OBITUARY NOTICE.

Sir John Murray, K.C.B., LL.D., Ph.D., D.Sc., F.R.S., Knight of the Royal Prussian Order *Pour le Mérite*, Grand Cross of the Royal Norwegian Order of St Olav. By **J. Graham Kerr.**

(Read July 5, 1915.)

JOHN MURRAY was born on March 3, 1841, in the town of Coburg, Ontario, the second son of Robert Murray, accountant, an immigrant from Scotland, and his wife Elizabeth Macfarlane of Coney Hill, Stirlingshire. After spending his boyhood on the plains of Ontario, Murray came at the age of seventeen to relatives in Scotland to complete his education. It was at the period of this first transatlantic voyage that there occurred what were perhaps the first recognisable steps in the scientific career of the great oceanographer, for Murray has told us of the indelible impression produced upon his mind by the great salt rolling sea, so different from the fresh-water lakes which he had hitherto known, and of the fascination which he felt in watching the navigational duties of the officers of the ship as they picked their way across the trackless ocean. And he has told us again how the impressions received during the voyage were deepened when on the west coast of Scotland he watched the rhythmic rising and falling of the tide, like the movements of some great living thing.

After some time spent at the Stirling High School,* Murray proceeded to the University of Edinburgh, where, without working through the regular curriculum for any degree, he received invaluable scientific training under Allman, Goodsir, Turner, Lyon-Playfair, and, above all, Tait, in whose laboratory he spent much time researching in association with a number of men who later became distinguished in very various spheres of activity. Murray's researches were particularly directed towards thermal conductivity and thermo-electricity, and he was especially interested in the construction of an electrical thermometer for use in deep-sea work. Apart from his more systematic training in laboratories, Murray gained experience of value for his future work by making a voyage to the

* For delightful reminiscences by Murray of his school-days, see "*Old Boys*" *and their Stories of the High School of Stirling*, collected and edited by J. Lascelles Graham. Stirling, 1900.

Arctic regions on board a whaler in 1868, on which occasion he not only collected large numbers of marine organisms, but made many observations in what we should now call oceanography.

Murray's great opportunity came in 1872 when he was appointed to the staff of the *Challenger* Expedition, that famous expedition, organised in this city, which will probably be for all time recognised as the most important in the history of oceanic exploration. Murray played a large part in the preliminary organising and fitting out as well as in the conduct of the expedition. During the four years of the actual voyage he specialised particularly in the collection and study of pelagic organisms and deep-sea deposits, but his greatest work in this connection and the great work of his life was after the return of the expedition. Owing to the failing health of Sir Wyville Thomson the main share in organising the working out of the enormous collections fell very soon to Murray, and after Thomson's death in 1882 he became in name, as he already was in fact, responsible for this side of the work. For nineteen years Murray managed the most remarkable team of scientific workers which was probably ever brought into collaboration. Agassiz, Allman, Buchan, Buchanan, Bergh, Brooks, Carpenter, von Graff, Günther, Haddon, Haeckel, R. Hertwig, Harmer, Herdman, Huxley, Hubrecht, Kölliker, Moseley, M'Intosh, Pelseneer, W. K. Parker, Renard, Sars, Sollas, Schulze, Selenka, Sclater, Tait, Théel, Turner: all these, in addition to other and younger workers, contributed, and contributed of their best, to these wonderful fifty volumes which form not merely the foundation but a great part of the whole edifice of modern oceanography. One of the most remarkable feats in Murray's life was surely his management of this great body of workers, differing widely in nationality, in temperament, and in industry: in getting each one of them to carry out investigations of the most arduous kind extending in some cases over many years, and to get his results completed and put into form for publication. The extraordinary driving power which Murray possessed is shown by the carrying of this great work to a triumphant completion, and his ability as a leader of men is testified to by the address, expressive of esteem and friendship, presented to him by his collaborators on its completion. There were other difficulties in Murray's path besides those naturally inherent to such a work. The Government had behaved with liberality unusual in a British Government in paying the expenses of the actual expedition; but, in strict accordance with custom, difficulties were raised about the expenditure necessary for working out and publishing the results—in other words, about securing that the main expenditure should not have been so much money thrown away. The annual grant was with-

drawn in 1889, and it was only after offering to finish the work of publishing at his own expense that Murray was able to get a further grant of £1600. As it was, Murray spent a large amount of his own money in completing the undertaking.

