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MORPHOLOGY OF THE ROOF PLATE OF THE
FOREBRAIN AND THE LATERAL CHOROID
PLEXUSES IN THE HUMAN EMBRYO

A DISSERTATION
SUBMITTED TO THE FACULTY
OF THE OGDEN GRADUATE SCHOOL OF SCIENCE
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
DEPARTMENT OF ANATOMY

BY
PERCIVAL BAILEY

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MORPHOLOGY OF THE ROOF PLATE OF THE FORE- BRAIN AND THE LATERAL CHOROID PLEXUSES IN THE HUMAN EMBRYO

PERCIVAL BAILEY

From the Anatomical Laboratory of the University of Chicago

THIRTY-ONE FIGURES

CONTENTS

Introduction.....	79
History.....	80
Material and methods.....	84
Description.....	86
1. The 19 mm. embryo.....	86
2. The 28 mm. embryo.....	91
3. The 32 mm. embryo.....	96
Discussion.....	99
1. Telencephalon.....	99
2. Diencephalon.....	108
Summary.....	110

INTRODUCTION

The researches of Minot, von Kupffer, Burckhardt, G. Elliot Smith, C. Judson Herrick, J. B. Johnston and others, have succeeded in homologizing with considerable certainty the structures in the roof of the prosencephalon of the lower vertebrates, and of some of the lower Mammalia. The results of these comparative studies Johnston extended to the human embryo and it seemed desirable to examine some other human embryos of different ages in the hope that additional light might be shed on the method of development of these structures.

HISTORY

Concerning the structures with which this study is concerned, the writings of such authors as Faivre ('54), Luschka ('85), and Haeckel ('60), previous to the work of Wilhelm His, contain very little of value.

Of the choroid plexus of the lateral ventricle, His writes ('04):

Sein dem Thalamus angehefteter Randstreifen bleibt ependymal und in ihm bildet sich die Fissura chorioidea, von der aus die Epithelfaltungen des Corpus chorioideum in den Seitenventrikel sich einstülpen.

Minot ('01) considers the lateral plexus to be developed from the velum transversum.

In both birds and mammals the lateral portions of the velum, i.e., the choroid plexus of the lateral ventricle is highly developed. It thus appears that as we ascend the vertebrate series there is first a broadening of the velum, and an increase in its lateral development, then occurs a further reduction and flattening out of the velum, and a much greater growth of the lateral plexus.

G. Elliot Smith ('03) attempted another explanation for the formation of the lateral plexus.

Now, although in the whole of its extent the epithelial layer of the choroid plexus presents uniform features, it is difficult to admit a common origin for the whole structure; with regard to that part of the plexus which is found in the region of the foramen of Monro, there can be little doubt of its origin from the primitive roof of the forebrain. . . . But the case is very different with that portion of the plexus which is not directly connected with the roof of the forebrain, but is attached to the stria terminalis. There is no evidence to show that this portion is derived from the roof, and all the facts of development point to the conclusion that its proximal attachment to the optic thalamus is a primitive and not a secondarily acquired relation. Such being the case, the caudal extension of the epithelial choroidal fold in the mammalian hemisphere would appear to be derived from a stretching of the attachment of the labium caudale of the cerebral hemisphere to the optic thalamus. As a result of this, the connecting band becomes reduced to an epithelial lamina, which becomes invaginated and folded by an extension backward of the choroidal folding which begins farther forward in the region of the foramen of Monro.

Johnston ('09) after showing that the velum transversum is continued down the side-wall of the prosencephalon as the ditelencephalic groove, returns to a modification of Minot's original idea.

In the angle between the [cerebral] vesicle and the diencephalon appears the choroid plexus pushing into the lateral ventricle. It appears as a folding of the anterior limb or wall of the velum transversum and its lateral prolongation [di-telencephalic groove].

Concerning the mesodermal portion of the lateral plexus, Meek ('07) makes the following statement.

The choroid plexuses of the lateral ventricles are due to an ingrowth of the pia mater pushing the mesial wall of the hemispheres into the ventricles.

This is the current notion.

The arachnoid is not supposed to be present, although the plexus is but a fringe of the velum interpositum, into the structure of which the arachnoid does enter. The neural wall is, of course, preserved, but consists only of a simple epithelium. The plexuses are then thin laminae covered with an epithelium, beneath which is a connective tissue stroma containing an extraordinarily rich network of blood-vessels.

Findlay's ('99) idea of a single membrane, the pia-arachnoid, removes the difficulty concerning the involvement of the arachnoid.

Finally, Hochstetter ('13) has written a purely descriptive account of the development of the lateral choroid plexus with no attempt to analyze its parts. He summarizes his work as follows:

Fassen wir das bisher Mitgeteilte zusammen, so können wir sagen, dass sich die Plexus chorioidei der Seitenventrikel ungefähr in derselben Richtung entwickeln wie die Hemisphärenblasen selbst. Zuerst angelegt, wenn auch nicht gleich als Anlage der Plexus chorioidei kenntlich, ist ihr vorderster, im Bereiche der Decke des Cavum Monroi befindlicher Abschnitt. Er entsteht hier, wie wir gesehen haben, aus den die Sulci hemisphaerici [di-telencephalic grooves] bildenden Hirnwandfalten, sowie aus dem diese beiden, in der Fortsetzung des Zwischenhirndaches verbindenden, vorerst kielförmig vorspringenden Wandteile des Endhirns. Ein zweiter Abschnitt erscheint wesentlich später in Form einer jederseits zunächst einfachen gegen den Hohlraum der Seitenkammer zu vorspringenden Falte, der als Area chorioidea bezeichneten Wandplatte der Hemisphäre. Diese Falte geht vorn in die Wandfalte des Sulcus hemisphaericus über, während sie sich nach rückwärts etwas von ihr entfernt (fig. 4), noch weiter nach rückwärts aber bald verstreicht. So erscheint bei dem ältesten von den drei

bisher besprochenen Embryonen (H. Sch. 2) der hinterste dem Zwischenhirn anliegende Abschnitt der Area chorioidea nach vollkommen glatt und ungefaltet.

All of his figures, with the exception of figure 6, appear to be through the diencephalon, back of the velum transversum.

The development of the paraphysis in the human embryo has never been followed. In fact, its identification is very much in doubt. Francotte ('94) claims to have found it in an embryo of twelve weeks. It is said to be an organ characteristic of all vertebrates, but becomes very rudimentary in birds and mammals. Its development has been followed by Dexter ('02) in the common fowl, and it has been described by Selenka ('91) in the opossum. A good review of the literature is given by Warren ('05).

Of the human embryo, Streeter in Keibel and Mall's *Human Embryology* says,

Orally this choroid roof [of the third ventricle] is continued into the telencephalon where it forms a pointed pouch overlapping the lamina terminalis and the contained commissures. . . . The anterior choroidal pouch has been homologized with the paraphysis of the lower vertebrates.

It should be borne in mind that in all vertebrates, the paraphysis, if present, arises from the roof of the telencephalon just cephalad to the velum transversum. In view of this fact, the structure labelled paraphysis by Goldstein ('03) is obviously not so, since it lies behind a structure called the velum transversum and at the posterior end of the diencephalic roof.

The epiphysis is a constant organ in the vertebrate series (except in the alligator) but probably concerning no other organ has there been so much confusion and misinterpretation. For a review of the literature, reference may be had to Gaupp ('98). The development of the epiphysis has not been followed completely in the human embryo, and so far as I know, an indication of the division into the two parts, epiphyseal stalk and pineal vesicle, which seems to be so characteristic of many vertebrates, has never been recorded.

With the recognition of the velum transversum in Cyclostomes by Sterzi ('07), the velum has been established as a constant

morphological feature in the roof of the prosencephalon of vertebrates.

The tela chorioidea diencephali has been the subject of an extensive anatomical, embryological and comparative study by Lachi ('88). It presents few features of interest. A number of names have been applied to parts of it (Zirbelpolster, dorsalsac, post-paraphysis, post-velar arch, etc.), but it has generally been recognized as extending from the superior commissure to the velum transversum.

With regard to the roof of the telencephalon, however, there is no such unanimity of opinion. I shall not attempt to review the observations on the lower vertebrates. Johnston ('13) reviews the literature fully and on the basis of this and his own extensive observations presents the following scheme as covering all the forms of the roof of the telencephalon, beginning with the preoptic recess in which the sulcus limitans ends:

- Lamina terminalis (containing the anterior commissure)
- Recessus neuroporicus
- Lamina supraneuroporica (containing the pallial commissures)
- Recessus superior
- Tela chorioidea telencephali
- Paraphysis
- Velum transversum (anterior leaf)

Instead of tela chorioidea telencephali, the more definite term, tela chorioidea telencephali medii, will be used in this paper.

This plan may be completed for the diencephalon as follows:

- Velum transversum (posterior leaf)
- Tela chorioidea diencephali
- Commissura superior
- Epiphysis

The posterior commissure belongs to the mesencephalon. The neuropore itself has never been followed through the successive stages of its development in the human embryo.

The evidence for transferring the above scheme to the human embryo is not wholly conclusive, and the present work was undertaken primarily to determine in how far the morphology in this region in certain human embryos was compatible with the above scheme.

I wish here to express my indebtedness to Dr. C. J. Herrick, whose broad knowledge and mature judgment has been of invaluable assistance, and especially to Dr. Geo. W. Bartlemez, at whose suggestion the work was undertaken and without whose kindly interest the work would have been impossible. Thanks are also due to Mr. A. B. Streedain for the care he has taken with the illustrative work.

MATERIAL AND METHODS

The material upon which this study was chiefly based consists of three very well preserved human embryos, cut in transverse series, stained in bulk with borax carmine, and counterstained on the slide with orange G. Wax-plate reconstructions were made, the plates being stacked from a side view of the embryo drawn from a photograph, taken after fixation. The shrinkage after embedding was calculated and the outline reduced accordingly. Although the primary object of this study is the morphology and relations of the roof plate, in two cases the entire forebrain has been modeled. This was done because the embryos happened to fall in at opportune intervals between His' embryo CR (13.6 mm.) and the embryo of 50 mm. also modeled by him, and also in order that the relations of the choroid plexuses might be seen more clearly.

Embryo H 173 was obtained from an aborted ovum of 42 x 32 x 19 mm., presented by Dr. N. R. Engels of Chicago. The only available history was that the patient had missed two menses. The intact ovum was placed in physiological salt solution and kept at about 0°C. for 11 hours. It was then opened and fixed in formalin-Zenker for 24 hours, stained in bulk with borax carmine, imbedded by the celloidin-paraffin method and cut 10 μ thick in a plane parallel to the hindbrain. The embryo measured 19.1 mm., crown-rump length after fixation. The sections were counterstained on the slides with orange G. The total shrinkage was about 20 per cent. There are frequent mitoses in embryo and chorion. The brain was modeled at a magnification of 50 diameters with the aid of the Edinger pro-

jection apparatus. One millimeter plates were used and every other section drawn except in the region of the foramen interventriculare, where half millimeter plates were used and every section drawn. The epiphyseal region was modeled at a magnification of 100 diameters. Millimeter plates were used and every section was drawn.

Embryo H 91 was obtained from an aborted ovum 50 x 34 x 30 mm. presented by Dr. G. C. Dittmann of Chicago, whose data indicate a clinical pregnancy of 60 days. The ovum was left unopened in physiological salt solution for 10 hours, then opened and fixed in an 8 per cent solution of formaldehyde, neutralized with magnesium carbonate. It measured 27.8 mm. crown-rump length after fixation in formalin and showed a shrinkage of 13.6 per cent after imbedding in paraffin. It was stained in bulk in borax carmine and on the slide with orange G. It was cut in 20μ sections, and modeled at a magnification of 40 diameters. Millimeter plates were used and every fifth section was omitted.

