wagneri. Within either of these groups, as yet, it has not been found possible to make any serological distinction. The study of blood relationship within the order Rodentia is being continued, using both birds and rabbits as antibody producers.

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LUMINESCENCE

I READ with very great interest the article on "The Excitation of Luminescence by the Agitation of Mercury in Glass and Transparent Fused Silica Tubes and Vessels" by W. L. Lemcke in SCIENCE of January 18. At the close of the article it was suggested that it would be of scientific interest to examine the radiations coming from a transparent fused silica vessel with the aid of a spectrograph with quartz prism and lenses. This problem has occupied my time for the past few months. It is my aim to examine, as Lemcke suggests, the effect on the luminescence produced when certain gases and solids are present in the vessel.

Using a standard "Shaker" tube of transparent fused silica and a Hilger E_2 Quartz Spectrograph I was able to record very definitely on a plate the resonance line λ 2537 Å of Hg with exposures as short as forty-five minutes. The tube was 2.5 cms in diameter and had the usual central inner tube. That part of the tube which contained the inner tube and the mercury was 15 cms in length. Only mercury, its vapor and air at very low pressure were present in the tube. A crank on the shaft of a small electric motor gave the tube a horizontal reciprocating motion in front of the slit of the spectrograph, which was distant about 3 cms from the axis of the tube.

A trial exposure of forty-two hours with the same apparatus brought out a great number of lines in the visible region as well as a faint continuous spectrum and a very interesting looking band extending from λ 2537 Å to about λ 2570 Å, where it cut off sharply. Further work is being done on this problem and the results will be published.

Interesting in connection with this problem is the work of Duffieux[1, 2] and of Robertson, MacKinnon and Zinn.[3] The former examined the luminescence produced when an evacuated spherical Pyrex bulb containing a large drop of mercury is rotated, and the latter rolled a drop of mercury on the inside of an evacuated quartz tube in order to produce a continuous mercury spectrum. In both cases the temperature was from 60° to 240° C. I have thus far confined my investigation to temperatures near 30° C.

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[1] Duffieux, *Comptes Rendus,* 1927, *184,* p. 1434.

[2] Duffieux, *Jour. de Phys. et le Rad.,* 1928, *9,* p. 61.

[3] Robertson, MacKinnon and Zinn, *J. O. S. A. and R. S. I.,* 1928, *17,* p. 417.

SPECIAL CORRESPONDENCE

THE DANISH CIRCUMNAVIGATION EXPEDITION

IN May, 1904, the Danish research vessel *Thor,* fishing over deep waters west of the Faroes, found a fully grown larva of the common European fresh-water eel. Up to that time corresponding stages were only known from the Straits of Messina, in the Mediterranean. The find led the young fishery biologist, Johs. Schmidt, into whose hands it came, to devote himself to the problem of the eel, and for twenty-five years he has been engaged upon the task. He is now on his way around the globe with an expedition mainly designed to ascertain the breeding grounds of eels all over the world. Endeavors will, however, also be made to elucidate various other oceanographical questions which have arisen during the past twenty-five years of research.

Thus, as so often before in the history of science, an apparently small discovery has led to far-reaching developments; many problems have been solved, and even more have arisen, in the course of the cruises organized by Professor Johs. Schmidt, of the Carlsberg Laboratory, Copenhagen, in connection with his investigations on the eel. During the past twenty-five years, the following expeditions have been sent out from Denmark, with eel investigations among their principal aims; the cost of these expeditions has been defrayed by the Danish government, by the Carlsberg Foundation, by the East Asiatic Company in Copenhagen and by private persons interested in the work.

Thor, 1905–06, in the Atlantic west of Europe.
Thor, 1908–10, in the Mediterranean.
Margrethe, 1913, Europe, West Indies.
Dana I, 1920–21, Europe, West Indies.
Dana II, 1921–22, Europe, South America, West Indies, Panama, West Indies, U. S. A.

The present *Dana* expedition, which is to occupy two years, left Denmark in June, 1928, and is under the patronage of His Royal Highness Prince Valdemar of Denmark.