The completion of the publication of the *Challenger* Reports did not mean that the great centre for oceanographical research which Murray had created in Edinburgh passed out of existence. Right down to the time of his death Murray's laboratory, with its skilled staff, remained open as a centre of active investigation where foreign or British workers were always made welcome, and every facility, including access to the unique collection of oceanic deposits, placed at their disposal.

It must not be supposed that Murray's work was confined to inspiring, assisting, and organising the activities of other investigators, great and pre-eminent though this work was. He was all the while engaged in active and fruitful research himself, and the three volumes associated specially with his authorship—that on Deep-Sea Deposits, written jointly with Professor Renard, and those which summarise the general scientific results—are amongst the most valuable of the whole series. In these investigations Murray by no means confined himself to data obtained during the actual voyage of the *Challenger*: with the object of checking and amplifying these, he conducted a number of independent inquiries.

In 1880 and 1882 he carried out with Tizard important explorations in the Government surveying ships *Knight Errant* and *Triton*. One of the most interesting results of these explorations was the solution of an oceanographical puzzle dating from the time of the cruise of the *Lightning* (1868), when the discovery was made that in the region of ocean commencing about 70 geographical miles N.N.W. of Cape Wrath and extending about 85 miles in a north-westerly direction there existed a remarkable sharp line of demarcation between a warmer area (so far as the deeper waters were concerned) to the south-west and a colder area to the north-east. The solution of the puzzle turned out, as suspected by Tizard, to rest on the presence of a submarine ridge running in a north-west and south-east direction, reaching to between 300 and 200 fathoms of the surface, and forming an efficient barrier to the circulation of ocean water below this level.

Murray organised an excellent little marine laboratory at Granton, and another at Millport. The latter was eventually handed over to a local committee, which later on developed into the Marine Biological Association of the West of Scotland. In connection with this local Scottish work the steam yacht *Medusa* was built and specially equipped, and on it Murray,

with the assistance of Mill, Cunningham, and other colleagues, carried out continuous investigations over a period of about eleven years. In this way an immense body of valuable observations was accumulated, some of which were made use of in working out the *Challenger* results, and published partly in the reports of the expedition, partly elsewhere. Amongst the residuum not immediately published there remained a mass of valuable data regarding the marine fauna of the west of Scotland, the working up of which had been undertaken only a few months before Murray's death. These data when fully worked out will form a valuable foundation for future work, so it is greatly to be hoped that means will be found to have this done.

Murray's studies upon the mode of formation of coral islands, in which he emphasised the importance of submarine deposits—particularly of the calcareous skeletons of marine animals which are protected from solution by the bottom layer of water becoming saturated with calcium carbonate—in providing the foundations upon which the atoll-forming organisms can proceed to build; his studies upon rainfall and drainage of continents in their relation to submarine deposits; and again his studies upon the extent —present and past—of the Antarctic continent, can only be mentioned here, although these are alike of great value in themselves and of still greater value as sources of inspiration of subsequent research on the part of others.

Apart from the *Challenger* Expedition, perhaps the greatest work of Murray's life was the carrying out of the Murray-Pullar survey of the fresh-water lochs of Scotland, the result of which has been to place Scotland in the same premier position in limnology as it had been placed in as regards oceanography. Murray had endeavoured without success, although backed up by powerful representations from the Royal Societies of London and Edinburgh, to induce the Government to undertake a bathymetrical survey of the fresh-water lochs of Scotland; so in 1898 he commenced the work on his own responsibility, assisted by a young and enthusiastic colleague, Mr Fred Pullar. The survey met an untimely check on the lamentable death of the younger worker by accident in 1901, but was started again in the following year with funds provided by his father, Mr Laurence Pullar, and was prosecuted actively, with the help of a staff of able young assistants, during the following seven years. During that time systematic soundings, with supplementary physical and biological observations, were carried out on no less than 562 separate lochs. The results of the survey were published from time to time by the Royal Geographical Society, and appeared in collected form in 1910 in six large

volumes, with numerous charts and other illustrations, forming a contribution to limnology of which Scotland may well be proud, and at the same time a worthy memorial of the able young naturalist who was Murray's colleague during the earlier stages of the work.

