down the minimum at $\frac{727}{760} \times 4{\cdot}50 = 4{\cdot}30$ c.c., because it is liable to constant diminution by the processes of life and putrefaction and processes of oxidation generally."

The apparatus and methods used for extracting the gases were Jacobsen's modification of those of Bunsen. It may be stated here that the water was run very carefully into the bottom of the flask through a tube with narrow orifice, so as to produce the least possible commotion in the water, and consequent contact of it with the air. The flask was thus filled quite full, and allowed to overflow to a certain extent, so as to eliminate the water which had entered the flask first. The gas collecting apparatus was then immediately inserted. It would, no doubt, be satisfactory to have a water-bottle which would be available for use on the sounding line and in the laboratory, so that the sample could be boiled out without the water having been brought into contact with the air at all, and indeed Mr. Buchanan's stopcock water-bottle was originally designed with a view of meeting this requirement, but without success. Stopcocks which are quite tight at a uniform temperature cannot be depended on to remain so when the temperature is varied.

That the method of decantation adopted worked quite satisfactorily is shown by the analyses of the air-samples so obtained, and notably in the following case. A sample of water obtained from 2875 fathoms in lat. 30° 22′ N., long. 154° 56′ W., the depth of the sea being 2950 fathoms, was decanted as described and boiled. The gas collected from it and freed from carbonic acid contained only 3·84 per cent. of oxygen. The same water if shaken up with air would have furnished a gas containing about 34 per cent. of oxygen. It is evident then that, if a water so far removed from saturation can be decanted, and after the short unavoidable exposure to the air is found to furnish a gas with less than 4 per cent. of oxygen, any error arising from this cause, when the operation is carried out with the requisite skill and expedition, is negligible. When the gas collecting apparatus had been attached the bulb containing distilled water was boiled briskly, keeping up a *continuous* stream of steam for twelve minutes, when the open end of the gas tube was closed and sealed. Connection was then re-established between the flask and the gas tube, and heat was applied to the water-bath in which the flask was immersed. The water in the water-bath was thus gradually heated to boiling, attention being paid to securing as steady and regular an ebullition in the flask as possible. The flask was heated for about two hours, if possible never less than an hour and a half, when connection was interrupted between the flask and the gas tube, the moment of doing so being chosen so as to leave as little air as possible in the distilled water bulb. The gas tube was then sealed off at the lower end. Connection was then re-established between the bulb and the flask, and air admitted into the upper part of the bulb. The water in the bulb was thus forced back into the flask, and as a rule filled it up completely and at once, without leaving a trace of air. Occasionally, however, a minute air-bell remained, but it was never larger than a pin's head. Although Mr. Buchanan had no fear that the results would be vitiated by the loss of this minute quantity, even supposing it to consist entirely of oxygen and nitrogen, he nevertheless on a number of these occasions attached a second gas tube and repeated the boiling. The results of the analyses of the contents of these tubes fully bears out the assumption that no loss of nitrogen or oxygen could have taken place if the residual air-bell had been neglected. The capacity of the gas tubes was from 35 to 40 cubic centimetres, and the volume of air extracted from the sample of about 900 c.c. of water varied from 15 to 20 c.c. when reduced to standard pressure of 760 mm. and temperature of 0° C. The amount of carbonic acid in the gas from surface water varied from 1 c.c. to 5 c.c. When a second tube was used and the boiling repeated, the reduced volume of the gas so extracted was usually under 1 c.c., and was completely absorbed by caustic potash. In only one case could it be said that there was any appreciable amount of permanent gas. In it the total volume of the gas extracted was 2·89 c.c., and 95·4 per cent. of it was carbonic acid. These observations prove that the air in the gas tube is completely eliminated by the steam from the bulb when its contents are kept in constant ebullition for ten to twelve minutes, and that the gas tubes so freed of air and having a capacity of not more than 40 c.c., are capable of receiving completely all the oxygen and nitrogen contained in 940 c.c. of sea water when boiled by Jacobsen's method.

The gas tubes were, through the kindness of Dr. Jacobsen, supplied from Germany. In order to comply with instructions prohibiting the use of straw in packing the apparatus put on board the ship, they were repacked in sawdust, without however having been wrapped in paper. The consequence was that particles of sawdust got into the inside of the tubes and could in no way be got out except by removing one of the drawn out ends of the tube and sweeping them out with a feather. This operation had to be performed on every tube that was used, as it was essential that the samples of gas collected should be preserved in perfectly clean vessels. Even if the tubes had been perfectly clean, the same operation would have had to be performed in order to remedy a defect in their construction at the point where they were intended to be sealed up. Here they were merely thickened instead of being drawn out. The consequence of this thickening was that it was almost impossible to seal the tubes up without the danger that the points might crack on cooling. Amongst the first tubes that were used this was a constant occurrence, but it was completely obviated by the aid of the blowpipe. The crack as a rule was confined entirely to the point, and as Mr. Buchanan found that after some days the contents of one of the cracked tubes were still at a pressure of less than one-half of that of the atmosphere, the tubes were preserved, and when they came to be opened years afterwards, their contents were still found at a pressure of from one-third to one-half of that of the atmosphere, and the analysis of their contents did not indicate any contamination with atmospheric air.[1]

In the analyses of the samples Mr. Buchanan used Doyère's apparatus,[2] for which he was indebted to the kindness of Dr. Edmund Ronalds of Bonnington. Professor Dittmar used a modification of this method, which he has fully described in his Report. Although it was unlikely that anything besides carbonic acid, oxygen, and nitrogen would be found in the gases, both Professor Dittmar and Mr. Buchanan tested the nitrogen remaining from the gas extracted out of a bottom water for combustible gas, but with negative results.

That water may be kept even under somewhat difficult circumstances without changing its atmospheric contents is shown by experiments with water taken from 400 fathoms in the North Pacific on 5th July 1875. The stopcock water-bottle was sent twice to that depth. From the first collection a flask was filled immediately and at once boiled and the gases collected and preserved. The contents of the second water-bottle were run carefully into a bottle with the same precautions as when running it into the gas flask, and it was closed with an india-rubber cork, through which a short glass tube with capillary opening passed. As the water when collected was colder than the atmosphere, it was able to expand and overflow through the capillary tube, but no circulation could take place. Next day 900 c.c. of this water were siphoned off into the gas flask and boiled, the gases being collected and preserved. The gases from the first sample were analysed by Mr. Buchanan, those from the second by Professor Dittmar.

The values were :—

[1] In connection with leakage through cracks, the following observation is of interest. Some years ago I had occasion to have a flask of about a litre and a half in capacity very perfectly evacuated and hermetically sealed, containing about 50 c.c. of distilled water perfectly freed from air. On going into my laboratory one morning, I was struck by a sound like the singing of a kettle at some distance, and it was a little time before I traced it to the flask, which I then found had cracked, the crack taking the form of a star about half an inch in diameter. As the crack was in the bottom of the flask it was completely covered by the water in it. Through a point in one of the radii of the crack the air was entering and passing through the water in a continuous stream of minute bubbles, each of them not larger than a pin's head. It was this stream of air-bells which caused the noise or note which, though low, was very penetrating. As the air was entering in a visible stream, I was somewhat surprised to find that at the end of the day there was no apparent relaxation, and I was much interested to find it still going on the next morning. For fifteen days I watched it rushing in without intermission, and being obliged to go from home I opened the flask under water, which immediately rushed in, and more than half filled it. The amount of air which had passed did not weigh more than 1 gramme, yet it produced a continuous sound for fifteen days.—J. Y. B.

[2] Ann. Chim. Phys., sér. 3, t. xxviii. p. 1.

	1st Sample.	2nd Sample.
Total gas, ... c.c.	22·74	20·50
Total gas less carbonic acid (CO_2), . . ,,	16·12	14·70
CO_2 in total gas, . . . per cent.	29·12	28·29
Oxygen (O_2) in gas free from carbonic acid (CO_2), ,,	12·03	14·47

In the process used for extracting the gases from the water the nitrogen and oxygen are completely extracted, and they are always accompanied by a certain portion of the carbonic acid. The total volume (reduced to 760 mm. and 0° C.) of gases so removed from a litre of sea water averaged for surface waters about 18 c.c., 15 per cent. of which, or about 3 c.c., usually consisted of carbonic acid. As the surface water contains on an average rather more than 20 c.c. of carbonic acid per litre which is eliminated by boiling with chloride of barium, it will be seen that only a very small percentage of the carbonic acid present in the water was so removed. When a second tube was adapted and the water boiled again, not more than 3 c.c., and rarely as much as 1 c.c., could be extracted, and it consisted entirely of carbonic acid.

The maximum amount of gas was found at Station 153 in the Antarctic Ocean, indeed almost on the Antarctic Circle. Excluding carbonic acid, the water contained 23·58 c.c. of nitrogen and oxygen, and 35·01 per cent. of it was oxygen. The minimum amount of gas was found between Stations 214 and 215, in lat. 4° 33′ N., long. 127° 6′ E., to the southeast of the Philippine Islands. Here the total gas, per litre of water, was only 13·73 c.c., of which 13·68 per cent. consisted of carbonic acid, leaving 11·85 c.c. of mixed nitrogen and oxygen, of which 33·11 per cent. was oxygen. The temperature was 27°·2 C. Excluding two values of 30·47 and 29·87 respectively, the lowest "oxygen percentage" found was 32·2, in lat. 3° 21′ N., long. 145° 35′ E., in the Pacific north of the Admiralty Islands. The temperature of the water was 28°·6 C. There were 13·47 c.c. of mixed oxygen and nitrogen. The variations in the gaseous contents of surface water are due mainly to temperature. It will be seen from Professor Dittmar's table that a litre of sea water is capable of taking up at 0° C. 23·78 c.c. of air freed from carbonic acid, and of the mixture so dissolved 34·4 per cent. is oxygen; at 30° C. it absorbs only 13·44 c.c., containing 33·47 per cent. of oxygen. The variations actually observed were greater, especially as to the oxygen percentage, which varied from 35·01 to 32·2. The Norwegians in their Arctic explorations found oxygen percentages as high as 36·7. Also there were greater variations in the absolute amount of gas dissolved than would have been expected from the table. The chief cause of variation is due to the barometric pressure, which has a range amounting to nearly 2 inches, and to the vapour tension in the air, which has a range of 1 inch. The following examples will illustrate this: in the Antarctic Ocean at the highest latitudes attained, the barometer stood generally at about 28·8 inches, the temperature being 29° F. The tension of vapour at this temperature is 0·16 inch, consequently the pressure of dry air was 28·64 inches. In equatorial regions the barometric pressure was usually about 29·8 inches and the temperature 80° F. At this temperature the tension of aqueous vapour is 1·023 inch, therefore the pressure of dry air was 28·777 inches, or nearly identical with that in the Antarctic Ocean. Between these two regions is that of the trade winds, characterised by a high barometer and low humidity. Here the barometer is as high as 30·4 inches, the temperature 70° F., and the relative humidity 80 per cent., therefore the vapour tension is 0·54 inch; consequently the pressure of dry air is here 29·86 inches, or quite 1 inch more than is the case either at the Equator or at the Antarctic Circle.

On the 18th, 20th, and 21st December 1875, when the ship was passing through an area of high pressure off the west coast of South America, the gases were extracted from a number of samples of surface water. The mean barometric pressure on these days averaged 30·2 inches, the temperature was 58° F., and the humidity 85 per cent. The vapour tension was therefore 0·41 inch, the pressure of dry air 29·79 inches. The analyses of the gases extracted from those waters gave the following results per litre of water:—

Analyses of Gases extracted from Surface Waters of South Pacific.

Date, December 1875.		18th.	20th.	21st.
Total gas, ... c.c.	V_0	19·57	22·08	19·87
Carbonic acid (CO_2) in total gas, per cent.	...	12·94	18·59	11·14
Gas freed from carbonic acid (CO_2), .	v_0	17·04	17·98	17·66
Oxygen, . . . per cent.	...	33·95	34·36	34·66
Carbonic acid, . . . c.c.	...	2·53	4·10	2·21
Nitrogen, ... „	...	11·25	11·80	11·54
Oxygen, ... „	...	5·79	6·18	6·12
Nitrogen, . . calculated c.c.	...	11·05	11·24	11·24
Oxygen, . . . „	...	5·77	6·06	5·92
Excess of nitrogen, . . . c.c.	...	0·20	0·56	0·30
Excess of oxygen, . . . „	...	0·02	0·12	0·20

These results are remarkable, because although the pressure of dry air is below the standard of 760 mm., the volumes both of nitrogen and oxygen dissolved are greater than would have been the case at 760 mm. according to Professor Dittmar's tables; and further, there is more dissolved oxygen as compared with nitrogen than there should have been. It is only in this region that the excesses are sufficiently pronounced and constant to justify their being attributed to a natural cause. The few other cases which occur cannot be considered as other than accidental. It is possible that the excess of oxygen and nitrogen in the waters off the coast of Chili may be owing to the fact that there is a strong northerly current in these parts known as the Humboldt Current, which carries a temperate climate almost up to the Equator. It is possible that those waters may have been collected before equilibrium had been established between their gaseous contents and the atmosphere, though this can only be looked on as a very doubtful explanation. As a rule there is a deficiency of dissolved air, on the assumption that it had been absorbed at a pressure of 760 mm., and the temperature of the water *in situ*. This is what was to be expected, as the aqueous vapour reduces the effective pressure by the amount of its tension.

The highest temperature at which water was collected at the surface was 29°·4 C., and according to Professor Dittmar's table, the oxygen percentage ought to have been 33·5. In nearly every case where the temperature of the water was above 25° C., the oxygen percentage was below 33. This would indicate that oxygen disappears faster than it is absorbed. Towards elucidating this curious phenomenon it may be remembered that oxidation of organic matter goes on with greatly increased energy at high temperatures, and that these high temperatures occur chiefly in the regions of equatorial calms and rains. Calm weather is a great obstacle to the thorough aeration of the water, and rain affords an abundant supply of easily oxidised organic matter, the oxidation of which is much assisted by the sun's light as well as by its heat, to which the water, owing to its low density, is constantly exposed.

That rain water does bring from the air to the sea, and also to the land when it falls on it, much organic and probably organised matter was shown by some experiments made on rain water collected on several occasions when the ship was becalmed in the sea to the north of New Guinea. Here the temperature of the water of the surface was very constantly 83°·5 F., that of the air being slightly less, 81°·5. When a rain squall came on the temperature of the air fell considerably, and tended to assume that of the rain, which was found to be 73° to 74°. On several occasions the rain water was collected in stoppered bottles filled perfectly up to the stopper. Samples were then carefully transferred to the boiling flask, generally the day after collection, and the gases extracted as usual. All the samples were tested at the time of boiling with hydrate of baryta, but they remained perfectly clear. The samples of rain were collected on the 15th, 16th, and 19th February 1875; the gases were boiled out from the waters of the 15th and

16th on the 17th, and from that of the 19th on the 20th February. The first two were perfectly clear, the last had a peculiar slight opalescence. The composition of the gases extracted from them is remarkable.

TABLE VII.—*Composition of Air dissolved in Rain Water.*

Date, February 1875.		15th.	16th.	19th.
Carbonic acid,	c.c. per litre	1·84	1·22	3·95
Oxygen,	,,	2·47	3·91	0·06
Oxygen and carbonic acid,	,,	4·31	5·13	4·01
Nitrogen,	,,	10·83	11·70	11·65
Total gas,	,,	15·14	16·83	15·66
Oxygen in gas freed from carbonic acid,	per cent.	18·56	25·42	0·52
Carbonic acid,	,,	12·15	7·26	25·21
Oxygen,	,,	16·31	23·24	0·40
Carbonic acid and oxygen,	,,	28·45	30·50	25·61
Nitrogen,	,,	71·55	69·50	74·39
		100·00	100·00	100·00
Nitrogen theoretical (assumed value),	per cent.	66·40	66·40	66·40
Oxygen and carbonic acid found,	,,	26·40	29·14	22·86
Deficiency,	,,	7·20	4·46	10·74
		100·00	100·00	100·00

When allowance is made for the moisture in the air and the low barometric pressure of equatorial regions, the theoretical amount of nitrogen which should have been dissolved in the water would be 11·6 c.c. The waters of the 16th and 19th agree closely with the theory, that of the 15th contains less nitrogen than would be expected.

Too much importance, however, should not be attached to the absolute amounts of gas found. When all the various manipulations to which the water sample is subjected have been taken intoaccount, there is seen to be considerable room for error, which in the present case might conceivably be as high as half a cubic centimetre. As regards the analysis of the sample of gas after it has been isolated, no such errors are to be feared. The most striking fact shown by the percentage composition of this gas is the deficiency of oxygen. In the water of the 19th it has almost completely disappeared, there being only 0·40 per cent., or not more than 0·06 c.c. per litre of water. In the others the percentage of oxygen was 16·31 per cent. on the 15th, and 23·24 per cent. on the 16th. It must be remembered that the waters collected on the 15th and 16th were both boiled on the 17th, so that while the water of the 16th had stood for twenty-four hours, that of the 15th had stood for forty-eight hours at a temperature of 80° F., but entirely out of contact with the air. Both of these samples were clear. That of the 19th was slightly opalescent, and was boiled on the 20th. Baryta water produced no turbidity in any of the waters. They all gave off ammonia on boiling with carbonate of soda, and frequently the addition of Nessler's reagent indicated its presence in the freshly collected water without heating. Solution of permanganate of potash was also reduced. These indications of the presence of organic matter were confirmed by the appearance of a fungoid growth in all the bottles after the lapse of a few days. It is not unlikely that the opalescence of the water of the 19th was due to the presence of this fungoid matter in greater quantity than in the others. It is certain that some very energetic reducing agent was present in this water, an agent which was capable of depriving it almost completely of its oxygen.

Returning to the consideration of the percentage composition of the gases, it is seen that side by side with the disappearance of oxygen there is production of carbonic acid. Neglecting the amount of carbonic acid which could be ascribed to absorption from the atmosphere, if the oxygen had been all used in the production of carbonic acid the sum of the volumes of the two gases should be equal to that of the oxygen originally present. According to Professor Dittmar a litre of distilled water at 24° C. absorbs from a dry atmosphere of 760 mm. 18·08 c.c. of air containing 33·6 per cent. oxygen and 66·4 per cent. nitrogen. In the Table (VII.) the results have been calculated, putting the nitrogen at 66·4 per cent. in each case, and reducing the amount of oxygen and carbonic acid in the same proportion, the deficiencies which come out are considerable, and vary from 4·46 to 10·74. The meaning of this is that from 5 to 10 per cent. of the air, or from 15 to 30 per cent. of the oxygen, has disappeared without producing an equivalent of carbonic acid. In the oxidation of organic matter some of it has no doubt been used in the formation of water, and it is possible that another part of it may have been utilised in the production of less perfectly oxidised substances, such as, for instance, oxalic acid or intermediate bodies of aldehydic nature.

These observations on the rain water of equatorial regions prove that it is highly charged with organic matter of animal or vegetable origin which is readily oxidised and absorbs for this purpose the oxygen dissolved in the water. When this water falls upon land the whole of the organic matter is arrested by the soil and utilised in the support of the dense vegetation which characterises these regions. Purified by the most efficient form of filtration, through clean soil, the water joins the stream free from all liability to putrefaction. When it falls directly on the sea, it remains in the surface layer where it is exposed to all the power of the sun's light and heat. In these regions calms prevail, and oxidation may easily go on too rapidly for the immediate replacement of the removed oxygen. The greatest deficiency of oxygen in these regions only amounts to one per cent. In a liquid in a state so near to complete saturation, renewals are only effected slowly.

In distilled or rain water it is admissible to compare the carbonic acid with the oxygen, which is deficient, and to consider them to some extent as mutually interdependent. In sea water no such comparison can be made, because the carbonic acid is present in it in such abundance, and is retained in it by an affinity much stronger than that caused by absorption. While the amount which is present in virtue of absorption from the atmosphere cannot exceed a cubic centimetre and a half, the amount actually present which can be eliminated by boiling with chloride of barium solution rarely falls below 10 c.c. even in the warmest regions and at the surface, while in the cold water of the bottom of the oceans it may amount to as much as 40 c.c. per litre. According to Professor Dittmar's experiments, sea water of the lowest temperature met with cannot contain more than 8·18 c.c. of oxygen per litre, hence the maximum amount of carbonic acid which can be due to the consumption of oxygen by carbon after the water has left the surface is 8·18 c.c. It was rare to meet with water which had lost one-half of its oxygen, while a loss of one-third was not uncommon. Hence not more than from 3 to 4 c.c. of the carbonic acid present in a water from the bottom or intermediate depths is likely to have been produced at the expense of the oxygen which it held dissolved. The carbonic acid eliminated by distillation from such waters varies from 15 to 40 c.c., it is therefore altogether impossible to trace in it the oxygen which is deficient.

The amount of carbonic acid present in the gas tubes along with the oxygen and nitrogen has been extracted by boiling *in vacuo*, and therefore deserves attention. In the gases from surface waters it averages about 15 per cent. of the total gas, there being very few cases even in the coldest waters where it exceeds 20 per cent. In bottom waters it averages 27 per cent., in several cases it exceeds 40, and in one case reached 50 per cent. In intermediate waters from 300 fathoms and greater depths, it averages 25 per cent., the maximum being 40 per cent. The amount of carbonic acid extracted in this way from bottom and intermediate waters is therefore much greater than can be taken from surface water, although the average amount of loosely bound or free carbonic acid as determined by the method of distillation with chloride of barium is not very much higher in the one case than in the other. Further, in surface waters the amount of carbonic acid extracted along with the oxygen and nitrogen is always very small, amounting to from 2 to 4 c.c. per litre, in bottom waters it is almost invariably over 5 c.c., and reached in one case 13·5 c.c. in a water from the North Pacific, which gave 32 c.c. of carbonic acid by the distillation method. Although the absolute amount eliminated in this case was large, the relative amount or the percentage of what was present was, though considerable, not specially large. In two cases, again of waters from the North Pacific, the amount extracted by boiling *in vacuo* very nearly equalled that found by the distillation method. In the one case 15 c.c. were found by the distillation method, and 14 c.c. were extracted by boiling *in vacuo;* in the other 17 c.c. were found by distillation and 15·8 c.c. by boiling *in vacuo.* That these differences in the amount of carbonic acid extracted by boiling *in vacuo* are not due to accidental circumstances, of the duration of the boiling process or of the size of the gas tube, is shown by the fact that in all the cases where a second tube was attached and the boiling continued, the further amount of gas extracted was quite insignificant. It would appear therefore that the carbonic acid in sea water is retained in three different states—first there is a portion which is retained in a similar way to the nitrogen and oxygen, along with which it is extracted by boiling *in vacuo;* second, there is a portion in the half-bound condition which is eliminated by distillation at atmospheric pressure; and finally there is the portion present in the form of neutral combination or completely combined to bases. In surface water the carbonic acid belonging to the first category, which behaves to a great extent like a free gas retained by the simple absorptive power of the water, is present in comparatively insignificant quantity. This is only what might have been expected, as contact with the atmosphere would always tend to remove any excessive amount of it which might be present. This means of removal is not available to waters at great depths, hence the gases extracted from such are found to be contaminated with much more carbonic acid than is to be found in the gases from surface water.

If sea water, so long as it is at the surface, can only contain from 3 to 4 c.c. of carbonic acid in this state of solution, and the deep waters are found to contain a much larger quantity of it in the same state, how does it come to attain this state of freedom? It might be naturally expected that carbonic acid which was in the half-bound state at the surface would continue so when it passed into deeper strata, yet the reverse seems to be the case. If it be the presence of carbonates in the sea water which is the cause of the retention of a further amount of carbonic acid so that the two together form bicarbonate, then it would be expected that waters which give off their carbonic acid easily and in large quantity when boiled *in vacuo* would be found deficient in carbonates. Although Mr. Buchanan made a few experiments in this direction, the results which he obtained are of no great value, because it has been shown that, in evaporating to dryness sea water containing carbonates, the latter are in great part decomposed by the chloride of magnesium, which is so large and important a constituent of sea salt, and the solution of which acts in this respect like an acid. Mr. Buchanan evaporated the samples of sea water in a platinum basin in the water-bath, therefore the tendency to decomposition would be less than if it had been directly boiled down. In many waters thus experimented on, carbonates were found, in others they were not. It is therefore exceedingly desirable that experiments should be made on freshly drawn samples of the deep water of the ocean. The experiments of Professor Dittmar were all made on samples which had been preserved for six or seven years in glass bottles, and those of the Norwegians on samples similarly preserved for various lengths of time up to two years. Their results, though correct in themselves, and of value as corroborative evidence, do not replace investigations on the freshly collected water which was used for the extraction of the gases and the carbonic acid on board.

Table VIII. gives the results of the analyses of some of the samples of gas extracted from waters of various depths. It will convey a more definite idea of the nature of the gaseous contents of the waters than can be obtained from a general description. In the part devoted to surface waters the pressure of dry air is given in the column otherwise devoted to "Depth," and the observed volumes of nitrogen and oxygen are reduced to their value, supposing the dry air pressure to have been 760 millimetres.

Bottom Waters.—Of the three samples from the Antarctic Ocean, only two (Nos. 383 and 395) belong really to it, the third (No. 414) is rather from the colder temperate zone, and resembles much more a water from the South Pacific or South Atlantic. In the first two, from the neighbourhood of the Antarctic Circle, the volume of total gas is large, 29 to 30 c.c., of which about 23 per cent. is carbonic acid. In most of their properties the two waters agree well with each other, but there is an exception in the amount of carbonic acid given off during distillation with chloride of barium; in the case of No. 383 it is 42·2 c.c. and in that of No. 395 only 29·32 c.c.; the volumes of carbonic acid extracted by boiling *in vacuo* are 6·59 c.c. in the case of No. 383 and 7·03 c.c. in that of No. 395. The oxygen percentages are high in all three waters, agreeing in this respect with the Arctic waters examined by the Norwegian chemists. The absolute amount of oxygen is 5·75 c.c. and 6·71 c.c.; when compared with the amount which would be present along with the nitrogen observed, there is a deficiency of 2·92 c.c. and 1·73 c.c. Subtracting these amounts from the volume of carbonic acid extracted by boiling *in vacuo*, there remain 3·67 c.c. and 5·33 c.c., which would not be excessive in a surface water.

The amount of nitrogen present in both of these waters is very high, 16·57 and 16·07 c.c. From an atmosphere of dry air of 760 millimetres pressure these volumes would be absorbed at temperatures of 2°·3 and −1°·2 C. respectively. Although the absolute volumes of the gases must not be considered as quite accurate, these figures tend to show that the bottom water at these high latitudes may have a temperature which is more nearly that of the surface than that of the intermediate warm layers. No. 414 and the three samples from the South Atlantic agree in all points very closely with one another; the oxygen percentage, however, 28·42, is decidedly higher than the average of the South Atlantic waters, 25·81, consequently the absolute amount of oxygen is also higher and the oxygen deficiency less. Judging from the amount of nitrogen, the temperature at which these waters had been exposed to the atmosphere would be from 2° to 4° C., or probably lower. In all these bottom waters from the Antarctic and South Atlantic Oceans there is considerable uniformity in the composition of the gases; in examining the waters of the North Pacific more irregularity is found. The oxygen percentage is very low, being generally under 20. The carbonic acid which is given off on boiling *in vacuo* is very high, over 10 c.c., and the amount of carbonic acid eliminable by distillation with chloride of barium varies much. Except in the case of No. 771 the amount of nitrogen is high, and indicates a low temperature of exposure to the atmosphere, while the deficiency of oxygen and the excess of carbonic acid indicate a prolonged seclusion from its influence.

