both sight and hearing would be less acute in the fatigued person; and the fact that such is not always the case tells rather against the value of the tests as an index of fatigue. Taking into account, however, the comparatively small number of observations recorded up to the present by Prof. Kent, irregular results of this kind must be expected, and it is quite possible that a large series of observations would prove these anomalous results to be of minor importance. The simplicity of the tests and the ease with which they can be carried out is a strong argument for their adoption, provided that extended observation shows that they yield constant results.

THE CHILKA LAKE SURVEY.[1]

THE object of the memoirs referred to below is to inaugurate for the fauna of the brackish waters and waters of fluctuating salinity of the Indian coasts a register co-ordinate with that essayed by the *Investigator* for the Indian abyssal fauna. In the Chilka Lake, which is one of the best-defined and most strictly conditioned of these brackish tracts, and in the hands of such skilled explorers and many-sided zoologists as Dr. Annandale and Mr. Stanley Kemp, the undertaking makes a singularly happy inception.

The first instalment of the results of this Chilka survey contains a most interesting introduction to the topography and hydrography of the lake, and a detailed account of its Sponges, Cnidaria, Ctenophora, Oligochæta, Echiuroidea, Polyzoa, and Cirripedia: the introduction, the Echiuroidea, and the Ctenophora are the joint work of both authors; the short report on the Oligochæta is contributed by Col. J. Stephenson; for all the other groups Dr. Annandale is solely responsible. The second instalment is composed of four reports—on the Mysidacea, the Stomatopoda, the Mammals, Reptiles, and Batrachia, and the Aquatic Insects —the first being by Dr. W. M. Tattersall, and the last containing a contribution by Mr. F. F. Laidlaw.

The Chilka Lake is situated not far from the famous shrine of Jaganath at Puri, at the Mahanaddi Delta end of the tract of sand-waste, scrub, and screwpine-swamp that lies between the Ganjam hills and the Bay of Bengal. It is about forty miles long, with a maximum breadth of about sixteen miles, and a depth of a few feet; and in its origin it is a silted bay which—except for a mouth about 300 yards wide near the north-easterly limit—has been finally cut off from the sea by a narrow sand-spit formed (in the way usual along the east coast of India) by the strong northerly currents. By its narrow mouth it is in communication with the sea, while into the same north-easterly end run some of the waning effluents of the Mahanaddi Delta.

The survey under report embraced all the cardinal seasons of the year, and included 171 collecting stations. The observations show that in the wet season, when the Mahanaddi is in flood, the water of the lake is nowhere more than slightly saline, and over most of the area is quite fresh; while in the dry season it is nowhere anything but distinctly brackish, and in all the seaward area is as salt as the sea outside—facts of the greatest interest in their biological bearings.

The vegetation is considered mainly from the zoological point of view. Dense beds of Potamogeton give shelter to certain kinds of animals, and the leaves of a creeping Halophila afford anchorage to others; these are the characteristic water-weeds; for true seaweeds, of the higher kinds, are absent. At the water's edge there is little encouragement for sedentary organisms—no mangrove, and few screwpines, the most conspicuous shore-growth being a tall reed (Phragmites).

Beyond stating that the fauna as a whole is—as might be expected—mainly of marine origin, and specifying some distinctive features of the different habitats to which it conforms, the authors for the present make no generalisations outside the particular groups dealt with in their initial reports. Among interesting items it is noted that both fresh-water and marine sponges are found growing side by side, the former (Spongilla) being unable to resist high degrees of salinity, but the marine forms seeming perfectly comfortable in the wet season when the water is quite fresh; among the latter the world-wide *Cliona vastifica* and the Japanese *Suberites sericeus* are common, both producing gemmules in abundance. The Cœlenterates include eight or nine Hydrozoa, six Actinozoa, a Scyphomedusa, and a Ctenophore. The last, like several of the Hydrozoa, is a periodic visitor during favourable conditions; but the Scyphomedusa, though a common inhabitant of the Bay of Bengal, has established itself in the lake, and subsists, though in a state of repose, even when the water is quite fresh. Two species of Actinozoa (*Halianthus limnicola* and *Edwardsia tinctrix*) and one Hydrozoon (*Bimeria fluminalis*) seem also to be quite acclimatised, though the two first-named are inclined to be torpid, but with fecundity unaffected, in the fresh-water season. The barnacles of the lake belong to two widely distributed marine species, and also are inured to fresh water.

