JOURNAL OF ANATOMY AND PHYSIOLOGY

NOTES ON THE DEVELOPMENT OF THE HUMAN SPHENOID.

By Professor FAWCETT, *University of Bristol.*

THE development of the chondro-cranium so admirably described by Giuseppe Levi[1] leaves but little to be added so far as concerns the earlier stages of the process in the human sphenoid.

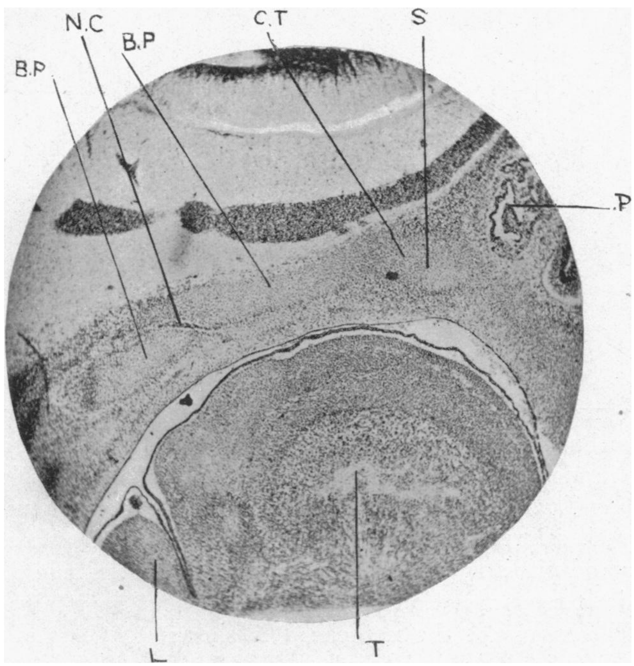

FIG. 1.

He combats the older accounts which suggest the formation of parachordal and trabecular cartilages as given in the classic views, using the peculiar

[1] "Beitrag zum Studium der Entwickelung, des knorpeligen Primordialcraniums des Menschen," *Archiv für mikroskopische Anatomie und Entwicklungsgeschichte*, 1900.

course of the notochord described by so many now, in its relation to the basilar plate, and the manner of chondrification of the sphenoid in its basilar region, in support of his views. Unfortunately, he has not given us illustrations of the sections from which his main findings are derived; and as photography never does justice to wax-plate models, the no doubt admirable models shown at the end of the paper are almost unintelligible even to one who has given considerable attention to the subject. In order to remedy this defect a few figures are submitted here, drawings of models and photomicrographs of the sections from which some of the models were made.

In fig. 1, a sagittal section of the head of a 15 mm. embryo, the basilar plate (B.P.) is shown extending from behind forwards over the roof of

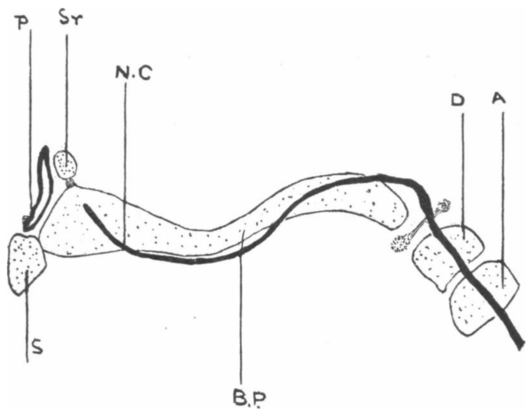

FIG. 2.

the oropharynx and perforated from behind forwards and above downwards by the notochord (N.C.), and the plate is seen to end at a bridge of loose connective tissue, which, though not identical here in position with that mentioned by Levi and others, may be taken as being a more advanced condition. S. represents the clivus region of the sphenoid; P. the hypophysis and pituitary; T. is the tongue; and L. the side of the larynx.

Fig. 2 is a reconstruction of four sections cut sagittally of a 21 mm. embryo. The course of the notochord is shown (N.C.), and at this stage the basilar plate is one complete whole.

There is evident behind the pituitary body a rounded mass of cartilage which is the dorsum sellæ (Sattellehne) connected to the rest by a fibrous bridge. I do not find that Levi noticed that this chondrifies separately, as the sections he had probably did not show (Fischer has noticed it in the monkey). In my 19 mm. embryos and 21 mm. embryos it is quite independent; also in a 19 mm. one lent me by Professor Minot of Harvard. P. pituitary; S.R. dorsum sellæ or saddle ridge; N.C. notochord; B.P. basilar plate; S. prepituitary part of sphenoid; D. dens; A. body of axis.

Fig. 3 is a photograph of a sagittal section of the head of the 21 mm. embryo from which the reconstruction (fig. 2) was made, and at S.R. shows this independent rod of cartilage, which is rounded in section and connected by a fibrous band with the clivus region. In a 30 mm. embryo lent by Professor Bryce of Glasgow this rod of cartilage is no longer independent.

