PROGNOSIS.—The prognosis must always be guarded. In slight cases recovery is generally to be expected. Unfavorable signs are coma, very slow pulse, convulsions, and paralysis. Signs of compression and of lacerations in the stage of reaction modify the prognosis.

TREATMENT.—The treatment must vary with the stage at which the case is seen. If an external wound exists it must be treated, as in ordinary cases, according to its character. General directions for the stage of collapse are to regulate the depression of the circulatory and respiratory systems by means of warmth applied to the body; stimulants may be administered by the mouth if the patient can swallow; per rectum, or hypodermatically. Alcohol is contraindicated unless stimulation is indicated. The stimulants that may be used are ether, musk, strychnine, atropine, sparteine, nitroglycerin, camphor; counter-irritants such as sinapisms may be applied over the præcordium and epigastrium or to the calves of the legs. If the patient continues to be unable to swallow he may be fed through a stomach tube or per rectum. Black coffee enemata are also useful.

In the stage of reaction stimulants should be withheld, the diet should be light, and the bowels should be kept open by purgatives and enemata. Darkness and quiet are essential. When recovery is delayed shaving the head and the application of cold by Leiter's bags are to be commended; calomel and salines are beneficial.

In the stage of convalescence the patient should not be permitted to work and should be shielded from all mental excitement. Fresh air, rest, and light diet are essential.

Chloral hydrate and potassium bromide are indicated in cases of irritation. Potassium bromide aids in preventing inflammation. There must be no constriction at the neck; the head must be kept low; the scalp should be shaved and examined with care, for in fractures of the skull there are often no symptoms of a concussion for days or even weeks.

"Railway spine" or spinal concussion, formerly used to describe the results of concussion, is a misnomer.

Traumatic neurasthenia may result; this is similar to the condition following injuries to the spine when health, on account of organic diseasé or of overstrained nerves, is at a low ebb at the time of the injury. Traumatic inflammation of the brain or of its membranes may result. Abscesses may also follow.

Cerebral irritation is a condition sometimes following concussion. Its symptoms are probably owing to bruising of the frontal lobes. The patient lies on the side with the limbs curled up and is unconscious. He is restless and very irritable; the eyelids are closed; the pulse is slow—from 40 to 50; there is an absence of heat in the regions of the head and spinal cord; and generally there is incontinence of fæces and urine.

This condition may continue for as long a time as three weeks. The patient then extends the extremities and assumes the supine position. The temperature becomes normal, the pulse more rapid, and recovery may supervene. On the other hand, the mind may be permanently affected. There is absence of memory during the illness.

The findings at the autopsy table have been substantiated by the animal experiments performed by Koch, Fiehlene, Wittkowski, Albert, Goltz, and others.

Emma E. Walker.

BRAIN, DEVELOPMENT OF THE.—The development of the brain is bound up with that of the nervous system at large. While in the lower animals the nerve cells appear scattered or grouped in various parts of the body, and such scattered ganglion cells are found in even the highest animals, yet it is characteristic of the central nervous system as found in vertebrates that the nervous structures are collected into a common aggregate which contains only such admixture of other than nervous tissue as may serve to protect, support, and insulate the latter. It is obvious that the ordinary vegetative functions of life and many adaptive processes may be satisfactorily performed without a nervous system as such, as may be seen in the higher plants. The development of a central system, then, is an indication of preparation for higher functions than those of nutrition and metabolism or even of complex adjustment to the environment.

Early Stages.—After the egg has been differentiated into an animal and a vegetative pole and after the vegetative cells (by a process of invagination or substitute for it) have acquired an internal position, the cells remaining at the periphery (ectoderm or epiblast layer) represent the rudiments from which are to spring all the cells and specific organs not only of the central nervous system but of the sensory apparatus which forms the avenue from the external world to the central system. The ectoderm also contains, of course, the forerunners of the cells of the epidermis at large.

In general, the rudiments of the central nervous system collect in a broad longitudinal band extending along the dorsum of the embryo, while the rudiments of the sense organs exhibit a tendency to be arranged in one or more series along either side of the central band or medullary plate (Fig. 822).* In lower, especially aquatic, forms this lateral sensory band is evident in late life as the series of lateral-line organs, and it is plain that some or all of the

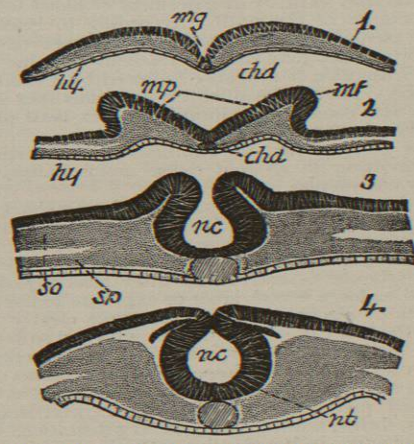

FIG. 822 (Nos. 1 to 4).—Transverse Sections through the Neural Plate and Neural Tube of an Embryo Bird. *chd*, Notochord; *hy*, entoderm; *mf*, neural folds; *mg*, neural groove; *mp*, neural plate; *nc*, neural canal; *nt*, neural tube; *so*, somatopleure; *sp*, splanchnopleure. (Mihalkovics and Balfour.) In No. 4 the rudiment of the spinal ganglia is represented but not lettered.

organs of special sense obey the same law of serial arrangement, the ear in particular betraying relationships to the lateral-line system. (Compare Vol. I., p. 627.)

The Neural Plate and Tube.—The neural or medullary plate is supported from below by a band of cells derived from the original entoderm which separates from the latter to form a solid rod (perhaps theoretically a tube at one stage), called the chorda dorsalis. The medullary plate grows more rapidly than the adjacent ectodermal tissue, and thus forms a raised border on either side with a groove in the median dorsal line. This medullary groove is continuous behind with the lip of the blastopore or opening left after the invagination of the entoderm. As the lateral margins of the medullary groove rise higher above the surface (both nervous and epidermal portions participating in the growth), the groove is transformed into a tube. The concrescence of the lips of the fold begins at a point corresponding with the site of the future midbrain. In the vicinity of the blastopore the groove may remain open for some time, and there is formed a direct communication with the primitive digestive tract through what is known as the canalis neurentericus, a

* These and several of the following cuts are introduced without change from the article by Professor H. F. Osborn in the former edition.

communication that is disturbed only by the final closing of the blastopore. At the cephalic extremity also the closing of the tube is long delayed, and there is left an opening called the neuropore communicating with the exterior at the front of the head.

