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DESCRIPTION OF A RECONSTRUCTION OF THE HEAD OF A THIRTY-MILLIMETRE EMBRYO. By Professor FAWCETT, *University of Bristol.*

THE embryo from which the model was made was kindly lent, already cut and stained, by Professor Bryce of Glasgow, and was well adapted to the purpose. I will first attempt to describe the cartilaginous neuro-cranium, and before doing so may say that it presents many objects of very great interest, to which attention will be drawn in the proper place.

NEURAL CHONDRO-CRANIUM.

The basilar region is completely chondrified from foramen magnum to the anterior end of the nasal capsule. The basilar plate has the usual relation to the notochord, which, as now well known, is the following. The notochord on leaving the dens passes for a short distance over the dorsal aspect of the basi-occipital cartilage, then sinks through it to lie underneath and between the cartilage and the pharyngeal mucous membrane. Then it turns upwards and forwards to enter again the basilar plate and terminate just behind the pituitary fossa.

A well-marked dorsum sellæ is present, and fused with the basilar mass.

The cochlear capsules have commenced to fuse with the basilar plate medially, and are now continuously chondrified with that cartilage which surrounds the semicircular canals, which, by the way, shows a well-marked fossa subarcuata. From the side of the corpus sphenoidale there passes out a large processus alaris, which by its outer end fits into a hollow in the ala temporalis (great wing), and sends back a process on the outer side of the internal carotid artery to come into contact with the cochlear capsule as noticed by Jacoby.

The ala temporalis (great wing), which, by the way, would much more suitably be named the ala zygomatica for a reason which we will see shortly, is now of characteristic form, and when seen from the front resembles the forefinger bent inwards with the superior maxillary nerve in its concavity (fig. 1). The nerve actually perforates the upper part of this ala at the foramen rotundum. It is of great interest to notice that the ala orbitalis does not reach further than a very short distance into the orbital cavity; at its lower end one sees the membranous external pterygoid

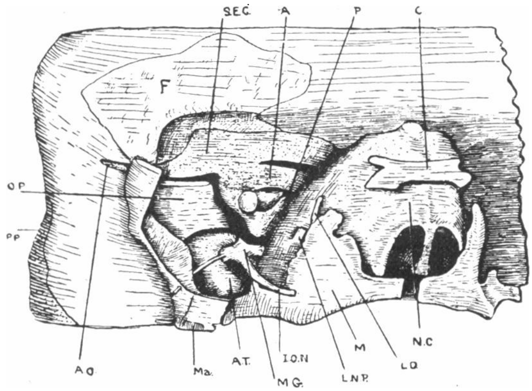

FIG. 1.—Part of the reconstructed head of the Bryce 30-mm. embryo as seen from the front and left side.

A., ant. limb of ala orbitalis; A.O., outer end of ala orbitalis of sphenoid; A.T., ala temporalis, perforated by superior maxillary nerve; C., connective tissue bar over nasal capsule in which nasal bones and internal angular processes of frontal bones will develop; F., frontal bone; L.D., lacrymal duct; L.N.P., lateral nasal process; I.O.N., infraorbital nerve; M., maxilla; Ma., malar bone at lower end of vertical bar of connective tissue which is perforated by temporo-malar nerve; M.G., Meckel's ganglion; O.P., part of outer wall of orbit formed by connective tissue and which later ossifies to form the orbital plate of the great wing of the sphenoid; P., posterior limb of ala orbitalis (lesser wing of sphenoid); between A and P notice optic nerve; P.P., parietal plate; S.E.C., ethmoidal or spheno-ethmoidal plate.

plate, and to the inner side of the latter the already ossified internal pterygoid plate surmounting a cartilaginous hamulus. On its outer side one sees the inferior maxillary nerve leaving the cranium, but the cartilage is neither perforated nor, for the matter of that, even grooved by either it or the middle meningeal artery. At the inner side of its lower end this ala temporalis is hollowed out to fit on the outer end of the processus alaris. The upper end of the ala temporalis is covered in great part by the enormous Gasserian ganglion, and being small it can contribute but very little to the basis cranii (fig. 2).