Embryo H 41 was obtained from an ovum of 71 x 39 x 32 mm., presented by Dr. L. A. Beaton of Chicago. The chorion was opened and the entire ovum fixed in formalin. The crown-rump measurement of the embryo after fixation was 32.1 mm. and it showed a shrinkage of 10 per cent after imbedding in paraffin. The staining was the same as that of H 91. This embryo was sectioned 20μ in paraffin, and modeled at a magnification of 25 diameters. Millimeter plates were used and every other section was drawn. The region around the foramen of Monro was modeled at a magnification of 100 diameters; 2 mm. plates were used and every section was drawn.

Two points in the technical procedure are to be emphasized because they are in large measure responsible for the exceptionally good preservation of the form relations of the delicate roof plate of the brain. Both of the older embryos (H 91 and H 41) had the cranial cavity opened by an incision in the line of the sagittal suture. Distortions due to unequal shrinkage of the brain and overlying structures were thereby in great measure avoided. All three were passed from 95 per cent alcohol to

ether-alcohol, then through 0.5, 1, 2 and 3 per cent celloidin, hardened in chloroform-alcohol, cleared in benzol and imbedded in paraffin under the air pump.

The plane of section in each case is shown in figures 29, 30 and 31.

Several other human embryos were studied, the most helpful being embryo H 44 of the Chicago collection, which measured 60.4 mm. after fixation in formalin. A transverse series from a 25 mm. pig in the collection of Dr. F. R. Lillie was also used.

DESCRIPTION

1. *The 19 mm. embryo (H. 173)*

The recessus preopticus is well marked (fig. 18, *r.pre.*). The roof plate stretches dorsad from this recess as a thickened lamina (fig. 18, *l.t.*) to about the level of the sulcus separating the medial and intermediate roots of the corpus striatum. Above this point the roof plate narrows and extends cephalad and dorsad (fig. 18, *l.s.?*), forms a broad arch (fig. 18, *r.s.*), and then passes caudad and dorsad (fig. 18, *t.c.t.m.*) as a still thinner membrane toward the velum transversum. Just in front of the velum transversum, the roof plate forms a small narrow arch (fig. 18, *p.a.* and fig. 2, *p.a.*), from the sides of which arise the lateral choroid plexuses.

(Throughout these descriptions, narrow and wide are used of dimensions tangential to the ventricular surface, and thick and thin of dimensions perpendicular to the ventricular surface. For example, in figure 12, the tela chorioidea diencephali is thin and wide.)

The velum transversum is well marked (fig. 18, *v.t.*), indicating the boundary in the roof plate between the diencephalon and telencephalon.

The roof of the diencephalon (fig. 18, *t.c.d.*) is still narrow throughout most of its extent. It is also relatively thick, with several rows of nuclei in cross-section. It is narrowest at its posterior end and remains narrow almost to the anterior end of the thalamus, where it suddenly widens (fig. 1, *t.c.d.*). The

entire structure, when viewed from above, is somewhat trumpet-shaped, with the bell at the anterior end. There is no indication of plexus formation. The entire roof plate of the diencephalon is perfectly smooth. The commissura superior is clearly indicated (fig. 18, *com.s.*).

The epiphyseal evagination is a hollow outgrowth (figs. 18 and 3, *e.e.*). The top of the evagination is cupped and in this cup lies a ball of cells (figs. 3, 10 and 18, *e.v.*). This ball of cells has an irregular lumen in its center (fig. 10, *e.v.*). The cells of the ball stain more lightly than the cells of the cup, and the line of separation is fairly distinct. It will be seen that this ball of cells, while not in actual contact with the epidermis, approaches it very closely (fig. 10, *e.v.*). The epiphyseal evagination lies some distance cephalad of the commissura posterior (fig. 18, *c.p.*).

The extent and morphology of the lateral choroid plexus is shown in figure 19. It is clearly divisible into two parts, an anterior part (figs. 2 and 19, *p.c.v.l., p.a.*) attached to the lateral margin of the paraphysal arch along its entire length, and by the taenia fornicis (fig. 2, *t.f.*) to the medial hemisphere wall immediately above and lateral to it; and a posterior part (figs. 1 and 19, *p.c.v.l., p.p.*) attached by the taenia chorioidea (fig. 1, *t.c.*) to the lateral thalamic wall and by the taenia fornicis (fig. 1, *t.f.*) to the medial hemisphere wall immediately below the hippocampus. The fissura chorioidea is very wide throughout most of the extent of the posterior part of the lateral choroid plexus.

If the angle between the taenia chorioidea and the thalamic wall be followed anteriorly, it is found to be continuous with the velum transversum; if the angle is followed posteriorly, it continues backward between the lateral thalamic wall and the medial hemisphere wall, turns downward between them and passes anteriorly and downward behind the optic nerve on the lateral wall of the hypothalamus (fig. 19, *d-t. gr.*). This groove is more clearly marked on the lateral wall of the 32 mm. embryo.

The endymal portion of the plexus is still relatively thick (fig. 27). The mesenchymal tissue of the plexus is typical em-

bryonal connective tissue. The blood capillaries are particularly numerous near the ependyma.

If one examines now the ventricular surface, the corpus striatum (fig. 19, *c.s.*) appears at the posterior point of attachment of the lateral plexus as a single ridge in the floor of the lateral ventricle. As it is followed anteriorly, this ridge is soon divided by a groove into two portions. The lateral portion is

REFERENCE LETTERS

- | | |
|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| <i>a.c.a.</i> , area chorioidea anterior. | <i>n.post.</i> , recessus postopticus |
| <i>a.c.p.</i> , area chorioidea posterior. | <i>o.n.</i> , optic nerve |
| <i>a.p.</i> , anterior pouch (of the tela chorioidea diencephali) | <i>p.a.</i> , paraphysal arch |
| <i>aq.S.</i> , aqueduct of Sylvius | <i>p.c.v.l.</i> , plexus chorioideus ventriculi lateralis |
| <i>cb.</i> , cerebellum | <i>p.c.v.l.</i> , <i>p.a.</i> , plexus chorioideus ventriculi lateralis, pars anterior |
| <i>c.o.</i> , chiasma opticum | <i>p.c.v.l.</i> , <i>p.p.</i> , plexus chorioideus ventriculi lateralis, pars posterior |
| <i>com.s.</i> , commissura superior | <i>p.o.hy.</i> , pars optica hypothalami |
| <i>c.p.</i> , commissura posterior. | <i>r.m.</i> , recessus mamillaris |
| <i>c.s.</i> , corpus striatum | <i>r.n.</i> , recessus neuroporicus |
| <i>c.s.i.r.</i> , corpus striatum, intermediate root | <i>r.post.</i> , recessus postopticus |
| <i>c.s.l.r.</i> , corpus striatum, lateral root | <i>r.pre.</i> , recessus preopticus |
| <i>c.s.m.r.</i> , corpus striatum, medial root | <i>r.s.</i> , recessus superior |
| <i>d.p.</i> , deep pit (in telencephalic roof plate) | <i>s.a.</i> , striatal area |
| <i>d-t.gr.</i> , di-telencephalic groove | <i>s.l.</i> , sulcus limitans |
| <i>e.e.</i> , epiphyseal evagination | <i>s.m.</i> , stria medullaris |
| <i>ep.</i> , epidermis | <i>s.M.</i> , sulcus Monroi |
| <i>e.r.</i> , epiphyseal ridge | <i>s-t.</i> , subthalamus |
| <i>e.v.</i> , epiphyseal vesicle | <i>t.c.</i> , taenia chorioidea |
| <i>f.a.</i> , fissura arcuata | <i>t.c.d.</i> , tela chorioidea diencephali |
| <i>f.c.</i> , fissura chorioidea | <i>t.c.t.m.</i> , tela chorioidea telencephali medii |
| <i>f.int.</i> , foramen interventriculare | <i>tf.</i> , taenia fornicis |
| <i>f.r.</i> , fasciculus retroflexus (Meynerti) | <i>tg.</i> , tegmentum |
| <i>h.a.</i> , and <i>hip.</i> , hippocampal area | <i>th.</i> , thalamus |
| <i>hem.</i> , hemisphere | <i>th.1.</i> , <i>th.2.</i> , parts of thalamus |
| <i>h.s-t.r.</i> , habenulo-subthalamic ridge | <i>th.</i> , <i>e.s.</i> , thalamus, ependymal surface |
| <i>hy.</i> , hypothalamus | <i>th.</i> , <i>p.s.</i> , thalamus, pial surface |
| <i>inf.</i> , infundibulum | <i>t.i-c.</i> , taenia infrachorioidea |
| <i>l.s.</i> , lamina supraneuroporica | <i>t.r-p.</i> , telencephalic roof plate |
| <i>l.t.</i> , lamina terminalis | <i>t.s-c.</i> , taenia suprachorioidea |
| <i>mt.</i> , metathalamus | <i>t.t.</i> , taenia thalami |
| <i>n.h.</i> , nucleus habenulac | <i>v.t.</i> , velum transversum |
| <i>n-p.a.</i> , neopallial area | |

at first in the floor of the lateral ventricle but anteriorly comes to lie in the lateral wall (figs. 2 and 23, *c.s.l.r.*). The medial portion

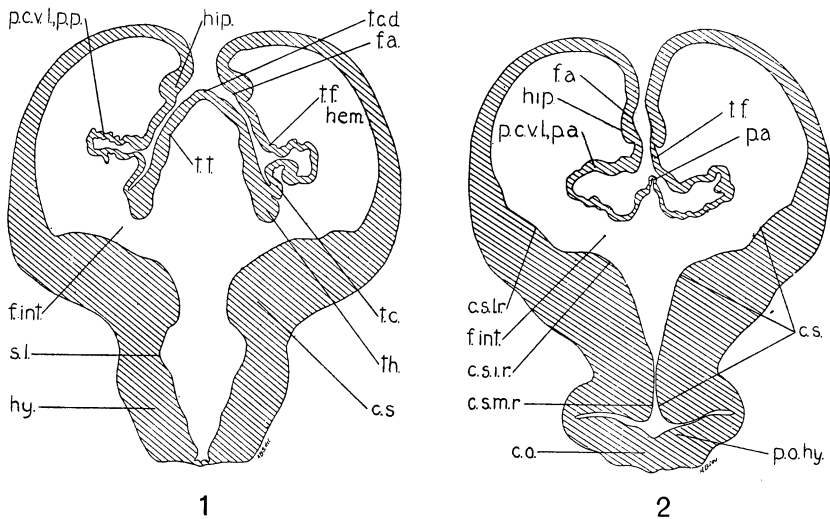


Fig. 1 Section through the diencephalon of the 19 mm. embryo, H 173. $\times 13\frac{1}{2}$. Slide 21, Sect. 11. Compare the photograph of this section, figure 27.

Fig. 2 Section through paraphysis and hypothalamus of the 19 mm. embryo, H 173. $\times 13\frac{1}{2}$. Slide 23, Sect. 13.