The last of Murray's major works was the *Michael Sars* expedition to the North Atlantic in 1910. This arose out of a visit to Copenhagen in 1909, when he urged upon the International Council for the Exploration of the Sea the desirability of carrying out systematic observations in the North Atlantic with a view to their bearings on the problems of the North Sea. Later on, Murray made a definite offer to pay the expenses of a four months' expedition on condition that the Norwegian Government lent the *Michael Sars* and her scientific staff for the purpose. This offer was accepted, and the *Michael Sars* sailed from Plymouth on April 7, 1910, with Murray on board. The expedition made its way along the western edge of the continental slope to Gibraltar, where valuable studies were made of the great currents which traverse the strait, the ship being anchored in mid-channel by a steel cable, in water of two hundred fathoms.

From Gibraltar the expedition worked southwards along the continental edge as far as the Canaries, thence to the Azores, then westwards to the Gulf Stream and northwards to Newfoundland, and finally back across the Atlantic towards Ireland. A call was made at the Clyde, a visit paid to the neighbourhood of Rockall, and finally the concluding observations of the expedition were made in the Faroe-Shetland channel.

The *Michael Sars* had on board her full scientific staff under the leadership of Dr J. Hjort; she was admirably equipped with the necessary scientific apparatus, and, as might have been expected, during the four months of the cruise an immense mass of valuable observations was accumulated, together with large collections of marine organisms. Murray gave £500 towards putting these into preliminary order, and now they are being worked up and the results published under the auspices of the Bergen Museum. Of the purely physical observations, mention may be made of the studies of the outflow of warm water of high salinity through the Strait of Gibraltar; of the very considerable fall in temperature of large masses of the Atlantic water which was found to have taken place since the voyage of the *Challenger* thirty-seven years earlier; of the numerous glaciated stones brought up from a depth of 1000 fathoms to the south-west of Ireland; and of the corroboration of J. Y. Buchanan's views as to the occurrence of tidal currents, strong enough to wash away the ooze, far out in the open ocean in regions of diminished depth of water: and again, in the realm of pure biology, the obtaining of a number of young, developing

individuals of that wonderfully archaic siphonopod *Spirula*, and of numerous leptocephalus larvæ of the common European eel in mid-Atlantic, south of the Azores—an important addition to the data available towards a solution of the problem of the life history of that elusive fish.

Much of the most interesting and important work of the expedition bore upon the relations of organisms to physical environmental conditions. Thus, in relation to depth, the *Michael Sars* results point to the great poverty of life at the extreme depths and to its comparative richness at intermediate depths—in contradiction to commonly held views. Particularly important studies were made bearing on the relationships of pelagic animals to light. The *Michael Sars* naturalists did not fall into the common blunder of supposing that a deep-sea animal which looks red when drawn up to the surface does so in its native haunts, but fully realised that such animals at the depths in which they live, where no red rays penetrate, have simply a dark appearance like those of their fellows which actually are dark-coloured when seen by ordinary daylight. The upper limit of these dark-coloured and red organisms of deep water was found to vary in level at different latitudes in a manner corresponding to the different depths to which daylight penetrates, being deeper in low latitudes and at a less depth in higher latitudes. Careful measurements were made of the actual depths to which daylight penetrates by exposing sensitive photographic plates submerged at different depths.

Apart from the splendid additions to detailed knowledge which the *Michael Sars* Expedition has produced, a lesson of great general importance for the future of oceanography has been taught, viz. that oceanographical research of the highest class may be carried out even in the deepest and most extensive oceans by means of a vessel no larger than an ordinary good steam trawler.*

While Murray's achievements in pure science—the *Challenger* Expedition, the Scottish Lake Survey, and the *Michael Sars* Expedition, and the researches centred round them—are what concern us more especially, these by no means exhausted his activities.

