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THE

ANATOMY

OF THE

FŒTAL BRAIN;

WITH A

COMPARATIVE EXPOSITION OF ITS STRUCTURE IN ANIMALS.

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TRANSLATED FROM THE FRENCH OF

A. J. L. JOURDAN,

BY

WILLIAM BENNETT, M.D.

TO WHICH ARE ADDED,

SOME LATE OBSERVATIONS ON THE INFLUENCE OF THE SANGUINEOUS SYSTEM OVER THE DEVELOPEMENT OF THE NERVOUS SYSTEM IN GENERAL.

ILLUSTRATED BY FOURTEEN ENGRAVINGS.

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MDCCCXXVI.

Non fingendum, aut excogitandum ;
Sed quid natura faciat, observandum.—Bacon.

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TO

WILLIAM SAUNDERS HALLARAN, M. D.

PHYSICIAN TO THE LUNATIC ASYLUM OF CORK,

&c. &c. &c.

THIS HUMBLE ATTEMPT

TO FACILITATE THE STUDY OF THE BRAIN,

IS MOST RESPECTFULLY DEDICATED,

BY

HIS OBLIGED SERVANT,

WILLIAM BENNETT.

TRANSLATOR'S PREFACE.

A CONSIDERABLE time having now elapsed since the publication of Professor Tiedemann's researches on the brain of the fœtus, and even since their more general circulation on the Continent, through the assiduity of M. Jourdan ; still, an acquaintance with the facts and observations contained in the original work, has not appeared to me so general as the interest of the subject, and the minute inquiries of the German Professor deserve. I therefore offer the present translation, with the hope that the indulgent reader will not weigh the merits of the original work, by my feeble exertions to establish a more general acquaintance with the facts which it contains. Well aware of the importance of the subject, I have preferred to trace the steps of M. Jourdan, and enter into these minute and interesting details, in the full conviction that a brief and summary sketch of the Work, would not only be an injustice to its author, but the most probable means of circulating erroneous ideas on the formation and structure of an organ even now so little known. There is no subject in the vast range of medical science, which carries with it so much interest, as that of the brain and nervous system; nor is there one which has so completely baffled the genius of the most celebrated Physiologists. It is difficult to determine, whether the impediments to the advancement of our knowledge on the functions of this organ, are owing to any one cause alone; yet we have been hitherto continually following the same narrow path in the pursuit of inquiry, and confining our researches too closely to the examination of this organ, in its state of perfect developement, in which it affords full scope to the fanciful imagination, and consequently to the circulation of absurd ideas and theories.

For the advancement of any science, it is requisite that we gain such a knowledge of its first principles, as shall prevent our hasty acquiescence to any conclusions which the imagination is so ready to adopt; and thus by a proper examination of the more simple parts, be better enabled to promote the advancement of our knowledge in those more complicated. Notwithstanding this generally received principle, it must be regretted, that in our pursuit of inquiry into the various functions of the human body, we have deviated too far from this path. We are at present occupied in endeavouring to explain the different functions of the body, by an examination of their respective organs, which in man have reached the very maximum of developement. We are impeded at each step by those difficulties which arise from our unacquaintance with the different degrees of complicated structure, the necessary consequence of the gradual developement of each organ. Either from the difficulty of examining the organs in their early or fœtal state, or from considering man totally apart from the rest of the organized creation, we appear little solicitous to change our path of pursuit, to call to our aid comparative anatomy. In other words, we are not anxious to seek for the true principles on which we may establish a firm foundation for our future inquiries; but are submitting ourselves to blind chance, and retarding rather than advancing science.

The present state of our knowledge on the anatomy and physiology of the fœtus is too true an example of the erroneous path which we have taken. Could Newton ever have made those brilliant discoveries which have immortalized his name, and tended so much to the advancement of science, if he was unacquainted with those principles by which he established so many important truths? Certainly not. Why then should we neglect the examination of a subject from which we can draw such principles as shall be a firm basis for our future inquiries? Why turn from the examination of the animal kingdom, where we find, from the most simple of organized beings, up to man the most complicated, who is the very type of animal perfection, so delicate a link admirably uniting the whole chain, so gradual a change in the structure of the different parts, that, to arrive at the knowledge of a complicated organ, the most rational method of pursuit would be to examine its earliest state of developement, and proceed in our inquiries from the simple to the compound?

Tiedemann has at length entered upon this path, and science is indebted to his talents and exertions for a number of interesting facts and observations on the structure of the fœtal brain. His elaborate researches shall long be estimated as leading to fruitful and unerring results, and as being the means of removing many opinions on the structure of this organ, some of which have been the offspring of a fanciful imagination. Unwilling to exact too long the attention of the reader, I have omitted the preliminary discourse of M. Jourdan, which, though not without merit, can scarcely add to that interest which the subject of the work must necessarily excite. Thus, ever anxious for the advancement of science, I shall feel myself sufficiently recompensed, if by these my feeble efforts, I promote the more general circulation of such opinions and facts as seem to me deserving of record.

AUTHOR'S PREFACE.

THE anatomy of the human body, if we except the researches on the structure of the brain, has arrived, within these thirty years, to such a degree of perfection, that further progress now seems nearly impossible. The configuration of all the organs of man in their complete developement has been described; the structure of most of them known; the articulations of the bones, the mutual relation of the muscles, the distribution of the vessels and nerves studied; in a word, anatomy, in its literal acceptation, has become purely descriptive. But it must be evident to every one, who does not suppose that the sole, the principal object of this science, is merely to describe the organs, to unveil their structure, and to draw from these notions conclusions applicable to medicine and surgery, that it never can aspire to the rank of a true science, until it comprises the history and laws of the formation of the animal body. To acquire such a knowledge, we must be guided by the anatomy of animals and of the fœtus, which alone can unveil to us the curious facts of the gradual multiplication of the organs, their developement, their successive complication, and the relative degree of their importance in the support of life. This vast field of research has been left entirely to the Moderns, and I feel myself called on, as Professor of Anatomy, to apply all my zeal to the solution of this grand problem. I now publish the results of my researches for many years on the brain of the fœtus, and which may furnish the subject of a chapter in the history of the formation of man. I have added a comparative sketch of the structure of the brain in the four classes of vertebral animals, with the view of proving that the formation of this organ in the fœtus passes through, in the different months of gestation, the principal degrees of organization, in which it is permanently arrested in animals. From whence we conclude, that nature follows an uniform plan in the creation and evolution both of the brain of the human fœtus, and of that of vertebral animals.

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ANATOMY

OF THE

FŒTAL BRAIN.

INTRODUCTION.

THE brain, the most noble of organs, the key of the entire animal organization, has, for nearly three thousand years, been a subject of continual study and meditation. Successive ages have produced many celebrated men, who have anxiously endeavoured to unravel its structure; they have neglected, as it would appear, no method, no means, which seemed proper to unveil its texture and use. Yet, notwithstanding the efforts of so many celebrated writers, its intimate structure has remained unknown; its organic connexions are shadowed from our view, and the functions of its different parts are involved in obscurity.

If our knowledge of its structure is so little advanced, we must rather accuse the method generally adopted of studying it in man, in whom it presents a very complicated organization, than the difficulties which the dissection of this viscus presents. Anatomists have been hitherto lost in this inextricable labyrinth, and only arrived to positive data in using violence, breaking and tearing the delicate parts, the union of which constitutes the encephalic mass.

In my method of viewing the subject, there are but two paths, hitherto little frequented, which can lead to the knowledge of the structure of the brain; these are comparative anatomy, and the anatomy of the fœtus.

Comparative anatomy unveils to us the origin and successive developement of the brain and nervous system, from the most simple animals, up to man, the most complicated. There is no set of organs, in the formation of which, we find so perfect a gradation from the simple to the compound, as in the cerebral and nervous system; in fact, this system is established on an uniform plan in the whole animal scale. So, in studying the gradual complication of the structure of the brain in animals, can we have a clear idea of the complex organization of this viscus in man, and at length succeed in comprehending its assemblage and relations.

Though the moderns have well estimated the utility afforded by comparative anatomy in this subject, they have however profited little from the advantages placed before them. If we take a rapid view of the great work of Gall, we find one idea reigning through the whole; that it is necessary to study the structure of the brain and nervous system, gradually ascending from the more simple animals, up to man. But what has he done? he has merely described and represented, respecting the nervous system of animals, the nerves of the caterpillar, the brain and spinal marrow of the chick, and of some of the mammiferous animals; yet even his work on this subject is not exempt from errors. To set out from so small a number of data, in order to arrive at general conclusions respecting the structure of the brain and nervous system, would indeed render the question still more complicated than it really is, in place of throwing one salutary ray of light upon it. We should consider these partial works but as materials of a grand edifice; but while we employ them as elementary principles for general propositions, we cannot fail to be led into new errors. No axiom relative to any point of anatomy or physiology can be established, unless skilfully deduced from all the facts and observations on the object in question.

As by the study of the brain and nervous system of animals, we can alone arrive at the knowledge of the gradation which the former undergoes in its formation and progressive complication, so also shall we have need of a comparative psychology to conceive the uses and manner of action of each portion which composes this mass. We must observe attentively the phenomena of cerebral action, from animals the lowest in the scale up to man, and then compare them with the structure of the organ itself. This comparative study of the actions and organization of the brain in the different animals, will dispel the cloud from o'er the functions devolving on its separate parts, a knowledge to be derived from no other means than those already mentioned. It is a general truth, recognised at present, that the cerebral functions of animals become more numerous and diversified, according as their brain and nervous system possess a more complicated structure; and we also know, that the nerves of sense, and their roots in the brain, are more voluminous, according as the organs of sense are better developed. We cannot then doubt the existence of a perfect relation, an intimate connexion, between the acts of intelligence in animals, and the structure of their brain.

In following this method we may arrive at the knowledge of the function of each part of the encephalic mass; but the intimate essence, the proximate cause of all these phenomena, will still remain shadowed from our view by the thick veil of darkness which covers them. Is the mind similar to the matter of the brain? or rather, are they different things, and is then the brain in some degree the organ, the material instrument of the mind? Such problems, philosophers and physiologists have not yet been able to resolve, nor never will. I repeat it, anatomy, physiology, and psychology, may teach us the structure of the brain, and the action or function of its different parts; but they will never unveil to us the essence of this action:—Such is my opinion.

Even so is our knowledge of physics; we know the movements of the celestial bodies ; we have found out the laws of magnetic, electric, and galvanic phenomena; we have discovered the circulation of the blood, &c.; but how these various phenomena act, is still unknown to us. To penetrate the very essence of all existence, of every phenomenon, we must form this very essence itself; in fact, we must create an Almighty power. It is a mere abuse of our knowledge to suppose that we can penetrate the infinite depths of the Divinity when we have established the empty formula of our senses, which speak not to the mind; but it is a noble employment of the faculties accorded to man, to seek after a true knowledge of the phenomena produced by a divine cause, and generalize them as far as the narrow sphere of his intelligence can permit him to do.

Another part of anatomy and physiology, which has also been hitherto neglected, is the history of the formation and developement of the brain of the fœtus. The sagacity of Harvey had led him to the discovery of a law, the truth of which the Germans have during the latter periods sufficiently verified; and according to which the fœtus, both of man and animals, is by no means a diminutive representation of the adult, but commences by a more simple form, and passes through many successive degrees of organization, before arriving at its last term of developement. Does not a similar progression take place in the structure of the brain of the embryo? And can we not draw from hence some light on the formation of an organ which is found so complex, when once it has attained complete perfection? Anxious to resolve these two questions, I have been occupied for many years in the study of the organization of the brain in the fœtus. The results of my researches are the subject of the following work; and I have been induced to lay them before the public, as the facts which they contain appear to me to possess some interest. It is true, that, since I commenced this study, the Wenzells have published some scattered remarks in their extensive work, and Dœlinger also a particular treatise on the brain of the fœtus; still I cannot think that the publication of my researches will appear useless, particularly if we consider that they comprise the brain of even the youngest fœtuses on which the anatomist can well employ the scalpel.

As it is my intention to give the reader a clear idea of the successive manner in which the formation of the brain is effected, I shall commence with the general description of this viscus, examined in each month of gestation, in order to embrace within one view all the gradations of its developement. I shall afterwards add some general considerations on each of its component parts, comparing them with corresponding portions of the brain of animals. This plan has appeared the most suitable in order to become acquainted with the successive states through which not only the brain in general passes, but also the different portions which compose it, the relations which exist between these states, and those which we observe in different animals; and lastly, the manner in which the brain is gradually elevated from a very simple organization to one of a much greater complication.

The brain and spinal marrow of the fœtus being very soft and nearly fluid in the first periods, a circumstance which prevents the examination of it in its fresh state, I had recourse to the means which Reil employed with so much success, that is to say, preserving the embryos in spirits of wine for a considerable time.* This prolonged immersion augments the consistence of the brain, and consequently renders the dissection more easy. It may perhaps be objected, that such a method changes the texture of the organ, and the fibres rendered apparent are produced by the alcohol; but I would answer, that if the liquor produces a greater density in the cerebral mass, it cannot influence the direction of the fibres, as this direction is the same on all brains submitted to the action of alcohol. Thus, for example, the fibres of the crura cerebri are always longitudinal, those of the pons varolii always transverse ; that is to say, that their direction differs not from that which they follow when examined in the fresh state.

I should however mention, that I preserve the brains of embryos at all periods of gestation,

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* Reil recommends the hardening of the brain to be effected by immersion for some time in alcohol, and then placed in a solution of carbonated or pure alkali for two days, and hardened again in alcohol, if thus rendered too soft ; or by maceration in alcohol, in which pure or carbonated potass or ammonia has been previously dissolved. (T.)

with the view of convincing such as raise any doubts on the exactness of my figures and descriptions. This precaution is always useful, particularly in the present age, when we find so many representations and descriptions of things which really exist not in nature.

PART I.

RESEARCHES ON THE STRUCTURE OF THE BRAIN OF THE EMBRYO, AT THE DIFFERENT PERIODS OF ITS DEVELOPEMENT.

FIRST MONTH.

ANATOMISTS in general are aware that the human embryo, at the period when we can first perceive it, that is to say, towards the end of the fourth week after impregnation, has the form of an elongated mass, slightly bent on itself, gelatinous, of little consistence, semi-transparent, and suspended by the delicate umbilical vessels proceeding from the internal surface of the ovum. One of the extremities of this gelatinous cord forms a rounded swelling, representing the head; the other, gradually diminishing, terminates also in a rounded surface, constituting the breech. The middle portion, which is thick and in the form of a pad, communicates with the umbilical vessels. Ruysch, Sœmmering,[2] and some other anatomists, have represented embryos of this age. If embryos recently removed from an ovum also recent, be examined, we soon acquire the conviction, whether we view them with the naked eye, or with glasses proper to magnify, that no organ is yet perceptible. The cephalic and cervical swellings are altogether transparent; they seem to contain a limpid fluid not having the slightest relation with the cerebral or nervous substance.

The embryo of birds, which is developed in the egg submitted to incubation, differs not from

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[1] Thesaurus Anatomicus, vi. tab. ii. fig. 2, 3; vii. tab. ii. fig. 2.

[2] Icones Embryorum Humanorum, tab. 1, fig. 1.

the human fœtus, during its first periods, that is to say, towards the end of the second day. Of this we may be convinced in reading the works of Harvey, Malpighi, Haller, Wolff, &c. whose observations I have repeatedly proved. The embryos of mammiferous animals present the same appearance in the beginning. Regnier de Graaf [1] having removed an embryo from a rabbit fourteen days after copulation, observed the head voluminous, but still transparent; Haller also observed it entirely pellucid. [2]

It remains proved, after these facts, that the brain and spinal marrow do not yet exist during the first periods of the life of the fœtus, a limpid fluid occupying their place.