Intermediate Waters.—At great depths the gases from intermediate waters resemble those from bottom waters of the same locality. In the North Pacific the water No. 1001 has by far the lowest oxygen percentage, 3·84, and the amount of carbonic acid in the gas tube is actually less than the "oxygen deficiency." No. 1009, on the other hand, is a deep water with abnormally high oxygen percentage, and No. 1269 a similar one from the South Pacific. Generally, however, in the Pacific Ocean the water at depths of from 100 to 500 fathoms above the bottom contain from 20 to 22 per cent. of oxygen. No. 1532 is from 1400 fathoms in the South Atlantic, and No. 1645 from 1500 fathoms under the Equator in the same ocean. The difference in the oxygen percentage is very striking. The water from the South Atlantic contains 27·54, while that from the Equator contains only 13·24, per cent. of oxygen. This is a phenomenon which repeats itself at more moderate depths. The water of higher latitudes contains a greater percentage of oxygen than that of lower latitudes at the same depth, and it is especially observable in the case of waters from near the Equator. It is not particularly observable at 800 and 400 fathoms, but at 300, 200, and 100 fathoms it is remarkable. In equatorial latitudes the surface has usually a lower salinity than the water at 50 or 100 fathoms below it, which impedes vertical circulation; it is also largely drawn away, forming the Equatorial Currents, and is to a certain extent replaced by water from greater depths, already to some extent impoverished as regards oxygen. When this water has risen to within 300 fathoms of the surface it enters a region where life is more abundant than at greater depths, and where, consequently, there is an increased consumption of oxygen. In the table there are two equatorial waters, Nos. 1661 and 1672, from 300 fathoms, and one, No. 1633, from 100 fathoms from

TABLE VIII.—*Results of the Analyses of some of the Samples of Gas extracted from Waters from Various Depths.*

Number.	Latitude.	Longitude.	Depth.	Temperature. Observed °C.	Temperature. Calculated °C.	Tot. Vol. of Gas, c.c. per Litre.	Carbonic Acid. Per Cent.	Carbonic Acid. c.c. per Litre.	Carbonic Acid. Extr. by Distillation, c.c. per Litre.		Volume of Gas, less CO_2, c.c. per Litre.	Nitrogen, c.c. per Litre. Observed.	Nitrogen, c.c. per Litre. Calculated.	Deficiency.	Oxygen. Per Cent.	Oxygen. c.c. per Litre.	Oxygen. Deficiency.	
	Bottom Waters. Antarctic Ocean.		d	t	T	V_0	$100\frac{c}{V_0}$	c	C	$100\frac{c}{C}$	v_0	n	n'	$n'-n$	$100\frac{o}{v_0}$	o	q	$c-q$
383	65° 42′ S.	79° 49′ E.	1675	?	−2·3	28·91	22·83	6·59	42·20	15·6	22·32	16·57	..	...	25·74	5·75	2·92	3·67
395	64 37 ″	85 49 ″	1800	?	−1·2	29·81	23·60	7·03	29·32	24·0	22·78	16·07	...	...	29·46	6·71	1·73	5·30
414	53 55 ″	108 35 ″	1950	?	+3·5	23·45	14·62	3·43	22·55	15·2	20·02	14·33	...	...	28·42	5·69	1·79	1·64
	North Pacific.																	
771	5 31 N.	145 13 E.	2325	1·9	15·9	27·03	49·98	13·51	31·51	42·9	13·52	11·17	14·89	3·72	17·36	2·35	3·38	10·13
964	37 52 ″	160 17 W.	2740	1·8	2·5	27·84	36·53	10·17	21·48	47·3	17·67	14·67	14·92	0·25	16·95	3·00	4·67	5·50
974	38 9 ″	156 25 ″	3090	1·7	3·2	...	...	...	15·32	...	17·72	14·45	14·96	0·51	18·46	3·27	4·27	...
1096	7 35 ″	149 49 ″	2900	1·5	2·9	34·11	46·41	15·83	17·46	90·6	18·28	14·55	15·03	0·48	20·40	3·73	3·87	11·96
	South Atlantic.																	
1496	36 9 S.	48 22 W.	2800	0·3	4·3	25·40	25·23	6·41	26·37	24·3	18·99	14·08	15·45	1·37	25·88	4·91	2·43	3·98
1533	37 29 ″	37 31 ″	2200	1·1	4·7	23·14	19·50	4·55	23·71	19·2	18·59	13·95	15·17	1·22	24·98	4·64	2·63	1·92
1544	35 36 ″	21 12 ″	2025	1·8	2·2	24·72	18·56	4·59	22·70	20·2	20·13	14·76	14·92	0·16	26·57	5·35	2·38	2·21
	Intermediate Waters.																	
1001	30 22 N.	154 56 W.	2875	1·8	1·4	22·46	30·20	6·78	...	...	15·68	15·08	14·92	−0·16	3·84	0·60	7·61	−0·83
1009	27 33 N.	154 55 ″	2850	1·6	5·8	30·62	37·91	11·61	...	...	19·01	13·63	15·00	+1·77	28·31	5·38	1·71	+9·90
1244	40 3 S.	132 58 ″	2125	1·7	4·4	22·45	20·89	4·62	...	...	17·83	14·26	14·96	0·70	21·19	3·78	3·54	1·08
1209	28 22 ″	141 22 ″	1975	1·8	4·5	22·52	20·84	4·69	26·06	17·9	17·83	14·23	14·92	0·69	21·38	3·81	3·50	1·19
1241	36 32 ″	132 53 ″	1925	1·7	6·8	22·72	21·74	4·94	...	...	17·78	13·33	14·96	1·63	25·01	4·45	2·48	2·46
1296	39 22 ″	98 46 ″	1775	1·7	2·2	25·23	26·07	6·58	...	...	18·65	14·79	14·96	0·17	20·72	3·86	3·87	3·71
1269	39 13 ″	118 49 ″	1775	1·7	7·3	23·74	22·24	5·30	21·53	24·6	18·44	13·19	14·96	1·77	28·48	5·25	1·60	3·70
1645	0 15 S.	14 25 W.	1500	3·3	6·6	22·26	30·70	6·84	...	...	15·42	13·38	14·40	1·02	13·24	2·04	4·91	1·93
1532	37 29 S.	37 31 ″	1400	2·9	6·4	22·76	18·55	4·22	...	...	18·54	13·43	14·54	1·11	27·54	5·11	1·87	3·35
1220	32 36 S.	137 43 W.	800	3·2	5·4	21·19	16·90	3·58	...	...	17·61	13·73	14·37	0·64	22·05	3·88	3·26	0·32
1528	37 47 S.	30 20 W.	800	2·8	4·1	23·03	20·38	4·69	...	...	18·34	14·13	14·51	0·38	22·95	4·21	3·16	1·53
1546	35 45 ″	18 31 ″	800	2·9	−0·5	26·89	23·41	6·29	...	...	20·60	15·81	14·54	−1·27	23·25	4·79	3·51	2·78
1615	10 6 ″	13 44 ″	900	3·5	+6·5	23·03	19·21	4·42	...	...	18·61	13·40	14·46	+1·06	27·99	5·21	1·75	2·67
1655	3 10 N.	14 51 ″	800	4·2	12·8	21·71	29·98	6·51	...	...	15·20	11·80	14·12	2·32	22·22	3·38	2·71	4·80
1605	12 16 S.	13 44 W.	400	4·6	6·0	21·18	20·99	4·45	...	...	16·73	13·57	13·98	0·41	18·90	3·16	3·90	0·55
933	37 41 N.	177 4 ″	400	4·2	3·9	22·74	29·12	7·62	19·95	38·2	15·12	13·46	14·12	0·66	12·03	1·66	...	...
594	5 24 S.	130 37 E.	400	6·4	10 7	21·39	31·91	6·83	20·36	33·5	14·56	12·31	13·44	1·13	15·44	2·25	4·11	2·72
1661	5 28 N.	14 38 W.	300	6·7	5·4	22·14	30·49	7·25	...	...	15·39	13·74	13·35	−0·39	10·75	1·65	5·60	1·65
1672	9 9 ″	16 41 ″	300	6·9	10·7	20·29	31·20	6·33	...	...	13·96	12·29	13·29	+1·00	11·98	1·67	4·58	1·75
823	22 1 ″	140 27 E.	300	11·1	13·6	18·92	18·94	3·58	17·40	20·6	15·34	11·65	12·21	0·56	24·06	3·69	2·30	1·28
797	14 44 N.	142 13 E.	200	11·5	18·8	17·60	21·73	3·82	17·15	22·3	13·78	10·58	11·11	0·69	23·25	3·20	2·20	1·62
1181	22 21 S.	150 17 W.	200	13·4	17·8	17·86	15·90	2·84	21·95	12·9	15·02	10·80	11·69	0·89	28·10	4·22	1·31	1·53
1205	28 22 ″	141 22 ″	200	12·5	20·8	16·88	15·61	2·63	18·20	14·4	14·25	10·28	11·88	1·60	27·84	3·97	1·27	1·36
543	15 58 ″	160 50 E.	200	13·0	13·0	20·96	26·75	5·61	22·60	24·4	15·35	11·76	11·77	0·01	23·40	3·59	2·47	3·14
1539	35 36 S.	21 12 W.	100	12·8	14·8	18·59	12·08	2·24	18·95	11·9	16·35	11·39	11·81	0·42	30·31	4·96	0·89	1·35
1585	17 26 ″	13 52 ″	100	15·4	18·5	16·92	11·90	2·01	...	...	14·91	10·43	11·26	0·83	30·02	4·48	1·10	0·91
1633	2 42 ″	14 41 ″	100	12·9	9·0	20·36	23·04	4·69	...	...	15·67	12·74	11·79	−0·95	18·70	2·93	3·67	1·02
1704	32 41 N.	36 6 W.	100	17·3	18·9	17·49	12·99	2·27	...	...	15·22	10·61	10·89	+0·28	30·29	4·61	0·81	1·46
678	5 47 N.	124 1 E.	50	25·4	30·3	19·82	35·91	7·12	15·20	46·8	12·70	8·91	9·56	0·65	29·86	3·79	0·69	6·43
830	26 29 ″	137 57 ″	50	18·9	19·3	18·38	16·26	2·99	16·70	17·9	15·39	10·53	10·60	0·07	31·55	4·86	0·52	2·47
397	63 30 S.	89 6 ″	50	−1·8	1·6	25·11	14·27	3·48	35·94	9·7	21·53	15·00	16·35	1·35	30·32	6·53	1·32	2·16
	Surface Waters. Antarctic Ocean.		Pressure of Dry Air, millim.															
386	66 29 S.	78 0 E.	728	−0·7	−1·0	28·32	16·75	4·74	28·63	16·5	23·58	15·99*	15·88	−0·11	35·01	8·61*	−0·22	4·95
387	65 10 ″	78 42 ″	724	+0·7	+3·5	25·19	17·15	4·32	26·32	15·2	20·87	14·32*	15·33	+1·01	34·86	7·63*	−0·13	4·45
389	64 4 ″	83 26 ″	728	−1·7	0·25	25·79	12·64	3·26	24·69	13·2	22·53	15·49*	16·30	0·81	34·25	8·04*	+0·09	3·17
396	64 1 ″	87 41 ″	716	+0·4	2·70	23·69	11·70	2·76	24·79	11·1	20·84	14·62*	15·44	0·82	34·17	7·56*	0·10	2·66
	Atlantic Ocean, Tropical.																	
1590	14 33 S.	13 42 W.	743	25·1	24·0	16·31	12·66	2·06	17·90	11·5	14·25	9·76*	9·61	−0·15	33·21	4·85*	0·09	1·97
1687	21 33 N.	31 15 ″	740	22·8	23·3	16·67	13·34	2·22	19·00	11·9	14·45	9·87*	9·95	+0·12	33·33	4·94*	0·07	2·15
1699	29 50 ″	35 55 ″	758	20·5	20·5	18·70	17·87	3·34	17·18	19·8	15·36	10·28*	10·32	0·04	33·26	5·12*	0·13	3·21
	Pacific Ocean, Equatorial.																	
682	4 33 N.	127 6 E.	733	26·9	...	13·73	13·68	1·88	12·78	14·7	11·85	8·21*	9·33	1·12	33·11	4·05*	0·10	1·78
759	3 21 ″	145 35 ″	735	28·6	26·2	15·54	13·35	2·07	...	...	13·47	9·45*	9·12	−0·33	32·20	4·49*	0·27	1·80
761	4 21 ″	145 18 ″	735	28·7	32·9	15·42	20·16	3·11	15·42	20·2	12·31	8·59*	9·11	+0·52	32·58	4 15*	0·18	2·97

* The observed volumes of nitrogen and oxygen in the surface waters are corrected, so as to give the volumes which would have been absorbed under a dry air pressure equivalent to 760 millimetres of mercury.

the Equatorial Atlantic. At 300 fathoms the oxygen percentage is 10·75 and 11·98, and at 100 fathoms it is 18·70. At 200 fathoms there is no example of an equatorial water, but the examples that there are show a diminution of oxygen percentage as the Equator is approached. The water from a depth of 300 fathoms below the surface at the Equator is probably quite free from mixture with surface water from any low latitude, consequently there can be no renewal of the oxygen removed. Between 100 or 150 fathoms and the surface partial renewal begins to be experienced, but with water at 100 fathoms, containing only 18·7 per cent. of oxygen, and with the low temperature of 12°·9 C., it is evident that the mixture does not extend to any great depth.

Considering the largeness of the subject, the data available are very meagre, and hardly justify any very confident generalisations, but they seem to point to the following general conclusions. The surface water contains an amount of nitrogen which corresponds closely with the theoretical amount for the temperature at which it is exposed to the atmosphere; there is, however, usually a small deficiency. The variations in the amount of oxygen absorbed along with the nitrogen are much greater than would be expected from laboratory experiments, and taking the Norwegian observations along with those of the Challenger, there is reason to believe that the percentage of oxygen in the air, freed from carbonic acid, dissolved in surface water may vary between arctic and equatorial regions, from 37 to 32 per cent. In intermediate and bottom waters the nitrogen is usually deficient compared with what ought to have been absorbed from the atmosphere at the temperature of the water, but this deficiency is not generally of any great account; the oxygen is, as might have been expected, always deficient, the lowest percentage found being 3·84. With the exception of the case where the water was from about 50 fathoms above the bottom, bottom water is more deficient in oxygen than intermediate water of great depths, which is no doubt due to the fact that some of it is used up in oxidation of mineral matter as well as of animal matter.

The temperature and other meteorological observations taken during the voyage of the Challenger are being discussed by Mr. Alexander Buchan as regards their bearing on oceanic circulation. The following are the more important of the results already arrived at:—

"The daily range of the temperature of the surface of the North Atlantic has been determined from observations made on 126 days from March to August 1873, and in April and May 1876, the mean latitude of all the Stations being nearly 30° N. and mean longitude 42° W. The daily minimum, which is 0°·33 below the mean, occurs at 4 A.M., and the maximum, 0°·47 above the mean, at 3 P.M. Thus in this part of the ocean where the sun's heat is strong, and at the time of the year when the sun is north of the Equator, the diurnal range of the temperature of the surface of the sea is only 0°·8. An examination of the temperatures taken in other parts of the globe renders it highly probable that nowhere over the ocean does the mean daily fluctuation of the temperature of the surface amount to 1° F. Hence the atmosphere over the ocean may be regarded as resting on or blowing over a surface the temperature of which is practically uniform at all hours of the day. This small variation is a prime factor in meteorology, particularly in those discussions which relate to atmospheric pressure and winds.

"The temperature of the air over the sea on the same 126 days has been examined, and the amplitude of the daily variation is seen to be 3°·21, or nearly four times greater than that of the sea over which it lies. During this time the Challenger was near land on 76 days, and on these days the diurnal variation was 4°·38, thus showing a larger range in the temperature of the air when near land than when out in the open sea. This larger variation in the daily temperature of the air than in that of the sea over which it lies is a point of no small significance in atmospheric physics from the important bearings of the subject on the relations of the atmosphere and its aqueous vapour to solar and terrestrial radiation.

"With respect to the diurnal variation in the elastic force of the aqueous vapour of the air, the observations made in the North Atlantic, at a distance from land, from March to July 1873, give a mean elastic force of 0·659 inch, falling to the minimum 0·639 inch at 4 A.M., and attaining the maximum 0·679 inch at 2 P.M. Thus the phases of the elastic force of vapour occur at the hours of the maximum and minimum temperatures of the sea and the air. On approaching land, however, the curve of the elastic force no longer follows the corresponding phases of the temperature of the sea and the air. The disturbance caused by proximity to land in the distribution through the day of the aqueous vapour in the lower stratum of the atmosphere is very striking. Under the influence of the land breeze, the time of the minimum humidity is delayed from 4 to 6 A.M.; and under the influence of the sea breeze and its effects, the amount of the aqueous vapour shows a secondary minimum from noon to 2 P.M. The latter minimum occurs at the hours when the surface of the land is most highly heated, when the ascending current of heated air rising from it is therefore strongest, and the resulting breeze from the sea towards the land also strongest. This diminution in the amount of the aqueous vapour observed on board the Challenger near land, points clearly to an intermixture with the body of air forming the sea breeze of descending thin air-filaments or currents to supply the place of the masses of air removed by the ascending currents which rise from the heated surface of the land.

"From the same observations it is seen that the daily maximum of the relative humidity occurs from midnight to 4 A.M., or when the temperature of the air is at the minimum, and the minimum humidity at 2 P.M., when the temperature is at the maximum, the curve of relative humidity being thus inverse to that of the temperature. This is substantially the curve of humidity for all climates and seasons.

"The consideration that over the open sea the atmosphere rests on a floor or surface with a diurnal range of temperature so small as to render that temperature practically a constant both day and night, leads to the all important conclusion that the diurnal oscillations of the barometer are not caused by the heating and cooling of the earth's surface by solar and terrestrial radiation and by the effects that follow these changes in the temperature of the surface; but that they are primarily caused by the direct and immediate heating by solar radiation and cooling by nocturnal radiation to the cold regions of space, of the molecules of the air and its aqueous vapour through the whole height of the atmosphere.

"The phenomena of the double diurnal barometric tide are given in their simplest form by the observations made in the centre of the Pacific, or in the midst of the largest water surface of the globe. The following are the variations of pressure from the observations made from September 1st to 12th, 1875, in mean lat. 1° 8′ S. and long. 150° 40′ W., the mean pressure for the time being 29·928 inches:—

	inch		inch
2 A.M.	−0·012	2 P.M.	−0·043
4 "	−0·022	4 "	−0·055
6 "	0·003	6 "	−0·028
8 "	0·028	8 "	0·004
10 "	0·032	10 "	0·013
noon	0·006	midnight	0·012

"The noteworthy features in these oscillations are the amplitude of the range from the morning maximum to the afternoon minimum, amounting to 0·087 inch, and the rapidity of the fall from 10 A.M. to 2 P.M., and these features appear in all the means deduced from the observations made at least 12° on each side of the Equator.

"On the other hand, from October 12th to 22nd, 1875, in mean lat. 35° 1′ S. and long. 134° 35′ W., when the mean pressure was as high as 30·298 inches, the difference between the morning maximum and the afternoon minimum was only 0·036; and from July 12th to 19th, in mean lat. 36° 16′ N. and long. 156° 11′ W., when the mean pressure was 30·328 inches, the difference between the morning maximum and the afternoon minimum was only 0·025 inch. Thus, with a mean pressure in the Pacific about lat. 35° to 36° N. and S., much greater than near the Equator, the oscillation is much less, being, in the North Pacific, less than a third part of what occurs near the Equator. Similarly this diurnal oscillation is very small in the analogous high pressure regions of the North and South Atlantic as compared with the same oscillation near the equatorial belt of that ocean. The following are the mean oscillations in the middle regions of the two great oceans about lat. 36° from the morning maximum to the afternoon minimum about the time of the year, in each case, when the sun is highest in the heavens:—South Pacific 0·036 inch, North Pacific 0·025 inch, South Atlantic 0·024 inch, and North

Atlantic 0·014 inch. Thus it is shown that these amplitudes diminish as the ocean becomes more land-locked with continents, or as the anticyclonic region, which characterises these parts of the globe, becomes better defined and currents of air are poured down more steadily from the higher regions of the atmosphere.

"In the open ocean the morning minimum of pressure is largest in the equatorial regions, and it diminishes with latitude; but the rate of diminution with latitude, through anticyclonic and other regions, is generally less, and is more uniform than is the case with the afternoon minimum. Further over the open sea, in high latitudes, the diurnal barometric tide shows only one maximum and one minimum.

"During the cruise, observations of the force of the wind were made on 1202 days, at least twelve times each day, 650 of the days being on the open sea, and 552 near land. As regards the open sea, the diurnal variation of the force of the wind is exceedingly small, the difference between the hour of least and greatest velocity being less than a mile per hour, and the hours of occurrence of the small maxima and minima vary with the different oceans.

"Quite different is it with the winds encountered near land, the force of the wind there giving a curve as pronouncedly marked as the diurnal curves of temperature or pressure. The minimum force occurs from 2 to 4 A.M. and the maximum from noon to 4 P.M., the highest velocity being at 2 P.M. The curves for each of the five great oceans give one and the same result, or a curve closely congruent with the curve of diurnal temperature. The differences between the hours of least and greatest velocity are:—Southern Ocean 6½ miles, South Pacific 4½ miles, South Atlantic 3½ miles, North Atlantic and North Pacific 3 miles per hour.

"As regards each ocean the velocity of the wind on the open sea is very considerably in excess of that near land, and it is to be specially noted that in no case does the maximum velocity near land, attained at or shortly after noon, reach the velocity of the wind on the open sea. The 650 daily observations on the open sea gave a mean hourly velocity of 17½ miles, whereas the 552 near land give a velocity of only 12½ miles per hour. The difference is greatest at 4 A.M., when it amounts to 6 miles per hour, and least at 2 P.M., when it is a little less than 3 miles per hour.

"The observations made in the region of the northeast trades in the Atlantic in 1873 show a small diurnal variation in the direction of the wind, the variation being from E. 47° 5′ N. at 2 to 6 A.M. to E. 56° N. at 10 A.M. to 2 P.M., being thus 8° 55′ towards north during the hottest hours of the day in the regions of the northeast trades of the Atlantic.

"The variation in the amount of cloud in the sky over the open sea is very small, there being indicated, however, two maxima, the one about or shortly after sunrise and the other in the early part of the afternoon; and two minima, the one at noon and the other from sunset to midnight. The difference between the daily extremes is only 6 per cent. of the whole sky.

"The observations show that the diurnal occurrence of rain on the open sea is inversely as the temperature, 684 days' observations giving 96 cases in the seven hours from 9 A.M. to 4 P.M., but 135 in the two hours from midnight to 2 A.M., these being the periods of minimum and maximum occurrence.

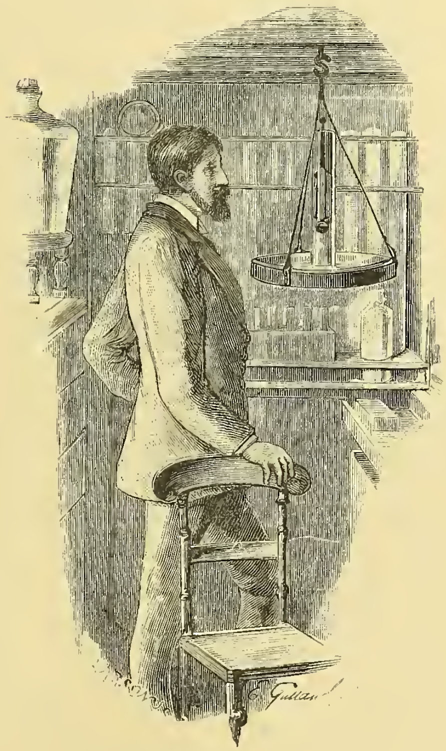
"The observations on the open sea give the hours of maximum frequency of thunderstorms from 10 P.M. to 8 A.M., twenty-two having been observed during these ten hours, and ten only during the other fourteen hours of the day. The daily curve of variation is thus precisely the reverse of what is observed everywhere to occur in continental climates; and the result suggests that over the ocean terrestrial radiation, or radiation from the earth with its gaseous envelope, is more powerful than solar radiation in bringing about vertical disturbances in the equilibrium of the atmosphere. Similarly, by far the greatest number of the squalls encountered during the cruise occurred during the night and the least during the day.

"The whole of the observations of the temperature of the surface of the sea and the air have been examined and compared together and sorted into 174 groups, according to geographical position, and the differences entered on the chart of the cruise. In the Southern Ocean, between lat. 45° and 60° S. the temperature of the sea was lower than that of the air, the mean difference being 1°·4, the air being warmer owing to the prevalence of W.N.W. winds, and the sea colder owing to the numerous icebergs. South of lat. 60° S. the sea was nearly 2°·0 warmer than the air, the result being due to the open sea maintaining a higher surface temperature, and to a greater prevalence in these higher latitudes of cold southerly winds.

"The temperature of the sea exceeded that of the air from June 1874 to March 1875, or during the part of the cruise from Sydney to New Zealand, through the East Indian Islands to Hong Kong, and thence to the Admiralty Islands. During these months, except when passing the north of Australia, the sea was much warmer than the air, the general excess being from 2° to 3°, even rising near Tongatabu to upwards of 4°. In June, when the Challenger passed the north of Australia, the climate was very dry, the sunshine strong, the evaporation large, and consequently the sea there colder than the air; whereas in the other parts of the above extensive region the rainfall was comparatively large, the sky much clouded, the evaporation and sunshine small, and the sea consequently warmer than the air.

"On the other hand, in the North Atlantic from lat. 40° to 20° N. the sea was on the mean half a degree colder than the air. This region is remarkable for its high pressure, for the winds and currents flowing out from it in all directions, its generally clear skies, strong sunshine, and consequently large evaporation, by which the temperature of the surface of the sea is lowered, while that of the air resting on it is raised, being open to the heating influence of the sun. Similarly in the North Pacific from lat. 40° to 30° N. the temperature of the surface of the sea was half a degree lower than that of the air.

"These remarks apply only to the observations made strictly on the open sea. Near land, very large differences were recorded which varied with the season. Thus at Hong Kong, during the latter half of November 1874, the air was 3°·7 colder than the sea, being occasioned by the low temperature of the land at this season and the prevailing northerly wind. On the other hand, at Valparaiso in November and December of the following year the sea was 5°·8 colder than the air during the three weeks the Challenger was off that coast, the difference being caused by the cold oceanic current which sweeps northwards past that coast, and the rapid increase in the temperature of the air which takes place at this time of the year in Chili."




INDEX.
above 1·0280.
between 1·0275 and 1·0280
„ 1·0270 „ 1·0275
„ 1·0265 „ 1·0270
„ 1·0260 „ 1·0265
„ 1·0255 „ 1·0260
„ 1·0250 „ 1·0255
below 1·0250.
TRACK OF
H.M.S CHALLENGER
Decr 1872 to May 1876.
Showing the Dredging and Trawling Stations
This Chart shows the distribution of Density in the Surface waters of the Ocean.
It is prepared from the Observations made on board H.M.S. Challenger
and other Vessels.

APPENDIX I.

EXPLANATION OF SYMBOLS AND ABBREVIATIONS USED IN THE CHARTS AND DIAGRAMS.

Figures enclosed thus, (37), indicate the position and distinguishing number of a Sounding, Dredging, or Trawling Station.

Figures in block letter thus, **2650**, indicate the depth in Fathoms.

The letters under the depth indicate the nature of the Deposit at the Bottom:—

gl. oz.	signifying	Globigerina ooze.
di. oz.	,,	Diatom ooze.
pt. oz.	,,	Pteropod ooze.
rad. oz.	,,	Radiolarian ooze.
r. cl.	,,	red clay.
crl. m.	,,	Coral mud.
volc. m.	,,	volcanic mud
r. m.	,,	red mud.
gr. m.	,,	green mud.
bl. m.	,,	blue mud.
s.	,,	sand.
st.	,,	stones.
sh.	,,	shells.
g.	,,	gravel.
crl.	,,	Coral.
r.	,,	rock.
h. g.	,,	hard ground.

Arrows thus, ↙, indicate the mean direction of the Wind, the number at the base giving the mean Force (in Beaufort's Scale). Arrows thus, ↙ 24, indicate the direction of the Surface Current, the numbers at the base giving the rate in miles per 24 hours.

The position of the Ship each day at Noon is indicated by a black dot. When the position at noon corresponds with a Sounding Station the black dot is replaced by the number of the Station. The day of the month is noted in hair line thus, 25, and occasionally the month and year are also given, the month being shown in Roman figures, thus, 1.V.74.

In the Diagrams the thick *Horizontal lines* represent lines of equal temperature in Fahrenheit Scale. The figures above each *Vertical line*, thus, (37) 2650·68°, indicate, (37), the number of the Station, 68°, the Surface Temperature, and, 2650, the Depth in fathoms. The figures below each *Vertical line* indicate the temperature at the Bottom.

These Diagrams are constructed from the curves published in Phys. Chem. Chall. Exp., part iii., 1884.

APPENDIX II.

REVISED TABLE showing the Positions of the Soundings obtained by H.M.S. Challenger, the Temperature and Specific Gravity of the Surface and Bottom Water, and the Stations where Serial Temperatures, Trawlings, and Dredgings were procured.

(The Soundings in brackets are only the approximate depths.)

