Johannes Schmidt.

(1877—1933).

PROFESSOR JOHANNES SCHMIDT died in Copenhagen on February 21, 1933, at the age of 56. For some years he had suffered from heart trouble, and he was unable to withstand an attack of influenza; nevertheless his death came as a shock to his friends, for he looked well and vigorous, and was so full of his plans and ideas, that it was not easy to realize that his health was far from good. Only last November he was in London, and after a Royal Society

Club dinner delighted those present with an account of the migrations of the cod from Greenland to Iceland, and back again after breeding.

Schmidt was born on January 2, 1877. He studied at the University of Copenhagen, taking the degrees of M. Sc. in 1898 and Ph. D., in 1903. In 1899 he accompanied, as botanist, an expedition to Siam, and on his return, after a short service in the Danish Biological Station, he was attached to the Botanical Department of the University of Copenhagen, and also acted as biologist of the Danish Commission for Investigation of the Sea, holding both posts (1902—1909) until he became a member of the Commission. In 1910 he was appointed Director of the Carlsberg Physiological Laboratory, a post that he held until his death.

Schmidt's first published works, in 1899, were an experimental study of the influence of external agents on the structure of the leaves of maritime plants, and a monograph of the Cyanophyceae of Denmark. In collaboration with Fr. Weis he published a large general work on Bacteria (Copenhagen, 1899—1901), of which a German edition appeared in 1902. In 1901 he published a description of *Richelia*, a new alga living in plankton diatoms, and in 1903 an account of the Cyanophyceae of Iceland, and a considerable work on mangrove shoots. From this time his botanical interests were for some years confined to the "Flora of Koh Chang", which he edited, writing the introduction in 1900 and the conclusion in 1916, and contributing the sections on Peridinales, Rhizophoraceae, and Combretaceae. From 1913 to 1917 he made experiments on hops, and published papers on their growth, aroma, and the results of cross-breeding.

The above short summary of Schmidt's botanical work indicates that his achievements in this field were by no means negligible; they were, however, overshadowed by the oceanographical work that made him famous throughout the world.

As biologist to the Commission for Investigation of the Sea Schmidt made expeditions to Iceland, the Faroes, and as far south as Spain; he studied especially the places and seasons of spawning of fishes, the distribution of the fry, and the distinctive characteristics of species and races in their larval and post-larval stages. He had always in mind the relation of life-history and distribution to hydrographical factors such as temperature, salinity, and currents. During this period (1903—9) his papers on this subject, all of a high standard, were published by the Commission, except the last

and perhaps the most important, namely, "The Distribution of the Pelagic Fry and the Spawning Regions of the Gadoids in the North Atlantic from Iceland to Spain" published by the International Council (Rapp. et Procès-Verb. X, 1909, pp. 1—229).

In 1897 G r a s s i had shown that *Leptocephalus brevirostris* was a larval form of the Common Eel, by finding at the surface of the sea in the Straits of Messina a number of specimens illustrating the change from leptocephalus to elver. He believed that eels bred near the coasts in deep water, and that the larvae lived at the bottom, and were brought to the surface of the Straits of Messina by whirlpools. S c h m i d t was first led to suspect the correctness of these conclusions in 1904, by the capture of an eel-larva at the surface of the sea between Iceland and the Faroes. This clue was followed up, and in the spring and summer of 1905 and 1906 numerous larvae were caught, all near the surface, over deep water in the Atlantic, from the Hebrides to Spain. All these, however, were full-grown, and it had to be established whether the earlier larvae were to be found in the same places at a different season, or not. As it was impossible to work with the "Thor" in the Atlantic in winter, the Mediterranean was chosen as the site of further operations, which began in December, 1908, and continued to 1910. The result was most surprising; no early larvae were taken; full grown larvae were found to be abundant in the Mediterranean west of Italy, but not further east, in the summer, and a few were taken near Gibraltar in the winter. It was clear that the breeding-place of the Mediterranean eels, as well as of those of Western Europe, was in the Atlantic, and was somewhere to the west of the region where larvae were so far known to occur. A search through the collections of the Zoological Museum of Copenhagen now enabled S c h m i d t to identify some smaller larvae from the North Atlantic as larvae of the Common Eel, and Danish vessels crossing the Atlantic in 1910 and 1911 made collections, with the result that larvae 35 to 50 mm. long were described as occurring near the surface of the Atlantic, between 18° and 53° W. and 25° and 41° N. The results up-to-date were summarized in an important paper, entitled "Danish Researches in the Atlantic and Mediterranean on the Life-history of the Freshwater-eel" (Internat. Rev. Hydrobiol. V. 1912).