SECOND MONTH. [3]

On the fifth and sixth week after conception, the embryos have acquired a length from about four to five lines; the head is voluminous and

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[1] De Mulierum Organis: opera omnia, Leyden, 1768, p. 218.

[2] Opera minora, v. iii. p. 444.

[3] Plate I. fig. 1, 3.

bent forwards: at this period we can distinguish a small fissure representing the mouth, and two small eyes without lids. The thoracic and pelvic extremities are developed on the surface of the trunk in the form of small tubercles; the breech forms a considerable prominence. Above the insertion of the umbilical vessels in the abdomen, we can perceive the canal of the heart filled with blood. Ruysch,[1] Albinus,[2] and Sœmmering[3] have represented embryos at this period. If we examine it a little after its exit from the ovum, we find the head and trunk nearly transparent. Having had three at my disposal, I opened cautiously the head and trunk of one, with a sharp needle, and found, immediately beneath, a canal or tube, which in the head swelled so as to form a rounded pouch. The canal of this pouch, the walls of which were somewhat firm, contained a whitish and nearly diaphanous fluid; in two embryos it presented slight depressions, transverse and longitudinal,

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[1] Thes. Anatom. vi. tab. ii. fig. 4, 5.

[2] Annotation. Academ. lib. i. tab. 5, fig. 4, 5.

[3] Loc. Cit. fig. 2, 3.

giving it the appearance of small vesicles agglomerated together.

The brain and spinal marrow exist absolutely the same in the embryo of birds, that is to say, that the brain presents very many vesicular prominences, and the spinal marrow forms a canal enveloped by the trunk. In the embryo of the chick, on the third day, that is to say, after the formation of the canal of the heart, and its vesicular dilatations, we can perceive some vesicles in the head, the anterior part of which is composed of two sacs filled with a limpid, transparent fluid, and but a single sac for the occiput. Towards the end of this day, or on the commencement of the following, we find between the two anterior and one posterior, a third, which shortly divides into two by a longitudinal division. These swellings have been termed cerebral vesicles by Coiter,[1] Harvey,[2]

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[1] De ovorum gallinaceorum generationis primo exordio progressuque et pulli gallinacei creationis ordine: in Schwift, externarum et internarum principalium humani corporis partium tabulæ. Nuremberg, 1753, in fol. p. 32. Coiter observed the vesicles on the sixth day.

[2] Exercitationes de generatione animalium. Amster-

Stade,[1] Langly,[2] Steno,[3] Malpighi,[4] and Haller.[5]

The two anterior vesicles represent the two hemispheres of the brain; the two middle, the optic chambers; and the posterior, the cerebellum. All those who have studied the formation of the chick in ovo, agree in saying that the fluid contained in the cerebral vesicles is limpid,

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dam, 1651, in 12mo. Harvey observed the vesicles on the fifth day, p. 82. In vesiculis cerebri et cerebelli, praeter aquam limpidissimam, nihil reperias.

[1] Observationes in ovis institutae. Amsterdam, 1668, in 12mo. Stade perceived them on the end of the sixth day.

[2] Ovi fecundi singulis ab incubatione diebus factae inspectiones. Amsterdam, 1674, in 12mo. Langly observed them on the fourth day.

[3] Observationes in ovo et pullo: in the act: Hafn. vol. ii. p. 81. Steno perceived them on the fifth day.

[4] Dissertatio epistolica de formatione pulli in ovo. London, 1673. Malpighi pretended to have seen the vesicles at the end of the twenty-fourth hour.

[5] Two memoirs on the formation of the heart in the chick. Lausanne, 1758, in 12mo. and in his Opera Minora, vol. ii. p. 54. Haller perceived the vesicles on the end of the third, but he gives a very different account of their number.

transparent, and serous, and afterwards gives origin to the brain. The spinal marrow contained in the vertebral column, represents a long canal communicating with the cerebral vesicles, and containing a similar limpid fluid. I should further observe, that the canal of the spinal marrow and cerebral vesicles communicate together; these latter are in reality but swellings of a single large sac, formed by the pia mater, and which penetrating in certain points, thus marks the limit of the principal portions of which the brain is ultimately to consist. That the walls of the cerebral vesicles, and the canal of the spinal marrow, are formed by the pia mater, is proved by the first traces of blood, and the first vessels appearing in their substance, as Malpighi and Haller have shown.

The brain of mammiferous animals has equally a vesicular form at first. Harvey has proved this fact in the embryo of the deer;[1] and we may easily be convinced of its exactness, in examin-

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[1] Loc. cit. p. 317. Caput ex tribus vesiculis sive globulis parvis imperfecte compositum cernitur. In another embryo of the size of a bean; p. 320. Cerebrum albumine.

ing that of the rabbit. The vesicles are always found filled with a limpid and diaphanous fluid.

In embryos of the seventh and eight week, such as those represented by Ruysch,[1] Albinus,[2] and Soemmering,[3] the total length of the body is from six to eight lines. Besides the eyes and mouth, we perceive the nasal and auricular openings ; the extremities having become larger, are terminated by a flattened portion, on the rounded border of which, are subsequently to be developed the fingers and toes ; the head, always very large, and the trunk, have lost their transparency. Having procured many embryos of this age, recently taken from the egg, I opened, with the necessary precaution, the spine and head ; an operation easily effected, as the vertebral column, the bones of the cranium, and the muscles both of the back and neck, are not yet formed. After having divided these parts, I first observed a whitish membrane adhering to the internal surface of the cranium, and being

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[1] Loc. cit. Thes. tab. 3, fig. 2.

[2] Loc. cit. tab. 1, fig. 12; tab. 5, fig. 4.

[3] Loc. cit. tab. 1, fig. 4, 5.

evidently the dura mater; beneath this I perceived another very thin membrane, in the tissue of which, by the assistance of a magnifying-glass, I could distinguish blood-vessels of extreme delicacy. This second membrane, undoubtedly the pia mater, contained the brain and spinal marrow; and on opening it, the white and pulpy substance of the brain, of the consistence of the white of an egg, issued out. As the extreme delicacy of this substance prevented me from examining the structure of the brain and spinal marrow, I endeavoured to bring it to a proper degree of solidity, by immersing the embryo in alcohol. This experiment having frequently succeeded, I shall now mention the result of my observations.

In an embryo, which, curved in the manner already described, was about seven lines in length, (Pl. I. *fig.* 1,) and the configuration of which seemed to announce that it came from a woman about seven weeks pregnant, I was enabled, to my great surprise, to distinguish perfectly the structure and disposition of the brain and spinal marrow. The cavity destined to receive this latter, was situated immediately beneath the common integuments, because the dorsal muscles and arches of the vertebræ were not yet formed. Having made a longitudinal incision in order to lay open this cavity, I prolonged it with a pair of small scissors as far as the forehead, following the middle line of the occiput and summit of the head; and then opening completely the cranial cavity, by a crucial incision, I perceived the membrane which covered the internal surface of the cranium and vertebral canal, and which consequently enveloped the brain and spinal marrow. This membrane, the dura mater, nearly divided the cavity of the cranium into two equal portions, the limit of which was the tentorium cerebelli; and beneath were the brain and spinal marrow, enveloped by the pia mater. This latter membrane adhered so intimately to the substance of the two organs, that it was difficult to detach it without in some degree destroying the inclosed pulp. The spinal marrow, bent in the same direction with the vertebral column, (Pl. I. *fig.* 2,) was very large and thick, in comparison to the volume of the embryo, and in particular to that of its brain; it extended nearly as far as the inferior extremity of the trunk, where it terminated in a point; its thickness was very nearly the same in its whole extent, and it was about half a line in breadth. On the middle of the posterior surface, existed a longitudinal fissure, (Pl. I. *fig.* 3, b,) into which penetrated the pia mater. The margins of this fissure were very thin; and in passing between them the extremity of a flattened needle, I easily separated them from one another, and turning them aside, thus laid open the interior canal, which extended as far as the inferior extremity of the spinal chord, and was continuous above with the fourth ventricle. I have found it constantly in the spinal chord of embryos; and have therefore termed it the spinal canal. The exterior surface of this latter was composed of two cords, the demarcation of which was indicated by a slight longitudinal groove, but in which I could not distinguish any trace of fibrous structure, even with the assistance of a powerful lens.

At its superior part, where it was continuous with the brain, it formed, on either side, a projection of considerable size, (*fig.* 2, b; *fig.* 3, c,) and was nearly one line in breadth. It was, no doubt, this projection which formed the tubercle observed on the nape of the fœtus, (*fig.* 1, a). Beneath this the spinal marrow formed a curve, and bent forwards, to be continuous with the brain contained in the cranium; it was dilated in front of this enlargement, at the point where it gave origin to the fourth ventricle. On either side of this latter, arose, from the spinal marrow, a thin and narrow plate, a flattened fasciculus, which inclined from without inwards, and remained in apposition with that of the opposite side, without uniting into a single mass; these two fasciculi constituted the cerebellum, and formed a sort of arch over the fourth ventricle. I have been frequently convinced, both on this brain, as also on others taken from embryos of the same age, that they were not united on the middle line; for I have succeeded in separating them with two delicate needles. The cerebellum was one line and two-thirds in breadth. The spinal marrow, after having furnished the plates consituting the cerebellum, rose a little, and forming the crura cerebri, terminated by bending from before backwards, and from below upwards; in this curve (*fig.* 2, g,) was contained the rudiment of the tentorium cerebelli, of which I have already spoken.

In front of the cerebellum (*fig.* 2, c; *fig.* 3, d, d), I perceived two other membraniform productions, also bent inwards, and separated from one another by a longitudinal fissure, (*fig.* 2, d ; *fig.* 3, e, e). These productions are evidently masses, which subsequently give origin to the tubercula quadrigemina. Taken together, they are about one line in breadth, and one in length. After having turned them to the outer side, as also the two fasciculi of the cerebellum, I observed the fourth ventricle passing into the interval between them, and forming thus the aqueduct of Sylvius, still very broad at this period. At the bottom of this aqueduct, I perceived very distinctly the two crura cerebri, forming two elongated cords, from the summit of which rose two membranous semi-arches, corresponding to the tubercula quadrigemina.

More anteriorly were two rounded protuberances (*fig.* 2, e,) about two-thirds of a line in length, and parted from one another by the aqueduct of Sylvius, at their superior part, but united together below. These eminences, lying upon the crura cerebri, or formed by them, were evidently the optic chambers (Thalami optici), and the interval existing between them corresponded to the third ventricle.

In front of these eminences existed two others, (*fig.* 2, g,) in apposition with them; they were about one line in length, and appeared to be the rounded extremities of the anterior part of the crura cerebri. These were evidently the corpora striata.

Finally, from the second pair of eminences, rose two membranous productions, curving inwards and backwards, (*fig.* 2, f,) forming the commencement of the hemispheres of the brain.

I have perceived no traces of the other parts of the brain, particularly of the pons varolii, commissures, corpus callosum, or fornix or its appendages. I shall hereafter more fully explain when and how these different organs are formed.

The basis of the parts which exist in the fœtus similar to those now mentioned, are, the spinal marrow and its two anterior prolongations, the crura cerebri, which unite all together, either from before backwards, or from below upwards. The posterior surface of the spinal marrow is open, as also the superior surface of the brain, through the whole extent of which the canal of the former is extended. The fourth ventricle, the aqueduct of Sylvius, and the third ventricle, are but enlargements of the superior and anterior portion of this canal. The cerebellum and tubercula quadrigemina are still simple membranous plates, which rising from the spinal marrow and crura cerebri, proceed from above downwards, inclining towards one another at their summit.

I could perceive no trace of the nerves coming from the spinal marrow or brain; I do not however on this account pretend that there exists none, but I believe that their delicacy prevents our detecting them.[1] The substance of the brain and spinal marrow examined with a glass, presented no fibrous appearance; it seemed composed of excessively small globules.

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[1] The general law of organization laid down by Professor Serres, in his extensive work on the comparative anatomy of the brain, viz. that the developement of the nervous system proceeds from the circumference to the centre, would appear a better explanation of the absence of the nerves at the brain and spinal marrow at this period; for in all embryos, the nerves are formed previous to their communication with these two organs. The latter author mentions to have seen, in a human embryo, between the sixth and seventh week, some of the dorsal nerves implanted on the middle part of the spinal marrow; but there were no traces of those of the cervical region. —Anatomie Comparée du Cerveau, tom. 1, p. 98. (T.)

THIRD MONTH.*

In an embryo of about eleven lines and one-third in length, and about the age of nine weeks, the head was very large, and formed more than one-third of the total mass of the body; the eyes were very large, but still without lids; a small cutaneous elevation surrounded the auditory holes; the two nostrils were directed forwards; and the fingers and toes appeared on the hands and feet in the form of so many tubercles. As the embryo had remained some time in alcohol, it was easy, after having opened the vertebral canal and cranium, to examine the spinal marrow and brain, now hardened in their membranes. The spinal marrow presented, at its posterior surface, a longitudinal fissure penetrating into its vast canal, which latter enlarged at the superior part, between its more separated cords, to give origin to the fourth ventricle. From either cord arose a plate, (Plate I. *fig.* 4, b, b,) which bent inwards to join that of the opposite side.

* Plate I. fig. 4, 7. Plate II. fig. 1, 5.

These two plates, evidently the corpora restiformia, were united on the middle line, and thus formed the cerebellum, stretched like a bridge over the fourth ventricle; they were not however in perfect apposition, for that of the right side was a little in front, that of the left a little behind. The cerebellum was extremely narrow and thin, of a ribbon form, convex on the outside, and concave within. The spinal marrow, which enlarged in front, and was prolonged into two cords representing the crura cerebri, described a curve, as in the preceding brain.

In front of the cerebellum, I perceived two elongated eminences, oval, convex, and smooth on the upper surface, (Plate I. *fig.* 4, c,) and separated by a longitudinal groove. They were formed by two plates proceeding from the crura cerebri, and mutually inclining. The cavity situated under these eminences was a prolongation of the fourth ventricle anteriorly, that is to say, the aqueduct of Sylvius, still at this period a vast cavity, a true ventricle. In front of these eminences, destined to form the tubercula quadrigemina, were two other prominences, (Plate I. *fig.* 4, d,) smooth and convex above, not containing a cavity in their interior. These latter corresponded to the optic chambers, between which was situated the third ventricle.

Lastly, more anteriorly still, I perceived two other distended masses analogous to the corpora striata. The cerebral substance, in the form of a membrane, (Plate I. *fig.* 4, e,) bent backwards and inwards, so as to cover the corpora striata. This membrane evidently represented the rudiment of the cerebral hemispheres.

The spinal marrow was about one line and a quarter in breadth, in front of the fourth ventricle; the transverse diameter of the cerebellum was about three lines; the mass of the tubercula quadrigemina, two lines in length, and one line and a half in breadth; the length of the optic chambers one line and a half, and their breadth one line and three-fourths. The other parts of the brain, as the pons varolii, the corpus callosum, fornix, cornua ammonis, commissures, &c. were not yet in existence.