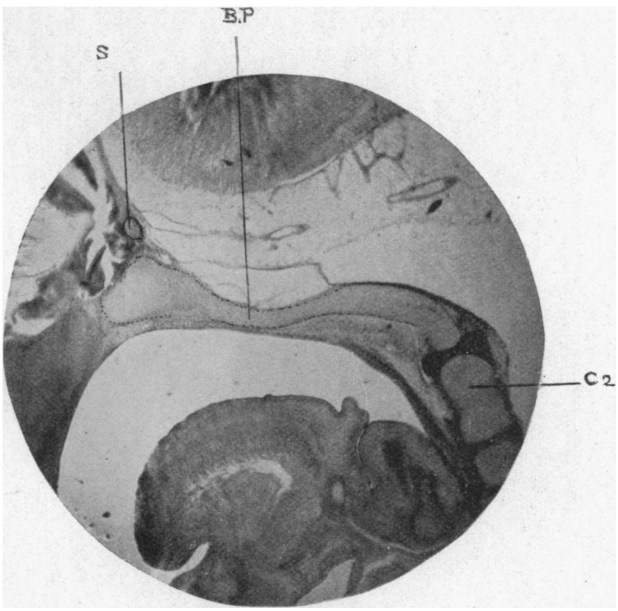

FIG. 3.

Levi has conveniently divided the young sphenoid into three segments:

1. The hindmost—clivus—which stretches from the connective tissue bridge which connects it with the occipital cartilage, up to the sella.
2. The sella.
3. The sulcus chiasmatis, which is the smallest and most anterior part.

Levi describes independent chondrification of the lesser (orbital) wings. This I confirm in all my sections and in the models.

Fig. 4 is a drawing of a model constructed from sections of a 19 mm. embryo. The orbital wings are seen ascending almost vertically from the median mass (C.S.). A nucleus of chondrification is seen at O.W. This is connected by a bridge of connective tissue and procartilage with the corpus sphenoidale (C.S.).

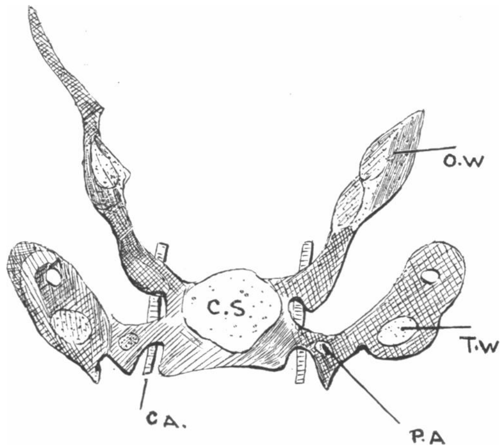

FIG. 4.

In the same paper Levi describes independent chondrification of the greater (temporal) wings (T.W.); but in the specimen from which this model

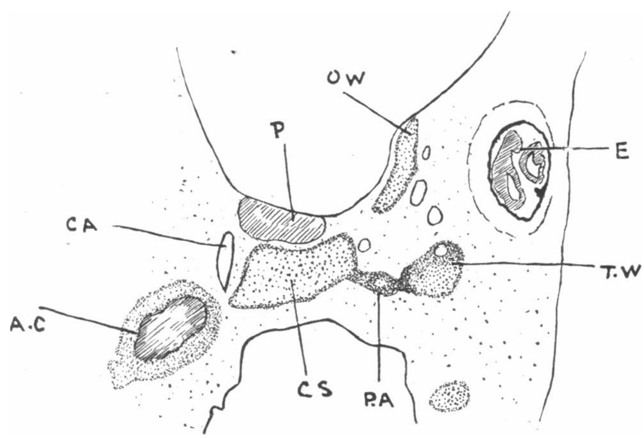

FIG. 5.

was made, another process—that connecting the corpus sphenoidale with the temporal wing, viz., the processus alaris (lingula) (P.A.)—an independent nucleus of chondrification, is also visible. C.A. is the internal carotid artery.

Fig. 5 is a drawing of a coronal section of the embryo from which the model (fig. 4) was made. P. is pituitary; O.W. orbital wing; E. eye; C.A. carotid artery; C.S. corpus sphenoidale; P.A. processus alaris, showing independent nucleus of chondrification; T.W. temporal wing, with light dotted part cartilaginous, above which, in darker procartilage, the 2nd division of the 5th nerve is contained.