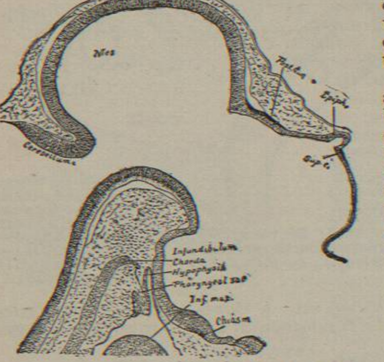

FIG. 823.—Median Section of Brain of Bird Embryo, to Show Hypophysis and Pharyngeal Sac.

In bony fishes and other vertebrates whose eggs have much yolk, the tube may be formed first as an apparently solid cord of cells, but the final result is the same.

At the cephalic extremity of the digestive tract, which at this stage ends in a blind sac separated from the pharyngeal invagination by the portion of the ectoderm known as the septum of Remak, is a region of fusion called the *area reuniens*. Here the cephalic end of the chorda, the base of the brain tube, and the angle of the enteric cavity tend to adhere temporarily. On the cephalic side of the septum the ectoderm gives rise to (an apparently single) median invagination which extends dorsally to meet a similar outgrowth of the infundibular region of the brain, combining with the latter to form the hypophysis or pituitary body. On the opposite side of the septum a somewhat similar outgrowth from the cephalic dorsal angle of the digestive tract forms the so-called Seessel's sac, which in some cases seems to connect with the cephalic end of the chorda. In birds at least this sac is distinct from the chorda which subsequently degenerates and leaves a convoluted thread-like vestige behind it that is closely connected with the site of origin of Seessel's sac. The latter, after the breaking through of the septum, comes, in birds, to lie in connection with the base of the hypophysis (Fig. 823).

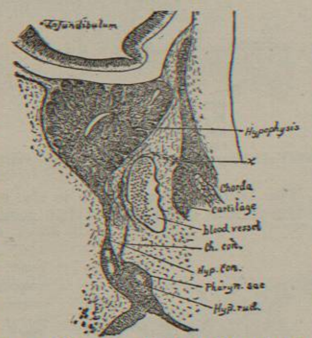

FIG. 824.—Later Stage of Hypophysis.

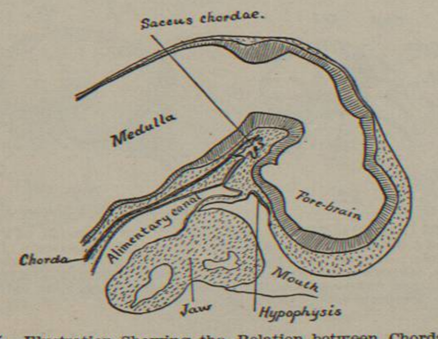

FIG. 825.—Illustration Showing the Relation between Chordal Sac, Alimentary Canal, and Brain Flexure in Opossum. (From Selenka.)

This region seems to mark the morphological front of the head, and the medullary tube is often open at front, forming a neuropore (Fig. 826). Gradually the tube extends cephalically, and the base and roof unite along a line a part of which becomes that part of the base of the

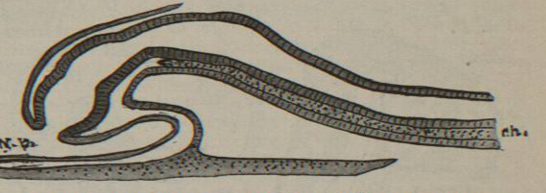

FIG. 826.—Brain of Torpedo, to Show the Neuropore, *n.p.*

brain occupied by the postoptic and preoptic recesses, the remaining part being the lamina terminalis (Fig. 826). The portion of the brain developed cephalad of the area reuniens, *i.e.*, in front of the cephalic end of the chorda, is called the prechordal as distinguished from the remaining, or epichordal part of the brain, and is morphologically different from the latter. In early stages of the development of the brain tube it appears segmented, and many attempts have been made to prove that these segments, or neuromeres, have a morphological significance and that they correspond with the segments discoverable in other and especially the mesodermal tissues. It has also been supposed that evidence of this primitive seg-

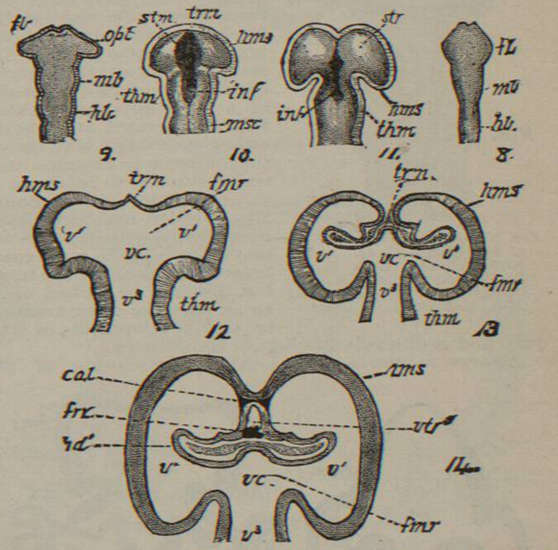

FIG. 827 (Nos. 8 to 14).—Horizontal Sections of the Forebrain (8 and 9, of a bird; 10 to 14, of a rabbit). (Kölliker, Mihalkovics, Löwe.) *cal*, Corpus callosum; *chd*, choroid plexus; *fmr*, foramen of Monro; *frx*, fornix; *hms*, cerebral vesicle; hemisphere; *inf*, infundibulum; *msc*, mesencephalon; *stm*, stem; *str*, corpora striata; *trm*, lamina terminalis; *thm*, optic thalami; *vc*, ventriculus communis; vtr^5, fifth ventricle; v', lateral ventricle; v^3, third ventricle. Other letters as above.

mentation could be seen in the arrangement of the roots of the cranial nerves. On the whole, however, it must be admitted that, while it is not difficult to detect the segmental arrangement in the epichordal part of the brain, the prechordal portion either was not derived from