Number of Sounding.	Distinguishing Number of Station.	Date. 1872-73.	Latitude.	Longitude.	Depth in Fathoms.	Nature of Bottom.	Temperature of the Sea-water. Bottom	Temperature of the Sea-water. Surface	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Bottom.	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Surface.	Trawling or Dredging.	Serial temperatures were obtained at the stations marked*	Plans on which the Station is shown.	
			NORTH. ° ′ ″	WEST. ° ′ ″			°	°						
1	I	December 30	41 58 0	9 42 0	1125	Blue mud.	...	...	...	...	Dredged.		2	Cape Finisterre to Lisbon.
2	IA	January 1	40 25 0	9 38 30	325	Hard ground.	52·0	57·0	...	...	...		3	
3	IB	„ 1	40 24 0	9 45 0	730	Hard ground.	49·0	57·0	...	...	...		3	
4	IC	„ 1	40 23 0	9 43 0	950	Hard ground.	...	57·0	...	...	Dredged.		3	
5	ID	„ 2	39 55 0	10 5 0	1975	Blue mud.	...	57·0	...	...	Dredged.		3	
6	II	„ 13	38 10 0	9 14 0	470	Green mud.	...	57·0	...	...	Dredged.		3	Off the Tagus.
7	IIA	„ 13	38 5 0	9 39 0	1270	Blue mud.	...	57·0	...	...	Dredged.		3	
8	IIB	„ 14	38 31 0	9 31 0	84	Green mud.	...	57·0	...	...	...		3	
9	IIC	„ 14	38 28 0	9 35 0	280	Green mud.	...	57·0	...	...	...		3	
10	IID	„ 14	38 26 0	9 38 0	560	Green mud.	52·0	57·5	...	...	...		3	
11	IIE	„ 14	38 22 30	9 44 0	1290	Blue mud.	...	57·0	...	...	...		3	
12	IIF	„ 14	38 14 25	9 49 42	1475	Blue mud.	37·5	57·5	...	...	...		3	
13	IIG	„ 14	38 9 43	9 48 0	1380	Blue mud.	38·0	57·5	...	...	...		3	
14	IIH	„ 14	37 56 0	10 8 0	1800	Blue mud.	37·0	57·0	...	...	...		3	
15	IIJ	„ 15	37 1 45	9 23 45	1000	Blue mud.	39·5	59·5	...	...	...		3	Lisbon to Gibraltar.
16	IIK	„ 15	36 58 50	9 14 20	525	Blue mud.	54·0	60·0	...	...	Dredged.	*	3	
17	III	„ 15	37 2 0	9 14 0	900	Blue mud.	...	60·0	...	...	Dredged.		3	
18	IV	„ 16	36 25 0	8 12 0	600	Blue mud.	...	60·0	...	...	Both.		2 & 3	
19	V	„ 28	35 47 0	8 23 0	1090	Globigerina ooze.	38·5	61·0	...	...	Trawled.	*	2	Gibraltar to Madeira.
20	VA	„ 29	36 13 0	10 7 0	2500	...	...	59·0	...	...	...		2 & 3	
21	VI	„ 30	36 23 0	11 18 0	1525	Globigerina ooze.	36·0	58·0	...	...	Trawled.		2 & 3	
22	VII	„ 31	35 20 0	13 4 0	2125	Globigerina ooze.	37·0	60·0	...	...	Trawled.		2	
23	VIIA	February 1	34 4 0	14 18 0	2250	Globigerina ooze.	37·0	61·0	...	...	...		2	
24	VIIB	„ 2	32 43 0	15 52 0	2225	Globigerina ooze.	37·0	63·0	...	...	...		2	
25	VIIC	„ 2	32 21 0	16 24 0	670	Volcanic sand.	46·8	63·0	...	...	...		4	Off Madeira.
26	VIID	„ 2	32 16 0	16 28 0	1150	Volcanic mud.	...	64·0	...	...	...		4	
27	VIIE	„ 2	32 20 15	16 32 0	930	Volcanic mud.	43·5	63·5	...	...	...		4	
28	VIIF	„ 2	32 27 0	16 40 30	1500	Volcanic mud.	...	63·0	...	...	Trawled.		4	
29	VIIG	„ 3	32 32 45	16 48 0	1150	Volcanic mud.	39·0	63·0	...	...	...		4	
30	VIIH	„ 3	32 35 0	16 51 0	790	Volcanic mud.	45·0	62·8	...	...	...		4	
31	VIIJ	„ 3	32 36 15	16 53 15	490	Volcanic mud.	...	63·0	...	...	...		4	
32	VIIK	„ 6	29 19 0	16 38 0	1975	Volcanic mud.	36·2	62·5	...	...	...		2 & 5	Madeira to Tenerife.
33	VIIL	„ 10	28 28 0	16 12 30	278	Volcanic mud.	...	64·0	...	...	...		5	Between Canary Islands.
34	VIIM	„ 10	28 28 0	16 10 0	630	Volcanic mud.	45·0	64·0	...	...	...		5	
35	VIIN	„ 10	28 30 30	16 3 30	975	Volcanic mud.	41·0	64·0	...	...	...		5	
36	VIIO	„ 10	28 33 0	16 4 0	560	Volcanic mud.	45·5	64.0	...	...	...		5	
37	VIIP	„ 10	28 35 0	16 5 0	78	Volcanic sand.	...	64·0	...	...	Dredged.		5	
38	VIIQ	„ 10	28 38 0	16 5 0	179	Hard ground.	...	64·0	...	...	...		5	
39	VIIR	„ 10	28 41 0	16 6 0	640	Volcanic mud.	45·8	64·0	...	...	...		5	
40	VIIS	„ 10	28 45 0	16 7 0	1390	Volcanic mud.	38.5	63·0	...	...	...		5	

Number of Sounding.	Distinguishing Number of Station.	Date. 1873.	Latitude.	Longitude.	Depth in Fathoms.	Nature of Bottom.	Temperature of the Sea-water. Bottom	Surface	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Bottom.	Surface.	Trawling or Dredging.	Serial temperatures were obtained at the stations marked*	Plans on which the Station is shown.	
			NORTH. ° ′ ″	WEST. ° ′ ″			°	°						
41	VIIt	February 11	28 42 0	17 8 0	1750	Volcanic mud.	37·5	63·0	...	...	...		5	Off Canary Islands.
42	VIIu	,, 11	28 20 0	17 34 0	1340	Volcanic mud.	38·5	65·0	...	...	...		5	
43	VIIv	,, 11	27 58 0	17 39 0	1620	Volcanic mud.	37·5	65·0	...	...	...	*	5	
44	VIII	,, 12	28 3 15	17 27 0	620	Volcanic mud.	...	64·5	...	...	Dredged.	*	5	
45	1	,, 15	27 24 0	16 55 0	1890	Globigerina ooze.	36·8	64·5	1·02650	1·02730	Dredged.	*	5 & 6	Tenerife to Sombrero Island.
46	2	,, 17	25 52 0	19 22 0	1945	Globigerina ooze.	36·8	67·0	1·02602	1·02739	Dredged.	*	6	
47	3	,, 18	25 45 0	20 14 0	1525	Hard ground.	37·0	65·0	...	1·02719	Dredged.		6	
48	4	,, 19	25 28 0	20 22 0	2220	...	...	66·0	...	1·02720	...	*	6	
49	5	,, 21	24 20 0	24 28 0	2740	Red clay.	37·0	68·0	1·02744	1·02753	Dredged.	*	6	
50	6	,, 23	23 14 0	28 22 0	2950	Red clay.	37·0	69·2	1·02745	1·02760	...		6	
51	7	,, 24	23 23 0	31 31 0	2750	Red clay.	36·9	68·0	1·02609	1·02763	...		6	
52	8	,, 25	23 12 0	32 56 0	2700	Red clay.	37·0	67·0	1·02613	1·02773	Dredged.	*	6	
53	9	,, 26	23 23 0	35 11 0	3150	Red clay.	36·8	69·0	1·02653	1·02778	Dredged.		6	
54	10	,, 28	23 10 0	38 42 0	2720	Red clay.	36·5	71·0	1·02753	1·02774	...	*	6	
55	11	March 1	22 45 0	40 37 0	2575	Globigerina ooze.	36·5	72·2	1·02621	1·02767	Dredged.	*	6	
56	12	,, 3	21 57 0	43 29 0	2025	Globigerina ooze.	36·9	73·0	1·02641	1·02761	Dredged.		6	
57	13	,, 4	21 38 0	44 39 0	1900	Globigerina ooze.	36·8	72·0	1·02695	1·02777	Dredged.	*	6	
58	14	,, 5	21 1 0	46 29 0	1950	Globigerina ooze.	36·8	74·0	...	1·02756	Trawled.		6	
59	15	,, 6	20 49 0	48 45 0	2325	Globigerina ooze.	36·2	72·5	1·02616	1·02768	...	*	6	
60	16	,, 7	20 39 0	50 33 0	2435	Globigerina ooze.	36·2	74·0	1·02751	1·02770	Dredged.		6	
61	17	,, 8	20 7 0	52 32 0	2385	Globigerina ooze.	36·5	74·0	...	1·02766	...	*	6	
62	18	,, 10	19 41 0	55 13 0	2650	Red clay.	36·0	74·0	1·02615	1·02732	Dredged.	*	6	
63	19	,, 11	19 15 0	57 47 0	3000	Red clay.	35·5	75·0	1·02614	1·02728	...		6	
64	20	,, 12	18 56 0	59 35 0	2975	Red clay.	36·0	75·0	1·02727	1·02727	Dredged.	*	6	
65	21	,, 13	18 54 0	61 28 0	3025	Red clay.	35·5	76·0	1·02688	1·02685	...		6	
66	22	,, 14	18 40 0	62 56 0	1420	Pteropod ooze.	38·4	76·0	...	1·02698	Trawled.	*	6 & 7	
67	23	,, 15	18 24 0	63 28 0	450	Pteropod ooze.	...	76·0	...	...	Dredged.		7	Off Sombrero.
68	23A	,, 15	18 26 0	63 31 15	460	Pteropod ooze.	...	76·0	...	...	Dredged.		7	
69	23B	,, 15	18 28 0	63 35 0	590	Pteropod ooze.	...	76·0	...	1·02693	Dredged.		7	
70	24	,, 25	18 38 30	65 5 30	390	Pteropod ooze.	...	76·0	...	...	Dredged.		7	St. Thomas to Bermuda.
71	24A	,, 25	18 43 30	65 5 0	625	Pteropod ooze.	...	76·0	...	1·02704	Dredged.		7	
72	25	,, 26	19 41 0	65 7 0	3875	Red clay.	...	76·0	1·02631	1·02692	Dredged.	*	6 & 7	
73	26	,, 27	21 26 0	65 16 0	2800	Red clay.	...	76·0	1·02594	1·02704	...		6	
74	27	,, 28	22 49 0	65 19 0	2960	Red clay.	36·2	75·5	1·02601	1·02710	...	*	6	
75	28	,, 29	24 39 0	65 25 0	2850	Red clay.	36·3	75·0	1·02608	1·02710	Dredged.	*	6	
76	29	,, 31	27 49 0	64 59 0	2700	Red clay.	36·4	72·0	1·02607	1·02739	Dredged.	*	6	
77	30	April 1	29 5 0	65 1 0	2600	Red clay.	36·5	72·0	1·02774	1·02735	...		6	
78	31	,, 3	31 24 0	65 0 0	2475	Globigerina ooze.	36·5	69·5	1·02651	...	...		6	
79	32	,, 3	31 49 0	64 55 0	2250	Globigerina ooze.	36·7	68·0	1·02605	...	...		6 & 8	
80	32A	,, 3	32 1 0	64 51 0	1820	Globigerina ooze.	...	68·0	...	1·02728	...		6	
81	32B	,, 3	32 10 0	64 52 0	950	Coral mud.	...	68·0	...	...	...		8	
82	32C	,, 4	32 17 30	64 39 5	780	Coral mud.	...	67·0	...	...	...		8	Off Bermuda.
83	32D	,, 4	32 19 0	64 40 0	380	Coral mud.	...	67·0	...	...	...		8	
84	32E	,, 4	32 19 30	64 40 35	120	Coral mud.	...	67·5	...	...	Dredged.		8	
85	32F	,, 4	32 20 40	64 38 15	125	Hard ground.	...	67·5	...	...	...		8	
86	32G	,, 4	32 21 25	64 37 15	265	Hard ground.	...	68·0	...	...	Dredged.		8	
87	33	,, 4	32 21 30	64 35 55	435	Coral mud.	...	68·0	...	...	Dredged.		8	
88	33A	,, 21	32 31 10	64 42 55	175	Coral sand.	...	67·2	...	...	...		8	
89	33B	,, 21	32 32 30	64 46 0	640	Coral mud.	...	67·2	...	...	...		8	
90	34	,, 21	32 33 55	64 52 18	1370	Coral mud.	...	67·2	...	...	...		8	
91	35A	,, 22	32 39 0	65 6 0	2450	Globigerina ooze.	36·5	67·8	...	...	...		8	
92	35B	,, 22	32 26 0	65 9 0	2100	Globigerina ooze.	36·5	68·0	...	1·02715	...		8	
93	35C	,, 22	32 15 0	65 8 0	1950	Globigerina ooze.	...	68·0	...	...	...		8	
94	36	,, 22	32 7 25	65 4 0	30	Coral.	...	67·5	...	...	Dredged.		8	
95	37	,, 24	32 18 0	65 38 8	2650	Globigerina ooze.	36·5	68·0	...	...	Dredged.	*	8 & 9	Bermuda to Halifax.
96	38	,, 25	33 3 0	66 32 0	2600	Globigerina ooze.	36·5	70·0	...	1·02723	...	*	9	
97	39	,, 27	34 3 0	67 32 0	2850	Red clay.	36·5	65·0	...	1·02701	...	*	9	
98	40	,, 28	34 51 0	68 30 0	2675	Blue mud.	...	69·5	...	1·02698	Dredged.		9	
99	41	,, 29	36 5 0	69 54 0	(2500)	...	...	65·0	...	1·02703	...	*	9	
100	42	,, 30	35 58 0	70 35 0	2425	Blue mud.	36·8	65·0	1·02668	1·02695	...	*	9	
101	43	May 1	36 23 0	71 46 0	(2600)	...	36·8	75·0	...	1·02674	...	*	9	
102	44	,, 2	37 25 0	71 40 0	1700	Blue mud.	36·2	56·5	...	1·02541	Dredged.	*	9	
103	45	,, 3	38 34 0	72 10 0	1240	Blue mud.	37·2	49·5	...	1·02504	Dredged.	*	9	
104	46	,, 6	40 17 0	66 48 0	1350	Blue mud.	37·2	40·0	...	1·02403	Dredged.		9	
105	47	,, 7	41 14 0	65 45 0	1340	Blue mud.	...	42·0	...	1·02419	Dredged.		9	
106	48	,, 8	43 4 0	64 5 0	51	Rock.	...	38·0	...	..	Dredged.		9	

Number of Sounding.	Distinguishing Number of Station.	Date. 1873.		Latitude.	Longitude.	Depth in Fathoms.	Nature of Bottom.	Temperature of the Sea-water.		Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1.		Trawling or Dredging.	Serial temperatures were obtained at the stations marked*	Plans on which the Station is shown.	
								Bottom	Surface	Bottom.	Surface.				
				NORTH. ° ′ ″	WEST. ° ′ ″			°	°						
107	49	May	20	43 3 0	63 39 0	85	Gravel, stones.	35·0	40·5	1·02400	1·02354	Dredged.	*	9	Halifax to Bermuda.
108	50	,,	21	42 8 0	63 39 0	1250	Blue mud.	38·0	45·0	1·02546	1·02451	Dredged.	*	9	
109	51	,,	22	41 19 0	63 12 0	2020	Blue mud.	36·0	59·0	1·02595	1·02625	...	*	9	
110	52	,,	23	39 44 0	63 22 0	2800	Blue mud.	36·2	67·2	1·02701	1·02714	...	*	9	
111	52A	,,	24	38 16 0	63 17 0	...	...	...	73·0	...	...	...	*	9	
112	53	,,	26	36 30 0	63 40 0	2650	Red clay.	36·3	73·0	1·02700	1·02708	...	*	9	
113	54	,,	27	34 51 0	63 59 0	2650	Red clay.	...	70·5	...	1·02715	Trawled.	*	9	
114	55	,,	28	33 20 0	64 37 0	2500	Globigerina ooze.	...	70·5	...	1·02711	...	*	9	
115	55A	,,	28	32 46 0	64 39 0	1775	Globigerina ooze.	36·2	70·5	...	...	...		8 & 9	
116	55B	,,	29	32 7 35	64 53 45	1325	Coral mud.	...	72·0	...	...	Dredged.		8	Off Bermuda.
117	56	,,	29	32 8 45	64 59 35	1075	Coral mud.	38·2	72·5	...	...	Dredged.		8	
118	56A	,,	29	32 10 45	64 58 20	506	...	...	72·5	...	...	Dredged.		8	
119	57	,,	30	32 11 7	65 3 20	690	...	...	72·5	...	...	...		8	
120	57A	,,	30	32 9 30	65 7 35	1250	Coral mud.	...	73·0	...	...	Dredged.		8	
121	57B	,,	30	32 9 45	65 10 50	1575	Coral mud.	...	73·0	...	...	Trawled.	*	8	
122	58	June	13	32 37 0	64 21 0	1500	Globigerina ooze.	37·2	73·5	...	...	...		6 & 8	Bermuda to Azores.
123	59	,,	14	32 54 0	63 22 0	2360	Globigerina ooze.	36·3	74·0	1·02650	1·02715	...	*	6	
124	60	,,	16	34 28 0	58 56 0	2575	Red clay.	36·2	71·5	1·02704	1·02709	Trawled.	*	6	
125	61	,,	17	34 54 0	56 38 0	2850	Red mud.	36·2	71·0	...	1·02708	Trawled.	*	6	
126	62	,,	18	35 7 0	52 32 0	2875	Red clay.	36·4	70·0	1·02709	1·02716	...	*	6	
127	63	,,	19	35 29 0	50 53 0	2750	Red clay.	...	71·0	1·02613	1·02720	Trawled.		6	
128	64	,,	20	35 35 0	50 27 0	(2700)	Red clay.	...	75·0	...	...	Dredged.	*	6	
129	65	,,	21	36 33 0	47 58 0	2700	Red clay.	36·2	72·5	1·02598	1·02721	...	*	6	
130	66	,,	22	37 24 0	44 14 0	2750	Red clay.	36·5	70·0	1·02621	1·02712	...	*	6	
131	67	,,	23	37 54 0	41 44 0	2700	Globigerina ooze.	36·3	70·0	1·02614	1·02699	...	*	6	
132	68	,,	24	38 3 0	39 19 0	2175	Globigerina ooze.	36·2	70·0	1·02612	1·02688	Trawled.		6	
133	69	,,	25	38 23 0	37 21 0	2200	Globigerina ooze.	36·2	71·0	...	1·02712	Trawled.	*	6	
134	70	,,	26	38 25 0	35 50 0	1675	Globigerina ooze.	...	70·0	...	1·02708	Trawled.		6	
135	71	,,	27	38 18 0	34 48 0	1675	Globigerina ooze.	36·8	71·0	1·02668	1·02696	Trawled.	*	6	
136	72	,,	28	38 34 0	32 47 0	1240	Globigerina ooze.	37·8	71·0	...	1·02718	...	*	6	
137	73	,,	30	38 30 0	31 14 0	1000	Pteropod ooze.	39·4	69·0	1·02691	...	Dredged.	*	6 & 10	
138	74	July	1	38 22 0	29 37 0	1350	Pteropod ooze.	...	69·8	...	...	...		6 & 10	
139	75	,,	2	38 38 0	28 28 30	450	Volcanic mud.	...	70·0	...	...	Dredged.		10	Off the Azores.
140	76	,,	3	38 11 0	27 9 0	900	Pteropod ooze.	40·0	70·0	1·02688	1·02699	Dredged.	*	10	
141	77	,,	4	37 52 0	26 26 0	750	Hard ground.	...	69·2	1·02675	1·02686	...		10	
142	78	,,	10	37 26 0	25 13 0	1000	Volcanic mud.	...	71·0	...	...	Dredged.	*	10	
143	79	,,	11	36 21 0	23 31 0	2025	Globigerina ooze.	35·9	71·5	...	...	Dredged.	*	6	Azores to Madeira.
144	80	,,	12	35 3 0	21 25 0	2660	Globigerina ooze.	36·6	71·0	1·02601	1·02706	...	*	6	
145	81	,,	13	34 11 0	19 52 0	2675	Globigerina ooze.	37·0	71·0	...	1·02710	...		6	
146	82	,,	14	33 46 0	19 17 0	2400	Globigerina ooze.	36·6	70·7	1·02695	1·02715	...	*	6	
147	83	,,	15	33 13 0	18 13 0	1650	Globigerina ooze.	37·0	71·0	1·02626	1·02742	Dredged.		6	
148	84	,,	18	30 38 0	18 5 0	...	...	...	71·0	...	1·02729	...	*	6	Madeira to Cape Verde Islands.
149	85	,,	19	28 42 0	18 6 0	1125	Volcanic mud.	...	69·2	...	1·02735	Dredged.	*	6 & 5	
150	86	,,	21	25 46 0	20 34 0	2300	Globigerina ooze.	36·6	71·0	1·02626	...	...		6	
151	87	,,	21	25 49 0	20 12 0	1675	Rock.	...	72·0	...	1·02747	Dredged.		6 (st. 3)	
152	88	,,	22	23 58 0	21 18 0	2300	Globigerina ooze.	36·4	72·0	1·02618	1·02755	...	*	6	
153	89	,,	23	22 18 0	22 2 0	2400	Globigerina ooze.	36·6	73·5	...	1·02719	Trawled.	*	6	
154	90	,,	24	20 58 0	22 57 0	2400	Globigerina ooze.	36·5	74·0	1·02645	1·02688	...	*	6	
155	91	,,	25	19 4 0	24 6 0	2075	Globigerina ooze.	36·5	74·0	1·02696	1·02710	...	*	6	
156	92	,,	26	17 54 0	24 41 0	1975	Globigerina ooze.	...	74·7	...	1·02699	Dredged.	*	6	
157	93	,,	27	17 12 45	24 55 45	1070	Volcanic mud.	...	75·0	...	...	...		11	Off Cape Verde Islands.
158	93A	,,	27	17 3 30	24 53 0	1000	Volcanic mud.	...	75·0	...	1·02696	...		11	
159	93B	,,	27	16 59 15	24 57 45	465	Volcanic mud.	43·5	75·0	...	...	...		11	
160	93C	,,	27	16 57 15	25 1 0	52	Coralline mud.	...	76·0	...	...	...		11	
161	93D	August	5	16 55 45	25 3 45	103	Coralline mud.	...	78·0	...	...	...		11	
162	93E	,,	5	16 52 15	25 6 45	85	Coralline mud.	...	78·0	...	...	...		11	
163	93F	,,	5	16 50 0	25 8 0	260	Volcanic mud.	...	78·0	...	...	...		11	
164	93G	,,	5	16 46 0	25 10 0	675	Volcanic mud.	...	78·0	...	...	...		11	
165	94	,,	5	16 42 0	25 12 0	1150	Volcanic mud.	...	78·0	...	...	...		11	
166	95	,,	10	13 36 0	22 49 0	2300	Globigerina ooze.	36·5	79·0	1·02605	1·02680	...	*	12	St. Vincent to St. Paul's Rocks.
167	96	,,	11	12 15 0	22 28 0	...	...	...	78·7	...	1·02651	...	*	12	
168	97	,,	13	10 25 0	20 30 0	2575	Red clay.	36·6	78·0	1·02604	1·02610	...	*	12	
169	98	,,	14	9 21 0	18 28 0	1750	Globigerina ooze.	36·7	78·2	1·02605	1·02605	Dredged.	*	12	
170	99	,,	15	7 53 0	17 26 0	...	...	...	78·0	...	1·02600	...	*	12	

Number of Sounding.	Distinguishing Number of Station.	Date. 1873.	Latitude.	Longitude.	Depth in Fathoms.	Nature of Bottom.	Temperature of the Sea-water. Bottom	Temperature of the Sea-water. Surface	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Bottom.	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Surface.	Trawling or Dredging.	Serial temperatures were obtained at the stations marked*	Plans on which the Station is shown.	
			NORTH. ° ′ ″	WEST. ° ′ ″										
171	100	August 16	7 1 0	15 55 0	2425	...	...	79·0	...	1·02612	...	*	12	St. Vincent to St. Paul's Rocks.
172	101	,, 19	5 48 0	14 20 0	2500	Blue mud.	36·4	79·2	...	1·02635	Trawled.	*	12	
173	102	,, 21	3 8 0	14 49 0	2450	Globigerina ooze.	36·4	78·0	1·02595	1·02589	...	*	12	
174	103	,, 22	2 52 0	17 0 0	2475	Globigerina ooze.	36·0	77·0	...	1·02622	...	*	12	
175	104	,, 23	2 25 0	20 1 0	2500	Globigerina ooze.	36·6	78·0	1·02601	1·02602	Trawled.	*	12	
176	105	,, 24	2 6 0	22 53 0	2275	Globigerina ooze.	36·0	78·0	...	1·02604	...	*	12	
177	106	,, 25	1 47 0	24 26 0	1850	Globigerina ooze.	36·6	78·8	...	1·02615	Trawled.	*	12	
178	107	,, 26	1 22 0	26 36 0	1500	Globigerina ooze.	37·9	78·8	...	1·02613	Trawled.		12	
179	108	,, 27	1 10 0	28 23 0	1900	Globigerina ooze.	36·8	78·0	...	1·02641	...		12	
180	109	,, 28	0 55 38	29 22 35	104	Hard ground.	...	77·7	...	...	Dredged.		13	Off St. Paul's Rocks.
181	109A	,, 29	0 54 43	29 23 32	475	Hard ground (gravel).	...	78·0	...	...	...		13	
182	109B	,, 29	0 54 55	29 22 17	510	Hard ground.	...	76·5	...	...	...		13	
183	109C	,, 29	0 56 23	29 22 15	780	Pteropod ooze.	...	76·5	...	...	...		13	
184	109D	,, 29	0 56 4	29 25 2	1425	Pteropod ooze.	...	77·0	...	...	...		13	
185	110	,, 30	0 9 0	30 18 0	2275	Globigerina ooze.	34·8	77·5	1·02602	1·02667	...	*	12	St. Paul's Rocks to Fernando Noronha.
			SOUTH.	WEST.										
186	111	,, 31	1 45 0	30 58 0	2475	Red clay.	33·7	78·0	...	1·02677	...		12	
187	112	September 1	3 33 0	32 16 0	2200	Globigerina ooze.	34·0	78·0	1·02607	1·02669	...	*	12&14	
188	113	,, 1	3 40 45	32 22 0	1010	Hard ground.	37·5	78·0	...	...	...		14	
189	113A	,, 1	3 47 0	32 24 30	25	Volcanic sand and gravel.	...	78·0	...	...	...		14	Fernando Noronha to Pernambuco.
190	113B	,, 3	3 50 30	32 30 0	400	Hard ground.	...	78·0	...	...	...		14	
191	113C	,, 3	3 54 0	32 36 15	525	Hard ground.	...	78·0	...	...	...		14	
192	114	,, 3	3 58 0	32 42 0	820	Hard ground.	...	78·0	...	...	...		14	
193	115	,, 3	4 2 0	32 47 0	2150	Globigerina ooze.	...	78·0	...	...	...		14	
194	116	,, 4	5 1 0	33 50 0	2275	Globigerina ooze.	34·3	78·0	1·02609	1·02628	...	*	12	
195	117	,, 6	5 56 0	34 45 0	1375	Red mud.	...	78·0	...	1·02673	...		12	
196	117A	,, 6	6 4 0	34 51 0	500	Red mud.	...	78·0	...	...	...		15	
197	118	,, 8	7 28 0	34 2 0	2050	Red mud.	35·2	77·5	...	...	...		12&15	
198	119	,, 8	7 39 0	34 12 0	1650	Red mud.	37·2	77·5	...	1·02745	...	*	12&15	
199	120	,, 9	8 37 0	34 28 0	675	Red mud.	...	78·0	...	1·02740	Trawled.		12&15	Off the coast of S. America between Pernambuco and Bahia.
200	121	,, 9	8 28 0	34 31 0	500	Red mud.	...	78·0	...	...	Trawled.		15	
201	122	,, 10	9 5 0	34 50 0	350	Red mud.	...	77·5	...	...	Trawled.		15	
202	122A	,, 10	9 10 0	34 52 0	120	Red mud.	...	77·5	...	...	Trawled.		15	
203	122B	,, 10	9 9 0	34 53 0	32	Red mud.	...	77·5	...	...	Trawled.		15	
204	122C	,, 10	9 10 0	34 49 0	400	Red mud.	...	77·5	1·02669	1·02739	Trawled.		15	
205	123	,, 11	10 9 0	35 11 0	1715	Red mud.	37·0	77·5	...	1·02681	...		12&15	
206	124	,, 11	10 11 0	35 22 0	1600	Red mud.	...	77·5	1·02671	...	Trawled.		15	
207	125	,, 12	10 46 0	36 2 0	1200	Red mud.	...	77·0	1·02730	1·02746	...		15	
208	126	,, 12	10 46 0	36 8 0	770	Red mud.	..	77·0	...	...	Trawled.		12&15	
209	126A	,, 12	10 45 0	36 9 0	700	Red mud.	...	77·0	...	...	Trawled.		15	
210	127	,, 13	11 42 0	37 3 0	1015	Red mud.	38·5	77·0	...	1·02748	...		12&15	
211	128	,, 14	13 6 0	38 7 0	1275	Red mud.	...	76·5	...	...	...		12&15	
212	129	,, 30	20 13 0	35 19 0	2150	Red mud.	34·2	74·0	...	1·02759	Dredged.	*	16	Bahia to Tristan da Cunha.
213	130	October 3	26 15 0	32 56 0	2350	Red clay.	34·7	69·0	1·02714	1·02710	Trawled.	*	16	
214	131	,, 6	29 35 0	28 9 0	2275	Globigerina ooze.	34·6	65·0	...	1·02663	Trawled.	*	16	
215	132	,, 10	35 25 0	23 40 0	2050	Globigerina ooze.	35·0	58·0	1·02590	1·02619	...	*	16	
216	133	,, 11	35 41 0	20 55 0	1900	Globigerina ooze.	35·4	58·0	1·02587	1·02626	Trawled.	*	16	
217	134	,, 14	36 12 0	12 16 0	2025	Globigerina ooze.	36·0	53·5	1·02583	1·02616	Dredged.	*	16	Off Tristan da Cunha.
218	135	,, 15	37 1 50	12 19 10	360	Volcanic sand.	...	53·5	...	...	...		17	
219	135A	,, 16	37 16 50	12 45 15	75	Hard ground shells, gravel.	...	54·0	...	...	Dredged.		17	
220	135B	,, 17	37 22 30	12 33 0	465	Hard ground shells, gravel.	...	53·5	...	...	...		17	
221	135C	,, 17	37 25 30	12 28 30	110	...	...	54·0	...	...	Dredged.		17	
222	135D	,, 17	37 25 0	12 30 30	72	...	...	54·0	...	...	Dredged.		17	
223	135E	,, 18	37 21 0	12 22 30	1000	Hard ground shells, gravel.	...	53·5	...	...	Dredged.	*	17	
224	135F	,, 18	37 14 45	12 20 15	1100	Hard ground.	...	53·5	...	...	Dredged.		17	
225	135G	,, 18	37 10 50	12 18 30	550	Hard ground.	...	54·0	...	...	Dredged.		17	
226	136	,, 20	36 43 0	7 13 0	2100	...	35·2	54·0	1·02592	1·02616	Dredged.	*	16	Tristan da Cunha to Cape of Good Hope.
			SOUTH.	EAST.										
227	137	,, 23	35 59 0	1 34 0	2550	Red clay.	34·5	56·1	1·02585	1·02637	Dredged.	*	16	