Fig. 6 is a photomicrograph of a coronal section of a 19 mm. embryo kindly lent by Professor Minot. A.O. is the orbital wing (ala orbitalis); P.A. the processus alaris—in this embryo fused with the corpus sphenoidale

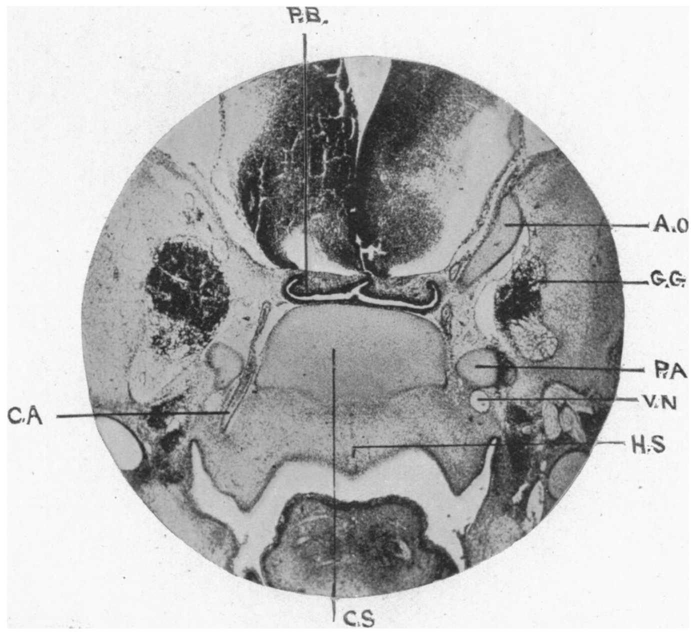

FIG. 6.

(C.S.), but only connected with the temporal wing by thick perichondrium, as seen on the right side of the figure above; V.N. the vidian nerve; C.A. is the internal carotid artery; P.B. the pituitary body; G.G. the Gasserian ganglion.

Fig. 7 is taken a little in front of fig. 6, and it shows (O.W.) the orbital wing; P.A. the processus alaris connected by a thick perichondrium sheet with (A.T.) the ala temporalis or great wing; C.S. is the corpus sphenoidale; II. 5, is the second division of the Trigeminus piercing the as yet in this region procartilaginous ala temporalis; V.N. the vidian nerve; M.C. Meckel's cartilage; P.B. the pituitary body—note its great transverse width.

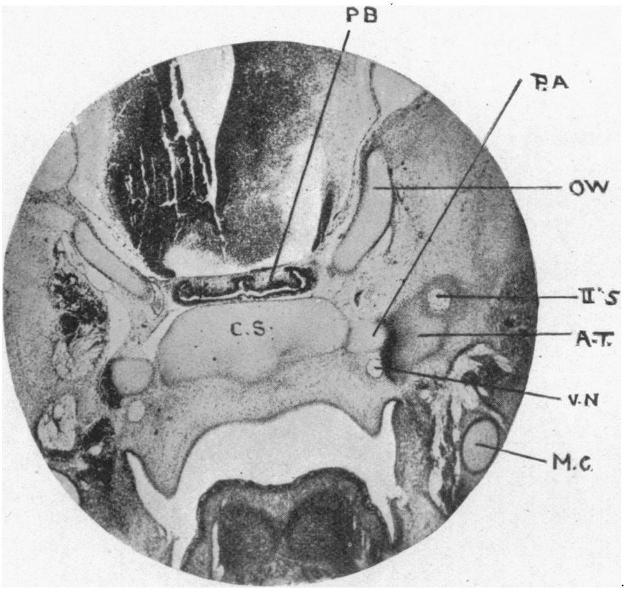

FIG. 7.

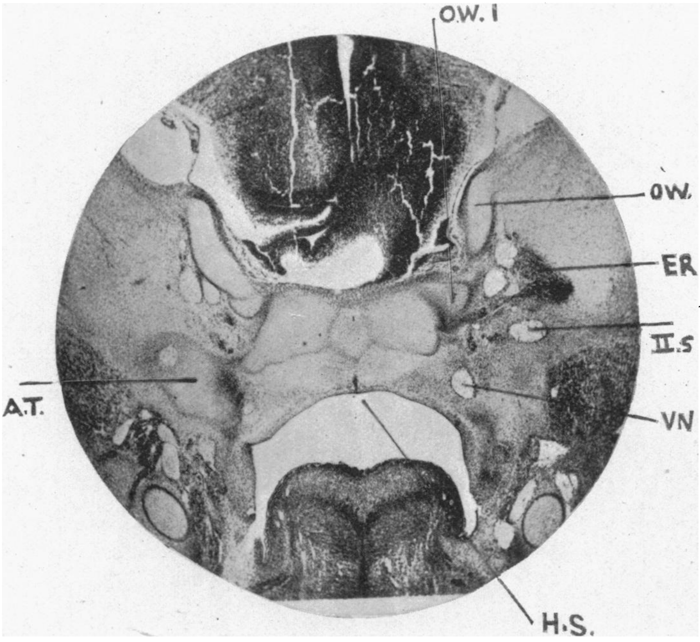

FIG. 8.