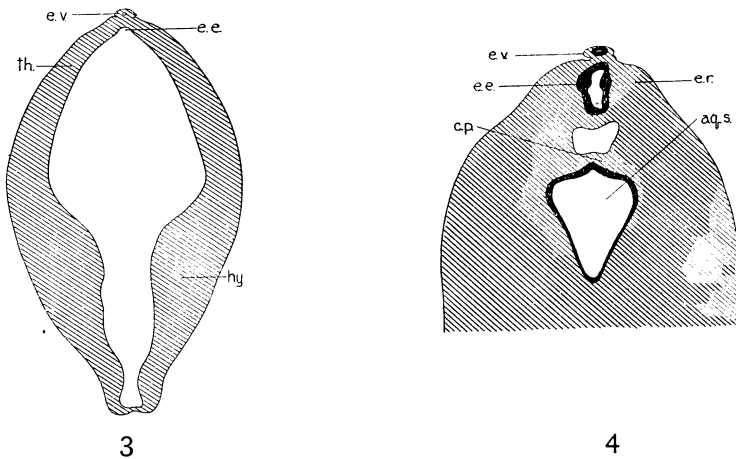


Fig. 3 Section through epiphysis of the 19 mm. embryo, H 173. $\times 15$. Slide 12, Sect. 4.

Fig. 4 Section through epiphysis of the 28 mm. embryo, H 91. $\times 10$. Slide 9, Sect. 148. Ependyma solid black.

continues to the foramen interventriculare where it divides into two parts, the lateral part passing forward in the floor of the lateral ventricle (the intermediate root of the corpus striatum, figs. 2 and 23, *c.s.i.r.*), and the medial part passing through the foramen interventriculare, forming its floor, and extending in the lateral wall of the third ventricle behind the lamina terminalis as far as the recessus preopticus (fig. 18, *c.s.m.r.*). It is very likely that this elevation which I have just described as the medial root of the corpus striatum contains in its lower end other things besides striatal tissue. I shall continue to describe the entire elevation as the medial root of the corpus striatum, following the usage of His, and shall not enter into a discussion of its internal structure.

Above the taenia fornicis on the ventricular surface of the medial hemisphere wall may be seen an elevation (fig. 19, *hip.*) extending from the posterior pole of the hemisphere just above the choroid plexus, and beyond it over the foramen interventriculare. This is the anlage of the hippocampus, at least in part. There is corresponding to it on the outer pial side of the hemisphere wall, a shallow groove (figs. 1 and 2, *f.a.*). This groove is not due to the folding in of a thin weak place in the wall, for the wall at this point is very definitely thicker (fig. 27).

Turning now to the wall of the third ventricle, we find just below the tela chorioidea diencephali a low ridge (fig. 18, *n.h.*) extending from the epiphyseal evagination almost to the velum transversum. This is the habenula. From its anterior end a sharp ridge runs backward and downward to the subthalamus (fig. 18, *h.s-t.r.*). Above this ridge, the wall is shrunken and thin up to the habenular thickening. Below the ridge, is an elevation (fig. 18, *th.1*) which extends upward and forward in front of the habenula toward the velum transversum.

The sulcus limitans is indicated on figure 18 by a dotted line running above the tegmentum and subthalamus, below the elevation last mentioned (fig. 18, *th.1*) and behind the corpus striatum to the preoptic recess. Just back of the corpus striatum and between it and the hypothalamus, the sulcus limitans runs into a very deep recess (fig. 2).

Below the sulcus limitans lie the subthalamus (fig. 18, *s-t.*) and hypothalamus (fig. 18, *hy.*). The elevation which marks this region is very long. The pars optica is only indistinctly marked off (fig. 18, *p.o.hy.*). At its posterior end, the elevation divides into two portions, one of which, subthalamus, continues upward into the tegmentum, the other, hypothalamus, backward into the mammillary recess.

The floor plate is thin and somewhat widened (fig. 3). The infundibulum (fig. 18, *inf.*) lies a considerable distance back of the optic chiasm. The postoptic recess is but poorly marked (fig. 18, *r. post.*).

2. The 28 mm. embryo (*H. 91*)

The entire telencephalon is not modeled in this embryo. The model was made primarily to show the lateral choroid plexus. Those portions not modeled differ in no essential respect from the corresponding portions of the 32 mm. embryo.

Immediately cephalad of the velum transversum (fig. 20, *v.t.*), which is clearly indicated, the roof plate forms a small arch (fig. 20, *p.a.*) to the sides of which are attached the lateral choroid plexuses. In front of the arch, the roof plate becomes very thin for a few sections (fig. 5, *t.c.t.m.*). Then as we pass cephalad of this thin lamina, we come to a region where the roof plate thickens in a peculiar manner (fig. 6, *t.r-p.*).

The hemisphere wall on each side of the roof plate is thin and in it two distinct zones are discernable, a broader zone next the ependymal surface, where the nuclei are very numerous, mantle layer, and a narrower zone next the pial surface which is relatively free from nuclei, marginal layer. In the roof plate, however, these two zones are not discernable, the nuclei are equally numerous throughout from the pial to the ependymal surface, and at the ependymal surface are loosely arranged, so that the outline is indefinite and irregular. This is the characteristic arrangement, and such an arrangement I have found in this region in five human embryos of about this age in the collection of the Department of Anatomy and in a 25 mm. pig embryo in the

collection of Dr. F. R. Lillie. In the embryo under consideration toward the anterior end of this region (fig. 7, *t.r-p.*) the morphology is somewhat different from that shown in figure 6. In the mid-line again, the nuclei are evenly distributed from ependymal to pial surface and are very numerous. Immediately on either side, however, the wall is greatly thickened in such manner that,

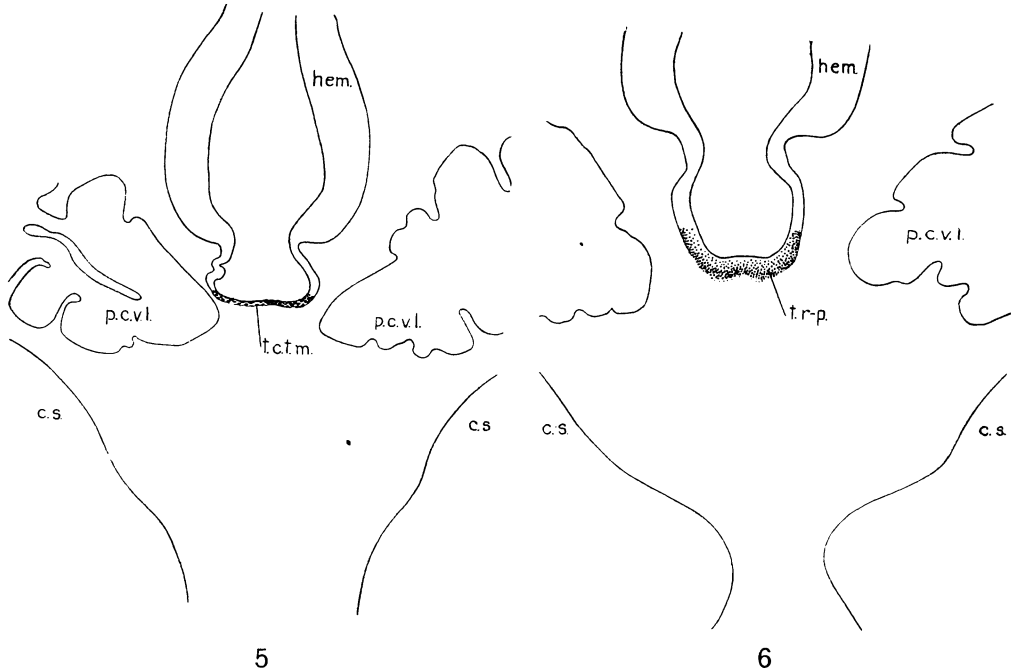


Fig. 5 Section through tela chorioidea telencephali medii of the 28 mm. embryo, H 91. $\times 50$. Slide 28, Sect. 362.

Fig. 6 Section through roof plate of telencephalon medium of the 28 mm. embryo, H 91. $\times 50$. Slide 29, Sect. 367.

although the pial surface still forms a regular curve, the ependymal surface shows a deep notch in the mid-line. The outline of the ependymal surface is again indefinite owing to the loosely arranged cells. The marginal layer approaches almost to the midline. At the extreme anterior end of this region the notch disappears; the ependymal outline becomes definite; and the roof plate thickens markedly in an undoubted lamina terminalis (fig. 20, *l.t.*).

The tela chorioidea diencephali is very broad and very thin (fig. 11, *t.c.d.*). It does not exhibit any folding except at the extreme anterior end. Toward the posterior end of the tela, a narrow strip of the alar plate is curved lateralward, resembling the rhomboidal lip of the rhombencephalon, and which we may term the thalamic lip (fig. 9, *t.l.*).

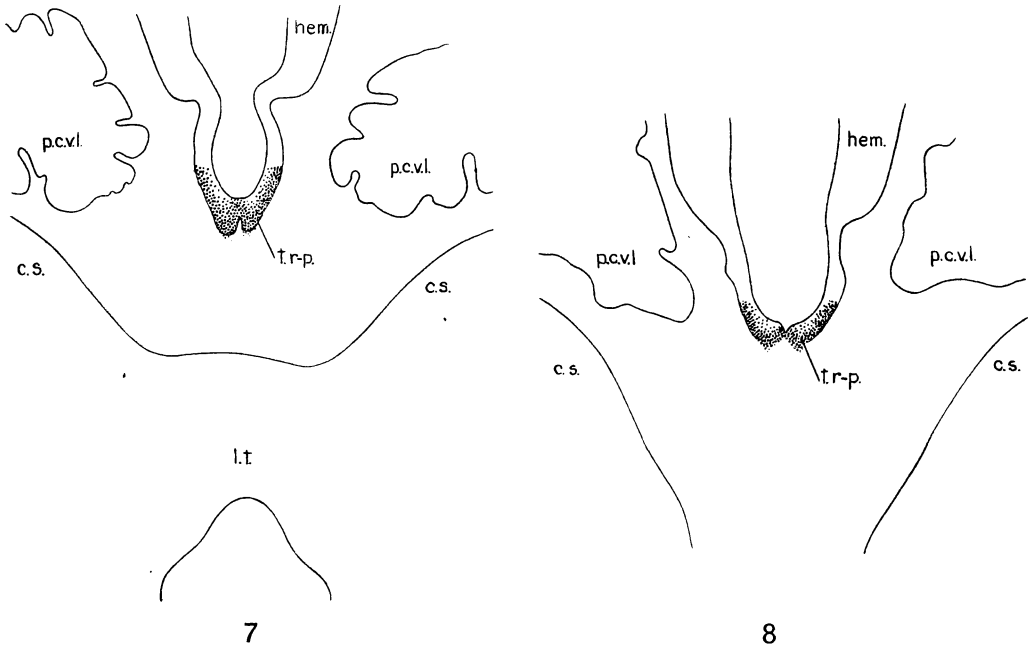


Fig. 7 Section through the roof plate of telencephalon medium of the 28 mm. embryo, H 91. $\times 50$. Slide, 29, Sect. 372.

Fig. 8 Section through the roof plate of telencephalon medium in the 32 mm. embryo, H 41. $\times 50$. Slide 32, Sect. 2.

The thalamic lip carries with it lateralward the taenia thalami (fig. 9, *t.t.*) and the roof plate. Toward the anterior end of the tela, the thalamic lip bends laterally more and more until its pial surface comes into contact with the pial surface of the thalamic wall (fig. 11, *t.l.*). The ependymal surface of the roof plate is hereby brought into contact with the ependymal surface of the thalamic lip (fig. 11). At the apex of the angle between the thalamic lip and the thalamic wall lies the stria medullaris (fig. 11, *s.m.*). The entire tela when viewed from above is wedge-

shaped, the anterior end being very broad. Heuser ('13) has noted a similar condition in the pig. The commissura superior is well marked (fig. 20, *com. s.*).

