CHAPTER IX.

Kerguelen Island—Proceedings of the Expedition—History of previous Exploration—Geology, Meteorology, Zoology and Botany of the Island—The Spheniscidæ.

THE island of Kerguelen is throughout mountainous, made up of a series of steep-sided valleys separated by ridges and mountain masses, which rise to very considerable heights. Mount Ross, the highest, is 6120 feet in altitude, Mount Richards 4000 feet, Mount Crozier 3250, Mount Wyville Thomson 3160, Mount Hooker 2600, and Mount Moseley 2400.

The island thus, when viewed from the sea at a distance, presents a remarkable jagged outline of sharp peaks, which is most striking when observed from the south. The valleys run down everywhere to the sea, broadening out as they approach it. The whole coast is broken up by deep sounds or fjords, which resemble closely in form the fjords of Norway and other parts of the world. They are long channel-like excavations of the coast line, occupied by arms of the sea, often shallower at the mouths than nearer to the upper extremities, and bounded on either hand by perpendicular cliffs.

Christmas Harbour, almost on the extreme north of the island, is a small example of one of the Kerguelen fjords; it is a deep inlet with dark frowning cliffs on either hand at its entrance. The land on either side runs out into long narrow promontories, separating the harbour from another similar fjord on the south and from a bay on the north. The promontories thus formed are high and bounded throughout almost their entire extent by sheer precipices on either hand. On the northern side only of Christmas Harbour, somewhat above its mouth, does the land rise in a steep broken slope, which can be ascended directly from the sea. (See Frontispiece of Christmas Harbour.)

At the seaward termination of the southern promontory is the well-known arched rock of Christmas Harbour, a roughly rectangular oblong mass, evidently at some former period directly continuous with the rest of the promontory, but now separated from it, except at its very base, by a chasm, and perforated so as to form an arch. Above the high cliffs on the south side of the harbour towers a huge and imposing mass of black-looking rock with perpendicular faces, named Mount Havergal; this overhangs somewhat towards the harbour from the weathering out of soft strata beneath it, and looks as if it might fall and fill the upper part of the harbour. On the north side rises a flat-topped rocky mass 1215 feet in height, called Table Mountain.

At the head of the harbour is a sandy beach and small stretch of flat land, such as exists at the heads of all the fjords, and beyond this the land rises in a series of steps, separated by short cliffs towards the bases of Table Mountain and Mount Havergal. The

appearance of the whole is extremely grand, and the marked contrast between the blackness of the rocks and the bright yellow green of the rank vegetation clothing all the lower region of the land, so characteristic of all these so-called Antarctic Islands, renders the general effect in fine weather very beautiful.

The observing parties were fortunate enough to obtain on the same day all the observations required at Christmas Harbour, for, although the morning was cloudy, the sun was visible nearly the whole day after 8 A.M. From the summit of Table Mountain, in the forenoon, the mountain ranges on the east end of the island, distant 50 miles, were distinctly visible, but before angles to them could be obtained the clouds hid them from view. The scud was flying fast over the land, and occasionally enveloped the surveying party on the summit of Table Mountain for a short time, whilst all the islands to leeward appeared free from mist. The islands to the northwest, named by Cook the Cloudy Islands (a very significant appellation), were enveloped in thick mist, so much so that it was only by remaining five hours on the summit of the hill, and watching for breaks in the mist, that the requisite angles were obtained to their summits and salient points. This was probably the first time an angle had been obtained to Bligh's Cap from Table Mountain. It was with surprise that Cook was found to be considerably (nearly two points) out in his bearing of Bligh's Cap from Cape François.

Magnetic observations were obtained on the beach at the head of Christmas Harbour on Ross' old observing spot. The astronomical observations were taken on the east side of a low bluff on the north coast of the harbour, close to the beach head.

On the 8th January, at 5 A.M., the Challenger left Christmas Harbour for Accessible Bay in a snow-storm, making sail and banking the fires when outside the harbour. The day was cloudy and bleak, with a fresh northwest wind and occasional showers of snow, but little or no mist. After passing between Swain Island and Howe's Foreland, which being unmistakably an island will in future be called "Howe Island," a line of soundings was carried and angles taken to all the salient points of the coast, to facilitate the construction of a chart after a sufficient number of stations for triangulation had been taken up. Here groups of rocks were seen on both bows; those to the northward, about 6 feet high, were named "Glass Rocks," and those to the southward "Bird Rocks," after two of Ross's officers. Large patches of Kelp surrounded the Bird Rocks, extending some considerable distance seaward from them. At noon Mount Campbell and the Chimney Top Hill to the southward were sighted. The former is a remarkable hill, 460 feet high, in shape somewhat like a truncated cone, standing alone in a plain of considerable extent, and when once seen cannot be mistaken. The Chimney Top, 2400 feet high, is apparently a basaltic mass on one of the peaks of a considerable range of hills, the highest point of which (Mount Crozier) rises to a height of 3250 feet above the level of the sea. After passing the Bird Rocks, a course was shaped towards the small and low Kent Islands, which were sighted at 3 P.M., and

passed at 4 P.M. in a rain squall, and the ship then steamed into Accessible Bay, looking for Betsy Cove, which was entered at 6 P.M. The cove looked very small, but letting go an anchor in 9 fathoms in the middle of the entrance, with the east cliff of Elizabeth Head shut in behind the northeast point of the harbour, and veering three shackles of cable the ship just swung clear of the kelp that lines the shore, the stern being in 6 fathoms.

On the 9th, early in the morning, the boom boats were got out, and at 8 A.M. the surveying and exploring parties left the ship. The weather was cloudy and unfavourable, and on the tops of the hills the wind was fresh and very cold; no astronomical observations could be obtained, but angles were taken from Elizabeth Head, Mount Campbell, Cape Anne, and a flat-topped hill inshore; the distant peaks were, however, clouded over all day.

On the 10th January the weather was much more favourable, and equal altitudes and circummeridians were obtained at Elizabeth Head. A base was measured by sound between the Rocks of Despair and the observing station, and angles obtained at several prominent points. Table Mountain was not seen from Mount Campbell, as the weather was misty, but the high ranges to the southward culminating in Mount Wyville Thomson could be distinguished, as well as the glacier on Mount Richards to the westward.

Sunday the 11th was a beautiful, bright, sunny day, with a light breeze, more like a May day in England than the foggy weather of the Southern Ocean. The ship's company were allowed a run on shore to stretch their legs for the first time since leaving the Cape, and the number of ducks shot by the officers and naturalists was sufficient to provide for all hands.

On the 12th, at 4 A.M., the barometer, which had been high and gradually falling, began to do so rapidly, going down 0·25 inch between 4 and 6 A.M. At this time, although the weather was gloomy and foggy, with drizzling rain, there was but little wind, but shortly after 6 A.M. a sudden squall from N.E. came down, swinging the ship across the cove, and sending a nasty swell into Accessible Bay. The cove was too narrow to allow more than the three shackles of cable that were out to be veered, so that it was necessary to lay a hawser out to the north shore, and let go the second anchor under foot as a precaution. Had the anchor dragged or the cable parted, the ship would certainly have grounded, as the cove was so small that the stern was but a few feet from the coast; fortunately, the holding ground was good, and the wind shifted gradually to the westward and cleared up by 10 A.M., when in order to swing in less room the vessel was moored. This would have been done before had a breeze from the northeast been expected, but as strong winds were only expected from the westward, and seeing there was plenty of room with westerly winds, it was considered superfluous to do so until experience taught the necessity of taking this precaution. The weather in the afternoon was sufficiently fine to allow the survey to be proceeded with, and at 6 P.M. there was not a cloud in the sky. The barometer continued falling till 9 A.M., after which it again rose, but slowly.

On the 13th the weather was bright and clear, with a fresh cold wind. The surveying parties were engaged in sounding the cove and Cascade Harbour, delineating the coast line, &c.; the sounding boats' crews found it very cold work on account of the wind.

At 8 P.M. a whaling schooner (the "Emma Jane") came into the cove from Island Harbour, Royal Sound. Her captain (Bailey) said that a barque called the "Roman," Captain Swain, was in the neighbourhood, and that there were two other schooners engaged in the fishery hereabouts, viz., the "Roswell King," Captain Fuller, and the "Charles Coldgate." The Kerguelen whale and seal fishery would appear to have dwindled very considerably since the time of Sir James Ross. At the time of the Challenger's visit (1874) it employed a barque, two schooners, and a party of twenty-nine men on Heard Island. The barque and schooners belong to New London, Connecticut; the schooners remain at Kerguelen, whilst the barque (the "Roman") keeps up the communication with America, bringing out supplies and taking back the season's oil and seal-skins. The "Roman" arrives at Kerguelen every year in September, and meets the two schooners ("Roswell King" and "Emma Jane") at Island Harbour, Royal Sound. They then start for Heard Island, and remain in its vicinity until the Elephant Seal season is over,—about the middle of December,—after which they return to Kerguelen, when the "Roman" leaves for America, and the schooners hunt for whales until the end of June. Just now, another schooner (the "Charles Coldgate") had come to the island fishing on her own account. The men engaged in the fishery are Americans and Portuguese, the latter from the island of Brava, one of the Cape Verde group. They sign articles for three years, and are relieved, so many annually, by new hands brought out in the "Roman."

The 14th was squally and misty, with a considerable swell outside, so much so that the steam pinnace, which had started with a surveying and exploring party to the westward, was obliged to return, being unable to face the sea. The surveying operations were limited to completing the soundings in the cove.

On the 15th equal altitudes were obtained, which gave rates for the chronometers, and boom boats were got in ready to start for either Christmas Harbour or Royal Sound, as the weather permitted.

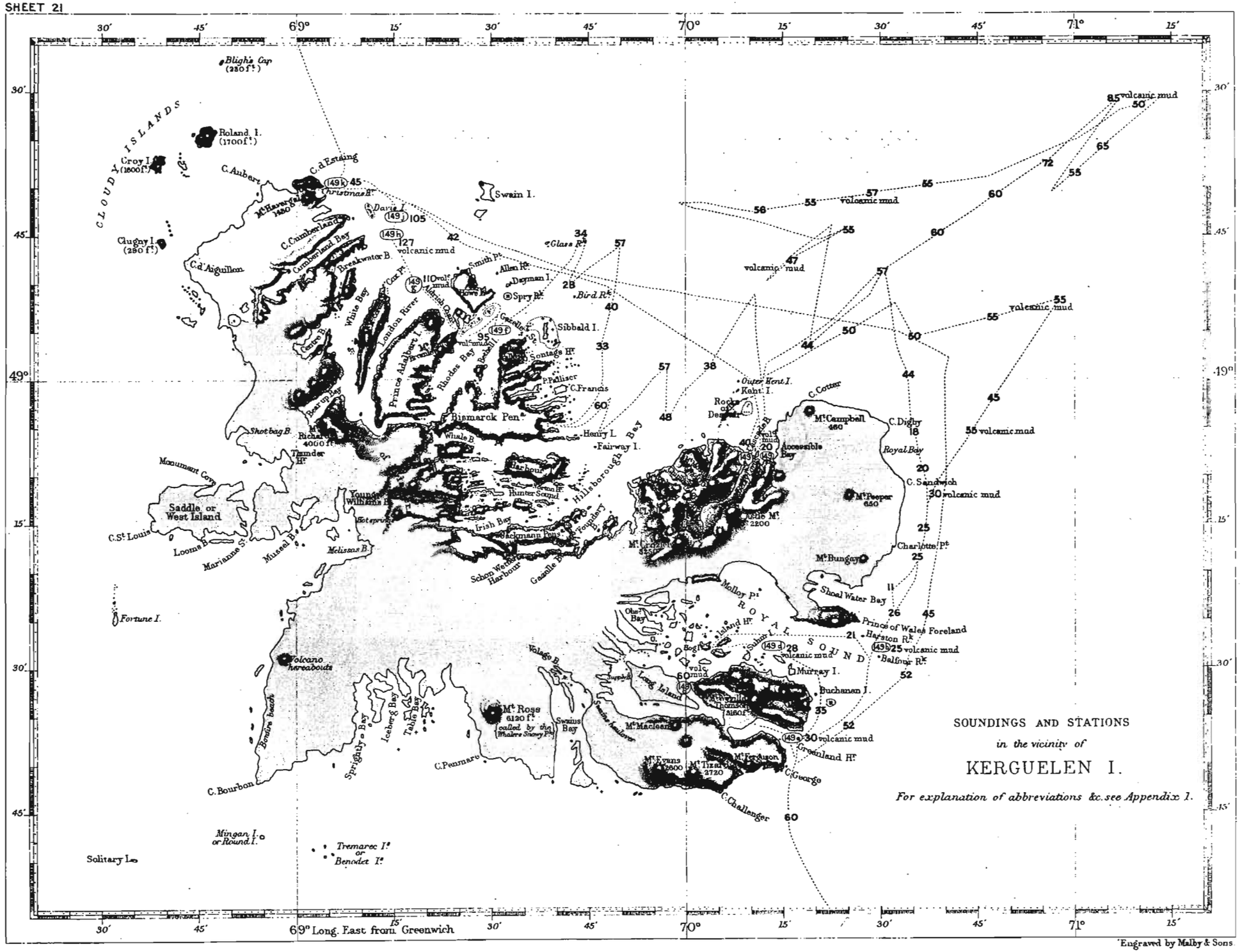
On the 16th the ship left Betsy Cove at 7 A.M., but had scarcely got outside when the wind freshened considerably, so that with two boilers sufficient headway could not be made, and it was therefore necessary to make sail to single-reefed topsails and courses, and work out of Accessible Bay under sail and steam. At 9.30 A.M. the land was cleared, and sail shortened to single-reefed topsails, and the fires banked; but at 10 A.M. the weather was so misty that the land was completely obscured, and the wind having now freshened to a gale, the ship was laid to under triple-reefed fore and main topsails on the port tack until the wind should moderate, and the mist clear off, sounding from time to time, and obtaining no bottom at 50 fathoms. The sun was

occasionally visible, but the atmosphere continued misty. At 9 P.M. the gale was at its height, the force of the wind being 10.