Number of Sounding.	Distinguishing Number of Station.	Date. 1873–4.	Latitude.	Longitude.	Depth in Fathoms.	Nature of Bottom.	Temperature of the Sea-water. Bottom	Temperature of the Sea-water. Surface	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Bottom.	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Surface.	Trawling or Dredging.	Serial temperatures were obtained at the stations marked*	Plans on which the Station is shown.	
			SOUTH. ° ′ ″	EAST. ° ′ ″			°	°						
228	138	October 25	36 22 0	8 12 0	2650	Red clay.	35·1	56·2	1·02580	1·02631	...	*	16	Tristan da Cunha to Cape of Good Hope.
229	139	„ 27	35 35 0	16 9 0	2325	Globigerina ooze.	34·1	56·2	1·02582	1·02614	...	*	16	
230	140	„ 28	35 0 0	17 57 0	1250	Globigerina ooze.	...	59·0	...	1·02620	...	*	16	
231	141	December 17	34 41 0	18 36 0	98	Green sand.	49·5	66·5	...	...	Dredged.	*	18	Cape of Good Hope to parallel of 46° S.
232	142	„ 18	35 4 0	18 37 0	150	Green sand.	47·0	65·5	1·02658	1·02665	Dredged.		18	
233	143	„ 19	36 48 0	19 24 0	1900	Globigerina ooze.	35·6	73·0	1·02607	1·02657	Dredged.	*	18	
234	144	„ 24	45 57 0	34 39 0	1570	Globigerina ooze.	35·8	43·0	1·02525	1·02516	...	*	18	
235	144A	„ 26	46 48 0	37 49 30	69	Volcanic sand.	...	41·0	...	...	Dredged.		19	Off Marion Island.
236	145	„ 27	46 43 0	38 4 30	140	Volcanic sand.	...	41·0	...	...	Dredged.		19	
237	145A	„ 27	46 41 0	38 10 0	310	Volcanic sand.	...	41·5	...	1·02515	Dredged.		19	
238	146	„ 29	46 46 0	45 31 0	1375	Globigerina ooze.	35·6	43·0	1·02555	1·02512	Trawled.	*	18	Marion Island to Crozets.
239	147	„ 30	46 16 0	48 27 0	1600	Diatom ooze.	34·2	41·0	1·02550	1·02515	Trawled.	*	18	
		1874.												
240	147A	January 1	46 45 0	50 42 0	600	Volcanic mud.	...	42·0	...	1·02503	...		20	Off Crozet Islands.
241	148	„ 3	46 47 0	51 37 0	210	Hard ground gravel, shells.	...	41·0	...	...	Dredged.		20	
242	148A	„ 3	46 53 0	51 52 0	550	Hard ground gravel, shells.	...	41·0	...	1·02504	Dredged.		20	
243	149	„ 9	49 8 0	70 12 0	20	Volcanic mud.	...	...	...	...	Dredged.		21	At Kerguelen Island.
244	149A	„ 14	49 8 0	70 9 0	40	Volcanic mud.	...	...	...	...	Dredged.		21	
245	149B	„ 17	49 28 0	70 30 0	25	Volcanic mud.	...	40·5	...	...	Dredged.		21	
246	149C	„ 19	49 32 0	70 0 0	60	Volcanic mud.	...	...	...	...	Dredged.		21	
247	149D	„ 20	49 28 0	70 13 0	28	Volcanic mud.	...	41·0	...	...	Dredged.		21	
248	149E	„ 21	49 37 0	70 16 0	30	Volcanic mud.	...	...	...	...	Dredged.		21	
249	149F	„ 27	48 55 0	69 31 0	95	Volcanic mud.	...	41·7	...	1·02537	Dredged.		21	
250	149G	„ 29	48 50 0	69 18 0	110	Volcanic mud.	...	40·2	...	...	Dredged.		21	
251	149H	„ 29	48 45 0	69 14 0	127	Volcanic mud.	...	39·8	...	...	Dredged.		21	
252	149J	„ 29	48 43 0	69 15 0	105	Volcanic mud.	...	39·0	...	...	Dredged.		21	
253	149K	„ 29	48 40 0	69 6 0	45	Volcanic mud.	...	39·0	...	...	Dredged.		21	
254	150	February 2	52 4 0	71 22 0	150	Coarse gravel.	35·2	37·5	...	1·02515	Dredged.	*	18	Heard Island.
255	151	„ 7	52 59 30	73 33 30	75	Volcanic mud.	...	36·2	...	1·02515	Dredged.		22	
256	152	„ 11	60 52 0	80 20 0	1260	Diatom ooze.	...	34·5	1·02561	1·02512	Trawled.	*	23	In vicinity of Antarctic Ice.
257	153	„ 14	65 42 0	79 49 0	1675	Blue mud.	...	29·5	1·02567	1·02413	Dredged.	*	23	
258	154	„ 19	64 37 0	85 49 0	1800	Blue mud.	...	32·0	1·02529	1·02458	...	*	23	
259	155	„ 23	64 18 0	94 47 0	1300	Blue mud.	...	31·0	...	...	Dredged.		23	
260	156	„ 26	62 26 0	95 44 0	1975	Diatom ooze.	...	33·0	1·02515	1·02508	Trawled.	*	23	
261	157	March 3	53 55 0	108 35 0	1950	Diatom ooze.	32·1	37·2	1·02561	1·02509	Trawled.	*	24	Termination Land to Melbourne.
262	158	„ 7	50 1 0	123 4 0	1800	Globigerina ooze.	33·5	45·0	1·02554	1·02522	Trawled.	*	24	
263	159	„ 10	47 25 0	130 22 0	2150	Globigerina ooze.	34·5	51·5	1·02564	1·02566	Trawled.	*	24	
264	160	„ 13	42 42 0	134 10 0	2600	Red clay.	33·9	55·0	1·02570	1·02570	Trawled.	*	24	
265	161	April 1	38 22 30	144 36 30	33	Sand.	...	63·5	...	1·02568	Trawled.		25	Melbourne to Sydney.
266	162	„ 2	39 10 30	146 37 0	38	Sand and shells.	...	63·2	...	1·02632	Dredged.		25	
267	163	„ 4	36 57 0	150 34 0	2200	Green mud.	34·5	72·0	1·02601	1·02652	...	*	25	
268	163A	„ 4	36 59 0	150 20 0	150	Green mud.	...	71·0	...	...	Dredged.		25	
269	163B	June 3	33 51 15	151 22 15	35	Hard ground.	63·0	69·0	...	...	Dredged.		26	Off Sydney.
270	163C	„ 12	33 55 0	151 35 0	85	Hard ground (shells).	62·2	67·5	...	1·02644	...		26	
271	163D	„ 12	33 57 30	151 39 15	120	Green sand.	...	68·0	...	...	...		26	
272	163E	„ 12	34 0 15	151 44 15	290	Green sand.	...	70·2	...	...	...		26	
273	163F	„ 12	34 3 15	151 51 30	650	Green mud.	40·8	70·2	...	...	...		26	
274	164	„ 12	34 8 0	152 0 0	950	Green mud.	36·5	69·5	...	1·02650	...		26	
275	164A	„ 13	34 9 0	151 55 0	1200	Green mud.	...	70·2	...	...	...		26	
276	164B	„ 13	34 13 0	151 38 0	410	Green mud.	...	69·0	...	1·02636	Trawled.		26	
277	164C	„ 13	34 19 0	151 31 0	400	Green mud.	40·0	67·0	...	...	Dredged.	*	26	
278	164D	„ 14	34 3 0	152 20 0	2100	...	...	67·5	...	...	...		26&27	Sydney to New Zealand.
279	164E	„ 16	34 27 0	154 57 0	2550	...	...	64·0	...	1·02644	...	*	27	
280	165	„ 17	34 50 0	155 28 0	2600	Red clay.	34·5	64·5	1·02613	1·02638	Dredged.		27	
281	165A	„ 19	35 41 0	158 29 0	2600	Red clay.	34·4	62·5	...	1·02637	...	*	27	
282	165B	„ 21	37 53 0	163 18 0	1975	Globigerina ooze.	34·7	59·5	1·02625	1·02616	...	*	27	
283	165C	„ 22	38 36 0	166 39 0	1100	Globigerina ooze.	36·4	58·2	1·02594	1·02614	...	*	27	

Number of Sounding.	Distinguishing Number of Station.	Date. 1874.	Latitude.	Longitude.	Depth in Fathoms.	Nature of Bottom.	Temperature of the Sea-water. Bottom	Temperature of the Sea-water. Surface	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Bottom.	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Surface.	Trawling or Dredging.	Serial temperatures were obtained at the stations marked*	Plans on which the Station is shown.	
			SOUTH. ° ′ ″	EAST. ° ′ ″			°	°						
284	166	June 23	38 50 0	169 20 0	275	Globigerina ooze.	50·8	58·5	1·02668	1·02625	Trawled.	*	27	Sydney to New Zealand.
285	166A	,, 23	38 57 0	170 10 45	350	...	...	58·5	...	...	...		27	
286	166B	,, 23	39 8 0	170 43 0	400	Globigerina ooze.	...	58·5	...	...	...		27	
287	166C	,, 24	39 21 0	171 28 0	400	Globigerina ooze.	...	58·0	...	...	...		27	
288	167	,, 24	39 32 0	171 48 0	150	Blue mud.	...	58·5	...	1·02617	Trawled.		27	
289	167A	,, 27	41 4 0	174 19 0	10	Mud.	...	51·5	...	1·02593	Dredged.		...	
290	168	July 8	40 28 0	177 43 0	1100	Blue mud.	37·2	57·2	1·02584	1·02622	Trawled.	*	27	New Zealand to Tongatabu.
291	169	,, 10	37 34 0	179 22 0	700	Blue mud.	40·0	58·2	1·02594	1·02636	Trawled.	*	27	
			SOUTH.	WEST.										
292	170	,, 14	29 55 0	178 14 0	520	Volcanic mud.	43·0	65·0	...	...	Trawled.	*	27	
293	170A	,, 14	29 45 0	178 11 0	630	Volcanic mud.	39·5	65·2	...	1·02644	Trawled.		27	
294	171	,, 15	28 33 0	177 50 0	600	Hard ground.	39·5	66·5	...	1·02685	Trawled.		27	
295	171A	,, 17	25 5 0	172 56 0	2900	Red clay.	34·3	72·0	1·12626	1·02642	...	*	27	
296	172	,, 22	20 58 0	175 9 0	18	Coral mud.	...	75·0	...	...	Dredged.		28	Off Tongatabu.
297	172A	,, 22	20 56 0	175 11 0	240	Coral mud.	...	75·0	...	1·02640	Dredged.		28	
			SOUTH.	EAST.										
298	173	,, 24	19 9 35	179 41 50	315	Coral mud.	...	76·0	...	1·02642	Dredged.		29	Off Matuku.
299	173A	,, 24	19 9 32	179 41 55	310	Coral mud.	...	77·0	...	...	Trawled.		29	
300	174	August 3	19 6 0	178 14 20	140	Coral mud.	...	77·0	...	...	...		30	Off Kandavu Island.
301	174A	,, 3	19 6 32	178 16 20	160	Coral mud.	...	77·0	...	...	...		30	
302	174B	,, 3	19 6 45	178 17 0	255	Coral mud.	...	77·7	...	...	Trawled.		30	
303	174C	,, 3	19 7 50	178 19 35	610	Coral mud.	39·0	78·0	...	...	Trawled.	*	30	
304	174D	,, 3	19 5 50	178 16 20	210	Coral mud.	...	77·7	...	...	Dredged.		30	
305	175	,, 12	19 2 0	177 10 0	1350	Globigerina ooze.	36·0	77·5	1·02633	1·02647	Trawled.	*	27	Fiji Islands to Raine Island.
306	176	,, 15	18 30 0	173 52 0	1450	Globigerina ooze.	36·2	77·5	1·02621	1·02686	...	*	27	
307	177	,, 18	16 45 0	168 7 0	130	Volcanic sand.	...	78·7	...	1·02624	Dredged.		27	
308	178	,, 19	16 47 0	165 20 0	2650	Red clay.	35·8	79·0	...	1·02621	...	*	27	
309	179	,, 21	15 58 0	160 48 0	2325	Red clay.	36·0	79·0	1·02594	1·02634	...	*	27	
310	180	,, 24	14 7 0	153 43 0	2450	Red clay.	36·0	80·0	1·02601	1·02611	...	*	27	
311	181	,, 25	13 50 0	151 49 0	2440	Red clay.	35·8	80·0	1·02591	1·02649	Trawled.		27	
312	182	,, 27	13 6 0	148 37 0	2275	Globigerina ooze.	35·8	78·5	1·02584	1·02619	...	*	27	
313	183	,, 28	12 42 0	146 46 0	1700	Globigerina ooze.	36·0	78·0	1·02595	1·02630	...	*	27	
314	184	,, 29	12 8 0	145 10 0	1400	Globigerina ooze.	36·0	77·5	1·02613	1·02630	Trawled.	*	27	
315	185	,, 31	11 35 25	144 2 0	135	Coral sand.	...	77·0	...	1·02639	Dredged.		27	Off Raine Island.
316	185A	,, 31	11 36 20	144 1 50	150	Coral sand.	...	77·0	...	...	Dredged.		27	
317	185B	,, 31	11 38 15	143 59 38	155	Coral sand.	...	77·0	...	...	Dredged.		27	
318	186	September 8	10 30 0	142 18 0	8	Coral mud.	...	77·2	...	...	Dredged.		31	Cape York to Arrou Islands.
319	187	,, 9	10 36 0	141 55 0	6	Coral mud.	...	77·7	...	1·02691	Dredged.		31	
320	188	,, 10	9 59 0	139 42 0	28	Green mud.	...	78·5	...	1·02599	Both.		31	
321	189	,, 11	9 36 0	137 50 0	25	Green mud.	...	79·0	1·02529	1·02550	Trawled.		31	
322	190	,, 12	8 56 0	136 5 0	49	Green mud.	...	79·2	...	1·02545	Trawled.		31	
323	191	,, 23	5 41 0	134 4 30	800	Green mud.	39·5	82·2	...	1·02496	Trawled.	*	31 & 32	Arrou Islands to Banda.
324	191A	,, 24	5 26 0	133 19 0	580	Green mud.	40·7	81·5	1·02581	1·02579	...	*	31 & 32	
325	192	,, 26	5 49 15	132 14 15	140	Blue mud.	...	82·0	...	1·02585	Trawled.		32	
326	193	,, 28	5 24 0	130 37 15	2800	Blue mud.	38·0	83·5	1·02558	1·02565	...	*	31	
327	194	,, 29	4 34 0	129 57 30	200	Volcanic mud.	...	83·0	...	...	Dredged.		33	
328	194A	,, 29	4 31 0	129 57 20	360	Volcanic mud.	...	82·5	...	...	Trawled.		33	
329	195	October 3	4 21 0	129 7 0	1425	Blue mud.	38·0	82·0	1·02568	1·02602	Trawled.		31	Banda to Amboina.
330	196	,, 13	0 48 30	126 58 30	825	Hard ground.	36·9	83·0	1·02584	1·02558	Trawled.		31	Amboina to Samboangan.
			NORTH.	EAST.										
331	197	,, 14	0 41 0	126 37 0	1200	Blue mud.	35·9	82·5	1·02593	1·02523	...	*	31	
332	198	,, 20	2 55 0	124 53 0	2150	Blue mud.	38·9	85·0	1·02586	1·02551	Trawled.	*	31	
333	199	,, 22	5 44 0	123 34 0	2600	Blue mud.	38·6	83·0	1·02535	1·02545	...	*	31	
334	200	,, 23	6 47 0	122 28 0	250	Green mud.	...	85·5	...	1·02536	Trawled.		31	
335	201	,, 26	7 3 0	121 48 0	82	Stones, gravel.	...	83·0	...	1·02515	Trawled.		31	Samboangan to Manila.
336	202	,, 27	8 32 0	121 55 0	2550	Blue mud.	50·5	83·0	1·02555	1·02494	...	*	31	
337	203	,, 31	11 6 0	123 9 0	20	Mud.	...	85·0	...	...	Trawled.		31	
338	204	November 2	12 28 0	122 15 0	705	Green mud.	...	84·0	...	1·02517	...		31	
339	204A	,, 2	12 43 0	122 9 0	100	Green mud.	...	84·0	1·02569	...	Trawled.		31	
340	204B	,, 2	12 46 0	122 10 0	115	Green mud.	...	84·0	...	1·02521	Trawled.		31	

Number of Sounding.	Distinguishing Number of Station.	Date. 1874–5.	Latitude.	Longitude.	Depth in Fathoms.	Nature of Bottom.	Temperature of the Sea-water. Bottom	Temperature of the Sea-water. Surface	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Bottom.	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Surface.	Trawling or Dredging.	Serial temperatures were obtained at the stations marked*	Plans on which the Station is shown.	
			NORTH. ° ′ ″	EAST. ° ′ ″			°	°						
341	205	November 13	16 42 0	119 22 0	1050	Blue mud.	37·0	82·0	1·02574	1·02502	Trawled.	*	31	Manila to Hong-Kong and back.
		1875.												
342	206	January 8	17 54 0	117 14 0	2100	Blue mud.	36·5	75·2	1·02568	1·02538	Trawled.	*	31	
343	207	,, 16	12 21 0	122 15 0	700	Blue mud.	51·6	80·0	1·02557	1·02515	Trawled.	*	31	Manila to Samboangan.
344	208	,, 17	11 37 0	123 31 0	18	Blue mud.	...	81·0	...	1·02517	Trawled.		31	
345	209	,, 22	10 14 0	123 54 0	95	Blue mud.	71·0	81·0	...	...	Both.		31	
346	210	,, 25	9 26 0	123 45 0	375	Blue mud.	54·1	80·2	...	...	Both.	*	31	
347	210A	,, 26	9 15 0	124 38 0	185	Green mud.	57·1	80·7	...	1·02520	...		31	
348	211	,, 28	8 0 0	121 42 0	2225	Blue mud.	50·5	81·0	1·02546	1·02571	...	*	31	
349	212	,, 30	6 54 0	122 18 0	10	Sand.	...	83·0	...	...	Both.		31	
350	213	February 8	5 47 0	124 1 0	2050	Blue mud.	38·8	83·0	1·02567	1·02475	Trawled.	*	31	Samboangan to New Guinea.
351	214	,, 10	4 33 0	127 6 0	500	Blue mud.	41·8	80·5	1·02562	1·02551	Trawled.	*	31	
352	215	,, 12	4 19 0	130 15 0	2550	Red clay.	35·4	81·8	1·02572	1·02597	Trawled.	*	31	
353	216	,, 16	2 46 0	133 58 0	1675	Globigerina ooze.	35·4	82·8	1·02585	...	...	*	31	
354	216A	,, 16	2 56 0	134 11 0	2000	Globigerina ooze.	35·4	82·8	1·02567	1·02570	Trawled.		31	
			SOUTH.	EAST.										
355	217	,, 22	0 39 0	138 55 0	2000	Blue mud.	35·2	83·0	1·02595	1·02518	...	*	31	
356	218	March 1	2 33 0	144 4 0	1070	Blue mud.	36·4	84·0	1·02572	1·02564	Trawled.	*	31	New Guinea to Admiralty Ids.
357	219	,, 10	1 54 0	146 39 40	150	Coral mud.	...	84·0	...	1·02571	Trawled.		34	Admiralty Islands to Yokohama.
358	220	,, 11	0 42 0	147 0 0	1100	Globigerina ooze.	36·2	83·8	1·02560	1·02580	Trawled.	*	31	
			NORTH.	EAST.										
359	221	,, 13	0 40 0	148 41 0	2650	Red clay.	35·4	83·8	...	1·02624	...	*	31	
360	222	,, 16	2 15 0	146 16 0	2450	Red clay.	35·2	82·8	1·02560	1·02634	...	*	31	
361	223	,, 19	5 31 0	145 13 0	2325	Globigerina ooze.	35·5	82·0	1·02578	1·02595	Trawled.	*	31	
362	224	,, 21	7 45 0	144 20 0	1850	Globigerina ooze.	35·4	81·2	1·02567	1·02585	Dredged.	*	31	
363	225	,, 23	11 24 0	143 16 0	4475	Radiolarian ooze.	35·2	80·2	1·02579	1·02568	...	*	31	
364	226	,, 25	14 44 0	142 13 0	2300	Radiolarian ooze.	35·5	79·0	...	1·02595	Trawled.	*	31	
365	227	,, 27	17 29 0	141 21 0	2475	Red clay.	35·2	79·2	...	1·02572	...	*	31	
366	228	,, 29	19 24 0	141 13 0	2450	Red clay.	35·2	80·2	...	1·02582	...	*	31	
367	229	April 1	22 1 0	140 27 0	2500	Red clay.	35·2	78·5	...	1·02613	Trawled.	*	31	
368	230	,, 5	26 29 0	137 57 0	2425	Red clay.	35·5	68·5	...	1·02606	Trawled.	*	31	
369	231	,, 9	31 8 0	137 8 0	2250	Blue mud.	35·2	64·0	1·02579	1·02541	...	*	31	
370	232	May 12	35 11 0	139 28 0	345	Green mud.	41·1	64·2	...	1·02539	Both.	*	35	Off Japan.
371	233	,, 17	34 39 0	135 14 0	8	Mud.	...	62·3	...	...	Dredged.		35	
372	233A	,, 19	34 38 0	135 1 0	50	Sand.	...	62·6	...	...	Dredged.		35	
373	233B	,, 26	34 18 0	133 35 0	15	Blue mud.	...	66·3	...	1·02361	Trawled.		35	
374	233C	,, 28	34 18 0	133 21 0	12	Blue mud.	59·9	66·8	...	1·02381	Trawled.	*	35	
375	234	June 3	32 31 0	135 39 0	2675	Blue mud.	35·8	69·5	...	1·02541	...	*	35	
376	235	,, 4	34 7 0	138 0 0	565	Green mud.	38·1	73·0	1·02560	1·02557	Trawled.	*	35	
377	236	,, 5	34 58 0	139 29 0	775	Green mud.	37·6	66·5	1·02546	1·02560	Trawled.		35	
378	236A	,, 5	34 59 0	139 31 0	420	Green mud.	...	66·5	...	...	Trawled.	*	35	
379	237	,, 17	34 37 0	140 32 0	1875	Blue mud.	35·3	73·0	1·02555	1·02570	Trawled.	*	35&36	Yokohama to Sandwich Islands.
380	238	,, 18	35 18 0	144 8 0	3950	Red clay.	35·0	70·5	1·02558	...	...	*	36	
381	239	,, 19	35 18 0	147 9 0	3625	Red clay.	35·1	70·2	1·02572	1·02577	...	*	36	
382	240	,, 21	35 20 0	153 39 0	2900	Red clay.	34·9	64·8	...	1·02556	Trawled.	*	36	
383	241	,, 23	35 41 0	157 42 0	2300	Red clay.	35·1	69·2	1·02558	1·02574	Trawled.	*	36	
384	242	,, 24	35 29 0	161 52 0	2575	Red clay.	35·1	68·5	1·02560	1·02590	...	*	36	
385	243	,, 26	35 24 0	166 35 0	2800	Red clay.	35·0	71·0	...	1·02562	Trawled.	*	36	
386	244	,, 28	35 22 0	169 53 0	2900	Red clay.	35·3	70·5	1·02571	1·02566	Trawled.	*	36	
387	245	,, 30	36 23 0	174 31 0	2775	Red clay.	34·9	69·0	1·02553	1·02556	...	*	36	
388	246	July 2	36 10 0	178 0 0	2050	Globigerina ooze.	35·1	73·0	1·02572	1·02567	Trawled.	*	36	
			NORTH.	WEST.										
389	247	,, 3	35 49 0	179 57 0	2530	Red clay.	35·2	73·0	1·02568	1·02574	...	*	36	
390	248	,, 5	37 41 0	177 4 0	2900	Red clay.	35·1	69·2	...	1·02573	Trawled.	*	36	
391	249	,, 7	37 59 0	171 48 0	3000	Red clay.	35·2	65·2	1·02542	1·02540	...	*	36	
392	250	,, 9	37 49 0	166 47 0	3050	Red clay.	35·0	65·0	1·02568	1·02550	Trawled.	*	36	
393	251	,, 10	37 37 0	163 26 0	2950	Red clay.	35·1	65·0	1·02572	1·02522	...	*	36	
394	252	,, 12	37 52 0	160 17 0	2740	Red clay.	35·3	65·0	1·02567	1·02535	Trawled.	*	36	
395	253	,, 14	38 9 0	156 25 0	3125	Red clay.	35·1	67·7	1·02569	1·02536	Dredged.	*	36	
396	254	,, 17	35 13 0	154 43 0	3025	Red clay.	35·0	72·0	1·02533	1·02570	Trawled.	*	36	
397	255	,, 19	32 28 0	154 33 0	2850	Red clay.	35·0	74·0	1·02569	1·02602	...	*	36	
398	256	,, 21	30 22 0	154 56 0	2950	Red clay.	35·2	74·0	1·02565	1·02636	Dredged.	*	36	
399	257	,, 23	27 33 0	154 55 0	2875	Red clay.	34·9	76·5	1·02581	1·02611	...	*	36	
400	258	,, 24	26 11 0	155 12 0	2775	Red clay.	35·2	77·0	1·02525	1·02591	...	*	36	
401	259	,, 26	23 3 0	156 6 0	2225	Red clay.	34·9	77·0	1·02577	1·02574	...	*	36	
402	260	,, 27	21 11 0	157 27 0	310	Volcanic mud.	44·0	76·8	1·02542	1·02565	Trawled.	*	37	