The route to be followed is as follows, westward around the globe: First to Spain, Portugal and the Straits of Gibraltar, with the western part of the Mediterranean; then via Madeira to the West Indies and on through the Panama Canal into the Pacific, to Tahiti, the Fiji Islands and New Caledonia; thence to New Zealand and Eastern Australia. In the waters east of Australia, two months will be spent, and the vessel will then proceed, in March, 1929, northward to Japan and China; later, the Malay Archipelago will be visited (Dutch Indies, Siam, etc.); and investigations will then be made in the Indian Ocean along a line from Java to Madagascar. From Madagascar, the course will lie along the East Coast of Africa, and through the Red Sea and the Mediterranean. The expedition is expected to terminate in the spring of 1930. A great part of the route has already been covered, and the *Dana* is now working in the area between the Fiji Islands and New Caledonia. The vessel, which is of 360 tons, is the marine research vessel of the Danish government, but is sent out at the expense of the Carlsberg Foundation; it is equipped with the most modern apparatus for the various forms of deep-sea fishery investigations, as well as the most recent instruments for hydrographical observations, etc. Throughout the voyage, soundings will be taken with an echo-sounding machine, the observations thus covering the circuit of the globe. The vessel is in constant direct communication with Copenhagen by means of a short-wave transmitter.

It will be natural here to give a survey of the historical progress of the special eel investigations which form one of the principal objects of the expedition.

Prior to 1904, it was believed that the breeding grounds of the eel were situated in the Mediterranean; there was nothing to show that it ever bred elsewhere. The expeditions of 1905–06 established the fact that the eels of Scandinavia and those of Western Europe came from the Atlantic. The further work of the 1908–10 expeditions showed that the eel did not breed in the Mediterranean at all, the larvae found there having made their way in through the Straits of Gibraltar. Then came the discovery, on the cruise of 1913, that the eel larvae increase in number and decrease in size (age) from east to west across the Atlantic, leading to the conclusion that the breeding grounds must lie in the western part of that ocean.

Finally, the expeditions of 1920–22 demonstrated the fact that all the eels of Europe spawn only in a restricted area of the Western Atlantic, in the vicinity of the West Indies. From here, the larvae migrate across the ocean, increasing in size until—about three years after their first coming into the world—they appear as elvers ascending into the fresh waters of Europe and Northern Africa. It was further shown that the American eel (*Anguilla rostrata*) has its center of production close to that of the European form, that its larvae occur in the ocean together with those of the European eel, and that the larvae of the two species may be distinguished one from the other by the number of myomeres (vertebrae). In contrast to those of the European, the larvae of the American eel take only one year to accomplish their development, *i.e.*, about one year after birth they make their way as elvers into the fresh waters of North America. The difference in duration of the larval stage as between the European and the American eel, together with the direction of the ocean currents, afforded an explanation as to how the young of the two species, starting from approximately the same point, were distributed to opposite sides of the ocean.

The results of the above-mentioned expeditions show that the biology of the two species of eel found in the Atlantic is of a highly remarkable and differentiated character, especially as regards the European eel, the larval migrations of this species far surpassing anything known among other animal forms. In accordance with this biology, we find that all the millions of eels in Europe and North Africa belong to one and the same race. It is immaterial whether samples be drawn from Iceland, the Baltic or Egypt; no racial difference can be shown to exist between them. The average number of vertebrae is invariably about 114.7 (that of the American eel about 107.2).

It was desirable now to ascertain how the distribution of the fresh-water eel throughout the globe took place, and the biological effect of its larval migrations, often of enormous extent, as contrasted with the highly stationary species of many coastal fishes which have developed into a great number of different races. Accordingly, in 1922, racial investigations to comprise all species of fresh-water eels throughout the globe were entered on the program of the special racial investigations to be carried out by the Carlsberg Laboratory, in the course of which Schmidt has been endeavoring for many years to elucidate various important biological questions.

And in the course of the past five years, the laboratory has procured a very great amount of material of Anguilla from all parts of the world in which the genus is represented.

While serving its original purpose, *viz.*, the racial investigations of the Carlsberg Laboratory, the study of the genus Anguilla and its classification has at the same time given rise to various problems of great interest from the point of view of biological and physical oceanography, providing, moreover, the zoological basis for their solution.