I succeeded particularly well in proving the structure of the brain and spinal marrow in the next embryo, which, like that already mentioned, had remained a long time in alcohol. Its length, from the summit of the head to the extremity of the trunk, was sixteen lines, the body preserving the slight curve which it naturally has at this period. The head, which was very large, was nearly the third of the total mass of the body; the forehead a little prominent; the eyes nearly covered by lids; the profile of the nose made a slight prominence, scarcely perceptible ; the nostrils directed forwards and upwards ; the auditory holes representing a simple fissure, while the different parts of the ear were in apposition with one another; the regions of the pectoral and pelvic extremities were developed ; the umbilical cord contained many folds of intestine. This embryo might have been about eleven weeks old.

After having made a longitudinal incision in the integuments of the back, I perceived some traces of the muscles in this region, still soft and whitish. As the arched portions of the cartilaginous vertebræ were not united, and as a great space intervened, I at once perceived the spinal marrow contained in its membranes. I prolonged the incision as far as the root of the nose, cutting the membranous bones of the cranium ; and having made another transverse incision, I turned the flaps aside. The dura mater, adhering to the internal surface of the cranium, passed between the hemispheres of the brain, forming the commencement of the falciform process: the tentorium, which it formed in front of the cerebellum, was well marked. The longitudinal and lateral sinuses contained coagulated blood. The dura mater passed into the interior of the vertebral canal, forming a sheath for the spinal marrow; it was impossible to perceive any thing which resembled the arachnoid membrane. The pia mater, rather thick, enveloped all the cerebral parts, and folding in the interior of the hemispheres of the brain, formed the choroid plexus contained in the lateral ventricles; there was a similar plexus in the fourth ventricle. It covered in like manner the spinal marrow, into the canal of which it penetrated by the posterior fissure.

The spinal marrow, (Plate I. *fig.* 6,) extended the whole length of the vertebral column, as far as the sacral region, where it terminated in a point; the caudiform expansion was not yet in existence. The length of the spinal marrow was ten lines and a half, and nearly of an uniform breadth of half a line in its whole extent; it appeared a little thicker at the origin of the nerves destined for the pelvic and pectoral extremities, but it augmented considerably in volume in its superior portion, where it was continuous with the brain. On the middle of its posterior surface, I perceived a longitudinal groove extending from the fourth ventricle to its extremity, gradually diminishing. On examining the fourth ventricle at the point where its posterior part, the calamus scriptorius, gained the spinal marrow, I observed that it extended to the cavity formed in the thickness of this latter. I succeeded in turning aside the margins of the spinal marrow along its posterior longitudinal groove, from its extremity as far as the fourth ventricle, so that I could perceive the entire extent of the canal which it contained, (Plate II. *fig.* 6, a, a). Hence it results that, rigorously speaking, the fourth ventricle is a simple dilatation of the canal of the spinal marrow; for the latter, enlarging at its superior and anterior part, a mutual separation of the walls takes place, leaving a free space between them. I perceived also on its anterior surface, a longitudinal groove of little depth, and terminating in a cul-de-sac, (Plate I. *fig.* 7,) which had no communication with the canal. From either side of the spinal marrow arose the spinal nerves, (the bulk of which was proportionally very considerable.) At the point generally termed the medulla oblongata, it became evidently thicker and broader, (Plate I. *fig.* 6, b; *fig.* 7, b, b,) and was bent forward, (Plate I. *fig.* 5, c,); the separation of its margins at the posterior and superior part produced the fourth ventricle. In front and below it was continuous with the crura cerebri, (Plate I. *fig.* 5, e; *fig.* 7, b, b, e, e; Plate II. *fig.* 5, d, f, i,); which continuity was particularly evident, as the pons varolii was not in existence. Although the medulla oblongata was very thick and strong, the corpora pyramidalia and olivaria did not appear on its surface. The crura cerebri proceeded from below upwards in front of the cerebellum, (Plate I. *fig.* 5, e,) and then inclined downward, to be continuous, in this latter direction, with the hemispheres of the brain.

On examining the encephalic mass, I discovered the following parts: 1°, the cerebellum (Pl. I. *fig.* 5, d, *fig.* 6, b,); 2°, the two masses of the tubercula quadrigemina, situated in front of the cerebellum, and not covered by the hemispheres of the brain (Pl. I. *fig.* 5, f, *fig.* 6, d,); 3°, the two cerebral hemispheres still very small, (Pl. I. *fig.* 5, h; *fig.* 6, c,) and parted by a deep fissure. On the inferior surface of the organ, I observed; 1°, the crura cerebri (Pl. I. *fig.* 7, e, e,); 2°, in front of these, and on the inner side, a large mass destined to the formation of the corpora mammillaria (Pl. I. *fig.* 6, 7; Pl. II, *fig.* 1); 3°, the pituitary gland, still very small (*fig.* 7; Pl. II. *fig.* 1,); 4°, the apposition or junction of the optic nerves (Pl. I. *fig.* 7, k,); 5°, the two olfactory nerves, short and terminating each by a bulbous enlargement, (Pl. I. *fig.* 7, l, l,); 6°, and lastly, the two hemispheres, representing the anterior lobes of the brain, (Pl. I. *fig.* 7, h, h,) also the middle and posterior lobes, yet but little developed, and in some degree confounded together, (Pl. I. *fig.* 7, i, i).

The crura cerebelli, (Pl. I. *fig.* 6, b; Pl. II. *fig.* 2, b, b,) arose from the spinal marrow, at the point where the two plates which form its posterior surface separated to produce the fourth ventricle. They proceeded from behind forwards, and a little from within outwards, and curving in this latter direction, terminated by uniting together, thus giving origin to the cerebellum (Pl. I. *fig.* 5, d; Pl. II. *fig.* 1, c, c;

fig. 2, b, b; *fig.* 5, b, b; *fig.* 4, b, b). This latter, stretched like a bridge over the fourth ventricle, was extremely narrow on the median line, at the point of union of the two crura; its external surface was convex, smooth, and without grooves; the internal was concave, and formed in part the vault or roof of the fourth ventricle. As the cerebellum, on the whole, was nothing more than the result of union of the two narrow plates arising from the margins of the spinal marrow, I could not yet perceive, in a perpendicular section, any trace of stems, lobes, or leaves. Its posterior and free border was reflected inwards. With regard to the interior, it was united to the membranous masses of the tubercula quadrigemina (Pl. II. *fig.* 5, h), which union consequently represented the great cerebral valve, or valve of Vieussens. The cerebellum was four lines in its transverse diameter.

The masses of the tubercula quadrigemina, placed in front of the cerebellum, and very large in proportion to this organ (Pl. I. *fig.* 5, f; *fig.* 6, d; Pl. II. *fig.* 1; *fig.* 4, d, d), were not yet covered by the hemispheres of the brain; they were two lines and a half in length, and only two lines in breadth; their superior surface was smooth and convex. On their middle part, I perceived a longitudinal groove, dividing them into two portions, but not penetrating into the aqueduct of Sylvius. These masses coming from the crura cerebri, rose like thin membranes, and were bent inwards, mutually approaching and uniting together (Pl. I. *fig.* 5, f); their thin walls (Pl. II. *fig.* 5, k, k) enclosed a spacious cavity, a true cerebral ventricle (Pl. II. *fig.* 3, c, d; *fig.* 5, l), the posterior part of which communicated with the fourth ventricle, and was continuous in front with the third, situated between the optic chambers.

In front of the membranes which were subsequently to form the tubercula quadrigemina, existed two oblong eminences, smooth, convex, parted by a longitudinal fissure, and in other respects entirely massive (Pl. II. *fig.* 1. e, e; *fig.* 4, f, f; *fig.* 5, o), as appeared on separating and turning aside the membranous hemispheres.

These two protuberances, taken together, about two lines and a half in length, and as many in breadth, corresponded to the optic chambers. On separating them from one another, their interior wall was brought into view, being smooth and polished (Pl. II. *fig.* 4, f, f), also their posterior commissure (Pl. II. *fig.* 4, g), and lastly, the third ventricle (Pl. II. *fig.* 4, c; *fig.* 5, m), situated between them, which prolonged from above downwards, and from behind forwards, constituted the funnel-shaped cavity (Pl. II. *fig.* 5, m), extending as far as the pituitary gland (Pl. II. *fig.* 5, n). I could not at this period find either the pineal gland or its pedicles.

The two hemispheres of the brain (Pl. I. *fig.* 5, h; *fig.* 6, c, c) were extremely small in proportion to the volume of the parts which I have already mentioned, for they were but four lines in length, five in breadth, and three in height. Properly speaking, their anterior lobes (Pl. I. *fig.* 7, h, h) alone were formed: the posterior and middle lobes resembled two short appendages (i, i), rounded behind, and situated before, and on the sides of the crura cerebri. This slight degree of developement of the hemispheres accounts for our perceiving the tubercula quadrigemina and cerebellum uncovered, which are so concealed in the adult.

The surface of the hemispheres was smooth, without grooves or convolutions; the deep fissure which parted them above, lodged a delicate falciform fold of the dura mater; and on separating them, the optic chambers and third ventricle were seen, because the corpus callosum and fornix were not yet formed; they were united at their anterior part only, in front of the optic chambers (Pl. II. *fig.* 1, i). In this latter point, their junction marked the origin of the corpus callosum, of which we might form a correct idea, by a vertical section of the brain (Pl. II. *fig.* 5, q).

The hemispheres evidently represented two membranous vesicles, the walls of which were scarcely one-fourth of a line in thickness. On cautiously turning them aside, I succeeded in spreading them out in the form of membranes (Pl. II. *fig.* 1, g, g, g, g), so that the interior of the lateral ventricles (k, k), and the eminences analogous to the corpora striata, which occupied the floor (h, h), were brought to view. At this period, the lateral ventricles contained a choroid plexus of an enormous size, which, formed by a prolongation of the pia mater flattened on itself, had passed over the optic chambers, and beneath the inferior edge of the membranous hemispheres.

The eminences analogous to the corpora striata (Pl. II. *fig.* 1, h, h; *fig.* 4, h, h), were two lines and a half in length, and one in breadth; they were a little broader in front than behind, and divided into two by a depression. Their superior surface was convex and smooth. They were situated near the optic chambers, resting on the crura cerebri; or, more properly speaking, they constituted the last dilatation of these crura. From their external and anterior border rose the membranous hemispheres, which resulted from the radiation of the fibres of the crura; the fan-like expansion of the fibres of the spinal marrow, on the internal surface of the membranous hemispheres, was easy to be distinguished when they were everted (Pl. II. *fig.* 1, g, g, g, g). These membranes were reflected backwards and inwards, so as to form the lateral ventricles, and envelope the corpora striata. Those of the two sides united together in front of the optic chambers, and here gave origin to the corpus callosum, which was yet very small in the embryos already described, but which might be seen in a vertical section of the brain (Pl. II. *fig.* 5, q). In the brains already described, the membranous hemispheres were still so little developed, that they did not cover the optic chambers: we shall see hereafter that they become more and more ample, are gradually prolonged backwards, and terminate by expanding over the tubercula quadrigemina, as also over the cerebellum.

By a perpendicular section of the brain, I perceived in front of the optic chambers, and behind the commencement of the corpus callosum, a narrow band (Pl. II., *fig. 5*, r), rising from the base of the brain, particularly from the mammillary eminences, and proceeding upwards; then curving backwards in front of the optic chambers, and behind the corpus callosum, now very narrow and perpendicular, went to unite with the membranous hemispheres; this band was evidently the anterior pillar of the fornix. As the pillars on either side were not united together, nor even in apposition, and were separated by the continuation of the third ventricle, the fornix did not yet cover the optic chambers, between which latter and the pillars was the broad opening of the lateral ventricle, through which the choroid plexus penetrated. The subsequent description of embryos farther advanced, will point out in what manner the fornix is formed, and how the anterior pillars prolonged backwards, give origin to the cornua ammonis and corpora fimbriata.

The mammillary eminences and pituitary gland, situated at the base of the brain, formed soft masses applied on the crura cerebri, as also on the inferior surface of the optic chambers, and were completely united to these parts.

The olfactory nerves, very voluminous (Pl. I. *fig.* 7, l, l), formed two bands, rising laterally from the fissure of Sylvius, between the anterior lobes and posterior appendages, and terminating by a small rounded tubercle. They bore a strong resemblance to the mammillary eminences in the brain of animals. They were both hollow, and their cavity was continuous with the anterior cornu of the lateral ventricle, which passed into the olfactory nerve, in front of the corpus striatum. It is evident that these two nerves are prolongations or hollow appendages of the brain.

Behind the olfactory were the two optic nerves, voluminous and united together (Pl. I., *fig.* 7, k); the two ribbon-like cords which they represented wound round the crura cerebri from below upwards, and from before backwards. I succeeded in tracing them as far as the surface of the optic chambers, and of the common mass of the tubercula quadrigemina. I could not at this period perceive the corpora geniculata.

The other cerebral nerves existed, but the extreme delicacy of their tissue, and the considerable thickness of the pia mater, prevented me from tracing them to their origin. I have most distinctly seen the nervus accessorius of Willis (Pl. I. *fig.* 5, 1).

The brain and spinal marrow presented the same structure in another embryo of eleven weeks, and in a third of twelve.

FOURTH MONTH.*

I now proceed to the description of an embryo from fourteen to fifteen weeks old, which, in the state of the general curve of the body at this period, was two inches four lines in length, from the summit of the head to the inferior extremity of the trunk. On exposing the cavity of the cranium and vertebral canal, I found the bones of the former and the arches of the verte-

* Plate III., fig. 1, 3. Plate IV., fig. 1, 3.

bræ still cartilaginous ; the dura mater adhered to the internal surface of the cranium, and was strong and thick ; its folds had formed the falciform process and tentorium cerebelli, and the sinuses placed between them contained coagulated blood. The pia mater, of some consistence, was traversed with numerous vessels ; it not only covered the exterior of the brain and spinal marrow, but passed into the lateral ventricles, fourth ventricle, and into the canal of the spinal marrow. I could not yet perceive the arachnoid membrane. As the embryo had remained a considerble time in alcohol, the brain and spinal marrow were in a good state. The latter, very large in proportion to the brain, was nineteen lines in length, and descended, without forming a caudiform expansion, as far as the os sacrum, where it terminated in a point ; its middle portion, that covered by the dorsal vertebræ, was two-thirds of a line in breadth ; at the origin of the nerves forming the brachial plexus one line and a fourth, and one line and a third at the origin of the nerves for the pelvic extremities. It gradually became more voluminous at its superior part, presenting a breadth of two lines and a half at the point where the extremity of the fourth ventricle was continuous with its anterior canal. I perceived at its posterior surface the longitudinal groove generally marked there, and which advances as far as the interior of the same canal. This latter became apparent as soon as I separated the edges of the two plates of the spinal marrow; it presented some slight swellings at its broader points. On its anterior surface I perceived also a slight longitudinal groove (Pl. III. *fig.* 2, b). At the superior part, where it takes the name of medulla oblongata, it became broader and thicker, and was slightly bent forwards (Pl. III. *fig.* 3, b). On this curve and on its anterior surface I observed two oblong eminences (Pl. III. *fig.* 2, c, c), which were evidently the corpora pyramidalia. The portions of the medulla oblongata situated on either side of these bodies (e, e), were smooth, and presented not the slightest trace of the eminences applicable to the corpora olivaria. Near the point where these bodies were at a subsequent period to be developed, I perceived on either side a cord (Pl. III. *fig.* 2, d, d), proceeding forward to gain the pons varolii, and rising a little obliquely from before backwards, gave origin to the cerebellum. These two cords, which formed the swelled margins of the fourth ventricle, were the corpora restiformia. The spinal marrow, hardened by the action of the alcohol, was evidently of a fibrous texture on its anterior surface and lateral parts, for, in puncturing the surface with a sharp needle, I succeeded in detaching fibrous portions from its whole length, but it was impossible to separate any transversely. The surface of the canal was somewhat softer, and presented no appearance of fibres. The two cords of the spinal marrow, situated on the anterior surface, and on the sides, and composed of longitudinal fibres, many of which in rising proceeded obliquely backwards, and were reflected inwards to form the canal; these two cords, I say, augmented gradually in thickness at their superior part, thus forming the medulla oblongatâ. Each divided into three fasciculi; 1°, the corpus restiforme, situated on the outer side; 2°, the middle fasciculus, on which is subsequently developed the corpus olivare, and which proceeds forward to gain the crura cerebri; and lastly, the internal fasciculus, representing the corpus pyramidale, also continued forwards into the crura. The fibres of the two internal fasciculi, or pyramidalia, crossed before forming the corpora pyramidalia; this decussation I clearly perceived in separating the margins of the canal of the spinal marrow: in doing so, I observed the fibres which proceeded from behind forwards, the one from the right fasciculus to the left pyramid, the other from the left fasciculus to the right pyramid. However, these fibres should be very numerous to authorize our admitting a complete decussation of the principal cords of the spinal marrow.