The practical importance of these researches was considerable. The main fisheries were in the autumn, when the silver

eels were intercepted on their way to the open sea. When it was believed that eels bred near the coast, and that the elvers that ascended a river were the offspring of eels that had come from the same river, it was reasonable to suppose that the stock might be increased by allowing a proportion of the eels to escape the traps or nets, and so reach their breeding places. The demonstration that all European eels bred far away in the Atlantic made it clear that such a method would have no effect; the only way to increase the number of eels in rivers remote from the Atlantic was to supply them with elvers from Atlantic rivers, and this would have no permanent effect, but would have to be done year after year. These things were quickly realized in Germany, and from 1910 to 1914 millions of elvers were transferred from the Severn, a river that could spare them easily, to German rivers. These operations were resumed after the war.

Further researches on the Eel were postponed by the Great War, but in the years 1920 to 1922 Schmidt made two voyages across the Atlantic, the first in the schooner "Dana" and the second, from the Mediterranean to the Gulf of Panama, in the research ship, a converted trawler, of the same name. As a result he was able to show that the earliest larvae, less than 10 mm. long, were to be found only in an area S.E. of Bermuda, and that this area must be the breeding place to which all European eels resort. He demonstrated the growth of the larvae as they spread out across the Atlantic, and showed that the full-grown larvae that occur off the coast of Europe in the summer are 2½ years old, and the elvers about 3 years old. A surprising feature of this investigation was the capture of larvae of European and American Eels in the same hauls in the Western Atlantic, sometimes in almost equal numbers. The breeding area of the American Eel was established as a little south and west of that of the European Eel, but overlapping it. Schmidt found that the American Eel had a similar larval history to the European Eel, but much shorter, the elvers being only one year old instead of three. The prolonged larval life of the European Eel appeared to be peculiar to that species, in relation to the long distance to be travelled. These discoveries were published in 1922, in a memoir entitled "The Breeding Places of the Eel" (Phil. Trans. Roy. Soc. B. CCXI.).

The question why European eels travel such a long distance was answered as follows, that the eel, like many other

fishes, is peculiarly sensitive to external conditions at the breeding season, that it breeds probably at about 500 metres below the surface, and that its breeding-place is one where the water at that depth has a higher temperature and a higher salinity than anywhere else in the Atlantic. Thus the paradoxical conclusion was reached that the distribution of a fish that ranges from Iceland to the Nile, and inhabits both fresh and salt water, depends on temperature and salinity. That all species of *Anguilla* breed under similar conditions, and that this explains the peculiar distribution of the genus, was put forward in 1925, in a paper published by the Danish Academy, and was fully established as the result of the voyage of the "Dana" round the world in 1928 to 1930, an expedition led by S c h m i d t and financed by the Carlsberg Foundation.

The "Thor" and "Dana" expeditions have been mentioned in relation to eel investigations, but these were by no means their sole object. Even to establish where, and at what depths, eel-larvae did and did not occur, numerous hauls had to be made, and many other things than eel-larvae were caught. In addition larger mid-water nets were fished at depths down to 3000 metres below the surface, and enormous collections were made, far surpassing those of all previous oceanic expeditions put together. Even the preliminary sorting of this material was an enormous task, and the finding of specialists to work out and report on the different groups one of great difficulty, for the "Dana" collections would occupy the time of the zoologists of the world for a good many years. S c h m i d t acted as editor of the series of reports, of which ten of the Mediterranean Expedition (1908—10), eight of the North Atlantic Expedition (1920—22), and one of the Carlsberg Foundation's Expedition round the World (1928—30) have so far appeared. These contribute greatly to knowledge of oceanic life, include descriptions of many novelties, and contain much that is new concerning the classification, development, and distribution of oceanic organisms. It is to be hoped that the continuation of these reports, which S c h m i d t had planned and so much desired, will be carried on.

The "Dana" is a small ship to have journeyed so far and achieved so much; but S c h m i d t said to the writer of this notice: "When the ship is rolling about in the middle of the ocean, and the nets are being fished, it is a great advantage to be near your work". In these conditions also he found simplicity desirable, and did not use devices for closing nets,

but relied on a comparison of numerous hauls made at different depths to give the true vertical range of a species.