Of Murray's achievements outside the realm of pure science there is none of greater interest than that extraordinary by-product of his *Challenger* work by which he converted an almost unknown and uninhabited tropical island into a busy hive of industry and a valuable centre of commercial activity. The initial discovery was made during the routine examination of oceanic deposits, for amongst a certain series of samples Murray detected a

* The *Michael Sars* measures 125 feet between perpendiculars, is of 226 tons burden, and has engines of 300 horse-power which give her a speed of 10 knots.

fragment of phosphatised limestone which appeared to him clearly to be of terrigenous origin. Further inquiry showed that it had come from Christmas Island in the Indian Ocean, and Murray duly followed up the indication so provided that rich phosphatic deposits were to be looked for on that island. After a great deal of trouble, and the application of much pressure, the Government of the day was induced to hoist the British flag upon the hitherto derelict island, and thereafter a joint lease of the island was granted to Murray and the late Mr Ross of Cocos Keeling. A company was formed, the immensely valuable deposits of phosphate duly located, the tropical vegetation was opened up, railways, piers, waterworks constructed, and the island became a centre of activity with a population of about 1500 engaged in the main industry of quarrying and shipping phosphate, as well as in subsidiary industries such as the growing of rubber, cotton, hemp, bananas, etc. Naturally, the purely scientific investigation of the island was not neglected. Murray himself made two exploring expeditions thither in 1900 and in 1908, and he also organised and financed two expeditions under the auspices of the British Museum. During these expeditions extensive collections were made by Dr. C. W. Andrews, and the main results of the first expedition were published as *A Monograph of Christmas Island* by the Trustees of the British Museum (1900). The special interest of this work lies, perhaps, not so much in the fact that it makes known a mass of valuable information about a tropical island of which, hitherto, very little had been known, as in the fact of its being a study of the fauna and flora of an island previously uninhabited by man, but which was about to undergo colonisation. It forms thus a foundation for subsequent investigations, which will be of the greatest interest, into the effects of the presence of man, and animals and plants introduced by him, upon the native fauna and flora.

Incidentally Murray in his Christmas Island work has provided a remarkably impressive lesson in regard to the practical value of pure science. The Ruler of our Country—the "Man in the Street"—does not realise that all the great achievements in applied science are built upon a foundation of pure science. He does not know that the ships which bring him necessities and luxuries and wealth are enabled to pick their way across the ocean and complete their voyages with regularity through our knowledge of laws which we owe to the labours of pure mathematicians. He is not aware that the successful completion of such an engineering work as the Panama Canal was rendered possible by the results of investigations upon parasites of mosquitoes. He has heard the name of Kelvin, and associates it with numerous inventions of practical importance, but he

is unaware that their invention was rendered possible by a profound grasp of purely scientific principles. While in these days he dare no longer express other than respect for the practical results of science, he as a rule fails completely to appreciate the pure science which has made them possible. The worker at pure science he treats at the most with a good-natured toleration: most likely he looks on the expenses incurred in his investigations as so much money thrown away. Murray's line of work on submarine deposits he would regard as a particularly good example of such waste of money. And yet these studies led to the discovery and development of the wealth of Christmas Island, and the small fraction of that wealth which went to the British Government, in the form of rents, royalties, and taxes, exceeded within fifteen years the entire cost of the *Challenger* Expedition and the publication of its results.

Murray was an active supporter of various of our Scottish institutions. He acted for a time as scientific member of the Fishery Board. He was the enthusiastic secretary of the committee which got together funds for the erection of a high-level observatory on Ben Nevis, and remained a director and convener of the Works Committee until the observatory was closed. He was President of the Scottish Natural History Society and of the Royal Scottish Geographical Society. In our own Society he served continuously for about twenty years on the Council, and for a prolonged period acted as one of the Secretaries and as Vice-President. He was one of those who objected most strongly to the eviction of the Society from its old quarters on the Mound.

Murray's achievements as a great man of science won full recognition both at home and abroad. He was created a Knight Commander of the Bath, a foreign Knight of the Prussian Order *Pour le Mérite*, a Knight Grand Cross of the Royal Norwegian Order of St Olav: he was an honorary graduate of Edinburgh, Oxford, Harvard, Jena, Geneva, Christiania, Liverpool: he was an honorary member of most of the important scientific societies and academies of the world: and he was the recipient of numerous medals and other distinctions. The end came to his busy and fruitful life on 16th March 1914, when he was instantaneously killed, near Edinburgh, in a motor accident.