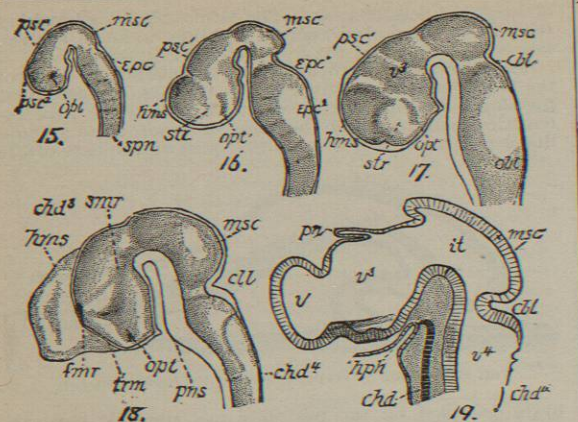

FIG. 828 (Nos. 15 to 19).—Vertical Sections of the Brain (15 to 18, of the rabbit; 19, of the bird). (Mihalkovics.) *cbl*, Cerebellum; *chd⁴*, tela vasculosa; *chd³*, choroid plexus of third ventricle; *epc*, epencephalon; *hph*, hypophysis; *it*, iter; *psc²*, prosencephalon; *psc¹*, diencephalon; *pns*, pons Varolii; *smr*, sulcus of Monro; *v⁴*, fourth ventricle.

a segmented rudiment, or, if so, it has suffered such complete alteration as to prevent the identification of the neuromeres.*

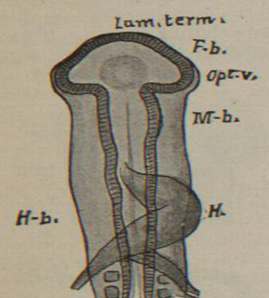

FIG. 829.—Dorsal View of Chick of Fifty-Eight Hours. (After Mihalkovics.) *Lam. term.*, Lamina terminalis; *F-b.*, forebrain; *Opt. v.*, optic vesicle; *M-b.*, midbrain; *H.*, heart.

In all vertebrates the portion of the medullary tube destined to become brain is divided at an early stage into three embryonic vesicles, the forebrain, midbrain, and hindbrain respectively (Figs. 827 and 829). In all higher vertebrates the midbrain is the site of a very important flexure which is formed at an early embryonic stage and causes the forebrain to assume a ventral position with reference to the remainder of the brain. The division into three lobes homologous with the vesicles may take place in some cases before the closing of the tube, but this may be looked upon as an instance of retardation in the development of the tube and is of no morphological significance.

Embryonic Brain Zones.—After the closing of the

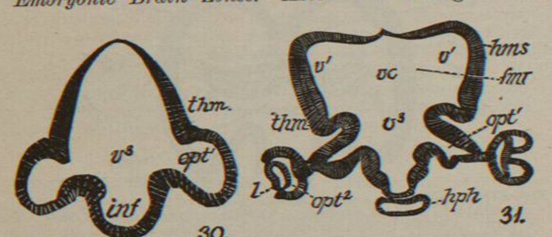

FIG. 830 (Nos. 30 and 31).—Transverse Sections through the Forebrain of a Rabbit, Showing the Development of the Optic Vesicles and Rudimentary Parts of the Eye. (Kölliker.) *l*, Lens; *hph*, hypophysis; *opt¹*, primary optic vesicle; *opt²*, secondary optic vesicle.

medullary tube the dorsal and ventral median portions are thinner than the lateral walls and have been called by His basal plate and roof plate respectively, though they are rather lines or zones than plates. On either side

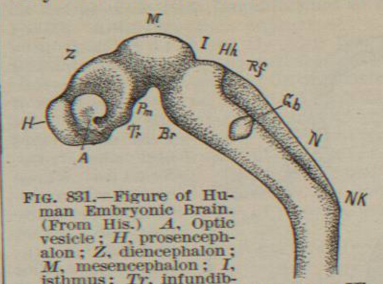

FIG. 831.—Figure of Human Embryonic Brain. (From His.) *A*, Optic vesicle; *H*, prosencephalon; *Z*, diencephalon; *M*, mesencephalon; *I*, isthmus; *Tr*, infundibulum; *Pm*, mammillare; *Br*, pons; *Hh*, cerebellum; *Rf*, roof of fourth ventricle; *Gb*, auditory vesicle; *N*, medulla; *Nk*, cervical flexure.

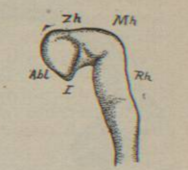

FIG. 832.—Youngest Stage of Ichthyophis. *I*, Infundibulum; *Abl*, optic vesicle; *Zh*, diencephalon; *Mh*, mesencephalon; *Rh*, metencephalon.

the walls are divided into a dorsal and a ventral zone, called respectively fundamental and alar zones or plates.

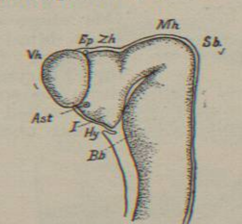

FIG. 833.—An Older Embryo of Ichthyophis. *Ep*, Epiphysis; *Ast*, optic peduncle; *Sb*, mesencephalic flexure; *Bb*, pons flexure.

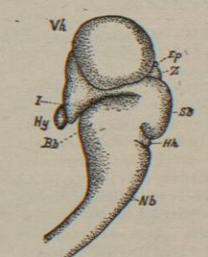

FIG. 834.—Embryo of a Still Later Stage.

The fundamental plate is the site for the development of the motor cells and is the zone of origin for the ventral

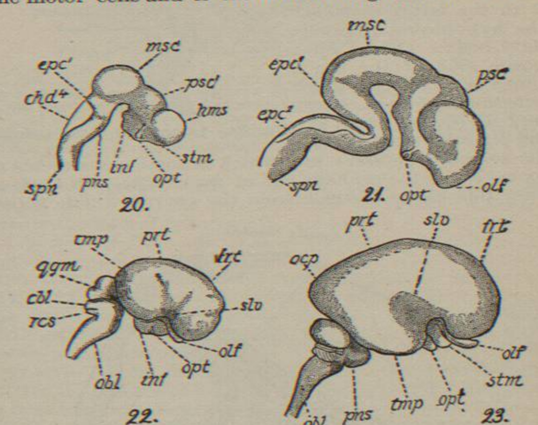

FIG. 835 (Nos. 20 to 23).—Lateral Views of the Brain (20, of a bird; 21, 22, of a human embryo; 23, of a pig). (Mihalkovics.) *frt*, Frontal lobe; *ocp*, occipital lobe; *olf*, olfactory lobe; *prt*, parietal lobe; *qgm*, corpora quadrigemina; *obl*, medulla oblongata; *prt*, parietal lobe; *rcs*, recessus lateralis; *slv*, Sylvian fissure; *spn*, spinal cord; *tmp*, temporal lobe. Other letters as above.

or motor nerve roots, while the alar plate includes the zone of the sensory roots.