The ala orbitalis (lesser wing) is of relatively enormous size as compared with the ala temporalis; at its inner extremity it presents to view two limbs, of which the more posterior runs inwards to fuse with the corpus sphenoidale and complete behind the foramen opticum (fig. 2). The anterior limb, although well developed, has not as yet fused with the corpus sphenoidale; at its outer end the ala orbitalis forms a long tapering point, which, projecting beyond the outer wall of the orbit, ends in the temporal fossa making towards but not reaching that plate of cartilage, which will be later

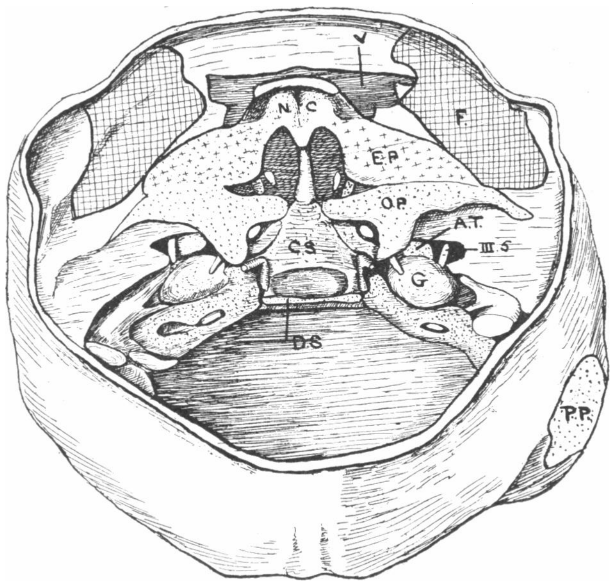

FIG. 2.—View from above of the interior of the base of the neuro-cranium of the Bryce 30-mm. embryo. The cartilage is everywhere "stippled" and crosses are placed on the ethmoidal plate.

A.T., ala temporalis or pars zygomatica of great wing; C.S., corpus sphenoidale; D.S., dorsum sellæ; E.P., ethmoidal plate, continuous in front with nasal capsule (N.C.) and behind with ala orbitalis (O.P.); the fissure at the inner side of the junction of ala orbitalis and ethmoidal plate is the spheno-ethmoidal fissure; F., frontal bone; P.P., parietal plate; V., vacuity owing to large blood-vessel or perhaps extravasation.

described as the parietal plate of Spöndli, and so forming the anterior moiety of what is in many mammals, *e.g.* Echidna, Talpa, Erinaceus, Tatusia, Dasypus, Sus, Bos, and Ovis (Gaupp), the commissura orbito-parietalis. In its outer half the anterior border of the orbital wing is prolonged into a flat plate of cartilage which passes inwards to the nasal capsule to fuse with the outer wall of the capsule. This plate, the ethmoidal plate (fig. 2), forms a considerable part of the roof of the orbit at this time, and between it and the inner half of the anterior border of the ala orbitalis a spheno-ethmoidal fissure exists.

The nasal capsule is well developed, but the cribriform plate is represented by a small bridge which connects the septum with the outer wall of that side (fig. 2). From the outer wall of the nasal capsule there projects in an upward and forward direction the lateral nasal process of Mihalkovics, which has been regarded as evidence of a cartilaginous maxillary arch (palato-pterygo-quadrate) in man (figs. 1 and 3). This process partly surrounds the lacrymal duct. At the forepart of the under border of the nasal septum one sees the two paraseptal cartilages (Jacobson), and behind them the two centres for the vomer are evident. The sphenoidal turbinal cartilages can be seen turning inwards at the back of the nasal cavity from the outer wall of the nasal capsule.

The crista galli is well developed, and in front of it one sees a large transversely elongated mass of connective tissue which will later become ossified to form the internal angular process of the frontal bones and the two nasal bones (figs. 1, 2, and 3).