It will be seen that the roof of the epiphyseal evagination (fig. 20, *e.e.*) becomes epithelial for a short space in its uppermost portion. Just in front of this epithelial region there is a small aggregation of cells (fig. 4, *e.v.*) which recalls the ball of cells described in the epiphysis of the 19 mm. embryo. The nuclei

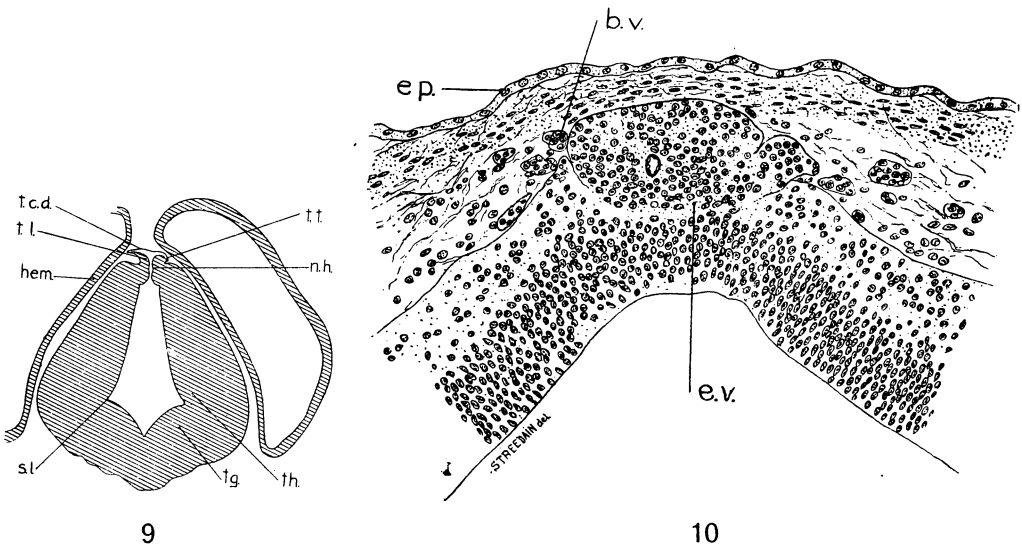


Fig. 9 Section through the diencephalon of the 28 mm. embryo, H 91. $\times 6\frac{2}{3}$. Slide 15, Sect. 228.

Fig. 10 Section through the epiphysis of the 19 mm. embryo, H 173. $\times 150$. Slide 12, Sect. 4.

of these cells stain densely like the nuclei of the ependymal cells, and lie very close together. The cytoplasm is stained a deep yellow like the cytoplasm of the ependymal cells. They are surrounded by more lightly staining cells, and are nowhere in connection with the ependymal cells. The lateral wall of the epiphyseal evagination is very massive (fig. 4, *e.r.*). A ridge arises from the postero-superior portion of the lateral wall of the diencephalon and extends upward and backward to the epiphyseal evagination (fig. 21, *e.r.*).

The lateral choroid plexus (fig. 21, *p.c.v.l.*) is of considerable size, but does not nearly fill the ventricle (fig. 11, *p.c.v.l.*). In antero-posterior extent the plexus measures 1.55 mm., the ventricle measuring 2.97 mm. The anterior end of the plexus is much the larger and is less folded. Thompson ('09) has described a similar condition in the cat. The attachment of the plexus to the roof plate is now much narrowed, owing to the relatively small size of the paraphysal arch (fig. 20, *p.c.v.l.*, *p.a.*). The taenia fornicis is now closely approximated to the taenia chorioidea, the fissura chorioidea being reduced to a narrow

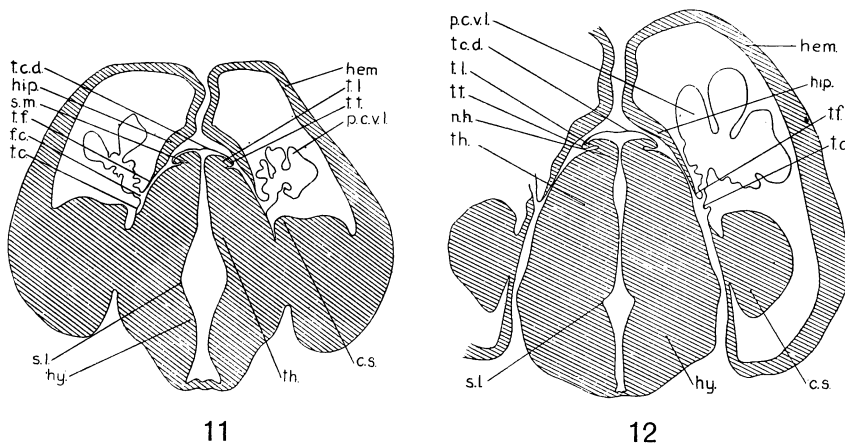


Fig. 11 Section through the diencephalon of the 28 mm. embryo, H 91. $\times 6\frac{2}{3}$. Slide 24, Sect. 318.

Fig. 12 Section through the diencephalon of the 32 mm. embryo, H 41. $\times 6\frac{2}{3}$. Slide 24, Sect. 2.

slit (fig. 11, *f.c.*). In its growth, the plexus has extended some 0.25 mm. anterior to its point of attachment to the mid-line of the telencephalon. The connective tissue resembles that of the 19 mm. embryo closely, except that the cells are farther apart, but the ependymal layer has become much thinner and consists clearly of a single layer of columnar cells, with the nuclei in the ends of the cells next the ventricular cavity (fig. 28). The ependyma of the posterior part of the plexus resembles more closely that of the 19 mm. embryo, there being several layers of irregularly arranged nuclei. The posterior part of the plexus is much attenuated and much more folded than the anterior end.

In the wall of the third ventricle, the habenula is well marked (fig. 20, *n.h.*) and from its posterior end a ridge extends downward to the tegmentum (fig. 20, *f.r.*). Just below the habenula, the wall of the diencephalon is much thicker than in the 19 mm. embryo, and extends anterior to the velum transversum to form the posterior wall of the foramen interventriculare.

3. The 32 mm. embryo (*H.* 41)

Just in front of the velum transversum, as in the 28 mm. embryo, the roof plate forms a low arch (figs. 22 and 25, *p.a.*) to the sides of which are attached the lateral choroid plexuses. Immediately anterior to this arch the roof plate becomes very thin (fig. 25, *t.c.t.m.*). Anterior to this thin lamina, the roof plate is thickened again in the manner noted in the case of the 28 mm. embryo (see fig. 6, *t.r-p.*). At the anterior end of this region (fig. 25, *l.s.?*), there is an indication of the median notch on the ependymal surface (fig. 8, *t.r-p.*). It is, however, not nearly so well marked as the similar notch in the 28 mm. embryo (fig. 7, *t.r-p.*). At the extreme anterior end of this region is a structure not found in any of the other embryos. A deep narrow pit extends into the roof plate from the pial surface, which causes the roof plate to project into the ventricle (figs. 13, 14, and 25, *d.p.*). This pit is found only in one section, with indications of it in the two adjacent sections. Immediately anterior to the pit, the roof plate thickens markedly and extends as a thickened lamina (fig. 22, *l.t.*) to the recessus preopticus. There is, however, a short distance anterior to the pit a shallow notch on the ventricular surface of the lamina terminalis (fig. 25, *r.n.?*).

The tela chorioidea diencephali shows only slight indications of longitudinal folding. The outwardly curved and very prominent thalamic lip (fig. 12, *t.l.*) is not in contact with the lateral wall of the thalamus. At the anterior end, the tela chorioidea diencephali is very broad, and a pouch (fig. 25, *a.p.*) arises which extends forward over the velum transversum. The whole tela resembles very closely the same structure in the 28 mm. embryo.

The commissura superior is very readily identified (fig. 22, *com.s.*).

The epiphyseal evagination (fig. 22, *e.e.*) is, in all essential respects, identical with that of the 28 mm. embryo.

The lateral choroid plexus (fig. 12, *p.c.v.l.*) also resembles that of the 28 mm. embryo. The posterior portion is more swollen, resembling more nearly the anterior part. The ependyma

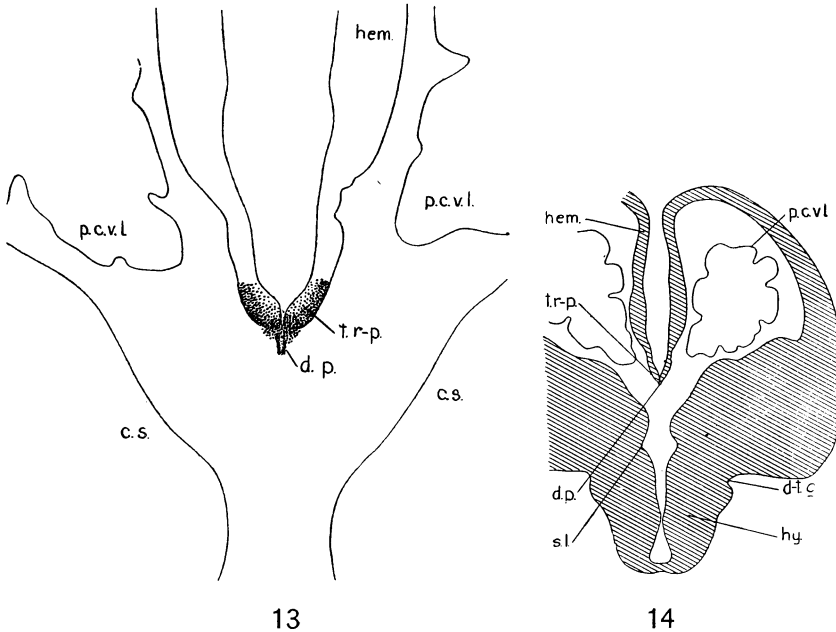


Fig. 13 Section through the roof plate of the telencephalon medium of the 32 mm. embryo, H 41. $\times 50$. Slide 32, Sect. 4.

Fig. 14 Section through the roof plate of the telencephalon medium of the 32 mm. embryo, H 41. $\times 5$. Slide 32, Sect. 4.

is almost entirely a single layer of cells except at the extreme caudal end of the plexus. The plexus extends through 4.44 mm.; the ventricle through 7.2 mm. The plexus extends 1.6 mm. anterior to its most anterior point of attachment.

On the ventricular surface we find again that the corpus striatum exhibits three roots at its anterior end (fig. 24, *c.s.*). The most medial root, in the lateral wall of the third ventricle, is narrow, lies immediately back of the lamina terminalis, and

forms more the anterior boundary than the floor of the foramen interventriculare (fig. 22, *c.s.m.r.*). The intermediate root is also small, extending beyond the foramen interventriculare in the floor of the lateral ventricle. The intermediate root unites at its posterior end with the medial root, the two being separated from the lateral root by a groove. The lateral root is the largest, and lies more in the floor than in the lateral wall of the ventricle (fig. 24, *c.s.l.r.*). The two ridges, one formed by the lateral root and the other by the union of the medial and intermediate roots, extend backward some distance and then turn sharply downward as a single elevation (fig. 24).

The hippocampus (fig. 12, *hip.*) is a broad, slightly thickened portion of the medial hemisphere wall, just above the taenia fornicis. The external sulcus is very shallow and broad.

The habenular ridge is prominent, extending on the ventricular surface of the diencephalon just below the tela chorioidea diencephali from the region of the velum transversum to the epiphysis (fig. 22, *n.h.*). The ridge extending from the posterior end of the habenula to the tegmentum is also prominent (fig. 22, *f.r.*).