On the 17th, shortly after midnight, the gale moderated. At daylight (3.30 A.M.), the ship wore and made sail to double-reefed topsails and courses, and stood in towards the land, which was seen at 7 A.M. through the mist, and Mount Peeper, a round-backed hill, 650 feet high, with an ill-defined summit, distinguished; Mount Campbell was looked for, but it was afterwards found that when south of Cape Digby it is hidden by a low range of hills between it and that Cape, that is, to vessels near the coast, farther off, it can be seen over these low hills. At 8.30 A.M. the Prince of Wales Foreland, the hills on the south side of Royal Sound, and Mount Crozier were distinguished, and were all free from cloud. When within 3 miles of Cape Sandwich the ship ran to the southward along the land towards Royal Sound, carrying a line of soundings, and keeping about 3 miles from the coast, which was low between Cape Sandwich and Charlotte Point. From Charlotte Point the low land continued until it turned to the westward into Shoal Water Bay, the turning point being marked by a low cliff. Between Charlotte Point and Bluff Point (at the entrance to Shoal Water Bay), $1\frac{3}{4}$ miles inland, is a remarkable low hill, named Mount Bungay, with two conspicuous boulders on its flat summit. All along the coast kelp was observed, stretching in some cases a considerable distance from the shore; the soundings varied from 25 to 30 fathoms, the bottom being mud, and the lead frequently bringing up fragments of Sponges. At noon the ship was off the Prince of Wales Foreland, and the wind being then quite light, and the weather fine, sail was shortened, and steam got up to dredge, and surveying parties sent away to take up stations on the Foreland, and on the flat-topped rock four miles to the southward (Balfour Rock). The landing on Balfour Rock was difficult owing to the swell, but at the Foreland it was easy. From the station on the Foreland an excellent view was obtained, the snow-clad summit of Mount Ross being distinctly visible, but before all the angles to the numerous peaks could be obtained, the mist again came on.

Prince of Wales Foreland, the peninsula marking the northern entrance to Royal Sound, is a long-backed hill, the highest part of which is 840 feet above the sea level. On its south side are precipitous cliffs; on its north side it slopes gradually down to the coast of Shoal Water Bay; a remarkable boulder stands out conspicuously on a whity-brown patch against this northern slope which is covered with moss; walking up the side of the hill is rendered laborious in consequence of the leg frequently sinking knee-deep into this moss. The Foreland is joined to the mainland by a low isthmus which separates Shoal Water Bay from Royal Sound. In Shoal Water Bay (which derives its name from its comparative shallowness), is a conspicuous rocky little island (Matelot Island), and the greater part of the bay is overgrown with kelp. Off the eastern point of Prince of Wales Foreland a ledge of rocks extends about a quarter of a mile. Harston

SHEET 21



Engraved by Malby & Sons

and Balfour Rocks are two flat-topped islets, about 20 feet high, apparently free from danger, at the entrance to Royal Sound, the depths between which are 14 to 25 fathoms with a rocky bottom; two miles outside the outer rock (Balfour) a depth of 52 fathoms was obtained (see Sheet 21).

The southern side of the entrance to Royal Sound is formed by a large peninsula (50 square miles in extent) of rugged mountainous land, culminating in Mount Wyville Thomson, 3160 feet above the level of the sea. On the spurs descending from Mount Wyville Thomson are several conspicuous conical peaks, Thumb Peak, Sugar Loaf, Cat's Ears, and Mount Wild, varying from 1200 to 2500 feet in height; and off its northern coast are several peaked islands, Buchanan, Murray, and Suhm, from 200 to 500 feet above the sea level. This peninsula is joined to the mainland by a low, narrow isthmus, separating Royal Sound from Greenland Harbour. At 5.30 P.M. the surveying parties returned to the ship, which then proceeded up Royal Sound for Island Harbour, carrying a line of soundings, and carefully avoiding all kelp. At 7.30 P.M. a schooner, the "Charles Coldgate," was observed at anchor in the harbour; and at 8 P.M. the ship anchored there in 11 fathoms. From the captain of the "Charles Coldgate" no information could be obtained; he was a sulky kind of fellow, and seemed much disappointed that the Expedition knew so much about Kerguelen. He supposed the Challenger to be a few thousand miles out of her reckoning, and to have mistaken Royal Sound for one of the harbours of New Zealand.

On the 18th, shortly after midnight, the barometer began to fall, and the weather became thick and rainy. At noon a sudden gale sprang up from the northward, and the wind blew with considerable force (9) for two hours, after which it moderated rapidly, and there was a fine sunset.

The 19th was a fine day, so that astronomical observations were obtained from the summit of Hog Island, and various stations taken up at suitable points, in the sound, in prosecution of the survey. From the elevated stations on the summit of Hog Island, Suhm Island, and the western extremity of the spur from Mount Wyville Thomson, magnificent views were obtained of the mass of islands in what Cook fittingly designated a "Royal Sound." A base was measured by sound between Mouse and Hog Islands, and a survey of Island Harbour commenced on a large scale, whilst the stations on elevated points enabled the positions of the numerous islands westward of Island Harbour to be fixed, if not with absolute accuracy, still near enough for all present requirements.

The morning of the 20th was very fine, without a cloud in the sky or over the land, and the clearness of the atmosphere was very remarkable, every peak and spur from the mountain range sharply defined, and hills 15 or 20 miles off appearing only half that distance away, not a breath of air stirring, and the sea as smooth as glass. The calm continued until 9 A.M., after which a breeze sprang up from the northward, and the sky

gradually clouded over. Advantage was taken of the fine weather to complete the survey of Island Harbour, and the outer part of Royal Sound. In the afternoon the ship left Island Harbour and sounded and dredged until 5 P.M., and then anchored for the night off Murray Island, where the surveying boats returned, having completed the survey so far as practicable in the time.

Royal Sound is a magnificent sheet of water, extending a distance of 20 miles from its entrance to its head, and, with its various arms, occupies an area of nearly 200 square miles. A portion of this area is taken up by an archipelago of islands of various sizes, the largest being 6 miles in length and 2 miles in breadth, and the smallest little more than a rock. These islands are congregated towards the head of the sound, and between them there appears to be deep water; in fact, in some of the channels the depths are considerable, for 95 fathoms were obtained in the arm running to the southwestward towards Greenland Harbour. They are all flat-topped, with erratics on their upper surfaces, and they appear to increase gradually in height towards the head of the Sound. They are of the same form as the hills about Betsy Cove, and if the great valley there were submerged, the hills on its northern side projecting as islands would give a miniature representation of those in Royal Sound (see Pl. XVII.).

There seems but little doubt that the whole of these islands in Royal Sound were once connected, and that there was thus a broad sheet of lava rock with a gentle inclination from inland towards the sea. This slope may have been once covered with a huge glacier, which was bordered by the mountain ridges now bounding the Sound to the north and south, and perhaps deposited some of the talus at present forming part of the ridge above Mutton Cove. After grinding the whole surface of its bed, the glacier probably shrunk and cut deeper channels between masses of rock, which were left standing, and thus formed the present islands. Either during this period, or after glaciation had ceased, the whole may have been submerged till the upper surfaces of all the islands were under the sea, and then ice drifting seawards from the remnants of the shrunken glaciers at the heads of the fjords, dropped upon the rock surfaces the erratics which at present lie upon them, and at this time all the moraines were washed away. At the base of the hills about Betsy Cove, the bottoms of the secondary valleys are as distinctly glaciated as the main valleys themselves, and the slopes of the smoothed surfaces seem to lead towards the cavity and mouth of the present Cascade Harbour.

About Betsy Cove thin beds of a red earthy matter a foot or two in thickness are very common, underlying beds of basalt and weathering out in the cliffs so as to leave ledges and low-roofed caverns. They occur in exactly the same manner as the beds of coal at Christmas Harbour; and when this coal is burnt in the fire it bakes to a compact mass of red earthy matter, exactly resembling that above referred to. There seems no doubt that these red beds, as well as the coal beds, represent old land surfaces. The soil consisting of black peaty matter as now, not many feet thick, has been overflowed by

HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

TRAP HILLS, KERGUELEN ISLAND.

lava streams, which in the case of the coal have been only hot enough to char all the vegetable matter, while in the other case they have burnt it to an ash.

Eleven miles from the entrance of Royal Sound is a well-protected anchorage called Island Harbour, formed by a group of four islands,—Hog Island, Grass Island, Cats Island, and North Island, the passages into which are all safe and deep, except that between Hog and Grass Islands; this passage, besides being shoal, is blocked with kelp, which also marks the edge of the danger line round the other islands.

Island Harbour is the headquarters of the whaling vessels at Kerguelen. Here they rendezvous yearly to receive supplies and get rid of their oil; here they have erected two huts (on Hog Island) for convenience in boiling down the oil; and from here they start for Heard Island. From the entrance of the sound to Island Harbour the depths vary from 15 to 30 fathoms over a muddy bottom. Above that harbour the soundings are irregular.

Midway between the entrance to Royal Sound and Island Harbour, and on the south side of the sound, is an anchorage called Mutton Cove, sometimes used by the sealing schooners; from their description of its position it would appear to be on the west side of Murray Island.

One and a half miles outside Buchanan Island, at the entrance to the sound, is Pearcey Rock, upon which the sea breaks when there is any swell. With this exception, no danger was seen in Royal Sound, but it is highly probable that rocks exist in it; for it is unlikely that, over such a large area, where so many islands exist, there will not be also some submarine pinnacles; fortunately, these dangers will, to a certain extent, be indicated by kelp, for it is very rare to see a rock in a sheltered place at Kerguelen which has not a mass of this weed attached to it. The golden rule, therefore, in navigating these waters is to avoid that weed; and this more especially applies to screw steamers, for it is sometimes so thick and strong that there is danger of its disabling the propeller.

On the 21st January, at 6 A.M., the ship left Royal Sound and proceeded towards Cape George, in order to fix the south extremity of the island. Passing between Buchanan Island and Pearcey Rock, a line of soundings of from 20 to 35 fathoms was obtained; as the vessel proceeded to the southward the wind freshened and the weather became thick and squally. On nearing Cape George the land opened out to the southward, proving that this cape was not the southern extremity of Kerguelen, as was supposed by Captain Cook; but the weather was so unfavourable, and the swell from under the lee of Cape George so considerable, that the ship was unable to proceed farther at this time; and consequently bore up for Greenland Harbour, and after obtaining a haul of the dredge in 30 fathoms at its entrance, anchored at noon in 11 fathoms. The weather was very squally, the willywaughs coming down from the hills with much force and raising a quantity of spoondrift.