Number of Sounding.	Distinguishing Number of Station.	Date. 1875–6.	Latitude.	Longitude.	Depth in Fathoms.	Nature of Bottom.	Temperature of the Sea-water. Bottom	Temperature of the Sea-water. Surface	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Bottom.	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Surface.	Trawling or Dredging.	Serial temperatures were obtained at the stations marked*	Plans on which the Station is shown.	
			NORTH. ° ′ ″	WEST. ° ′ ″			°	°						
403	261	August 12	20 18 0	157 14 0	2050	Volcanic mud.	35·2	78·5	1·02577	1·02586	...	*	37	Sandwich Islands to Tahiti.
404	262	„ 20	19 12 0	154 14 0	2875	Red clay.	35·2	77·5	1·02569	1·02585	...	*	38	
405	263	„ 21	17 33 0	153 36 0	2650	Red clay.	35·1	77·5	1·02544	1·02593	Trawled.	*	38	
406	264	„ 23	14 19 0	152 37 0	3000	Red clay.	35·2	77·5	1·02594	1·02572	Trawled.	*	38	
407	265	„ 25	12 42 0	152 1 0	2900	Red clay.	35·0	79·2	1·02551	1·02564	Dredged.	*	38	
408	266	„ 26	11 7 0	152 3 0	2750	Radiolarian ooze.	35·1	80·0	1·02579	1·02582	...	*	38	
409	267	„ 28	9 28 0	150 49 0	2700	Radiolarian ooze.	35·0	80·0	1·02572	1·02490	...	*	38	
410	268	„ 30	7 35 0	149 49 0	2900	Radiolarian ooze.	34·8	81·0	1·02569	1·02570	...	*	38	
411	269	September 2	5 54 0	147 2 0	2550	Radiolarian ooze.	35·2	81·2	1·02571	1·02591	Dredged.	*	38	
412	270	„ 4	2 34 0	149 9 0	2925	Globigerina ooze.	34·6	79·5	1·02578	1·02621	...	*	38	
			SOUTH.	WEST.										
413	271	„ 6	0 33 0	151 34 0	2425	Globigerina ooze.	35·0	78·7	1·02587	1·02661	Trawled.	*	38	
414	272	„ 8	3 48 0	152 56 0	2600	Radiolarian ooze.	35·1	79·0	1·02636	1·02650	Trawled.	*	38	
415	273	„ 9	5 11 0	152 56 0	2350	Radiolarian ooze.	34·5	80·7	...	1·02638	...	*	38	
416	274	„ 11	7 25 0	152 15 0	2750	Radiolarian ooze.	35·1	80·2	...	1·02656	Trawled.	*	38	
417	275	„ 14	11 20 0	150 30 0	2610	Red clay.	35·0	80·0	1·02602	1·02678	...	*	38	
418	276	„ 16	13 28 0	149 30 0	2350	Red clay.	35·1	80·0	1·02593	1·02628	Trawled.	*	38	
419	277	„ 17	15 51 0	149 41 0	2325	Red clay.	35·1	79·0	1·02581	...	...	*	38	
420	278	„ 18	17 12 0	149 43 0	1525	Volcanic mud.	36·5	79·5	1·02565	1·02696	...	*	38	
421	279	October 2	17 30 26	149 33 45	420	Volcanic mud.	...	79·0	...	...	...		39	Off Tahiti.
422	279A	„ 2	17 29 53	149 34 0	590	Volcanic mud.	...	79·0	...	...	...		39	
423	279B	„ 2	17 29 38	149 34 7	620	Volcanic mud.	...	79·0	...	....	...		39	
424	279C	„ 2	17 29 11	149 34 32	680	Volcanic mud.	...	79·0	...	...	Trawled.	*	39	
425	280	„ 4	18 40 0	149 52 0	1940	Globigerina ooze.	35·3	77·2	1·02630	1·02707	Trawled.	*	38	Tahiti to Valparaiso.
426	281	„ 6	22 21 0	150 17 0	2385	Red clay.	34·9	74·5	1·02628	1·02670	Trawled.	*	38	
427	282	„ 7	23 46 0	149 59 0	2450	Red clay.	35·1	73·2	1·02582	1·02676	...	*	38	
428	283	„ 9	26 9 0	145 17 0	2075	Globigerina ooze.	35·4	68·5	1·02583	1·02633	...	*	38	
429	284	„ 11	28 22 0	141 22 0	1985	Globigerina ooze.	35·1	68·0	1·02615	1·02631	Trawled.	*	38	
430	285	„ 14	32 36 0	137 43 0	2375	Red clay.	35·0	65·0	1·02575	1·02621	Trawled.	*	38	
431	286	„ 16	33 29 0	133 22 0	2335	Red clay.	34·8	63·0	1·02570	1·02608	Trawled.	*	38	
432	287	„ 19	36 32 0	132 52 0	2400	Red clay.	34·7	57·8	1·02564	1·02586	...	*	38	
433	288	„ 21	40 3 0	132 58 0	2600	Red clay.	34·8	54·5	1·02564	1·02561	...	*	38	
434	289	„ 23	39 41 0	131 23 0	2550	Red clay.	34·8	54·5	1·02565	1·02533	Trawled.	*	38	
435	290	„ 25	39 16 0	124 7 0	2300	Red clay.	34·9	52·5	1·02546	1·02533	...	*	38	
436	291	„ 27	39 13 0	118 49 0	2250	Red clay.	34·6	53·0	1·02550	1·02548	Trawled.	*	38	
437	292	„ 29	38 43 0	112 31 0	1600	Globigerina ooze.	35·2	53·2	1·02559	1·02532	Trawled.	*	38	
438	293	November 1	39 4 0	105 5 0	2025	Globigerina ooze.	34·4	53·7	1·02573	1·02522	Trawled.	*	38	
439	294	„ 3	39 22 0	98 46 0	2270	Red clay.	34·6	57·5	...	1·02519	...	*	38	
440	295	„ 5	38 7 0	94 4 0	1500	Globigerina ooze.	35·3	58·5	1·02562	1·02536	Trawled.	*	38	
441	296	„ 9	38 6 0	88 2 0	1825	Globigerina ooze.	35·3	59·8	1·02544	1·02536	Trawled.	*	38	
442	297	„ 11	37 29 0	83 7 0	1775	Globigerina ooze.	35·5	57·0	1·02565	1·02542	Trawled.	*	38	
443	298	„ 17	34 7 0	73 56 0	2225	Blue mud.	35·6	59·0	...	1·02533	Trawled.	*	38	
444	299	December 14	33 31 0	74 43 0	2160	Blue mud.	35·2	62·0	1·02567	1·02529	Trawled.	*	40	Valparaiso to Gulf of Penas.
445	300	„ 17	33 42 0	78 18 0	1375	Globigerina ooze.	35·5	62·5	1·02543	1·02526	Trawled.	*	40	
446	301	„ 22	37 29 0	84 2 0	(1800)	...	...	59·5	...	1·02539	...	*	40	
447	302	„ 28	42 43 0	82 11 0	1450	Globigerina ooze.	35·6	55·0	1·02562	1·02531	Trawled.	*	40	
448	303	„ 30	45 31 0	78 9 0	1325	Blue mud.	36·0	54·8	1·02563	1·02504	...	*	40	
449	304	„ 31	46 53 15	75 12 0	45	Green sand.	...	57·2	...	1·02295	Dredged.		41	In various channels leading to Magellan Strait.
450	305	January 1	47 47 0	74 47 0	165	Blue mud.	...	55·5	1·02519	1·02251	...		41	
451	305A	„ 1	47 48 30	74 47 0	125	Blue mud.	...	55·0	...	...	Trawled.		41	
452	305B	„ 1	47 48 0	74 46 0	160	Blue mud.	...	55·0	...	...	Trawled.		41	
453	306	„ 2	48 17 0	74 33 0	565	Blue mud.	...	57·0	...	1·01521	...		41	
454	306A	„ 2	48 27 0	74 30 0	345	Blue mud.	46·0	57·5	1·02515	1·00480	Trawled.	*	41	
455	307	„ 4	49 24 30	74 23 30	140	Blue mud.	...	53·0	1·02465	1·01508	Trawled.		41	
456	308	„ 5	50 8 30	74 41 0	175	Blue mud.	...	51·7	...	1·01401	Trawled.		41	
457	309	„ 8	50 56 0	74 15 0	40	Blue mud.	47·0	50·5	...	1·01896	...		41	
458	309A	„ 8	50 56 0	74 14 0	140	Blue mud.	..	50·5	1·02446	...	Trawled.		41	
459	310	„ 10	51 27 30	74 3 0	400	Blue mud.	46·5	50·5	1·02451	1·01910	Trawled.		41	
460	311	„ 11	52 45 30	73 46 0	245	Blue mud.	46·0	50·0	1·02454	1·01904	Trawled.		41	
461	312	„ 13	53 37 30	70 56 0	9	Blue mud.	...	47·8	...	1·02233	Dredged.		...	
462	313	„ 20	52 20 0	67 39 0	55	Sand.	47·8	48·2	1·02439	1·02437	Trawled.		41&42	Sandy Point to Falkland Islands.
463	314	„ 21	51 35 0	65 39 0	70	Sand.	46·0	48·0	1·02476	1·02468	Trawled.		42	
464	314A	„ 22	51 24 0	61 46 0	110	Hard ground.	41·8	49·0	1·02504	1·02486	Trawled.	*	42	
465	315	„ 26	51 40 0	57 50 0	12	Sand, gravel.	...	50·0	...	...	Dredged.		...	
466	316	February 3	51 32 0	58 6 0	4	Mud.	...	51·2	...	...	Dredged.		...	

Number of Sounding.	Distinguishing Number of Station.	Date. 1876.	Latitude.	Longitude.	Depth in Fathoms.	Nature of Bottom.	Temperature of the Sea-water. Bottom	Temperature of the Sea-water. Surface	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Bottom.	Specific Gravity of Sea-water at 60° F. Distilled Water at 39°=1. Surface.	Trawling or Dredging.	Serial temperatures were obtained at the stations marked*	Plans on which the Station is shown.	
			SOUTH. ° ′ ″	WEST. ° ′ ″			°	°						
467	317	February 8	48 37 0	55 17 0	1035	Hard ground (gravel).	35·7	46·7	1·02531	1·02524	Trawled.	*	42	Falkland Islands to Rio de la Plata
468	318	" 11	42 32 0	56 29 0	2040	Blue mud.	33·7	57·5	1·02584	1·02524	Trawled.	*	42	
469	319	" 12	41 54 0	54 48 0	2425	Blue mud.	32·7	59·5	1·02552	1·02555	...	*	42	
470	320	" 14	37 17 0	53 52 0	600	Green sand.	37·2	67·5	1·02541	1·02523	Trawled.	*	42	
471	321	" 25	35 2 0	55 15 0	13	Mud.	...	73·5	...	...	Trawled.		...	
472	322	" 26	35 20 0	53 42 0	21	Sand, shells.	...	71·5	...	1·02288	Trawled.		16	
473	323	" 28	35 39 0	50 47 0	1900	Blue mud.	33·1	73·5	1·02641	1·02670	Trawled.	*	16	Rio de la Plata to Tristan da Cunha.
474	324	" 29	36 9 0	48 22 0	2800	Blue mud.	32·6	71·5	1·02600	1·02603	Trawled.	*	16	
475	325	March 2	36 44 0	46 16 0	2650	Blue mud.	32·7	70·8	1·02583	1·02675	Trawled.	*	16	
476	326	" 3	37 3 0	44 17 0	2775	Blue mud.	32·7	67·8	1·02585	1·02491	...	*	16	
477	327	" 4	36 48 0	42 45 0	2900	Blue mud.	32·8	70·2	1·02614	1·02633	...	*	16	
478	328	" 6	37 38 0	39 36 0	2900	Blue mud.	32·9	68·0	...	1·02571	...		16	
479	329	" 7	37 31 0	36 7 0	2675	Red clay.	32·3	64·5	1·02576	1·02606	...	*	16	
480	330	" 8	37 45 0	33 0 0	2440	Red clay.	32·7	64·2	1·02608	1·02620	...	*	16	
481	331	" 9	37 47 0	30 20 0	1715	Globigerina ooze.	35·4	64·5	1·02588	1·02620	Trawled.	*	16	
482	332	" 10	37 29 0	27 31 0	2200	Globigerina ooze.	34·0	64·0	1·02580	1·02604	Trawled.	*	16	
483	333	" 13	35 36 0	21 12 0	2025	Globigerina ooze.	35·3	67·0	1·02584	1·02612	Trawled.	*	16	
484	334	" 14	35 45 0	18 31 0	1915	Globigerina ooze.	35·8	68·5	1·02604	1·02604	Trawled.	*	16	
485	335	" 16	32 24 0	13 5 0	1425	Pteropod ooze.	37·0	73·5	1·02585	1·02666	Dredged.	*	16	Tristan da Cunha to Ascension Island.
486	336	" 18	27 54 0	13 13 0	1890	Globigerina ooze.	36·5	76·0	1·02590	1·02693	...	*	16	
487	337	" 19	24 38 0	13 36 0	1240	Pteropod ooze.	37·2	77·0	1·02639	1·02704	Dredged.	*	16	
488	338	" 21	21 15 0	14 2 0	1990	Globigerina ooze.	36·3	76·5	...	1·02752	Dredged.	*	16	
489	339	" 23	17 26 0	13 52 0	1415	Pteropod ooze.	37·2	76·0	1·02568	1·02775	...	*	16	
490	340	" 24	14 33 0	13 42 0	1500	Pteropod ooze.	37·6	77·2	1·02598	1·02752	...	*	16	
491	341	" 25	12 16 0	13 44 0	1475	Pteropod ooze.	38·2	79·0	1·02601	1·02706	...	*	16	
492	342	" 26	9 43 0	13 51 0	1445	Pteropod ooze.	37·5	80·0	1·02600	1·02721	...	*	16	
493	343	" 27	8 3 0	14 27 0	425	Volcanic sand.	40·3	80·8	1·02612	1·02688	Dredged.	*	43	
494	344	April 3	7 54 20	14 28 20	420	Volcanic sand.	...	82·0	...	1·02658	Dredged.		43	Ascension Island to St. Vincent.
495	345	" 4	5 45 0	14 25 0	2010	Globigerina ooze.	36·8	82·8	1·02599	1·02627	...	*	12	
496	346	" 6	2 42 0	14 41 0	2350	Globigerina ooze.	34·0	82·7	1·02622	1·02624	Dredged.	*	12	
497	347	" 7	0 15 0	14 25 0	2250	Globigerina ooze.	36·2	82·0	1·02589	1·02639	...	*	12	
			NORTH.	WEST.										
498	348	" 9	3 10 0	14 51 0	(2450)	...	...	84·0	...	1·02578	Dredged.	*	12 (St. 102)	
499	349	" 10	5 28 0	14 38 0	...	...	...	83·5	...	1·02616	...	*	12	
500	350	" 11	7 33 0	15 16 0	...	...	...	84·0	...	1·02615	...	*	12	
501	351	" 12	9 9 0	16 41 0	...	...	...	81·8	...	1·02653	...	*	12	
502	352	" 13	10 55 0	17 46 0	...	...	...	77·7	...	1·02662	...	*	12	
503	353	May 3	26 21 0	33 37 0	2965	Red clay.	37·6	70·7	1·02708	1·02768	...	*	6	St. Vincent towards Azores.
504	354	" 6	32 41 0	36 6 0	1675	Globigerina ooze.	37·8	70·0	1·02665	1·02729	...	*	6	

APPENDIX III.

REPORT on the CHRONOMETERS supplied to, and the MERIDIAN DISTANCES obtained by, H.M.S. Challenger, between the 1st December 1872 and the 12th June 1876, by Staff-Commander T. H. TIZARD, R.N.

THE sixteen chronometers supplied to the Challenger at Sheerness were twelve box and four pocket watches, and in addition a deck watch for ordinary use on board.

The chronometer room was on the port side of the lower deck just abaft the mainmast. In it a platform was constructed on which a wooden tray with twelve partitions rested, and the box chronometers were packed in this tray with horse hair (at Sheerness), and remained there undisturbed until they were finally returned on the ship's arrival in England in 1876. The platform consisted of three wooden stools of elm, 4 inches in thickness, with legs 4 inches in height and width, constructed in such a manner that when these stools were placed one upon the other, the legs of the upper stool rested on the middle stool immediately over its legs, which again were over the legs of the lower stool, so that copper bolts could be driven through the stools and their legs into one of the main beams, and thus securely fasten the platform. The wooden tray was secured to the top of the upper stool with brass screws, care being taken to keep all iron away from the chronometers. Around the platform a wooden screen was constructed, which reached just above the top of the tray, and on the top of this wooden screen was a glazed lid on hinges, so that the chronometers might be seen for purposes of comparison at any time, but neither they nor the platform on which they rested could be touched without lifting this lid, which was only done once a day for the purpose of winding. The wooden screen which protected the platform and trays was secured to the deck, and kept perfectly free from any of the bulkheads, so that its movement, like that of the platform, depended only on the working of the beam on which it rested, and not on the working of the bulkheads, which were secured to beams at top and bottom. Before being packed in the tray the lids of the boxes which contained the chronometers were unscrewed from the hinges, the screws wrapped in paper and put in their respective boxes, and the lids put on a shelf overhead in the chronometer room.

The pocket chronometers were kept in a small tray separate from the box chronometers, so that when they were required for shore observations they might be taken out of the chronometer room without disturbing the box chronometers. The tray in which they were placed rested on a solid block of fir secured to a beam.

Of the sixteen chronometers originally supplied at Sheerness one stopped before leaving England, and was replaced at Portsmouth; one stopped in August 1873, and was replaced at the Cape of Good Hope; and one stopped in December 1875; the rest were brought home in good condition, with the exception of one pocket chronometer which was injured in consequence of the sight-boat having been capsized in the surf at Fernando Noronha.

Directly they were received, letters were given to the chronometers, which were afterwards only known by those letters, so that there could be no prejudice in favour of any particular maker.

The following table shows the chronometers supplied, and the letters by which they were distinguished on board, &c. :—

LIST OF CHRONOMETERS IN H.M.S. CHALLENGER.

	Makers' Names.	No. of Chronometer.	When received.	From whom received.	Distinguishing letter on board.	How disposed of.
	Molyneux,	2119	Nov. 22d 1872.	Greenwich Observatory.	Z	Returned to England, August 1873, (stopped).
	Dent,	1763	Do.	Do.	A	Returned at Sheerness on paying off, June 1876.
	Hewitt,	2553	Do.	Do.	B	Do.
	Carter,	197	Do.	Do.	C	Do.
	Park & Bouts,	801	Do.	Do.	D	Do.
	Pennington,	241	Do.	Do.	E	Do.
	Cotterell,	$\frac{782}{1984}$	Do.	Do.	F	Do.
	Arnold & Dent,	742	Do.	Do.	G	Do.
	Pennington,	1512	Do.	Do.	H	Do.
	C. Frodsham,	1765	Do.	Do.	J	Do.
	M'Cabe,	166	Do.	Do.	K	Do.
	Muston,	658	Do.	Do.	L	Returned to Portsmouth Observatory, Dec. 14, 1872 (stopped).
	Lister & Sons,	608	Dec. 14th 1872.	Portsmouth Observatory.	L	Returned at Sheerness on paying off, June 1876.
	R. & H. Molyneux,	1948	Nov. 20th 1873.	C. of G. Hope Observatory.	M	Do.
Pocket.	Molyneux,	5778	Nov. 22d 1872.	Greenwich Observatory.	M	Returned to England, Sept. 1873.
Pocket.	Arnold,	6221	Do.	Do.	N	Returned at Sheerness on paying off, June 1876.
Pocket.	Parkinson and Frodsham,	701	Do.	Do.	O	Do.
Pocket.	Molyneux,	706	Do.	Do.	P	Do.
	Pennington (Deck),	1299	Do.	Do.	Q	Do.

With these chronometers a regular chain of meridian distances was carried on from the date of leaving England to the date of the return of the Expedition, the chronometers being rated at each place of observation, except when the stay was too short to permit of doing so. For this purpose equal altitudes were in all cases obtained when practicable;

occasionally, owing to the short stay or to a run of bad weather, dependence had to be placed on single sights, but as a rule equal altitudes were successfully obtained.

Owing to the unfavourable state of the weather on leaving England in December 1872, it was necessary to rate the chronometers originally by time-ball, observations not being obtainable; consequently the meridian distance between Greenwich and Lisbon is not of so much value as it would have been had the chronometers been rated at each place by the same observer with the same instrument, as the personal and instrumental errors are not the same at each end of the meridian distance. In all the other distances given in the tables, the observer and instrument used by the observer were the same throughout.

The meridian distances have been in all cases worked by Dr. Tiarks' method as given by him in the voyage of the "Chanticleer."

The following tables give all the particulars requisite, viz., the rates of the chronometers as ascertained at the different ports touched at during the voyage, the meridian distances between the observing stations, and the positions of those observing stations, as determined by our observations with the meridians upon which those positions are based.

It will be noticed from these tables that, with the exception of Bermuda, St. Michael's, Tristan da Cunha, Levuka, Tongatabu, Dobbo, and Ternate, the positions as determined by the Expedition agree well with the positions on the published Admiralty Charts.

TABLE I.—Abstract of the daily rates of the Chronometers used for calculating Meridian Distances in H.M.S
on different days at the same observ

Places where rated.	Date.	Number of days rates.	Mean Temp. in Chronometer Room during rating period.	RATES OF THE CHRO						
				Z	A	B	C	D	E	F
				s.	s.	s.	s.	s.	s.	s.
Portsmouth.	20/12/72	11	53°·0	−3·400	−0·900	+ 9·610	−3·964	+6·220	+0·400	−7·01
Lisbon.	12/ 1/73	8	60°·0	−3·008	−4·640	+12·760	−3·770	+6·236	+1·140	−8·94
Gibraltar.	25/ 1/73	7	60°·5	−2·956	−5·206	+14·760	−3·384	+6·580	+1·544	−9·077
Tenerife.	14/ 2/73	6	64°·0	−2·973	−6·140	+17·527	−3·282	+6·427	+2·493	−8·82
St. Thomas.	24/ 3/73	6	77°·5	−3·313	−7·147	+24·112	−3·972	+4·070	+1·203	−10·747
Bermuda.	11/ 4/73	6	72°·5	−3·171	−7·047	+24·487	−3·905	+4·520	+1·903	−9·78
Do.	19/ 4/73	8	69°·5	−2·852	−6·771	+24·366	−3·740	+4·366	+2·729	−9·35
Halifax.	19/ 5/73	9	52°·5	−2·933	−4·617	+23·928	−3·761	+4·189	+2·066	−6·71
Bermuda.	12/ 6/73	10	76°·0	−3·342	−7·952	+24·973	−4·142	+5·113	+1·868	−9·78
St. Vincent.	3/ 8/73	6	78°·0	−17·815	−10·632	+26·510	−4·707	+6·493	+1·618	−10·13
Bahia.	22/ 9/73	6	78°·0	...	−21·198	+26·952	−5·048	+7·360	+1·901	−9·53
Do.	25/ 9/73	9	78°·0	...	−21·421	+26·951	−5·104	+7·551	+1·807	−9·54
Cape of Good Hope.	7/11/73	6	64°·0	...	−20·868	+28·115	−4·101	+8·032	+3·257	−5·67
Do.	21/11/73	14	66°·0	...	−20·666	+27·187	−4·252	+8·055	+3·308	−6·15
Do.	11/12/73	8	65°·0	...	−20·537	+27·775	−4·263	+7·963	+3·312	−5·72
Do.	16/12/73	5	66°·0	...	−20·908	+27·462	−4·218	+7·802	+3·282	−6·09
Elizabeth Harbour, Kerg. I.	15/ 1/74	5	52°·0	...	−19·382	+27·358	−3·942	+7·438	+2·678	−6·24
Christmas Harbour, Kerg. I.	30/ 1/74	23	51°·0	...	−19·455	+27·499	−4·026	+7·358	+1·238	−6·06
Melbourne.	30/ 3/74	12	64°·0	...	−20·986	+28·431	−3·777	+8·306	+0·589	−7·66
Sydney.	13/ 4/74	6	72°·0	...	−22·507	+28·718	−4·332	+8·027	+0·510	−8·76
Do.	11/ 5/74	28	69°·0	...	−22·132	+29·425	−3·989	+8·316	+1·486	−8·25
Do.	18/ 5/74	7	64°·0	...	−22·133	+29·710	−3·526	+8·367	+1·588	−7·29
Do.	1/ 6/74	14	62°·0	...	−21·758	+29·542	−3·465	+8·374	+1·788	−7·21
Do.	8/ 6/74	7	60°·0	...	−21·100	+29·628	−3·821	+8·336	+2·074	−6·63
Wellington.	5/ 7/74	6	58°·0	...	−19·783	+30·953	−3·417	+8·793	+1·110	−5·90
Ngaloa Harbour.	9/ 8/74	13	78°·0	...	−23·929	+29·863	−4·272	+8·409	+4·352	−8·78
Cape York.	8/ 9/74	5	81°·0	...	−25·634	+30·426	−5·214	+7·926	+3·086	−10·01
Arrou Islands.	22/ 9/74	5	83°·0	...	−26·234	+30·696	−5·104	+7·836	+3·436	−11·16
Amboina.	10/10/74	5	83°·0	...	−28·116	+30·654	−4·946	+7·934	+4·034	−11·72
Manila.	11/11/74	6	84°·0	...	−34·113	+30·887	−4·363	+8·595	+3·720	−11·65
Hong Kong.	24/11/74	7	72°·0	...	−32·796	+32·193	−3·188	+9·147	+5·340	−7·84
Do.	5/12/74	11	67°·0	...	−31·793	+32·057	−2·893	+8·662	+3·762	−6·31
Do.	15/12/74	10	69°·0	...	−31·871	+31·139	−3·096	+8·629	+4·689	−6·61
Do.	27/12/74	12	72°·0	...	−32·189	+30·723	−3·202	+8·761	+6·852	−6·78
Do.	4/ 1/75	8	64°·5	...	−31·191	+31·009	−2·529	+8·959	+1·327	−6·34
Zebu.	24/ 1/75	5	82°·0	...	−35·236	+30·454	−3·596	+8·494	+3·054	−9·79
Samboangan.	5/ 2/75	7	82°·5	...	−35·110	+31·226	−3·438	+8·440	+1·793	−9·81
Nares Harb., Admiralty Is.	10/ 3/75	6	83°·5	...	−37·345	+31·938	−3·395	+7·988	+1·205	−11·26
Yokohama.	18/ 4/75	4	62°·5	...	−30·885	+32·715	−1·848	+9·302	+1·265	−6·57
Do.	22/ 4/75	4	61°·0	...	−30·818	+32·482	−1·218	+9·220	+0·982	−5·84
Do.	4/ 5/75	12	61°·0	...	−30·826	+32·362	−0·238	+9·074	+1·787	−5·5
Do.	7/ 6/75	34	69°·0	...	−32·794	+31·394	−0·484	+9·082	+3·697	−7·2
Do.	14/ 6/75	7	73°·5	...	−33·941	+32·637	−1·834	+9·258	+2·687	−9·0
Honolulu.	4/ 8/75	7	80°·5	...	−35·416	+31·921	−5·557	+9·350	+1·257	−10·8
Do.	10/ 8/75	6	81°·5	...	−36·200	+31·866	−5·466	+9·017	+1·625	−10·4
Tahiti.	1/10/75	9	80°·0	...	−34·117	+32·078	−5·139	+9·384	+1·628	−9·0
Valparaiso.	27/11/75	7	67°·0	...	−33·011	+33·060	−3·490	+9·060	+1·724	−5·7
Do.	4/12/75	7	66°·0	...	−32·393	+32·844	−2·570	+9·287	+2·116	−5·3
Do.	9/12/75	5	66°·0	...	−32·038	+33·152	−2·198	+9·512	+2·532	−4·8
Sandy Point.	17/ 1/76	3	57°·5	...	−31·983	+33·242	−2·673	+9·127	+1·877	−5·3
Port Stanley, Falkland Is.	31/ 1/76	6	57°·5	...	−31·556	+32·969	−3·096	+8·764	+1·337	−5·3
Do.	6/ 2/76	6	56°·5	...	−31·061	+32·218	−1·391	+9·990	+1·727	−4·4
Monte Video.	24/ 2/76	8	71°·0	...	−33·689	+33·217	−3·657	+9·292	+2·305	−6·5
Ascension.	2/ 4/76	5	83°·0	...	−37·088	+33·092	−5·258	+8·862	+1·202	−9·6
St. Vincent.	25/ 4/76	5	75°·0	...	−34·522	+33·088	−4·182	+11·078	+1·518	−7·5

Challenger, deduced from observations made on Shore, the rates being in each case found by observing ation. + Gaining. — Losing.

OMETERS.						How rated.	Remarks.
G	H	J	K	L	M		
s.	s.	s.	s.	s.	s.		
-5·870	+0·020	-1·145	-8·780	-0·870	-4·240	Time ball.	Chronometer Z stopped on August 8th 1873, and was sent to England. Chronometer M stopped on 2nd September and was sent to England. Afterwards at the Cape of Good Hope another chronometer, R. & H. Molyneux 1948, was supplied, and used subsequently for Meridian distances under the distinguishing letter M.
-6·614	+0·249	-0·532	-9·000	-0·460	-4·910	Equal alts.	
-6·850	+0·337	-0·506	-9·277	-0·306	-2·827	Equal alts.	
-6·657	-0·015	-0·498	-8·915	-0·140	-3·223	Equal alts.	
-7·263	-0·813	-0·613	-9·622	+0·937	-4·080	Equal alts.	
-8·763	-0·497	-0·013	-8·761	+0·211	-2·897	Equal alts.	
-8·871	-0·327	+0·179	-8·427	+0·222	-3·134	Equal alts.	
-7·983	-0·344	-0·039	-5·722	+0·194	-0·333	Equal alts.	Chronometer G stopped on December 9th 1875.
-9·092	-0·587	+0·633	-8·397	+0·508	-3·156	Equal alts.	
10·607	-1·182	+0·560	-9·548	+0·327	-4·548	Equal alts.	
16·965	-1·206	+0·026	-8·532	+0·943	...	Equal alts.	
17·199	-1·204	+0·051	-8·666	+0·840	...	Equal alts.	
18·877	+0·248	+0·948	-6·468	+1·415	...	Equal alts.	
18·948	+0·294	+0·919	-6·488	+1·283	...	Equal alts.	
18·825	+0·400	+0·750	-6·763	+1·275	-3·025	Time ball.	
18·618	+0·412	+0·902	-6·788	+1·152	-2·948	Equal alts.	
19·522	+0·688	+0·288	-5·222	+2·688	-2·522	Equal alts.	
19·476	+0·476	+0·117	-5·555	+2·601	-2·629	Equal alts.	
19·261	+0·581	+0·973	-7·136	+2·156	-4·336	A.M. sights.	
20·373	+0·193	+0·393	-8·690	+1·277	-4·832	Equal alts.	
21·912	+0·372	+0·942	-7·359	+1·650	-4·230	Equal alts.	
23·583	+0·638	+1·581	-6·633	+2·260	-3·904	Equal alts.	
23·597	+0·545	+0·956	-6·186	+2·171	-3·933	Equal alts.	
23·828	+0·414	+0·864	-6·378	+1·921	-3·778	Equal alts.	
24·057	+0·800	+1·166	-5·610	+2·283	-3·166	A.M. sights.	
25·494	-0·083	+0·908	-8·129	+1·840	-4·814	Equal alts.	
29·314	-1·114	+0·546	-8·874	+0·886	-4·974	A.M. sights.	
30·034	-1·484	+0·716	-8·884	+1·216	-4·454	Equal alts.	
30·906	-1·256	+1·054	-8·776	+1·324	-4·126	Equal alts.	
33·947	-1·347	+0·737	-9·088	+1·028	-4·358	A.M. sights.	
33·296	-0·067	+1·054	-6·753	+2·019	-3·246	Equal alts.	
32·934	+0·112	+1·066	-6·179	+1·857	-3·129	Equal alts.	
32·711	+0·354	+1·464	-6·036	+2·099	-3·146	Equal alts.	
32·814	+0·402	+1·373	-6·310	+2·136	-3·252	Equal alts.	
32·666	+0·559	+1·359	-6·366	+2·227	-3·147	Equal alts.	
34·526	-0·626	+0·974	-8·146	+1·874	-4·526	Equal alts.	
34·881	-0·538	+1·204	-8·117	+1·540	-4·474	Equal alts.	
36·345	-1·012	+0·605	-10·128	+1·038	-5·012	A.M. sights.	
4·510	-0·752	+1·965	-6·447	+2·752	-2·810	Equal alts.	
4·555	+0·808	+1·958	-5·780	+2·682	-3·692	Equal alts.	
4·947	+0·824	+1·587	-6·197	+2·712	-3·342	Equal alts.	
5·805	+0·470	+1·664	-7·800	+2·531	-3·917	Equal alts.	
6·398	+0·501	+1·930	-8·991	+2·880	-4·277	Equal alts.	
7·200	-0·817	+1·521	-9·686	+1·943	-4·971	Equal alts.	
7·283	-1·075	+1·300	-9·217	+2·058	-5·158	Equal alts.	
8·258	-0·450	+1·450	-8·200	+2·211	-4·689	Equal alts.	
1·026	+1·081	+1·974	-7·169	+2·724	-3·704	Equal alts.	
6·606	+1·216	+2·073	-6·620	+2·987	...	Equal alts.	
...	+1·452	+2·032	-6·248	+3·452	-4·118	A.M. and P.M. sights.	
...	+1·577	+2·210	-6·090	+3·360	-2·873	Equal alts.	
...	+1·354	+1·693	-5·679	+2·928	-3·219	Equal alts.	
...	+1·320	+1·981	-5·120	+3·252	-2·832	Equal alts.	
...	+1·380	+2·230	-7·345	+3·167	-4·451	Equal alts.	
...	-0·298	+1·252	-10·158	+1·922	-4·398	Equal alts.	
...	+0·728	+1·928	-8·492	+2·658	-4·242	Equal alts.	