In connection with this notice I have to record my indebtedness to Mr Laurence Pullar for clearing up certain points regarding which I was in doubt, and to Mr James Chumley — Murray's long-time secretary and assistant—for providing the accompanying bibliography.

APPENDIX.

Publications of the late Sir John Murray.

1876. Preliminary Reports to Professor Wyville Thomson, F.R.S., Director of the Civilian Scientific Staff, on work done on board the *Challenger*:—

(1) Preliminary Report on specimens of the sea-bottoms obtained in the soundings, dredgings, and trawlings of H.M.S. *Challenger* in the years 1873–75, between England and Valparaiso;

(2) Preliminary Report on some surface organisms and their relation to ocean deposits;

(3) Preliminary Report on Vertebrates: *Proc. Roy. Soc.*, vol. xxiv, pp. 471–542.

1876. On the distribution of volcanic debris over the floor of the ocean, its character, source, and some of the products of its disintegration and decomposition: *Proc. Roy. Soc. Edin.*, vol. ix, pp. 247–261.

1877. The cruise of the *Challenger*,—Two lectures delivered in the Hulme Town Hall, Manchester, December 11 and 18, 1877: *Manchester Science Lectures*, 1877, pp. 105–139.

1880. On the structure and origin of coral reefs and islands: *Proc. Roy. Soc. Edin.*, vol. x, pp. 505–518.

1885. Report on the specimens of bottom deposits collected by U.S.S. *Blake*, 1877 to 1880: *Bull. Mus. Comp. Zoöl.*, vol. xii, pp. 37–61.

1885. The great ocean basins,—Lecture delivered at the Aberdeen meeting of the British Association, and published in *Nature*, vol. xxxii, pp. 581–584, 611–613.

1886. The physical and biological conditions of the seas and estuaries about North Britain,—Paper read before the Philosophical Society of Glasgow, March 31, 1886, and published in *Proc. Phil. Soc. Glasgow*, vol. xvii, pp. 306-333.

1886. The exploration of the Antarctic regions: *Scot. Geog. Mag.*, vol. ii, pp. 527–543.

1886. Drainage areas of the continents and their relation to oceanic deposits: *Scot. Geog. Mag.*, vol. ii, pp. 548–555.

1886. Chairman's opening address to the Royal Society of Edinburgh, December 6, 1886: *Proc. Roy. Soc. Edin.*, vol. xiv, pp. 1–20.

1887. On the total annual rainfall on the land of the globe, and the relation of rainfall to the annual discharge of rivers,—Paper read before the Royal Society of Edinburgh, January 17, 1887, and published in *Scot. Geog. Mag.*, vol. iii, pp. 65–77.

1887. On some recent deep-sea observations in the Indian Ocean: *Scot. Geog. Mag.*, vol. iii, pp. 553–561.

1887. On the height of the land and the depth of the ocean,—Paper read before the Royal Society of Edinburgh, December 19, 1887, and published in *Scot. Geog. Mag.*, vol. iv, pp. 1–41, 1888.

1888. Structure, origin, and distribution of coral reefs and islands,—Address to the Royal Institution of Great Britain, March 16, 1888: *Proc. Roy. Inst.*, vol. xii, pp. 251–262.

1888. On the effects of winds on the distribution of temperature in the sea- and fresh-water lochs of the west of Scotland: *Scot. Geog. Mag.*, vol. iv, pp. 345–365.

1889. On marine deposits in the Indian, Southern, and Antarctic Oceans: *Scot. Geog. Mag.*, vol. v, pp. 405–436.

1890. The Maltese Islands, with special reference to their geological structure: *Scot. Geog. Mag.*, vol. vi, pp. 449–488.

1891. On the temperature of the salt- and fresh-water lochs of the west of Scotland, at different depths and seasons, during the years 1887 and 1888: *Proc. Roy. Soc. Edin.*, vol. xviii, pp. 139–228.

1893. The discovery of America by Columbus; the influences which led up to that great event, and its effect on the development of oceanographical knowledge: *Scot. Geog. Mag.*, vol. ix, pp. 561–586.