Fig. 8. Coronal section further forward than fig. 7, showing (O.W.1) the posterior limb of the orbital wing which bounds posteriorly the optic foramen. The anterior limb is not yet chondrified. Between O.W. and O.W.1 the outgoing optic stalk is evident; H.S. is the hypophysis stalk; above it is a curious middle piece to the corpus sphenoidale, which, though appearing to be independent, is not so, as models prove. A.T. is the ala temporalis (greater wing); II. 5, the 2nd branch of the Trigeminus; E.R. the external rectus. The chief interest in the figure is the independence of

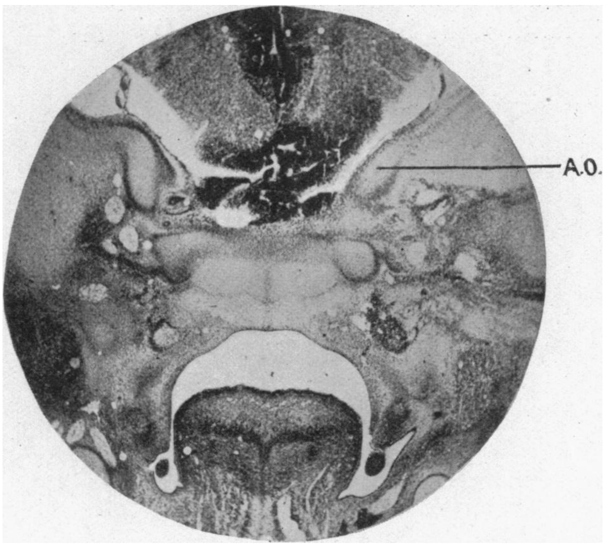

FIG. 9.

the orbital wing (O.W.1). This is proved by the model to be described later.

Fig. 9 is a little anterior to fig. 8, and shows us the two orbital wings (A.O.). The lower limb of each is seen to be independent of the corpus sphenoidale.

Let us now examine drawings of a model made from sections of this 19 mm. (Harvard) embryo. Only cartilage is represented in the orbital wings.

Fig. 10 is a view of the model from below and in front.

Notice first the corpus sphenoidale, which we may divide into a prehypophyseal and a post-hypophyseal part. The hypophysis stalk (H.S.) is seen surrounded by a hillock of cartilage, the under aspect of the mass alluded to in fig. 8. Lying by the side of the prehypophyseal part of the corpus sphenoidale is the curiously shaped ala orbitalis (A.O.). On one side the optic nerve (N.O.) is represented, and it is evident that only the posterior wall of the optic foramen is complete, and that this posterior wall is prolonged forwards by the side of the corpus sphenoidale. The anterior limb has not yet been chondrified, and the whole ala orbitalis is seen to be an independent formation, as Levi first pointed out.

If we follow back the lateral margins of the prehypophyseal segment of the corpus sphenoidale we see that they lead us to a backwardly and at the same time outwardly projected process, the processus alaris (lingula) (P.A.), which articulates, as it were, with the ala temporalis (A.T.), through which the 2nd branch of the Trigeminus passes. It is apparent here that the

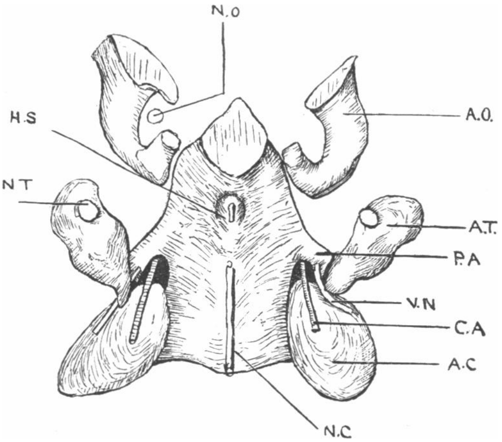

Fig. 10.

ala orbitalis is already larger than the ala temporalis, and this disparity in size is emphasised in a remarkable degree in a 30 mm. embryo kindly lent by Professor Bryce. The notochord (N.C.) can be traced along the under aspect of the basilar plate till it ascends into it, as seen in the model. N.O. is the optic nerve; A.O. the ala orbitalis; A.T. the ala temporalis; P.A. the processus alaris; H.S. the hypophysis stalk; N.T. the second division of the 5th nerve; V.N. the vidian nerve; C.A. internal carotid artery; A.C. auditory capsule; N.C. the notochord.