TABLE II.—Chain of Meridian Distances round the world, from St. Vincent, East round Cape of Good Hope, returning to St. Vincen
twenty-four hours, as well as the Arithmetica

From	To	MERIDIAN DISTANCES													
		A.		B.		C.		D.		E.		F.		G.	
		E.	W.	E.	W.	E.	W.	E.	W.	E.	W.	E.	W.	E.	W.
		h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
St. Vincent.	Bahia.	...	0.54.15.37	...	0.54. 1.70	...	0.54. 6.95	...	0.54. 1.87	...	0.53.45. 2	...	0.53.49.22	...	0.54.14.44
Bahia.	C. Good Hope.	3.47.56.67	...	3.47.51.15	...	3.48. 0.78	...	3.48. 6.72	...	3.48.11.03	..	3.47.31.38	...	3.48.18.02	...
C. Good Hope.	Christmas Harb.	3.22. 6.61	...	3.22.14.92	... .	3.22.12.66	...	3.22.11.76	...	3.22.10.10	...	3.21.59.26	...	3.22.17.21	...
Christmas Harb.	Melbourne.	5. 3.24.28	...	5. 3.28.12	...	5. 3.51.91	...	5. 4.14.76	...	4.59.44.47	...	5. 3.20.30	..	5. 3.51.37	...
Melbourne.	Sydney.	0.25.13.09	...	0.25.17.38	...	0.25.15.63	...	0.25.14.45	...	0.25.16.62	...	0.25.13.38	...	0.25.14.21	...
Sydney.	Wellington.	1.34.43.45	...	1.34.14.56	...	1.34.15.66	...	1.34.17.00	...	1.34. 5.55	...	1.34.14.54	...	1.34.13.60	...
Wellington.	Levuka.	0.16.33.20	...	0.16. 7.51	...	0.16.18.24	...	0.16.23.58	...	0.16.22.92	...	0.16.12.03	...	0.16.13.05	...
Levuka.	Sextant Rock.	...	2.25. 7.72	...	2.25.35.59	...	2.25.12.20	...	2.25.19.52	...	2.25.12.54	...	2.25.37.19	...	2.25. 9.85
Sextant Rock.	Dobbo.	...	0.33.18.34	...	0.33.18.65	...	0.33.17.94	...	0.33.20.02	...	0.33.18.51	...	0.33.19.14	...	0.33.14.63
Dobbo.	Amboina.	...	0.24. 9.63	...	0.24.10.24	...	0.24.11.18	...	0.24.11.61	...	0.24. 3.16	...	0.24. 1.79	...	0.24.10.47
Amboina.	Manila.	...	0.28.47.74	...	0.28.52.28	...	0.28.51.63	...	0.28.53.17	...	0.28.41.75	...	0.28.46 39	...	0.28.43.73
Manila.	Zebu.	0.11.52.76	...	0.11.48.00	...	0.11.47.71	...	0.11.46.51	...	...	...	0.11.49.11	...	0.11.48.40	...
Zebu.	Samboangan.	...	0. 7.18.02	...	0. 7.19.96	...	0. 7.18.05	...	0. 7.18.64	...	0. 7.25.08	...	0. 7.21 44	...	0. 7.19.16
Samboangan.	Humboldt Bay.	1.14.30.67	...	1.14.36.28	...	1.14.35.16	...	1.14.31.16	...	1.14.21.41	...	1.14.22.68	...	1.14.27.73	...
Humboldt Bay.	Admiralty Is.	0.23.52.82	...	0.24. 2.94	...	0.23.55.19	...	0.23.55.22	...	0.23.53.62	...	0.23.54.65	...	0.23.55.60	...
Admiralty Is.	Yokohama.	...	0.27.27.42	...	0.28.15.37	...	0.27.45.80	...	0.28. 7.70	...	0.28. 0.31	...	0.27. 6.66	...	0.27.27.47
Yokohama.	Honolulu.	4. 9.58.89	...	4. 9.59.97	...	4.10.35.35	...	4.10. 1.60	...	4.10.34.10	...	4. 9.23.82	...	4.10.11.20	...
Honolulu.	Tahiti.	0.33.36.81	...	0.33.24.12	...	0.33.47.86	...	0.33.28.59	...	0.33.29.19	...	0.33.15.17	...	0.33.13.75	...
Tahiti.	Valparaiso.	5.10.49.58	...	5.11.21.23	..	5.11.27.58	...	5.11.11.83	...	5.11.35.98	...	5. 9.55.08	...	...	...
Valparaiso.	Sandy Point.	0. 2.59.63	...	0. 3. 4.85	...	0. 3. 4.44	...	0. 2.57.42	...	0. 3.27.38	...	0. 2.41.28	...	...	...
Sandy Point.	Port Stanley.	0.52. 5.72	...	0.52. 5.36	...	5.51.57.16	...	0.52. 4.12	...	0.52. 9.49	...	0.52. 4.15	...	...	...
Port Stanley.	Monte Video.	0. 6.20.63	...	0. 6.21.58	...	0. 6.19.05	...	0. 6.33.36	...	0. 6.29.09	...	0. 6.16.44	...	...	...
Monte Video.	Ascension.	2.47. 1.43	...	2.47.14.18	...	2.46.57.93	...	2.46.46.55	...	2.47. 8.54	...	2.46.51.30	...	...	...
Ascension.	St. Vincent.	...	0.42.12.69	...	0.42.25.38	...	0.42.23.03	...	0.42.28.64	...	0.42.15.62	...	0.42.12 41	...	...
Totals.		30. 3. 6.24	6. 2.36.93	30. 3.12.15	6. 3.59.17	30. 4.22.31	6. 3. 6.78	30. 3.44.63	6. 3.41.17	Only partially used.		29.59. 4.57	6. 2.14.24	Only partially used, as it stopped between Tahiti and Valparaiso.	
Deduct Westerly Mer. Dist.		6. 2.36.93		6. 3.59.17		6. 3. 6.78		6. 3.41.17				6. 2.14.24			
Result.		24. 0.29.31		23.59.12.98		24. 1.15.53		24. 0. 3.46				23.56.50.33			

via Magellan Strait. Table showing the results obtained by each Chronometer, and the errors of the Chronometers in the whole chain of Mean of the Chronometers and the selected mean.

BY CHRONOMETERS.										Extreme range of all Chronometers.	Mean of all Chronometers.		Day's running distance.	Meridian Distance by selection of Chronometers.		Chronometers selected.	Extreme range of selected Chronometers.
H.		J.		K.		L.		M.									
E.	W.	E.	W.	E.	W.	E.	W.	E.	W.		E.	W.		E.	W.		
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*s.*	*h. m. s.*	*h. m. s.*		*h. m. s.*	*h. m. s.*		*s.*
...	0.53.57.10	...	0.53.53.47	...	0.53.55.37	...	0.54. 4.07	...	...	30.37	...	0.54. 0.43	44	...	0.54. 0.08	B C D H J K L	13.48
3.48. 7.87	...	3.48. 8.65	...	3.47.57.68	...	3.48.14.53	...	...	...	46.64	3.48. 2.22	...	37	3.48. 3.06	...	A C D H J K	11.98
3.22.18.82	...	3.22.19.51	...	3.22. 8.90	...	3.22. 9.24	...	3.22. 7.50	...	20.25	3.22.11.37	...	22	3.22.12.47	...	A B C D E G H J K L M	12.90
5. 3.58.08	...	5. 4.13.48	...	5. 3.43.37	...	5. 3. 0.82	...	5. 3.17.37	...	270.29	5. 3.20.69	...	47	5. 3.36.85	...	A B C F G H K M	40.71
0.25.17.31	...	0.25.12.84	...	0.25.16.23	...	0.25.16.80	...	0.25.17.56	...	4.72	0.25.15.46	...	8	0.25.15.46	...	All	4.72
1.34.17.18	...	1.34.12.38	...	1.34.35-34	...	1.34.18.87	...	1.34.25.98	...	37.90	1.34.19.51	...	21	1.34.15.47	...	B C D F G H J L	6.49
0.16.15.84	...	0.16.12.05	...	0.16.31.58	...	0.16.18.64	...	0.16.12.40	...	25.69	0.16.18.42	...	31	0.16.14.61	...	C F G H J L M	6.61
...	2.25.16.04	...	2.25.13.60	...	2.25.18.24	...	2.25.15.03	...	2.25.20.62	29.47	...	2.25.18.18	37	...	2.25.15.97	C D E H J K L M	8.42
...	0.33.21.17	...	0.33.19.94	...	0.33.16.90	...	0.33.17.85		0.33.17.06	6.54	...	0.33.19.18	12	...	0.33.18.26	A B C E F J K L M	3.04
...	0.24.12.82	...	0.24.10.11	...	0.24. 6.90	...	0.24. 9.35	...	0.24. 7.38	11.03	...	0.24. 8.72	10	...	0.24. 9.65	A B C D G J K L M	4.71
...	0.28.51.70	...	0.28.51.53	...	0.28.48.86	...	0.28.52.16	...	0.28.49.59	11.42	...	0.28.49.21	26	...	0.28.50.21	A B C F H J K L M	5.89
0.11.48.03	...	0.11.47.61	...	0.11.49.35	...	0.11.48.99	...	0.11.50.76	...	6.25	0.11.48.84	...	7	0.11.48.66	...	B C F G H J K L M	3.15
...	0. 7.17.96	...	0. 7.17.79	...	0. 7.18.74	...	0. 7.17.87	...	0. 7.17.44	7.64	...	0. 7.19.18	5	...	0. 7.18.46	A B C D G H J K L	2.17
1.14.32.43	...	1.14.38.60	...	1.14.29.66	...	1.14.34.91	...	1.14.34.42	...	17.19	1.14.31.24	...	19	1.14.31.99	...	A C D G H K L M	7.43
0.23·55.87	...	0.23.54.43	...	0.23.55.03	...	0.23.56.67	...	0.23.55.48	...	10.12	0.23.55.63	...	8	0.23.55.18	...	C D E F G H J K L M	3.05
...	0.27.50.21	...	0.27.45.16	...	0.27.11.26	...	0.27.50.62	...	0.27.39.38	68.71	...	0.27.42.28	35	...	0.27.46.23	C H J L M	11.24
4. 9.55.32	...	4.10. 8.88	...	4. 9.55.88	...	4.10. 3.08	...	4. 9.54.21	...	71.53	4.10. 3.52	...	45	4.10. 1.00	...	A B D G H J K L M	16.99
0.33.33.86	...	0.33.46.05	...	0.33.45.67	...	0.33.33.45	...	0.33.25.08	...	34,11	0.33.31.63	...	43	0.33.30.16	...	A B D E H L M	12.69
5.10.59.63	...	5.11.43.18	...	5.10.47.28	...	5.11,14.48	...	5.10.58.08	...	108.13	5.11. 5.81	...	50	5.11.12.88	...	A B C D E H J K L M	55.90
0. 3. 4.55	...	0. 3.11.80	...	0. 2.47.21	...	0. 3.19.86	...	0. 3. 4.94	...	46.10	0. 3. 3.94	...	36	0. 3. 2.64	...	A B C D H M	7.52
0.52. 7.46	...	0.52. 9.49	...	0.52. 6.11	...	0.52. 9.48	...	0.52. 6.78	...	12.33	0.52. 5.94	...	8	0.52. 6.82	...	A B D E F H J K L M	5.37
0. 6.25.38	...	0. 6.33.98	...	0. 6.21.23	...	0. 6.25.77	...	0. 6.24.52	...	17.54	0. 6.24.64	...	10	0. 6.20.81	...	A B C E H K L M	10.04
2.47. 7.03	...	2.47.13.23	...	2.47.12.65	...	2.47.17.49	...	2.47.19.82	...	33.27	2.47. 6.38	...	33	2.47.13.28	...	B E H J K L M	12.79
...	0.42.11.13	...	0.42.14.18	...	0.42.12.65	...	0.42.16.93	...	0.42.12.92	17.51	...	0.42.16.87	18	...	0.42.13.57	A C F H J K L M	5. 8
30. 3.44.66	6. 2.58.13	30. 5.26.16	6. 2.45.78	30. 3.23.17	6. 2. 8.92	30. 3.43.08	6. 3. 3.88	Only partially used. Supplied at Cape of Good Hope.			30. 3. 5.24	6. 2.54.05		30. 3.21.34	6. 2.52.43		
6. 2.58.13		6. 2.45.78		6. 2. 8.92		6. 3. 3.88					6. 2.54.05			6. 2.52.43			
24. 0.46.53		24. 2.40.38		24. 1.14.25		24. 0.39.20					24. 0.11.19			24. 0.28.91			

TABLE III.—Se

From	To	MERIDIAN DISTANCE BY CHRO													
		Z		A.		B		C.		D.		E.		F.	
		E.	W.	E.	W.	E.	W.	E.	W.	E.	W.	E.	W.	E.	W.
		h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
Greenwich.	Lisbon.	...	0.36.35.79	...	0.36.41.43	...	0.36.32.80	...	0.36.40.40	...	0.36.41.33	...	0.36.42.18	...	0.36.35.29
Lisbon.	Gibraltar.	0.15.15.53	...	0.15.19.54	...	0.15.15.58	...	0.15.15.69	...	0.15.14.59	...	0.15.16.35	...	0.15.16.63	...
Gibraltar.	Madeira.	...	0.46.13.03	...	0.46. 4.66	...	0.46.10.70	...	0.46.12.05	...	0.46.14.78	...	0.46.14.83	...	0.46.14.22
Madeira.	Tenerife.	0. 2.43.44	...	0. 2.43.25	...	0. 2.43.62	...	0. 2.43.50	...	0. 2.32.74	...	0. 2.42.75	...	0. 2.42.83	...
Tenerife.	St. Thomas.	...	3.14.44.82	...	3.14.46.92	...	3.14.30.79	...	3.14.48.09	...	3.14.55.12	...	3.14.47.71	...	3.14.44.37
St. Thomas.	Bermuda.	0. 0.24.78	.	0. 0.26.87	...	0. 0.25.57	...	0. 0.23.67	...	0. 0.27.52	...	0. 0.26.46	...	0. 0.26.13	...
Bermuda.	San Miguel.	2.35. 9.97	...	2.36.46.31	...	2.36.34.70	...	2.36.36.94	...	2.36.39.42	...	2.36.27.29	...	2.36.34.92	...
San Miguel.	Madeira.	0.34.30.60	...	0.35. 2.26	...	0.35. 1.98	...	0.34.59.67	...	0.34.59.49	...	0.34.59.22	...	0.35. 3.31	...
		3.12.48.79	3.14.44.82	3.14.58.69	3.14.46.92	3.14.45.87	3.14.30.79	3.14.43.78	3.14.48.09	3.14.39.17	3.14.55.12	3.14.35.72	3.14.47.71	3.14.47.19	3.14.44.37
	Mean.	3.13.46.80		3.14.52.80		3.14.38.33		3.14.45.93		3.14.47.14		3.14.41.71		3.14.45.78	
Bermuda.	Halifax.	0. 4.55.79	...	0. 5. 9.60	...	0. 4.52.41	...	0. 4.52.07	...	0. 4.57.79	...	0. 4.51.86	...	0. 5. 2.16	...
Halifax.	Bermuda.	...	0. 4.57.18	...	0. 4.53.94	...	0. 5. 3.95	...	0. 5. 2.42	...	0. 4.59.83	...	0. 4.58.25	...	0. 4.44.57
	Mean.	0.4.56.48		0.5.1.77		0.4.58.18		0.4.57.24		0.4.58.81		0.4.55.05		0.4.53.36	
Madeira.	St. Vincent.	...	0.33.22.84	...	0.32.20.02	...	0.32.17.24	...	0.32.21.70	...	0.32.23.48	...	0.32.22.78	...	0.32.18.43
St. Vincent.	Porto Praya.	...	...	0. 5.54.31	...	0. 5.57.43	...	0. 5.56.68	...	0. 5.57.14	...	0. 5.58.07	...	0. 5.54.95	...
,,	St. Paul's Rocks.	...	...	...	0.17.35.25	...	0.17.23.95	...	0.17.25.45	...	0.17.23.88	...	0.17.17.33	...	0.17.23.55
C. of Good Hope.	Tristan da Cunha.	...	...	...	2. 3. 1.41	...	2. 3.14.02	...	2. 3.15.21	...	2. 3.18.71	...	2. 3.19.39	...	2. 2.52.33
,, ,,	Marion Island.	...	...	1.17.23.38	...	1.17.19.01	...	1.17.22.13	...	1.17.20.61	...	1.17.21.17	...	1.17.16.66	...
Christmas Harb.	Elizabeth Head.	...	...	0. 4.36.23	...	0. 4.38.82	...	0. 4.38.47	...	0. 4.39.11	...	0. 4.37.07	...	0. 4.38.53	...
,, ,,	Hog Island.	...	...	0. 4. 3.53	...	0. 4. 5.33	...	0. 4. 4.96	...	0. 4. 5.55	...	0. 3.55.52	...	0. 4. 5.35	...
Levuka.	Tongatabu.	...	...	0.23.37.58	...	0.23.54.18	...	0.23.46.80	...	0.23.48.53	...	0.23.53.34	...	0.23.48.19	...
Levuka.	Ngaloa Harbour.	...	...	...	0. 2.40.95	...	0. 2.38.36	...	0. 2.39.25	...	0. 2.38.31	...	0. 2.39.51	...	0. 2.38.03
Dobbo.	Ki Doulan.	...	...	...	0. 5.53.84	...	0. 5.53.27	...	0. 5.53.59	...	0. 5.53.96	...	0. 5.51.02	...	0. 5.53.05
Amboina.	Banda.	...	...	0. 6.51.77	...	0. 6.51.70	...	0. 6.51.97	...	0. 6.52.55	...	0. 6.50.34	...	0. 6.49.94	...
,,	Ternate.	...	...	...	0. 3.10.50	...	0. 3.11.21	...	0. 3.11.68	...	0. 3.10.98	...	0. 3. 7.65	...	0. 3.10.20
,,	Samboangan.	...	...	...	0.24.22.14	...	0.24.25.04	...	0.24.22.50	...	0.24.23.95	...	0.24.16.63	...	0.24.22.55
,,	Ilo Ilo.	...	...	...	0.22.22.13	...	0.22.25.33	...	0.22.24.02	...	0.22.25.31	...	0.22.14.75	...	0.22.23.22
Manila.	Hong Kong.	...	...	...	0.27. 1.24	...	0.27.12.88	...	0.27. 7.00	...	0.27. 8.46	...	0.27. 2.68	...	0.27. 5.92
Hong Kong.	Manila.	...	...	0.27.11.83	...	0.27. 6.26	...	0.27. 4.99	...	0.27. 7.28	...	0.26.58.95	...	0.27. 4.98	...
				0.27.6.53		0.27.9.57		0.27.6.00		0.27.7.87		0.27.0.81		0.27.5.45	
Sandy Point.	Tom Bay.	...	...	...	0.15.35.98	...	0.15.40.37	...	0.15.45.62	...	0.15.37.56	...	0.15.47.52	...	0.15.40.51

[Se]condary Meridian Distances.

[CHRO]NOMETERS. G. E.	G. W.	H. E.	H. W.	J. E.	J. W.	K. E.	K. W.	L. E.	L. W.	M. E.	M. W.	Extreme range of all Chronometers.	Mean of all Chronometers. E.	Mean of all Chronometers. W.	Day's running Distance.	Meridian distance by selection of Chronometers. E.	Meridian distance by selection of Chronometers. W.	Chronometers selected.	Extreme range of selected Chronometers.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	s.	h. m. s.	h. m. s.		h. m. s.	h. m. s.		s.
	0.36.47.27	...	0.36.35.57	...	0.36.37.29	...	0.36.33.58	...	0.36.33.90	...	0.36.35.39	14.47	...	0.36.37.86	15	...	0.36.37.47	Z A C D E F H J K L M	8.60
47	...	0.15.18.24	...	0.15.16.20	...	0.15.16.81	...	0.15.16.70	...	0.15.15.48	...	5.07	0.15.16.29	...	6	0.15.16.87	...	Z B C E F J K L M	1.33
	0.46.11.97	...	0.46.10.01	...	0.46.12.34	...	0.46.13.94	...	0.46. 9.87	...	0.46.14.32	10.17	...	0.46.12.06	10	...	0.46.12.67	All but A	4.96
68	...	0. 2.43.17	...	0. 2.43.07	...	0. 2.43.06	...	0. 2.44.26	...	0. 2.40.73	...	11.52	0. 2 42.16	...	4	0. 2.42.95	...	All but D	2.58
	3.14.43.40	...	3.14.45.46	...	3.14.40.93	...	3.14.38.54	...	3.14.28.02	...	3.14.35·52	27.10	...	3.14·42.28	32	...	3.14.44.47	Z A C E F G H J K	9.55
37	...	0. 0.29.47	...	0. 0.22.37	...	0. 0.26.98	...	0. 0.29.57	...	0. 0.24.47	..	7.20	0. 0.26.14	..	12	0. 0.26.08	...	Z A B D E F G K M	3.05
54	...	2.36.40.14	...	2.36.49.94	...	2.36.46.76	...	2.36.42.06	...	2.37.17.32	...	127.35	2.36.35.71	...	25	2 36.39.88	...	A B C D F G H K L	12.06
37	...	0.35. 0.99	...	0.35. 4.12	...	0.35. 1.26	...	0.34.58.12	...	0.34.54.25	...	33.52	0.34.58.16	...	9	0.35. 0.72	...	A B C D E F G H K L	5.19
06	3.14.43.40	3.14.53.77	3.14.45.46	3.14.59.50	3.14.40.93	3.14.58.06	3.14.38.54	3.14.54.01	3.14.28.02	3.15.16.77	3.14.35.52	...	3.14.42.17	3.14.42.28	...	3.14.49.63	3.14.44.47		...
	4.45.23	3.14.49.61		3.14.50.21		3.14.48.30		3.14.41.01		3.14.56.14			3.14.42.22			3.14.47.05			
5	...	0. 5. 1.89	...	0. 4.55.94	...	0. 5. 4.12	...	0. 5. 1.44	...	0. 5.11.43	...	19.57	0. 4.59.18	...	21	0. 4.57.65	...	Z B C D F G H J K L	9.75
	0. 5. 4.71	...	0. 4.59.95	...	0. 4.56.56	...	0. 4.46.48	...	0. 4.57.38	...	0. 4.37.69	27.02	...	0. 4.55.61	14	...	0. 4.58.19	Z A C D E H J L	8.48
	58.78	0.5.0.92		0.4.56.25		0.4.55.30		0.4.59.41		0.4.54.56			0.4.57.39			0.4.57.92			
	0.32.20.56	...	0.32.23.40	...	0.32.18.41	...	0.32.23.16	...	0.32.21.46	...	0.32.18.83	65.60	...	0.32.25.55	12	...	0.32.20.79	All but Z	6.24
	...	0. 5.56.91	...	0. 5.57.18	...	0. 5.55.10	...	0. 5.55.47	...	0. 5.55.99	...	3.76	0. 5.56.19	...	6	0. 5.56.19	...	All	3.76
	0.17.30.82	...	0.17.21.72	...	0.17.17.45	...	0.17.26.77	...	0.17.27.60	...	...	17.92	...	0.17.24.89	25	...	0.17.24.72	B C D F H K L	5.88
	2. 3.18.95	...	2. 3.18.99	...	2. 3.20.69	...	2. 3. 7.31	...	2. 3.21.00	...	...	28.67	...	2. 3.13.46	17	...	2. 3.18.37	B C D E G H J L	6.98
	...	1.17.24.65	...	1.17.24.86	...	1.17.21.75	...	1.17.24.60	...	1.17.21.16	...	8.20	1.17.21.99	...	10	1.17.22.48	...	A B C D E G H J K L M	5.85
	...	0. 4.37.86	...	0. 4.38.51	...	0. 4.37.16	...	0. 4.36.20	...	0. 4.36.91	...	3.90	0. 4.37.91	...	3	0. 4.37.71	...	All but G	2.91
	...	0. 4. 4.03	...	0. 4. 4.55	...	0. 4. 2.59	...	0. 4. 3.32	...	0. 4. 5.12	...	12.94	0. 4. 4.03	...	...	0. 4. 4.43	...	A B C D F H J K L M	2.96
	...	0.23.50.67	...	0.23.50.38	...	0.23.44.65	...	0.23.48.29	...	0.23.45.58	...	16.60	0.23.48.31	...	10	0.23.48.74	...	C D F G H J L M	5.93
	0. 2.37.21	...	0. 2.37.82	...	0. 2.38.16	...	0. 2.39.56	...	0. 2.38.89	...	0. 2.39.15	3.74	...	0. 2.38.77	3	...	0. 2.38.70	B C D E F H J K L M	1.43
	0. 5.53.81	...	0. 5.54.52	...	0. 5.54.06	...	0. 5.53.76	...	0. 5.53.61	...	0. 5.54.17	3.50	...	0. 5.53.55	3	...	0. 5.53.79	A B C D F G H J K L M	1.25
	...	0. 6.52.13	...	0. 6.51.13	...	0. 6.50.18	...	0. 6.51.53	...	0. 6.51.91	...	2.61	0. 6.51.41	...	3	0. 6.51.41	...	All	2.61
	0. 3.10.94	...	0. 3.11.30	...	0. 3.11.73	...	0. 3. 9.16	...	0. 3.10.69	...	0. 3.10.51	4.08	...	0. 3.10.55	6	...	0. 3.10.81	All but E	2.57
	0.24.25.85	...	0.24.23.86	...	0.24.24.33	...	0.24.20.78	...	0.24.23.68	...	0.24.22.91	9.22	...	0.24.22.85	15	...	0.24.23.24	A C D F H J L M	2.19
	0.22.19.43	...	0.22.24.44	...	0.22.24.27	...	0.22.21.19	...	0.22.25.39	...	0.22.21.96	10.64	...	0.22.22.62	19	...	0.22.23.73	A B C D E G H J K L M	4.20
	0.27. 6.76	...	0.27. 8.25	...	0.27. 7.53	...	0.27. 4.36	...	0.27. 7.54	...	0.27. 6.52	11.64	...	0.27. 6.59	6	...	0.27. 7.25	C D F G H J L M	2.54
	...	0.27. 9.33	...	0.27. 4.12	...	0.27. 7.61	...	0.27. 7.87	...	0.27. 5.27	...	12.98	0.27. 6.36	...	8	0.27. 6.25	...	B C D F G J K L M	3.75
	2 .30	0.27.8.79		0.27.5.82		0.27.5.98		0.27.7.70		0.27.5.89			0.27.6.47			0.27.6.75			
	...	...	0.15.39.11	...	0.15.41.46	...	0.15.37.99	...	0.15.43.96	...	0.15.40.28	11.54	...	0.15.40.94	...	...	0.15.40.15	B D F H J K L M	6.40

TABLE IV.—Abstract of the positions obtained by H.M.S. Challenger, with the Meridians from which those positions were calculated.

Place.	Exact position of the observing stations.	Latitude of observation spot.	Longitudes of observation spot on Chart.	Longitude of observation spot by Challenger's observer.	Meridian based upon
		° ′ ″	° ′ ″	° ′ ″	
Lisbon.	The landing place at the packet stairs.	38 42 0 N.	9 10 45 W.	9 9 28 W.	Greenwich.
Gibraltar.	The head of the mole in Rosia Bay.	36 6 55 N.	5 21 15 W.	...	Standard Δ.
Madeira Island.	Fort Pontinha, Funchal Bay.	32 37 46 N.	16 55 17 W.	16 54 25 W.	Gibraltar.
Tenerife Island.	Fort San Pedro, Santa Cruz.	28 28 0 N.	16 14 22 W.	16 13 41 W.	Do.
St. Thomas Island.	Fort Christian (Charlotte Amalia).	18 20 27 N.	64 55 40 W.	64 55 27 W.	Do.
Bermuda Island.	Dockyard clock tower.	32 19 4 N.	64 51 36 W.	64 49 24 W.	Gibraltar and Halifax.
Halifax, N.S.	Observatory hill in the Dockyard.	44 39 38 N.	63 35 10 W.	...	Standard Δ.
San Miguel Island.	Castillo di Brazo, Ponta Delgada.	37 44 0 N.	25 41 0 W.	25 39 36 W.	Gibraltar.
St. Vincent Island.	Obelisk on the south shore of Porto Grande.	16 55 8 N.	25 0 11 W.	24 59 37 W.	Do.
Porto Praya.	Landing place, west side of Quail Island.	14 54 2 N.	23 30 42 W.	23 30 34 W.	Do.
St. Paul's Rocks.	Northeast side of the Boat cove.	0 55 36 N.	29 22 32 W.	29 20 48 W.	Do.
Bahia.	Obelisk in the public gardens in front of Fort San Pedro.	12 59 20 S.	38 31 15 W.	38 30 49 W.	Gibraltar & C. Good Hope.
Tristan da Cunha I.	Herald Point.	37 2 45 S.	12 18 30 W.	12 20 50 W.	Cape of Good Hope obsy.
Cape of Good Hope.	The observatory.	33 56 3 S.	18 28 45 E.	...	Standard.
Marion Island.	Observation spot.	46 49 30 S.	37 49 30 E.	37 49 22 E.	Cape of Good Hope obsy.
Christmas Har. (Kerguelen Island.)	On a bluff point at the north side of the head of the harbour.	48 40 2 S.	69 1 35 E.	69 1 52 E.	Do.
Elizabeth Head (Kerguelen Island.)	On the summit of the head.	49 7 43 S.	70 11 15 E.	70 11 18 E.	Do.
Hog Island. (Kerguelen Island.)	On the summit of the island.	49 27 55 S.	70 3 50 E.	70 2 58 E.	Do.
Melbourne.	At the old lighthouse at Point Gellibrand.	37 52 10 S.	144 54 52 E.	144 56 5 E.	Do.
Sydney.	Garden island.	32 51 55 S.	151 14 47 E.	151 14 57 E.	Do.
Wellington.	The protestant cathedral.	41 16 45 S.	174 47 40 E.	174 48 39 E.	Sydney.
Levuka.	The old mission schoolhouse.	17 40 45 S.	178 49 3 E.	178 52 18 E.	Do.
Tongatabu.	The church at Nukalofa.	21 7 51 S.	175 8 7 W.	175 10 31 W.	Do.
Ngaloa Harbour.	The beacon on Ngaloa Island.	19 5 30 S.	178 12 53 E.	178 12 37 E.	Do.
Cape York.	Sextant Rock.	10 41 29 S.	142 33 18 E.	142 33 18 E.	Do.
Dobbo.	At the end of the sand spit on which the village stands.	5 45 16 S.	134 16 0 E.	134 13 44 E.	Do.
Ki Doulan.	On the pier.	5 34 42 S.	132 44 24 E.	132 45 17 E.	Do.
Banda.	The flagstaff of the Resident.	4 31 53 S.	129 53 22 E.	129 54 10 E.	Do.
Amboina.	The flagstaff in Fort Victoria.	3 41 30 S.	128 10 0 E.	128 11 19 E.	Do.
Ternate.	The flagstaff of the Resident.	0 47 30 N.	127 20 45 E.	127 23 37 E.	Do.
Samboangan.	The inner end of the pier on which the lighthouse stands.	6 54 50 N.	122 4 10 E.	122 4 53 E.	Sydney and Hong Kong.
Ilo Ilo.	The fort.	10 42 10 N.	122 34 14 E.	122 35 23 E.	Sydney.
Manila.	The lighthouse on the end of the mole.	14 36 24 N.	120 57 18 E.	120 56 43 E.	Hong Kong.
Hong Kong.	Wellington battery.	22 16 23 N.	114 10 2 E.	...	Standard.
Zebu.	The monument in the gardens by the fort.	10 17 32 N.	123 54 0 E.	123 53 53 E.	Hong Kong.
Humboldt Bay.	Observatory Islet.	2 27 0 S.	140 41 10 E.	140 42 53 E.	Samboangan.
Admiralty Islands.	Observatory Islet, Nares Harbour.	1 55 0 S.	146 38 40 E.	146 41 41 E.	Do.
Yokohama.	Naval Hospital square.	35 26 30 N.	139 39 24 E.	139 45 8 E.	Do.
Honolulu.	The flagstaff of the King's cottage.	21 18 0 N.	157 51 0 W.	157 48 50 W.	Valparaiso.
Tahiti.	The lighthouse on Point Venus.	17 29 15 N.	149 28 45 W.	149 26 18 W.	Do.
Valparaiso.	The fort immediately over the custom house.	35 1 48 S.	71 38 5 W.	...	Standard.
Tom Bay.	On observatory point.	50 11 26 S.	...	75 33 7 W.	Valaparaiso.
Sandy Point.	The boat house on the beach.	53 10 0 S.	70 53 37 W.	70 52 26 W.	Do.
Port Stanley.	The flagstaff of the saluting battery.	51 41 10 S.	57 51 30 W.	57 50 44 W.	Do.
Monte Video.	The chimney of the pumping engine of the graving dock.	34 54 15 S.	56 14 54 W.	56 15 32 W.	Do.
Ascension Island.	Fort Thornton.	7 55 20 S.	14 25 30 W.	14 27 13 W.	Do.

