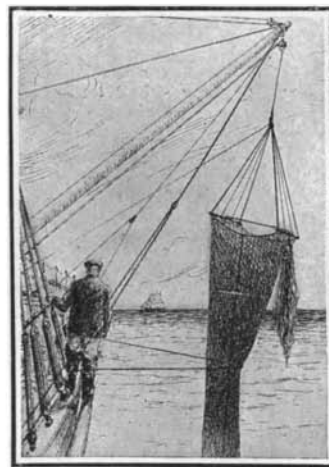


THE LIFE OF THE DEEP SEA

THE MODERN SCIENCE OF MARINE BIOLOGY

BY HERBERT T. WADE



Sir John Murray, the distinguished oceanographer who recently visited the United States, remarked in an address made a few years ago before the British Association for the Advancement of Science, that "The deep sea discoveries of the past quarter of a century have been the most important additions to the natural knowledge of this planet since the great voyages of Columbus and Magellan." To-day more than ever interest is being manifested in deep-sea biology. The methods and apparatus used in the study of the oceans and their living forms are as replete with interest as the results obtained are valuable to science.

The sea supports animal life as varied as the land, and the conditions under which it exists are even more diversified. In fact it is usual to divide the animal life of the deep sea into three great categories. The first of these, the Plankton, consists of organisms, for the most part minute, to be found nearly everywhere floating in great abundance on the surface of the open ocean. Next come the Pelagic forms which live near the surface, but choose the open sea in preference to shore waters, moving about either in schools as in the case of the smaller fishes, or singly as do the whales and sharks. Finally there is the bassalian fauna, the life of the depths known as the Benthos, which embraces the animals living below a depth of 500 feet or about 85 fathoms, and includes forms varying from fishes, swimming freely, to sea-urchins, shrimps, crabs, crinoids and a great number of microscopic organisms. The area inhabited by the bassalian fauna lies for the most part below the point where sunlight penetrates, and is of cold and constant temperature. Here the pressures are great, and at a depth of water of one mile there is experienced a pressure of 2,312 pounds to the square inch as compared with the 15 pounds to the square inch at the earth's surface due to an atmosphere rising to a height of about 40 miles. In the deep sea this pressure increases proportionately with the increase of depth or roughly by a ton per square inch for every mile or thousand fathoms of depth.

FAMOUS EXPEDITIONS.

Oceanography, or the science that deals with the study of the ocean, its currents, winds, bed, water, and inhabitants, bears a most obvious relation to navigation, and the early collection of data relating to depths and currents was undertaken rather for practical ends than for theoretical investigation. By referring the depth obtained by the sounding lead and line to the bathymetrical chart, and the sample of the bottom brought up in the arming, or tallow in a recess at the lower end of the lead, to a lithological chart on which the nature of the bottom at different points is indicated, the navigator is enabled to ascertain his position, especially on certain well traversed sea routes where these conditions have been carefully observed and recorded. In most cases early hydrographic work and deep-sea exploration were undertaken by naval officers of scientific tastes who became interested in the biological questions arising in such exploration, both in so far as they concerned fisheries and as mere scientific problems. Thus, in 1818, John Ross while sounding in Baffins Bay found an *Asteria* at a depth of 984 fathoms, and from this time there was a growing interest in the forms of life that might be found at or near the bottom of the ocean. In 1846 the United States Coast Survey undertook an investigation of the Gulf Stream, and in 1860 while making soundings for the Atlantic cable between Ireland and Newfoundland *Asteria* and *Serpula* were brought up from depths of 670 and 1,240 fathoms. On a scientific expedition Pourtales in the United States Coast Survey steamship "Corwin" dredged down to a depth of 600 fathoms, and then the British steamships "Lightning" and "Porcupine" made what have been termed trial trips in deep-sea exploration. As a result of these opportunities to study the bottom of the ocean, interest in biological problems in this new field was stimulated, and when the British ship "Challenger" started on its memorable three years' cruise in 1872, deep-sea biology was placed on a firm foundation. The work of the "Challenger" was largely in the Pacific, but in the Atlantic along the eastern