Greenland Harbour is a fjord, 7 miles in length, and a little over a mile in breadth, which separates the mountain masses of the Wyville Thomson Peninsula from those of the peninsula next south of it. At its head is a narrow neck of land, separating it from Royal Sound; similar low isthmuses, dividing capacious harbours, or inlets, from each other, exist in many parts of Kerguelen, and from the custom the whalers and sealers have adopted of hauling their boats over them, are called by these men "Haulovers."

The sides of Greenland Harbour rise abruptly from the water's edge and half-way up the hills on both sides, the horizontal line where all verdure ends is very well marked at a height of about 600 or 700 feet above the sea level. This line is to be seen more or less in all the mountain ranges of Kerguelen, but not in such a conspicuous manner as in this harbour.

Four miles inside the entrance to the harbour is a reef of rocks, which appeared to extend across the channel, but it was learnt afterwards, from Captain Fuller of the schooner "Roswell King," that there was a deep channel between this ledge and the south side of the harbour. If so, the anchorage in the upper part would be well protected in all kinds of wind and weather; otherwise Greenland Harbour cannot be recommended, as below the reef it is open to the southeast winds.

On the 22nd, at 5 A.M., the ship left Greenland Harbour in a shower of sleet and snow, which succeeded a promising sunrise, of which advantage was taken to land on the small green islet at the entrance of the harbour, and obtain a true bearing. Outside the harbour the weather was unfavourable for proceeding to the westward round Cape George, consequently the vessel bore up and ran along the land to the northward, in order to proceed to Christmas Harbour, there to deposit in a cairn a tin can containing the result of the investigations as to the locality best adapted for observing the Transit of Venus. After passing Royal Sound the weather was much finer, but the mist and rain squalls could be seen at Cape George. After rounding Cape Sandwich the wind hauled to the northward, when the ship had to work to windward for Christmas Harbour. At 9 P.M., Mount Campbell bearing S.S.W. about 12 miles distant, sail was shortened to topsails and jib, and the ship stood off on the port tack for the night. During the afternoon clouds came over the land.

On the 23rd, at 2 A.M., the ship wore and stood in for the land, and at daylight (3.30 A.M.) sail was made. At 4 A.M. the barometer began to fall, and the wind freshened, until at 5.30 A.M., when the ship was about 20 miles eastward of Swain Island, it had increased to a moderate gale with thick weather, necessitating shortening sail and standing off until it cleared. The gale and thick weather continued all day (force of wind 8 to 9). The soundings gave depths of from 50 to 60 fathoms, and several patches of detached kelp were seen at intervals, which being collected in a mass floating well out of the water, cannot be easily mistaken for kelp attached to rocks. The sea was short and heavy, so much so, that at 5 P.M. a sea which struck the ship on the port bow stove in a

main deck port, and washed away a sounding platform and part of the head berthing. In the first watch the wind moderated, and shifted more to the westward.

On the 24th, at 2 A.M., the ship again stood in for the land, made Mount Campbell at 3 P.M., and then proceeded for Cascade Reach, anchoring there at 7.30 P.M.

On the 25th the barometer low and falling, the weather outside looking dirty, and a swell setting into Cascade Reach, the ship steamed round to Betsy Cove, anchoring there at 6 A.M., and it was fortunate that this was done, for at 9.45 A.M. a sudden gale from the westward sprang up (force 8), which necessitated a second anchor being let go. The wind was fresh and squally all day, the sky clear overhead, but the hills capped with clouds, and the scud flying rapidly over in detached masses.

On the 26th, the weather being more settled, with a N.W. wind, the ship left Betsy Cove at 6 A.M., and worked to windward for Port Palliser, reaching Hopeful Harbour and anchoring there at 5 P.M. in 15 fathoms. The dangers hereabouts are well marked by kelp, so that the passages into the harbour may readily be followed with security. When opposite Hillsborough Bay it was observed that Fairway Island was low and devoid of verdure, being evidently waterwashed. Henry Island and those immediately adjacent to it are remarkable rectangular blocks readily distinguished. Harbour Island is high. Several whales were seen during the day.

On the 27th, at 5 A.M., the ship left Hopeful Harbour and worked to windward towards Howe Island, in a moderate northwest wind with slightly misty weather. The clouds collected principally over Mount Crozier, but above it, leaving its summit clear and apparently blue sky to the southward over Royal Sound. At noon two whaling schooners were seen standing out from under Swain Island, and the ship stood towards and communicated with them; and finding from their report that good anchorage existed south of Howe Island, followed them into Fuller Harbour after dredging in 95 fathoms just outside it, in Rhodes Bay.

One of the whaling schooners was the "Roswell King" before referred to, commanded by Captain Fuller, a most intelligent and obliging man, who readily answered all questions, and gave the benefit of his large experience in the neighbourhood of Kerguelen, where he had been engaged in sealing and whaling for nearly ten years.

On the 28th the ship remained at anchor in Fuller Harbour, and the surveying parties took up several stations on Howe Island and adjacent salient points, to connect the southern part of Kerguelen with the northern portion. The early part of the day was fine, and a true bearing and angles were obtained to the mountain ranges of Crozier, Wyville Thomson, and Mount Campbell. The northern hills, Table Mountain, Mount Havergal, &c., were also free from cloud, so that the triangles were completed, joining Mount Wyville Thomson to Christmas Harbour.

The wind during the day was moderate, but the weather was very cold on the top of the hills, rendering it wretched work standing in an exposed position by a

theodolite for three or four hours; towards evening the weather changed to mist and rain.

On the 29th, between 1 and 4 A.M., the weather was very squally, but at 6 A.M. the wind had moderated, and the ship left Fuller Harbour, proceeding through the Aldrich Channel for Christmas Harbour; after 8 A.M. the weather cleared up and a beautiful sunny day succeeded. North of Howe Island some hauls of the dredge were obtained, in depths varying from 45 to 127 fathoms. Looking up London River and White Bay, a fine view of the glacier descending from Mount Richards was obtained, but the summit of that hill could not be seen as it was covered with cloud and mist.

The Aldrich Channel, though narrow, is deep and free from danger; on the southeast side of M'Murdo Island, and between it and the islets facing Rhodes Bay, there appeared to be good anchorage. Off Breaker's Bluff is a flat rock and rock awash; on the west side of the channel there was little or no kelp. At 5 P.M. the ship anchored in Christmas Harbour.

On the 30th the morning was very fine, a little mist on the highest and western hill tops, the rest of the island clear. Mount Ross was seen from the top of Mount Havergal, but not the actual summit, which was hidden by intervening clouds. Equal altitudes were obtained at the observing station, which gave rates for the chronometers. Towards evening the weather changed and became thick, Swain Island being hidden.

On the 31st the morning was cloudy and gloomy, with passing showers. At noon, having completed tracings of surveys and copies of remarks, these were soldered in a tin case, and deposited in a cairn on the north side of the harbour. At 3 P.M. the ship left Christmas Harbour under sail and proceeded towards Cape Digby; at 8 P.M. passed the Bird Rocks, and then steered southeast for 36 miles, when, as the ship cleared the land and got away from Cape François, the weather cleared considerably. It had been the intention to pass down the western coast of Kerguelen from Christmas Harbour, to make a running survey of it, but the weather was unfavourable and the time could not be spared to wait, for the summer was now at its height, and every day was precious if any researches were to be prosecuted farther south in the neighbourhood of the Antarctic ice.

On the 1st February, at 1 A.M., sail was shortened and the ship hove to till daylight. At 4 A.M. sail was again made and the ship steered along the land to the southwestward towards Cape George. It was a peculiar heavy looking morning, with high clouds, and a pale green sky before sunrise; the Mount Crozier range was capped with clouds, but the Wyville Thomson range and the hills to the westward were clear, and Mount Ross very distinct. At 11 A.M. the wind fell light, so sails were furled and the ship proceeded under steam. After passing Cape George the westerly swell prevented the ship proceeding farther west without expending more coals than could be afforded, so it was thought sufficient to cut in the land from the ship, and fix the position of the southern Cape of Kerguelen—Cape Challenger. Cape Challenger is a ragged point, at

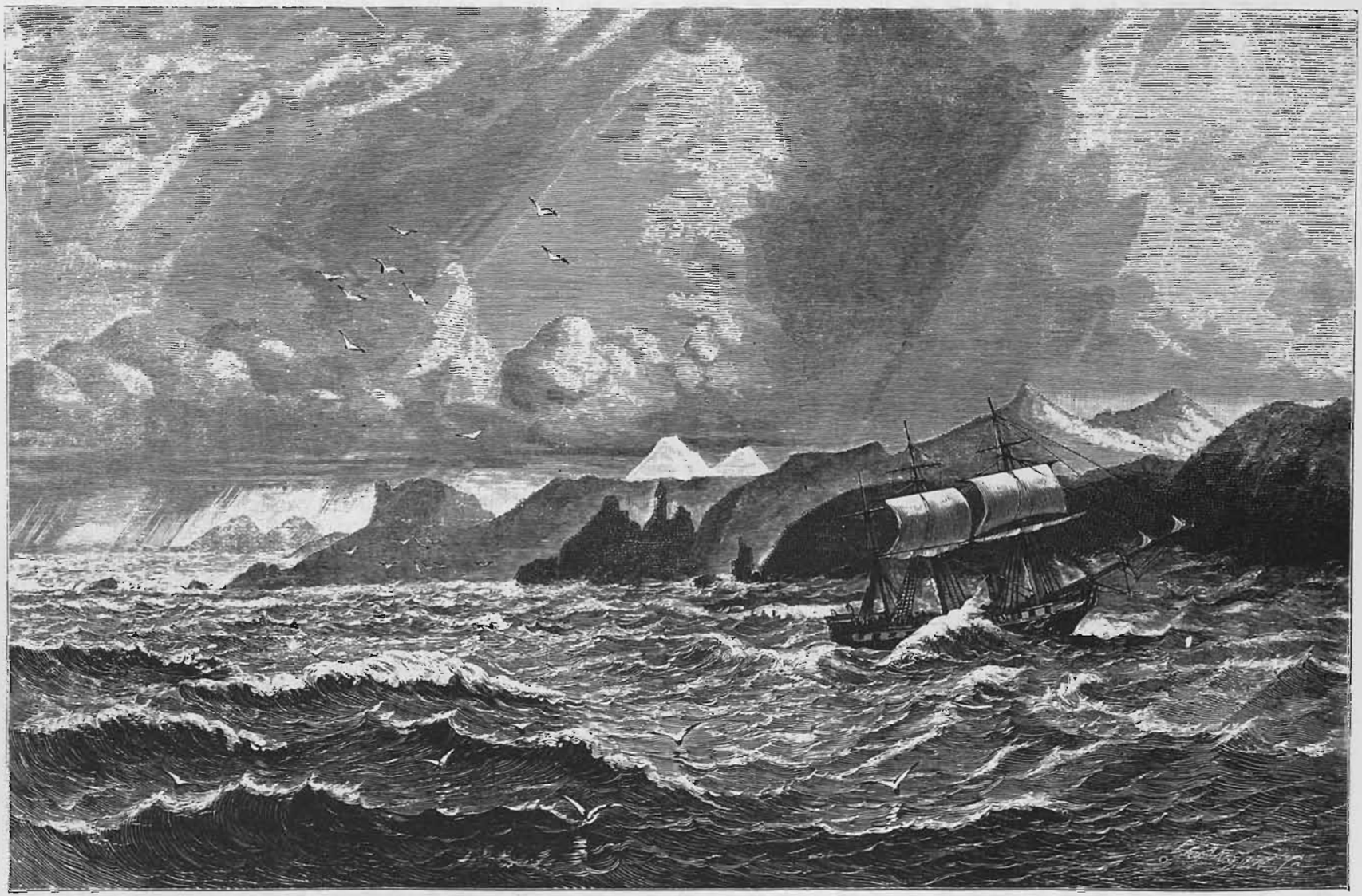


FIG. 133.—Cape Challenger, Kerguelen Island, with Mount Ross in the distance.

the extremity of which are two pinnacle rocks, of considerable height, evidently joined at one time to the high land in the neighbourhood, but probably separated by the action of water. Between Cape Challenger and Cape George the coast is high and precipitous, midway between them is a break in these cliffs, which forms a small cove, Big Belly Bay, from which a deep ravine runs up to the northwestward towards Mount Crosbie. Westward of Cape Challenger the coast is not so precipitous, descending less abruptly from the ridge of hills, on the top of which stands the double peak, Mount Tizard, 2720 feet high, and the single cone, Mount Evans, 2600 feet high. The projecting points of the coast between Cape Challenger and Swain's Bay have each of them tapering basaltic columns near their extremities, of considerable height; off the point at the end of the spur from Mount Evans are two low islands. The details of the coast westward of Swain's Bay could not be distinguished, but the land was seen about Cape Bourbon, which satisfactorily proved that Cape Challenger was the southern point of the main island. At 3 P.M. the fires were banked and sail made for Heard Island.

