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THE MEMBRANE BONES IN THE SKULL OF A YOUNG AMPHIUMA.

BY H. W. NORRIS.

The specimen upon which the following description is based was 51 mm. in length. In the state of development of the skull it appears to be intermediate between the two stages described and illustrated by Winslow with figures of wax models. The chondrocranium appears to be almost exactly like that of the older specimen described by him, except that the ossification in my specimen is less advanced. The specimen was sectioned and a reconstruction of the skull was made after Born's method.

THE CRANIUM.

Ethmoidal Region. Of the bones found in the adult in this division of the skull only the nasals are wanting at this stage of development. The premaxilla has essentially the adult form described by Wiedersheim and by Hay. Along the border of the alveolar process of the premaxilla are about thirty teeth, of which ten are attached to the bone, five on one side and four on the other, with an unpaired tooth in the middle. Mention should be made here of the small unpaired cartilage situated in the roof of the mouth ventral to the palatine process of the premaxilla. Hay's theory is that "the anterior lobes of the trabecular cornua * * * grow downward until they meet below the palatine process and then coalesce." Afterward the part below the plane of the vomers becomes cut off and forms the unpaired piece. In my specimen this unpaired piece, while very distinct, has not yet developed a hyaline structure. It is in a semi-membranous condition, but

shows no connection with the nasal cartilages except through the connective tissue that in this region binds together premaxilla, vomers and nasal cartilages. Wiedersheim says that in the adult the anterior ends of the vomers come in contact in the middle line just posterior to this isolated unpaired cartilage. In a dry preparation of an adult skull I find a postero-ventrally directed occipital bony process of the premaxilla slightly overlapping and wedged in between the anterior ends of the vomers. This is in the position occupied by the isolated cartilage in question in my young specimen and in the adult condition as described by Wiedersheim and Hay. I do not find the bony process in the young specimen.

The vomers (vermero-palatines) require little mention beyond that of the preceding paragraph.

The maxillae and the prefrontals have essentially the adult relations. Along the border of the maxilla are numerous teeth, of which only three are as yet consolidated with the maxilla.

The frontals at this stage do not meet in the middle line, except at the peculiarly modified anterior portion underlying the dorsal process of the premaxilla. The frontal consists of two portions. There is an external part roofing in the anterior brain cavity of its respective side. Posteriorly this portion overlaps the parietal, and antero-laterally rests on the anterior prolongation of the trabecula, known as the tectal cartilage. A second portion of the frontal is, at this stage, a thin sheet extending antero-ventrally from the anterior border of the dorsal part of the bone, mesial to the tectal cartilage as far as the ethmoidal basal plate and nearly to the middle line, forming the chief part of the anterior wall of the brain cavity and closing the greater part of the large opening between the dorsal tectal cartilage and the ventral trabecula. At this stage this part of the frontal is imperfectly ossified and its exact limits are hard to define. At its dorso-median border is the olfactory opening into the nasal capsule. The peculiar structure of the anterior end of the frontal has been noticed and figured by Wiedersheim, by

Hay, and by Wilder. A process which may be regarded as a prolongation of the dorsal part of the frontal extends antero-ventrally dorsal to the cartilaginous nasal septum so far as to lie at the side of the posterior part of the bony nasal septum (premaxilla). The portion of the process immediately posterior to the bony nasal septum meets in the middle line the corresponding process of the opposite side ventral to the dorsal process of the premaxilla. This, the posterior part of the dorsal process of the frontal, forms the dorsal and median wall of the olfactory opening, the ventral and external wall of the latter is formed by the border of the second part of the frontal above described. In later stages the antero-dorsal process apparently fuses with the ventral sheet near the middle line, thus forming a complete ring of bone around the olfactory opening. At this stage, however, the ring is incomplete on the median side. Hay seems to question the accuracy of the statement of Wiedersheim that in the adult the anterior part of the frontal forms a canal in which lies the olfactory nerve as it passes into the nasal capsule, but a careful examination of an adult skull can hardly fail to confirm Wiedersheim's statement. In my specimen the olfactory opening has not as yet assumed a canal-like form.

The parasphenoid has approximately the relations of the adult condition. Anteriorly, the pointed portion lying between the two vomers has a groove on its ventral surface, and in this groove is the posterior part of the palatine process of the premaxilla. Toward the tip of the parasphenoid the groove breaks completely through the bone so that the latter is forked and ends in two delicate processes, each closely wedged in between the vomer of its respective side, and the palatine process of the premaxilla. The extreme posterior tip of the latter is so coalesced with the parasphenoid that no line of demarcation can be discerned in the sections.