The most striking feature, probably, is the great thickening of the posterior extremity of the thalamus. The anterior extremity of the thalamus extends well into the foramen interventriculare, some distance anterior to the velum transversum.

The sulcus limitans is indicated on figure 22 by a dotted line. It is deepest below the posterior pole of the thalamus. Behind the lamina terminalis it is relatively shallow.

The hypothalamic region is marked mainly by its great length. The mammillary recess is indicated (fig. 22, *r.m.*); the floor plate is wide and thin. The infundibular recess (fig. 22, *inf.*) is near the optic chiasm but is separated from it by an unmistakable postoptic recess (fig. 22, *r.post.*). There is no clear external division between hypothalamus and subthalamus.

DISCUSSION

1. *Telencephalon*

a. *Recessus preopticus*. In all three embryos there is no doubt about the identity of this recess.

b. *Velum transversum*. Just as obvious is the location of the velum transversum. It is marked by the groove running across the roof plate joining the anterior ends of attachment of the tela chorioidea diencephali to the thalamus. At the lateral end of the velum transversum the taenia thalami meets the taenia chorioidea (fig. 26) and at this point the velum transversum becomes continuous with the angle between the taenia chorioidea and the lateral thalamic wall. In figure 26 an arrow lies in the angle between the taenia chorioidea and the lateral thalamic wall and continues in the velum transversum. The position of the head of the arrow in the mid-line is shown in figure 25. It was noted in the account of the 19 mm. embryo and appears more clearly in the 32 mm. embryo, that if this angle be followed backward it passes behind the attachment of the hemisphere to the thalamic wall, and then as a diagonal groove downward and forward across the lateral wall of the hypothalamus and ends at the optic chiasm. This is the di-telencephalic groove (figs. 14 and 19, *d-t.gr.*) of Johnston.

With the preoptic recess and the velum transversum fixed, the extent of the telencephalic roof plate is determined. Between the preoptic recess and the velum transversum should appear the lamina terminalis, recessus neuroporicus, lamina supraneuroporica, recessus superior, tela chorioidea telencephali medii, and paraphysis.

c. *Paraphysis*. Just in front of the velum in each embryo is a small arch (figs. 18, 20 and 25, *p.a.*) relatively largest in the 19 mm. embryo, and smallest in the 32 mm. embryo. In each case it lies immediately in front of the velum transversum. In each case also the lateral choroid plexuses arise from its sides. There can be no doubt that this is the paraphysal arch. No indication of the development of a glandular structure could be found. The resemblance of the paraphysal arch in

the 19 mm. embryo to those of the 10 mm. cat and 20 hr. chick figured by Tilney ('15) and of a 4 mm. embryo of *Platydactylus mauritanicus*, figured by Tandler and Kantor ('07), is rather striking.

d. Recessus neuroporicus. An identification of this point is absolutely essential to a final definition of the boundary between lamina terminalis and lamina supraneuroporica. By recessus neuroporicus is meant the most caudal point, i.e., last point, of closure of the neuropore. In many vertebrates at this point a recess appears on the ventricular surface of the roof plate (Johnston, '09).

It was found impossible to identify with certainty this point in the embryos examined. In the 19 mm. embryo, and the 28 mm. embryo, no such recess is apparent. In the 32 mm. embryo, there has been noted just in front of the pit in the roof plate, a shallow notch on the ventricular surface (fig. 25, *r.n.?*). But there is no evidence that this is the recessus neuroporicus, since no such notch appears in either younger embryo.

e. Lamina terminalis. The upper end of the lamina terminalis, as defined by Johnston, has not been determined because the recessus neuroporicus is not apparent. Concerning the major portion of the lamina, however, there can be no doubt. The thick lamina above the recessus preopticus is unmistakable (figs. 18, 20 and 22, *l.t.*).

f. Tela chorioidea telencephali medii. Just in front of the paraphysal arch in the 28 mm. embryo, and the 32 mm. embryo, the roof becomes a single layer of flattened cells (fig. 5, *t.c.t.m.*). This is certainly tela chorioidea telencephali medii. The identification of this tela in the 19 mm. embryo is not so easy. However, I am inclined to identify the summit of the greater arch of the roof plate (fig. 18, *r.s.*) as the recessus superior. This would make the roof between this point (fig. 18, *r.s.*) and the paraphysal arch, tela chorioidea telencephali medii (fig. 18, *t.c.t.m.*). The roof plate here is somewhat thinner than the lower limb of the greater arch (fig. 18, *l.s.?*) and the adjacent hemisphere wall is considerably thinner. The angulus terminalis

of His probably represents all the membranous parts anterior to the velum transversum.

g. Lamina supraneuroporica. Between what is obviously lamina terminalis and what is just as obviously tela chorioidea telencephali medii in the 28 mm. embryo and the 32 mm. embryo, lies the peculiar thickening of the roof plate before noticed (fig. 6, *t.r-p.*) which seems by a process of elimination to be lamina supraneuroporica. Whether this interpretation is correct, I cannot say, because I have not had material with which to follow this region in its later development. There is in the 32 mm. embryo, a short portion of the roof plate between the deep pit (fig. 25, *d.p.*) and the shallow recess on the ventricular surface (fig. 25, *r.n.?*) which may be lamina supraneuroporica. In the 19 mm. embryo, the lower limb of the greater arch (fig. 18, *l.s.?*) seems its most likely location.

h. Plexus chorioideus ventriculi lateralis. The problem of the formation of the lateral choroid plexuses is one of considerable difficulty, because of the complex morphological relations involved, but if a few facts of development be remembered, the problem becomes relatively simple.

If the brain of a half-grown frog tadpole be examined, it will be found that "the membranous roof of the forebrain ventricle is attached to the massive wall of the hemisphere by the taenia fornicis which is directly continuous caudad with the taenia thalami" (Herrick, '10). The taenia thalami is the attachment of the roof plate posterior to the velum transversum to the lateral wall of the thalamus. It might be added also that the taenia fornicis becomes continuous with the taenia thalami at the lateral end of the velum transversum. In the middle of the membranous roof in front of the velum transversum arises the paraphysis. There is no plexus lateralis in the larval or adult frog, but in urodele Amphibia it is between the paraphysis and the taenia fornicis that the lateral choroid plexus makes its appearance, pushing into the ventricle. Warren ('05) in describing the development of the lateral plexuses of *Necturus maculatus* says, "The telencephalic plexus develops from the

paraphysal arch. . . .” “The plexuses of the hemispheres arise on either side from the origin of the telencephalic plexus and pass into the lateral ventricles. . . .”

If we turn now to the human embryo and examine, say, the 19 mm. embryo, H 173, we find that it is easy to trace the tela chorioidea telencephali medii over the paraphysal arch and velum transversum to the tela chorioidea diencephali. If, however, we attempt to follow backward the taenia fornicis, it will not be found to be continuous with the taenia thalami at

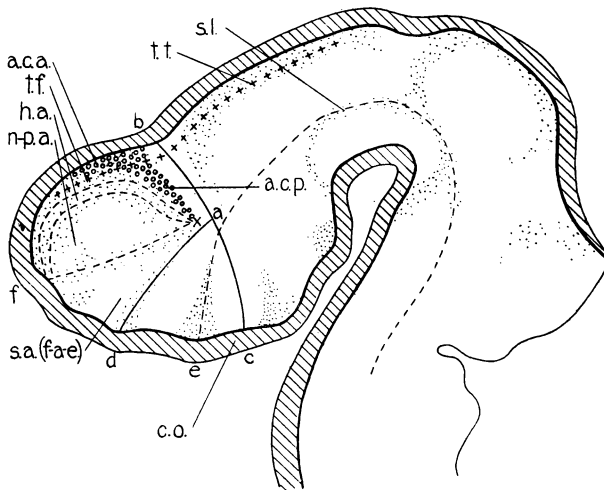
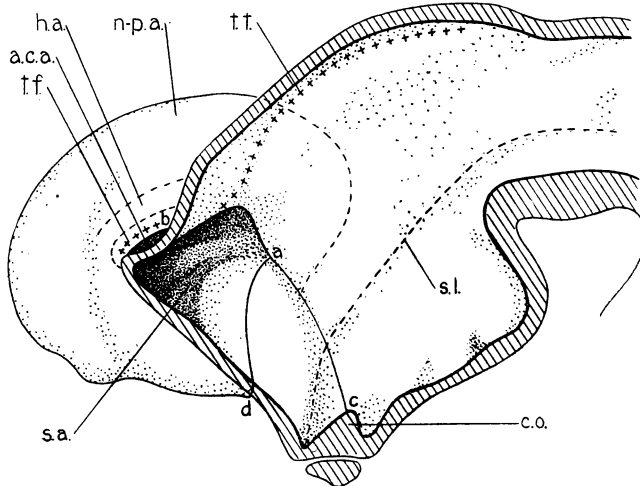


Fig. 15 Median view of a model of the forebrain in His' 6.9 mm. embryo, Br. 3.

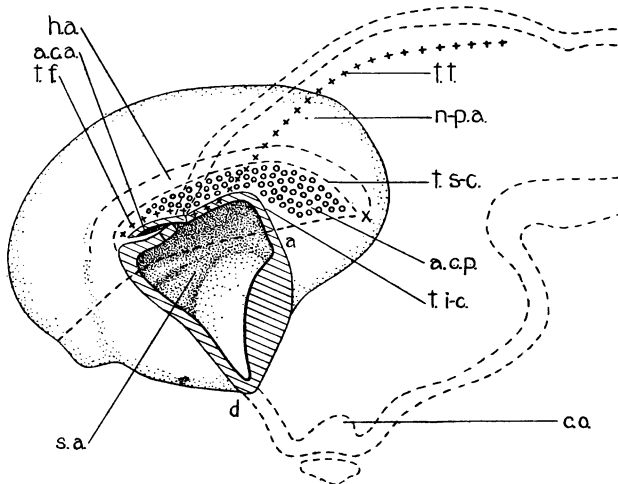
the lateral end of the velum transversum, but is separated from the taenia thalami by the fissura chorioidea. In order to explain the difference between the condition in the frog and in the human embryo it is necessary to analyze more closely some younger human embryos.

Figure 15 shows a medial view of the forebrain of His' embryo Br 3, 6.9 mm. in length. On it is indicated by a row of crosses a line homologous with the taenia fornicis et taenia thalami in the tadpole. The anterior limb of the di-telencephalic groove is marked by small circles and labeled area chorioidea posterior for reasons which will appear later. On the opposite side of

the taenia fornicis from the area chorioidea posterior, that is, between the taenia fornicis and the mid-dorsal line, is placed another area of circles labeled area chorioidea anterior. It is



16



17

Fig. 16 Median view of a model of the forebrain in His' 13.6 mm. embryo, CR.

Fig. 17 Hypothetical view of the median wall of the cerebral hemisphere from His' 13.6 mm. embryo, CR. The hemisphere has been excised along the line *b-a-d* in figure 16.

in this latter region that the lateral choroid plexus makes its appearance in urodele Amphibia as we have just remarked, and here also it makes its first appearance in the human embryo. The hippocampal area is not apparent in this embryo but later developments show that its anlage must lie in some such position as indicated in figure 15. The part of the telencephalon which is evaginated to form the cerebral hemisphere is the part anterior to the line *d-a-b*. The division between telencephalon and diencephalon is represented by the line *b-a-c*.