coast of North America the United States Coast Survey vessel "Blake," under the scientific direction of the late Prof. Alexander Agassiz, made several important cruises. The success of the "Blake" led to the construction of the "Albatross" in 1883, and this vessel, shown on our frontispiece, is still in service and entitled to first place on the honor roll of deep-sea exploration, in addition to its other work for the United States Fish Commission. Supplied with special machinery for sounding and dredging as well as with laboratories for the scientific staff, it soon became a veritable and complete oceanographical laboratory itself. Its deep-sea work was under the direction of Prof. Agassiz, who until his recent lamented death was the recognized leader in this field of scientific endeavor. After service on the Atlantic coast the "Albatross" was transferred to the Pacific, where many discoveries were made on cruises that included vast areas hitherto unexplored. On the Atlantic since about 1881 the United States Fish Commission steamer "Fish Hawk," when not engaged in fish hatching, has been used for dredging and other deep-sea biological work. Sharing the honors with the "Challenger" and "Albatross" have been the various vessels of the Prince of Monaco, who to-day is one of the most active students and patrons of oceanography. From 1885, when he commenced his scientific exploration in his ocean-going yacht "Hirondelle" to the present day, when aboard his "Princess Alice" well equipped and specially designed for deep-sea exploration, he has been engaged a great part of each year on scientific expeditions. Nor is his interest in oceanography confined to the sea; for the recently completed oceanographical museum at Monaco forms an imposing and useful monument to the scientific activity of the Prince and affords not only a home for his collections, but laboratories for investigators. Another ship more recent is the Norwegian vessel "Michael Sars," put in commission within a year, and now under charter to Sir John Murray, the famous Scotch oceanographer and veteran of the "Challenger" expedition, the compilation of whose valuable records he brought to a successful close. The "Albatross" and the "Princess Alice" stand out as the only vessels engaged in such exploration which have been maintained in constant commission over extended periods of time.

DEEP-SEA APPARATUS.

First and most important of the various devices for sounding and collecting is the sounding machine by which a lead or weight at the end of a fine steel piano wire is dropped to the bottom, together with a registering thermometer and a cylinder or other arrangement which opens to inclose a sample of the ooze or mud at the sea floor. On this line may also be sent down various cups which fill with sea water at any desired depth and then close tightly. This wire is paid out from a reel placed on a platform in the bows and, as it is unwound, the distance or depth is read off from indicators. For the lesser depths lighter weights or ship's leads are employed and the specimen from the bottom is secured from the arming. Next to the depth and the character of the bottom the temperature is the most important item, and self-registering thermometers housed in a metallic frame or cover and of sufficient strength to resist deep-sea pressures are employed. It is estimated that 92 per cent of the entire sea floor has a temperature less than 40 deg. F. as contrasted with the surface of the sea where only 16 per cent is at a mean temperature lower than 40 deg. F. The self-closing water cups afford material for the determination of the density and salinity and for chemical analysis. With increased depth the difficulties in sounding as in all deep-sea work increase, but depths up to 5,269 fathoms, or nearly six miles, have been recorded, this being the record made by the United States cable ship "Nero" in the Western Pacific, using the "Albatross" apparatus. To make a sounding to a depth of three miles and to get the instruments back on board the ship requires about an hour and the use of a special steam engine in connection with the reeling mechanism.

For biological studies such physical data are even more essential than for navigation, as they show the

environment of the life of the seas. For the collection of living specimens nets are towed through the sea or dredges or trawls are dragged over the bottom. At the surface there can be employed hand nets or surface tow-nets of any convenient form rigged from the end of a suspended spar or boom. Often this is done when the ship is engaged in deep-sea dredging, but on the opposite side of the vessel from the trawl. The surface tow-net captures the minute crustaceans, pelagic molluscs, and other small fry, and is arranged with pockets to prevent the escape of the specimens. When the marine naturalist wishes to obtain representatives of the animal forms at intermediate depths he may use a gravitation trap, which consists of a metal cylinder covered with gauze at the upper end and having a flat valve at the lower end. This valve can be kept open during a rapid vertical descent of the cylinder between any two depths as may be desired, and the specimens captured and retained. Somewhat more practical than the gravitation cylinder is some form of closing tow-net which can be used at depths from 20 to 200 fathoms and consists of a series of nets one within the other attached to a folding brass ring. This net, after being lowered to a desired depth, is towed through the water until it is desired to heave in, when the jars are closed by means of a messenger or weight sent down along the tow line to a tripping device, which closes the jaws as shown in the front page illustration.

