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"From possibility to reality" seems an appropriate phrase to describe the development of oceanography in the past three-quarters of a century. It is of little more than academic interest to pick a particular date or event as marking the birth of a field of endeavor; however, for oceanography, the late 1860's and the early 1870's unquestionably mark the period which gave the greatest impetus to research on the chemistry, physics and biology of the sea. Seventy-five years ago Her Majesty's Ship CHALLENGER was well started on her round-the-world expedition which covered 69,000 miles and took three and a half years. Seventy-five years ago, also, there was published "The Depths of the Sea" by Charles Wyville Thomson (1). Oceanography at that time was a possibility. That it is now a reality is self-evident—although too often taken for granted, with little realization of the relatively short space of time it took to accomplish the transition "a posse ad esse." If Thomson's book ". . . may be regarded as the first general textbook on oceanography" (2, p. 41), the comprehensive volume by Sverdrup, Johnson and Fleming (3) would appear to be the last. This field is now so large that it is doubtful if another similar account will ever again be placed between the two covers of a single book. It is

[1] It is with infinite pleasure that I acknowledge my indebtedness to my wife, Mary Wieland Merriman, whose painstaking searches for original material made this work possible.

appropriate in honoring Dr. Sverdrup that we should look back seventy-five years to the bare beginnings of the field to which he has made such notable contribution.

One of the major problems in the third quarter of the 19th century was the question as to the depths at which animal life might exist in the ocean. The position is summarized nicely in a review (4) of Thomson (1).

> In no department of zoology has there been of late years a greater revolution than in that to which belongs the existence of life at great ocean depths. Not twenty years ago, it may be said, with almost all naturalists as with one not less distinguished than the late Edward Forbes, the belief in a zero of life, or a depth below which no animal existence was possible, was an article of the scientific creed. Under conditions of pressure, of defective light, temperature, and aëration, such as were held to prevail in the abysses of the deep sea, nothing approaching to known varieties of animal life could, it was thought, by possibility exist. Cases, however well authenticated, of animals comparatively high in the scale of life having been brought up by sounding lines from great depths, were set aside even by men of eminent standing in science, as having been due to careless observation, or to the fact of the creatures having got entangled in the line while floating near the surface. It is to the operations involved in laying and subsequently fishing up the Atlantic telegraph cable that the first great impulse towards an opposite belief is to be traced. Solitary or infrequent cases had indeed occurred to stir the thoughts of naturalists. There was the beautiful Medusa's head, fished up by Sir John Ross from one thousand fathoms in Baffin's Bay, lat. 73° 37′ N., September 1, 1818; and there were the rich hauls of coralines, and other varieties of invertebrate life, obtained by Sir J. C. Ross in equally far Southern latitudes and from much the same depths, suggesting to those able explorers, though contrary to the received opinion of naturalists, that the lowest depth to which we might succeed in penetrating would be found to teem with animal life. The minute samples of Atlantic ooze brought up by the sounding apparatus introduced by Mr. Brooke in 1854 made known the existence and diffusion of microscopic forms not distinguishable from the fossil constituents of chalk, which the discovery of identical specimens from the Pacific showed to be in all probability distributed over the whole ocean floor. Doubt still existed whether these organisms had their life at the bottom of the sea, or were precipitated in fine showers after death. The opinion of Ehrenberg in favour of the first of these hypotheses was balanced by that of Professor Baily, of West Point, on the contrary side; Professor Huxley in 1858, in his report upon the problem to the Admiralty, expressing himself guardedly as on the whole inclined to believe that the Globigerinae and other foraminifers and diatoms really lived at these depths. Dr. Wallich's dredgings in the North Atlantic, though not conclusive of the question, contributed much to strengthen the same belief, which was generally held to be established for good when Mr. Fleeming Jenkin showed the manifold specimens brought up with the submerged cable between Bona and Sardina from depths extending to 1,200 fathoms, among which Professor Allman readily identified fifteen animal forms, including the ova of a cephalopod. Subsequent examination of organisms derived from the same source enabled M. Milne Edwards to pronounce the problem finally solved.

In the spring of 1868 Charles Wyville Thomson[2] was working in Ireland with W. B. Carpenter, then one of the Vice Presidents of the Royal Society, on the structure and development of crinoids. Together they decided to urge upon the Admiralty the importance of providing ". . . a vessel properly fitted with dredging gear and all necessary scientific apparatus, that many heavy questions as to the state of things in the depths of the ocean which were still in a state of uncertainty, might be definitely settled" (1, p. 50).