The problems here in question are those of the biology of the Indo-Pacific Anguilla species, especially their migrations (position of the breeding grounds) and the movement of the larvae from the breeding grounds to the fresh waters of the continents, all in relation to the physical conditions of the oceans. It has already been possible to show that the eels of the Indo-Malayan area, like those of the Atlantic, breed in deep water, though these tropical species do not appear to undertake migrations of so great extent as those recorded from the Atlantic.

The researches of the Carlsberg Laboratory have shown that there are two species of Anguilla in the Atlantic, about six in the Indian Ocean and about twelve in the Pacific, making in all about a score of different species or a little over. These have been further examined in regard to a series of characters, the number of vertebrae in particular, as this feature differs greatly in the different species, and can also be distinguished even in the young larvae. The determination of the number of vertebrae in all the different species has thus provided a means whereby it is possible to identify the separate forms even as tiny larvae floating in mid-ocean. And this again furnishes the zoological basis for solution of the problem as to migration of the species.

In the Pacific, we find a whole series of biological types within the genus Anguilla, the most stationary being the tropical forms, whereas those of the temperate regions (China and Japan in the northern, New Zealand and Southeastern Australia in the southern hemisphere) are, as far as can be seen, migratory, albeit not to the same extent as the European eel.

Among exclusively tropical species we find, for instance, in *Anguilla mauritiana,* which has an enormous range of distribution, that the various populations differ in structure from one locality to another; it is, therefore, most unlikely that they should undertake migrations of any extent; it seems, indeed, as if some species only exist within a certain restricted area (*Anguilla borneensis*).

As regards the temperate species, on the other hand, everything seems to suggest that all these undertake a migration in the direction of the tropics, in order to breed there, the larvae then migrating in their turn, with the aid of the ocean currents, to those same temperate regions whence their forebears had come, and where the growth of the species takes place, in fresh water.

The *Dana* investigations in the Indian Ocean and in the Pacific have now two main objects: (1) to study and map out the distribution of the larvae of the various Anguilla species, and to ascertain in each case, as far as possible, how the different larval stages themselves are distributed; (2) to ascertain the physical and chemical conditions prevailing in the waters concerned, including the currents.

The route of the expedition has been determined beforehand with a view to these eel investigations, but a great number of other problems may also be solved in the course of the work.

Thus, while carrying out the operations necessary for its main purpose, the expedition will—judging from previous cruises of the *Thor* and *Dana*—automatically procure, in the first place, representative collections of the pelagic fauna, and, further, a general view of the physicochemical conditions in the waters traversed.

Some of the researches which have been or will be undertaken by the expedition in this direction may here be noted.

The study of the oxygen content in the deeper layers of the Pacific and the Indian Ocean, which may be said to have originated from the investigations of the *Dana* in the Gulf of Panama[1] in January, 1922, is of great general importance, and a survey of the distribution of oxygen will be most valuable as an indication of where the bottom water of the Pacific is formed, as well as for the understanding of the currents generally, or movements of the water at deep levels in both the oceans mentioned. The quantities of nitrates, etc., in the sea water will be investigated throughout the entire circuit of the globe.

As noted above, the topography of the sea floor will be studied in the Atlantic, Pacific and Indian Oceans by means of echo soundings. Particular attention will here be devoted to an investigation of the deep basins in the Pacific east of Australia and New Guinea, both as regards their topography and hydrography (by temperature and other observations, and drift bottles for current measurement).

Hydrographical sections will, as already apparent, be taken throughout the route. In the Straits of Gibraltar, especially, attention will be devoted to the interchange of water between the Atlantic and the Mediterranean; in the Straits of Bab-el-Mandeb, likewise, as between the Red Sea and the Indian Ocean.

The expedition will have abundant opportunities to procure material of pelagic organisms from the different oceans, and thus furnish important contributions to the zoogeography of the oceanic regions, for comparison between the pelagic animal communities of the different oceans, and for a further extension of the classification of many groups of pelagic fauna, as has already been done by the expeditions previously mentioned in the case of the Mediterranean and Atlantic.

The expedition will also be able to obtain a survey of the quantitative distribution of plankton in the waters traversed.

In the waters of New Caledonia, where a stay of some duration will be made, it will be possible to make closer investigation of the fauna of the sea

[1] *Cf.* Johs. Schmidt, "On the Contents of Oxygen in the Ocean on Both Sides of Panama," SCIENCE, June 5, 1925.

floor, partly by means of the bottom-sampler, partly by dredging and trawling.