Most of the fish living at the surface of the water in the deep sea as distinguished from those inhabiting shore waters on the continental slopes, where the distribution of animal life is often continuous, are restricted in their habitation and the intermediate nets usually obtain but little of consequence save near the surface and at the bottom. When the sea floor, with a more extensive fauna, is reached, there are a number of devices available. Such are the tangles, which are dragged along a rocky bottom to capture specimens. They consist of deck swabs or bundles of rope yarn attached to an iron bar bent in the form of a V. For such forms as mollusca, annelids, crustacea, etc., which burrow beneath the surface out of reach of ordinary apparatus, there is employed the rake dredge, which is a frame with teeth about seven inches in length, followed by a dredge proper into the net of which the specimens are gathered. With a dredge or trawl may be used a mud bag to collect a compact mass of the bottom mud or ooze, which not only affords a sample greater in amount than that supplied by the cylinder with the sounding weight, but often contains numerous specimens. For dredging along the sea bottom, which has been done down as deep as four and one-half miles, the deep-sea beam trawl is used, which consists of a net arrangement rigged to an iron frame across the mouth of which there extends an iron beam which may be dragged along the bottom to sweep the specimens into the net. Ordinarily the trawl is about 11 feet wide by 2 feet high, with a net 20 feet in length, being towed by a wire rope rigged through a boom carried on the starboard side. A dredge haul from a depth of four and one-half miles is quite an undertaking and requires 10 hours.

In the course of the journey to the surface most of the ooze is washed away, but with good fortune the specimens are retained. These of course vary with the locality and the depth, and it must be remembered that those from the greatest depths live under truly extraordinary conditions, and a deep-sea animal expires on its upward trip long before it reaches the surface. If from a sufficient depth where the pressure is great its appearance suggests an internal explosion due to the sudden relief of pressure, and the eyes seem to be blown out of their sockets and the bodies greatly swelled. Many of the animals from the depths are cartilaginous and do not have a bony structure, as the very cold water at the bottom, only a few degrees removed from a freezing temperature, is not conducive to the formation of carbonate of lime.

In addition to the cold there is also the absence of sunlight, and recent observations by Sir John Murray show that from 300 fathoms downward the effect of light gradually decreases to zero at about 900

fathoms, the violet rays penetrating deeper than other parts of the spectrum. Down in the depths phosphorescence plays an important part, and many animals have organs or processes for generating light which may be used where otherwise sight would be useless. Again in other cases the organs of sight have degenerated or disappeared entirely. It is the opinion of most deep-sea explorers, and confirmed by the cruises of the "Albatross" in 1899, and of Sir John Murray in the "Michael Sars" in the present year, that at great depths at considerable distance from land and away from any great oceanic current there is comparatively little animal life to be found, though specimens were obtained by the "Albatross" from 4,173 fathoms.

The Prince of Monaco argued that the deep-sea animals might be too cunning to be caught in a clumsy trawl, and accordingly designed a trap which could be used on the bottom surface, and with it he has caught an amphipod at as great a depth as 3,000 fathoms, and often at 700 fathoms. Increasing the size of the dredge has also brought to light larger fish, and while dredging from the "Albatross" off the coast of Chile, Gill and Townsend secured at a depth of 1,000 fathoms a very heavy fish five feet in length, entirely unknown to naturalists.

The animals of the deep sea occasionally present archaic characteristics, but taken as a whole among them are not represented any more remnants of the faunas of remote geological periods than are to be found in the shallow and fresh waters of the continents. This can be readily understood, as the deep sea is believed to be the last place on the earth's surface to be inhabited, and the comparison of deep-sea animal forms with those known to the paleontologist in fossil remains seems to bear out this theory.

On the sea bottoms are found fish and members of the invertebrate groups quite unlike those of the shores, while the very ooze of the bottom itself often is formed by the decomposition of dead organisms from a higher level falling with their shells. On the illustration have been noted some of the curious fish with the depths of their habitation, and while they can be considered as typical, yet it must be remembered that the variety of life is almost infinite and that the microscopic organisms concern the zoologist quite as much as those of more appreciable size. Sir John Murray believes that there is animal life through all the layers of sea from the surface to the bottom, and that there is not, as has been believed, a stratum where life is absent, located below those layers of the sea where the pelagic forms are most numerous.

When attention is called to the fact that great reefs and islands have been formed through the activity of small coral animals we have but a single instance of the importance of zoological studies in the deep seas, and other results already attained in the biological branches of oceanography are of no less importance. To-day hundreds of naturalists are working on the materials and data collected by Agassiz, the Prince of Monaco, and other deep-sea explorers, and each year science is enriched with further knowledge of the interesting planet on which we live as the depths of the sea are beginning to yield up their secrets long hidden from man.

Joseph Brucker on Wellman.