As a result of Carpenter's and Thomson's proposition to the Admiralty, Her Majesty's steam vessel LIGHTNING was assigned for the purpose of carrying out dredging operations in July 1868. The oft-quoted description of the vessel (1, p. 57) merits repetition here:

> The surveying ship 'Lightning' was assigned for the service—a cranky little vessel enough, one which had the somewhat doubtful title to respect of being perhaps the very oldest paddle-steamer in her Majesty's navy. We had not good times in the 'Lightning.' She kept out the water imperfectly, and as we had deplorable weather during nearly the whole of the six weeks we were afloat, we were in considerable discomfort. The vessel, in fact, was scarcely seaworthy, the iron hook and screw-jack fastenings of the rigging were worn with age, and many of them were carried away, and on two occasions the ship ran some risk. Still the voyage was on the whole almost pleasant.

In the six weeks at their disposal, just ten days were decent enough for dredging in the open sea and on only four of these were they in depths over 500 fathoms. Nonetheless, they revealed varied, abundant, and hitherto unknown animal life down to 650 fathoms, as well as deep-water masses of different temperatures; this was sufficient to convince the Admiralty that another vessel should be assigned for the same purpose in 1869. The PORCUPINE was more seaworthy, and she made several cruises in the North Atlantic and Mediterranean during the summers of 1869 and 1870 under the direction of Thomson, Carpenter, and Gwyn Jeffreys. Dredging first at 1,476 and later at 2,435 fathoms, the existence of animal life at these depths was proven beyond question. "In the Mediterranean Dr. Carpenter found the conditions of temperature and of the distribution of animal life entirely

[2] Thomson (5), born March 5, 1830, had received his education at the University of Edinburgh from 1845 to 1850, where his chief interests were botany, geology and zoology. Although he took no degree, his standing was such that he immediately became Lecturer on Botany in King's College at the University of Aberdeen. In 1853 he was made Professor of Natural History in Queen's College, Cork, and in 1854 was transferred to the Chair of Mineralogy and Geology at Belfast, where in 1860 he became Professor of Zoology and Botany. Such, in brief, was the background of the man who was destined to play a leading role in the development of oceanography from 1868 until his death in 1882.

exceptional, as might have been to a certain extent anticipated from the exceptional circumstances of that land-locked sea" (1, p. 179).

In 1870 Thomson became Professor of Natural History at the University of Edinburgh, thus following in the footsteps of Edward Forbes who had named the region below 300 fathoms the "Azoic zone." Some modern writers who contradict the theories of their predecessors would do well to read Thomson on Forbes (1, pp. 6–18) as a model of expression and fairness.

There followed the arrangements for the CHALLENGER Expedition, culminating in the appointment of Thomson as director of the civilian scientific staff, and the departure of Her Majesty's Ship in December 1872. The details of the ship, her voyage and discoveries are well known to us at first hand through the works of several authors (6, 7). However, the degree of public interest and the attention these first truly oceanographic investigations drew at the time deserve mention. The first paragraph of a column-and-a-half article (8) in the The (London) Times just before the CHALLENGER sailed is quoted herewith:

> An early day of the ensuing week will witness the departure of the most important naval surveying Expedition which has ever been sent forth by any country. We have from time to time recorded the results obtained by Dr. Carpenter, Professor Wyville Thomson, and Mr. Gwyn Jeffreys, in the brief voyages of the Lightning and the Porcupine; results which showed previously-unsuspected variations in the deep sea temperature, the existence of a general oceanic circulation, the presence of life at the greatest depths, and the active progress of submarine chalk formated even in the present day. The great scientific and practical importance of the facts revealed by these short and imperfect inquiries was such as to render their continuance a matter of national concern, and Dr. Carpenter, who had from the first been most active in their prosecution, exerted himself to bring the whole subject under the consideration of the Government. Mr. Lowe, however strict in protecting the public purse against demands for which private enterprise may be legitimately called upon, fully recognizes that matters which it is fitting for the country to undertake should be carried through with every advantage that money can secure, and he gave early intimation of his approval of the proposed Expedition. The Admiralty, in like manner, asked only the official approval of the Royal Society; and, as soon as this was given, Mr. Goschen lent himself heartly to the scheme. The suggestion made to the Royal Society was that a ship should be fitted out for an expedition of three or four years' duration, during which soundings, themometric (*sic*) observations, dredging, and chymical examination of sea water, should be carried on continuously, with a view to a more perfect knowledge of the physical and biological conditions of the great ocean basins, and in order to ascertain their depth, temperature, specific gravity, and chymical character. At the same time it was recommended that observations should be made on the direction and velocity of the great drifts and currents, especially those of the Gulf Stream, the Equatorial and Japan, both at the surface and in intermediate strata, as well as on the fauna of the

deep water, and on the zoology and botany of those portions of the globe which are at present comparatively unknown.