The chondro-cranial vault is represented by two cartilages which rise up and forwards from that part of the auditory capsule which encloses the semicircular canals. It is of large size, and proceeds forwards in the main towards the outer pointed end of the ala orbitalis as before mentioned, but does not reach it. This parietal plate (Spöndli) is the posterior moiety of the commissura orbito-parietalis (figs. 3 and 4).

Behind the parietal plate the auditory capsule of one side is connected with that of the other by a bridge of some width, the tectum synoticum (fig. 4). This tectum synoticum is of great interest, and has received considerable attention from Louis Bolk. In this particular instance it sends forward in the middle line a short process which seems to correspond exactly with the ascending process of the tectum synoticum of reptiles and amphibia as figured in Hertwig's *Handbook of Embryology*. There is also a small backwardly projected process which, starting from the middle of the posterior edge of the tectum synoticum, projects into the membrane which closes the foramen magnum behind. How much of this bridge which I have termed belongs to the occipital and how much, if any, to the temporal cartilage, I know not. According to Bolk the tectum synoticum is formed independently of both temporal and occipital cartilages, but I must confess the appearances in his figures scarcely explain what is seen in this cranium.

The occipital alæ are separated from one another by a triangular gap which is filled in with the spino-occipital membrane (fig. 4), which is triangular in shape, the apex of the triangle appearing to be bifid and to embrace the median posterior process of the tectum synoticum.

MEMBRANOUS NEURO-CRANIUM.

This is very extensive, and divided into an anterior large segment and a posterior smaller one by the tectum synoticum; it is continued downwards on both sides to form the temporal fossæ, which are limited above by

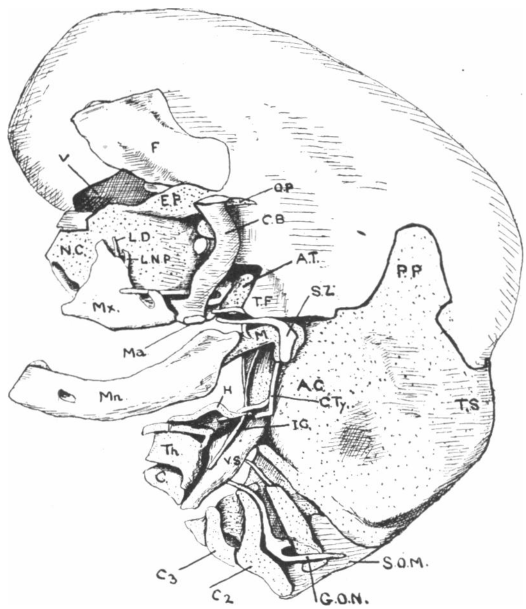

FIG. 3.—Profile view of neuro-cranium, visceral cranium, and upper part of neck skeleton. The cartilage is everywhere "stippled."

A.C., auditory capsule; A.T., ala temporalis or pars zygomatica (the third division of the 5th nerve is seen crossing its outer side); C., cricoid cartilage; C.Ty., chorda tympani nerve; C_2, neural arch of second cervical vertebra; C_3, neural arch of third cervical vertebra; C.B., connective tissue bar which forms part of outer wall of orbit which will later ossify to complete the malar bone and external angular process of the frontal bone; E.P., ethmoidal plate; F., frontal bone; I.C., internal carotid artery; H., cerato-, epi-, stylo- and tympano-hyal; G.O.N., great occipital nerve passing backwards from second cervical nerve; L.D., lacrymal duct; L.N.P., lateral nasal process; Ma., malar bone (behind and deep to it the palate bone is seen); Mn., mandible with Meckel's cartilage (M.) running backwards from it and forming malleus cartilage; Mx., maxilla, showing the infraorbital groove through which the infraorbital nerve is running; N.C., nasal capsule; O.P., ala orbitalis or lesser wing pointing backwards towards P.P., the parietal plate; P.P., parietal plate; S.O.M., spino-occipital membrane; S.Z., squamoso-zygomatic; T.S., tectum synoticum; T.F., temporal fossa limited behind and above by a groove; V., vacuity caused by large vein or extravasation; V.S., vagus and sympathetic ganglion.

a deep groove caused by the origin of the temporal muscle. Hence it runs inwards to form that part of the outer wall of the orbit generally credited to the cartilage of the great wing of the sphenoid. It is perforated by the 3rd division of the 5th nerve and the middle meningeal artery. Projected forwards from the membranous neuro-cranium is a vertical bar of connective tissue which later will be ossified to form the external angular process of the frontal bone and the malar bone; in fact, ossification has already commenced at its lower end to form the malar. This bar is perforated some distance above the malar bone by the malar branch of the temporo-malar nerve (figs. 1 and 3).