The island of Kerguelen,[1] including all outlying dangers, lies between the parallels of 48° 27′ and 49° 50′ S. latitude, and the meridians of 68° 30′ and 70° 35′ E. longitude. It was originally discovered by M. de Kerguelen on the 12th February 1772, who on that day sighted Solitary Island. Early the next morning the Fortune Islands and the whole of the coast from Cape St Louis to Cape Bourbon came in sight, and Kerguelen standing towards Cape Bourbon passed between it and Mingan Island, his consort, "Le Gros Ventre" preceding his own ship "La Fortune"; but the weather suddenly becoming thick and the wind freshening, he was obliged to stand off the land; and, after remaining in its vicinity until the 18th, battling against strong winds and foggy weather, in a ship whose masts were badly sprung, wisely returned to Mauritius without prosecuting his researches in a disabled vessel. His consort "Le Gros Ventre," Captain Saint Allouran, succeeded in sending a boat on shore in charge of M. de Boisquehennen, who landed in a bay which he named "Loup Marine," and took possession of the island in the name of the King of France, leaving on shore a bottle containing a paper giving an account of his visit. The precise position of Loup Marine Bay is doubtful, it is probably the first inlet east of Cape Bourbon, and may be that known at present as Sprightly Bay. As nothing has been heard of the bottle, with its enclosed papers, since it was deposited by M. de Boisquehennen, it may possibly yet be found, and serve to identify the spot in Kerguelen Island first visited by man. Kerguelen describes the coast between Cape St. Louis and Cape Bourbon as very high, Mingan Island as low, and about 3 miles round, and the Tremarec or Benodet Islands as rocks over which the sea broke furiously.

[1] Kerguelen's Voyage, 1782; Cook's Voyage, 1785; Page's Voyage; Morrell's Voyage; Ross's Antarctic Voyage; Wreck of the "Favourite"; "Venus" Expedition, Father Perry; Annalen der Hydrographie, 1875; Proceedings of the Royal Society, 1876; Reports to Hydrographic Office by Sir G. S. Nares, and documents in the Hydrographic Department of the Admiralty.

In 1773 Kerguelen was despatched from France in command of a squadron to complete his discoveries in the neighbourhood of the island that bears his name, which he sighted again on the 14th December, making the land on the parallel of 49° 10′ S. just north of Cape St. Louis, from thence he stood north, discovered the Cloudy Islands and Bligh's Cap, and rounded the north end of the main island; but although he remained in the vicinity until the 18th January 1774, never anchored. A boat from one of his consorts succeeded in reaching the shore, and M. de Rosnevet landed in Christmas Harbour, and again took possession of the island in the name of the King of France, leaving a bottle with a paper in it, which was afterwards found by Cook in his third voyage. Kerguelen gave names to the Cloudy Islands and the capes at the northern end of the island, which they still retain with two exceptions. The islet which he called "Reunion," being now known as Bligh's Cap, and "Bay de l'Oiseau" as Christmas Harbour.

On the 24th December 1776, Captain Cook, then on his third celebrated voyage, made the island, and on the 25th anchored in Christmas Harbour, thus accomplishing in one day what Kerguelen had failed to do in a month. On the 29th December, after watering and cutting grass for his sheep and cattle, Cook left Christmas Harbour and proceeded to the southeastward along the leeward side of the island. His track can be traced from the bearings given in his narrative; some of these bearings are, however, referred to the true and some to the magnetic meridian. Passing outside Howe Island, and between it and the Dayman Islands, dangerously close to the Spry Rock, which he did not see, and steering outside Sibbald Island, he found himself amongst a large field of kelp, and thick weather coming on, thought it unwise to proceed further, so anchored for the night in a harbour which he named Port Palliser. Leaving Port Palliser on the 30th, Cook proceeded in his exploration of the leeward side of the island, and steered towards a conspicuous hill which he named Mount Campbell, and which he well describes as appearing like an island when seen from a distance. After passing the Kent Islands, he rounded Capes Digby and Sandwich, and stood southward as far as Cape George, giving the names of Royal Sound, Prince of Wales Foreland, Charlotte Point, &c., to the conspicuous inlets and capes on the southeast side of the island, and being satisfied from the swell coming round Cape George that the land could not trend much further, if at all, to the southward, he bore up for Tasmania.

From 1776 to the present date Kerguelen Island has been more or less frequented by whaling and sealing vessels, whose captains have explored the whole of its coasts, and anchored in most of its numerous harbours, the positions of which they have delineated on rough charts for their own use, giving names to the different anchorages and points, often quaint but frequently appropriate. The vessels generally employed in the seal and whale fishery at this island were strongly built ships, of from 300 to 400 tons burthen; they usually took out with them, in their holds, in pieces, a cutter or two of about 40 tons burthen, which they put together on reaching a secure harbour. Sealing and whaling were then

carried on by means of these cutters and the ship's boats, which were stationed in a kind of cordon round the island, the cutters visiting the boats, taking them supplies, and collecting the skins and blubber, which they took to the ship, where it was boiled down. The men on shore remained at times months away from their vessel, their only shelter being their boat turned bottom up on the beach, with the leeward side elevated and built round with peat cut from the boggy moss which covers the ground. The small cutters frequently circumnavigated the group, and doubtless their crews experienced many anxious moments, especially when on the windward side. Meanwhile, the parent ship lay snugly in some landlocked port; thus, the "Hillsborough," Captain Rhodes, wintered in Winter Harbour, the "Frances" and "Royal Sovereign" in Greenland Harbour, the "Favourite" in Marianne Strait, the "President," "Emerald," and "Kingston" in Iceberg Bay, the "Vansittart" in Table Bay, and the "Emily" and "Kingston" in Swain's Bay.

At the present date sealing and whaling operations are confined almost entirely to the leeward side; the weather side is, however, occasionally visited by Captain Fuller in the "Roswell King," who is thoroughly acquainted with the whole island. He starts about September from Christmas Harbour, and passing to windward of the Cloudy Islands, visits all the anchorages from Cape d'Aiguillon to Greenland Harbour. Some idea of the danger of this enterprise may be formed from the fact that the "Roswell King," a schooner of 100 tons, carries for use on the weather side of Kerguelen Island, an anchor and cable of the same size as that used in the Challenger, a vessel of 1420 tons, and that no harbour on that side can be left except with a northerly, or leading wind, for the high swell continually breaking against the iron-bound coast renders it certain destruction to leave the shelter of an anchorage unless a sufficient offing can be gained before the westerly wind begins.

Although well known to the whaling and sealing vessels, whose crews talk of Thunder Harbour, William's Bay, Marianne Strait, &c., with the same familiarity as of Spithead or Plymouth Sound, no accurate information respecting the island was obtained from the time of Cook's visit until 1840, when Sir James Ross touched at Christmas Harbour to obtain magnetic observations, and during his stay—from May 12th to July 20th—explored the inlets between that harbour and Howe Island, whilst Dr. MacCormick investigated the geology, and Sir Joseph Hooker the botany of this desolate spot.

From 1840 to the date of the visit of the Challenger to ascertain the most suitable site for the observation of the transits of Venus (in 1874 and 1882), no additional information appears to have been published. The southeastern portion of the island was surveyed by the Challenger from the entrance of Hillsborough Bay to Cape Challenger, and Ross's work connected with that of this Expedition. Since then the German frigate "Gazelle" has surveyed that part of the coast between Howe Island and Hillsborough Bay, thus completing the leeward side, and the "Volage" has added somewhat to the

knowledge of the southern coast, but all the western or windward side is still imperfectly explored, and is at present delineated on the charts from the rough sketches of the whaling vessels; so that, notwithstanding the lapse of a century since its discovery, Kerguelen Island is far from being thoroughly known, and the interior has been seldom visited, as the difficulty of travelling is so great, owing to the severity of the climate, the absence of trees or wood of any kind, the want of supplies, and the rugged nature of the ground, that long excursions inland are all but impracticable. The temperature, even in the summer season, is but a few degrees above freezing point on the coast, rendering it requisite for an exploring party to carry tents and blankets, besides fuel, in addition to their provisions; and these necessaries have to be transported over ground covered with a boggy vegetation, into which the leg sinks ankle, and frequently knee-deep, which renders the work of exploration very laborious, and reduces the distance that can be travelled over in a day very considerably, a walk of 10 miles in Kerguelen being fully equal to one of 25 or even 30 miles on hard ground.

The island appears to be the upper portion of a submerged plateau of considerable extent, for Sir James Ross found depths of 70 to 80 fathoms extending 100 miles north-east of Cape François, and the Challenger found depths of 50 to 60 fathoms 45 miles northeast of Cape Digby, and of 80 to 150 fathoms between its south coast and Heard Island, whilst the German frigate "Gazelle" sounded in 125 fathoms 40 miles west of Bligh's Cap, and in the same depth 80 miles north of Swain Island. It is therefore probable that Heard Island is the southern peak of the backbone of this submerged plateau, for a reference to the chart shows that the main watershed of Kerguelen Island, of which the culminating point is Mount Ross, 6120 feet above the level of the sea, runs in a N.W. by N. and S.E. by S. direction; and as the summit of Heard Island lies 260 miles S.E. by S. of Mount Ross, and comparatively shallow water has been obtained between them, it may be concluded that they both belong to the same system of mountains, although part of the range is submerged.

As before mentioned, the main watershed of the island runs in a N.W. by N. and S.E. by S. direction, and consequently the general direction of the ravines and water-courses is N.E. and S.W., the northeastern slope being more gentle than the southwestern, where the descent is sometimes very abrupt. The summit of the watershed is perpetually snow-clad, and from it glaciers descend on each side, occasionally reaching the sea. The most notable glaciers are those from Mount Richards, which fall on the east side into London River, and on the west side into Thunder Harbour,—a bay deriving its name from the noise made by the frequent fall of large pieces of ice over the cliffs into the sea. Owing to the almost perpetual cloud and mist covering the snow-clad summits of the main ridge of the island, the glaciers are seldom visible; they may, however, under favourable circumstances be seen and even visitod, as an exploring party from the "Gazelle" reached the foot of

the glaciers, descending the valleys into Whale Bay Irish Bay, &c. The glacier, visited from Whale Bay ended in a steep wall of ice about 70 feet high, and at its foot, partly underlying it, was a small lake, supplying a rapid brook flowing into the sea. The glacier next south of that descending into Whale Bay slopes gradually, and feeds a stream, hidden by the ice, which only betrays its existence by the noise of the falling water. It is full of crevasses, caused probably by the sharp curve of the mountain slope, which renders travelling on it difficult and dangerous, as the explorer has frequently to jump across these crevasses. The glacier descending into Irish Bay fills the whole valley about 200 feet above the sea level. All these glaciers show distinct traces of having receded, for the furrows left by them on the rocks of the lower parts of the valleys can be traced distinctly.

On the western side of the island there is still an active volcano, while a mineral pitch has been met with, and petroleum and hot water springs, the temperature of which is said to be high, have been found by the sealers.