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REPORTS

BATHYGENETIC AND OROGENETIC MOVEMENTS

PROFESSOR ALBRECHT PENCK, of the University of Berlin, addressed the Boston Geological Society in the North Hall of Walker Memorial at the Massachusetts Institute of Technology on Friday evening, September 28, 1928.

That a period of mountain making generally follows the formation of geosynclines, in which a great thickness of rocks was deposited in a gradually sinking basin, was an old idea originated by James Hall and further advanced by the studies in the Appalachian region. In the Bavarian Alps a limestone formation occurs, known as the Wettersteinkalk. It is of Lower Triassic age, and although it has a thickness of five thousand feet, it shows no important change from bottom to top. It represents deposition in a shallow sea, the bottom of which was slowly subsiding. The Wettersteinkalk is covered by the Raibl shales, which are in turn overlain by the Upper Triassic Haupt Dolomite, a formation also about five thousand feet thick. The thickest part of the Haupt Dolomite is offset geographically from the thickest part of the Wettersteinkalk, so that the great limestone masses form overlapping lenses. The whole thickness of the Haupt Dolomite also consists of deposits formed in shallow water, thus implying continuous subsidence. This type of progressive subsidence Penck called "Bathygenetic movements."

Walcott found evidence of similar movements in the northwestern part of the United States during his study of the Cambrian rocks. These rocks were formed in separate basins that continuously sank during the period of deposition. When bathygenetic movements occur successively at different times and the area of maximum depression shifts or migrates from one locality to another, the large lenses of sediments will be found either with overlapping edges or in separate basins.

An important observation in the Bavarian Alps is that the Raibl strata contain pebbles of Wettersteinkalk, indicating that sufficient elevation followed the sinking of the geosyncline to allow a conglomerate to form. The structure of the Wettersteinkalk is complex, but since the Raibl beds are horizontal, a compression must have followed closely upon the bathygenetic movements.

Professor Penck had just come east from a summer at the University of California where he had become familiar with the geology around Berkeley. There the Orinda formation of the Coast Range has a thickness of about five thousand feet, but its geographical extension is a very narrow one, being only ten to fifteen miles wide. The formation, which consists of clay, conglomerate and sands that were deposited in very shallow water, is of Upper Miocene and early Pliocene age. In the vicinity of Berkeley there are some other more recent formations also of narrow width and of great thickness. West of Berkeley, however, the Jurassic Franciscan formation is found, and no more Pliocene rocks are met until San Francisco is reached. There seem to have been two blocks, separated by north-south faults; the western one, containing the Franciscan rocks, was being elevated while the eastern one was sinking. Into the basin so formed, the material derived from the erosion of the elevated western block was deposited. Thus the Orinda formation was made.

The manner of deposition of the Orinda differs from that in geosynclines, which are structures of wide extent, and indicates the sinking to very considerable depths of very narrow belts. As to the cause of such sinking there are varying opinions. One view is that the basin is of synclinal form, while another is that the sinking block is bounded by faults and represents a graben. Professor Penck believes that the block was not pushed down by the sediments as they were deposited, but that the sinking took place by the movement of the underlying block, and into the trench so made the detritus was deposited. Another observation bearing on this same problem was made by Walcott, who noted that each sinking basin has its own individual succession of strata.

In no place are the Orinda beds horizontal, and all have been considerably disturbed. This disturbance followed closely on the deposition, as in the case of the Wettersteinkalk in the Bavarian Alps.

Returning to a discussion of the European locality Professor Penck noted that the chain of the Alps is bounded by the Alpine foreland, in which there is a great thickness of Miocene formations, several thousand feet in total, although elsewhere the deposits are not thick. Fifty years ago he made a study of this Alpine foreland, and found that although the lower strata could not be followed, one upper layer was sufficiently unique to trace, which he did with Franz Edward Suess. This layer, although somewhat tilted, is nearly horizontal. During the World War some drilling for coal and oil gave the opportunity to study the underlying strata. Bore holes, one of which was four thousand feet in depth, showed that all the underlying strata are inclined about 20 degrees. This indicates that the lower part was disturbed while the upper was not, and proves that the crustal movements