1893. The renewal of Antarctic exploration,—Paper read before the Royal Geographical Society, November 27, 1893, and published in *Geog. Jour.*, vol. iii, pp. 1–42, 1894.

1894. Notes on an important geographical discovery in the Antarctic regions: *Scot Geog. Mag.*, vol. x, pp. 195–199.

1894. The crust of the earth,—Paper read before the Royal Society of Edinburgh, May 21, 1894, and published in abstract in *Scot. Geog. Mag.*, vol. x, pp. 378–379.

1895. A summary of the scientific results obtained at the sounding, dredging, and trawling stations of H.M.S. *Challenger*; two volumes, 1627 pages, published by H.M. Government.

1895. The general conditions of existence and distribution of marine organisms: *Comptes-rendus des Séances du 3^me^ Congrès international de Zoologie, Leyde*, 1895, pp. 99–111.

1896. On the deep- and shallow-water marine fauna of the Kerguelen region of the Great Southern Ocean: *Trans. Roy. Soc. Edin.*, vol. xxxviii, pp. 343–500.

1896 Marine organisms and the conditions of their environment,—Address to the Royal Institution of Great Britain, February 28, 1896, and published in abstract in *Proc. Roy. Inst.*, vol. xv, pp. 75–77.

1897. Some observations on the temperature of the water of the Scottish fresh-water lochs: *Scot. Geog. Mag.*, vol. xiii, pp. 1–21.

1897. Balfour Shoal: a submarine elevation in the Coral Sea: *Scot. Geog. Mag.*, vol. xiii, pp. 120–134.

1897. On the distribution of the pelagic Foraminifera at the surface and on the floor of the ocean: *Natural Science*, vol. xi, pp. 17–27.

1898. The scientific advantages of an Antarctic expedition: *Proc. Roy. Soc.*, vol. lxii, pp. 424–451.

1898. The Antarctic: a plea for a British Antarctic expedition: *Scot. Geog. Mag.*, vol. xiv, pp. 505–510.

1898. On the annual range of temperature in the surface waters of the ocean, and its relation to other oceanographical phenomena,—Paper read before the Royal Geographical Society, February 28, 1898, and published in *Geog. Jour.*, vol. xii, pp. 113–137.

1899. On the temperature of the floor of the ocean, and of the surface waters of the ocean: *Geog. Jour.*, vol. xiv, pp. 34–51.

1899. Presidential Address to the Geographical Section of the British Association: *Report Brit. Ass.*, 1899 (Dover), pp. 789–802.

1900. On the deposits of the Black Sea: *Scot. Geog. Mag.*, vol. xvi, pp. 673–702.

1901. The South Pole: *Quarterly Review*, Oct. 1901, pp. 451–473.

1902. Deep-sea deposits and their distribution in the Pacific Ocean, with notes on the samples collected by s.s. *Britannia*, 1901: *Geog. Jour.*, vol. xix, pp. 691–711.

1902. Remarks on the deep-sea deposits collected by the U.S.S. *Albatross* in the Tropical Pacific, 1899–1900: *Mem. Mus. Comp. Zoöl.*, vol. xxvi, pp. 109–111.

1906. On the depth, temperature of the ocean waters, and marine deposits of the south-west Pacific Ocean: *Queensland Geog. Jour.* (Brisbane), vol. xxi, pp. 71–134.

1908. The distribution of organisms in the hydrosphere as affected by varying chemical and physical conditions: *Intern. Revue Hydrobiol. und Hydrogr.*, Bd. i, pp. 10–17.

1910. The deep sea: *Scot. Geog. Mag.*, vol. xxvi, pp. 617–624.

1910. On the depth and marine deposits of the Indian Ocean, with descriptions of the deposit-samples collected by Mr J. Stanley Gardiner in 1905: *Trans. Linn. Soc. Lond.*, 2nd ser., Zool., vol. xiii, pp. 355–396.

1911. Exploring the ocean's floor: *Harper's Monthly Mag.*, March 1911, pp. 541–550.

1911. Alexander Agassiz: his life and scientific work: *Bull. Mus. Comp. Zoöl.*, vol. liv, pp. 139–158.

1913. The ocean: a general account of the science of the sea: Home University Library, No. 78, London (Williams & Norgate).