The common species of Squilla and all the four species of Mysidæ found in the lake appear to adapt themselves comfortably to all the seasonal changes of salinity. In the account of the aquatic insects, Mr. Laidlaw records as particularly noteworthy the existence in brackish water of the larvæ of an Agrionid dragonfly. The higher vertebrate fauna includes an otter, a dolphin (Orcella), the gharial and another crocodile, the hawksbill and edible turtles and a mud-tortoise, and three species of water-snakes.

The individual reports are instructive in fact and fertile in inference; all their regard for detail is infused with discernment; there is none of that assiduous piling up of wearying and bewildering minutiæ which so often makes eclectic work of this kind stale and unprofitable.

The memoirs are illustrated by numerous text-figures and twelve fine plates, which in the main are the work of those accomplished artists, Abhoya Charn Chowdhary and Shib Chunder Mondul.

[1] Memoirs of the Indian Museum, vol. v., No. 1, July. "Fauna of the Chilka Lake." By N. Annandale and S. Kemp. Pp. iii+146+plates. Price 15 rupees. Vol. v., No. 2, October. "Fauna of the Chilka Lake." Pp. 147-197+plates. Price 3.8 rupees. (Calcutta: Indian Museum 1915.

A VEGETATIVE CRUSTACEAN.[1]

EVERY text-book of zoology mentions, as one of the stock examples of degeneration, the curious cirripede, Sacculina, which lives as a parasite on crabs. Through the researches of Prof. Delage, more recently confirmed and extended by Mr. Geoffrey Smith, its life-history is now well known. After passing through free-swimming larval stages closely comparable with those of the normal barnacles, Sacculina attaches itself to its host and becomes endoparasitic, developing a system of branching roots which ultimately permeate all the organs of the crab. These roots radiate from a central mass of cells within which the sac-like body is differentiated, to emerge later on the surface beneath the crab's abdomen. While Sacculina is, as a rule, solitary, some related forms occur in considerable

[1] "On the Rhizocephalan genus Thompsonia, and its Relation to the Evolution of the Group." By F. A. Potts. Papers from the Department of Marine Biology of the Carnegie Institution of Washington, vol. viii., 1915. Pp. 32+ 2 plates.

numbers on a single host. The development of these has hitherto been something of a puzzle, since all the individuals found on one host are approximately in the same stage of development, and simultaneous infection by a swarm of larvæ seems improbable on account of the rare occurrence of the parasites. Mr. Geoffrey Smith, in 1906, made the suggestion that these gregarious parasites might be produced by some process of polyembryony or budding in the endoparasitic stage. He based the suggestion on the fact, observed by Delage and confirmed by himself, that the developing Sacculina may, as a rare exception, produce twin rudiments of the body within a single embryonic mass.

During the recent expedition sent by the Carnegie Institution of Washington to Torres Straits, Mr. F. A. Potts, of Cambridge, was able to investigate some of these "social" species of Rhizocephala and to obtain striking and conclusive evidence of the truth of this suggestion. The forms which he studied belong to the genus Thompsonia of Kossmann (with which he identifies Thylacoplethus of Coutière), and are parasites on various tropical crabs and shrimps. The saccular bodies occur in hundreds on the surface of the body and limbs of a single host, and are of much simpler structure than in the case of Sacculina. There is no mantle-cavity, nor are there genital ducts or associated glands, and the nervous system, reduced to a vestige in Sacculina, has entirely disappeared. Further, while Sacculina, like most cirripedes, is hermaphrodite, Thompsonia has no trace of male organs, and there is reason to believe that it reproduces solely by parthenogenesis. The sac-like bodies contain nothing but a mass of developing eggs or larvæ, which are set free in the so-called "cypris" stage, the earlier nauplius stage being suppressed. Mr. Potts was able to show that all the external sacs are in connection with a single continuous system of roots, and, further, that when the sacs are cast off by the moulting of the host (probably after their contained larvæ have been matured and set free), a fresh crop of sacs is budded off from the root-system.