The brain, viewed from above downwards (Pl. III. *fig.* 2), formed five masses or portions; 1°, the cerebellum, broader in the transverse direction than elsewhere, the surface still without grooves (Pl. III. *fig.* 1, c); 2° and 3°, the two masses of the tubercula quadrigemina, convex, smooth, polished, mutually confounded, but not covered by the hemispheres; 4° and 5°, the two hemispheres of the brain (Pl. III., *fig.* 1, d, d), oblong and parted, on the mesial line by a longitudinal fissure, into which passed the falciform process. On the inferior surface of the organ (Pl. III., *fig.* 2) I observed the pons varolii, still very narrow (Pl. III., *fig.* 2, h); in front of it were the two crura cerebri

(Pl. III., *fig.* 2, i, i), which, on separating aside, left between them a small triangular space, in front of which I perceived a large mass corresponding to the mammillary eminences (l), and in front of these latter was the pituitary gland (m), a round body, hollow in its interior, and communicating with the third ventricle through the infundibulum. Lastly, in front of the pituitary gland, were the optic chambers united together (n). The hemispheres extended but little backwards, each being composed of an anterior lobe (s, s), and of another portion corresponding both to the middle and posterior lobes. The anterior lobe was parted from this second portion by the fissure of Sylvius, into which the middle cerebral artery penetrated, the continuation of the trunk of the internal carotid. From this fissure arose, on either side, the olfactory nerve, forming a prominent cord (Pl. III., *fig.* 2, o, o), which bending inwards, terminated by a small orbicular eminence. The posterior mass, corresponding to the middle and posterior lobes, was marked on the inner side by a slight groove indicating their separation (q, q, r, r). On both sides, the nerve of the fifth pair, very large (k, k), either issued in front of the pons varolii, or from this protuberance itself; the other nerves came off from their usual points of origin.

At the point where the spinal marrow enlarged, while proceeding from below upwards, and from behind forwards, and where these two cords mutually parted, to pass aside, I observed the fourth ventricle (Pl. III. *fig.* 1, b; Pl. IV. *fig.* 2, b, c; *fig.* 1, c), of considerable size, communicating behind and below with the canal of the spinal marrow (b), by the extremity of the calamus scriptorius, and continuous in front with the cavity of the tubercula quadrigemina. I could not perceive, on the floor of this ventricle, the white streaks which have been erroneously regarded as the origin of the acoustic nerves;[1] but

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[1] M. Serres has observed, in the brain of a musician who died of apoplexy, nine medullary fasciculi on the floor of the fourth ventricle, six on the right, and three on the left, one of these latter joined the acoustic nerve. Still, however, analogy will lead us to the conclusion, that the auditory nerves do not take their origin in these white streaks, as in all mammiferous animals and in birds, these streaks are wanting, although the nerves of audition are well developed. See his Anatomie Comparée. (T.)

I observed on either side, near the edge of the cords of the spinal marrow, where they jut outward, a small eminence (Pl. IV. *fig.* 1, d), resembling the grey band described for the first time by the Wenzells,[1] and which we are sanctioned in considering as the origin or ganglions of the auditory nerves.[2]

The corpora restiformia (Pl. III. *fig.* 2, d, d; *fig.* 3, d) rose from the swelled margins of the cords of the spinal marrow, at the point where these latter jut aside. These bodies, proceeding from behind forwards, and bending backwards, form the cerebellum; they sent however some fibres to the pons varolii. The cerebellum (Pl. III. *fig.* 1, c; *fig.* 3, g; Pl. IV. *fig.* 2, b, b; *fig.* 3, c, c, d) was a mass formed by the union of the corpora restiformia, and extended like a bridge over the fourth ventricle; it was five lines and a half in breadth, and one and a half

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[1] De penitiori structurâ cerebri, p. 189.

[2] According to a late author, the origin of the acoustic nerve is in the peduncle of the cerebellum, uniting by one part, its medullary portion, to this peduncle; and by the other, its soft pulpy layer, which fills the internal auditory hole, to the lobule of the cerebellum. (T.)

in length in its middle portion, surrounding nearly in a semi-circle the posterior surface of the tubercula quadrigemina. Its superior surface was convex and smooth, without a trace of grooves or hemispheres. Its posterior border was thin (Pl. III. *fig.* 1, e), and bent backwards and a little to the inside. Properly speaking, neither hemispheres nor processus vermiformis could be distinguished. Its inferior surface was concave, which concavity could be seen even when the cerebellum remained attached to the spinal marrow (Pl. III. *fig.* 2, g, g); the pia mater penetrated here, and formed a choroid plexus. I have also observed on either side of the inferior surface of the cerebellum, where the restiformia penetrate into this organ, a small rounded swelling, which appeared to be the origin of the ciliary or moriform body. In a perpendicular section of the cerebellum, I could perceive neither stems, branches, ramifications, nor leaves. Its commissures were perfectly evident, that is to say, that at the point where the corpora restiformia penetrated, transverse fibres existed, forming the pons varolii (Pl. III. *fig.* 2, h). These fibres covered the cords of the spinal marrow, before their separation to form the crura cerebri, and united beneath the two halves of the cerebellum. The pons varolii was very narrow, for its antero-posterior diameter was at farthest but one line; its thickness was inconsiderable, but the transverse fibres were very distinct. After having made a slight incision, I succeeded in detaching these fibres from the cords of the spinal marrow, and in reverting them aside. From its anterior border arose, on either side, a large nerve (Pl. III. *fig.* 2, k), the fifth, which I traced across the pons varolii to its posterior part, where it formed a small swelling in the spinal marrow, between the corpus restiforme and middle fasciculus, on the surface of which is subsequently developed the corpus olivare. From the anterior margin of the middle portion of the cerebellum, a plate was detached, which gained the tubercula quadrigemina, and covered the communication of the fourth ventricle, with the cavity hollowed in the centre of the mass of these tubercles; this plate consequently represented the great cerebral valve, or valve of Vieussens. With regard to the posterior valve, it did not yet exist: it is formed, together with the lobular appendages, as we shall hereafter see, by the posterior margin of the cerebellum.

The portion giving origin to the tubercula quadrigemina (Pl. III. *fig.* 1; *fig.* 3, f; Pl. IV. *fig.* 2, d, d; *fig.* 3, f, f), represents, when viewed from below upwards, a large convex mass, situated between the cerebellum and cerebral hemispheres. It was still uncovered in the fœtus of the third month; but in the present one it was partly concealed (Pl. III. *fig.* 1), because the hemispheres becoming more voluminous, were prolonged farther back than in the embryos of preceding months. It was three lines and a half long, and only three broad; on its middle was a slight longitudinal groove (Pl. IV. *fig.* 3), the trace of its original separation into two halves; its interior was hollow (Pl. IV. *fig.* 1, g), and the cavity which it contained communicated behind with the fourth ventricle, and in front with the third. Its membranous walls rested on the crura cerebri, from which they received some fibres which were reflected upwards and inwards, so as to meet on the middle line, where they united; the thickness of these walls was one line and a quarter at the inferior part, but scarcely one-third of a line at the superior (Pl. IV. *fig.* 1, h).

On separating the two hemispheres from one another (Pl. IV. *fig.* 3), I entirely exposed the mass of the tubercula quadrigemina (f, f), in front of which were the optic chambers (g, g), and pineal gland (h), a small round body, the stalks of which (i, i) arose from these chambers, between which was situated the third ventricle (k).

The two hemispheres were united in front (m); from whence resulted the corpus callosum, still very small at this period, and behind which rose from the floor of the third ventricle, two thin cords (l, l), the anterior pillars of the fornix. The anterior commissure was situated in front of these pillars, which proceeded first upwards, and uniting together at the posterior part of the corpus callosum, separated again, passing backwards in the form of two thin productions (n, n), and winding round the optic chambers, descended, behind these latter, to the base of the posterior lobes of the hemispheres; these two productions were the posterior pillars of the fornix. Exteriorly and inferiorly I perceived their thin border, turned towards the optic chambers, and termed the corpus fimbriatum, between which, on the one side, and the supero-posterior surface of the optic chambers, on the other, appeared on either side, a wide opening where the pia mater penetrated, in the form of the choroid plexus. On the outside of the posterior pillars of the fornix, I observed on the exterior of the hemispheres, a depression (o, o), bent in the same direction with them, and with which they formed, in the lateral ventricle (Pl. IV. *fig.* 2, k), a prominence, evidently destined to produce the cornu ammonis. A small lateral depression (Pl. IV. *fig.* 3, q, q), detached from this fossa, passed backwards to gain the posterior lobe, and also formed in the lateral ventricle a little eminence (Pl. IV. *fig.* 2, l), the hippocampus minor. The pia mater lined these two depressions, to which corresponded in the ventricles, eminences proportional to their depth.

The optic chambers (Pl. IV. *fig.* 3, g, g) were two elongated masses, convex and smooth on their superior surface; each measured three lines in length, and one and two-thirds in breadth. These masses rested on the crura cerebri, of which they were properly speaking but enlargements; the posterior commissure united them behind; their anterior or internal one was not yet formed, so that the third ventricle was exposed. From their internal border arose the delicate and soft pedicles (Pl. IV. *fig.* 3, i, i), of the pineal gland, which uniting together posteriorly, thus formed the gland itself, very small, round and flattened (h).

The two cerebral hemispheres (Pl. III. *fig.* 1, d, d) were ten lines in length, each two lines and a half in breadth before, and four lines behind. Their superior surface was smooth and polished, and I perceived here and there some grooves (Pl. III. *fig.* 1, e), into which the pia mater penetrated. On a side view, each hemisphere was divided into two lobes, the one anterior, the other posterior (Pl. III. *fig.* 3, k, l), by a superficial groove, corresponding to the fissure of Sylvius (Pl. III. *fig.* 3, o). On examining the brain from below upwards, I also perceived the fissure of Sylvius (Pl. III. *fig.* 2, p, p), in front of which was the great anterior lobe (s, s), and behind, the large mass common to the middle (g, g) and posterior lobes (r, r). The separation of these two lobes was marked by a slight depression. The hemispheres were membranous sacs. The best method of exposing their cavities is by a horizontal incision (Pl. IV. *fig.* 2). When the superior wall, detached in this manner, is turned aside (Pl. IV. *fig.* 2, e, e, e), the vast lateral ventricles are exposed, as also the choroid plexuses (f) which fill them. These plexuses were prolongations of the pia mater, which, reflected from without inwards between the hemispheres, penetrated into the ventricles between the superior surface of the optic chambers, and band of the fornix (or corpus fimbriatum). The internal surface of the posterior wall which had been turned aside on the border of the incision made in the hemispheres, presented prominences on all the points where depressions were observed exteriorly. When the choroid plexus of the lateral ventricle was removed, I observed many parts worthy of notice. In front, and on the side, on the floor of the ventricle, rested the corpus striatum, voluminous, convex, smooth above, narrow behind, and broad in front (Pl. IV. *fig.* 2, i); next, a slight eminence looking backwards, outwards, and downwards; this was the cornu ammonis (r). This part corresponded to the posterior pillar of the fornix (Pl. IV. *fig.* 3, n), as also to the fossa or depression situated near it (o). Behind it arose another eminence (Pl. IV. *fig.* 2, l), representing the hippocampus minor, and corresponding to the depression, the description and figure of which I have already given (Pl. IV.

fig. 3, q). The anterior part of the lateral ventricle (g) was continuous with the cavity of the olfactory nerve, while the posterior (h) terminated in a cul-de-sac in the posterior lobe. The greatest degree of thickness of the membranous walls of the hemispheres was on the outer-side, in front, and along the corpora striata; on the contrary, the internal part had the least degree, being scarcely one-fourth of a line in this point.

I shall here describe, as far as I was enabled to trace them, the manner of distribution of the fibres of the cerebral substance, which are too well marked to allow of the slightest doubt on their existence. The two crura cerebri (Pl. III. *fig.* 2, i, i), which are nothing more than the two principal cords of the spinal marrow, proceeding forwards, after having been covered by the transverse fibres of the annular protuberance, separate a little from one another to the right and to the left; they are of a fibrous texture, the fibres proceeding obliquely forwards and upwards. They send at first to the membranes of the tubercula quadrigemina, ascending fibres, which, reflecting inwards, and uniting with those of the opposite side, form the roof of the mass common to these tubercles. I perceived these fibres as soon as I had scraped away a thin layer of unfibrous cerebral substance from the external surface of the membranes which were subsequently to become the tubercula quadrigemina. The crura cerebri afterwards passed into the optic chambers, or rather swelled out to produce these eminences, in which I could not distinguish the fibres until I had elevated from their superior and internal surface a thick layer of unfibrous cerebral substance. Some fibrous fasciculi, the progress of which I shall hereafter describe, descended into the corpora mammillaria. All the other fibres, which were very numerous, passed beneath the optic chambers, and proceeding forwards and outwards, spread like the branches of a fan into the membranes of the hemispheres. This radiation became evident on detaching the corpora striata from the crura cerebri, and turning them backwards ; by means of which I also observed many fibres ascending into these bodies, where they were covered by a thick layer of unfibrous substance. The fibres which radiate in the hemispheres proceeded laterally, forwards, and backwards, but all from below upwards ; they were then reflected inwards to form the superior wall or roof of the lateral ventricles, and re-descended afterwards, along the internal surface of the hemispheres, to gain the pillars of the fornix. Those of the two sides united together in front, from whence resulted the corpus callosum, the commissure of the hemispheres. On the internal wall of the hemispheres, I traced the cerebral fibres with the greatest facility. The hemispheres of the brain are then but membranes reflected inwards and backwards, and produced by the expansion or radiation of the crura cerebri. We can now conceive without difficulty, why, on the outer side near the corpora striata, they are the thickest (Pl. IV. *fig.* 2, m, m), and on the inner side, on the contrary, the thinnest, for the fibres of the crura cerebri are still very compact near the corpora striata, while at the other extremity they are so expanded as to have lost more than one-half of their thickness.

Such of the fibres as descend on the internal side of the optic chambers, and proceed to the corpora mammillaria, turn from behind forwards in these eminences, and ascend behind the corpus callosum, in the form of the anterior pillars of the fornix (Pl. IV. *fig.* 1, q, q), to re-descend farther into the depth of the brain, as the posterior pillars of the same fornix, or the cornua ammonis.