For the next three and a half years the Times carried frequent and detailed articles on the progress of the CHALLENGER, her itinerary and accomplishments, and various incidents of the voyage.

Further indication of the general interest in the expedition is to be found in Punch, or the London Charivari; Fig. 1 is a reproduction of the sketch accompanying the Preface to Volume 63 (9), and the Preface itself is the somewhat ribald conversation between Mr. Punch and the Captain on the occasion of the sailing of the CHALLENGER.

Early in 1873, several months after the CHALLENGER had sailed, Thomson's "The Depths of the Sea" was published. The extensive reviews of the book in contemporary papers and journals again provide evidence of the widespread interest in oceanographic research. All of these reviews give high praise to Thomson's researches and powers of expression. Two typical quotations follow:

> . . . we already know a good deal more of the sea—its depths, currents, temperature, density, and animal and vegetable life—than was known only a few years since; and if all goes well with the expedition of the *Challenger*, which recently left our shores, a knowledge of this department of science will

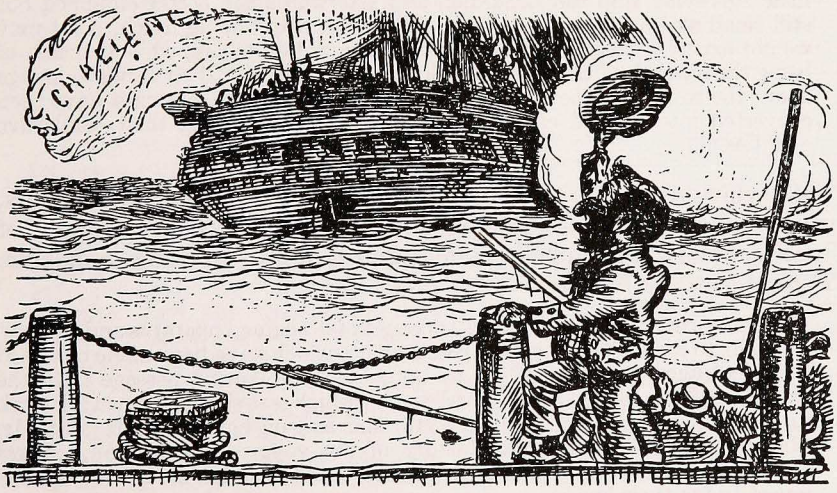

Figure 1. " 'Good luck to you all!' shouted MR. PUNCH, for the last time, and he shouted in the name of all HER MAJESTY'S subjects." (9, p. IV). Reproduced by permission of the Proprietors of PUNCH.

ere long be materially extended. As regards the facts lately acquired, those who happen to be curious on a subject of so much interest should peruse the work lately published, *Depths of the Sea*, by Dr. C. Wyville Thomson, a goodly octavo, embellished with wood-engravings, and abounding in what we would call very pleasant reading. As among the many thousands we address, few may have an opportunity of seeing the book, we shall endeavour to give some idea of its character and purport. . . .

We unfortunately have not space to pursue this interesting subject, which is treated in its various details in the work before us. The book is an important contribution to physical science, and we cordially recommend it for attentive perusal (10).

It is a rare treat to the reviewer to be able to introduce to the public of this age a book which really enlarges the boundaries of our knowledge, and is the result of original investigation conducted with the care, caution, and independence which are the elements which compose the atmosphere of true science. Overwhelmed as we are with publications of the parasitical order, which coil around the stems of classic literature and run to the limit of endurance, it is refreshing to find that something both new and true, and which can be startling without losing its simplicity, can still be told, and told so well, by one who has just started with fairer and fuller appliances to reap fresh harvests in the same almost untouched, and almost exhaustless field.

The information here given certainly marks an epoch in the chronicles of science. It establishes by experiment data which completely reverse not only popular notions, but also the sober instructions which the science of yesterday unhesitatingly inculcated. It shows also how the resources of a Government are both necessary and efficient for the furtherance of science. If that cranky little surveying ship the *Lightning*, and afterwards the better equipped but still small and defective vessel, the *Porcupine*, could do so much, what may we not expect from the naval equipment of a nation which, while it boasts of being the mistress of the seas, has allowed its vessels and their crews to lounge about the world like the idlers of a village green, when they might have been converted into trained explorers, without at all impairing their combative qualities (11).