That part of the base of the brain tube which is adjacent to the area reuniens forms an expansion in a ventral, caudal, and cephalic direction, giving rise to the fundus basi-

* Locy and his school identify eleven neuromeres in the brain, five of them being cephalad of the cerebellum.

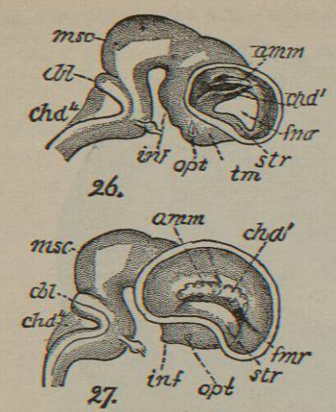

FIG. 836 (Nos. 26 and 27).—Lateral Views of the Brain, with the Lateral Ventricles Exposed. (Mihalkovics.) *amm*, Cornu ammonis; *tm*, stem. Other letters as above.

laris with a cephalic extension, the recessus opticus, and a caudal prolongation, the recessus infundibuli. The recessus opticus is divided into the preoptic and the postoptic division by the chiasm. At the apex of the infundibulum is the place of the pituitary, while the tuber cinereum with its olfactory connections develops behind the infundibulum. In amphibia the infundibulum is produced caudad to form the saccus vasculosus. In fishes the so-called lobi inferiores appear behind the infundibulum, but these have no relation to either the infundibulum or the cinerea, as has been supposed, but are diverticles from the walls of the pes.

Roof of the Brain.—The dorsal walls of the brain nat-

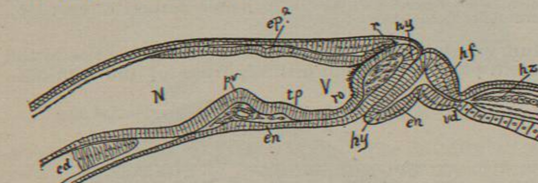

FIG. 837.—Median Section of Embryo of Acipenser Sturio, Forty-Five Hours After Fertilization.

urally develop more rapidly than the base. The roof of the hindbrain for a large part of its length fails to develop nervous elements, but remains membranous and forms the velum medullare posterius or kilos. This membrane becomes associated with a rich plexus of blood-vessels, and together these penetrate the cavity of the hindbrain (fourth ventricle), and furnish the vascular supply to that region. The triangular form of the velum, where its sides converge to the point where the solid parietes meet, has given rise to the term calamus for this locus. Cephalically the latero-dorsal walls of the hindbrain thicken and are reinforced by outgrowths of ventricular epithelium to form

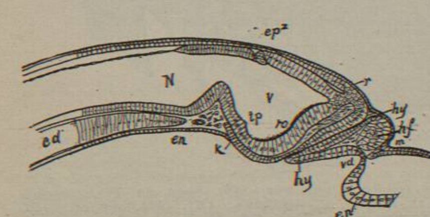

FIG. 838.—Similar Section of Embryo, Sixty-Four Hours After Fertilization.

a paired body which becomes apparently single by the concrescence of the two halves. This is the cerebellum. In amphibia the cerebellum remains obsolescent and its development varies greatly in the different groups; but in general it can be seen that the relative development of this organ is commensurate with the necessities for motor coordination. In birds, for example, it is highly developed, while the brain as a whole remains upon a rather low plain of development. Immediately cephalad of the cerebellum is the velum medullare anterius or valvula in which the fibres of the fourth nerve ultimately decussate and from which there is developed in many fishes a remarkable invagination into the cavity of the midbrain known as the volvula. The roof of the midbrain becomes thickened laterally and divides into a cephalic and a caudal portion. The larger or tectal portion in lower vertebrates forms two hemispherical projections connected by the Sylvian commissure and receiving the fibres from the optic brachia or extensions of the optic nerves. The caudal portion has a solid structure, and is composed of a mass of nerve cells

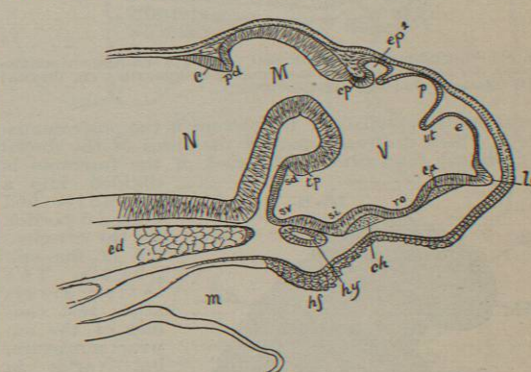

FIG. 839.—Similar Section of Larva, Three Days Old.

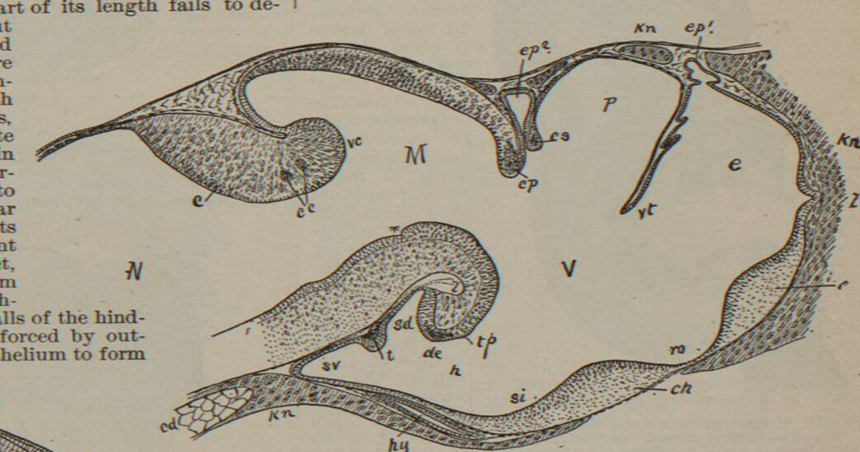

FIG. 840.—Similar Section of Larva, Four Weeks Old.

Description of Figs. 839 and 840.—*c*, Cerebellum; *ca*, precommissura; *cc*, commissura cerebelli; *cd*, chorda dorsalis; *ch*, chiasm and commissura postopticæ; *cp*, postcommissura; *cs*, supracommissura; *de*, commissura debilis; *e*, cerebrum; *en*, entoderm; *ep¹*, paraphysis; *ep²*, epiphysis; *h*, hypencephalon = infundibular region; *hf*, sucking disc; *hy*, hypophysis; *hz*, heart; *kn*, cartilage; *lo*, lobus olfactorius impar.; *M*, mesencephalon; *m*, mouth; *N*, metencephalon; *p*, præpineal roof of diencephalon (parencephalon); *pd*, plica dorsalis; *pv*, plica ventralis; *r*, median olfactory plate; *ro*, recessus opticus; *si*, sinus postopticus; *t*, commissura terminalis; *tp*, tuberculum posterius; *v*, prosencephalon; *vt*, velum transversum of the forebrain.

embedded in a stroma. This nucleus tends to drop below the surface, and it is probable that in it are found the reflex connections for the optic apparatus.

