# THE PINEAL EYE IN EXTINCT VERTEBRATES.

BY E. D. COPE.

THE discovery of the pineal eye in lizards is due to Leydig, who first recognized it as a probable sense organ in 1872. Dr. Graaf first determined its structural correspondence with the invertebrate eye in 1886. In the same year [1] Spencer examined a large series of Lacertilia, and pointed out the very diverse degrees of development of this organ presented by these reptiles. In 1882 Prof. Rabl Ruckhard refers to the large parietal foramen of Ichthyosaurus and Plesiosaurus as indications of the existence of a pineal sense organ in those ancient reptiles, perhaps especially sensitive to temperature. In the NATURALIST for 1885 (p. 1029), the present writer stated that the Pelycosauria of the Permian epoch possessed large pineal eyes. Mr. Spencer expresses a similar opinion with regard to the extinct Stegocephala or labyrinthodonts of the carboniferous system, in his paper above mentioned. He there maintains also the homology of the median eye of the Tunicata with the epiphysis of the Vertebrata.

In a paper published in the NATURALIST of 1885 (p. 291), the present writer described the characters of the supposed fish *Bothriolepis canadensis*, and homologized the orifice in the superior wall of the anterior part of the carapace (supposed to represent the head) with the orifice or mouth in a corresponding position in the Tunicata, especially referring to Chelyosoma, as having a general resemblance to Bothriolepis. I mention (p. 290) that a plate covers the middle part of this orifice, forming a median valve of the mouth, a character which is also described by Whiteaves in 1887.[2] It was already described in the allied Pterichthys by Pander and Owen. This plate covers the median part of the superior orifice, and leaves the lateral parts open. It has little fixity in the specimens I have examined, for which reason I called it a valve. See plate XV.

Subsequently I described the genus Mycterops[3] from the coal

[1] Mr. Spencer's paper is dated 1885, although he quotes De Graaf's and my own papers published in 1886.

[2] Illustrations of the fossil Fishes of the Devonian Rocks of Canada: Transac. Royal Society of Canada, 1886 (7), p. 102.

[3] American Naturalist, 1886, p. 1029.

measures of Pennsylvania (Plate XV), which is intermediate in the character of the anterior regions between Cephalaspis and Bothriolepis. The median orifice of the latter genus is present, and its middle portion is roofed by a plate. But this plate differs from that of Bothriolepis and Pterichthys, in being perforated by two orifices, which resemble in their position nostrils, while the lateral orifices have the position of the eyes of the Cephalaspididæ.

Under these circumstances the evidence in favor of the orifices in Bothriolepis being eyes, is stronger than that which points to its homology with the mouth of Tunicata. The structure of these primitive vertebrates strongly indicates the origin of lateral or paired eyes from a single median eye, such as is found in the Tunicata, and continues to point to the descent of Bothriolepis from those animals. Mycterops indicates a wider divergence than Bothriolepis; and Cephalaspis a still further stage of modification. Dr. Dollo, of Brussels, has expressed the view that the superior orifice of Pterichthys corresponds with the median eye of the Tunicata and the pineal eye of the Reptilia.

Of course, if the median eye of the Tunicata became specialized into the lateral eyes of higher vertebrates, it might seem improbable that it could be at the same time homologous, as there are no embryological reasons for refusing to believe (Spencer), with the pineal eye of the same forms, which possess also the lateral eyes. It may not be impossible, however, that this is really the case, and that the paired eyes, as well as the pineal eye, have been formed by evagination of differentiated parts of the Tunicate eye, so that the views of Lankester and Spencer may be both correct. The formation of the lens from two parts in the Tunicates, which precludes its correspondence with the pineal lens in Reptilia, probably has a significance in this connection, expressing the origin of the lateral eyes, while the retinal portion is homologous with the pineal retina.

In extinct American Batrachia the parietal foramen is wanting in Eryops and Zatrachys, and has not been observed in Trimerorhachis; but it is well developeds in Cricotus, the genus that leads probably to the Reptilia.

Among North American extinct reptiles I have described the characters [1] of the cast of the brain case in two widely distinct forms.