APPENDIX IV.

REPORT on the Health of the Crew of H.M.S. Challenger during the Years 1873–76. By Fleet-Surgeon George Maclean, R.N.

The medical history of the Challenger Expedition is, fortunately perhaps, of little interest. Considering the rapid variations of climate experienced, the large proportion of time spent at sea, and the trying nature of the seamen's work, the health of the ship's company during the Commission of nearly four years must be regarded as exceptionally good, and will probably compare favourably with that of an ordinary cruiser on any of the foreign stations.

Contrasted with most exploring expeditions of former times the medical history of the ship is chiefly remarkable for the entire absence of disease (such as scurvy) directly attributable to the nature of the dietary used on board—an immunity which was partly due to the fact that the duration of the various passages was limited and capable of being calculated with strict accuracy, owing to the use of steam; to the frequent interruptions, at short intervals, of the sea work by judicious stays in harbour where articles of fresh food, &c., were obtained and the monotony of the life varied; to the uniform and unvarying employment under all circumstances of water condensed on board; and, lastly, to the invariable rule observed of issuing a daily supply of lime juice to all hands when the ship was at sea.

The longest period during which the ship was absent from any inhabited region was in the passage from the Cape of Good Hope to Australia, when she visited the Crozets, Kerguelen, Heard Island, &c., and crossed the Antarctic Circle—three months being employed on this cruise. It is interesting to note that the men were glad to use, for making soup and as a vegetable, during this time the Kerguelen Cabbage (*Pringlea antiscorbutica*), which grows abundantly in Kerguelen—a vegetable which our wise old navigator, Captain Cook, compelled his ship's company to use—and that the health of the men during this period was exceptionally good.

The ordinary rations of the naval service were used during the commission, viz., salt-beef and pork, and preserved meat and vegetables at sea, fresh meat and vegetables in harbour, and the usual half-gill of rum daily. Lime juice, cocoa and tea, biscuit, and soft bread in harbour, complete the dietary (see Table). The average number of men on board

Table showing the Scale of Victualling in Her Majesty's Navy during the Expedition.

	When to be issued.	Articles.		Officers, Crew, and others, at Seamen's full Allowance.
1	Daily, (*See* Note *)	Biscuits, or	lb.	$1\frac{1}{4}$
2		Soft bread,	"	$1\frac{1}{2}$
3		Biscuit powder or rusks,	oz.	...
4		Spirit,	pint	$\frac{1}{8}$
5		Porter,	"	...
6		Sugar,	oz.	2
7		Chocolate,	"	1
8		Tea,	"	$\frac{1}{4}$
9		Rice,	"	...
10		Milk,†	pint	...
11		Soup and bouilli, essence of beef, or mutton broth, sufficient to make ‡	"	...
12		Oatmeal,§	oz.	...
12	Weekly,	Oatmeal,	"	3
13		Mustard,	"	$\frac{1}{2}$
14		Pepper,	"	$\frac{1}{4}$
15		Salt,	"	...
16		Vinegar,	pint	$\frac{1}{4}$
17		Pickles (of various descriptions),	oz.	...
18	Daily, when procurable,	Fresh meat,	lb.	1
19		Vegetables,	"	$\frac{1}{2}$
	When fresh provisions cannot be procured :—			
20	Every other day,	Salt pork,‖	lb.	1
21		Split peas,	"	$\frac{1}{3}$
22		Compressed mixed vegetables,	oz.	...
		Celery seed,¶	"	...
23	On one alternate day,	Salt beef,	lb.	1
24		Flour,	oz.	9
25		Suet,	"	$\frac{3}{4}$
26		Currants or raisins,	"	$1\frac{1}{2}$
6		Sugar,	"	...
22		Preserved potato,	"	...
9		Rice, or	"	...
		Preserved potato,	"	...
27	On the other alternate day,	Preserved beef, with either	lb.	$\frac{3}{4}$
28		(1) Preserved potato,	oz.	4
9		or (2) Rice,	"	4
28		or (3) Preserved potato, and	"	2
9		Rice,	"	2
24		or (4) Flour,	"	9
25		Suet,	"	$\frac{3}{4}$
26		Currants or raisins,	"	$1\frac{1}{2}$
11	On two days a week,	Soup and bouilli,	pint	...
9		Rice,	oz.	...

Scale of Substitutes.

In case it should be necessary to issue substitutes for any of the articles in this scale of victualling, the following substitution is to be adopted, viz. :—

Biscuits,	1 pound	are to be considered equal to each other.
Flour,	1 pound	
Rice,	1 pound	
Wine,	$\frac{1}{2}$ pint	do. do. do.
Spirit,	$\frac{1}{2}$ gill	
Porter,	1 pint	
Coffee,	1 ounce	do. do. do.
Cocoa,	1 ounce	
Chocolate,	1 ounce	
Tea,	$\frac{1}{4}$ ounce	

The following, when issued with meat rations, are to be considered equal to each other :—

		Seamen.	Troops, Women, and Children.
1	Split peas,	$\frac{1}{3}$ pound	$\frac{2}{9}$ pound
	Peas (whole),	$\frac{1}{2}$ pint	...
	Flour,	$\frac{3}{4}$ pound	$\frac{1}{2}$ pound
	Calavances,	$\frac{1}{2}$ pint	$\frac{1}{2}$ pint
	Dholl,	$\frac{1}{2}$ pint	$\frac{1}{2}$ pint
	Rice,	$\frac{3}{4}$ pound	$\frac{1}{4}$ pound
2	Vegetables,		$\frac{1}{2}$ pound
	Compressed mixed vegetables,		1 ounce
	Preserved potato,		2 ounces
3	Oatmeal,		$\frac{1}{6}$ pint or 2 ounces
	Split peas,		$\frac{2}{9}$ pound

NOTES.

* Soft bread is to be issued to troops, women, and children four days in the week, and biscuits (or oatmeal for children under five) the remaining three days.

† When fresh milk is not procurable, preserved milk is to be issued, sufficient to make these quantities of milk.

‡ These articles are to be provided in equal quantities, and are to be issued alternately. Soup and bouilli, $5\frac{1}{3}$ ounces, cooked with $\frac{1}{2}$ pint of water; essence of beef, $\frac{1}{3}$ of a quarter pint canister, cooked with $\frac{1}{2}$ pint of water; and mutton broth, 4 ounces, with a sufficient quantity of boiling water, will make the half pint required.

§ When troops are on fresh meat victualling, a sufficient quantity of oatmeal may be issued for thickening their soup.

‖ Salt pork or salt beef are to be issued at the discretion of the surgeon.

¶ Half an ounce to be issued with every eight pounds of split peas put into the coppers.

Boys of ten and under fourteen years of age to receive the woman's ration, but without porter. Boys of fourteen and under seventeen to receive the man's ration, but without porter.

Girls of ten and under seventeen years of age to receive the woman's ration, but without porter.

Boys and girls of seventeen years of age or upwards are to be considered in all respects as adults.

during the Commission was 240, and the number of cases on the sick-list was 956, giving a percentage per annum of 113·8. Seven deaths occurred, giving a percentage of 0·83 per annum. Only two of these last were due to natural causes, three of them being caused by violence and two by acute poisoning. Eleven men were invalided (1·30 per cent. per annum), and fifteen were sent to hospital, or at the rate of 1·78 per cent. per annum. The only other changes, besides those arising from deaths, invaliding, and sending men to hospital, were due to desertion, for which the attractions of the Australian ports visited are chiefly responsible.

The following brief enumeration of the principal diseases, &c., which prevailed on board, the localities in which these occurred, and the causes to which they were attributable, comprises all the information of medical interest that can be recorded in the limits of this short article :—

General Diseases.

Enteric Fever.—Two cases of this fever occurred, one at Sidney where, at the time of the visit, the disease prevailed in the lower and dirtier parts of the town frequented by blue-jackets when on leave, and where the sewage arrangements were very defective, the main sewer discharging into the land-locked harbour in the immediate vicinity of the most crowded part of the town. The second case occurred at Hong Kong, where the disease was also prevalent at the time.

Yellow Fever.—A single case occurred on board during the ship's stay at Bahia. The medical officers were assured on arrival that the town was quite free from this formidable disease, but within a few days some merchant seamen in the harbour died of it, and six days after arrival an ordinary seaman who had slept on shore four nights previously was taken ill and was landed at the Brazilian Yellow Fever Hospital, where he afterwards died. The weather was, at the time of the visit (September), hot and oppressive, and the sanitary arrangements of the town were very defective. The ship left Bahia immediately, and proceeded to a higher and cooler latitude. Fortunately no further case of this fever occurred.

Malarious Fevers.—It might have been expected, owing to the number of places in the tropics visited where these fevers are endemic, that there would have been a large amount of sickness among the ship's company from this cause. Only twenty-eight cases occurred, however, and these were of a comparatively mild description. This practical immunity may be ascribed to the care taken to avoid unnecessary exposure of the men employed in boats, surveying, &c., in malarious places; compelling men on leave to be on board by sunset; and lastly, perhaps, to the prophylactic use of quinine in places where the malarious poison was supposed to be unusually potent. No death nor invaliding occurred from this cause. The following are the places in which the disease was contracted:—Madeira, St. Thomas (West Indies), Bermuda, Cape Verde Islands, Bahia, Melbourne, Arrou Islands, Philippine Islands, Yokohama, and Tahiti.

Erysipelas.—A single case of this affection occurred in the person of a member of the scientific staff, and had a rapidly fatal termination. No special cause could be traced connecting the disease either with the ship or the last place visited (Honolulu); and it would seem probable that, beginning as a common inflammation of the integuments, the disease afterwards assumed an erysipelatous character, the change being favoured by the state of the patient's health, which had for some time previously been below par.

Syphilis.—Ten cases of constitutional syphilis occurred during the Commission, the primary disease having been contracted in the following places:—Bahia, Cape Town, Hong Kong, Yokohama, Valparaiso. They did not give rise to any invaliding.

Phthisis.—Six cases occurred during the period of the Expedition, two of which were invalided and two sent to hospital. In none of these cases can the disease be said to have been in any way specially connected with the work of the ship, as in all there was evidence of its existence in a latent form before leaving England—the frequent and rapid changes of climate experienced during the Commission bringing it into activity.

Diseases of the Nervous System.

In this subdivision are included one case of disease of the brain (cerebral softening), which had a suddenly fatal termination and was not preceded by any marked symptoms; and two cases of insanity, both of which originated in the ship. They were sent to hospital; one, a marine who was left at Hong Kong, subsequently dying in a state of acute mania.

Diseases of the Circulatory System.

In this subdivision are included three cases of organic disease of the heart, one of which was invalided, while the other two were sent to hospital.

Diseases of the Respiratory System.

In this section are included five cases of bronchitis, two of pneumonia, and numerous cases of catarrh, complaints which were generally ascribable to a more or less sudden change from a warm to a cold climate. No mortality nor invaliding was due to any of these diseases.

Diseases of the Digestive System.

In this subdivision are included sixty-nine cases of diarrhœa, generally of a mild description, which were in nearly every instance due to excessive heat or to "leave" in places where the sanitary arrangements were bad. Bahia, Bermuda, Manila, Hong Kong, and Yokohama were the places where the majority of cases occurred. Three cases of dysentery also occurred, two at Sydney where the exciting cause was probably contaminated water, and one at Ascension where, notwithstanding the most careful attention to sanitary measures, the disease is endemic, being probably due to climatic influence.

Poisoning.

Two deaths arose from this cause, one from alcohol and the other (suicidal) from chloral hydrate.

Wounds and Accidents.

Two deaths were caused by drowning, and one by fatal injury of the head in a boy who was caught by the dredging rope, which broke as he was stepping across it and dashed him violently against the hammock nettings. He sustained a fracture of the skull and severe injury of the brain, and lived only a few hours afterwards. One dislocation of the shoulder, one fracture of the fore-arm, and one of the lower jaw complete the list of more serious injuries that occurred.

Besides the diseases, &c., herein specified there were many cases of a trifling nature which it is unnecessary to particularise, the foregoing enumeration embracing all cases of any interest which occurred during the Commission.

APPENDIX V.

CHEMICAL ANALYSES.[1]

ANALYSES OF A SERIES OF SPECIMENS OF BONES AND TEETH FROM DEEP-SEA DEPOSITS AND OF FOSSIL AND RECENT BONES.

By Professor W. DITTMAR, F.R.S.

Specimens of nine bones of marine animals, which had been dredged up in the course of the Challenger Expedition, and along with these also three recent bones and one fossil bone, were placed in my hands to examine chemically, with the view of assisting in tracing the probable history of the deep-sea specimens.

I have analysed these specimens, some of them completely, the rest partially. Suffice it here to state, that in every case the reported quantities of the constituents were determined directly, so as not to lose the valuable check afforded by a comparison of the sum total of the constituents, with the weight of substance analysed.

In regard to the preparation of the specimens for analysis, I have to state that the deep-sea specimens (or such portions of them as were intended for investigation) were in each case powdered, washed with distilled water, until the last washings were free from chlorides (*i.e.*, sea water), then dried at 100° C., and lastly exposed to the air of the laboratory so that they should not be abnormally hygroscopic.

In this condition they were bottled as material for analysis. The recent bones were simply powdered and analysed in the air-dry condition.

What is reported as "moisture" is water volatile at 110° C., while "combined water" means total water eliminated by ignition, less "moisture." In most cases only a part of the substance was used for the analysis.

To avoid repetition, I may state that "Substance" always means homogeneous powdered substance prepared as above stated. "P." stands for per cent. by weight. "E." for "equivalent," that is, for that quantity of acid or base which in the normal salts is equivalent to "H_2O," the numerical value of "H_2O" being taken as 9, *i.e.*, $H=0{\cdot}5$; $O=8$, &c.

[1] The analyses given in this Appendix have been selected from a large number which will be published in the Report on Deep-Sea Deposits, where their bearing on questions of General Oceanography will be discussed in detail.—JOHN MURRAY.

I. The Recent Bones.

No. 8. *Portion of Recent Earbone, Balæna mysticetus.*

	P.	E.	$\frac{P.}{E.}$	
Phosphoric acid (P_2O_5),	31·66	: 23·67	= 1·3377	1·5612
Carbonic acid (CO_2),	4·77	: 22	= 0·2168	
Chlorine 0·038 = ($Cl_2 - O$),	0·029	: 27·5	= 0·0011	
Sulphuric acid (SO_3),	0·21	: 40	= 0·0053	
Fluorine (F_2),*	0·005	: 19	= 0·0003	
Lime (CaO),	41·52	: 28	= 1·4828	1·5758
Magnesia (MgO),	0·86	: 20	= 0·0430	
Potash (K_2O),	0·14	: 47	= 0·0030	
Soda (Na_2O),	1·46	: 31	= 0·0470	
Phosphates of iron and alumina,	0·20			
Moisture,	7·31			
Organic matter,	11·14			
	99·30			

No. 11. *Portion of Recent Mesorostral Bone of Ziphius, Cape of Good Hope.*

Partly decayed. The undecayed portion was analysed.

	P.	$\frac{P.}{E.}$	
Phosphoric acid (P_2O_5),	34·64	1·4635	1·7685
Carbonic acid (CO_2),	6·35	0·2886	
Chlorine 0·14 = ($Cl_2 - O$),	0·11	0·0039	
Sulphuric acid (SO_3),	0·05	0·0125	
Fluorine (F_2),	0·032		
Lime (CaO),	40·51	1·4467	1·6949
Magnesia (MgO),	3·59	0·1795	
Potash (K_2O),	trace		
Soda (Na_2O),	2·13	0·0687	
Phosphates of iron and alumina,	0·36		
Moisture,	3·51		
Organic matter,	7·49		
	98·77		

* Having found by preliminary experiments that the deep-sea specimens contained appreciable quantities of fluorine, I devoted particular attention to the exact determination of this element. The method adopted was as follows :—A sufficient quantity of ignited material (5 to 20 grms.) was heated with a large excess of pure quartz sand and pure oil of vitriol (previously charged with sulphate of silver to retain the bulk of the chlorine), and the fluoride of silicon formed, after having been filtered through dry asbestos to retain any sulphuric acid that might have come over, passed into water and determined titrimetrically by means of pure standard caustic soda. In the resulting mixture, the chlorine, if present, was determined and allowed for.

From the numbers found for $\frac{P.}{E.}$ it would appear probable that this bone contains a hydric phosphate such as $MgHPO_4$, which I remember having seen reported in other bone analyses; but I am more inclined to think that there is an unobserved error somewhere. Taking the deficiency (1·7685 − 1·6949) in bases to mean a loss of magnesia, we have for the percentage of that base 3·59 + 1·47 = 5·06, which would bring up the total percentage to 100·21.

No. 12. *Brain Case of Globiocephalus, European Seas.*

	P.	$\frac{P.}{E.}$	
Phosphoric acid (P_2O_5),	22·45	0·9485	1·1008
Carbonic acid (CO_2),	3·18	0·1446	
Chlorine 0·085 = ($Cl_2 - O$) or muriatic acid,	0·066	0·0024	
Sulphuric acid (SO_3),	0·21	0·0053	
Fluorine (F_2),	0·004		
Lime (CaO),	30·04	1·0727	1·1440
Magnesia (MgO),	0·38	0·0190	
Potash (K_2O),	trace		
Soda (Na_2O),	1·62	0·0523	
Phosphates of iron and alumina,	1·25		
Moisture,	8·93		
Organic matter,	31·79		
	99·92		

The fluorine was determined in 8 grms. of the ash of the substance, and found to amount to 0·57 mgrms., that is to 0·007 per cent. of the ash, or 0·004 per cent. of the original substance.

From these analyses it would appear that the percentage of fluorine in recent marine bones is very minute.

For the sake of comparison, I determined the fluorine in a sample of ordinary bone ash, and found it 0·004 per cent., *i.e.*, almost *nil.*

As it is stated that teeth contain more fluorine than ordinary bones, I procured a quantity of horses' teeth, ignited them, and determined the fluorine in the ash. It was found equal to 0·084 per cent., which, though decidedly higher than the number obtained with the bones, is still very minute.

I have no doubt that the 1 or 2 per cent. of fluoride of calcium, which we find reported in the older analyses of bones, is based on utterly erroneous determinations. This, however, only confirms what Nicklès gave some years ago as the result of an extensive investigation on the subject.

For the number of equivalents of carbonate present per equivalent of phosphate, we have in—

	No. 8.	No. 11.	No. 12.
	0·162	0·197	0·153
or,	$\frac{1}{6·2}$.	$\frac{1}{5·1}$	$\frac{1}{6·6}$

II. The Fossil Bone.

No. 13. *Portion of Ziphius Beak from Red Crag, Suffolk.*

A thin plate cut out of the beak, highly polished on one side. The specimen was wholly petrified and homogeneous. It was completely soluble in hydrochloric acid.

A complete analysis gave the following results :—

	P.	P./E.	
Moisture,	1·67		
Combined water (H_2O),	2·31	0·2566	1·8647
Phosphoric acid (P_2O_5),	33·83	1·4294	
Carbonic acid (CO_2),	7·50	0·3409	
Fluorine 1·50 = ($F_2 - O$),	0·87	0·0789	
Sulphuric acid (SO_3),	0·62	0·0155	
Chlorine and silica,	*nil.*		
Lime (CaO),	48·81	1·7431	1·9399
Magnesia (MgO),	1·08	0·0540	
Ferric oxide (Fe_2O_3),	2·00	0·0577	
Alumina (Al_2O_3),	0·18	0·0105	
Potash (K_2O),	0·52	0·0111	
Soda (Na_2O),	1·97	0·0635	
	101·36		

Ratio of equivalents—

($\frac{1}{3}P_2O_5$)	(CO_2)	(F_2)
1	0·239	0·055

In recent *Ziphius* bone, No. 11, they were—

1 : 0·197 : *nil.*

III. The Deep-Sea Bones.

No. 1. *Portion of a large piece of Whale's Bone.*

Station 286 ; 2335 fathoms, South Pacific.

The specimen was brown in colour, very porous, and readily reducible to a powder.

	P.	P./E.	
Moisture,	3·06		
Combined water (H_2O),	3·66		
Phosphoric acid (P_2O_5),	27·49	1·162	1·387
Carbonic acid (CO_2),	4·14	0·188	
Fluorine 0·71 = ($F_2 - O$),	0·41	0·037	
Lime (CaO),	39·00	1·392	
Magnesia (MgO),	2·01		
Ferrous oxide (FeO),*	1·04		
Ferric oxide (Fe_2O_3),*	4·83		
Binoxide of manganese (MnO_2),*	1·61		
Alumina (Al_2O_3),	2·70		
Silica and substances insoluble in hydrochloric acid,	9·08		
Alkalies and loss,	0·97		
	100·00		

* Direct result of analysis—

Manganous oxide (MnO),	1·31
Ferric oxide (Fe_2O_3),	5·98
Loose oxygen (O),	0·18

The insoluble residue consisted apparently of amorphous silica.

The part soluble in hydrochloric acid seemed to be a mixture of—

Phosphate of lime (Ca_32PO_4),	60·0 per cent.	of the whole substance,	
Carbonate of lime ($CaCO_3$),	9·4	,,	,,
Fluoride of calcium (CaF_2),	1·4	,,	,,
Binoxide of manganese (MnO_2),	1·6	,,	,,
Ferric oxide (Fe_2O_3),	4·8	,,	,,

and minor constituents.

Ratio of equivalents of phosphoric acid, carbonic acid, and fluorine—

$(\frac{1}{3}P_2O_5)$		(CO_2)		(F_2)
1	:	0·162	:	0·037

In the recent whale's bone (No. 8) we found :—

1 : 0·162 : *nil.*

No. 5. *Portion of a Whale's Bone much impregnated with Manganese.*

Station 286 ; 2335 fathoms, South Pacific.

The outer portions of this specimen were perfectly black ; most of the inner portion also was black, but a small portion in the centre had remained untinged with manganese. This comparatively uncoloured central portion was removed, prepared for analysis, and used for the following determinations :—

	P.	$\frac{P.}{E.}$
Moisture,	2·87	
Phosphoric acid (P_2O_5),	29·13	1·231
Fluorine (F_2),	1·44	0·076
Lime (CaO),	36·05	1·287
Parts insoluble in hydrochloric acid,	2·91	

Ratio of equivalents of phosphoric acid and fluorine—

1 : 0·062.

There was an appreciable quantity of manganese present, and also a trace of cobalt.

The outer manganiferous portion of this specimen was completely analysed, with the following results :—

	P.	$\frac{P.}{E.}$
Portion insoluble in hydrochloric acid,	5·76	
Total water (H_2O),	9·77	
Manganous oxide (MnO),	20·22	
Loose oxygen (O),	3·49	
Ferric oxide (Fe_2O_3),	6·54	
Alumina (Al_2O_3),	1·66	
Lime (CaO),	19·71	0·7039
Magnesia (MgO),	7·42	0·3710
Potash (K_2O),	0·55	
Soda (Na_2O),	1·12	
Phosphoric acid (P_2O_5),	18·59 *	0·7860
Carbonic acid (CO_2),	3·87	0·1759
Traces of copper, chlorine, fluorine, and loss,	1·30	
	100·00	

The manganese is probably present mostly as binoxide, combined chemically with water and part of the protoxides.

No. 3. *Half of Earbone of Balæna.*

Station 286 ; 2335 fathoms, South Pacific.

One corner of this specimen had a considerable cavity, which was pretty well filled with a brownish black, friable substance. This substance was scraped out and preserved as "3. (1)." The remainder consisted partly of a black coating (which was separated as far as possible and kept as "3. (2)") and partly of a very white siliceous looking core (which was put aside as "3. (3)"). Portions "3. (3)" and "3. (1)" were analysed.

Portion "3. (1)." *Contents of Cavity.*

Note.—The analysis of this substance was all but completed when it was found that it contained a small admixture of an "oil," which had no doubt become mixed with it accidentally in the cutting of the original specimen. The greater part of the substance dissolved readily in hydrochloric acid, with evolution of chlorine. Only the solution was analysed.

	P.	
Portion insoluble in hydrochloric acid,†	13·66	
Total water (H_2O),	27·00	
Manganous oxide (MnO),	27·13	: $MnO = 0·764 \div 0·764 = 1$
Loose oxygen (O),	3·13	: $O = 0·398 \div 0·764 = 0·52$
Ferric oxide (Fe_2O_3),	8·34	
Lime (CaO),	4·34	
Magnesia (MgO),	4·03	
Alumina (Al_2O_3),	6·54	
Silica (SiO_2),	1·31	
Phosphoric acid (P_2O_5),	2·39	
Potash (K_2O),	1·07	
Soda (Na_2O),	2·39	
Nickel and copper,	traces	
	101·33	

* Equal to 40·90 per cent. tricalcic phosphate.

† Apparently all amorphous silica.

The bulk of the part soluble in acids apparently consists of hydrated sesquioxides of manganese and iron and decomposible silicates.

Portion "3. (3)." *White Siliceous looking Core.*

	P.	$\frac{P.}{E.}$
Insoluble in acid,	0·06	
Moisture,	2·21	
Combined water (H_2O),	2·22	
Phosphates of iron and alumina,*	0·42	
Phosphoric acid (P_2O_5),*	34·13	1·4420
Carbonic acid (CO_2),	6·61	0·3042
Fluorine 1·4 = ($F_2 - O$),	0·81	0·0736
Sulphuric acid (SO_3),	0·81	
Chlorine,	trace	
Lime (CaO),	49·85	1·7801
Magnesia (MgO),	0·77	0·0385
Alkalies and loss,	2·11	
	100·00	

Ratio of equivalents of phosphoric acid, carbonic acid, and fluorine—

($\frac{1}{3}P_2O_5$)		(CO_2)		(F_2)
1	:	0·211	:	0·051

The following specimens were only partially analysed.

No. 4. *Portion of Beak of a Ziphius.*

Station 286 ; 2335 fathoms, South Pacific.

The body of the specimen looked pretty much like recent bone, but had veins of manganese running through it. The outer coating of the specimen was black.

Found in 100 parts of the inner portion—

Moisture,	1·14
Combined water (H_2O),	2·78
Carbonic acid (CO_2),	6·81
Phosphoric acid (P_2O_5),†	33·30
Fluorine (F_2),	1·65

Ratio of equivalents of phosphoric acid, carbonic acid, and fluorine—

1 : 0·220 : 0·062

* Total phosphoric acid found = 34·33 per cent. 34·13 phosphoric acid found = 74·5 per cent. tricalcic phosphate.
† Equal to 72·69 per cent. tricalcic phosphate.

No. 6. *Portion of a Whale's Bone much impregnated with Manganese.*

Station 286; 2335 fathoms, South Pacific.

The manganese was pretty well diffused all through the specimen.

Found in 100 parts—

Moisture,	5·49
Combined water (H_2O),	6·88
Phosphoric acid (P_2O_5),*	13·05
Fluorine (F_2),	0·65

Ratio of equivalents of phosphoric acid and fluorine—

1 : 0·062

No. 7. *Portion of Earbone (Ziphius).*

Station 289; 2550 fathoms, South Pacific.