Fig. 11 is a view of the same model from above. O.W. the orbital wing, with O.W.1, its posterior limb, lying behind the optic nerve and running forwards by the side of the prepituitary segment of the corpus sphenoidale. This is the part marked O.W.1 in the photographs 8 and 9. We see here, too, the middle piece (M.P.), which is thus evident both above and below, but is not an independent formation. P.B. is the pituitary body;

Hy. the hypophysis; S.R. is the saddle ridge—"Sattellehne" or dorsum sellæ—and *it is important to note, first, that it is a rod of cartilage transversely placed, and, second, that it is quite independent of the rest at this stage*; A.T. is the ala temporalis seen under cover of G.G., the Gasserian ganglion; C.A. is the carotid artery; A.C. the auditory capsule; whilst P.A. is the processus alaris.

To summarise the important points in this model one says:—

1st, that the orbital wings are independent and do not complete the optic canal in front (at 30 mm. they do so).

2nd, that the processus alaris is a backward growth of the prehypophyseal segment, perhaps also of the parahypophyseal segment.

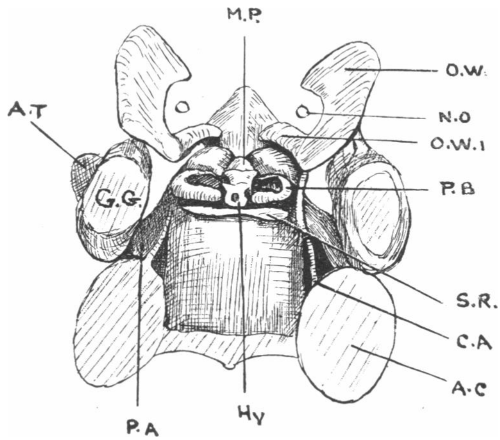

FIG. 11.

3rd, that the ala temporalis is independent and articulated with the processus alaris, but has not chondrified around the second division of the 5th nerve.

4th, that the dorsum sellæ is an independent formation.

A few remarks may be made here as to the condition of affairs at the 30 mm. stage, although at present I am unable to give a satisfactory drawing of the model.

At this stage, probably the stage at which the cartilaginous sphenoid reaches its highest degree of development, the orbital wings are enormously greater than the temporal wings, reaching out even beyond the orbital cavities into the temporal fossæ, making for but not reaching that extraordinary but temporary cartilage—the "parietal platte." Both limbs of the orbital wing are now developed, the posterior one being fused with the corpus sphenoidale, the anterior not so as yet, but in close contact with it, and so practically completing the optic foramen. Anteriorly this orbital wing is expanded so as to form a great part of the orbital roof, and this expansion becomes connected mesially with the perpendicular plate of the ethmoid—a spheno-ethmoidal fissure separating its inner segment from that of the ala orbitalis proper. This is well seen in Hertwig's model of the cranium of an 80 mm. embryo which is being figured in most of the text-books of to-day.

The alæ temporales (greater wings) are absurdly small by comparison

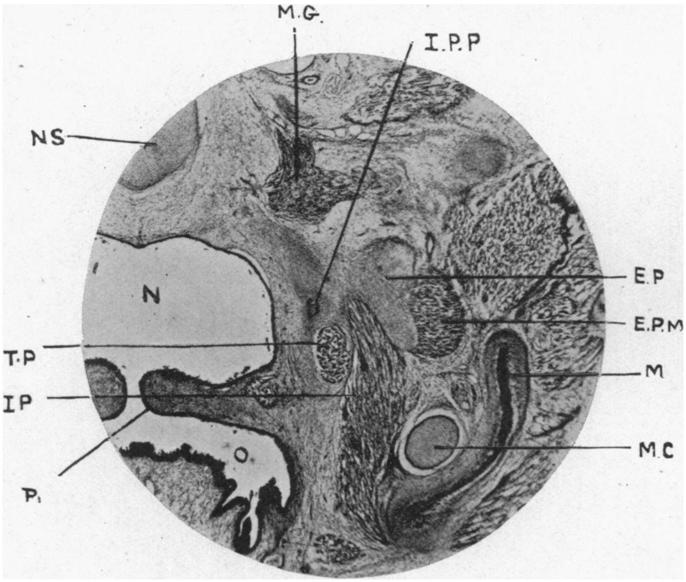

FIG. 12.

with the alæ orbitales. As seen from the front they lie almost wholly below the level of the orbit, extending not higher than the later formed lower margin of the orbital plate of the great wing of the bony sphenoid, and are perforated not far from their upper extremities by the second division of the fifth nerve. The whole, practically, of the orbital plate and that part of the sphenoid which is found in the temporal fossa, as well as the external pterygoid plate, are at this time membranous and will later be ossified ectochondrally, as will, to a large extent, be seen in the photograph of a section of an 80 mm. embryo (fig. 14). In the same model (30 mm.) the processus alaris sends backwards a pointed process which comes into contact with the auditory capsule (Jacoby). This condition is even visible at the 110 mm. stage (fig. 15).

It may be mentioned here that the foramen ovale and foramen spinosum are generally regarded as being formed in the cartilage of the great wing. That I doubt. It certainly is not the case in the 30 mm. embryo, and all the appearances suggest that they are formed in ectochondral bone.