I have found the structure of the brain precisely the same in a fœtus of sixteen weeks.

FIFTH MONTH.*

The spinal marrow and brain were well developed in a fœtus of seventeen to eighteen weeks, and which had been preserved a considerable time in alcohol. The cranium and vertebral column were opened in the same manner as in the preceding examples. The bones of the cranium still formed but a cartilaginous membrane. The dura mater was very thick, and traversed by fibres of a whitish-grey colour; it adhered to the internal surface of the cranium by vessels, but was easy to be separated. In folding on itself, it formed the great falciform process, between the cerebral hemispheres, as also the tentorium, between the brain and cerebellum; the sinuses comprised between its two folds, and

* Pl. V. fig. 1, 2; Pl. VI. fig. 1.

which contained coagulated blood, were of considerable size. It passed by the occipital foramen into the vertebral canal, and furnished an envelope to the spinal marrow; its external surface was united to the vertebræ by cellular tissue. I could not very distinctly perceive the arachnoid membrane, although I succeeded in detaching in many points from the surface of the pia mater, flaps of a membrane extremely delicate. The pia mater was very thick, covering all the exterior parts of the brain, and communicating directly with them by means of vessels coming from its internal surface and penetrating the cerebral substance; the adhesion between it and this latter was even so intimate in many places, that, on removing flaps of the pia mater, delicate layers of cerebral substance remained adherent to their internal surface.

These layers presented a velvety appearance, and on the points from whence they were elevated, the encephalic mass, examined by the microscope, seemed composed of globules. The pia mater was extended uniformly over the superior surface of the hemispheres, that is to say, presenting no folds, because this surface was not covered with convolutions or anfractuosities. It covered equally the internal surface[1] of the hemispheres, on which were marked numerous and deep grooves. Entering between the optic chamber and pillar of the fornix, it bent backwards, and penetrated into the vast cavity of the lateral ventricle, where it formed the choroid plexus, which was very voluminous and puckered, and sent off some vascular ramifications, which gained the walls of the ventricle. The pia mater equally covered the masses of the tubercula quadrigemina and cerebellum ; it penetrated into the few transverse grooves of the latter, and also passed backwards and on the side, into the fourth ventricle, where it formed an enormous choroid plexus, found no less in the adult than in the fœtus ; and lastly, it covered the entire spinal marrow, and entered, by the posterior fissure, into the canal of this cord, to the walls of which it adhered. When it was removed from the interior of this canal, a soft and flocculent mass remained adherent to its internal surface.

The spinal marrow (Pl. V. *fig.* 1) was two

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[1] This has been more appropriately termed the commutual regions. (T.)

inches five lines in length ; the point of its greatest breadth was where it opened to form the fourth ventricle ; here its transverse diameter was two lines and a half. Immediately next to this point it was slightly contracted, and soon after progressively enlarged to the breadth of one line and a third, from which part arose the nerves forming the brachial plexus. The portion corresponding to the pectoral region was very narrow, its breadth not exceeding a quarter of a line. The spinal marrow increased afterwards considerably in size in the lumbar vertebræ, where it was one line and a third in breadth ; it terminated in the sacrum by a delicate filament. The spinal nerves arose on either side by anterior and posterior roots. The posterior surface presented, as usual, a longitudinal fissure, into which the pia mater penetrated. On introducing a small tube into the calamus scriptorius, I succeeded in inflating the centre of this canal, which now presented dilatations in those points where I had previously said the spinal marrow was enlarged. As to the spinal marrow itself, it was composed of two large cords, evidently fibrous, whose limits on the anterior surface were marked by a slight longitudinal groove, through which passed one of the spinal arteries. On either side of these two cords rose the plates, reflected backwards and inwards, which formed the walls of the canal, and from which I succeeded in detaching two very thin bands of longitudinal fibres.

The spinal marrow, enlarging at its superior part, opened backwards, that is to say, its borders mutually separating, formed the beak of the calamus scriptorius, and, opening still more, produced the calamus itself, or the vast fourth ventricle, on the borders of which I observed a small swelling (Pl. VI. *fig.* 1), corresponding to the grey stripe (tœnia grisea) of the Wenzells. At its anterior surface, the spinal marrow formed a curve, in front of which were situated the corpora pyramidalia. Each of the two masses into which it divided after having formed what is termed the medulla oblongata, separated into three pair of fasciculi, the pyramidal, olivary, and restiform. The fibres of the two pyramidal fasciculi evidently crossed before their isolation, and extending forwards, traversing the pons varolii, formed the crura cerebri. The broad olivary fasciculi, situated on either side of the preceding, were smooth and superficial, as the olivary eminences had not yet appeared on their surface; they extended in the same manner across the pons varolii, and, applied to the sides of the pyramidal fasciculi, contributed with them to the formation of the crura cerebri. The restiform fasciculi, situated altogether on the outer side, and marking the borders of the fourth ventricle, proceeded downwards and backwards to form the cerebellum. The cerebellum, more extensive in the transverse direction than elsewhere (Pl. V. *fig.* 1; *fig.* 2, d, d), was a little depressed from above downwards, and evidently narrower on the mesial line than on the lateral parts; it was seven lines in the transverse diameter; in its antero-posterior one two lines in the middle, and two lines and a half on the sides. The fœtus which I now describe was the first which presented evident traces of the division of the cerebellum into a central part or vermiform process, and into lateral parts or hemispheres. The anterior semilunar notch embraced the posterior part of the tubercula quadrigemina; the posterior was yet but little marked. On the external and convex surface, I observed four transverse grooves, the depth of which was more considerable at the exterior of the vermiform process than elsewhere, but diminishing gradually on the hemispheres. These four grooves divided the cerebellum into five lobes, perfectly distinguishable in a perpendicular section of the organ (Pl. VI. *fig.* 1, g). The five stems destined to the five lobes corresponded to those described and represented by Reil; that is to say, the first vertical stem, the smallest of all, formed the central lobe, the second vertical stem, the superior lobe, and the three horizontal stems, the inferior, small, and digastric lobes.[1] None of these stems as yet bore branches or ramifications, so that I could not perceive the leaves on the exterior of the organ. The inferior surface of the cerebellum presented a concavity looking toward the stems, and covered the fourth ventricle as a vault or cupola. Its lateral parts or hemispheres, in which were buried the corpora restiformia, were remarkably swelled, and con-

[1] For a more particular description of these several lobes see Mayo's translation of Professor Reil's inquiries into the structure of the human cerebellum. Archiven für die Physiologie, achter band. p. 1—58. (T.) Also, the Edinburgh Medical and Surgical Journal, 1824, p. 123, and following.

tained each a ciliary body, or great medullary nucleus, as Reil has termed it. The commissures of the cerebellum were perfectly evident. The fibres situated on the side of the corpora restiformia, and which wound round the spinal marrow, in front of which they united, formed the pons varolii, being about two lines in its longitudinal diameter. From the small anterior stem of the cerebellum, proceeded the plate, which this organ sends to the tubercula quadrigemina, and which forms the valve of Vieussens, extended over the anterior prolongation of the fourth ventricle. The tonsils,[1] the flocks,[2] and valve of Tarin did not yet exist; the flocks and posterior valve being formed, as we shall hereafter see, by the posterior border of the cerebellum, reflected inwards.

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[1] Termed the almond-like lobules by Mayo; the spinal lobule of Dr. Gordon.—See their works.

[2] The flocks are a pair of additional processes found in the human cerebellum, and not in that of animals, which emerge obliquely from between the almond-like processes, the medulla oblongata, and the peduncles of the annular protuberance, and are connected by the posterior medullary velum.—Mayo's Physiological and Anatomical Commentaries, part I. p. 25. (T.)

The two hemispheres of the brain (Pl. V. *fig.* 1), were smooth, without convolutions or anfractuosities on their superior surface; they were one inch three lines in length, and one inch in breadth. Although extended considerably backwards, they did not altogether cover the mass of the tubercula quadrigemina (Pl. V. *fig.* 1, c, c), which I still perceived in front of the cerebellum, between this organ and the posterior part of the hemispheres.

On separating the superior surface of the hemispheres from one another (Pl. V. *fig.* 2, f, f, f, f), I perceived on their internal or commutual region many deep grooves and commencing convolutions (i, i), as also the two masses of the tubercula quadrigemina, parted by a longitudinal and superficial groove (e, e). These latter masses were convex and smooth, and presented no traces of the four eminences which were subsequently to be developed; they were four lines in length, and three in breadth. I also perceived the two optic chambers, smooth, convex, three lines and a half in length (k, k), and from their anterior internal side arose the pedicles of the pineal gland (l, l), which proceeding backwards, united with the small round body constituting the gland itself (m). Beneath this latter was the posterior commissure, uniting the optic chambers together, between which was the space termed the third ventricle, and anterior to it was the entry into the infundibulum. It merely required the separation of the hemispheres to perceive all these parts, for the corpus callosum and fornix had not yet covered them.

The two hemispheres of the brain were united in front by a commissure, evidently the corpus callosum (q), now very narrow; beneath and in front of which ascended the two anterior pillars of the fornix (p, p), rising from the corpora mammillaria. In front of these I observed the commissure which united the corpora striata, usually termed the anterior commissure of the brain (r). These two pillars sent upwards and forwards two thin plates, which gaining the inferior surface of the corpus callosum, gave origin to the septum lucidum. The third ventricle communicated with the interval comprised between these two plates, termed the ventricle of the septum, by a small triangular space situated in front, between the anterior pillars of the fornix, and above the anterior commissure. The pillars themselves were united not only together, but also with the postero-inferior part of the corpus callosum, and separating again, and proceeding backwards, winding round the optic chambers, were lost in the depth of the cerebral mass. These latter parts (t, t) were undoubtedly the posterior pillars of the fornix; and their inferior border, thin and turned towards the optic chambers, constituted the corpus fimbriatum, between which and the optic chambers the pia mater penetrated into the lateral ventricle, to form the choroid plexus. The internal wall of the hemispheres, in apposition with the posterior pillars of the fornix, was hollowed by a deep depression (s), inclining backwards in the direction of the pillars, and corresponding to a fold or eminence in the interior of each lateral ventricle, which contributed with the posterior pillars to form the cornua ammonis. The pia mater dipped into the two depressions corresponding to these folds.

On cutting circularly with a pair of scissors the internal wall of the membranous hemispheres, and removing it, the vast cavity of the lateral ventricles was exposed (g), as also the corpora striata which are rolled round the crura cerebri (h); the walls of the hemispheres were still very thin, as their section demonstrated. The eminence analogous to the corpus striatum, was situated in front and on the side, near the optic chamber, with which its superior surface was not yet united by means of the fibrous or horny band (tœnia semicircularis). Between these two protuberances existed a deep fissure, which marked superiorly their respective limits, and occupied the situation where the tœnia was subsequently to exist. The corpus striatum rested on the crus cerebri, which, issuing from the optic chamber, and expanding its fibres like a fan, in front and on the sides, wound round and enveloped it; its anterior part, the broadest, dipped into the anterior cornu of the lateral ventricle; the posterior, on the contrary, the narrowest, passed into the posterior cornu. When this body was elevated, the radiating fibres of the crus cerebri were exposed, expanding outwards and on the side in the wall of the hemispheres, and were reflected inwards, as I have already said, and formed the roof of the lateral ventricle. Anteriorly, the fibres of the two hemispheres united together, forming the corpus callosum. On opening the ventricle we can evidently perceive the radiation of the fibres of the crus cerebri, (Pl. V. *fig.* 2, g); in fact, we expose the slight prominences and depressions on the side of the corpus striatum, which proceeding upwards, separate from one another. The radiation becomes still more apparent, when by means of a blunt scalpel we remove a thin layer of unfibrous substance from the internal surface of the hemispheres.

All the depressions on the internal or commutual region of the hemispheres (Pl. V. *fig.* 2, i, i, s), form so many prominences in the interior of the lateral ventricles.

A perpendicular section, directly through the middle of the brain, enables us to examine without difficulty certain portions of this organ: I shall here describe the objects thus brought into view. The spinal marrow having become more voluminous in its superior portion (Pl. VI. *fig.* 1, a), contained a canal continuous with the fourth ventricle. Where its two principal cords separate to pass aside and form the crura cerebri (b), there appeared in front a small body (c), analogous to the grey band of the Wenzells. The spinal marrow described a curve forwards (d); the corpus pyramidale made a slight prominence, and traversed, augmenting a little in volume, the pons varolii (e), to gain the optic chamber, in the form of the crus cerebri (f). The cerebellum (g), which covered the fourth ventricle (h), from behind forwards, presented five stems, the anterior of which gave origin to the great cerebral valve, or valve of Vieussens, which united with the tubercula quadrigemina (k). The fourth ventricle (h) was continuous anteriorly with the great cavity of the tubercula quadrigemina (i), which latter (k), resting on the crura cerebri (f), formed a cavity with thin walls. More anteriorly still was the optic chamber (l), very voluminous. The fourth ventricle communicated with the third, which penetrated downwards into the pituitary gland (p), and even a little also into the corpora mammillaria (q). In front of the optic chamber ascended the anterior pillar of the fornix (w, r), which uniting with the inferior part of the corpus callosum (m), and taking the name of the posterior pillar (s, t), passed backwards round the optic chamber, and went to form the cornu ammonis. The third ventricle (r) passed anteriorly under the corpus callosum, and thus formed the ventricle of the septum lucidum, at this period very small. The anterior commissure of the brain (o) was placed in front of the anterior pillar of the fornix, and above it appeared the corpus callosum (n, n), uniting the two hemispheres together at their anterior part. The commutual region of these latter presented a number of grooves, or depressions (v, v, v, v, v), to which corresponded as many folds in the interior of the lateral ventricle.

From the infero-anterior part of the hemisphere arose the olfactory nerve, hollow, its cavity communicating with the anterior cornu of the lateral ventricle (w).

The two optic nerves evidently arose from the unfibrous substance which formed a part of the surface of the tubercula quadrigemina and optic chambers; the corpora geniculata were not yet in existence. The two optic nerves, proceeding downwards, and winding round the crura cerebri, were united in front. I can say nothing of their crossing.[1]

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[1] On this so disputed point, M. Serres observes, "J'ai vu manifestement les fibres internes former un angle avec les externes au point de la jonction des deux nerfs; j'ai suivi les fibres de droite jusque sur le nerf gauche; celles

I have found a similar state of parts in the brain of a fœtus a little older.

SIXTH MONTH.*

I shall here describe the brain of a fœtus from twenty-one to twenty-two weeks old, which I had preserved for a year in spirits.

The dura mater was of considerable thickness, and very dense; it adhered to the internal surface of the bones of the cranium by small vascular ramifications; its tissue, composed of fibres

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de gauche jusque sur le nerf droit; en passant d'un côté à l'autre, les fibres formaient un plexus aréolaire, ce qui rendait le chiasme assez semblable au ganglion des nerfs trijumeaux avant leur division; plus tard, sur des embryons plus âgés, les aréoles vides qui séparaient les faisceaux, ont été comblées par la déposition de la matière blanche; alors la décussation était beaucoup plus obscure, dans les cas où je l'ai le mieux observée, je n'ai pu suivre l'entrecroisement que sur deux ou trois faisceaux tout au plus. —Anatomie Comparée, p. 328.—Pathological facts and physiological experiments are much in favour of their crossing. (T.)