From a ship anchored in Christmas Harbour an excellent general view of the arrangement of the rocks can be obtained; they are seen to be arranged in apparently perfectly horizontal beds, the separating lines of the different beds being easily traced all round the harbour. Where the sides are not precipitous, the summit of the ridge is attained by a series of terraces, and it is, as might have been expected, almost perfectly flat. The continuity of the flat-topped surfaces, both of the northern and of the southern ridges, is broken by the two most conspicuous objects in the landscape, namely Table Mountain on the north, and Mount Havergal on the south. This rock-mass does not project above the horizontal hilltop but rather appears to stand out from it like a huge boulder. The summit of the ridge is formed of the ordinary bedded rock, this "neck" of conglomerate not reaching any greater height than that of the contiguous parts of the ridge. These hills belong to a class representatives of which were found again in the south in Greenland Harbour, and as they resemble each other closely they will be described together. In both places they protrude through the horizontal beds of basalt, without having caused any apparent disturbance in the arrangement of the beds which surround them. The horizontal beds which form the mass of the land are basaltic, and vary from 10 to 20 feet in thickness, being generally compact; but in ascending the hill, beds are frequently met with which contain large amygdaloid cavities filled with zeolites, principally analcite and stilbite. These minerals are very plentiful in this part of the island, and when rounded by the action of water form remarkable white pebbles on the otherwise dark-coloured sand. Up to the summit the alternation of beds of compact subcolumnar rock of amygdaloid is pretty regular. The amygdaloid is of two kinds; in one the cells are small, very thickly disseminated, and completely filled up by a zeolitic mineral; the other has larger cavities, less thickly spread, and generally only coated with crystals, while seams filled with crystalline matter are also frequently met with. The cavities contain generally analcite, the seams stilbite. The ridge on the southern side is higher

than that on the northern, and from it, on a clear day, a very extensive view of the island towards the southward can be obtained. The coast on this side being much indented by fjord-like inlets, the horizontal bedding of the rocks in which they are enclosed can be distinguished, even at great distances, by the consequent terracing of the hillsides, which is especially conspicuous on the shoulders and promontories. The heights of the ridges appear to differ very little from each other, the effect produced being that of a vast table-land quarried into deep indentations running down to the sea. Out of this plateau rise many peaks of considerable altitude, and often so sharp and steep in outline that they resemble volcanic cones. A nearer view of them, however, showed them generally to consist of similar horizontally bedded rock; and it was impossible to avoid the impression that they might be the remnants of a higher plateau, of which all but these peaks had been removed by weathering and erosion.

Fossil wood is found on the south side of Christma Harbour imbedded in the igneous rock, and occurs in stumps and smaller branches. The colour varies from yellowish white to chocolate-brown and black; its hardness is also very variable, and even in the perfectly white pieces there is still much organic matter remaining. The bark has been transformed into a brown crystalline mass of greasy appearance, which effervesces with acid. The inside of one rather large trunk, the core of which had probably rotted away, was entirely filled up with a mass of igneous rock with elongated cavities filled with crystals. Pieces of iron pyrites were occasionally observed. Parts that internally consisted of nothing but trap-rock often presented on the outside the fibrous appearance of the simply silicified wood; the thickness of this rind, however, was insignificant. A species of brown coal occurs on the south side of Christmas Harbour between two layers of basalt, and only a few feet above the sea. It is practically of no use, being too poor to burn alone.

Near the eastern point of Howe Island much amygdaloid was found, the geodes here consisting almost exclusively of agate. The tops of the hills were thickly strewed with those which, in the lapse of time, had been weathered out of the matrix. Many of these presented a very striking appearance, one of the corners of the cast of the cavity having been neatly planed off, and in some instances even highly polished, in others covered with a natural etching of great beauty. The occurrence of these abraded faces may furnish evidence of the recent prevalence of ice-action over the whole island.

It is worthy of remark that, although amygdaloids are common along the north-eastern side of the island, the nature of the geodes is different in different localities. In Christmas Harbour they are almost exclusively zeolites; in Cumberland Bay those who have visited it report numerous cavities in the rock filled with quartz crystals, and, indeed, one of the promontories in it is called Crystal Point; while at Howe Island the silica with which the cavities were filled occurred entirely in compact masses of agate and chalcedony. The cavities were usually quite full, the geodes being solid and forming an accurate cast of the cavity. Where this was not the case the interior presented a finely

mammillated surface. Quartz crystals were not observed either here or at Christmas Harbour; nor were the zeolites, so common in the last-named locality, found either at Howe Island or Betsy Cove.

Prince of Wales Foreland is an elevation formed by slender basaltic columns, many of which are clustered together into what, if perfect, would have formed spherical agglomerations. The basalt contained large cavities filled with olivine like that of Unkel on the Rhine. Behind this rocky point the usual flat-topped range of hills stretches inland, consisting of the same basalt with much olivine, not columnar however, but in tabular masses with almost slaty cleavage.

Nearly opposite Prince of Wales Foreland, and on the other side of the entrance to Royal Sound, is a very remarkable hill of a castellated appearance, called "Cat's Ears," belonging to the same class of hills as Table Mountain in Christmas Harbour. The ruggedly worn rock at the crest gives it its castellated look; this rock consists of a light-coloured ground, enclosing large crystals of augite and pieces of the recent scoriaceous lava which occurs immediately beneath it. The augite crystals, though apparently perfect when imbedded in the rock, were not found otherwise than broken when weathered out; and in places inside these natural battlements, where there was free play for the usually boisterous wind, all the lighter sand had been blown away, leaving the ground covered by a jet-black gravel. Both these crystals and the rocks show the abrading effect of blown sand, the crystals having lost their regularity of form, and the rocks having acquired a more definite shape than would have been the case had the weathering proceeded equally on all sides. Here, however, and still more remarkably in Heard Island (see pp. 372, 373), the constant and violent westerly winds, wherever they have an opportunity of charging themselves with sand, sculpture the rocks into shapes of apparently unnatural regularity. From this hill another similar but smaller one could be seen close to the base of the "Sugar-loaf." It resembled more a circle of Druidical stones protruding through the moorland than a hill; it was impossible, however, to visit either it or the imposing Sugar-loaf, the structure of which appeared from a distance to be quite peculiar.

On entering Greenland Harbour, which at its head is only separated by a narrow neck of land from Royal Sound, the eye is at once struck by the strange protrusions of light grey rock through the ordinary horizontal basaltic beds which form the hill ranges. The most extensive of them, on the summit of the range on the western side of the harbour, has at a distance a very strong resemblance to a ruined castle. Two of them were examined, one on the summit and one nearer the landing place, both on the west side of the harbour. The rock in both of them is identical, and consists of a light greenish white phonolite protruding through the horizontal beds of augitic rock. These cylindrical masses of phonolite are columnar at the outer edges, the columns lying horizontally and being arranged radially; this columnar structure, however, disappears

a few feet from the outside, and the rock is massive. The effect of weathering has been to split it up into loose blocks, which lie thickly scattered over the ground enclosed. The whole outside line being constructed of horizontal columns, forms a sort of natural cyclopian wall, much more capable of resisting the degrading influence of the weather than the massive inside; hence it might be expected that as they always protrude on a hillslope, the rock being disintegrated in the centre would slip down the hill, forming a heap or talus of rubbish below, and overwhelming the wall encircling the lower edge, but at the same time falling away from the wall of the upper edge, which, owing to its columnar structure, is able to keep its fragments together; and, in fact, this is what was observed. The upper wall of the more distant one, which stands out a prominent object on the summit of the ridge, is over 50 feet high, and presents a perfectly smooth wall face to the outside. As it stretches down the hillslope, which is here very steep, its height diminishes irregularly until it is lost in the heap of loose stones covering the lower wall and the whole inside.

The rock is hard and compact, of a light greenish grey colour, with much of the appearance, though without the ring, of phonolite. Near the outside, or in the columnar part, the rock is closer grained than in the centre, and has a distinct cleavage in a plane perpendicular to the length of the columns. It gelatinizes partially with hydrochloric acid, and the solution contains much soda and some sulphuric acid. It is therefore probable that both nepheline and nosean are present.

Another prominence on this side of the harbour is formed of precisely similar material. It is a round, greenish grey hill covered with phonolitic rock lying about in angular fragments, generally of a size to be easily lifted. The rock is very similar to that of the hills just described; and it seems to belong to the same class, differing from the others in the complete disappearance of the outside wall, large pieces of which lie scattered on the slope like portions of dislodged masonry.

It is to be remarked that in neither of these cases was there any distortion in the beds in which the phonolite occurred. The line of junction of the highest one with the augitic rock was very well shown, and specimens were obtained from it. For a few feet from the line of junction the basalt is considerably altered, the large crystals of augite and olivine disappearing as the line of junction is approached. This line is in general quite decided; there are many angular particles of the phonolite completely surrounded by the basalt, whereas basalt imbedded in phonolite was not observed. Further, the grain of this basalt, in immediate proximity to the junction, is very fine, becoming rapidly coarser, till the basalt at 10 feet from the junction has the porphyritic appearance which it presents at other parts of the hill. These two facts appear to point to the phonolite as being the more ancient of the two, and to the basalt as having flowed round it. There is no necessity for supposing that the portions of these phonolitic masses should be sections of cylinders; they may equally well be sections of domes.

The other view that the phonolite had burst through the lava appears to be untenable in view of the facts above stated.

Of the similar hills in Christmas Harbour, Table Mountain consists of columnar basalt with large cavities filled with olivine. The columns starting normally to the cylindrical surface of the enclosing rock curve upwards, and, unlike the phonolite, are continued well into the mass of the hill; the top of this hill is covered with loose fragments of basaltic columns. Specimens were not obtained from the junction of the columnar with the bedded rock; in fact there appeared to have been next to no fusion between the two. The corresponding hill on the south side of the harbour is formed entirely of volcanic conglomerate, intersected here and there by dikes, some of which show on the outside the obsidian-like bands produced by rapid cooling, which were observed in considerable abundance at Tristan da Cunha.

The rocks collected at Kerguelen were felspathic basalt, dolerite, anamesite, augite-andesite, phonolite, nephelinic rocks; trachyte, limbargite and palagonitic tufa.

The weather at Kerguelen is cold and boisterous, the prevailing wind being northwest (W. by N. true) at all seasons of the year, but this wind is often deflected on the lee side by the steep valleys and fjords which intersect the island; usually taking the direction of the valleys, which act as funnels, the wind descends in heavy gusts or willy-waughs, raising large masses of spoondrift. So violent are these gusts that Sir James Ross observes he was frequently obliged to throw himself on the ground, and the man whose duty it was to register the tides was actually driven into the water and nearly drowned, whilst the vessels moored at the head of Christmas Harbour were sometimes laid over on their beam ends, and the sheet anchor had always to be kept in readiness. On one occasion the whole body of his astronomical observatory was moved nearly a foot, and had not the lower framework been sunk to a good depth it would probably have been blown into the sea. The astronomers who visited Kerguelen for the purpose of observing the transit of Venus also complained of the violence of these squalls, which on one occasion tore a heavy shutter off one of the observing huts and carried it to a distance of more than 30 yards, and two of the "Volage's" boats were capsized when under sail. The westerly wind meeting the island is divided, curving round Capes François and Challenger, so that on the lee side the wind has a northerly tendency north of Mount Campbell and a southerly southward of that mountain.

Vessels proceeding from Royal Sound towards Christmas Harbour with a S.W. wind will probably meet with a N.N.W. wind off Cape Digby, or bound to Royal Sound with a N.W. wind after rounding Cape Digby will meet the wind at S.W.

During the continuance of the northwest wind the weather is squally with passing showers of rain or snow, the sky cloudy, but not so cloudy as altogether to exclude the sun, and the tops of the hills are frequently cloud-capped. On the western or weather side of

the island the air saturated with moisture impinging on the steep mountain ranges causes frequent showers of snow, hail, or rain, and the clouds arrested by the hills accumulate and sink down causing mists and fogs; whilst, as is usually the case, on the eastward or lee side of the island the air is generally dry and there is but little fog.

The difference between the amount of rainfall on the weather and lee sides of Kerguelen is well illustrated by the snow on the hills, for whilst the main range (the mean height of which cannot exceed 3500 feet) is always capped with snow and ice, the leeward hills, Mount Crozier, Mount Wyville Thomson, &c. (which exceed 3000 feet), are entirely free from snow in the summer season.

The prevailing westerly wind is sometimes interrupted by northeast and north winds (N. by E. to N.W. by N. true) which blow with considerable violence, and during their continuance the sky is overcast and the weather thick and rainy, they usually follow a high barometer and fine weather. Just before they commence the barometer falls rapidly and the thermometer rises, and their duration is inversely as the rate of descent of the mercurial column. On one occasion in Betsy Cove the Challenger experienced a sudden northeast gale which only lasted three hours, the barometer falling a tenth of an inch per hour for four hours. These northeasterly and northerly winds are called by the whalers "northers," and their liability to blow occasionally at all seasons of the year should be borne in mind in selecting an anchorage, for inlets such as Cascade Reach and Accessible Bay are open to these winds; Betsy Cove is, however, protected from them.