Since this was sent to print I have been able to show that the superior maxillary nerve does not either groove or pierce the cartilage of the great wing, but that both the foramen ovale and the foramen spinosum are developed in membrane bone. This is seen at the 100 mm. stage.

The Ossification of the Sphenoid.—This has been to a certain extent

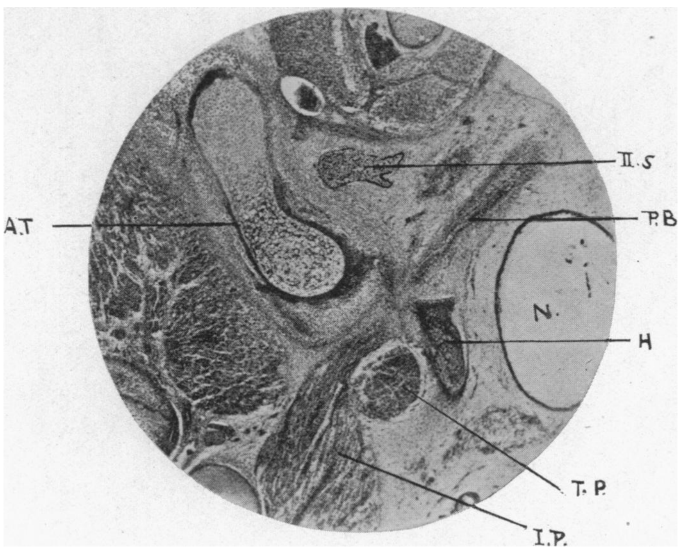

FIG. 13.

dealt with by me in a short note in the *Anatomischer Anzeiger*, vol. xxvi. p. 80, in which I pointed out that the internal pterygoid plate was the first part of the sphenoid to ossify.

Fig. 12 is from a coronal section of the head of a 37 mm. embryo (Harvard) collection. It shows us that the external pterygoid plate (E.P.) is composed of connective tissue. E.P.M. is the external pterygoid muscle; I.P.P. is the bony (ectochondral) internal pterygoid plate; T.P. the tensor palati; M. mandible; M.C. Meckel's cartilage; M.G. Meckel's ganglion; N.S. nasal septum; N. nasal cavity; O. the mouth; I.P. internal pterygoid muscle; P. the ununited palate.

At this stage the hamulus is ossifying in cartilage, which cartilage can be seen in the 30 mm. model.

Ossification next commences in the temporal or greater wing just external to the foramen rotundum (fig. 13) (A.T.) at about the 42 mm. stage.

Fig. 13, from the 42 mm. embryo, shows ossification in the cartilage of the great wing (A.T.), shows the cartilage bone in the hamulus (H), the superior maxillary nerve (II. 5); P.B. palate bone; N. nasal cavity; T.P. tensor palate; I.P. internal pterygoid plate.

Fig. 14, a coronal section of the head of an 80 mm. embryo. Here the cartilage of the great wing is shown with very characteristic form at this

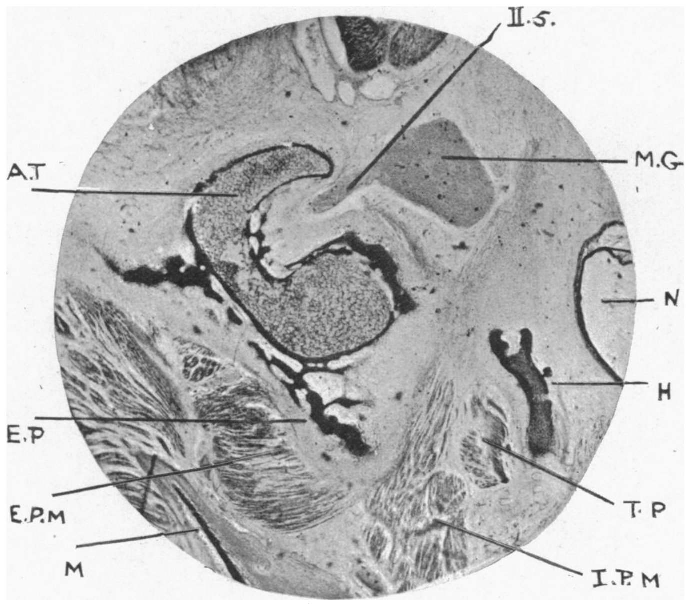

FIG. 14.

plane of section, appearing somewhat like a half-bent forefinger (A.T.), the concavity being the anterior end of the foramen rotundum; the superior maxillary division of the 5th nerve (II. 5) is seen in this concavity running outwards from Meckel's ganglion (M.G.). The cartilage is in a somewhat advanced condition of ossification, but its relative size is no greater than in the 30 mm. embryo, and its form is quite identical with that in the above-mentioned embryo. Projecting downwards from the lower end of the cartilage, membrane bone of deep black colour is seen forming the ectochondral external pterygoid plate (E.P.), whilst in the upward direction membrane bone is evident, and it will form, as previously stated, the orbital plate and that part of the great wing which is found in the temporal fossa.