In mammals the roof of the midbrain is occupied by two pairs of eminences, together constituting the corpora

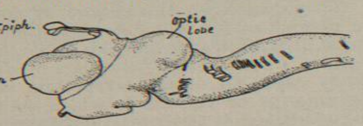

FIG. 841.—Lateral View of the Brain of Adult Petromyzon. *Epiph*, Epiphysis; *hem*, hemisphere; *optic lobe*, optic lobes.

quadrigemina, and the representatives of the tectum seem to be scattered among several adjacent parts of the midbrain walls. This is a region especially in need of study.

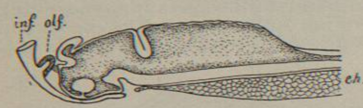

FIG. 842.—Longitudinal Perpendicular Section of the Brain of Ammocœtes, for comparison with the brain of Amphioxus. *ch*, Chorda; *olf*, olfactory sac; *inf*, infundibulum.

Immediately cephalad of the tectum is the postcommissure in which decussate part of the fibres of the dorsal longitudinal fasciculus. The roof of the forebrain is divided into a cephalic and a caudal portion by the evagination of the epiphysis. The latter always arises just caudad of the supracommissure, but varies in form and relations in the different groups. In many lizards it gives rise to the parietal organ, or "pineal eye." In snakes it becomes highly vascularized and glandular, while in mammals it appears to undergo retrograde metamorphosis. Near the supracommmissure, in the roof of the first vesicle, there develop clusters of cells forming the habenulæ. These nuclei are asymmetrically developed and sustain some relation to the pineal. From them or a group of cells closely associated arises Meynert's bundle (fasciculus retroflexus). Another mass of cells, called the subhabenular nucleus, arises in the deeper walls nearer the ventricle.

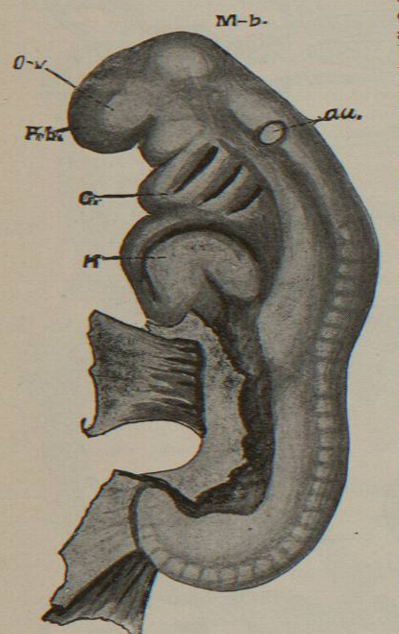

FIG. 843.—Human Embryo 4 Mm. Long. *M-b.*, Midbrain, flexure already developed; *O-v.*, optic vesicles; *F-b.*, forebrain; *Au.*, auditory vesicle; *H.*, heart; *C.*, pharyngeal clefts.

Cephalad of the supracommissure the roof tends to be membranous and gives rise to various outgrowths in different groups (the paraphyses) and to an ingrowing

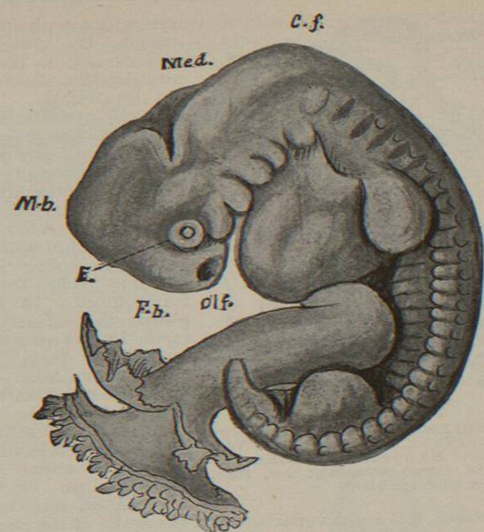

FIG. 844.—Human Embryo Older than Fig. 843. *M-b.*, Midbrain; *Med.*, medulla oblongata; *C-f.*, cervical (or nuchal) flexure; *E.*, eye; *F-b.*, forebrain; *Olf.*, olfactory pit.

velum which with its vascular associates gives rise to the choroid plexus. Through this portion of the roof, con-

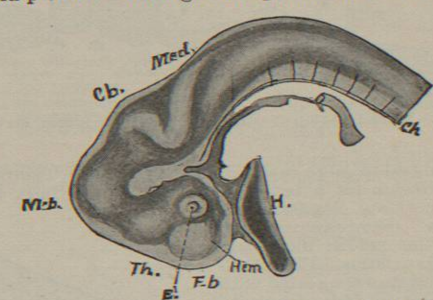

FIG. 845.—Similar View of an Earlier Embryo. *ch*, Chorda dorsalis. Other letters as above.

necting the two sides, there pass, first, the hippocampus commissure or fornix, and, in higher vertebrates at least,

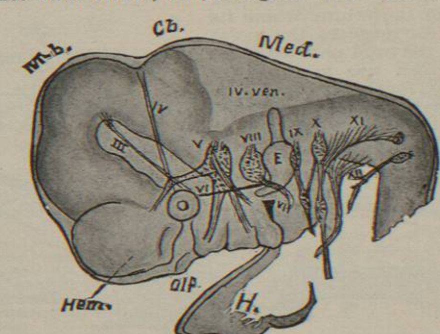

FIG. 846.—Embryo (Older than Fig. 843) Seen as Transparent. *M-b.*, Midbrain; *Hem.*, hemispheres; *Olf*, olfactory pit; *Cb*, cerebellum; *Med.*, medulla; *H*, heart; *IV. ven.*, space occupied by fourth ventricle; *E*, auditory vesicle. The cranial nerves are numbered.

the corpus callosum. The lamina terminalis contains the precommissure.

Such, in brief, is the course of development of the brain stem, but we may pass to the consideration of the several portions separately.