* Plate VI. fig. 2, 3. Plate VII. fig. 1, 2. Pl. VIII. fig. 1, 3.

of a greyish white colour, crossed in many directions. Besides the great falciform process and tentorium, I also observed the lesser falx, in the form of a slight prominence corresponding to the posterior notch of the cerebellum. The arachnoid, extremely delicate, formed a thin and transparent pellicle on the surface of the pia mater. This latter was thick and traversed by numerous vessels, and covered exteriorly all parts of the brain and spinal marrow, and dipped also backwards into the canal of this cord, as well as into the third, fourth, and lateral ventricles. It adhered to the cerebral substance by means of vessels which came off from its internal surface.

The spinal marrow, formed in the manner already described, terminated by a filament extending as far as the os sacrum, and on the sides of which I perceived the spinal nerves descending to form the caudiform expansion. It was three inches five lines in length, from the fourth ventricle to the filament now mentioned. The breadth of the enlargement in the inferior cervical vertebræ was one line and a half, and that of its second enlargement in the inferior dorsal and superior lumbar one line and three-fourths.

It was three lines broad at its superior portion, where it formed the three fasciculi, the pyramidal, olivary, and restiform. At this same point, it bent slightly forwards (Pl. VI. *fig.* 3, b), and in front of it became gradually broader, constituting the medulla oblongata. On examining each of these two principal cords, I observed the three fasciculi, already mentioned, which the direction of their fibres perfectly indicated, not only on the outside, but also within.

The pyramidal fasciculi (c, c), detached before the inflection of the spinal marrow, crossed at their internal edge, and proceeded forwards towards the pons varolii, which they traversed, to gain the crura cerebri. Their longitudinal fibres were covered by the transverse fibres of the pons varolii, in many points of the interior of which, the union of the two orders of fibres was very distinct.

The olivary fasciculi (d, d), were broad, smooth, and but slightly convex, for the corpora olivaria had not yet appeared on their surface; their fibres did not cross at the point of curvature of the spinal marrow. They also proceeded forwards towards the pons varolii, which they traversed, being afterwards in apposition with the superior external part of the pyramidal fasciculi, and contributing with them to the formation of the crura cerebri. From these fasciculi some fibres arose which penetrated the walls of the common mass of the tubercula quadrigemina; some united to those of the opposite side, in the roof of this mass, while others proceeded forwards to gain the optic chambers.

The restiform fasciculi, proceeding forwards, passed backwards into the cerebellum, where they united with the fibres going from this latter to the pons varolii.

On viewing the brain from above downwards, I observed the two hemispheres, voluminous, smooth, and without convolutions or anfractuosities (Pl. VI. *fig.* 2, d, d, d, d). They covered not only the tubercula quadrigemina, but nearly the entire of the cerebellum, for I could only perceive a small portion of the superior surface of this organ, behind and between the posterior lobes. Taken together, they were one inch six lines and a half in length; one inch in breadth before, and one inch three lines behind. Their internal surfaces or commutual region were covered with deep depressions, and I already perceived here the commencing convolutions (Pl. VII. *fig.* 2, y, y, y, y).

On the inferior surface of the brain (Pl. VI. *fig.* 3), I observed the pons varolii (e, e); it was broad, prominent, and marked, on the middle line, with a longitudinal groove to lodge the basilar artery. It was two lines and a half in length, and evidently formed of transverse fibres, uniting beneath the two hemispheres. On either side of this protuberance and of the medulla oblongata, I perceived the inferior surface of the two hemispheres of the cerebellum (g, g), grooved in the transverse direction; and I also observed an oblong fissure penetrating on either side into the cavity of the cerebellum and into the fourth ventricle (f, f), and by which the pia mater passed to form the choroid plexus of this cavity. In front of the pons varolii were the crura cerebri, slightly separated from one another; and anterior to and between them was a voluminous mass representing the mammillary eminences, at this period confounded together. At their anterior part I perceived the pituitary gland, in the form of a pyramid or cone, and in front of which was situated the optic nerves. The anterior lobes of the brain, both of considerable size, were separated from the middle by the fissure of Sylvius, which was of considerable depth, and ascended a little laterally. This fissure lodged, on either side, the middle artery of the brain, being the continuation of the trunk of the internal carotid, and remarkable for its size. I then perceived the olfactory nerve, which, after proceeding inwards, terminated by a swelled portion. The middle lobes formed a well marked rounded prominence; a small groove or slight depression separated them from the posterior, which were of considerable dimensions, and which covered the superior surface of the cerebellum.

Having cautiously separated the two hemispheres of the brain, I perceived the corpus callosum or great cerebral commissure (Pl. VII. *fig.* 1, g), which united them together, preventing their total separation without rupture. This body was three lines and two-thirds in length, and one line and a fourth in breadth, and extended so little backwards as not yet to entirely cover the optic chambers and third ventricle. It is then evident that the great cerebral commissure is formed from before backwards, according as the hemispheres are developed and extend in this same direction.

Independently of the corpus callosum, I could also distinguish the cerebellum (c), the common mass of the tubercula quadrigemina (d, d), the optic chambers (e), and the pineal gland, together with its pedicles, (f).

The cerebellum, nearly covered by the posterior lobes of the brain (Pl. VI. *fig.* 2, c; Pl. VII. *fig.* 1, c), was a little flattened from above downwards; its middle part or vermiform process was slightly sunk; the posterior notch existed, though but slightly marked. The entire organ was eight lines in breadth; its antero-posterior diameter two lines and a half over the vermiform process, and three lines over the hemispheres. On its superior surface I observed numerous deep transverse grooves; for not only the lobes already existed, but branches were developed on the stems, as appeared evident by the perpendicular section (Pl. VII. *fig.* 2, f). The cavity of the cerebellum was diminished in capacity, and the posterior border was reflected inwards. The superior peduncle or ascending portion of the crus cerebelli, the great cerebral valve, and the anterior peduncle destined to form the pons varolii, had far advanced in developement. I already perceived in the hemispheres the ciliary bodies (corpora dentata) or great medullary nuclei of Reil.

The fourth ventricle, situated above the spinal marrow and under the cerebellum (Pl. VII. *fig.* 2, d), communicated with the canal of the former, by means of the beak of the calamus scriptorius; anteriorly it was continuous with the third ventricle by the aqueduct of Sylvius, which was covered by the great cerebral valve, or valve of Vieussens. I could not perceive in the floor of the fourth ventricle the whitish striæ represented by some anatomists as the roots of the auditory nerves; but I saw very distinctly, on either side, the grey bands of the Wenzells (e).

The common mass of the tubercula quadrigemina, completely covered by the posterior lobes of the brain (Pl. VII. *fig.* 1, d, d), was convex and smooth on the superior surface; a slight longitudinal groove, traced on the middle line, divided it into two parts. It was four lines in length, and three in breadth, and rested principally on the middle or olivary fasciculi of the spinal marrow, from which it received some ascending fibres, which bending inwards, united to those of the opposite side; these fibres had much augmented in volume, as demonstrated by the perpendicular section of the brain (Pl. VII. *fig.* 2, l). The thickness of its parietes in front was one line and two-thirds. Behind, it gradually united to and was lost on the valve of Vieussens. The increase in thickness of its walls, had contracted remarkably the cavity which it contained (k).

The optic chambers (Pl. VII. *fig.* 1, e), convex and smooth on their superior surface, were three lines and two-thirds in length, and each three lines in breadth. They rested on the crura cerebri, proceeding forwards and laterally (Pl. VII. *fig.* 2, i, o), or rather they were enlargements of these crura. A commissure united them on the posterior internal side; but their middle commissure did not yet exist. From their superior internal border arose the pedicles of the pineal gland, which, uniting behind, gave origin to this small rounded body (f).

The optic nerves wound round the crura cerebri from before backwards and from below upwards. I succeeded in tracing them to the external surface of the tubercula quadrigemina and optic chambers, where they formed a small eminence, the corpus geniculatum, which I detached, with the nerve itself, in the form of a layer free from all fibrous appearance, from the external surface both of the tubercula quadrigemina, and of the optic chambers.

On making a horizontal incision into the left hemisphere of the brain, in order to expose the lateral ventricle and the parts which it contained, I found the walls of this cavity (Pl. VII. *fig.* 1, h, h, h) considerably augmented in thickness, particularly the external, for the internal was thinner by one half. The ventricle, still very spacious, was of an oblong form, and considerably elevated above the surface of the corpus callosum ; I observed here the anterior cornu extending into the anterior lobe of the brain (o), the inferior cornu descending into the thickness of the middle lobe (p), and the digital cavity passing into that of the posterior lobe (q). The ventricle was completely filled by a voluminous choroid plexus ; and on its floor I observed the great cornu ammonis (k, k) descending from before backwards, and from within outwards, into the middle cornu of the ventricles, as also its band, or corpus fimbriatum (i). The hippocampus minor (e) extended backwards into the posterior cornu. These two eminences, the first of which was the continuation of the posterior pillar of the fornix, gave origin to a fold of cerebral substance forming a prominence in the ventricle, the existence of which could not be doubted on examining the external surface of these different parts (Pl. VIII. *fig.* 1). To the posterior pillar of the fornix (d, d), and to its band (corpus fimbriatum) (c, c), corresponded on the outer side a deep excavation (e, e), on the posterior part of which appeared another depression (f). The portions of the brain reflected inwards to form these two cavities, were those which produced the eminences on the surface of the lateral ventricles; folds of the pia mater dipped into these two excavations.

On the anterior external side of the lateral ventricle I observed a large rounded protuberance winding round the crus cerebri, at its exit from the optic chamber. This protuberance (Pl. VII. *fig.* 1, n) represented the corpus striatum; its breadth was three lines and two-thirds in front, and only one line and a half behind; in its longitudinal diameter it measured seven lines. Between it and the optic chamber appeared a slight groove; consequently the tœnia semicircularis did not yet exist.

Having made an incision into the posterior part of the corpus striatum, and detaching it from the crus cerebri situated beneath it, turning it inwards (Pl. VIII. *fig.* 2), I perceived very distinctly the fibres of the crus, which expanded in the hemispheres of the brain. The crus cerebri, having issued laterally from the optic chambers (e), immediately spread its radiating fibres forwards, outwards, and backwards (h, h, h). Some (f, f) proceeded downwards into the corpus striatum (g, g), the superior surface of which was formed of a layer of unfibrous substance. The fibres radiating in the hemispheres proceeded first upwards, then bending inwards, formed in this manner the roof of the lateral ventricles, as also the superior surface of the hemispheres. Descended afterwards along the internal surface or commutual region of these latter, the anterior and middle, uniting with those of the opposite hemisphere, gave origin to the corpus callosum; while the posterior were confounded with the posterior pillar of the fornix, and formed the hippocampus major. The radiation of the fibres of the crura in front, laterally, and behind; their direction from without inwards, and the course which they pursue afterwards from above downwards, to form the corpus callosum, as also the cornu ammonis, explain the manner in which the lateral ventricle is formed. Into this we cannot penetrate, except by the opening situated under the fornix and tœnia semicircularis, and which gives a passage to the choroid plexus. But these fibres do not expand solely in the direction mentioned: they also radiate towards the periphery,—that is to say, that from their surface other fibres proceed outwards. I have perceived these latter very distinctly in a vertical section of the walls of the hemispheres (i, i, i, k, k, l, l). That these radiate directly from within outwards is evident, while those of the internal surface (h, h, h) proceed on the contrary from above downwards. There is consequently a double radiation of fibres in each hemisphere.

We have seen hitherto how the hemispheres, at first thin and membranous, each month augment gradually in thickness. The following is the manner in which this effect is produced, according to my opinion. The vessels of the pia mater which envelope the cerebral substance, and which will, without doubt, be generally considered as the creative and nutritive organ, separate from the blood which they convey to the brain by the many ramifications from the internal surface of the membrane, the new cerebral pulp or mass which gives origin to it. This pulp, disposed in layers from within outwards, crystalizes (if I may use the expression) in the form of fibres which are applied on the surface of those previously formed. The increase of the pia mater, and the successive depositions of new layers upon the old, produce a greater thickness in the walls of the hemisphere. The examination of the cerebral substance furnishes proofs in support of the opinion which I offer. When we detach the pia mater from the brain (Pl. VIII. *fig.* 2, b, b), layers more or less thick of the cerebral pulp (d) always remain adherent to its internal surface, evidently showing that the exterior soft substance, the later deposition, adheres still to the vessels arising from the internal surface of the hemispheres. The layer of cerebral substance adherent to the detached portions of the pia mater, and the superior layer of the brain divested of this covering (a, a), are both equally soft and free from all fibrous appearance. Examined by the microscope, they appear formed of very small globules. If we tear the brain (e, e), we see evidently the fibres, on which we can perceive a layer of soft unfibrous substance deposited (f, f), which being the last deposition, had not had time to assume the form of fibres. It might be asserted that it corresponds to the cortical substance; but this objection is not valid, as the latter substance is not deposited till after birth on the surface of the brain.

I proceed now to the description of the fornix. The fourth ventricle (Pl. VII. *fig.* 2, d), was continuous in front, by means of the passage under the valve of Vieussens (m), with the cavity of the common mass of the tubercula quadrigemina (k), which had become somewhat narrower; this latter communicated equally with the third ventricle (n, p, s), which, situated between the optic chambers (o), was extended downwards to the pituitary gland (q), and corpora mammillaria. From these latter arose the anterior pillars of the fornix (s), which bent backwards beneath the corpus callosum and in front of the optic chambers. Anterior to these I perceived the anterior commissure (z) uniting the two corpora striata together. As each pillar of the fornix passed upwards beneath the corpus callosum, it sent off to the inferior surface of this latter (t), a very thin plate, constituting the septum lucidum. An opening situated between the anterior pillars of the fornix formed the communication between the third ventricle and the space comprised between the two plates; which space formed the ventricle of the septum. The corpus callosum and septum lucidum were much better developed in this fœtus than in that previously described, because the brain had been more voluminous, and extended farther backwards. The anterior pillars of the fornix, composed of longitudinal fibres, bent backwards round the optic chambers, and passed on to gain the cornua ammonis, in forming the corpora fimbriata and posterior pillars.

SEVENTH MONTH.*

I shall now describe the brain of a fœtus of twenty-seven weeks, which had been preserved for a considerable time in spirits.

The spinal marrow, provided with the anterior and posterior grooves, was but one line in

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* Pl. IX. fig. 1, 2; Pl. X. fig. 1, 2; Pl. XI., Pl. XII., Pl. XIII. fig. 1.

breadth in its middle part, where it was narrower than elsewhere. At the origin of the lumbar nerves, remarkable for their considerable size, it was double the breadth; the same was observable at the origin of the brachial nerves. The spinal marrow terminated inferiorly in a point which extended as far as the last lumbar vertebra; the nerves representing the cauda equinæ were rather large. The canal of the spinal marrow was diminished in capacity, and its walls were lined with a thin layer of unfibrous substance, which remained adherent in patches to the folds of the pia mater destined to cover this canal, when this membrane was removed. The spinal marrow, composed of longitudinal fibres, bent a little forwards (Pl. IX. *fig.* 1, f), before arriving at the point where it takes the name of medulla oblongata; in this place it was one line and two-thirds in breadth. Anteriorly still it became much broader and thicker, and represented the medulla oblongata, on the surface of which were distinguishable the corpora pyramidalia (Pl. IX. *fig.* 1, c), olivaria (d), and restiformia (e). The transverse diameter of the medulla oblongata was four lines and a half at its superior part, where it also presented its greatest breadth. The pyramids formed a very distinct eminence; each three lines long and one broad; the pyramidal fasciculi crossed before forming these two eminences. Their fibres, which went to gain the crura cerebri, after having traversed the pons varolii, were covered by the transverse fibres of this protuberance, and evidently decussated with them at many points. The olivary fasciculi supported each an olivary body of an oval form, about two lines in length, and one in breadth, and composed of unfibrous pulp deposited on the surface of the medullary fibres, which passed forwards to gain the common mass of the tubercula quadrigemina. The external fasciculi of the spinal marrow, or corpora restiformia, passed into the cerebellum.