The hamulus (H) is well seen, still showing cartilage undergoing ossification, whilst at its top end the black membrane bone of the internal pterygoid plate is manifest.

A.T. the great wing (pterygoid process); M.G. Meckel's ganglion; II. 5, superior maxillary division of 5th nerve; E.P. external pterygoid plate; E.P.M. external pterygoid muscle; M. mandible; I.P.M. internal pterygoid muscle; H. hamulus; N. nasal cavity.

Fig. 15. This is a photograph of a horizontal section of the head of a

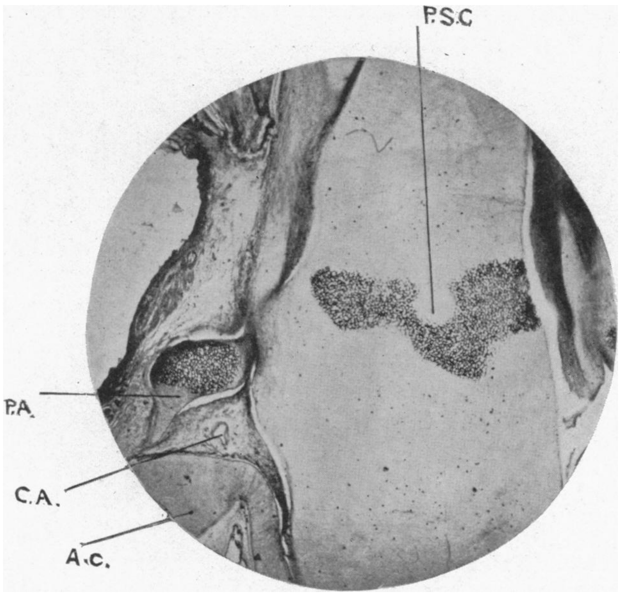

Fig. 15.

110 mm. embryo, and it shows two points of great interest, viz. ossification in the corpus sphenoidale—the post-sphenoidal centre (P.S.C.), which has a somewhat curious form, and giving rise to a little doubt as to whether it is a single centre or the result of fusion of two originally independent ones;[1] and ossification in the processus alaris (P.A.). This is obviously independent of that in the corpus sphenoidale, and its large size is somewhat surprising, if it form only that part commonly in our text-books called lingula. From its posterior end a pointed cartilaginous process is seen to pass backwards towards the auditory capsule (A.C.), and between the processus alaris and the auditory capsule the internal carotid artery (C.A.) is seen in transverse section.

[1] Later observations show that it arises by fusion of two independent centres.

P.S.C. post-sphenoidal centre or centres; P.A. processus alaris; C.A. internal carotid artery; A.C. auditory capsule.

General Conclusions.

It will now be evident that Giuseppe Levi's contentions, so far as they go, are absolutely accurate. And the intention is that this paper is supplementary to his, and that the two should be read together.

It is clear that the terms parachordæ and trabeculæ are scarcely applicable to man, or even mammals, as was long ago surmised by Kölliker; that the orbital and temporal wings are independent in chondrification; that the dorsum sellæ and the processus alaris are likewise independent in chondrification; that the cartilage of the temporal wing forms but a small part of the permanent sphenoid—little more, in fact, than the pterygoid process; that all other parts of this ala are formed ectochondrally; that the independent internal pterygoid plate is ossified both in cartilage, the hamulus, and in membrane, and is the first part of the sphenoid to be ossified. It may almost be assumed that where separate and independent nuclei of chondrification appear, they are independently converted into bone.

A point which appears to have been overlooked in the stock descriptions is the disparity in size between the greater and lesser wings. It is true that the statement is made that the young sphenoid differs from the adult form, say, in the fact that as in quadrupeds the lesser wing is greater than the greater wing, but this statement is true only of the cartilaginous condition. At present I am not in a position to give the chronological sequence in ossification of the sphenoid, but the matter is engaging my attention. It is clear, however, that the internal pterygoid plate ossifies first at about the 32 mm. stage, and is followed by ossification of the cartilage in the ala temporalis just below the foramen rotundum at the 40–42 mm. stage; that at the 110 mm. stage both the post-sphenoidal element and the processus alaris are ossified in cartilage; but whether the former is ossified by two independent centres, which subsequently run together, as seen or suggested in fig. 15, or remain separate, I know not. As to the date of appearance of the centres for the orbital wings and the pre-sphenoidal element, personal observations have yet to be made and are in progress.[1]

A word, finally, with regard to the so-called sphenoidal turbinates. These are clearly, and it is well known, at first quite independent of the sphenoid, being developed in connection with the ethmoidal cartilage; and though

[1] The order of ossification is thus: 1, int. pterygoid plate; 2, ala temporalis (great wing); 3, orbito-sphenoid; 4, processus alaris (lingula), post-sphenoid; 5, sphenoidal turbinate bones.

not represented in the model made from the 19 mm. Harvard embryo as figured in this paper, since the ethmoidal segment was removed in order to show better the sphenoid, yet they are present at that stage, and, according to Cleland, ossify constantly from four centres in the later months of gestation.