When the wind veers to the westward or southwestward (S.W. by W. and S. by W. true) the thermometer falls and the barometer rises, whilst the sky becomes fairly clear, but there are still occasional snow squalls.

It must be borne in mind by vessels visiting or navigating in the vicinity of Kerguelen Island that strong winds are the rule and moderate or light breezes the exception, and that though clear weather prevails immediately to leeward of the group, the land is not extensive enough to cause much alteration in the general condition of the atmosphere hereabouts, which is thick and foggy. During the 68 days Ross spent in Christmas Harbour in the depth of winter, it blew a gale on 45 days, and only three days were entirely free from snow and rain. In the 26 days spent here by the Challenger in January, strong breezes or gales prevailed for 16 days; and whilst the "Volage" was at the island attending on the Transit of Venus party from the 9th October 1874 to the 27th February 1875, in October 7 days' gales were registered, in November 14, in December 16, in January 10, and in February 12.

Occasionally, but very rarely, the usual boisterous weather is interrupted by a calm, or a light easterly wind, when the sky is perfectly free from clouds, and the atmosphere is remarkably clear, every hill-top being distinctly visible; but this fine enjoyable weather seldom lasts twenty-four hours, and is quickly succeeded by a gale. No strict rule can be laid down as to the connection between the state of the weather and the height of the

mercurial column. Generally, the wind is inclined to increase in strength with a falling, and decrease with a rising barometer. Bad weather may be expected with an unsteady, and fine weather with a steady pressure, no matter whether the height of the column be high or low.

The mean pressure at the island is probably about 29·70, and the extreme range from 30·30 to 28·40, or nearly 2 inches.

The climate of Kerguelen is much the same throughout the year, the mean summer temperature being about 45°, and the mean winter temperature 36°. Although the thermometer even in the depth of winter seldom descends below freezing point, and the snow never remains on the low ground more than two or three days at a time, a heavy fall is of no uncommon occurrence at all times of the year, even in the height of summer. In spite of cold, wind, and rain, the island is very healthy, the most general complaint being an excess of appetite.

As the mean winter temperature is nearly the same as that of the Falkland Islands, where sheep farming has lately been carried on with much success, and as the sheep landed from the "Erebus" and "Terror" in the depth of winter in Christmas Harbour, and those landed from the "Volage" in Royal Sound in summer, throve exceedingly well, and got very fat, there appears every reason to believe that the breeding of these useful animals at Kerguelen would prove a commercial success.

At the suggestion of Sir George Nares some rabbits and goats were landed by the Transit of Venus Expedition, and were doing well when the "Volage" left the island in February 1875.

A large party landed at the head of Christmas Harbour on the morning of the first arrival of the Expedition at Kerguelen, all eager to kill a Fur Seal; as the boat grounded on the black volcanic sand, some greyish-brown forms were made out, lying amongst the grass just above the beach. A rush was made to the spot, but they were found to be only four Elephant Seals, reclining beside a small stream which runs down here from a little lake, on a small plateau above, into the sea.

The Elephant Seals, when stirred up, raised their heads and put on the usual savage expression that they exhibit when disturbed, which is effected by contracting the facial muscles about the nose, so as to throw it into a series of very prominent transverse folds. They opened their mouths, showed their teeth and uttered a roar, consisting of a series of quickly succeeding deep guttural explosions. They bit savagely at a stick, and twisted it out of one's hands, but made no attempt to go to sea, making on the contrary into the stream, and up it inland, moving by a regular flop-flop motion of the body, like that of the common British Seal, but more clumsily performed.

Whilst the party was either looking at these Elephant Seals, or beating the ground for ducks, on a shot being fired the head of an animal raised high above the grass on

the flat close to the beach, was seen about a hundred yards off. It contrasted most strongly in its appearance and gait with the Elephant Seal, and was soon made out to be a Fur Seal (*Arctocephalus gazella*). It was an old male, covered with greyish-brown shaggy hair, and with a short greyish mane about the neck. It moved its head up and down uneasily when disturbed, just as a bear sways its head. On one of the party running up too close to the beast thinking it as helpless as the Elephant Seal, he was forced to retreat in a hurry, for it made a savage dash at him, open-mouthed.

Two of the whaling schooners met with at the island killed over 70 Fur Seals on one day, and upwards of twenty on another, at some small islands off Howe Island to the north. It is a pity that some discretion is not exercised in killing the animals, as is done in St. Paul Island in Behring Sea, in the case of the northern Fur Seal. By killing the young males, and selecting certain animals only for killing, the number of seals may even be increased;[1] the sealers in Kerguelen Island kill all they can find. They said that the southern Fur Seals sometimes eat Penguins, and that they had found the remains of them in their stomachs, and the sealers also said that sometimes, but very rarely, they found another kind of Seal, somewhat like the Fur Seal, which they called the "Sea Dog." A second species of Eared Seal probably thus occurs as a rarity at Kerguelen Island.

Professor Peters of Berlin identified the skull of a Fur Seal procured by the Challenger at Kerguelen as belonging to his new species *Arctocephalus gazella*. The skeleton of a specimen called by the sealers "Sea Leopard" has not yet been determined, but Professor Turner states that it is not a *Stenorhynchus*.

The flat stretch of land at the head of Christmas Harbour is covered with a thick rank growth of grass (*Poa cookii*), and a Composite herb with feathery leaves and yellow flower (*Cotula* [*Leptinella*] *plumosa*), also with *Azorella* and *Acæna* as at Marion Island (see Pl. XV.). The soil is black and peaty and saturated with water. It is almost impossible to find fuel; the *Azorella* is the only thing that will burn, and sometimes pieces of this may be found that are dry enough, in places where the bunches overhang small precipices, so that the water can drip away.

The feature which distinguishes the general appearance of the vegetation of Christmas Harbour from that of Marion Island is the presence of the Kerguelen Cabbage (*Pringlea antiscorbutica*) in large quantities. The plant grows on the slopes and bases of the cliffs in thick beds, and resembles a small garden cabbage, but often with a long trailing stalk. It is, however, not annual but perennial, and the flowering stalks instead of coming out from the centre of the head, come out laterally from the sides of the stalks between the leaves. The old flower stalks die and wither, but do not drop off. On one Cabbage at Betsy Cove were counted 28 flowering stalks, of different ages, three of them only being of the current year's growth and fresh; they appeared to belong to

[1] J. A. Allen, The Eared Seals. *Bull. Mus. Comp. Zoöl.*, vol. ii. pp. 1–88, 1870–71.

eight successive years. The Cabbage about Christmas Harbour was either in flower or green fruit, mostly the latter; it was only to the south of the island, about Royal Sound, that ripe seed was met with, but there, especially at Mutton Cove, it was abundant. This Cabbage, which like the familiar vegetable is a Cruciferous plant, is peculiar to the Prince Edward, Crozet, Kerguelen, and Heard Islands, and belongs to a genus with no near ally (see Pl. XVI.).

The ascent of the slope towards Table Mountain is up a succession of steps, the successive flat ledges presenting glaciated surfaces scattered over with stones fallen from above. The thick rank vegetation ceases at about 300 feet altitude, and then becomes more sparse. *Colobanthus kerguelensis*, a Caryophyllaceous plant, peculiar to Kerguelen and Heard Islands, affects the more barren stony ground at this elevation, whilst at Heard Island it grows at the sea level. At about 500 feet elevation, a very handsome Lichen (*Neuropogon taylori*) commences rather abruptly; it is a very conspicuous plant, being of a mingled bright sulphur-yellow and black colour, of large size, and is abundant everywhere on the higher rocks. *Azorella* and the Cabbage grow up to about 1000 feet, the height of the ridge from which the rocky mass forming the top of Table Mountain rises; here the Cabbage ceases, but *Azorella* is continued in very small quantities to the top of the mountain, growing on its very summit, but only in very sheltered corners between the rocks, and much dwarfed. *Azorella*, the Cabbage, and a Grass (*Agrostis magellanica*), were the only flowering plants growing at 1000 feet, and these only very sparsely. The land at this height presented a series of ridges of barren rock and piles of stones. At Mutton Cove and about Royal Sound, a very marked line, at about 1000 feet, separates the green lower slopes from the barren stony ridges and peaks above. It is probably the line above which snow lies for the greater part of the year unmelted, though the hills just above it, at Mutton Cove, were quite free from snow at the time of the visit.

A comparatively low ridge separates the head of Christmas Harbour from the sea directly beyond. On a flat expanse of this ridge are two small freshwater lakes, in which grow two water plants, *Limosella aquatica* and *Nitella antarctica*, both widely spread plants, the first occurring, amongst other places, in England, and the second being very closely allied to a common English species.

Crawling about the heart of the Cabbages, and sheltering there, are to be found swarms of the curious wingless Fly (*Calycopteryx moseleyi*), likewise peculiar to Kerguelen Island and the other localities where the Cabbage is found. It is simply a long-legged brown dipterous Fly, with very minute rudimentary wings, and crawls about lazily on the Cabbage. Another dipterous Fly (*Amalopteryx maritima*), with wings rudimentary but larger in proportion to the body than in the other, is found among the rocks on the sea shore, where it jumps about when hunted, like a small grasshopper. It is the same as was found by Dr v. Willemoes Suhm at Marion Island. Probably the *Calycopteryx* exists also at Marion Island, but Cabbages were not abundant there, and it was

not noticed; but it is possible also that the Fly does not extend there, for no Teal were seen on Marion Island, though they exist in abundance on the Crozets, and especially on Possession Island, where, as the sealers said, there is a lake full of them. However, only a very small tract of Marion Island was examined, and similar tracts are to be found in Kerguelen Island, with very few Cabbages, and consequently without Teal. A wingless Gnat (*Halirytus amphibius*) also inhabits the sea shore, living amongst the seaweed constantly wetted by the tide. A similar wingless Gnat, and a Fly apparently closely allied to the Kerguelen *Amalopteryx*, were found by the Expedition at the Falkland Islands.[1] A Spider (*Myro kerguelenensis*, Cambr.), already described from the Transit of Venus Expedition,[2] was obtained.

The Teal of Kerguelen Island (*Querquedula eatoni*) is peculiar to that island and the Crozets; it is somewhat larger than the common English Teal, and of a brown colour, with a metallic blue streak, and some little white on the wing. It is enormously abundant all about Kerguelen Island, near the coast; four or five guns used to bring back usually over 100 birds. They feed mainly on the fruit of the Kerguelen Cabbage, and are extremely good eating. They are to be found in flocks, except when breeding, when they occur in pairs; where they have not been shot at by sealers, they are remarkably tame, and almost require to be kicked up to afford a shot. Several of them were breeding at the time of the visit; some with young full-fledged and already away from the nest, others with eggs. Five eggs were found in one nest. The nest is a neat one, placed under a tuft of grass, and lined with down torn from the breast of the parent bird. The duck, when put up off the nest, to effect which the nest requires to be almost trodden upon, or when found with her young away from the nest, flutters a few yards only, as if maimed, and pitches again, and cannot be frightened into a long flight. It is curious that the bird should have retained this instinct where there are no four-footed or human enemies; possibly she finds it a successful ruse when the brood is attacked by the Skuas, to which ever-watchful enemies the young must constantly fall a prey, for in most cases only a single young one was found following the mother. There were no young met with in the condition of flappers, and the general breeding season was probably only about to begin, as was the case with many birds of the island; the greater part of them were yet in flocks.

The whole beach was covered with droves of the Johnny Penguin (*Aptenodytes* [*Pygosceles*] *tæniatus*) and the King Penguin (*Aptenodytes longirostris*), and encampments of these birds were to be seen on small level grassy spaces far up the hill slope. On the talus slopes beneath the cliffs, along the whole south side of Christmas Harbour, are vast Penguin rookeries, the Penguins here nesting amongst the stones where vegeta-

[1] A Moth with rudimentary wings (*Embryonopsis halticella*, Eaton) was found by the Transit of Venus Expedition at Kerguelen; see *Phil. Trans.*, extra vol. clxviii. pp. 228, 235, 1879.