This specimen resembled Nos. 2 and 3, but was smaller, and the cavity, which in them was filled up with a brownish friable mass, contained in this case a hard black substance. The inner portion was brownish; it consisted of hard vitreous looking matter with a yellowish soft powder diffused through it.

Found in 100 parts of the inner portion—

Moisture,	1·61
Phosphoric acid (P_2O_5),†	32·73
Fluorine (F_2),	1·61

Ratio of equivalents of phosphoric acid and fluorine—

1 : 0·061

No. 2. *Portion of Earbone of Balænoptera.*

Station 286; 2335 fathoms, South Pacific.

This specimen was very similar to No. 3, having a cavity with a brown incrustation, a black outer coating, and the inside being almost uncoloured by iron or manganese.

Found in 100 parts of the inner portion—

Moisture,	1·6
Combined water (H_2O),	1·34
Phosphoric acid (P_2O_5),‡	31·21
Fluorine (F_2),	1·89

Ratio of equivalents of phosphoric acid and fluorine—

1 : 0·0753.

* Equal to 28·48 per cent. tricalcic phosphate. † Equal to 71·44 per cent. tricalcic phosphate.

‡ Equal to 68·13 per cent. tricalcic phosphate.

No. 10. *Three Carcharodon Teeth.*

Station 285 ; 2375 fathoms, South Pacific.

The largest of these teeth, weighing 22 grms., was taken for analysis. The outer shell was readily detached from the inner portion.

1. The outside portion was found to contain 33·66 per cent. of phosphoric acid, equal to 73·48 per cent. of tricalcic phosphate, and 2·28 per cent. of fluorine.

Ratio of equivalents of phosphoric acid and fluorine—

1 : 0·1

2. The inside portion was completely analysed, with the following results :—

	P.	E.	$\frac{P.}{E.}$
Silica and portion insoluble in hydrochloric acid,	13·34		
Moisture,	8·41		
Combined water (H_2O),	6·93		
Manganous oxide (MnO),*	35·51	: 35·5	= 1
Loose oxygen (O),*	6·85	: 8	= 0·8562
Ferric oxide (Fe_2O_3),*	12·47	: 80	= 0·1556
Alumina (Al_2O_3),	5·09		
Lime (CaO),	3·72		
Magnesia (MgO),	3·74		
Potash (K_2O),	0·56		
Soda (Na_2O),	1·31		
Phosphoric acid (P_2O_5),	0·83		
Carbonic acid (CO_2),	1·19		
Silica (SiO_2) in solution,	0·30		
Chlorine and copper,	traces		
	100·25		

No. 9. *Eight Oxyrhina Teeth.*

Station 286 ; 2335 fathoms, South Pacific.

Colour, brownish black.

The teeth consisted of a tough outer shell filled up with a friable black mass.

Three of the teeth were taken, the inside portion separated from the shell, and the percentages of phosphoric acid determined, with the following results :—

	Inside.	Outside.
Per cent. of phosphoric acid (P_2O_5),	7·97	32·58
Equivalent to tricalcic phosphate,	17·39	71·12

* The extra oxygen in the ferric oxide, as the quotients show, is more than sufficient to convert the manganous oxide into binoxide.

From the preceding analyses it appears that deep-sea bones, like fossil ones, contain a far larger proportion of fluorine than recent bones. This fluorine cannot be assumed to be the original fluorine of the bones, but must be supposed to owe its origin to a continuous, though slowly progressing, double decomposition between the phosphate of the bone and the trace of dissolved fluoride in the sea water.

To test this view I have made the following experiment:—10 grms. of precipitated tricalcic phosphate (undried) were digested for six weeks in a solution of 30 grms. of common salt and 2 grms. of fluoride of sodium, in 1 litre of water; the precipitate was then collected on a filter, washed free from chlorides (and dissolved fluorides), dried, ignited, and tested quantitatively for fluorine by means of the method used for the bones. 5 grms. of ignited substance gave 0·120 grms. of fluorine = 2·41 per cent., equivalent to 4·95 per cent. of fluoride of calcium. It is quite reasonable to admit that what the 0·2 per cent. of fluoride of sodium in the solution employed effected in six weeks, the trace of fluoride in actual sea water (small as it is) may accomplish in thousands of years.[1]

The "manganese oxide" which was found diffused through, or at least as a deposit on, the surface of all the deep-sea bones examined, no doubt owes its origin to a slow decomposition of extraneous mineral matter in which the bones at some stage of their existence got embedded.[2]

MANGANESE NODULES.

These concentrations of ferric and manganic oxides, mixed with argillaceous materials, whose form and dimensions are extremely variable, belong generally to the earthy variety or wad, but pass sometimes, though rarely, into varieties of hydrated oxide of manganese with distinct indications of radially fibrous crystallisation. The interpretation adopted, in order to explain the formation of these manganese nodules, is the same as that which is admitted in explanation of the formation of coatings of this material on the surface of terrestrial rocks. These salts of manganese and iron, dissolved in water by carbonic acid, then precipitated in the form of carbonate of the protoxides of iron and manganese, become oxidised, and give rise in the calm and deep oceanic regions to more or less pure ferro-manganiferous concretions. The following analyses are of nodules from two Stations, one in the North and the other in the South Pacific.—John Murray.

[1] It may be that, owing to the fluoride of calcium being less soluble than the phosphate, a relatively large quantity of the former remains in the bones as the latter is dissolved away. In comparing the analyses of the bones and teeth dredged from the bottom of the sea with those of recent animals, the elimination of gelatinous organic matter from the former is very striking. These facts added to others support the view of the great antiquity of the deep-sea specimens.—J. M.

[2] On the Distribution of Volcanic Débris over the Floor of the Ocean, &c., by John Murray, *Proc. Roy. Soc. Edin.*, vol ix. p. 256, 1877.

Analysis of Manganese Nodules.

By Professor W. Dittmar, F.R.S.

Station 252 ; 2740 fathoms, North Pacific.

These nodules had a brown or brownish black colour, and, in size and shape, were pretty much like potatoes. They were easily broken by the hammer, and then seen to consist of a clay-like nucleus enclosed in concentric layers of dark coloured matter, the degree of blackness increasing with the distance from the centre. In some cases, however, the whole of a section was found to be almost uniformly black. My work was limited to exhaustively determining the elementary composition of the nodules, and to trying to ascertain, as far as possible by chemical methods, the state of combination of the several elements present. In the latter connection I proposed to direct my attention more particularly to the manganese, and to ascertain whether this metal were present altogether as binoxide, or perhaps partly if not wholly in the form of lower oxides.

To obtain a true average sample of the nodules, it would have been necessary to pound up finely and thoroughly mix the entire stock, but I did not consider myself justified in taking this course; I therefore satisfied myself with selecting a few nodules and pounding up these. The powder was well mixed and preserved as "substance to be analysed." A preliminary trial showed that the substance gave up to boiling water nothing but small quantities of chlorides and sulphates [1] (which I thought might safely be put down as sea-water solids), and besides showed that the filtration of the aqueous infusion was a very tedious process. Hence, in proceeding to the actual analysis (which was executed with 100 grms. of substance), the turbid liquid obtained in extracting the small portion of substance soluble in water was simply poured away. The residue was next digested in the cold in acetic acid of 25 per cent. until the carbonates of lime and magnesia and substances of a similar nature could be assumed to be dissolved, and the residue collected on filters and washed with water. This operation was not attended with any visible evolution of gas, which, however, does not prove the absolute absence of carbonates in the substance. The acetic acid extract was evaporated to dryness and the residue (5·23 grms.) analysed. Qualitative tests showed the presence of considerable quantities of lime, magnesia, and soda, of a little alumina, and of traces of iron, copper, and chlorine. There was absolutely no manganese, which proves that the original substance could not have contained any manganous carbonate or hydrate. The principal bases were determined quantitatively with the following results:—

Alumina (Al_2O_3), . . .	0·170	per 100 parts of original substance.
Lime (CaO), ...	0·446	
Magnesia (MgO), . . .	0·365	
Soda (Na_2O),*	0·597	

[1] The aqueous extract contained no lime salts, showing the absence of sulphate of lime.

* Including a little potash.

The residue left undissolved by the acetic acid was exhausted with hot hydrochloric acid of 20 per cent., the solution filtered, evaporated to dryness, to eliminate the dissolved silica, the silica filtered off and weighed. It amounted to 0·73 grms., *i.e.*, 0·73 per cent. of the original substance. The de-silicated solution was made up to 400 c.c., and aliquot portions used for the following experiments. One portion served for a thorough qualitative analysis, the results of which are included in the statement of quantitative determinations to be given below; but it is perhaps as well to state explicitly that lithium, beryllium, and the metals of the arsenic group, although very specially sought for, could not be detected. A second portion (25 grms. of original substance) was devoted to the quantitative determination of the cobalt, nickel, copper, and lead. A third portion was used for the determination of the alkalies.

The residue left undissolved by the hydrochloric acid amounted to 26·3 grms. (dried at 100°, but not completely). Of these 26·3 grms. of matter separate portions were used for determining the following components:—(*a*) the water volatile on ignition; (*b*) the silica which had been rendered soluble by the treatment with hydrochloric acid—it was extracted by means of boiling carbonate of soda solution and separated out and weighed as usual; (*c*) the part disintegrable by the method customarily used for the analysis of clays, viz., by treatment in the heat with concentrated sulphuric acid, and evaporation of the acid from the substance—the silica and alumina thus rendered soluble being determined by the usual methods.

Found in the 26·3 grms. of matter insoluble in hydrochloric acid—

Water (H_2O),	1·99
Silica (SiO_2), set free by hydrochloric acid,	6·74
Alumina (Al_2O_3),* rendered soluble by sulphuric acid,	1·62
Silica (SiO_2), rendered soluble by sulphuric acid,	0·83
Ultimate residue,	14·91
	26·09
Loss,	0·21
	26·30

As the hydrochloric acid solution had been nearly all used in the numerous qualitative trials made, and the quantitative determinations reported, a special portion of "original substance" (identical with the 100 grms. used for making that solution) was employed for determining the alumina, ferric oxide, manganese, lime, and magnesia extractable by hot hydrochloric acid. Other portions served for the direct determination of the total water and of the total carbonic acid.

The results are included in the following:—

* Includes a little oxide of iron.

Summary of Quantitative Determinations.

			P.	E.	$\frac{P.}{E.}$
Total water (H_2O),*			24·90		
Total carbonic acid (CO_2),			0·38		
Total phosphoric acid (P_2O_5) extractable by hydrochloric acid,			0·07		
(a) In Acetic Acid Extract.					
Lime (CaO),			0·45		
Magnesia (MgO),			0·36		
Soda (Na_2O),			0·60		
(b) In Hydrochloric Acid Extract from Acetic Acid Residue.					
Silica (SiO_2),			7·47		
Oxide of lead (PbO),	0·01	}	0·93		
Oxide of copper (CuO),	0·272	}			
Oxide of cobalt (CoO),	0·25	}			
Oxide of nickel (NiO),	0·40	}			
Manganous oxide (MnO),			19·39	35·5	0·546
Loose oxygen (O),			3·95	8	0·494
Lime (CaO),			1·33		
Magnesia (MgO),			1·42		
Alkalies (R_2O),			0·34		
Alumina (Al_2O_3),			3·03		
Ferric oxide (Fe_2O_3),			16·20		
(c) In Sulphuric Acid Extract from Hydrochloric Acid Residue.					
Alumina and ferric oxide,			1·62		
Silica (SiO_2),			0·83		
(d) Ultimate Residue.					
Silicates and silica,			14·91		
			98·18		

Special Experiments on the State of Oxidation of the Manganese.

The loose oxygen reported above had been determined in two ways, viz., firstly by Bunsen's method: distilling with hydrochloric acid, and titrating the iodine equivalent of the chlorine liberated by means of thiosulphate—chemically pure iodine serving as a standard; and secondly, by Fresenius and Will's method: digestion of the substance with dilute sulphuric and oxalic acids, collecting the carbonic acid liberated in a tared potash bulb and soda-lime tube, and determining the increase of weight shown by the absorption apparatus. In the latter case the carbonic acid of the carbonates was determined in

* Determined directly, by expulsion in a combustion tube and collecting in chloride of calcium.

a separate portion of substance, setting it free by means of a mixed solution of ferrous chloride and hydrochloric acid and weighing it as above. In order to see whether the second method is affected by the presence in the substance of ferrous oxide (as Bunsen's undoubtedly is), a quantity of a pure "peroxide" of manganese was made by heating pure nitrate first to about 200° C., then to redness, and the percentage of loose oxygen in this preparation determined according to Fresenius and Will; first in the usual manner and then after addition to the substance of a known weight of artificial ferroso-ferric oxide (Fe_3O_4) prepared in the wet way from ferrous sulphate.

The results were as follows :—

Percentage of Loose Oxygen found.

By the oxalic acid method, ...	7·99	8·13
By the same in presence of ferroso-ferric oxide,* . . .	7·98	

Hence the presence of ferrous oxide does not sensibly affect the oxalic acid method, which at the same time showed me that the manganese nodule substance analysed could not have contained much ferrous oxide. In fact the 3·95 per cent. of loose oxygen reported in the summary were deduced from the following determinations :—

Oxygen found by oxalic acid, ...	$4·02 = 0·502 \times$ "O"
Oxygen found by iodine method, ...	$3·88 = 0·485 \times$ "O"
Difference, ...	$0·017 \times$ "O"
Manganous oxide found, ...	$19·39 = 0·546 \times MnO$

The difference ($0·017 \times$ " O "), if not simply due to observational errors, would correspond to $0·017 \times Fe_2O_3 = 0·017 \times 72 = 1·22$ per cent. of ferrous oxide $= 1·36$ per cent. of ferric oxide, leaving $16·2 - 1·36 = 14·84$ of real ferric oxide. But at any rate there cannot be much ferrous oxide present, or it would have told more strongly on the iodine result.

Another result which would appear to follow from the reported numbers, is that the loose oxygen is not sufficient to supplement the manganous oxide into binoxide. Taking 4·02 as the correct percentage of loose oxygen, we have for the percentage of—

Manganous oxide (MnO), ...	$0·044 \times MnO$ †
Real manganese oxide (MnO_2), ...	$0·502 \times MnO_2$

Now the oxides MnO, FeO (as above calculated); CaO, MgO as reported under (*b*), amount in all to $0·197 \times R''O$.

These may be present in combination with manganese binoxide as components of psilomelanic compounds, leaving a balance of $0·305 \times MnO_2$ of real uncombined (or hydrated) binoxide of manganese.

* MnO . O $= 0·6454$ grms.; $Fe_3O_4 = 0·18$ grms., CO_2 obtained $= 0·2832 = 7·98$ per cent. of oxygen.

† Here, as everywhere, $H = 0·5$; ∴ $MnO = 35·5$.

I know of no test for discriminating between free manganese binoxide and manganese binoxide combined with oxides of the type R″O; but what can be done in a case like the one in hand is to determine the exact ratio of the "MnO" present in all to the loose oxygen present. But a complicated complete analysis like the one reported, however carefully done, cannot possibly supply sufficiently exact data for this purpose.

I therefore selected from my stock a nodule which seemed to be exceptionally rich in manganese, and determined, by a specially devised process, the total manganese, as manganous oxide, and (by the ordinary methods) the loose oxygen.

To determine the total manganese, a weighed quantity of homogeneous substance was disintegrated by hydrochloric acid, the iron and alumina precipitated by means of acetate of soda and filtered off, and from the filtrate the manganese precipitated by means of bromine in presence of zinc salt. The precipitate (which contained all the manganese as binoxide) was dissolved by dilute sulphuric acid in an atmosphere of carbonic acid with a known weight of standardized ferrous sulphate and the excess of "ferrosum" titrated by permanganate. That this method, which every chemist will recognise as a slight modification of Kessler's, gives exact results had been proved by a series of experiments on known weights of manganese given as a solution of pure chloride which had been standardized by means of nitrate of silver.

In the analysis of the nodule two determinations gave—

I.	II.	Mean.
16·54	16·30	16·42

per cent. of manganous oxide (present as $MnO . O_x$). The loose oxygen was found to be as follows:—

			Mean.
Iodine method,	3·775	3·764	3·77
Oxalic acid method,*	3·85	3·95	3·90

Dividing by the combining weights we have—

$$16·42 : 35·5 = 0·4626$$
$$3·77 : 8·0 = 0·4712$$
$$3·90 : 8·0 = 0·4874$$

Here the oxygen found is a little more than what would be sufficient to convert the manganous oxide into binoxide. Possibly some of the loose oxygen may have been present as peroxide of cobalt (Co_2O_3); but I have had no time yet to inquire further into the matter experimentally. All I can say is that the determinations were made with great care at a time when we had become very familiar with all the manipulations involved, and I think I am safe in asserting that that particular nodule in all probability contains its manganese in the form of binoxide only.

* 0·877 grm. of the substance when decomposed by acid (with ferrous chloride) gave less than 1 mgrm. of carbonic acid.

Analysis of a Manganese Nodule.[1]

By Professor A. Renard.

Station 276; 2350 fathoms, South Pacific.

I. 0·8271 grm. of substance dried at 100° gave 0·0787 grm. water (H_2O), 0·1600 grm. silica (SiO_2), 0·0264 grm. of lime (CaO), 0·0526 grm. alumina (Al_2O_3), 0·2208 grm. peroxide of iron (Fe_2O_3), 0·0148 grm. magnesia (MgO), 0·2354 grm. manganic oxide (Mn_2O_3) corresponding to 0·2189 grm. of manganous oxide (MnO), 0·0119 grm. nickel (Ni) corresponding to 0·0151 grm. oxide of nickel.

II. 0·1425 grm. of substance dried at 100° treated with hydrochloric acid and the resulting gas conducted into a solution of potassium iodide liberated iodine; 12 c.c. of potassium thiosulphate (1 c.c. = 0·937 c.c. of the standard solution); 1 c.c. of the standard solution $= \frac{Cl}{10}$ or $\frac{O}{20}$, whence 1 c.c. = 3·55 grms. of chlorine or 0·8 grm. of oxygen—

$$1000 : 0{\cdot}8 = 12 \times 0{\cdot}9377 : x.$$
$$\therefore\ 1000 : 0{\cdot}8 = 11{\cdot}24 : x.$$

$\therefore\ x = 0{\cdot}008992$ grm. of oxygen capable of liberating chlorine from hydrochloric acid, *i.e.*, 6·31 per cent. oxygen.

The atomic ratio of 0·384 O is required if Mn be present as MnO_2 and Ni as Ni_2O_3, but 0·394 O was the ratio observed—

	a	b	$\frac{a}{b}$
Manganous oxide,	26·46	MnO = 71	0·372
Nickel,	1·82	Ni = 74·8	0·024
Oxygen,	6·31	O = 16	0·394

$$0{\cdot}372 + \frac{0{\cdot}024}{2} = 0{\cdot}384$$

The formula $MnO_2 + \frac{1}{2}H_2O$ requires 9·18 per cent. water. Consequently 26·46 per cent. manganous oxide, which corresponds to 32·42 per cent. manganese binoxide, is equivalent to 3·28 per cent. water.

26·7 per cent. ferric oxide require as limonite 4·50 per cent. water.

	I.	II.	
Water (H_2O),	9·51	...	9·51
Silica (SiO_2),	19·34	...	19·34
Lime (CaO),	3·19	...	3·19
Alumina (Al_2O_3),	6·36	...	6·36
Ferric oxide (Fe_2O_3),	26·70	...	26·70
Magnesia (MgO),	1·79	...	1·79
Manganous oxide (MnO),	26·46	...	26·46
Nickel oxide (NiO),	1·82	...	1·82
Oxygen (O_2),	...	6·31	6·31
			101·48

[1] In the remainder of this Appendix the symbols are used with their ordinary value, H = 1 and O = 16.—J. M.

ANALYSES OF DEPOSITS.

Analysis of a Blue Mud.

By Dr. Hornung.

Station 323, February 21, 1876; 1900 fathoms, South Atlantic.

I. 0·8069 grm. of substance dried at 110°, fused with carbonates of soda and potash, gave 0·4804 grm. of silica, 0·1566 grm. of alumina, 0·0576 grm. of ferric oxide, 0·0135 grm. of lime, 0·0155 grm. of magnesia, 0·0503 grm. of loss on ignition.

II. 1·4212 grms. of substance dried at 110° C., treated with hydrofluoric and sulphuric acids, gave 0·0202 grm. of potash and 0·0382 grm. of soda.

Silica (SiO_2),	59·54
Alumina (Al_2O_3),	19·42
Ferric oxide (Fe_2O_3),	7·15
Lime (CaO),	1·68
Magnesia (MgO),	1·93
Potash (K_2O),	1·35
Soda (Na_2O),	2·68
Loss on ignition,	6·24
Phosphoric and sulphuric acids,	traces
	99·99

Analysis of a Red Clay.

By Dr. Hornung.

Station 9; 3150 fathoms, North Atlantic.

I. 1·1459 grms. of substance dried at 110°, fused with carbonates of soda and potash, gave 0·6519 grm. of silica, 0·2323 grm. of alumina, 0·1148 grm. of ferric oxide, 0·0150 grm. of lime, 0·0293 grm. of magnesia, and 0·0770 grm. of loss on ignition.

II. 1·1162 grms. of substance dried at 110°, treated with sulphuric and hydrofluoric acids, gave 0·0219 grm. of potash and 0·0092 grm. of soda.

	I.	II.	Mean.
Silica (SiO_2),	56·89	...	56·89
Alumina (Al_2O_3),	20·28	...	20·28
Ferric oxide (Fe_2O_3),	10·02	...	10·02
Lime (CaO),	1·31	...	1·31
Magnesia (MgO),	2·56	...	2·56
Potash (K_2O),	...	1·91	1·91
Soda (Na_2O),	...	0·81	0·81
Loss on ignition,	6·72	...	6·72
Barium, manganese, and phosphoric acid,	...	...	traces
			100·50

Analysis of the Residue of a Globigerina Ooze.

By Dr. Klement.

Station 338 ; 1990 fathoms, South Atlantic.

A large quantity of Globigerina ooze was treated with dilute hydrochloric acid, taking care not to exceed a feeble acid reaction ; after elimination of the carbonates, the sulphates and the phosphates, the residue was analysed and gave the following results :—

I. 0·8360 grm. of substance dried at 110° C., fused with carbonates of soda and potash, gave 0·4219 grm. of silica, 0·1506 grm. of alumina, 0·1066 grm. of ferric oxide, 0·0220 grm. of manganese binoxide (MnO_2), 0·0148 grm. of lime, and 0·0567 grm. of magnesium pyrophosphate.

II. 1·1293 grms. of substance dried at 110° C., gave 0·1235 grm. of loss on ignition, treated with hydrofluoric and sulphuric acids gave 0·0123 grm. of potash and 0·0135 grm. of soda.

Silica (SiO_2),	50·47
Alumina (Al_2O_3),	18·01
Ferric oxide (Fe_2O_3),	12·75
Lime (CaO),	1·71
Magnesia (MgO),	2·44
Potash (K_2O),	1·11
Soda (Na_2O),	1·05
Loss on ignition,	10·93
	101·47

Analysis of Radiolarian Ooze.

By Dr. Sipöcz.

Station 266 ; 2750 fathoms, Mid Pacific.

I. 0·6580 grm. of substance dried at 110° C., gave 0·1087 grm. loss on ignition, treated with hydrofluoric and sulphuric acids gave 0·3478 grm. of silica, 0·0011 grm. of cupric oxide, 0·0391 grm. of ferric oxide, 0·0529 grm. of alumina, 0·0263 grm. of phosphoric acid, 0·0115 grm. of manganous oxide (MnO), 0·0435 grm. of lime, 0·0318 grm. of magnesia, and traces of cobalt, potash, and soda.

Silica (SiO_2),	52·85
Copper oxide (CuO),	0·16
Ferric oxide (Fe_2O_3),	5·94
Alumina (Al_2O_3),	8·22
Manganous oxide (MnO),	1·74
Lime (CaO),	6·61
Magnesia (MgO),	4·84
Loss on ignition,	16·52
Cobalt oxide, potash, soda,	traces
	100·87

Analysis of Diatomaceous Ooze.

By Dr. Sipöcz.

Station 157; 1950 fathoms, Southern Ocean.

I. 0·5618 grm. of substance dried at 120° C. gave 0·0330 grm. loss on ignition, treated with hydrofluoric and sulphuric acids gave 0·5092 grm. of silica, 0·00112 grm. of barium oxide, 0·00085 grm. of potash and 0·00225 grm. soda.

II. 0·6487 grm. of substance dried at 120° C. gave 0·0379 grm. loss on ignition, treated with hydrofluoric and sulphuric acids gave 0·5870 grm. of silica, 0·0013 grm. of barium oxide, 0·0057 grm. of ferric oxide, 0·0085 grm. of alumina, 0·0022 grm. of lime, 0·00198 grm. of magnesia, and traces of phosphoric acid.

	I.	II.	Mean.
Silica (SiO_2),	90·63	90·49	90·56
Ferric oxide (Fe_2O_3),	...	0·88	0·88
Alumina (Al_2O_3),	...	1·31	1·31
Lime (CaO),	...	0·33	0·33
Baryta (BaO),	0·20	...	0·20
Magnesia (MgO),	...	0·30	0·30
Potash (K_2O),	0·15	...	0·15
Soda (Na_2O),	0·40	...	0·40
Phosphoric acid (P_2O_5),	trace	...	trace
Water (H_2O),	5·87	5·84	5·85
Loss on ignition,	...	...	...
			99·98

For analysis of glauconitic grains and casts see p. 468; and of Globigerina ooze see p. 915.

APPENDIX VI.

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β. On the Birds collected in the Admiralty Islands.
By P. L. Sclater M.A. Ph.D., F.R.S., Sec. Z.S., F.L.S.

γ. On the Birds collected in Tongatabu, the Fiji Islands, Api (New Hebrides), and Tahiti.
By Dr. O. Finsch, C.M.Z.S.

δ. On the Birds collected in Ternate, Amboyna, Banda, the Ki Islands, and the Arrou Islands.
By Count Thomaso Salvadori, M.D., C.M.Z.S.

ε. On the Birds collected at Cape York, Australia, and at the Neighbouring Islands (Raine, Wednesday, and Booby Islands).
By W. A. Forbes, B.A., F.L.S., F.G.S., F.Z.S.

ζ. On the Birds collected in the Sandwich Islands.
By P. L. Sclater, M.A., Ph.D., F.R.S., Sec. Z.S., F.L.S.

η. On the Birds collected in Antarctic America.
By P. L. Sclater, M.A., Ph.D., F.R.S., Sec. Z.S., F.L.S., and Osbert Salvin, M.A., F.R.S., F.Z.S., F.L.S.

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By P. L. Sclater, M.A., Ph.D., F.R.S., Sec. Z.S., F.L.S.

ι. On the Steganopodes and Impennes.
By P. L. Sclater, M.A., Ph.D., F.R.S., Sec. Z.S., F.L.S., and Osbert Salvin, M.A., F.R.S. F.Z.S., F.L.S.

κ. On the Laridæ.
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λ. On the Procellariidæ.
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μ. List of the Eggs collected.
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By W. E. Hoyle, M.A., M.R.C.S., F.R.S.E.

APPENDIX VIII.

LETTERS addressed by the ADMIRALTY to the CAPTAIN of H.M.S. CHALLENGER and the DIRECTOR of the CIVILIAN SCIENTIFIC STAFF after the arrival of the Expedition in England.

"ADMIRALTY, *8th July* 1876.

"SIR,—The Hydrographer of the Admiralty having reported to their Lordships the result of his examination of the documents, &c., bearing on the Scientific Investigations made in H.M.S. Challenger during her late cruise, I am commanded by my Lords Commissioners of the Admiralty to convey to you the expression of their entire satisfaction at the manner in which the various services in connection with deep-sea exploration, &c., were carried out on board that vessel, and to the intelligent interest in the ship's proceedings exhibited by the officers and men, which so greatly contributed to the complete success of the Expedition.

"2. Their Lordships' highest commendation is due to the patient care and unremitting attention which has been given to the special points of Scientific Inquiry throughout the late voyage of that vessel, and the expression of their marked approval will be communicated to the officers concerned, through the Commander-in-Chief at Sheerness.

"3. It is also a source of great satisfaction to their Lordships that the Challenger never once touched the ground during the whole period of her late Commission, although she passed through many very imperfectly known parts of the ocean.

"4. My Lords regret that, owing to the examination of the Reports and Records received from the Challenger not having been completed, their approval of the able services of the officers, and the zealous conduct of the men, could not be conveyed before the ship was paid off.

"I am, &c.,

"ROBERT HALL.

"*Captain Thomson, R.N.*"

14th June 1876.

"SIR,—I am commanded by my Lords Commissioners of the Admiralty to acquaint you that they embrace the opportunity of the Challenger being paid off, and the large collections in Natural History made under your direction being safely deposited in this country preparatory to their final disposal, to convey to you their great satisfaction at the success which has attended this novel and interesting Expedition carried on in one of Her Majesty's ships for the furtherance of Scientific Knowledge.

"2. Their Lordships have noted from time to time throughout the whole of the voyage of the Challenger the great interest that has been taken in it by Scientific Men of this and other countries, and now that the connection between the Admiralty and the Expedition from a nautical point of view has ceased, I am desired by their Lordships to assure you that the development of the labours of yourself and staff during the period of the voyage will still be watched and appreciated by them with undiminished interest, and their Lordships will be at all times ready to exert their influence for promoting the ultimate objects of the undertaking.

"3. I am further to request you will convey their Lordships' views to the several gentlemen associated with you during the voyage.

"I am, Sir,

"Your obedient Servant,

"ROBERT HALL.

"*Professor Wyville Thomson.*"

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