The Forebrain.—At an early stage the lateral walls of the forebrain evaginate on either side to form the

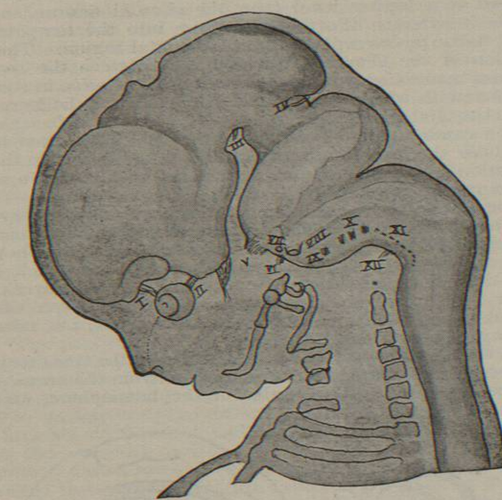

FIG. 847.—The Brain of a Human Embryo 20 mm. Long.

primary optic vesicles, which give rise in time to the retina and the choroid coat of the eye (Figs. 829 and 830). For some time the brain vesicle remains in communication with the optic vesicles through the hollow stalks of these outgrowths, and in the amphibia the optic stalks remain hollow though clothed exteriorly with the fibres of the optic nerve.

Their connection with the brain is near the base cephalad of the infundibulum. Cephalad of the points of origin of the eyes a second pair of evaginations form

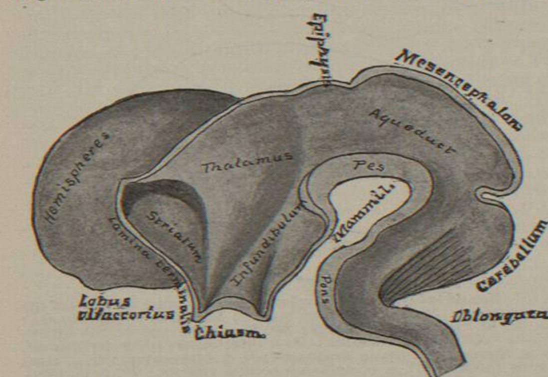

FIG. 848.—Diagrammatic Median Section of the Brain of a Human Embryo.

the rudiments of the hemispheres. These spheroidal pouches, separated from each other by the lamina terminalis, rapidly increase in size and soon outstrip all other parts of the brain. The communication between the ventricles of the hemispheres and the remnant of the forebrain vesicle is at first direct through the portæ, but at a later period the two portæ come to open into a median

recess narrowed off from the first vesicle and called the aula (see Fig. 860). What remains after the development of the eye vesicles and hemispheres is the thalamus or diencephalon, while the hemispheres collectively constitute the prosencephalon. (Another usage embraces the thalamus and hemispheres under the term prosencephalon and applies the term telencephalon to the hemispheres.)

At first the walls of the medullary tube are apparently nearly homogeneous, but after the separation of the various outgrowths the rate of development proceeds very differently in various parts. Thus, in the walls of the hemispheres certain areas develop with great rapidity while others are retarded. In the basilateral walls of the hemispheres especially there develop masses of cells

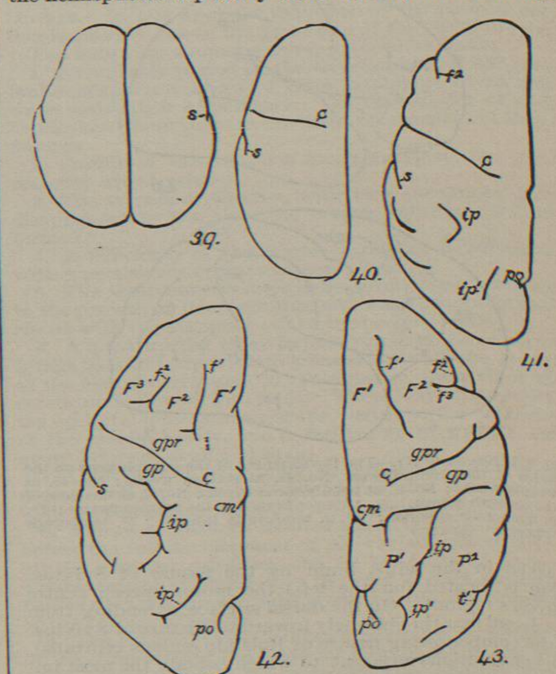

FIG. 849 (Nos. 39 to 43).—Development of the Fissures on the Upper Surface of the Hemispheres. No. 39, at sixteen weeks; No. 40, at twenty weeks; No. 41, at twenty-three weeks; No. 42, at the middle of the seventh month; No. 43, at the close of the seventh month. (Ecker.) *c*, Sulcus centralis; *cm*, calloso-marginalis; f^1, s. frontalis superior; f^2, s. frontalis inferior; f^3, s. præcentralis; F^1, gyrus frontalis superior; F^2, g. frontalis medialis; F^3, g. frontalis inferior; *gp*, g. postcentralis; *gpr*, g. præcentralis; *ip*, g. intraparietalis; ip^1, g. intrap. posterior; P^1, g. parietalis superior; P^2, g. par. inferior; *po*, s. parieto-occipitalis; *s*, fissura Sylvii.

which give rise to projections into the ventricles (Figs. 829 and 830). In this way a distinction is produced between the axial lobes of the cerebrum and the mantle portion. From the axial lobes arise in mammals the corpora striata through which pass the bundles of fibres from the cortex to lower centres and from the cord and lower parts of the brain to the cortex (see Fig. 859). Elsewhere in the cerebrum the development tends to cause the cells to collect on the peripheral aspect, and thus is formed the cortex cerebri, the most important portion of the brain from a psychical point of view, though from the physiological standpoint it may seem rather an epiphenomenon or afterthought.