Keeping these relations in mind, we may easily understand His' embryo CR, 13.6 mm. in length. Figure 16 shows a medial view of the forebrain. An invagination of the telencephalic roof has taken place between the taenia fornicis and the mid-line, forming the fissura chorioidea in the region which was marked area chorioidea anterior in figure 15. The hemisphere vesicle has enlarged mainly by enlargement and evagination of the neo-pallial area (fig. 15, *n-p.a.*), so that the hippocampal area which in figure 15 lay below the roof plate and in front of the area chorioidea posterior, now lies above the roof plate and behind the area chorioidea posterior, and its ependymal face has now come to look lateralward. So also with the area chorioidea posterior, which lies now in the evaginated cerebral hemisphere behind the di-telencephalic groove, and its ependymal face is now its lateral face. When the hemisphere evaginated, the wall bent for the most part along the line of the taenia fornicis in figure 15, the di-telencephalic groove as far as the point *a*, and then along the line *a-d*.

If now the hemisphere in embryo CR be excised along a line homologous with the line *b-a-d* in figure 15, the relations of the area chorioidea posterior and area chorioidea anterior are more clearly seen. The medial surface of such a hypothetical hemisphere is represented in figure 17. The area chorioidea anterior has invaginated into the lateral ventricle. The resulting plexus has been cut off in figure 17, leaving the fissura chorioidea. Since the invagination takes place between the taenia fornicis and the mid-line of the telencephalic roof, the taenia fornicis lies along the lateral and upper margin of the fissura

chorioidea, or in other words, along the line of attachment of the plexus to the medial hemisphere wall. If, therefore, we wish to follow the taenia fornicis et thalami in the embryo CR, we must follow the line marked with crosses in figures 16 and 17 along the wall of the diencephalon (figs. 16 and 17, *t.t.*), across the velum transversum, and then between the area chorioidea posterior and area chorioidea anterior above and lateral to the fissura chorioidea (figs. 16 and 17, *t.f.*).

It will be seen (fig. 17) that the area chorioidea anterior lies entirely anterior to the velum transversum. The lateral choroid plexus never approaches the mid-line except along the sides of the paraphysal arch, anterior to the velum transversum. The area chorioidea posterior has relations entirely analogous with its relations in figure 15, except for its change of face. It lies between the hippocampus and the di-telencephalic groove, and adjoins the posterior end of the taenia fornicis on the upper side, which in figure 15, was the lower side of the taenia.

This stage in the process bears a close resemblance to the condition in the brain of *Platydaetylus mauritanicus*, as described by Tandler and Kantor ('07). Concerning the development of the structures in the region of the foramen of Monro, they write (*italics mine*):

Die zwischen den beiden Foramina Monroi gelegene Decke des Ventriculus impar [telencephalon medium] ist rein epithelialer Natur and *grenzt sich lateralwärts durch je eine deutliche Furche Sulcus tegmenti ab.*

The lateral edge of this sulcus tegmenti is the taenia fornicis.

Die Fissura chorioidea, welche von hinten her den Raum des Foramen Monroi einengt, *entwickelt sich, wie die Durchsicht der Serie lehrt, derart, dass sie im vorderen Abschnitt aus dem Sulcus tegmenti selbst, hinten aber oberhalb dieser Furche entsteht, und hier die mediale Hemisphären wand einschneidet.*

Der Plexus chorioideus des Ventriculus lateralis stülpt nämlich *nur ein ganz kurzes Stück der Hirnwand ein. Die Einstülpungsstelle selbst, liegt wie man um Stadium V zeigen kann, gerade dort, wo das hintere Ende des Sulcus tegmenti die Decke des Telencephalon impar von der medialen Hemisphärenwand absetzt.*

Here again, as in the brain of *Necturus maculatus*, the half grown frog tadpole, and His' embryo CR, the taenia fornicis can be followed along the lateral margin of the sulcus tegmenti past the velum transversum to the taenia thalami. But when the sulcus tegmenti invaginates to form the fissura chorioidea, the posterior end of the taenia fornicis and a small part of the medial hemisphere wall are drawn in also. This latter process is carried much farther in the human embryo.

In the evagination of the hemisphere in the human embryo, the point marked *x* in figure 15, at the junction of the hippocampal area, striatal area, and area chorioidea posterior, remains always at the posterior pole of the hemisphere. The result on the corpus striatum, as the hemisphere extends backward, is to draw out the tail of the caudate nucleus. The result upon the area chorioidea posterior is to draw it out in a thin lamina marked in figure 17 by small circles.

The area chorioidea posterior now buckles into the lateral ventricle, and we have the condition found in the 19 mm. embryo, H 173. The area chorioidea posterior is clearly shown by figure 19, being all of the plexus back of the point marked *z*, and has buckled inward only slightly, leaving a very wide fissura chorioidea. The point *z* lies opposite the velum transversum.

It thus appears that the lateral choroid plexus is composed of two parts, a pars anterior plexus chorioidei ventriculi lateralis which is formed by the invagination of the area chorioidea anterior, between the paraphysal arch and the taenia fornicis, and a pars posterior plexus chorioidei ventriculi lateralis formed by the infolding of the area chorioidea posterior in the medial wall of the hemisphere.

If the taenia fornicis be now followed in the 19 mm. embryo, it will not be found to become continuous with the taenia thalami because the area chorioidea posterior, to which it was attached toward its posterior end, has now buckled into the ventricle. If, therefore, we follow the attachment of the lateral choroid plexus to the medial hemisphere wall, we follow the taenia forni-

cis as far as the area chorioidea posterior, then along the upper margin of the area chorioidea posterior (anterior margin in fig. 15) called also taenia fornicis in adult anatomy, around its posterior extremity (lower extremity in fig. 15), and back along its lower margin (posterior margin in fig. 15) called also taenia chorioidea, to the lateral end of the velum transversum where we finally reach the taenia thalami.

It thus appears that the portion of the taenia fornicis of human anatomy which lies adjacent to the pars posterior plexus chorioidei ventriculi lateralis is not homologous to the taenia fornicis in Anura and would better be called taenia suprachorioidea, and the taenia chorioidea correspondingly termed taenia infrachorioidea. The illustrations have been labeled in accordance with established usage. To place them in accord with the foregoing conclusions, in figures 1, 11, 12, 18, 24 and 26 taenia fornicis should be changed to taenia suprachorioidea, and taenia chorioidea to taenia infrachorioidea.

In later stages the taeniae infra- et suprachorioidea become approximated closely as is found in the 28 mm. embryo and in the 32 mm. embryo, and the fissura chorioidea is reduced to a narrow slit, its axis in the plexus of the 19 mm. embryo, lying probably along the dotted line in figure 19.

In the 28 mm. embryo and the 32 mm. embryo, it is impossible to distinguish the dividing line between the pars anterior and the pars posterior of the lateral choroid plexus, and the taenia fornicis in its restricted sense is relatively of very short length.

i. Sulcus limitans. The sulcus limitans is lost in a deep recess between the corpus striatum and hypothalamus. This recess has disappeared by fusion of its walls in the 32 mm. embryo. If the sections of the 19 mm. embryo be followed, the beginning of this process can be readily seen (fig. 2).

j. Corpus striatum. There is nothing extraordinary about the corpus striatum in either embryo. The approximation of the thalamus and corpus striatum in the foramen interventriculare (fig. 22) is of interest when one remembers Goldstein's work. Of course, the entire connection between the thalamus and

corpus striatum is not formed by fusion, and there is as yet no fusion here. The intermediate root of the corpus striatum probably extends into the medial hemisphere wall, but the external morphology does not suggest it.

2. *Diencephalon*

a. Tela chorioidea diencephali. It is to be noted that the tela chorioidea diencephali shows no indications of folding except at its anterior extremity. In the 32 mm. embryo, a pouch arises at the anterior end and extends forward over the velum transversum and the paraphysal arch (fig. 25, *a.p.*). Streeter, in Keibel and Mall's textbook, as was mentioned in the history, makes the statement that "Orally this choroid roof [of the third ventricle] is continued into the telencephalon where it forms a pointed pouch overlapping the lamina terminalis and the contained commissures. . . . The anterior choroidal pouch has been homologized with the paraphysis of the lower vertebrates." There is not up to this stage any pointed pouch in the telencephalic roof. The pouch noted above lies in the roof of the diencephalon, just back of the velum transversum and hence cannot be the paraphysis. The true paraphysal arch has been pointed out above. In comparing Francotte's figures with this region in embryos of approximately the same age in the Chicago collection, I feel sure that it was this anterior pouch of the tela chorioidea diencephali which he described as the paraphysis.

I have not followed the thalamic lip fully in later stages, but in an embryo of 60.4 mm. greatest length, H 44 of the Chicago collection, the thalamic lip is fused with the lateral thalamic wall toward the anterior end.

b. Epiphysis. The epiphysis, in the 19 mm. embryo especially, shows marked indications of a differentiation into epiphyseal stalk and epiphyseal vesicle. Such a condition is very characteristic of lower vertebrates, especially reptiles, but has never before been noticed in the human embryo. The epiphyses of the 28 mm. and 32 mm. embryos show similar indications.

In the 32 mm. embryo and in the 28 mm. embryo, the tela chorioidea continues on to the epiphyseal evagination. A similar condition has been noted in the cat by Thompson ('09).

c. Habenula. The character of the ridge running from the anterior end of the habenula to the subthalamus in the 19 mm. embryo (fig. 18, *h.s-t.r.*) is not apparent. It is probably only a temporary fold mechanically produced by inequalities in development of the thalamic wall. It has entirely disappeared in both older embryos.

The ridge extending from the posterior end of the habenular prominence in the 28 mm. embryo and the 32 mm. embryo (figs. 20 and 22, *f.r.*) indicates the position of the fasciculus retroflexus (Meynerti).

d. Thalamus. In the 19 mm. embryo, only the anterior, inferior part of the thalamic wall (fig. 18, *th.1.*) lying between the sulcus limitans and the habenulo-subthalamic ridge is thickened. In the 28 mm. embryo, the ridge has disappeared and the anterior portion of the thalamic wall which lay above the ridge is thickened (figs. 18 and 20, *th. 2*). This region probably contains the principal nuclei of the thalamus. The posterior extremity of the thalamus (figs. 18 and 20,) is still somewhat flattened and thin in the 28 mm. embryo, but becomes very thick in the 32 mm. embryo (fig. 22).

e. Sulcus limitans. There is no difficulty in following the sulcus limitans. In the 32 mm. embryo under the posterior pole of the thalamus, it is very deep.

f. Hypothalamus. The hypothalamus in all these embryos is of great antero-posterior extent. It will be noticed also that the infundibulum, especially in the 19 mm. embryo, lies a considerable distance back of the optic chiasm. It seems quite probable that, as Johnston ('09) has remarked, in His' model of the embryo CR of 13.6 mm., the recess marked infundibular is really postoptic, and the real infundibular recess lies back of it and is labelled tuber cinereum. Only in the 19 mm. embryo is the subthalamus clearly separated externally from the hypothalamus.

SUMMARY

1. The plexus chorioideus ventriculi lateralis is composed of two distinct portions, of which the anterior is developed from the roof plate in the angle between the paraphysal arch and the medial wall of the hemisphere, and the posterior from that part of the medial wall of the hemisphere just anterior to the di-telencephalic groove and homologous to the anterior limb of the velum transversum.

2. The taenia fornicis of adult human anatomy, except for its extreme anterior end, is not homologous with the taenia fornicis of Anura.

3. The position of the recessus neuroporicus could not with certainty be ascertained, and identification of the lamina supra-neuroporica was therefore uncertain.

4. The tela chorioidea telencephali medii is present in the embryos of 28 and 32 mm.

5. The paraphysal arch can be followed to the embryo of 32 mm., as an arch of the roof plate of the telencephalon. It lies just anterior to the velum transversum and from its sides arise the lateral choroid plexuses. The anterior pouch of the choroid plexus of the third ventricle lies in the diencephalon and is not, therefore, homologous to the paraphysis of the lower vertebrates. No indication of the development of a glandular structure was found.