My warmest thanks are due to Professors Minot of Harvard and Bryce of Glasgow for kindly placing at my disposal sections of valuable embryos, and to many old pupils, without whose aid this work could not have been done.

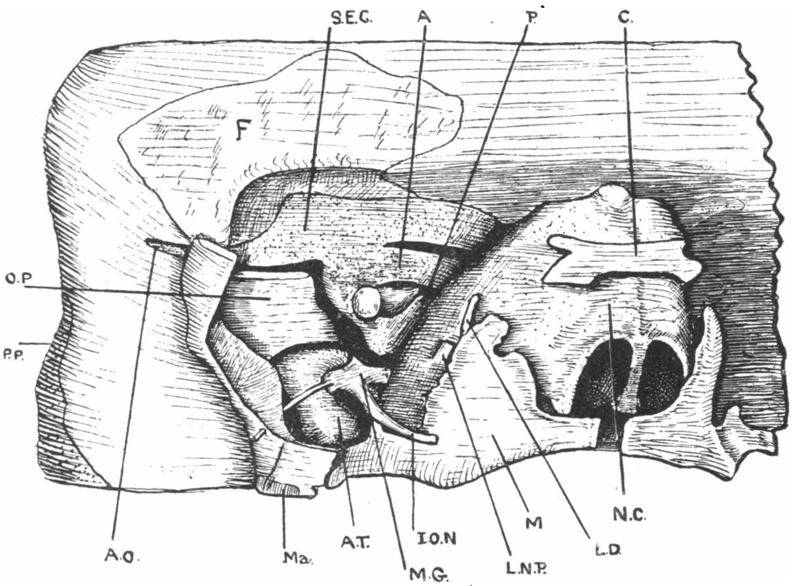

FIG. 16.—Part of the reconstructed head of the 30 mm. Bryce embryo, drawn especially to show the greater and lesser wings of the sphenoid at that stage. A full description of this model will be given later.

SUPPLEMENTARY.

A. The anterior wall of the optic foramen.

P. The posterior wall of the optic foramen. Note that the cartilage of this wall is prolonged along the inner side of the optic foramen.

S.E.C. The spheno-ethmoidal cartilage. Notice how it forms a considerable part of the roof of the orbit, how the ethmoidal segment is prolonged inwards to be attached to the nasal capsule (N.C.), and that it is separated in part by a fissure—the orbito-nasal from the inner end of the sphenoidal segment. Note, too, that the spheno-ethmoidal cartilage passes out beyond the outer wall of the orbit into the temporal fossa, making for, but not reaching, the parietal plate of cartilage (P.P.). Observe next the exceedingly small greater wing (A.T.) through which the superior maxillary division of the 5th nerve is emerging to at once engage with Meckel's ganglion (M.G.). The temporo-malar nerve has been represented, and it can be seen perforating a mass of as yet unossified tissue, later to complete the malar bone, which is apparent at the lower part of this mass (Ma.). From its shape and general relations it will be clear that this ala temporalis forms little more than the pterygoid process, and it is a little doubtful if the term ala temporalis is quite the happiest one. Above this mass one sees a larger one of connective tissue (O.P.) as yet wholly unossified. This obviously is to become the orbital plate, and without the orbit what doubtless is really ala temporalis. Between this mass and the cartilaginous ala orbitalis is the sphenoidal fissure, the contents of which, to avoid complication, are not represented. As this is not the place to describe this model in detail, I will content myself with merely appending the legend :—

A. Anterior limb of ala orbitalis forming anterior wall of optic foramen.
P. Posterior limb of ala orbitalis forming the posterior and inner walls of the optic foramen.
S.E.C. The spheno-ethmoidal cartilage.
A.O. Outer end of the spheno-ethmoidal cartilage extending into the temporal fossa.
I.O.N. Infra orbital nerve.
M.G. Meckel's ganglion.
A.T. Ala temporalis.
M. Maxilla.
N.C. Nasal capsule.
C. Connective tissue in which nasal bone ossifies together with part of the nasal process of the maxilla.
L.D. Lacrymal duct.
L.N.P. Lateral nasal cartilage (Mihalkowics).
Ma. Malar bone.
P.P. Parietal plate.
F. Frontal bone.