Fissures of the Cerebrum.—As a result of the rapid and unequal growth of the hemispheres they are at first bodily flexed about a horizontal axis afforded by the line of attachment to the axial portion of the brain. The first result of this flexure is the formation of the Sylvian flexure and fossa. This is one of the most important landmarks in the brain, giving rise to a depressed region of cortex (the insula) covered by flaps (the opercula) and

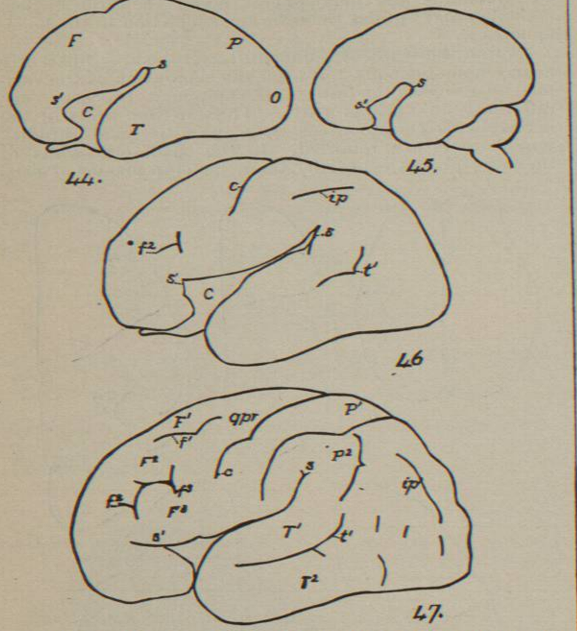

FIG. 850 (Nos. 44 to 47).—The Development of the Convolutions on the Sides of the Hemispheres. No. 44, at sixteen weeks; No. 45, at twenty weeks; No. 46, at twenty-three weeks; No. 47, at the close of the seventh month. S^1, Anterior branch of the Sylvian fissure; T^1, g. temporalis superior; T^2, g. temporalis inferior; t^1, temporalis superior. (Ecker.)

marked in the adult brain by the fissure of Sylvius. Here is located (on the left) the motor speech centre (Broca's region). On the dorsal surface, extending from the dorsal margin obliquely toward the fissure of Sylvius, is the compensating fissure of Rolando (sulcus centralis), the convolutions adjacent to which contain the most important centres for voluntary motion. By means of these landmarks the "lobes" of conventional anatomy are indicated at an early period. Instead of going farther into details as to the sequence of development of the fissures and convolutions we venture to quote from Dr. J. D. Cunningham,* who, in the "Memoirs of the Irish Academy of Science" bearing his name, gives an extended account of the comparative development of the surface anatomy of the cerebral hemispheres. We condense from this work the following statements:

Complete Fissures ("Total-Falten").—The transitory fissures which appear in an early period of the development of the hemispheres are distinguished by the fact that they are a result of a series of deep infoldings of the thin cerebral wall and form shelf-like projections into the ventricles.

Under normal conditions none of the fissures which appear on the lateral aspects of the hemispheres persist in the adult, though in the ape two at least are persistent. Upon the mesal aspect, on the contrary, the choroid, a portion of the arcuate, and sometimes the parieto-occipital with part of the calcarine fissures persist. The choroid and arcuate appear as early as the fifth week. The choroid fissure occupies the lowest limit of the mesal wall, reaching the porta, cephalad, and extending caudad nearly to the extremity of the temporal lobe. Though not at first occupied by blood-vessels, and therefore not formed by them, its walls do not develop into nervous tissue but remain epithelial and are occupied by this pre-plexus. The fissura arcuata (*Ammonsfurche* of Mihalkovics) makes its appearance on the mesal face of the hemisphere at a higher level than the choroid fissure, and while it extends, like the preceding, into the temporal lobe, it also passes cephalad into the frontal region. That portion of the hemisphere which lies between the two fissures mentioned is termed the *arcus marginalis*, in connection with which are formed the callosum, the gyrus dentatus, and the fornix.

The caudal part of the fissure arcuata is retained in adults as the hippocampal fissure, and gives rise to the elevation in the floor of the descending cornu known as the hippocampus major.

The remainder of the complete fissures are transitory. The mesal wall of the hemispheres being thicker than the outer, the transitory fissures there first appear. They may appear as early as the eighth week, and reach a high degree of development only after the tenth week. Their maximum development is reached between the periods when the fornix and callosum appear, *i.e.*, near the beginning of the fifth month.

On the mesal aspect of the hemispheres the transitory fissures, which vary in number, radiate from the arcuate fissure toward the free border of the hemisphere, and

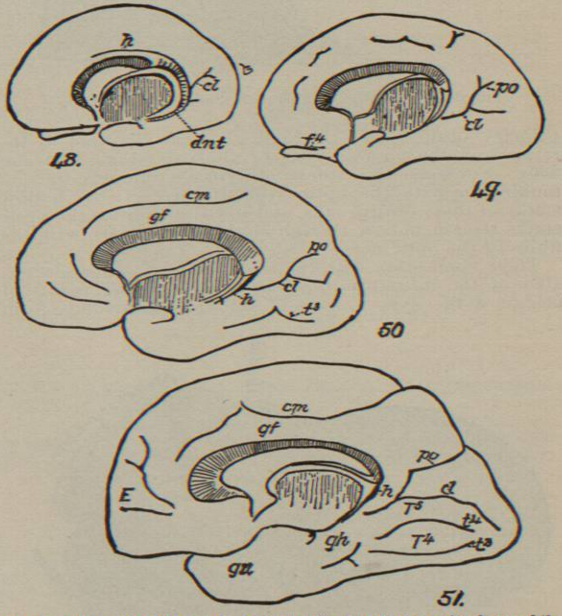

FIG. 851 (Nos. 48 to 51).—The Convolutions on the Inner Surfaces of the Hemispheres. No. 48, at sixteen weeks; No. 49, at twenty weeks; No. 50, at twenty-three weeks; No. 51, at the end of the eighth month. *cl*, Fissura calcarina; f^4, s. olfactorius; *gf*, g. fornicatus; *gh*, g. hippocampi; *gu*, g. uncinatus; *h*, s. hippocampi; t^3, s. temporalis inferior; t^4, s. occipito-temporalis inferior; T^4, g. occipito-temporalis lateralis; T^5, g. occipito-temporalis medialis.

others, lying between them, but not connecting with the arcuate fissure, appear near the margin. The usual number on each hemisphere appears to be eight.

The primitive fissures which bound the cuneus are the precursors of the calcarine and parieto-occipital fissures. As the wall of the cerebral vesicle thickens, and the hemisphere elongates, the stellate fissures become detached from the arcuate fissure and gradually disappear.

Upon the outer aspect the arrangement of the fissures

* "Contribution to the Surface Anatomy of the Cerebral Hemispheres," J. D. Cunningham, Cunningham Memoirs of Royal Irish Academy, vii.

is also radial, with the Sylvian fossa as the centre, but these fissures usually do not reach the fossa. There is frequently an additional fissure occupying the place of the future Sylvian. In some cases the precursor of the calcarine is carried horizontally around the occipital pole, appearing on the lateral surface as an external calcarine fissure.