The cerebellum was completely covered by the hemispheres of the brain, which formed a considerable prominence backwards. Its transverse diameter was nine lines and a half, and the longitudinal diameter of each of its hemispheres four lines and two-thirds. The anterior semicircular notch embraced the common mass of the tubercula quadrigemina; the posterior was yet very indistinct. The superior surface of the organ was covered in its whole extent with numerous transverse grooves; some penetrating to a certain depth, formed the lobes, while others, less deep, only gave origin to ramifications. The lobes, so well described by Reil, were completely separated by broad and deep grooves. I observed in front the central lobe of Reil (d), representing the anterior notch; behind it were the four-sided, or superior anterior lobes (e, e), followed by the superior posterior (f, f). I also distinguished the posterior inferior lobes (Pl. IX. *fig.* 2, f, f), the slender, and the digastric lobes (g, g). The inferior vermiform process was not yet sunk, evidently depending on the hemispheres of the brain not having yet taken, with relation to this process, such a developement as they were subsequently to acquire. However, I could already distinguish on this eminence the parts mentioned by Reil, that is to say, the knot or nodule, the spigot (l), the pyramid (k), and the short cross-bands;[1] though these parts

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[1] For a more particular description of these parts, see Mayo's Anatomical and Physiological Commentaries, Part I. p. 24, &c.—Reil's Essay on the Structure of the Cerebellum. (T.)

were found still on the same level with the lobes. The cavity of the cerebellum continued of considerable capacity. The posterior border of the organ, reflected inwards on the side of this cavity (h, h), represented the posterior valve, prolonged on either side into a thin and flattened production. No doubt these two appendages (i, i), (Pl. IX. *fig.* 1, g, h; Pl. X. *fig.* 1, g), were the parts termed by Reil the flocks.

The corpora restiformia, arising laterally from the spinal marrow, formed, in the interior of each hemisphere of the cerebellum, an oval swelling constituting the ciliary body (corpus dentatum) or the great medullary nucleus of Reil, from which some fibres radiated into the stems and ramifications. From the same point other fibres were detached, which, passing outwards and forwards, surrounded the olivary and pyramidal fasciculi of the spinal marrow, and united together to form the pons varolii. This protuberance (Pl. X. *fig.* 2) formed a considerable prominence; it was three lines in length, and four lines three-fourths in breadth. On its middle portion existed a longitudinal depression, destined to receive the trunk of the basilar artery. Some other fibres, coming from the ciliary body, proceeded forwards, and penetrated into the common mass of the tubercula quadrigemina; they formed there what is termed the superior peduncle, or ascending portion of the crus cerebelli. A medullary membrane extended between these two latter fasciculi, represented the valve of Vieussens.

By a perpendicular section of the cerebellum through its middle portion (Pl. XII.), I perceived its stems and ramifications radiating from the centre to the circumference, and corresponding to the different lobes. In front I observed the great cerebral valve, divided into two, and proceeding towards the common mass of the tubercula quadrigemina (g). I then perceived the vertical stem (h, i), which rose into the central lobe, as also into the four-sided or anterior superior lobe; afterwards the great horrizontal stem (k, l, m), belonging to the posterior superior lobe, to the posterior inferior, to the slender and biventral lobes, and to the different parts of the inferior vermiform process. The stems, branches, and ramifications evidently existed in the cerebellum, but there were yet no leaflets, a production altogether exterior, and of a later date. Of such we can easily be convinced in comparing the figure which I have given with that published by Reil.[1] It consequently results that the developement of the cerebellum takes place from within outwards; a conclusion against which we cannot raise a single doubt, when we examine the plates in which I have represented some vertical sections of this organ in fœtuses of three, four, five, six, and seven months of uterine life.

The fourth ventricle (Pl. X. *fig.* 2, d), situated between the two principal cords of the spinal marrow, which, separating, had passed aside, according as they advanced forwards, enlarged at its anterior portion, and was continuous with the aqueduct of Sylvius. On its floor I perceived the grey bands of the Wenzells, composed of a substance of an unfibrous texture; it lodged besides a choroid plexus, which sent some prolongations to the internal surface, both of the spinal marrow and of the cerebellum.

The brain was considerably augmented in

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[1] Archii für die Physiologie, tom. viii. pl. iii. fig. 1.

volume, in proportion to the spinal marrow and cerebellum; it not only covered the tubercula quadrigemina and cerebellum, but also extended much beyond this latter; it was one inch ten lines and three-fourths in length, one inch two lines in breadth before, and one inch five lines and two-thirds behind. On its superior and convex surface (Pl. X. *fig.* 1, e, e), I perceived here and there some slight excavations (f, f), the rudiments of the convolutions and anfractuosities, and into which folds of the pia mater penetrated. On either side, I observed the fissure of Sylvius, very deep, ascending high up, and bending backwards (Pl. X. *fig.* 1, m, m); it lodged some branches of the middle artery of the brain, which sent into the cerebral substance numerous ramifications, destined to nourish the corpora striata, situated here on the inner side. The olfactory nerve (n) descended from this fissure. I also observed in this part very many depressions, probably rudiments of anfractuosities (o, o, o).

On the inferior surface of the brain, I found the crura cerebri issuing from the pons varolii, and formed of longitudinal fibres (Pl. IX. *fig.* 1, k, k). In front of these crura arose the corpora mammillaria (l, l), anterior to which I perceived the pituitary gland (m). The anterior lobes of the brain (y, y) presented many well marked furrows (t, t, t, t). The olfactory nerves, very large, and coming from the fissure of Sylvius (r, r), proceeded fowards, and terminated by an oval swelling (s). The middle lobes formed (p, p) a considerable rounded prominence, with but one small depression. The posterior lobes (o, o) covered the cerebellum, beyond which they were prolonged; they formed a sort of depression, in which this organ was lodged.

Having cautiously separated the two hemispheres, the corpus callosum (Pl. IX. *fig*. 2, d) was exposed; it was nine lines and a half long, and extended backwards as far as the optic chambers. I easily perceived that it was composed of transverse fibres, penetrating into the hemispheres, and uniting them together. The two anterior or cerebral arteries proceeding upwards between the anterior lobes, wound round these bodies, and dipped, together with the pia mater, into the excavations formed on the internal or commutual surface of the hemispheres.

Having removed the superior part of the left hemisphere by a horizontal incision a line above the corpus callosum, I thus exposed the interior of the lateral ventricle. I must here remark, that the greater part of the contour of the medullary substance was still elevated much above the corpus callosum, while in its complete state of developement, it is perfectly on a level with this body. It is evident that this difference is owing to the hemispheres not having yet acquired as great a thickness as at a subsequent period, and also to their continuing to be reflected inwards, towards the corpus callosum, covering thus the lateral ventricle like an arch. The section of the hemisphere presented its greatest thickness near the corpus striatum, constituting the external wall of the lateral ventricle (Pl. IX. *fig.* 3, g, g); this thickness was about four lines and a half. It was but two lines and a half in front and behind (h, h), and but one line and a half in its thinnest portion (i, i). On the entire section I perceived the fibres radiating from below upwards and towards the periphery, which seemed to form from within outwards numerous layers, indicating, without doubt, the manner of their successive superposition.

The lateral ventricle was of considerable breadth in proportion to the thickness of its walls, and its length was one inch six lines and a half. It was completely filled by an enormous choroid plexus, which sent numerous prolongations to the internal surface of the convolutions. The ventricle formed three great cornua; the anterior (m) dipping into the anterior lobe, in the bottom of which it communicated with the cavity of the olfactory nerve; the middle (n), placed in the middle lobe; and the posterior (o), bending backwards into the posterior lobe.

On the side and base of the lateral ventricle I perceived the corpus striatum, a voluminous mass, convex on its superior surface (l), and placed in front and along the optic chamber (r). The cornu ammonis (p), bending backwards and outwards, dipped into the middle cornu of the ventricle; on its anterior border I observed the corpus fimbriatum, taking the same curved direction (q). Beneath this band the pia mater penetrated into the ventricle, to give origin to the choroid plexus. The posterior cornu contained an eminence (s), corresponding to the hippocampus minor.

Having divided the corpus callosum and anterior commissure by a vertical section, and separating the right hemisphere from the left, and removing it with the corpus striatum, I thus exposed the parts covered by the hemispheres. In front of the cerebellum were the tubercula quadrigemina, completely developed, and divided by a slight groove, into anterior (Pl. XI. h, h), and posterior (i, i); the anterior pair were a little more voluminous than the posterior. They were together four lines and a half in length, and as much in breadth in front, but a little narrower behind. Their walls were so augmented in thickness (Pl. XII.) that I could scarcely have supposed them hollow in the beginning. The fourth ventricle (e) was prolonged under the valve of Vieussens (g), and opened into the third, having first contracted to form the aqueduct of Sylvius (f). The tubercula quadrigemina were formed partly by the olivary fasciculi, partly also by the crura cerebelli. The former, at their exit from the pons varolii, ascended obliquely on the lateral parts of the tubercula quadrigemina, in the interior of which they expanded their fibres, which united to those of the opposite side. The latter, the superior peduncles of the cerebellum, penetrated forwards and outwards into the tubercles, and proceeded directly forwards; their fibres were covered on the outer side by the ascending oblique fibres of the olivary fasciculi. These different parts were enveloped, both on the inner and outer side, with unfibrous substance. After having removed with precaution this exterior layer, I perceived the fibres both of the olivary fasciculus and of the superior crus cerebelli, proceeding in the direction already mentioned. Many of these fibres passed forwards into the optic chambers.

On the lateral part of the anterior pair of the tubercula quadrigemina, appeared the corpus geniculatum externum, composed of unfibrous substance, and very vascular. I traced the optic nerve into this body, into the anterior pair of the tubercles, and into the unfibrous substance which formed the superior surface of the optic chambers; it is then from these three portions of the brain that it takes its origin.

Anterior to the tubercula quadrigemina I observed the optic chambers (Pl. XI. n, n, o, o), each four lines and a half long, and three broad in the middle part. Their middle commissure did not exist. From their superior surface arose the pedicles of the pineal gland (m, m), which, proceeding backwards and uniting together, formed the gland itself (l), a small, soft, round, and flattened body, without a trace of sandy matter. Having removed the unfibrous substance which covered the optic chamber exteriorly, I was enabled to distinguish the ascending fibres of the crus cerebri, which were prolonged into the corpus striatum.

In front and on the external side of the optic chambers were the corpora striata (Pl. XI. q, s), eminences of considerable size. A depression similar to a groove formed the line of demarcation between these and the optic chambers, for the tœnia semicircularis was not yet in existence. Each corpus striatum represented a large protuberance, convex above, and embracing the crus cerebri (Pl. XIII. *fig.* 1, i, i, i), which was nine lines in length, and broader before than behind. The fibres of the crura cerebri, after having traversed the optic chambers and corpora striata, radiated in the hemispheres (Pl. XI. t, t). The two orders of radiating fibres were here quite distinct; the one set, proceeding upwards, backwards, and inwards, gave origin to the corpus callosum, in uniting on the middle line to that of the opposite side; the other, spreading out at the periphery, formed a layer over the preceding. Thus, in whatever direction the hemispheres were broken, the fibrous structure was observable. The fibres were covered exteriorly with a layer of soft substance, which adhered to the internal surface of the pia mater, and into which folds of this membrane penetrated.

On examining the inferior surfaces of the crura cerebri and optic chambers, I perceived, on either side, a thin cord or fasciculus of fibres descending from the inferior surface of the optic chambers into the corresponding mammillary eminence. Gall described and represented[1] this cord, termed by Reil the roof of the anterior pillar of the fornix.[2] It forms a turn within the mammillary eminence, ascends afterwards, constituting the anterior pillar of the fornix (Pl. XII. s, s) behind the anterior commissure (t), and uniting to that of the opposite side, gives origin to the fornix. It was composed of longitudinal fibres, proceeding upwards and backwards. From its internal margin arose a thin plate, which, gain-

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[1] Anat. et Physiol. du Système Nerveux.

[2] Archiv für die Physiologie, t. ix. p. 192, pl. ix. y, n, n.

ing the inferior surface of the corpus callosum (z, z) with that of the opposite side, formed the septum lucidum (w, w). The narrow space comprised between these two medullary plates formed the ventricle of the septum, which communicated with the third, between the two anterior pillars of the fornix. The corpus callosum, formed by the union of the fibres of the two hemispheres (Pl. XI. v, v; Pl. XII. z, z), covered the cavity of the septum superiorly.

The cords of the fornix, after winding backwards over the optic chambers, and covering them, mutually separated behind, where they no longer were united together, but by a very thin medullary plate representing the lyre. Then, taking the name of the posterior pillars of the fornix (Pl. XI. x; XII. y; Pl. XIII. *fig.* 1, b), they plunged downwards and outwards into the cerebral substance, and went to form the cornua ammonis (Pl. XIII. *fig.* 1, d), after having united to a narrow fasciculus of longitudinal fibres (Pl. XIII. *fig.* 1, c), which, detached from the anterior pillars of the fornix, before their direction upwards, bent backwards, in front and above the corpus callosum, in order to gain the internal part of the hemispheres. Their anterior internal border, thin and flattened, represented the corpus fimbriatum (Pl. XI. y; Pl. XII. x; Pl. XIII. *fig.* 1, n). The hippocampus major penetrated into the middle lobe, at the bottom of which it terminated by a rounded extremity. On its side, I observed the depression already described (Pl. XIII. *fig.* 1, e), and into which a considerable fold of the pia mater dipped. I should also remark, that the longitudinal fibres of the great hippocampus expanded in the prominent portion of the middle lobe, where they united with those proceeding from the crura cerebri.

The nerves, very voluminous in proportion to the mass of the brain, were very evident. I have represented them in Plate IX. *fig.* 1.

EIGHTH MONTH.*

I now proceed to the description of the brain of a fœtus of thirty-four or thirty-five weeks. As this organ is already completely formed, in respect to the configuration and structure of its

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* Pl. XIII. fig. 2.

interior parts, and as there remain but those of the periphery still to be developed, the other parts being confined nearly to an augmentation in volume, I shall abstain from entering into minute details. Such parts as I shall not mention, differ in no respect in their texture, from what they were in the brain which made the subject of the preceding article.

The spinal marrow presented, as usual, swellings at the origin of the brachial and crural nerves ; these enlargements, both the superior and inferior, were two lines and a half in breadth. The canal of the spinal marrow still existed, but a soft vascular matter deposited on the interior wall, had considerably contracted it. On its surface I observed, first, the corpora pyramidalia, four lines and a half in length, and but one line in breadth ; the medullary fibres crossed at the moment of their exit. Next, the corpora olivaria, one line in breadth, and two lines and a half in length ; and lastly, the lateral fasciculi, which ascended into the cerebellum. The pyramidal fasciculi, prolonged forwards, formed the crura cerebri ; the olivary spread laterally into the tubercula quadrigemina. The pons varolii was four lines in length, and five in breadth.