The parietals do not meet in the middle line except near their posterior ends. Laterally each sends a process over the ear capsule nearly to the squamosum. Antero-laterally each overlaps the orbito-sphenoid cartilage. Poste-

riorly they slightly overlap the synotic tectum. The muscular crest overlapping the dorsal border of the squamosum of the adult condition is not yet developed.

The squamosum is an elongate plate extending obliquely across the ear capsule. About two-thirds of its length is applied to the ear capsule, the remainder overlaps the quadrate. Beginning at a level somewhat posterior to the posterior border of the operculum (stapes), it extends antero-dorsally, its ventral edge slightly overlapping the operculum, toward the middle line, nearly reaching the lateral border of the parietal above mentioned. After passing the operculum the squamosum turns and passes antero-ventrally to the quadrate, its ventral border in contact with and resting upon the columella and farther anteriorly upon the quadrate.

Underlying the squamosum is a bone figured and described by Hay as the "columellar process of the quadrate." One may be permitted to suggest that Hay is in error. He describes the bone in practically the adult condition, after it has completely coalesced with the ossification of the quadrate. He fails to see that there is an articulation between the columella and the quadrate, and that this bone lies anterior to the articulation, that is, it is not applied to the columella but to the quadrate. The articulation mentioned occurs at the level where a division of the mandibular branch of the facial nerve passes dorsally around the columella-quadrate bar to go to the oral (Kingsbury) line of sense organs. There is no external discontinuity in the bar, but at the point mentioned the hyaline structure is interrupted by a membranous structure so characteristic of articular surfaces. The bone in question appears as a distinct ossification lying in the hollow of the quadrate and covered by the squamosum, except at its extreme anterior end. Its antero-ventral edge rests upon and is closely applied to the quadrate. Anteriorly it reaches nearly to the anterior border of the latter, and projects slightly beyond the squamosum. Posteriorly its pointed extremity reaches nearly to the level of the articulation in the columella-quadrate bar above described.

Anteriorly it is almost completely coalesced with the ossification of the quadrate, but posteriorly is completely free. In the advanced stage described by Hay the bone has apparently fused with the ossified quadrate along nearly the entire length of the latter. It may be questioned whether the slight ossification of the quadrate at this stage is not derived from this membrane bone. Furthermore, the ossification of the adult quadrate may be derived, possibly, chiefly from the same source. No discussion of the homology of this bone will be attempted here, as this subject will receive the attention of Professor B. F. Kingsbury.

At this stage of development the elongate otic capsules are ossified but little except at their extreme anterior ends. Kingsley has pointed out the fact that in the younger stage described by him the anterior ends of the ear capsules "project slightly beyond the point of union with the cristae trabecularum." In the stage studied by me these projections are of considerable length and completely ossified. Posteriorly they coalesce with the ossified portions of the ear capsules, anteriorly they have every appearance of being membrane bones. But one must have access to earlier stages to definitely determine the origin of these projections.

On the pterygoid bars are small membrane bones.

THE VISCERAL ARCHES.

On the lower jaw are two membrane bones, a dentary and an angulare. I find no trace of an operculare, such as is found in *Necturus* and some others. Hay has called attention to the peculiar relations of the membrane bone on the ceratohyal bar in individuals of six inches in length, essentially the adult condition. The thin splint which in early stages lies on the median side of the ceratohyal later comes to lie between two bars of cartilage, of which the mesially lying one is interrupted at one point. Hay's theory is that the mesial bar is formed by growth from the main bar around the ends of the bone. In my speci-

men this supposed growth is really taking place, and at each end the bone for a short distance is imbedded in cartilage.

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THE SOLAR SURFACE DURING THE PAST TWELVE
YEARS--A REVIEW OF SUN-SPOT OBSERVA-
TIONS MADE AT ALTA, IOWA, FROM
1890 TO 1902.

BY DAVID E. HADDEN.

The following paper is a resume of a series of sun-spot observations commenced by the writer in 1890, August 1st, and continued without interruption, except by cloudy weather and other unavoidable causes—such as sickness or absence from the city—until the present time.

Embracing, as it does, the most interesting period of a sun-spot cycle—that of a maximum of solar activity, included between two minima—it is hoped that a study of the results may be of interest and value to students, and a contribution to the literature of solar physics.

The principal instrument used was a 3-inch telescope until 1897, February, after which time a 4-inch telescope,