6. The velum transversum can be traced up to the 32 mm. embryo, joining the anterior extremities of attachment of the tela chorioidea diencephali to the lateral thalamic wall, and its groove is continuous laterally with the angle between the taenia chorioidea and the lateral thalamic wall, the di-telencephalic groove.

7. The tela chorioidea diencephali is not folded nor vascularized except for its extreme anterior end in the embryo of 32 mm. It is broadened by the formation of a thalamic lip, very much resembling the rhomboidal lip of the rhombencephalon.

8. The epiphyses of all three embryos show indications of the presence of the homologue of the pineal vesicle of the lower

vertebrates. In the embryos of 28 and 32 mm., the tela chorioidea diencephali is continued on to the epiphyseal outgrowth.

9. The position of the fasciculus retroflexus (Meynerti) is indicated in the embryos of 28 and 32 mm. by a pronounced ridge.

10. There is evidence that the connection of the corpus striatum and thalamus is thickened by fusion of the medial root of the corpus striatum with the anterior extremity of the thalamus in the foramen interventriculare.

11. The sulcus limitans is lost in a very deep recess in the embryo of 19 mm. between the corpus striatum and hypothalamus, and this recess disappears in later stages by fusion of its walls.

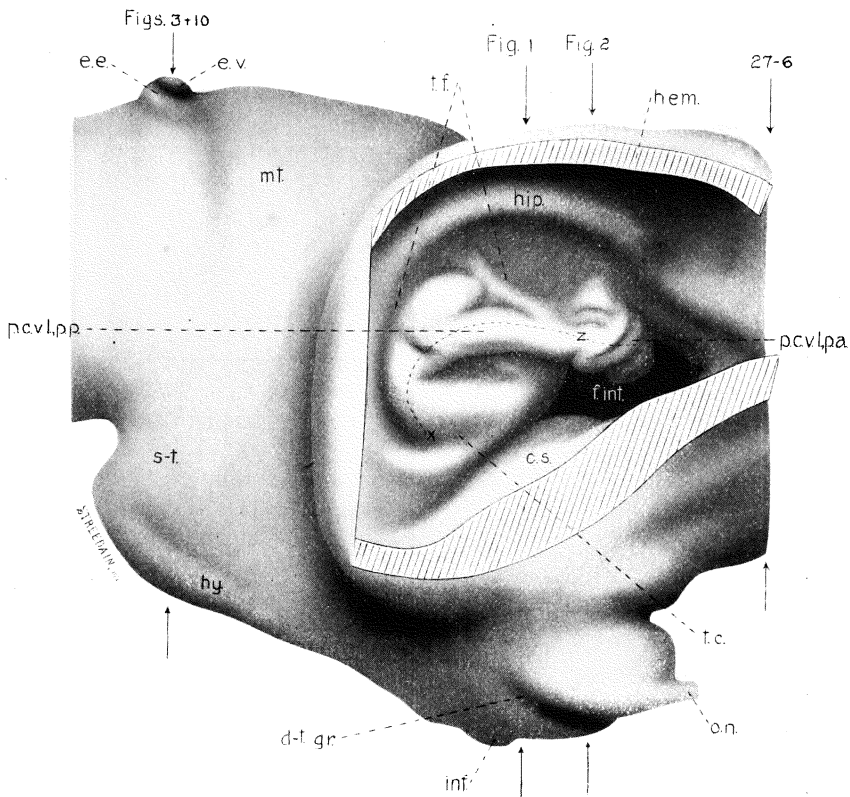
12. The length of the hypothalamus in embryos from 19 to 32 mm. is relatively very great. In the embryo of 19 mm. the subthalamus is separated externally from the hypothalamus.

13. The infundibular outgrowth is still some distance back of the optic chiasm at 19 mm. and becomes shifted nearer only in much later stages.

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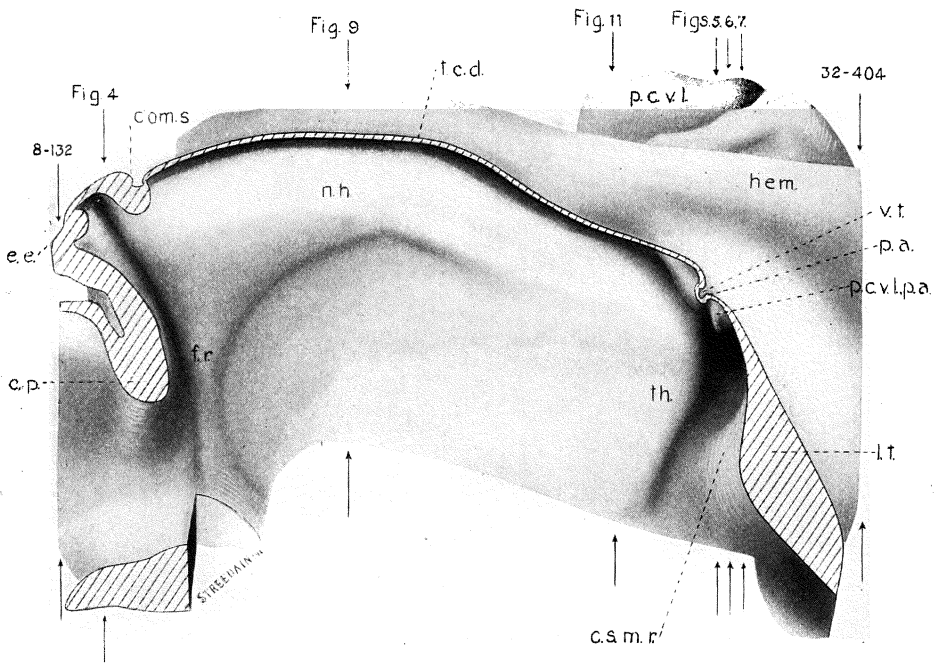


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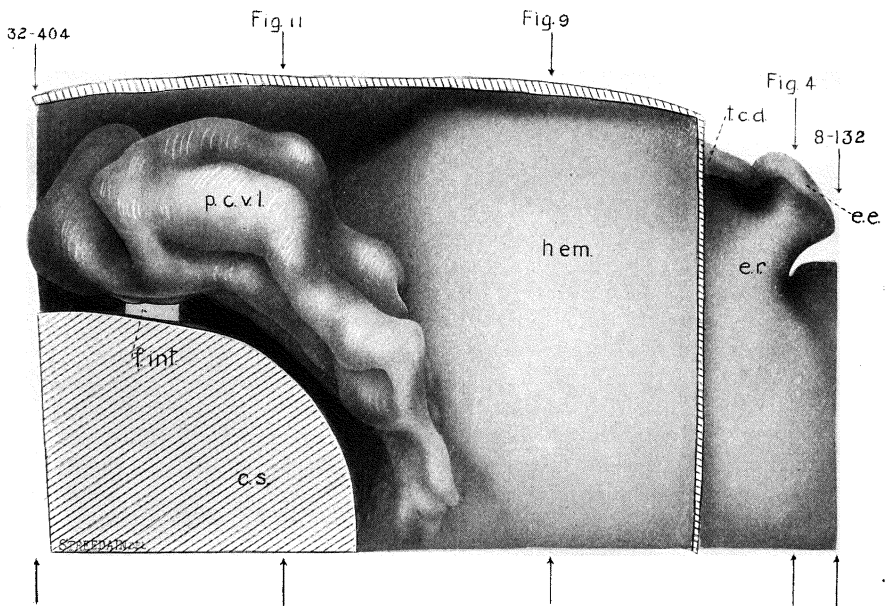
Fig. 19 Lateral view of a model of the forebrain from the 19 mm. embryo, H 173. $\times 22\frac{1}{2}$. The lateral wall of hemisphere has been cut away, exposing the lateral choroid plexus. Median surface of this model is shown in figure 18.

Fig. 20. Median view of a model of a portion of the forebrain from the 28 mm. embryo, H 91. $\times 18$.

Fig. 21 Lateral view of a model of a portion of the forebrain from the 28 mm. embryo, H 91. $\times 18$. The lateral hemisphere wall and corpus striatum have been cut away, exposing the lateral choroid plexus. Median surface shown in figure 20.



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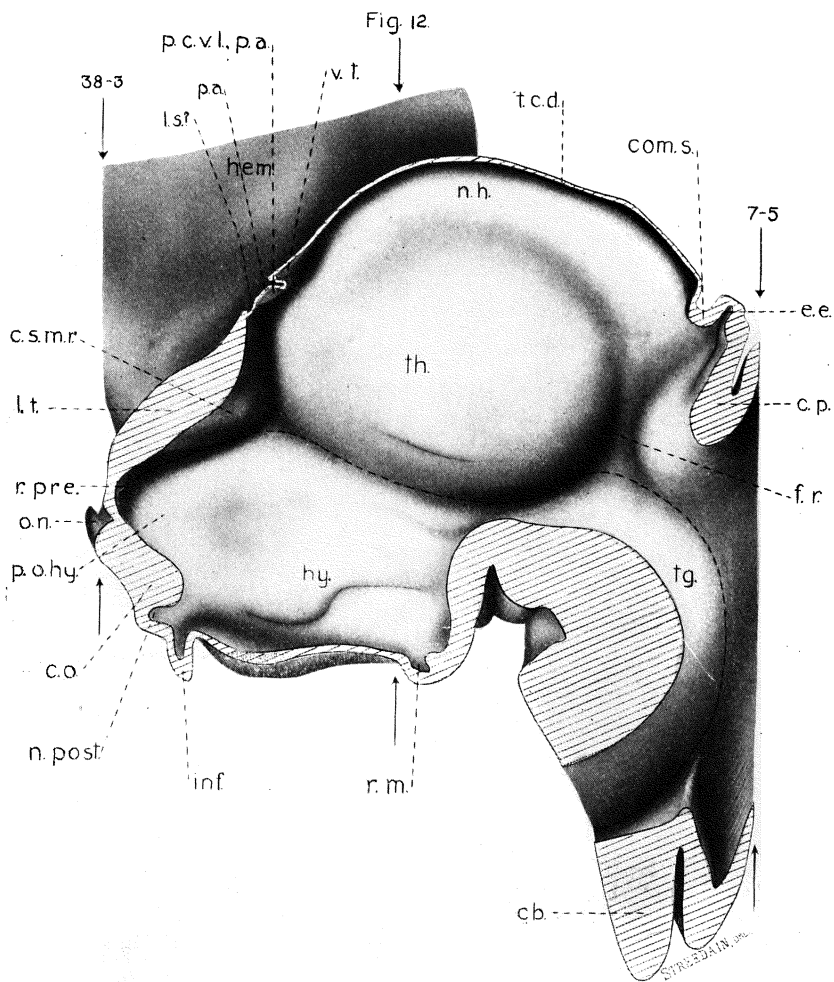
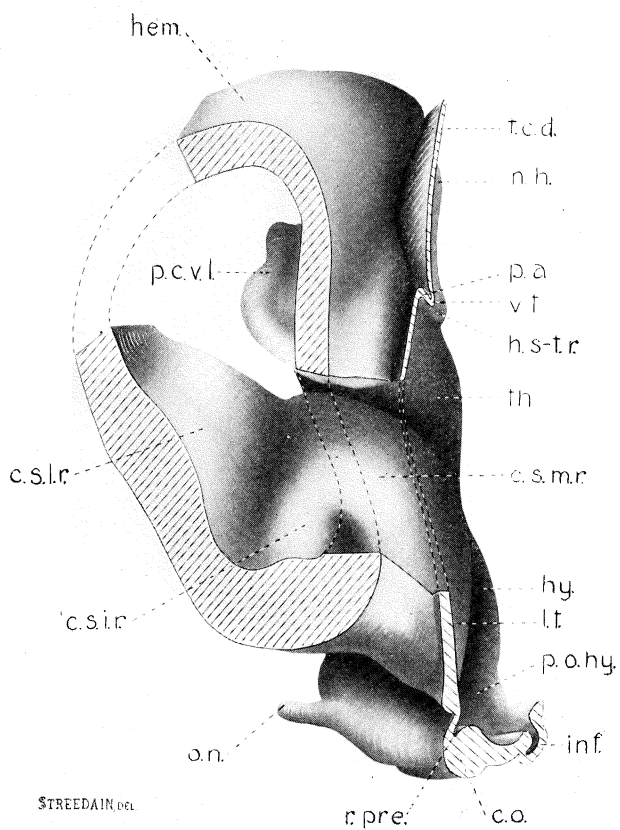


