longer waves travel chiefly in a region in which the ionic density varies very much between day and night and are thus less absorbed by night.

In a general way, therefore, the theory fits in with facts, but there are an immense number of well-known wireless wave effects which will require consideration and discussion before we can say we can account for them all on any theory. Meanwhile, the practical consequences of the discovery of the properties of this 32-metre wave are very great.

Is there, for example, any justification for creating new high-power all-round radio stations by which the communication is, so to speak, bellowed over the world on 20,000-metre waves, when on the beam system perhaps a dozen stations could be erected for the same capital and annual working cost, which would whisper their message on 32-metre waves along limited paths, taking up much less room in the ether? Time, and perhaps expensive experience, will show whether the all-round high-power station is necessary. In any event, the short-wave system has the enormous advantage that the receiving appliances used in connexion with it are vastly more immune from atmospheric disturbances and render all-day and all-night intercommunication possible over long distances, even up to the antipodes.

The Oldest Fossil Fishes.

By Sir ARTHUR SMITH WOODWARD, F.R.S.

IT has long been known that the fishes of the Downtonian age—the earliest fishes of which we have any real knowledge—are very different from those which appeared in later times and persist in part to the present day. Prof. Johan Kiær, of the University of Christiania, discovered fossil fishes in the rocks of this period in southern Norway a few years ago, and the first part of his memoir describing them has recently been issued.[1] Prof. Kiær's remarkable specimens add greatly to our knowledge of these fishes, and some of his conclusions are so unexpected that they are of extreme interest to both zoologists and geologists.

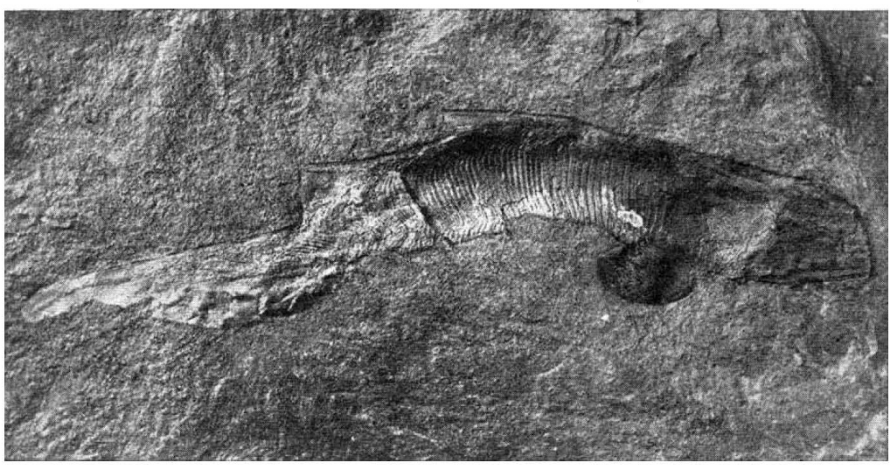

FIG. 1.—*Aceraspis robustus*, Kiær. Nearly complete specimen, nat. size. The foremost part of the head is incomplete. From "The Downtonian Fauna of Norway."

It appears that the Downtonian rocks of the Christiania region closely resemble those of Great Britain, and similarly contain the fishes in association with crustaceans and eurypterids in a good state of preservation. They are shallow water deposits, with frequent traces of ripple marks and sun cracks, and Prof. Kiær thinks they must have been formed in freshwater lakes on flood-plains. Some of the fishes are familiar, such as the beautiful Cephalaspidian reproduced in Fig. 1, which differs little from Cephalaspis itself except in having two dorsal fins instead of the single one. All, indeed, belong to known groups, and all are as usual small, none being more than two decimetres in length. The most striking novelties are referable to the Anaspida—laterally compressed fusiform fishes which were first described by the late Dr. R. H. Traquair from the Downtonian rocks of southern Scotland—and Prof. Kiær begins by devoting attention to the three new genera which he finds among these.

In the original Scottish specimens, Dr. Traquair was unable to make out any definite features in the head, and until he obtained examples with the heterocercal (or primitive unequal-lobed) tail, he felt uncertain as to which were the dorsal and ventral borders respectively. In the new Norwegian specimens Prof. Kiær has been more fortunate in finding both the head and the tail well preserved, and it now appears that the Anaspida differ from all other known heterocercal fishes in having the tapering end of the body bent downwards instead of upwards (see Fig. 2). Dr. Traquair indeed described all his specimens upside down. We have for the first time among fishes a form of tail which is known among the extinct marine reptiles, the ichthyosaurs, mosasaurs, and certain Jurassic crocodiles. Prof. Kiær, following Schmalhausen, supposes that this arrangement is correlated with the position of the centre of gravity of the fish.

The roof of the skull, which led to the discovery of the anomaly in the tail, is also very interesting. So far as it affords a clue to the underlying soft parts, it agrees with the cranial roof in the contemporary and allied cephalaspidians. As shown in Prof. Kiær's outline restorations (Fig. 3), the large orbits are distinct, not far apart, and each is surrounded by a hard rim. Between them is a plate pierced by a perforation doubtless for the pineal body; and immediately in front of this is a larger median perforation which may

[1] The Downtonian Fauna of Norway. I. Anaspida, with a Geological Introduction. By Johan Kiær. *Vidensk. Skrift. I. Mat.-naturv. Kl.* 1924, No. 6. Kristiania, 1924.

be rightly interpreted as an unpaired narial opening. The small dermal plates are symmetrically arranged and nearly on the same pattern in the three genera; but there is a tendency towards fusion into fewer and larger plates as shown in the three successive sketches *a*, *b*, *c*. In side view (Fig. 2) the cleft of the mouth is now seen for the first time in Anaspida, and it is bordered with large plates, at least in the genus here restored. In upper view (Fig. 3) the cranial dermal plates pass gradually backwards into the scales of the body, but on the side (Fig. 2) the limit of the head region is marked by a conspicuous oblique row of gill openings.