[1] Proceeds. Amer. Philos. Soc., 1886, p. 234.

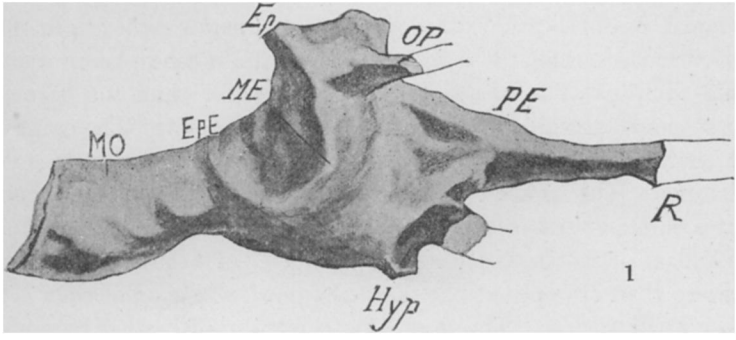
These are Diadectes,[1] a Permian genus of Theromora, and Belodon, a Parasuchian crocodile. The former has an immense parietal foramen, while the latter has none. The general characters of the brain in Diadectes are as follows: The widest part is at the origin of the trigeminus nerve. Both the cerebellum and nesencephalon are flat, and simple. The hemispheres are narrower than the segments posterior to them, and of greater vertical diameter. The epiphysis is enormous, and its flattened posteriorly extending peduncle is very distinct. The olfactory lobes were apparently large, and had a greater transverse diameter than the hemispheres. The reduced diameter of the hemispheres is a character of fishes and Batrachia rather than of reptiles, but the thalami are also smaller than is the case in Batrachia. The small, flat cerebellum is rather batrachian than reptilian. (Plate XVI.)

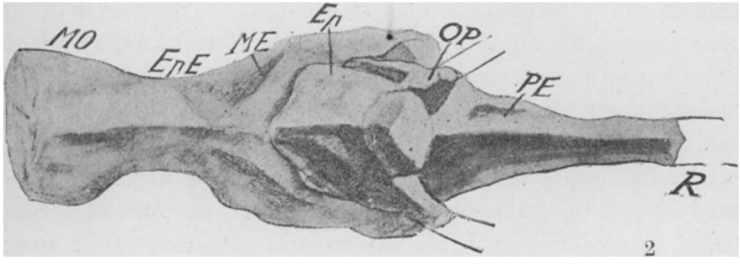
There is some reason to suspect that the Diadectes relied exclusively on the pineal eye for the sense of sight. The species of the family were subterranean in their habits, since their humeri indicate great fossorial power, resembling those of the existing monotremes, and even the mole. The vertebræ are locked together with the hyposphen beside the usual articulations, and the arches of the neural canal form an uninterrupted roof from the skull to the tail, of extraordinary thickness and strength. That the species are not aquatic is rendered probable by the fact that the orbits do not look upwards. Their superior borders are, on the contrary, prominent and straight. Add to this fact the apparent absence of optic foramina, and the probability that the Diadectidæ were blind and subterranean in their habits becomes still stronger.

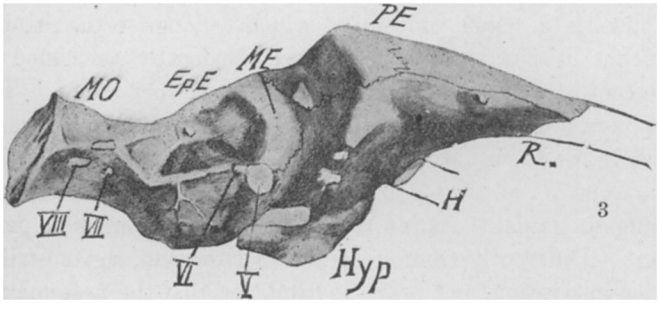
Belodon is a genus of reptiles which belongs to the sub-order Parasuchia of Huxley, which has been generally associated with the Crocodilia. It is characteristic of Triassic formations. Three species have been found in Europe, three in Eastern North America, and two in the Rocky Mountain region. One of the latter, *Belodon buceros* Cope, is represented in Plate XVII. It was about as large as the Gangetic gavial. As in Crocodilia generally there is no parietal foramen. Differently from crocodiles of later ages, the nostrils are posterior in position, and near the orbits, so that the nose might be plunged deeply beneath the surface of mud or water without inter-

[1] Loc. cit., 1887, p. 219.