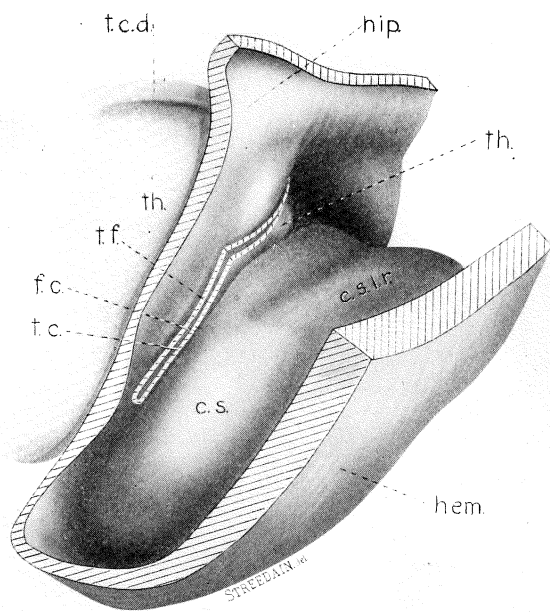
Fig. 22 Median view of a model of the forebrain from the 32 mm. embryo, H 41. $\times 12\frac{1}{2}$. The dotted line follows the sulcus limitans.

Fig. 23 View of the anterior end of the model of the forebrain from the 19 mm. embryo, H 173, shown in figure 18. $\times 22\frac{1}{2}$. View taken slightly from the medial side and above. A portion of the median hemisphere wall and lamina terminalis has been removed exposing the corpus striatum.

Fig. 24 View of the posterior extremity of the corpus striatum, in the model of the forebrain of the 32 mm. embryo, H 41, shown in figure 22. $\times 12\frac{1}{2}$. View taken from above, behind and lateralward.



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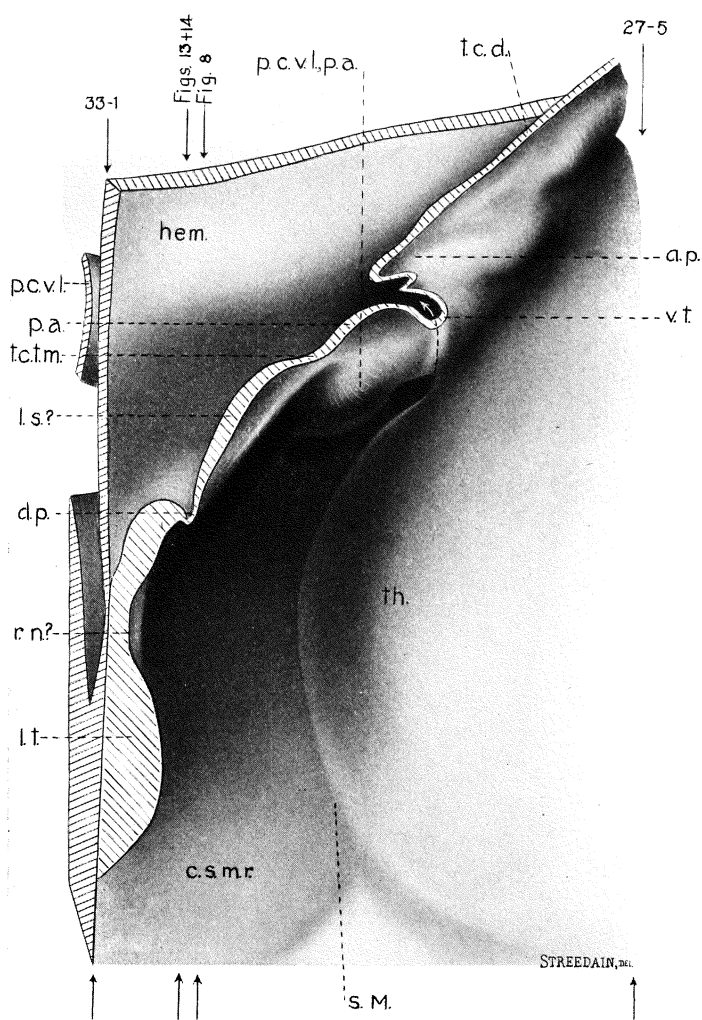


Fig. 25 Median view of a model of the region around the foramen interven-triculare from the 32 mm. embryo, H 41. $\times 50$. (The entire forebrain of this embryo is shown in figure 22.) The model was made at a magnification of 100 diameters. Anterior end to the left.

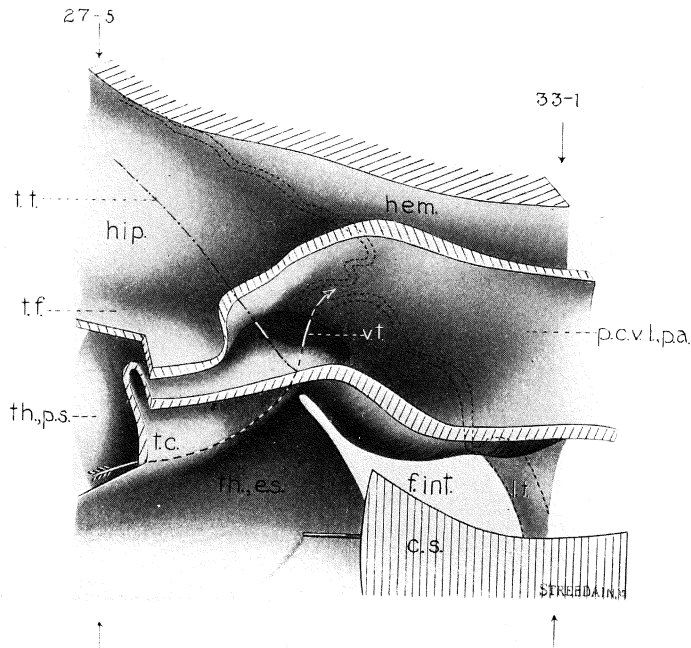


Fig. 26 Lateral view of a model of the region around the foramen inter-ventriculare from the 32 mm. embryo, H 41. $\times 50$. Median view of the same model is shown in figure 25. For help in orientation, the approximate position of the roof plate, which lies on the opposite side of the hemisphere wall, has been projected through as a dotted line. The location of the taenia thalami is indicated by a row of dots and dashes. An arrow lies in the di-telencephalic groove and continues across in the groove of the velum transversum. The position of its head may be seen by reference to figure 25. Anterior end of model to the right.

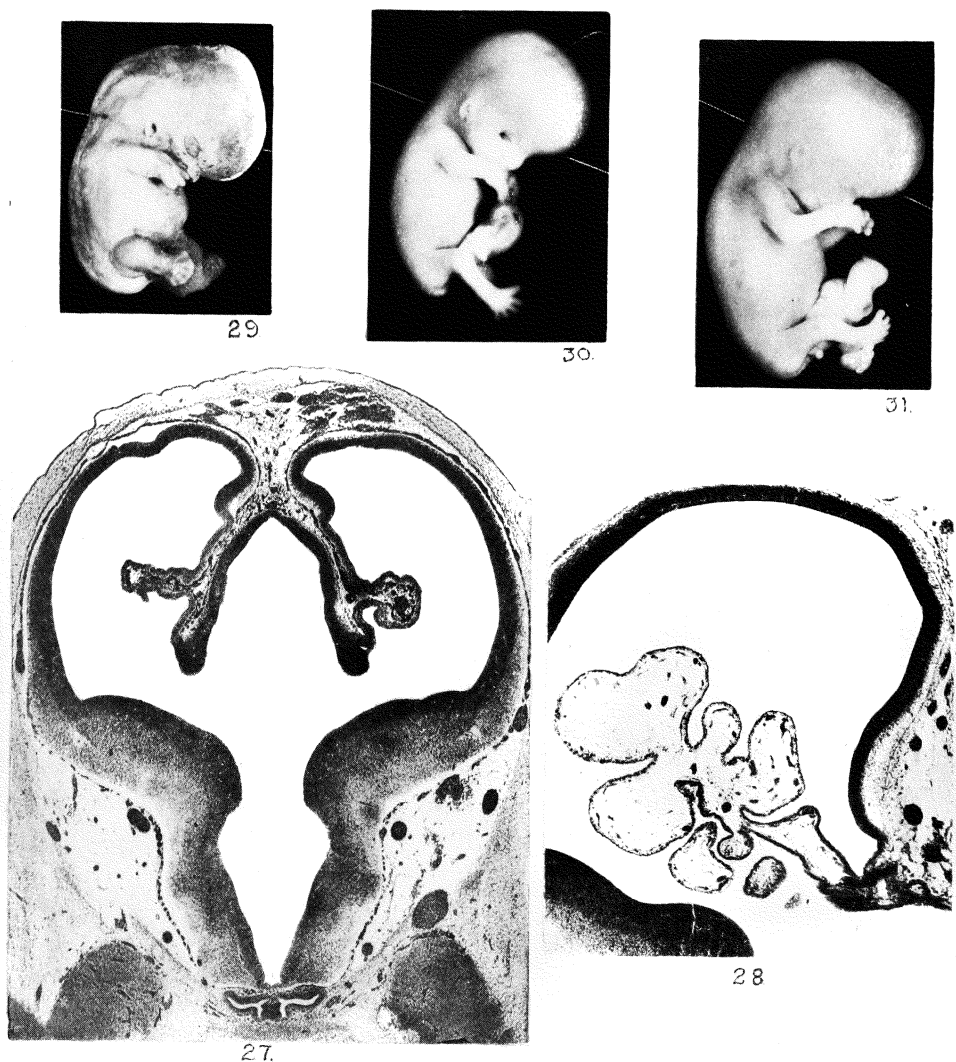


Fig. 27 Photograph of a section through the diencephalon of the 19 mm. embryo, H 173. $\times 16\frac{2}{3}$. Slide 21, Sect. 11. The break in the hemisphere wall to the left is an injury to this individual section. Compare figure 1, drawn from the same section.

Fig. 28 Photograph of a section through the lateral choroid plexus of the 28 mm. embryo, H 91. $\times 20$. Sect. 355. Section taken midway between figures 7 and 11, as shown in figure 20.

Fig. 29 Photograph of the 19 mm. embryo, H 173. $\times 2$. Plane of section indicated.

Fig. 30 Photograph of the 28 mm. embryo, H 91. $\times 1\frac{1}{4}$. Plane of section indicated.

Fig. 31 Photograph of the 32 mm. embryo, H 41. $\times 1\frac{1}{4}$. Plane of section indicated.