No traces of paired fins have hitherto been observed in these lowly forerunners of the fishes, but Prof. Kiær finds in several specimens a small plate bounding the gill region behind, and a tapering spine which he considers to represent a pectoral fin (Fig. 2). Behind this spine there are apparently sometimes a few fin rays. Pelvic fins are entirely unrepresented. Enlarged scales only mark the cloacal opening and arm the front of the anal fin.

There are many more interesting details, for which it must suffice to refer to the memoir itself. Prof. Kiær not only describes them, but also concludes with an exhaustive discussion of the affinities of the Anaspida as they are now understood. Their anatomy, of course, can only be inferred from the hard dermal armature which is the sole part represented in the fossils. The single median nostril and the relative proportions of the parts of the brain suggest that the late Prof. E. D. Cope and others were right in regarding the earliest fishes as belonging to the same class as the existing lampreys and hag fishes. Even Prof. Kiær's discovery of evidence of ordinary jaws and rudiments of paired pectoral fins does not appear to him to invalidate this conclusion. The lampreys, which are obviously degenerate members of their race, may well have lost the structures in question since the early geological period to which the Norwegian fossils date back. The Downtonian genera indeed represent the heyday of the class, when the higher fishes were only just beginning to appear.

Prof. Kiær is led finally into even wider speculations as to the origin of the paired fins in fishes. He thinks the new discoveries indicate that a pair of pectoral fins appeared first, and then extended backwards as a paired fringe, of which eventually the pelvic fins were the sole persistent remnants. There may be differences of opinion on these and some other inferences, but Prof. Kiær's memoir is one of the most inspiring contributions to palæichthyology that has appeared in recent years, and we eagerly look forward to the promised continuation of it.

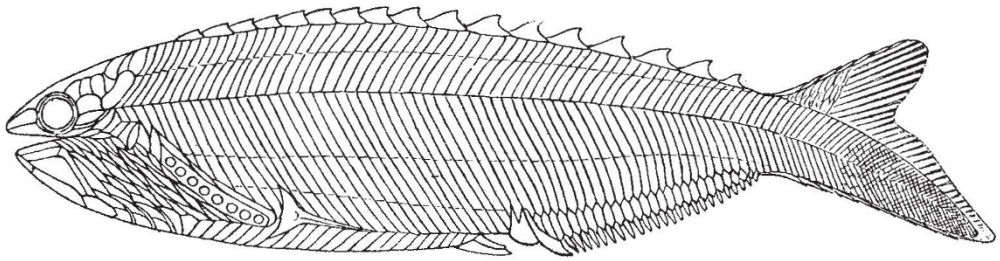

FIG. 2.—Reconstruction of *Rhyncholepis parvulus*, Kiær. × 2. From "The Downtonian Fauna of Norway."

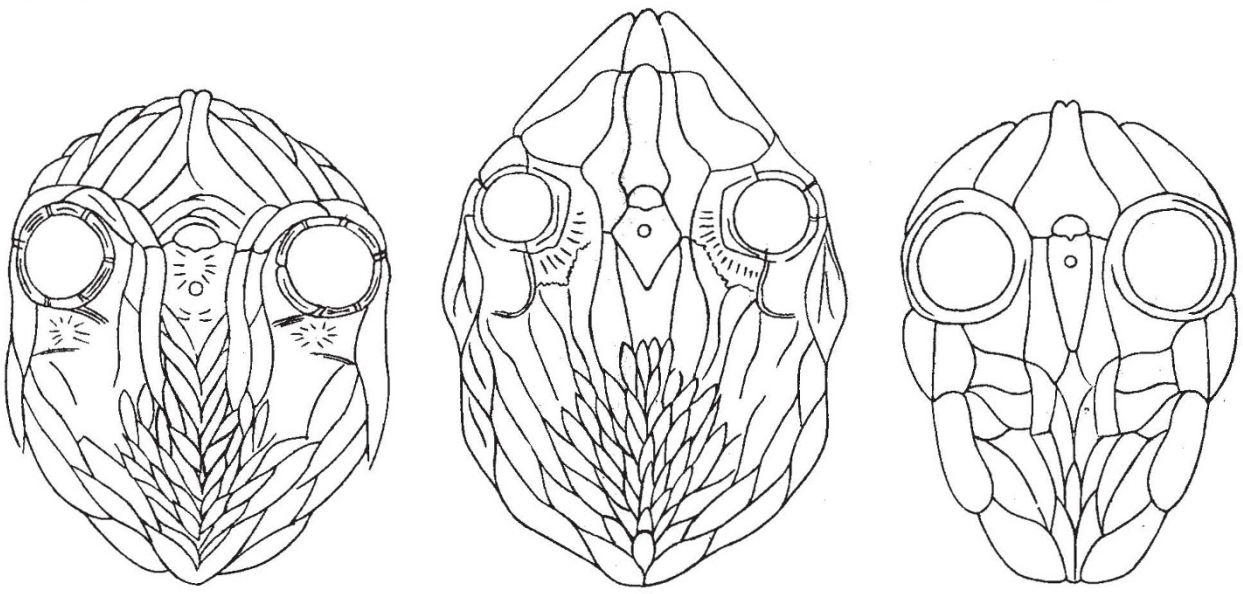

FIG. 3.—Cranial roof in schematic sketches of the Norwegian Anaspida. *a*, Pterolepis; *b*, Pharyngolepis; *c*, Rhyncholepis. From "The Downtonian Fauna of Norway."