[2] *Phil. Trans.*, extra vol. clxviii. p. 225, 1879.

tion is entirely wanting; and to the north of the harbour at its entrance are other similar rookeries. Towards the upper part of the harbour, the rookeries are those of the Smaller Crested Penguin (*Eudyptes chrysocome*) called "Rockhopper" by the sealers, the same as that at Marion Island, but nesting scattered amongst these is another kind of Penguin (*Eudyptes chrysolophus*), the "Macaroni" of sealers. This bird has a most beautiful golden crest, showing conspicuously on the middle of the upper part of the head, commencing just behind the beak, and with a plume on each side as in the bicrested species. The bird is larger than the Rockhopper, and is further distinguished from it by the presence of a naked, somewhat tumid space, at the base of the beak, which is of a light pink colour, in other colouring it resembles the Rockhopper. This Penguin occurs at the Falkland Islands, where it nests as at Kerguelen Island, in small numbers amongst the Rockhoppers. These birds, however, only thus nest amongst the other Penguins where they are few in number, towards the head of the harbour and under the natural arch they have enormous rookeries of their own, where singularly enough a few of the Rockhoppers nest as guests amongst them; they have extensive rookeries also in Heard Island, where their eggs are gathered in large quantities by the sealers for eating. No breeding places of King Penguins were met with at Kerguelen Island.

On several occasions during the stay at Kerguelen Island, excursions were made for the purpose of digging up birds and eggs for the natural history collections. Parties of stokers were always ready to volunteer for this work, which they thoroughly enjoyed and performed admirably, and by the help which they gave very many of the birds of Kerguelen were most readily procured. The beaten ground beneath the *Azorella* is perforated everywhere with holes of various Petrels; those of the Prion (*Prion desolatus*) are most numerous. They are about big enough to admit the hand, but the nest and egg are nearly always far out of reach, the holes going in sometimes a yard and a half. This Prion is a small grey bird, a Petrel from the form of the nostrils, but with a broad boat-shaped bill, with extremely fine horny lamellæ, projecting on either margin of the bill inside. The bird flies like a swallow, and was nearly always to be seen in flocks about the ship, or cruising over the sea, or attendant on a whale to pick up the droppings from its mouth, hence it is termed by sealers the "Whale Bird." It lays a single white egg.

Besides the Prion there is the "Mutton Bird" of the whalers (*Œstrelata lessoni*), a large Procellarid as big as a Pigeon, white, brown and grey in colour. It makes a much larger hole than the Prion, six inches in diameter, and long in proportion. At the end is a round chamber with a slight elevation in the centre, where is the nest, somewhat raised, with a deeper passage all round. The old bird is very savage when pulled out, makes a shrill cry and bites hard, the sharp decurved tip of the upper mandible being driven right through a man's finger if he be not careful in handling it. The egg is white, and about the size of a hen's.

Another Petrel (*Majaqueus æquinoctialis*), which also was often to be seen cruising

after the ship, but then always solitary, is called the "Cape Hen" by ordinary sailors, and "Black Night Hawk" by the whalers. It makes a hole, larger a good deal than that of the Mutton Bird, and nearly always with its mouth opening on a small pool of water, or in a very damp place. The hole is deep under the ground and very often two yards or more in length. The birds seem to make their holes in certain places in company, at one place on the shores of Greenland Harbour, a number of such holes were found, all within a small area. The bird utters a peculiar prolonged and high pitched cry, either when the nest is dug into and it is handled, or when it goes into the hole and finds its mate there.

More interesting is the diving Procellarid (*Pelecanoïdes urinatrix*), a Petrel which has given up the active aerial habits of its allies, has taken to diving, and become specially modified by natural selection to suit it for this changed habit, though still a Petrel in essential structure. The habits of the bird, which also occurs in the Strait of Magellan, are described by Darwin in his Journal.[1] It is to be seen on the surface of the water in Royal Sound when the water is calm, in very large flocks. On two days when excursions were made in the steam pinnace, the water was seen to be covered with these birds in flocks, extending over acres, which were black with them. The habits of the northern Little Auk are closely similar to those of this bird; so close is the resemblance, that the whalers have transferred one of their familiar names for the Little Auk to the Diving Petrel. These Petrels dive with extreme rapidity, and when frightened, rise, flutter along close to the water, and drop and dive again; it is a curious sight to see a whole flock thus taking flight. The birds breed in enormous quantities on the islands in Royal Sound, making holes in the ground like the Prions; they are readily attracted by a light, and some were caught on board through coming to the ship's lights. The single egg is white with a few red specks at one end.

The remarkable habits of the Sheath-bill (*Chionis minor*) have already been referred to (see p. 298). These birds, the "Paddy" of the sealers, are present everywhere on the coast, and from their extreme tameness and inquisitive habits, are always attracting one's attention, a pair or two of them always forming part of any view on the coast. They are pure white, about the size of a very large pigeon, but with the appearance rather of a fowl. They have light pink coloured legs, with partial webbing of the toes, small spurs on the inner side of the wings, like the Spur-winged Plover (they are related to the Plovers), and a black bill with a most curious curved lamina of horny matter projecting over the nostrils. Round the eye is a tumid pink ring bare of feathers; about the head are wattle-like warts. On sitting down on the rocks where there are pairs of Sheath-bills about, one soon has them round, uttering a harsh, half warning, half inquisitive cry on first seeing the intruder, and venturing gradually nearer and nearer, standing and gazing up at him with their heads turned on one side. The birds come frequently within reach of a stick, and can often be knocked over in that way, or bowled over with a big stone,

[1] Journal of Researches during the Voyage of H.M.S. "Beagle," p. 290, ed. 1879.

as they will sit quietly and allow half a dozen stones almost as big as themselves to be thrown at them. At length, only after being narrowly missed several times, they take flight, and make off, uttering their harsh note several times in succession. If a bird be knocked over with a stick, it is usually only stunned, for the Sheath-bills are very tenacious of life, and if the one thus caught be tied by the leg with a string and allowed to flutter on the rocks, the neighbouring Sheath-bills will come at once to fight with it and peck it, and can be knocked over one after another. When courting one another, the birds show all the attitudes of pigeons, the male bowing his head up and down, strutting, and making a sort of cooing noise. The birds eat seaweed and shell-fish, mussels and limpets, besides acting as scavengers. They carry quantities of the limpet and mussel shells up to the clefts or holes under the rocks which they frequent. They readily feed in confinement, and several were kept on board the ship, running about quite at home, one of them established itself in one of the cutters for a short time, and used to fly about during the voyage to Heard Island always returning to the ship. The birds, though usually to be seen running on the rocks, can fly remarkably well, their flight resembling that of a pigeon; they were seen at a great height about the cliffs of Christmas Harbour.

Mr. Moseley relates the following incident showing the relations of the various birds to one another in the struggle for existence:—"A Cormorant was seen to rise to the surface of the water and lifting its head, make desperate efforts to gorge a small fish which it had caught, evidently knowing its danger, and in a fearful hurry to get it down. Before it could swallow its prey, down came a Gull, snatched the fish after a slight struggle and carried it off to the rocks on the shore. Here a lot of other Gulls immediately began to assert their right to a share, when down swooped a Skua from aloft, right on to the heap of Gulls, seized the fish, and swallowed it at once. The Shag ought to learn to swallow under water, and the Gull to devour its prey at once in the air."

During the month of January 1874, the Challenger took many soundings and dredgings in the bays and several miles off the east coast of Kerguelen, in depths varying from 20 to 120 fathoms. In all cases the deposit was a greenish mud with a strong smell of sulphuretted hydrogen, and composed principally of mineral particles and the skeletons of siliceous organisms. Generally these muds did not effervesce with weak acid, sometimes, however, a few spots of effervescence were observed. The carbonate of lime never appeared to make up more than about 1 per cent., and consisted of a few fragments of Echinids, Mollusc shells, Polyzoa, and Foraminifera. These last were *Miliola*, *Uvigerina*, and *Discorbina;* no pelagic Foraminifera were noticed. The mineral particles made up from 50 to 75 per cent. of the muds, and consisted of fragments of felspars, plagioclases, augite, magnetite, hornblende, olivine sometimes decomposed with red tint, lapilli, pumice, and brown volcanic glass. The size of these particles varied from 0·5 mm. to 0·2 mm.

in diameter, the larger sized particles being found in those soundings nearest the coasts. The frustules of Diatoms made up in every case a large part of the deposit, and along with the siliceous spicules of Sponges, probably as much as 50 per cent. in some of the samples; the soundings farthest removed from the coast contained generally much the larger proportion of siliceous remains. These muds contained but little clayey matter, and when dried were grey-green, slightly coherent, and earthy in aspect.

The dredgings along this coast gave many Sponges, Hydroids, Comatulas, Starfish, Ophiurids, Echinids, Holothurians, Annelids, *Serolis*, Pycnogonids, Lamellibranchs, Gasteropods, Nudibranchs, Polyzoans, Ascidians and Teleosteans; siliceous Sponges (*Rossella*) were in some cases most abundant, over one hundred large specimens being taken in one haul. The absence of Decapod Crustaceans (except one Schizopod, *Pseudomma roseum*) in all these dredgings is very remarkable.

The Spheniscidæ.—A considerable number of Penguins, of different species, was collected at various points of the cruise, and handed to Professor Morrison Watson, F.R.S., who made an elaborate investigation into their anatomy,[1] of which he has furnished the following brief summary:—

"The skeleton of the Spheniscidæ is remarkable in that the bones of the wing are modified in accordance with the alteration of function of that organ, and its conversion from an instrument of aerial to one of aquatic progression. These modifications are manifested in the enormous size of the scapula, which thus affords attachment to the powerful muscles of the shoulder-joint; in the great strength of the coracoid bone, which in *Spheniscus* and *Eudyptes* is perforated by a foramen for the transmission of the nerve to the pectoralis medius muscle; in the lateral compression of all the bones of the wing, a character which obtains among certain other diving birds, but which only reaches its maximum in this group; in the presence of two sesamoid bones, developed in connection with the tendon of the triceps muscle; in the peculiar form and mode of articulation of the carpal bones; in the union of the first or radial metacarpal which, although independent in the embryo, becomes inseparably anchylosed with the second metacarpal bone in the adult; and in the absence of a free pollex.

"The muscular system of the Penguins is characterised by the great development of the cutaneous muscles, which present an arrangement quite peculiar to the group. It has been suggested to me that the large development of the cutaneous muscles is probably a means whereby water may be readily expelled from the interstices of the plumage so soon as the bird quits the water. Were it otherwise, in the low temperature of the Antarctic region which the majority of these birds inhabit, the plumage would soon be frozen into an icy mass, the high temperature of the bird being of itself insufficient to obviate this, seeing that the ready conduction of heat from the interior of

[1] Report on the Anatomy of the Spheniscidæ, Zool. Chall. Exp., part xviii., 1883.

the organism is prevented by the great development of the subcutaneous fatty layer which is found in every member of the group. The muscular system is further characterised by the great strength of all, and the peculiar disposition of certain of the extensor muscles of the vertebral column, more especially of the biventer cervicis, which extends from the iliac bone to the skull, these peculiarities being associated with the erect attitude of the Penguin when on land; by the presence and arrangement of the transverse cloacal muscle; by the great strength of the muscles which act at the shoulder-joint, that is upon the wing as a whole; by the peculiar disposition of the brachialis internus muscle; and by the almost complete atrophy of the muscles which act upon the fore-arm and hand, the last-mentioned peculiarities being associated with the alteration which has taken place in the function of the wing. As regards the muscles of the leg, the Penguins do not differ essentially from other Palmipedes.

"The peculiarities of the arterial system are no less striking than are those of the bony and muscular systems. They consist in (*a*) the presence of two common carotid arteries of equal size, symmetrically disposed on either side of the middle line; (*b*) the peculiar mode of distribution of the subclavian artery, which breaks up into an axillary and brachial rete mirabile from which branches are derived for the supply of the fore-arm and hand; (*c*) in the absence of the sciatic artery as a direct branch of the abdominal aorta, and its substitution by a branch of the crural artery.

"The respiratory organs closely resemble those of other birds in their general arrangement. In one important particular, however, they differ from all with the exception of those of the Procellariidæ. The presence of a tracheal septum, which more or less completely divides the air-tube into two lateral chambers, is met with only in the Spheniscidæ and in the Procellariidæ. This tracheal septum is usually but not constantly present in the Spheniscidæ. I found it in all the forms which I examined, with the exceptions of *Eudyptes chrysocome* from Tristan da Cunha and *Spheniscus minor*. The occasional absence of a tracheal septum, therefore, shows that this structure, *per se*, cannot be considered as a constantly reliable anatomical character of this group any more than of the Procellariidæ.