Our German contemporary Umschau publishes an article by Joseph Brucker on Wellman's attempted aerial voyage across the Atlantic. Mr. Brucker's remarks are of interest, because it is his intention to attempt a similar feat in the opposite direction from the Cape Verde Islands to the West Indies. He says:

"I have repeatedly pointed out that in the present state of the art, it will be impossible to cross the Atlantic Ocean with an airship north of the thirty-fifth parallel of latitude, because in that region one depression follows another, and above all at this period (October) of the year. Wellman was meteorologically ill advised. By that I do not mean that the weather reports which he received from Washington were not trustworthy, but that a serious study of the meteorological conditions must have dissuaded him from setting out on such an expedition.

"On Saturday, the 15th of October, it was well known that a violent hurricane was raging in Cuba. It is well known also that such violent disturbances of the atmosphere in those latitudes are followed by extraordinary collateral phenomena in latitudes thirty-five to forty degrees north. Whoever would take the trouble to follow the journey of the 'America' as charted by Wellman, will find this statement confirmed. The 'America' at first flew in a northeasterly direction until it was about south of Cape Sable. It was then suddenly driven in a southeasterly direction by a northwest storm and then again to the southwest to a spot where it crossed the direct line between New York and Bermuda almost in the same latitude as Cape Hatteras.

"It also seems that Wellman could not rely on his motors. One of his engines was disabled soon after he set out and the other was probably not powerful

enough to enable the 'America,' when the northwest winds blew up, to keep a more easterly course. The 'America' seems to have traveled more like a free balloon, for which reason this performance should not be regarded as a record for dirigible airships. Wellman would probably hardly maintain that he could follow a definite course with his 'airship.'

"Another fatal error was the 'equilibrator,' to which Engineer Vaniman pinned his fate. This 'equilibrator' was in itself a very cumbrous contrivance with its thirty gasoline tanks, and turned out to be a source of danger to the 'America.'

"Dr. Alt of the Munich Meteorological Station and I have made many experiments during the last few months with arrangements similar to Wellman's equilibrator. We have given the tanks the most diverse forms, only to come to the conclusion that all such devices, when an airship is traveling over water, not only produce an enormous resistance, but are also highly dangerous to the airship itself. The 'America' seems to have perished from appendicitis. A surgical operation, however, could not be performed, because the airship, if it had been relieved of its burden, would have risen to an enormous height, and would have faced new dangers.

"The expedition which I have organized is the result of scientific study. It is our intention to start from the Cape Verde Islands, about 2,350 miles from the Lesser Antilles. There are no counter winds in our course, no storms, no fogs, but we hope to travel with the wind at a rate of about seven meters per second.

"In the beginning of December we hope to attach the boat to the gas envelope, the capacity of which has been increased recently to nine thousand cubic meters. After that the airship will be christened 'Suchard' of the Parseval shed at Munich. By the end of January we will ship the entire apparatus to the Island of St. Vincent in the Cape Verde group. The latter part of February or the beginning of March, we hope to start our journey."

Motion of Molecules in the Tail of Halley's Comet.

Prof. Lowell has issued a bulletin on the motion of molecules in the tail of Halley's comet. In this bulletin he has endeavored to measure the recession of the tail particles, so as to obtain both an observational proof of the recession, and also something approaching an exact value of the velocity at a given time and place. He used some 200 photographs, more or less, of the comet, taken at his observatory between April 18th and June 6th. From this he selected a pair taken one after the other on the same evening, that of May 23rd, in which it was possible to detect irregularities capable of recognition and measurement. Choosing four of the more salient features, he measured their distance from the nucleus on the two plates. He found that the distance was greater on the second plate than on the first, and furthermore that the differential distances increased with distance from the heat. The first plate was exposed from 9 hours 23 minutes to 9 hours 53 minutes and the second from 10 hours to 10 hours 53 minutes.

When the angular amounts of the changes in place of the several knots were corrected for differential refraction and then reduced to speeds, account being taken of the distance of the comet from the earth and of the inclination to the line of sight of the respective positions along the tail, the results came out as follows:

TAIL OF HALLEY'S COMET.

	Angular distance from the nucleus to the point measured in the tail.		Velocity of the point of the tail away from the nucleus.
	Deg.	Min.	
Knot 1	1	28	13.6
Knot 2	3	12	17.2
Knot 3	4	36	19.7
Knot 4	6	15	29.7

The Current Supplement.