Visceral Cranium.

Mandibular Arcade.—Meckel's cartilage anteriorly ends in an upwardly projected swelling, whilst behind it ends in the malleus cartilage which articulates with the incus cartilage. There is no sign of ossification in Meckel's cartilage.

Hyoid Arcade.—The hyoid arcade was continuous with the auditory capsule, the chorda tympani concealing the root. Descending for a short distance, the cartilage then arches frontalwards, later turning in the ventral direction to reach but not fuse with the body of the hyoid. The body of the hyoid is well formed, and in many respects resembles the bony hyoid of the adult.

Thyroid Arcade.—This is represented by a dorsally and outwardly directed cartilaginous rod which is attached by its inner end to the body of the hyoid by connective tissue. At its outer end it is connected by connective tissue with the superior cornu of the thyroid cartilage.

The thyroid cartilage consists of two plates of cartilage separated by a fissure in the middle line. The upper and lower cornua are well marked and have the usual connections, the upper one being, of course, nearer the thyro-hyal than in the adult. In the lateral plate of the right side is a foramen in the position usually formed; the cricoid and arytenoids are well developed (fig. 3).

The Bony Cranium.

This consists entirely of "covering bones," there being no sign as yet of "substitution" or primordial bone.

The frontal bones are well developed, thickest at what later will be the base of the outer angular process, as if ossification had commenced there. They are separated from one another by a wide membranous interval. Each by the lower part of its inner border is in contact with the ethmoidal plate and the ala orbitalis of the sphenoid.

The *squamoso-zygomatic* presents a curious appearance, not unlike a boomerang, the posterior limb of which passes backwards (caudad) as a covering bone to the crus breve of the incus cartilage. The anterior limb was ventrally on the outer side of Meckel's cartilage.

These are the only calvarial "covering" bones developed at this time (fig. 3).

THE FACIAL BONES.

The *malar* is of very small size, and placed between the squamoso-zygomatic and the malar process of the maxilla, below which it lies also in

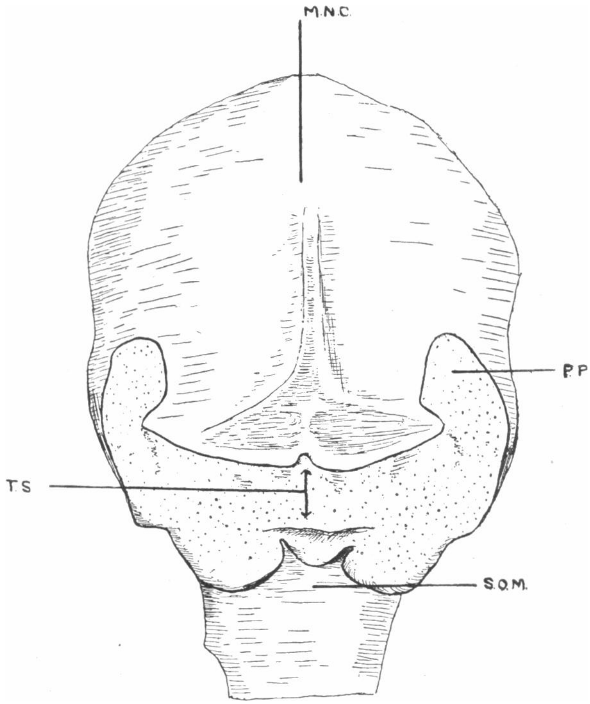

FIG. 4.—View from above and behind.