His early work on races of fish had shown Schmidt that these could often be distinguished by slight differences in averages of numerical characters. When he found reason to believe that the Mediterranean eels bred in the Atlantic, he made an analysis of the number of vertebrae in samples of eels from various localities, both Atlantic and Mediterranean, and found that each sample had the same range (110—120) and the same average (114.7), a result that suggested that all European eels were of one race and had one breeding-place. For comparison he now made a statistical investigation of *Zoarces viviparus*, an eel-like fish with about the same number of vertebrae as the eel, but viviparous, and not migrating for breeding. This fish is abundant in Danish waters, particularly in the shallow inlets known as fjords.

The fjord-fish are less slender than those outside in the open waters of the Kattegat or Baltic, and Schmidt found that they differed from these in numerical characters, the number of vertebrae, for example, decreasing in each fjord as the distance from the sea increased, until in the inner waters a population might be found differing from that of the open sea as much as the European from the American Eel, i. e., a difference in average of 10 vertebrae. Conditions of temperature, salinity, etc. varied so much in the fjords that the decreased number of vertebrae in them could not be assigned to the action of these agencies.

Having established, in 1917, that the non-migrating habit was correlated with localization, and the formation of populations of very different constitution, Schmidt investigated further. Offspring analyses, comparison of young with mothers, proved the number of vertebrae to be hereditary. Year-class analyses, the year-classes being ascertained from the structure of the scales, showed no significant fluctuation in average of vertebrae from year to year, but in another character investigated, the number of spinous rays in the dorsal fin, revealed a notable increase in one year, which appeared to be related to a particularly cold breeding season.

A little viviparous Cyprinodont, *Lebistes reticulatus*, was now selected for experimental work, its small size and quick breeding making it much more suitable than *Zoarces*. Among the results obtained was that the number of rays in the dorsal fin varied according to the temperature of the water at the time of early embryonic development, the rays being more

numerous with a high temperature than with a lower one. This, and other results, led Schmidt to hope that by analysis and experiment he might arrive at the solution of the problems of variation and of racial differences. When he died he had nearly ready for publication another contribution of great originality, and of far-reaching importance in this connection.

So far we have summarized Schmidt's contributions to science as botanist, oceanographer, biometrician, and experimenter. His success in these fields was due to his personal qualities, his enthusiasm, his capacity for hard work, and in particular a remarkable flair for visualizing the nature of a problem and the way in which it could be solved. His original papers, 126 in number, nearly all written in English, reveal the hand of a master in that the data are presented in such a manner that the inferences therefrom can readily be understood. As a director of researches and a leader he inspired others with confidence and enthusiasm, and had a band of willing helpers on whom he could rely.

Schmidt was a member of the Danish Academy, and an honorary member of many foreign societies. In 1923, he received an honorary D.Sc. from the University of Liverpool, and the Weldon Memorial Prize from Oxford. His other awards included the Agassiz Medal (U.S. Academy of Sciences, 1930), the Darwin Medal (Royal Society of London, 1930), the Galathea Medal (Royal Danish Geographical Society, 1930) and the I. Geoffroy St. Hilaire Medal (Société d'Acclimatation, Paris, 1931). He received decorations from no less than ten countries, including France, Italy, Holland, Norway, and Spain. These honours show that Schmidt's work was fully appreciated, but no notice of him would be complete without mentioning an extraordinary rebuff that astonished him greatly. His paper on the Life-history of the Eel, published in Germany in 1912, had first been sent to London for publication by the Royal Society, but was returned to him with an intimation that Grassi's work on this subject was considered to be sufficient. No better example could be given of the fact that the system of refereeing scientific papers has its imperfections. Ten years later the writer of this notice received from Schmidt his paper on the Breeding Places of the Eel, and communicated it to the Royal Society, who published it, and later made full amends by awarding Schmidt a medal.

S c h m i d t was dark, good-looking, youthful and intellectual in appearance; he had many friends and was a charming companion. Unlike some men of science he was always ready to tell what he was doing and what he hoped to achieve, but in a quiet and modest way, and with an appreciation of the views of others.

S c h m i d t's residence in Copenhagen, his connection with the International Council for the Exploration of the Sea, and his position as a leader, imposed social duties on him in which he was helped greatly by his wife. In 1903 he married Ingeborg Kühle, daughter of the chief director of the Old Carlsberg Brewery. To her gracious qualities as hostess a tribute was paid in "The Times" by the President of the International Council, and we offer her our sympathy for the loss of her husband, of whose distinction she was so proud.

C. T. R.