Mary Cynthia Dickerson's excellent description of the American Museum of Natural History's expedition in the heart of Africa is concluded in the current SUPPLEMENT, No. 1822.—Gen. J. P. Farley, U. S. A., retired, traces the evolution of the silencer for military rifles.—Cornelius D. Ehret's review of wireless telegraphy and telephony is concluded.—P. F. Mottelay writes sympathetically on André Marie Ampère.—The old geometrical problem that the square on the hypotenuse is equal to the sum of the squares on the other two sides is considered by Mr. Arthur R. Colburn. He presents many solutions different from those with which we are familiar.—Dr. Adolf Koelsch contributes an article on color sensitiveness in animals.—A description of the airship in which E. T. Willows recently crossed the English Channel is published.—Mr. J. Mayne Baltimore writes on the great bridge which spans the Copper River.—The concluding installment of Mr. Grover Cleveland Loening's paper on "The Practice and Theory of Aviation" is published.

Goiters and Cretinism.

We are often reminded that all science is one, and that we have sciences for convenience in investigating and classifying. We are also made to marvel at the remarkable interrelations that exist among different fields of knowledge; we come to expect the sciences to co-operate and are not startled when a discovery in astronomy advances the solution of a problem in chemistry, or when an accident in an electrical laboratory clears up a physiological mystery. But we have not yet learned to look to geology for help in medicine. But all science is one.

In certain parts of Switzerland goiters and imbeciles are as abundant as grafters in Pennsylvania or millionaires in Pittsburg.

The cause of the goiter is a swelling of the thyroid gland, which lies in the front part of the neck. The cause of cretinism is a failure of this same thyroid gland to produce the proper juice. But what makes the gland swell up, or go back on its normal juice-making function, has not been ascertained.

It has been known that these abnormalities are associated with the drinking of certain waters. In regions where these diseases are common an improvement always followed the introduction of a new water supply. That the water is responsible is further shown experimentally: rabbits and other animals, and even fishes, have developed goiters as a result of being supplied with water from "goiter-wells."

These facts led to the suspicion of "germs." This suspicion was strengthened by the fact that boiling the water makes it harmless. But attempts to isolate the supposed microbes all ended in failure. Not only was there no success in cultivating malignant germs from unquestionably harmful water, but whatever it is that makes the trouble goes right through a filter like a fool through a fortune; and the filtration of the water through the stone, while it separates out all other known causes of disease, leaves the goiter-water as efficacious as ever.

Now along comes Dr. M. Wilms, professor of surgery at the University of Basel, and calls attention again to the fact that the regions in which goiter and cretinism are endemic are characterized by certain geological formations: goiter-water comes from strata that had been sea-bottoms in ancient epochs of the world's history, but never from over granite deposits or chalk or ancient lakes. Prof. Wilms then develops the theory that the disturbance in the thyroid gland is brought about by some subtle poison derived from the decomposition of animals and plants that turned to fossils ages ago.

This theory is in perfect agreement with the fact that goiter-water continues to be active when heated up to 50 to 75 deg. C. (122 to 167 deg. F.), but it is quite harmless if heated beyond 80 deg. C. (176 deg. F.). Many organic poisons are known that behave in just this way. The conclusions are based upon the results of experiments conducted with animals.

While the actual cause of these distressing disorders is not known, it is a step forward to know how to avoid the diseases.

Experiments on the Rusting of Various Sorts of Iron in Warm Water.

A series of experiments on the rusting of various sorts of iron in warm water has been made in the royal technical laboratory in Berlin at the instance of the German society for the promotion of arts and manufactures.

German and English tubes and plates of Siemens-Martin, Thomas and ordinary wrought iron were tested. The tubes, which were about 1 inch in diameter and from 11 to 14 inches long, were joined together to form a steam-heating coil in an iron tank, the tubes being electrically insulated from the tank and from one another, in order to prevent the generation of electric currents. The plates, some of which were 0.2 inch and some between 0.03 and 0.04 inch thick, were also insulated and were suspended inside the coil. The tank was filled with water, and steam at a pressure between 1.5 and 3 pounds was passed through the coil 6 hours daily.

The temperature of the water was about 194 deg. F. at the surface and ranged from 131 to 158 deg. F. at the bottom. In the first experiment, which continued three months, the water was drawn from the city mains and was frequently renewed, in order to bring air to the specimens in conditions similar to those of practice. At the end of this experiment all of the specimens were found to be thickly incrustated with boiler scale. In the subsequent experiments distilled water was used in order to prevent incrustation, and the water was aerated daily, before the steam was turned on, by forcing air through four pipes which descended nearly to the bottom of the tank.

Very little difference was observed in the rusting of the various plates and tubes, except that plates which had been scoured with the sand blast were more affected by rust than specimens of the same sort of iron from which the "skin" produced by rolling had not been removed.