It is regarded as probable that under abnormal conditions, as when the callosum fails to develop, the transitory fissures may persist to a certain extent. The fact emphasized by Sir William Turner, that in *Macropus*, where the callosum is rudimentary, the radiating fissures resemble those of an immature human brain, is at least suggestive that the development of the callosum has some effect on the disappearance of these fissures.

Dr. Cunningham fully agrees with His and Kölliker that the occipital lobe is due to a general growth and not a local outpouching of the hemisphere; its peculiar form is due to the transformations produced by axial flexures—especially the pons flexure. This backward thrusting of the posterior part of the hemisphere is chiefly responsible for the preservation of the precursory calcarine and parieto-occipital fissures. The temporary fissures are in all probability peculiar to primates, and appear prior to the appearance of a distinct occipital lobe.

The parieto-occipital and calcarine fissures form upon the mesal aspect of a posterior part of the adult hemisphere a >— shaped figure. The stem is directed obliquely ventrad and intersects the gyrus fornicatus. The parieto-occipital fissure forms the more direct continuation of the stem, and continues on the ectal surface as the external parieto-occipital fissure. The calcarine branch passes toward the occipital pole. The stem is called the anterior calcarine fissure. The apex of the cuneus gives off two deep annectant gyri—the gyrus cunei and anterior cuneo-lingual gyrus. The gyrus cunei forms a barrier between the parieto-occipital fissure and the stem, while the gyrus cuneo-lingualis anterior separates the stem and the posterior part of the calcarine fissure.

The calcar (hippocampus minor) is formed wholly by the stem or anterior calcarine fissure.

In apes the calcarine fissure is deep and much more stable than the parieto-occipital. In the chimpanzee the gyrus cuneus is on the surface (a condition found in 3.9 per cent. of human brains), while in the orang and gibbon the cunei may be on the surface or at the bottom of the fissure. The gyrus cunei is never absent. Cunningham believes that the whole calcarine fissure of anthropoids corresponds to the "stem" of the human calcarine; or rather, the whole length of the precursor of the human calcarine is the equivalent of the ape calcarine. The posterior calcarine of man is of later origin and takes the place of an abolished portion of the original fissure. The cuneus of the ape does not have the same morphological value as that of man. Only the cephalic part is present in the ape; the caudal part is absent or blended with the gyrus lingualis. In the ape the entire length of the calcarine fissure is on the tentorial face of the hemisphere.

The posterior calcarine fissure is distinct from the "stem" in origin, the latter being a "complete fissure" and having unbroken continuity of existence with the fore-part precursor.

The Occipital and Parietal Indices are the distances along the mesal margin of the hemisphere intercepted by the intersection of the external parieto-occipital fissure and the fissure of Rolando respectively; in the first case the measurement being taken from the occipital pole, in the second from the parieto-occipital intersection, and both these distances being given in terms of hundredths of the entire length along the dorsal margin of the hemisphere.

For the human brain the following averages are given:

5½ to 6½ months	O. index,	18.8;	P. index,	28.5.
6½ to 7½ months	"	18.6;	"	24.7.
7½ to 8½ months	"	20.7;	"	24.1.
Full-time fœtuses	"	20.8;	"	25.7.
First 12 months	"	22.3;	"	25.6.
4 to 5 years	"	23.2;	"	24.2.
11 to 15 years	"	20.8;	"	27.4.
Adults	"	21.2;	"	25.5.

For apes the following table is given:

Orang	O. index,	23.2;	P. index,	21.3.
Chimpanzee	"	24.2;	"	19.9.
Hamadryas	"	29.5;	"	20.5.
Cynocephalus	"	29.7;	"	22.6.
Mangaby	"	30.5;	"	24.1.
Macaque	"	31.0;	"	19.0.
Cercopithecus	"	32.9;	"	19.0.
Cebus	"	33.1;	"	20.6.

The low parietal index and high occipital index are instructive features. In low apes there is an enormous increase in the occipital portion of the border; whereas in the high apes the amount of increase is smaller. The relative shortness of the parietal border in high apes is due to the relative increase of the occipital and frontal borders. In low apes the reduction of the parietal portion is entirely due to the great size of the occipital lobe.

The following summary is reproduced verbatim:

1. At an early period in the development of the cerebral hemisphere a series of deep infoldings of its thin walls make their appearance. On the exterior of each hemisphere these show in the form of sharply cut linear fissures.

2. Certain of these fissures are permanent; the great majority are transitory.

3. The transitory fissures, with two exceptions, have disappeared by the time the corpus callosum is fully formed.

4. A deficiency of the corpus callosum is associated with a persistence of the temporary fissures.

5. The temporary fissures indicate an important stage in the growth of the cerebrum, and are apparently associated with the mapping out of the occipital lobe.

6. A quadrupedal pause in the growth of the cerebrum brings the skull capsule into antagonism with the growth of the hemispheres, and, in consequence, the wall of the cerebrum is thrown into folds. These folds disappear as the occipital lobe assumes shape, owing to the expansion of the cranial cavity, and a restoration of growth harmony between skull and brain.

7. Consequently it is only in Primates, which alone possess well-developed occipital lobes, that transitory infoldings of the cerebral walls in all probability exist.

8. The two transitory fissures which do not disappear before the full development of the corpus callosum are: (*a*) the external calcarine, and (*b*) the external perpendicular fissure of Bischoff. In point of fact the latter fissure does not appear until after the full development of the corpus callosum.

9. The external calcarine fissure produces an infolding of the outer wall of the posterior horn of the lateral ventricle, which presents the same direction, and lies immediately opposite to the true calcarine infolding, or the calcar avis.

10. The fissure corresponding to this in apes is, as a rule, permanent, and in some species its anterior end forms in the adult a bulging on the outer wall of the ventricle.

11. The external calcarine fissure disappears before the sixth month of fœtal life in man.

12. The external calcarine fissure is present on the outer surface of the fœtal cerebrum from the beginning of the fifth month to the end of the sixth month.

13. It is a complete fissure and corresponds to the "Affenspalte" on the ape's brain.

14. The "Affenspalte" on the ape's brain is also a complete fissure, and presents a well-marked bulging on the outer wall of the posterior horn of the ventricle; but, unlike the external perpendicular fissure of the human fœtus, it is permanent.

15. Certain fissures, therefore, which are complete and temporary in the human brain, are complete and permanent in the ape's brain.

16. The complete permanent fissures in the human are: (*a*) the fore part of the calcarine; (*b*) the hinder part of the fissura arcuata; (*c*) in many cases the parieto-occipital; and (*d*) in some cases the midcollateral. The Sylvian fissure is not a complete fissure.