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H. W. Norris

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THE MORPHOLOGY AND FUNCTION OF THE AMPHIBIAN EAR.

BY H. W. NORRIS.

In the struggle for existence as individuals the Amphibians, or Batrachians, seem to have a minor position. For the most part of insignificant size, with poorly protected bodies, and with retiring and inoffensive habits, these forms which we know as toads, frogs and salamanders, seem to be poorly adapted to maintain their species. From what the paleontologist tells us, we may well believe that the Amphibians as a class arose, flourished, and then declined to their present insignificant proportions long ago. It is because of the relationships of this group that it is of profound interest to science. It forms a connecting link, or rather a series of connecting links between the strictly aquatic Vertebrates, the Fishes, and the terrestrial forms. Presenting two distinct phases, a larval aquatic and an adult terrestrial condition, it presents for our observation the actual evolution of an aquatic, branchiate form into a terrestrial pulmonate form. Furthermore some forms retain the branchial organs throughout life, while others hardly give us a hint of a much shortened aquatic stage. This metamorphosis is not merely superficial, but is accompanied by profound morphological and functional changes.

Experiments carried on in recent years, notably by Professor F. S. Lee, have made it very probable that the ear in Fishes is not an organ of hearing, but rather an organ of equilibration. That it has this latter function in all Vertebrates is very well known. It is then in the Amphibia that the ear changes from an organ of equilibration alone to an organ of hearing, for it is certainly

true that many of the toads and frogs have very acute auditory powers. We are not able to show experimentally whether there are any Amphibians in which the sense of hearing is wanting, since the bony skull and the small size of the ear capsule almost preclude the possibility of accurate experiments such as have been performed upon the Dog-fish. But we are justified, it seems to me, in basing some conclusions on the study of the structure of the Amphibian ear.

In the general form and relationships of its parts the inner ear, or labyrinth, of Amphibia, is essentially fish-like. The only important new structures are the pars basilaris, and closely associated with it the perilymphatic canal, the two structures that combine in the higher classes of Vertebrates to form that complicated organ, the cochlea. In Proteus, Necturus, Siren, Amphiuma, and presumably in that blind branchiate form, Typhlomolge, from the subterranean streams in Texas, the pars basilaris is wanting. In all other Amphibia, as far as investigation has gone, it is present. In the Urodela, with the exception of Amphiuma, in which it is absent, it is a small insignificant recess in the lagena and contains a small sense-organ. In the Anura it becomes a distinct part of the labyrinth with a well developed sense-organ, closely related to the perilymphatic canal. In the Anurous Amphibia there also occurs a well developed middle ear, or tympanum, a structure entirely wanting in the other members of the class and in the Fishes.

Is the ear in the tailed amphibians an organ of hearing? This cannot as yet be answered very satisfactorily. A distinct vocalizing apparatus is lacking in all but the Anurous Amphibia. Salamanders are notably silent creatures. John Burroughs, I believe, says that the Red Eft, that immature terrestrial form of *Diemyctylus viridescens*, produces a musical sound, but it is undoubtedly not a true vocalization. This lack of vocalizing powers in the Salamanders makes it very probable that they are defective in hearing. There being no tympanum present the ear covered up by bone and muscle, cannot well respond to

auditory stimulation. But the most significant fact, it seems to me, is that the pars basilaris is either absent or very imperfectly developed. This structure which finally evolves into the cochlea of the higher Vertebrates, is distinctively the organ of hearing, according to recent physiological interpretation.

We then, in all probability see in this transition class of Vertebrates, the Amphibia, the origin of an organ of hearing from an organ of equilibration, which latter function is always retained. To be sure it may be suggested that the lack of a pars basilaris in *Proteus*, *Necturus*, etc., may be due to degeneration. Admitting this possibility, yet as I have elsewhere shown, in the development of the ear of the Salamander, *Amblystoma*, the pars basilaris is the last of the parts of the labyrinth to be differentiated, and then only near the close of the larval period. That is, the order in which this structure appears in the embryo, undoubtedly corresponds to the way in which it originated in the Amphibians as they were evolving from the ancestral aquatic condition into the semi-terrestrial state of existing species.

A COMBINATION OF CHROMIC ACID, ACETIC ACID AND FORMALIN AS A FIXATIVE FOR ANIMAL TISSUES.

H. W. NORRIS.

That many of the fixing reagents in common use in the preparation of tissues for histological study are poorly adapted to the fixation of the ova and embryos of Amphibians, is evident to any one who gives more than casual attention to the matter. The large amount of yolk present in the cells of the Amphibian embryo makes completely uniform fixation with some reagents impossible, and then, too, the disintegrating effect of many fixing fluids upon the yolk granules makes the result very unsatisfactory. A fluid that gives good fixation is likely to interfere with