It would scarcely seem possible to imagine a wider departure from our ordinary conception of an arthropod than that presented by Thompsonia, with its "mycelium-like root-system producing its singular asexual reproductive organs." Mr. Potts directs attention to the analogies it shows with certain Hydromedusæ. As if to complete the resemblance, he finds evidence that germ-cells are in some cases produced within the root-system, although he was unable to discover whether they migrate from thence into the developing buds as they migrate from the cœnosarc into the sexual buds of some Hydromedusæ. W. T. C.

CONDUCTION OF ELECTRICITY THROUGH METALS.[1]

THE power of transmitting large electric currents is one of the most characteristic properties of metals, and one to which they owe no insignificant fraction of their industrial importance. If we imagine for a moment the revolution that would be made in our daily life if metals did not possess this property, how much we rely upon it for light, locomotion, and communication, we shall realise how large a part it plays in our social life. It is not, however, on this aspect of metallic conduction that I wish to speak this evening, but rather on the mechanism by which the flow of current is produced, and the light which electric conduction throws on the structure of metals.

It is remarkable that though the quantity of electric current which flows any day or week through liquids or gases is quite insignificant in comparison with that which flows through metals, our views of the nature of conduction through gases or liquids are much more settled and definite than any we possess with respect to metals; it is remarkable, too, that progress in this subject is the outcome of the study of the flow of electricity through gases rather than through liquids, and that it is gases and not liquids which have given us the clue which promises to lead to the solution of the conduction of electricity through metals, which from many points of view is by far the most important case of conduction.

Many physicists have had the idea that the passage of electricity through metals might be analogous to that through liquids, where we have strong evidence that the current is carried by atoms or groups of atoms charged with electricity. Some of these atoms are charged with positive electricity, others with negative, but all help to carry the current, the positively charged ones by moving in the direction of the current, the negatively charged ones in the opposite direction; in the case of liquids the passage of the current is inextricably connected with the movement of atoms through the liquid. A familiar instance of this is the ordinary electrolytic bath for electroplating. Now, as I have said, some physicists had the idea that electric currents get through metals by the motion of charged atoms in much the same way as they get through liquid, and they naturally made experiments to see if they could detect any transport of metal which is so marked a feature when currents pass through liquids. Speaking generally, these experiments were of two types. In one type the current was sent through a wire made of an alloy of two metals. The proportion of the two metals in the wire before a current was passed through it was determined with great care. A powerful current was then sent through the wire for a long time, and the wire was again analysed, samples being cut from the end at which the current went in and also from the end at which it went out. If there had been any transport of atoms by the current, the composition of the end where the current entered would be different from that of the end where it left. The experiment showed that no difference could be detected, even when enough current had passed through the wire to carry all the metal in the wire from one electrode to the other if the metal had been in a salt dissolved in an electrolytic bath. The other type of experiment was to put plates of two metals, say gold and lead, together, taking care that there was good contact, and then send a strong current across the junction for a considerable time, and at the end of that time see if any lead had been carried into the gold or any gold into the lead. Not the slightest trace of any such transport could be detected. These experiments showed that the electricity was not carried through metals by charges on atoms or any combination of atoms, and as at that time no other carriers of electricity were known, the difficulties in the way of supposing that the current was carried by moving electric charges seemed insuperable. Relief, however, came from the study of the passage of electricity through gases, which showed that there were other carriers of electricity besides atoms.

These carriers, which are called corpuscles or electrons, are exceedingly small compared with the smallest atom known, that of hydrogen. They form a part of every kind of atom, and, however different the atoms from which the electrons come may be, the electrons themselves are invariable. There is only one kind of electron, and this has a mass of $\frac{1}{1700}$ that of a hydrogen atom, and carries a constant charge of *negative* electricity. The discovery of the corpuscle or electron put an entirely different com-

[1] Lecture delivered before the Institute of Metals by Sir J. J. Thomson, O.M., F.R.S.