"The geographical distribution of the Spheniscidæ is of interest.[1] The various members of the group are entirely confined to the southern hemisphere, not one single species of Penguin being found north of the equator. In the southern hemisphere, however, their distribution is very extensive, reaching from the Galapagos Islands on the equator southwards to the Antarctic Islands. Of the various species of Penguin collected by the Expedition and referred to in the Report, *Spheniscus demersus* is confined to the vicinity of the Cape of Good Hope, *Spheniscus magellanicus* to that of Cape Horn, *Spheniscus mendiculus* to the coast of Chili, while *Spheniscus minor* inhabits the South Pacific, in the neighbourhood of Australia and New Zealand. The genus *Eudyptes*

[1] Wallace, Geographical Distribution of Animals, vol. ii. p. 366, 1876.

includes, according to ornithologists, the two separate species *Eudyptes chrysocome* and *Eudyptes chrysolophus*, along with others which I have not had an opportunity of examining. Of these *Eudyptes chrysocome* has much the more extensive geographical range, being met with as far north as the Island of Tristan da Cunha, whence it extends southward to Kerguelen Island. *Eudyptes chrysolophus* inhabits Kerguelen Island, whence it extends southward to the islands of the Antarctic.[1] The genus *Aptenodytes* (including *Pygoscelis*) has a wide geographical range in the southern hemisphere, extending from the Falkland Islands to the islands of the Antarctic Ocean. The limitation of the geographical range of the group to the southern hemisphere is not a little remarkable, and so far as I am aware no explanation of the fact has hitherto been offered.

"That it does not depend on temperature alone seems probable from the fact that they are met with from the equator southwards to the Antarctic Ocean. At the same time, it is interesting to observe that Penguins reach the equator only on the coasts of Chili and Peru. Along these coasts the cold Peruvian Current from the Antarctic Ocean carries a low temperature northward as far as the Galapagos Islands. This current, as shown by the position on the map of the isocheimal or cold water line, extends from the Antarctic Ocean along the west coast of South America, and has a surface temperature at the equator of from 62° to 68°, whereas elsewhere the equatorial region of the Pacific Ocean has a temperature varying from 81° to 88°. Now, it will be observed that the most northern geographical limit of the Penguins corresponds with that of this cold Peruvian Current, and it seems not improbable that while temperature does not directly affect the distribution of these birds, it may do so indirectly, inasmuch as this cold current passing from the pole to the equator will facilitate the passage northward of those cold water organisms which, inhabiting the Antarctic Ocean, constitute the food of the Penguins. The home of the Penguins is undoubtedly in the cold regions of the Antarctic, but their food supply being carried northward by means of the cold Peruvian Current, the area of distribution of the Spheniscidæ has been correspondingly extended, and now reaches from the Antarctic Ocean to the equator.

"The fact that the Challenger officers seldom noticed these birds more than 40 or 50 miles from land[2] or ice, seems to show that having once adopted a residence, they are very far from being addicted to those migratory habits which their peculiar structure and mode of life seem so well adapted to encourage.

"With regard to the distribution in time of the Spheniscidæ, we know very little at present, our knowledge of fossil forms being limited to a humerus, coracoid, and tarso-metatarsal bone, which were discovered in the Eocene formation of New Zealand.[3] The metatarsal bone has been described by Professor Huxley,[4] who established the genus

[1] Gray, Handlist of the Genera and Species of Birds, part iii. p. 98, 1871.
[2] Sclater, Zool. Chall. Exp., part. viii. p. 132, 1880.
[3] Hector, J., *Trans. New Zealand Inst.*, vol. v. p. 438, 1872.
[4] *Quart. Journ. Geol. Soc.*, vol. xv. p. 670, 1859.

Palæeudyptes for the reception of the bird of whose skeleton it formed a part. It apparently belonged to a bird closely allied to the genus *Eudyptes* of the present day, but evidently of much larger size than any living species of that genus. If the nature of the deposit (Eocene) from which this fragment was excavated has been correctly interpreted, it shows that the family of Spheniscidæ is one of great antiquity, and that it had even at that time deviated so far from the primitive avian stem as to present those modifications in structure which have remained unaltered down to the present time. This fact goes far to explain the difficulty which every one must acknowledge in attempting to allot to the Spheniscidæ their proper place in any classification of recent birds, a difficulty which will only disappear as the geological record is more fully deciphered, and the intermediate forms which at one time undoubtedly connected the Penguins with the primitive avian stem are brought to light. I have examined the following species of Penguins:—

Family.	Genus.	Species.	Variety.
SPHENISCIDÆ, . .	*Spheniscus*	*demersus*	*magellanicus.*
		mendiculus	
		minor	
	Eudyptes	*chrysocome*	*Eudyptes chrysocome*, from Tristan da Cunha.
			Eudyptes chrysocome, from the Falkland Islands.
			Eudyptes chrysocome, from Kerguelen Island.
		chrysolophus ?	
	Aptenodytes	*longirostris*	
		tæniatus	

"Of the various members of the genus *Spheniscus* enumerated above, it appears to me that *Spheniscus demersus* and *Spheniscus magellanicus* ought to be regarded as two varieties of one and the same species, while *Spheniscus mendiculus* and *Spheniscus minor* are undoubtedly distinct species. *Spheniscus minor* is moreover possessed of several cranial characters which approximate it to *Eudyptes.*

"Of the so-called species associated together by ornithologists under the genus *Eudyptes,* I have examined two, *Eudyptes chrysocome* and *Eudyptes chrysolophus.* Of these two species, *Eudyptes chrysocome* presents three varieties, which are met with at the Tristan da Cunha Group, the Falkland Islands, and Kerguelen Island respectively. That *Eudyptes chrysolophus* ought to be regarded as a species distinct from *Eudyptes chrysocome* is not doubted by any ornithologist, but an examination of the entire anatomy both of *Eudyptes chrysolophus* and of *Eudyptes chrysocome* appears to me rather to lend support to the view that they are simply two well-marked varieties of one and the same species of *Eudyptes.* The decision of this point must depend on the relative value attached by various ornithologists to difference in size and similarity of anatomical structure as elements in the determination of species as distinguished from variety.[1]

[1] "To discuss the question of the comparative values of external appearance and anatomical structure as elements in the determination of species as distinguished from variety, would extend this abstract beyond reasonable dimensions. I would merely wish to direct the attention of naturalists to the fact that, as it seems to me, sufficient weight has not hitherto been allowed to structure in the determination of species.

"The genus *Aptenodytes* includes the two species which I have examined, *Aptenodytes longirostris* and *Aptenodytes tæniatus*. The last named has been accepted by ornithologists as a type of another genus, *Pygoscelis*, but I see no reason on anatomical grounds

"As shown in the Report on the Spheniscidæ, we have in *Eudyptes chrysocome* and *Eudyptes chrysolophus* examples of two birds which, differing much in size and weight as well as in the form and mode of coloration of certain feathers, nevertheless present an almost complete similarity of anatomical structure. I am inclined, moreover, relying upon my own observations, not, however, specially directed to the elucidation of this point, to think that a corresponding similarity of structure obtains in the case of many other birds which, solely on the ground of difference in form and mode of coloration of the tegumentary appendages, are regarded by ornithologists as undoubtedly specifically distinct. The question therefore arises—What is the relative value of tegumentary appendages on the one hand, and of anatomical structure on the other, in the determination of species as distinguished from varieties? To answer this question conclusively is at present impossible, nor shall we arrive at the solution of the problem until our knowledge of the structural details of a number of these so-called species is much more exact than it is at present. But even if we suppose such an anatomical investigation to have been completed, it appears to me exceedingly doubtful whether the question—What constitutes specific distinctness? will ever be solved by the aid of morphology alone. Rather it seems probable that in the last resort the determination of species will rest upon physiological rather than upon morphological grounds, in other words, upon the impossibility of the production of fertile offspring by the sexual union of the members of two undoubtedly distinct species.

"But while I would insist on the necessity of taking into consideration the details of its anatomical structure in attempting to solve the question of the specific distinctness of any given species, I do not deny that in the present state of our knowledge the external appearance of an organism forms a safer foundation for the determination of species than does its anatomical structure. In corroboration of this view I may refer to the case of two of our most common birds, the Thrush (*Turdus musicus*) and the Blackbird (*Turdus merula*). These are undoubtedly distinct species, and have been decided to be such by ornithologists, not upon the physiological ground of the infertility of the offspring resulting from the union of members of the two species, nor upon any structural difference, but solely upon the difference in form and coloration of their feathers. And yet the entire structural anatomy of these two species is, as shown by Macgillivray (History of British Birds, pp. 82 and 128), almost identical. The same remark holds good of other species of birds, and the further question arises—How does it happen that two organisms are so different physiologically and in their external appearance while their anatomical structure is almost identical?

"It would appear at first sight that the influence of external conditions would in the first place influence the external appearance of an animal rather than its internal anatomy, and yet we find that under the influence of exactly similar external conditions in the case of the two species just referred to, their external appearance is quite different and yet their internal anatomy remains the same, this latter similarity being accompanied by specific physiological distinction. It appears to me that there can only be one explanation of these apparently anomalous facts, and that is, that there must be some embryological or physiological connection between the genital glands and the integument. So far as embryological connection is concerned, we know of none except that both the genital glands and the skin are derived from the mesoblast, unless indeed we take into consideration the hitherto inexplicable fact of the pathological occurrence of dermoid cysts in the ovaries. That, however, there is some intimate physiological connection between the genital organs and the skin is shown by the changes which are undergone by the tegumentary appendages at the time of sexual maturity, changes which are more pronounced in the skin than in any other part of the organism, and more especially by the occurrence of these remarkable phenomena included by Darwin within the category of secondary "sexual characters," such as the occasional assumption by the female of the male plumage, and *vice versa*, in birds, and the observed difference in coloration of the yolk of the egg, associated with a corresponding alteration in the colour of the tegumentary appendages (Darwin, Animals and Plants under Domestication, vol. ii. pp. 252 and 274 London, 1868). All these facts point to the existence of some more intimate connection between the sexual organs and the integument than between the sexual organs and the rest of the organism, and upon this supposition alone, as it seems to me, is it possible to account for the coincidence of variation in the integument with specific physiological distinction at the same time that the latter is unaccompanied by any marked morphological change of other parts of the organism.

"It seems possible on these lines to explain the facts recorded in the monograph on the Spheniscidæ with respect to the similarity of structure of two Penguins (*Eudyptes chrysolophus* and *Eudyptes chrysocome*), which nevertheless on the strength of difference in the form and coloration of their plumage and dermal appendages have without hesitation been regarded by ornithologists as specifically distinct.

"It may thus be true that, after all, tegumentary appendages are of more account in the determination of species than are the details of anatomical structure, the former being correlated with deep seated sexual and specific peculiarities,

why it should not be included along with *Aptenodytes longirostris* as another species of one and the same genus.

'Lastly, in their affinities the Penguins appear to be more closely allied to the Palmipedes than to any other group of birds, but the numerous important deviations which they present from every one of the various groups included within that very heterogeneous assemblage appear to show that the Spheniscidæ must have diverged at an early period from the primitive avian stem, and the connecting links having been lost, it seems at present hopeless to attempt to establish the exact affinities of the Penguins to other birds. At first sight, indeed, it appears that the nearest allies of the so-called wingless birds of the southern are to be found in the wingless birds of the northern hemisphere, but the researches of Professor Owen[1] on the osteology of the Great Auk (*Alca impennis*), abundantly show that the two groups have but little in common. We are compelled therefore to postpone the accurate determination of the affinities of the Spheniscidæ till the progress of Palæontology shall have made us acquainted with the intermediate forms connecting the Spheniscidæ with the primitive avian stem from which both they and the other Palmipedes were originally derived."

whilst the latter may only express the fact that under similar circumstances and the necessity of adopting similar modes of life the details of anatomical structure of two specifically distinct organisms tend also to become similar.

"I would only farther remark that an investigation into the entire subject of the relation which the sexual organs bear to the skin and tegumentary appendages on the one hand, and to the rest of the organism on the other, in different forms of animal life, is one which is likely to be productive of valuable results in enabling us to determine the essential morphological as distinguished from the physiological characteristics of a species."

[1] Description of the Skeleton of the Great Auk or Garfowl (Alca impennis), *Trans. Zool. Soc.*, vol. v. p. 317, 1866.