The reviews of Thomson's book are also full of interesting side lights, which reflect the times—a bare 14 years after Darwin's "Origin of Species," and which include many significant and amusing comments. Typical samples follow:

When one reads Prof. Thomson's account of dredging apparatus and engines, and calls to mind the elaborate arrangements which have been made on board the Challenger, it is interesting to compare the following passage from the narrative of the voyage of the Rattlesnake, which was sent on surveying work to the North Australian coast in 1846, and had on board as naturalist Mr. Macgillivray,—who wrote the history of the voyage,—as surgeon, no less distinguished a naturalist than Mr. Huxley. At Rio de Janeiro they determined to try their luck:—

"I had looked forward with eager anticipation to the result of the first dredging of the voyage. *None of the ship's boats could be spared*, so I hired one pulled by four negro slaves, who, although strong active fellows, had great objections to straining their backs at the oar when the dredge was down.

No sieve having been supplied, we were obliged to sift the contents of the dredge through our hands,—a tedious and superficial mode of examination. Still some fine specimens of a curious flat sea-urchin (*Encope marginata*), and a few shells, encouraged us to persevere. Two days after, Mr. Huxley and myself set to work in Botafogo Bay, provided with a *wire-gauze meat-cover*, and a curious machine for cleaning rice; these answered capitally as substitutes for sieves, and enabled us, by a thorough examination of the contents of the dredge, to detect about forty-five species of mollusca and radiata, some of which were new to science."

The Lords of the Admiralty have, we are glad to know, learned since that time to render it unnecessary for naturalists sent out by them to borrow meat-covers and machines for cleaning rice (12).

One of the most singular things about this deep-sea fauna is that it is by no means universally destitute of eyes. A mollusc, dredged up from 2,000 fathoms, "had a pair of well-developed eyes on short footstalks." Where there are eyes, there must one would suppose—equally on Darwinian or on teleological principles—be light. But it is scarcely possible that sun-light can visit these abysses, and Mr. W. Thomson is accordingly inclined to believe that whatever light affords an exercise to these deeply buried organs of sight may be due only to phosphorescence (13).

With nearly all the leading naturalists of his time, Forbes was a believer in the immutability of species. But upon this point the author alludes to the great change of opinion which has taken place within the last ten or twelve years, due to the ability and candor with which the question has been treated by Darwin and Wallace, and to the genius of Professor Haeckel, Dr. Fritz Müller, and others of their enthusiastic disciples and commentators. The author, however, states the case too strongly in asserting "that there is now scarcely a single competent general naturalist who is not prepared to accept some form of the doctrine of evolution." An illustrous example to the contrary is found in Professor Agassiz,—not to mention Chancellor Howard Crosby, or Professor Tayler Lewis (14).

If any one wishes to gratify at once his curiosity and his sense of beauty let him go up the great staircase of the British Museum, and, on entering the second corridor, turn either right or left to the cases which contain these sponges and other deep-sea forms—to which, by-the-by, in the present crowded state of the Museum, ghastly troops of monkeys serve as a foil—and there see how Nature is not only "*maxima in minimis*," greatest in her least, but "*pulcherrima in abditis*," fairest in her most hidden works; and how the Creative spirit has lavished as it were, unspeakable artistic skill on low-organized forms, never till now beheld by man, and buried not only in foul mud, but in the unsightly mass of their own living jelly.

But so it was from the beginning; and this planet, with its complicated wonders and beauties, was not made for man alone. Countless ages before man appeared on earth, the depths of the old chalk ocean teemed with forms as beautiful and as perfect as those, their lineal descendants, which the dredge now brings up from the Atlantic sea-floor (15).

This account, based mainly on contemporary quotations, perhaps provides some indication of the true beginnings of oceanography seventy-five years ago. It has been said that oceanography is a

young and inclusive science (16), and the implication is that it has undergone rapid development. That the growth of this field is not universally appreciated is indicated by a review (not to be taken seriously) of Sverdrup, Johnson and Fleming (3), which states that: ". . . great advances have been made in the science, particularly with regard to the topography of the ocean beds, the chemistry of the sea and, what is probably the most astonishing of all, the investigations of life at great depths. Contrary to expectations, it has been ascertained that life is possible at all depths . . . " (17).

Following the CHALLENGER Expedition efforts were mainly bent towards the discovery and description of new deep-sea forms; it was not until the 20th century that the science of oceanography began to take form in its modern and broad sense of the word. Under these circumstances this "Festschrift" is the more appropriate. The man for whom it is gathered together is pre-eminent in having advanced oceanography on two continents by his personal leadership and the world over by his researches and publications during the past three and a half decades.

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