In Collaboration.

1882. John Murray and T. H. Tizard, Exploration of the Faroe Channel during the summer of 1880, in H.M.'s hired ship *Knight Errant*: *Proc. Roy. Soc. Edin.*, vol. xi, pp. 638–720.

1884. John Murray and A. Renard, On the microscopic characters of volcanic ashes and cosmic dust, and their distribution in deep-sea deposits; *Proc. Roy. Soc. Edin.*, vol. xii, pp. 474–495.

1884. John Murray and A. Renard, On the nomenclature, origin, and distribution of deep-sea deposits: *Proc. Roy. Soc. Edin.*, vol. xii, pp. 495–529.

1885. John Murray, T. H. Tizard, H. N. Moseley, and J. Y. Buchanan, Narrative of the cruise of H.M.S. *Challenger*, with a general account of the scientific results of the expedition; two volumes, 1154 pages, published by H.M. Government.

1889. John Murray and R. Irvine, On coral reefs and other carbonate of lime formations in modern seas: *Proc. Roy. Soc. Edin.*, vol. xvii, pp. 79–109.

1891. John Murray and A. Renard, Report on deep-sea deposits based on specimens collected during the voyage of H.M.S. *Challenger* in the years 1872 to 1876; one volume, 546 pages, published by H.M. Government.

1891. John Murray and R. Irvine, On silica and the siliceous remains of organisms in modern seas: *Proc. Roy. Soc. Edin.*, vol. xviii, pp. 229–250.

1893. John Murray and R. Irvine, On the chemical changes which take place in the composition of the sea-water associated with Blue Muds on the floor of the ocean: *Trans. Roy. Soc. Edin.*, vol. xxxvii, pp. 481–507.

1894. John Murray and R. Irvine, On the manganese oxides and manganese nodules in marine deposits: *Trans. Roy. Soc. Edin.*, vol. xxxvii, pp. 721–742.

1898. John Murray and R. E. Peake, On the survey by the s.s. *Britannia* of the cable route between Bermuda, Turk's Islands, and Jamaica, with descriptions of the marine deposits brought home: *Proc. Roy. Soc. Edin.*, vol. xxii, pp. 409–429.

1901. John Murray and E. Philippi, Die Grundproben der *Valdivia* Expedition: *Centralblatt für Mineralogie*, 1901, pp. 525–527.

1901. John Murray and R. E. Peake, On the results of a deep-sea sounding expedition in the North Atlantic during the summer of 1899, with notes on the temperature observations and depths, and a description of the deep-sea deposits in this area: *Roy. Geog. Soc. Supplementary Papers*, 1901, pp. 1–44.

1900–1. John Murray and F. P. Pullar, A bathymetrical survey of the fresh-water lochs of Scotland, Parts I–III: *Geog. Jour.*, vol. xv, pp. 309–352; vol. xvii, pp. 273–295.

1903–8. John Murray and L. Pullar, Bathymetrical survey of the fresh-water lochs of Scotland, Parts IV–XIII: *Geog. Jour.*, vols. xxiii–xxxi.

1910. John Murray and L. Pullar, Bathymetrical survey of the Scottish fresh-water lochs: report on the scientific results; six volumes, Edinburgh (*Challenger* Office).

1904. John Murray and R. E. Peake, On recent contributions to our knowledge of the floor of the North Atlantic ocean: *Extra Publication of the Roy. Geog. Soc.*, pp. 1–35.

1908. John Murray and E. Philippi, Die Grundproben der Deutschen Tiefsee-Expedition: "*Valdivia*" *Reports*, Bd. x, Lief. 4, 128 pages.

1909. John Murray and G. W. Lee, The depth and marine deposits of the Pacific: *Mem. Mus. Comp. Zoöl.*, vol. xxxviii, pp. 1–169.

1912. John Murray and J. Hjort, The depths of the ocean: a general account of the modern science of oceanography, based largely on the scientific researches of the Norwegian steamer *Michael Sars* in the North Atlantic; one volume, 840 pages (London: Macmillan).