M.N.C., membranous neuro-cranium ; P.P., parietal plate ; S.O.M., spino-occipital membrane ; T.S., tectum synoticum (notice its ascending and descending processes).

part. It lies in the lower part of the vertical bar of connective tissue; before mentioned as forming the outer wall of the orbit, and is at this time considerably below the malar branch of the temporo-malar nerve.

The *maxilla* is of large size, with all its processes save the inner alveolar developed. (All the processes—nasal, palatine, malar, outer and inner alveolar—are developed as outgrowths from one common centre, and there is no warrant for the statement that the malar part, the orbito-facial, and palatine, are separate.) The nasal process has approached much more closely the nasal capsule than at an earlier age. The orbital surface is still very small and triangular in shape, with apex forwards. The groove for the infraorbital nerve is now being formed by the uprising of a process of bone to the outer side of the nerve. In earlier times the infraorbital nerve is separated by a wide interval from the maxilla. There is no sign of any premaxillary fissure. The palatine process has greatly thickened in height. There can be no doubt but that the whole maxilla, exclusive of premaxilla, ossifies from one centre only. Cartilage is developed in the malar process in this embryo (figs. 1 and 3).

The palate bone appears as a somewhat curved plate immediately behind the maxilla, and it bears out what I some time ago stated, that the vertical plate, not the tuberosity, is the first part to ossify.

The vomer is just in its earliest stage of ossification. It consists, as usual at this age, of two separate halves, lying between the paraseptal cartilage and below the nasal septum (at a later stage they will be added to by union with the ossified posterior ends of the paraseptal cartilages, 100 mm. embryo).

The internal pterygoid plate has commenced to ossify in membrane, but the hamulus is cartilaginous.

Before leaving the bones it may be well to say a little concerning the orbit.

The orbit is, as in the adult, directed forwards, and is relatively of large size. Its roof is formed partly by the cartilaginous ala-orbitalis, by the ethmoidal plate, by the frontal bone, and by unossified membrane. The floor is mainly membranous, but a small part is formed by the triangular orbital surface of the maxilla. The inner wall is formed completely by the nasal capsule, whilst the outer wall is formed by connective tissue, the ala temporalis taking practically no part in its formation; in fact, the so-called ala temporalis forms practically nothing more than the pterygoid process of the sphenoid, and as it is certainly nothing like a wing, it might well be called the ala or pars zygomatica, as it forms mainly that part of the sphenoid found in the zygomatic region (fig. 1).

The *mandible* is of enormous relative size; shows a ventral foramen, inner alveolar border, incisor canal, and commencing coronoid process. No condyle is as yet visible.

The Nerves.

Most of the cranial nerves are represented, but few require any special mention. The more striking points concern the ganglia, the Gasserian being of enormous size, as well as the spheno-palatine, otic and the ganglia of the vagus and glosso-pharyngeal.

The infraorbital nerve is practically straight, running forwards from the foramen rotundum along the outer side of the palate bone over the orbital surface of the maxilla, but not grooving it except near its anterior margin.

Blood-vessels.

Both arteries and veins were modelled. The most striking feature about the arteries is the great difference in size between the intra- and the extra-cranial parts. The intra-cranial parts of both carotids and vertebrals are relatively enormous, and are very thin-walled, — difficult, in fact, to distinguish from veins; the extra-cranial parts, on the other hand, have thick walls, and are of small size.

The veins in the model are two large lateral intra-cranial veins which, running from before backwards, cross the parietal plate, then turn downwards to leave the cranium at the posterior lacerated foramen, previously receiving the petro-squamous sinus. These two cranial veins are connected by a transverse vein under the tectum synoticum, which, I suppose, is the precursor of the lateral sinus. There was an enormous blood sinus over the nasal capsule, but it was not modelled. It is of interest to note that even at this early period the right lateral cranial vein is much larger than the left. Both lateral cranial veins are crossed before being joined by the transverse vein before mentioned, by the saccus endolymphaticus, which is of very large size—as wide, in fact, as the vein itself.