## PLATE XVIII.




Cast of brain-cases of *Belodon buceros* and *Alligator mississippiensis*, natural size. Figs. 1–3. *Belodon buceros.* Figs. 4–5. *Alligator mississippiensis.* Fig. 1. Right side. Fig. 2. Superior surface. Fig. 3. Right side.

## EXPLANATIONS OF PLATES.

### PLATE XV.

Fig. 1. Shell of *Bothriolepis canadensis* Whiteaves, from above. (From Whiteaves.)

Fig. 2. Anterior part of same, from below. (From Whiteaves.)

Fig. 3. Skull of *Mycterops ordinatus* Cope, from below, $\frac{2}{3}$ natural size.

### PLATE XVI.

Cast of brain-case of Diadectes sp.

Figs. 1 and 2, cast of cranial cavity, natural size. As the basicranial axis is lost, the inferior outline posteriorly is provisional only.

Fig. 1, from above.

Fig. 2, from the left side.

Fig. 3, skull of *Diadectes phaseolinus*, from above.

The letters signify as follows: *m.*, medulla; *cb.*, cerebellum; *opl.*, optic lobe; *ep.*, epiphysis; *ppe.*, posterior process of epiphysis; *lf.*, lateral foramen; *h.*, region of cerebral hemispheres; *v.*, cast of vestibule.

### PLATE XVII.

Cranium of *Belodon buceros* Cope, from Southwestern New Mexico, from which the following cast was taken; one-fourth natural size. Lateral, and one-half inferior and superior views.

### PLATE XVIII.

Cast of brain-cases of *Belodon buceros* and *Alligator mississippiensis*, natural size. Figs. 1–3. *Belodon buceros.* Figs. 4–5. *Alligator mississippiensis.* Fig. 1. Right side. Fig. 2. Superior surface. Fig. 3. Right side. RE. Rhinencephalon. PE. Prosencephalon. ME. Mesencephalon. Ep. E. Epencephalon (Cerebellum). MO. Medulla oblongata. Ep. Epiphysis. Hyp. Hypophysis. ii. Optic nerve; v. Trigeminus; vi. Abducens; vii. Facialis; viii. auditorius. Op. Orbitopineal process or nerve.

fering with the respiration. The characters of the brain are as follows:

The first point which arrests the attention in making a comparison with Diadectes is the similarly huge size of the epiphysis in the two types. A foramen on each side of the base of the epiphysis in the Diadectes gave exit to a process similar to that which enters the orbitopineal canal in the Belodon, and which I called the lateral process of the epiphysis in the latter. Plate XVIII, figs. 1–3, 1 f). The processes are probably homologous in the two genera, but in the Belodon they extend through the posterior wall of the orbit, filling a large canal. There is little resemblance between the two brains in other respects, but they agree in the small size of the prosencephalon, and in the complete enclosure of the rhinencephalon by osseous walls. In the Diadectes there is no optic foramen, but a huge trigeminus; in Belodon, an optic foramen, and a very small trigeminus.

The presence of such a huge epiphysis in the Belodon, as compared with its very small size in modern crocodiles, is a point of much interest, and points to its inheritance from the reptiles of the Permian. But if, as is probable, it contained the pineal eye, the latter could not receive light directly from above, since the parietal foramen is wanting. The presence of a communication with the orbit becomes interesting in this connection. A minute foramen passes from the base of the rhinencephalon into the orbit in the alligator, but the homology with the *canalis orbitopinealis* of Belodon is by no means made out. The *nervus orbitopinealis* may have supplied the lack of light due to the closure of the parietal foramen, but in what way we are left to conjecture.

The equality of size of the brain of the Belodon to that of the existing alligator is a point of interest.

The Belodons were probably aquatic reptiles, living on the shores of estuaries like modern crocodiles, and were of carnivorous habits.