The cerebellum was complete in respect to its form, but the number of leaflets was not quite so considerable, as in the state of complete developement. As the two hemispheres had augmented much in volume, the commissures or vermiform eminences appeared more sunk; the posterior notch and valve had become deeper and more ample. The transverse diameter of the organ was eleven lines, and its longitudinal one four lines and a half in the middle part, and six lines one-third in the hemispheres. On endeavouring to detach the pia mater from its superior surface, the leaflets, which seemed deposited by layers, remained adherent to this membrane, and the branches of the stems which they concealed were exposed.

The two hemispheres of the brain covered the cerebellum superiorly, and extended backwards considerably beyond it. They were two inches eleven lines in length, two inches one line in breadth, and one inch ten lines deep. On examining their inferior surface, I recognised the anterior and posterior lobes, the middle forming on the outer side a rounded prominence. In front of the crura cerebri, were the corpora mammillaria. The hemispheres were every where traversed with furrows, into which dipped folds of the pia mater; but no where were these furrows and prominences, or convolutions, which they produced, better marked than on the anterior and middle lobes; fewer were observed on the posterior lobes. On detaching the dura mater from the superior surface of the brain and walls of the anfractuosities, a layer of soft substance remained adherent to it; and on endeavouring to remove this substance, by immersion of flaps of the membrane in a liquid, it appeared covered with numerous flocculent prolongations, which were merely delicate vessels, giving it a velvety aspect, and which had penetrated the cerebral substance.

The tubercula quadrigemina were five lines in length, and as many in breadth. The increase of their mass had diminished the aqueduct of Sylvius. Each optic chamber was six lines and a half long, and four lines broad.

I traced the pyramidal fasciculi across the pons varolii, where their longitudinal fibres crossed and mutually united, in many points, with the transverse fibres of the pons varolii. They issued from this protuberance more voluminous than they had entered, and, forming the crura cerebri, passed upwards into the hemispheres of the brain. Having arrived at the external surface of these latter, after having traversed, in the same direction, the optic chambers and corpora striata, they expanded their fibres like a fan, from below upwards, and from before backwards. This radiation became very evident on removing, at the commencement of the fissure of Sylvius, the exterior layer of unfibrous substance, in which the convolutions were hollowed, and scraping this substance upwards with the flat handle of a scalpel (Pl. XIII. *fig.* 2, a, b, b, b). The fibres which rose from the fissure of Sylvius bent inwards over the lateral ventricle, covered this cavity like an arch, and uniting afterwards to those of the opposite side, formed the corpus callosum.

The roots of the anterior pillars of the fornix already described, arising from the inferior part of the optic chambers, descended inwards, to gain the corpora mammillaria, and forming a turn in the interior of the mass which supported these bodies, by this inflection gave origin to the eminences themselves, and afterwards proceeded from behind forwards, to constitute the anterior pillars of the fornix. These latter rose behind the anterior commissure, and formed the fornix itself, stretched like a bridge over the three ventricles and optic chambers. From the superior surface of the fornix were detached the two medullary plates of the septum lucidum, which reaching the inferior surface of the corpus callosum, united with it. I have observed in these plates very delicate fibres arising from the fornix, and radiating upwards. The posterior pillars of the fornix, gradually forming on either side the corpus fimbriatum, and cornu ammonis, plunged outwards into the prominence of the middle lobes.

NINTH MONTH.*

The spinal marrow of a fœtus on the commencement of the ninth month of uterine life, extended nearly to the third lumbar vertebra, where it formed a considerable caudiform expansion. Its middle portion, or that lodged in the dorsal vertebræ, was something more than one line in breadth. At the origin of the crural and

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* Pl. XIV. fig. 2, 3.

brachial nerves, its breadth was three lines; that of the medulla oblongata five lines.

The pia mater, traversed by numerous blood-vessels, enveloped the substance of the spinal marrow, and sent prolongations into its anterior and posterior grooves. Its canal was small and narrow, and its walls supported a thick layer of soft and reddish substance, penetrated by a number of vascular ramifications arising from the posterior fold of the pia mater. This substance was more abundant where nerves arose from the lateral parts of the spinal marrow, as also on a level with its enlargements.

The medulla oblongata formed on either side three principal fasciculi; the pyramidal crossed at their origin (Pl. XIV. *fig.* 1, b), and enlarged afterwards to produce the corpora pyramidalia. Each of these latter was four lines and a half long, and one line and a half broad. The two fasciculi (c, c), composed of longitudinal fibres, passed into the pons varolii (g), with the transverse fibres of which they interlaced (d), and issued more voluminous than when they entered, to give origin to the crura cerebri (e, e, e, e), which then passed upwards into the hemispheres of the brain. The olivary fasciculi, placed on the side of the preceding, formed, before their entry into the pons varolii, the corpora olivaria (*fig.* 1, h, h), the length of which was three lines and a half, and one line and a third in breadth. Their fibres, equally longitudinal, proceeded afterwards (*fig.* 2, f), from below upwards, between the pyramidal fasciculi (c), and corpora restiformia (e), and penetrating the common mass of the tubercula quadrigemina (k), united with those of the opposite side. Some of the more anterior fibres (o) passed into the optic chambers. The corpora restiformia entered the cerebellum, and formed there the medullary nucleus, or rhomboidal body.

The cerebellum was one inch four lines in breadth. Its longitudinal diameter was six lines and a half on the vermiform process, and nine lines on the hemispheres; the posterior notch was extremely large. Its superior and inferior surfaces were traversed by numerous grooves, the deepest of which separated the lobes, others the fasciculi, and the shallowest the leaflets or plates. All the parts mentioned by Reil, in the vermiform process, the short cross-bands, the pyramid, the spigot, and the nodule, or knot, were developed. On either side of the nodule was detached the narrow posterior cerebral valve, proceeding to the flocks. I also evidently perceived the tonsils. The corpora restiformia gave origin to the rhomboid bodies, which were of considerable size. From each of these nuclei (*fig.* 2, k) arose the medullary pillars in the form of stems (m, m, m), which afterwards divided into branches, ramifications, and leaves. From each also came off the middle peduncle, or crus cerebelli, the transverse fibres of which, embracing the olivary and pyramidal fasciculi, formed the pons varolii, by their union with those of the opposite side. This protuberance was five lines and a half long, and six and a half broad. Lastly, the rhomboidal bodies gave also origin to the superior peduncles of the cerebellum ; each of these two peduncles passed forwards into the corresponding half of the common mass of the tubercula quadrigemina, and was covered by the fibres of the olivary fasciculi, proceeding upwards and inwards. Between the two peduncles appeared the thin medullary plate, representing the valve of Vieussens. The brain was three inches four lines long, and two inches seven lines broad. Its two hemispheres covered the cerebellum, beyond which they extended. I observed on all sides deep furrows and numerous convolutions. The Sylvian fissures were of considerable depth, and ascending on either side, separated the anterior lobes from the middle, which were rounded, and formed a protuberance outwards. The posterior lobes covered the cerebellum. The corpora mammillaria and pituitary gland were of considerable size. The corpus callosum, which united together the two hemispheres, was one inch and a half in length, and was composed of transverse medullary fibres.

The tubercula quadrigemina were five inches in length, and six in breadth. On removing the layer of unfibrous substance which formed their surface, I observed the fibres coming from the olivary fasciculi. Beneath these fibres were the superior peduncles of the cerebellum passing forwards into the common mass of the tubercula quadrigemina, and interlacing their fibres with those of the olivary fasciculi. The aqueduct of Sylvius was very narrow.

The optic chambers were nine lines long, and five and a half broad. They were united behind by the posterior commissure, and in front, and on the inner side, by the commissura mollis, which passed from one side to the other. The pedicles of the pineal gland arose from their internal border, and proceeded backwards, where, by their union, they formed the pineal gland, an elongated, flattened, soft body, without a trace of sandy matter.

The corpora striata, fifteen lines in length, no longer formed an eminence so distinctly marked as in the brains previously described, they were more sunk in the external wall of the hemispheres, which had become thicker. Between these and the optic chambers, I perceived, on either side, a soft vascular mass, filling the space which had hitherto existed in this spot, and consequently representing the tœnia semicircularis. Beneath each mass passed a large vessel, in removing which I detached also the tœnia with it.

Having immersed the brain in alcohol for some months, to give it a little greater consistence, I was afterwards enabled to form a clear idea of the progress and distribution of the fibres.

The fibrous peduncles of the brain, the continuation of the pyramidal fasciculi, passed upwards into the optic chambers, which were covered, on their superior surface, by a soft unfibrous vascular mass. They passed afterwards into the corpora striata, to which they sent fibres directly upwards, and were also covered with a similar layer of unfibrous substance. Increased by their successive passage through these two orders of enlargements, they gained the external wall of the hemispheres, where their fibres radiated forwards, upwards, and backwards. On making a horizontal incision in the external surface of the hemisphere, where the fissure of Sylvius passes aside, and by scraping upwards the exterior layer of cerebral substance, together with the convolutions and anfractuosities, this radiation of the fibres became very distinct. I also observed the double radiation of the fibres of the peduncles of the brain, already mentioned. In effect, the one proceeded upwards, forwards, and backwards, and bending inwards, formed the roof of the lateral ventricle; then approaching those of the opposite side, they united together, and formed the corpus callosum, thus composed of transverse fibres. On these fibres, I perceived others applied, which, radiating from the centre to the circumference, passed into the convolutions, and were covered exteriorly by a soft unfibrous mass, into which penetrated the flocculent or velvety vessels, from the internal surface of the pia mater. I perceived this second order of fibres each time that I tore a portion of a brain which had remained some time in alcohol; it matters not whether the rupture be longitudinal or transverse.

The lateral ventricles and their cornua had a greater capacity than in the brains already described, but still were narrow in proportion to the increased thickness of their walls.

From the inferior part of each optic chamber came off a very thin fibrous cord (*fig.* 1, m), which descending into the corresponding corpus mammillare, was there reflected, so as to take a new direction from behind forwards (n). This fibrous cord was covered exteriorly by a soft unfibrous substance, forming the mammillary eminence. The fasciculi which issued from the united mass of the two eminences (o), proceeded upwards and forwards, along the anterior commissure, constituting thus the anterior pillars of the fornix, which uniting together, bent backwards over the optic chambers, and formed the fornix itself. The triangular medullary plates which rose from the fornix to gain the inferior surface of the corpus callosum, formed the septum lucidum; and the space between was the ventricle of the septum. The pillars of the fornix mutually separated behind, and the interval between them was filled up by a very thin plate of transverse fibres forming the lyre; the pillars continuing to separate, sunk into the middle lobes, there giving origin to the cornu ammonis and corpus fimbriatum. I observed on the outer side a considerable fold of the pia mater, plunging into the mass of the pes hippocampi. The cornu ammonis no longer represented a simple fold of cerebral substance, as in the brain of the preceding fœtuses; but the unciform eminence still formed a prominent fold in the interior of the posterior cornu of the lateral ventricle.

I have several times dissected brains in a fresh state, either of fœtuses of six, seven, eight, and nine months, or of new-born infants, in order to gain a just idea of the relation which might exist between the different cerebral substances in the different parts of the encephalic organ. The constant result of my researches has been, that it is impossible to establish a destinction between the cortical and medullary substance in the brain of the fœtus. Its component parts are formed of an homogeneous reddish-white substance. This rosy tint arises evidently from the great number of deli cate blood-vessels which are distributed to the cerebral substance. In all those parts in the adult where we find the grey substance accumulated in considerable masses, as in the crura cerebri, where it takes the name of the locus niger, the corpora striata, optic chambers, &c., I have only observed a greater number of vessels, and of a larger size, than in such parts as consist of medullary substance after the period of birth. Hence it arises, that the names applied by anatomists to certain parts of the brain are no longer applicable when we examine them in the fœtus; as, for example, the corpora striata. In truth, the parts which correspond to these eminences, in the brain of the fœtus, are not striated, but composed of an homogeneous mass, of a rosy tint, and traversed by numerous vessels of large calibre. Nor is there any difference with regard to colour between the cortical and medullary substance, either in the convolutions, or in the leaflets of the cerebellum. The exterior layer, corresponding to the cortical substance, is a reddish white, as also the interior layer which corresponds to the medullary substance. The only appreciable difference which can exist in the fœtus, between these two substances, which are so readily distinguished in the adult, consists in the exterior layer being softer, and perhaps a little more abundant in vessels, than the interior portion.

I shall terminate this account with some remarks on the arachnoid. This membrane, so accurately described by Bichat, belongs to the class of serous membranes, and forms, like them, a sac without an opening. It covers the external surface of the pia mater which envelopes the cerebral substance, but it neither accompanies it into the anfractuosities of the brain, nor into the grooves of the cerebellum, over which it passes. Where the nerves arise from the brain, and gain the dura mater to traverse it, the arachnoid sends off prolongations, which envelope them, as the pericardium surrounds the vascular trunks which come off from the heart, and are afterwards reflected on the internal surface of the dura mater as soon as the nerves have pierced this membrane. All the internal surface of the dura mater and its folds, the falciform processes and tentorium, are covered by the arachnoid, from whence they derive their smooth and polished appearance. The mutual adherence of the two membranes is very intimate, and it requires some difficulty to detach flaps of the serous fold. The arachnoid passes by the occipital hole, along the pia mater of the spinal marrow, which it equally envelopes; it invests also the anterior and posterior spinal nerves, and accompanies them until they pierce the dura mater of the spinal canal, the internal surface of which it afterwards lines. The denticulated ligaments (ligamenta denticulata) are simple folds of this membrane, which, from the internal surface of the dura mater, proceed to the external surface of the pia mater. Between the folds of each denticulated ligament, I observed a fibrous filament, extended from the internal surface of the dura mater to the spinal marrow. All these fibrous filaments descend on the lateral parts of the spinal marrow to the surface of the pia mater, between the anterior and posterior roots of the spinal nerves. It consequently follows that the arachnoid constitutes a sac without an opening, which envelopes the brain and spinal marrow, and proceeds along the nervous cords, to the internal surface of the dura mater, which it also lines. This distribution I have frequently found, both in the fœtus and adult.

PART II.

GENERAL CONSIDERATIONS

ON THE

DIFFERENT PARTS OF THE BRAIN,

WITH A

COMPARATIVE VIEW OF THEIR STATE IN MAN AND ANIMALS.

After having described the configuration of the brain and spinal marrow, during the different periods of gestation, I now proceed to trace, with the assistance of general data, the history of the formation of each of the parts, the union of which constitutes the encephalic mass. Such as have perused the preceding pages and examined the plates, will remain convinced that the brain of the fœtus is not, in the beginning, an organ as complex as in the adult; but that, on the contrary, being at first simple, it is gradually developed by the increase and successive complication of those parts previously observed. But as it evidently passes through very many degrees of formation, we may inquire if this latter obeys particular laws, or rather is submitted to the general law of formation of the brain in the animal kingdom. We can only expect to answer these queries by comparing the brain of the fœtus, in its different periods of evolution, with that of animals. Such is the comparison which I shall establish, in examining successively each portion of the encephalic mass, and pointing out the analogies and differences which it presents in animals and in the fœtus. The results of this comparison will resolve the problem, the solution of which interests no less psychology than anatomy and physiology. I need not impress the importance of such a task; for every one must be convinced that the anatomy of the human body, and comparative anatomy, can have but one end, that of observing and describing the organs; but that their principal object consists in deducing from these researches and descriptions, the manner of the formation of the various parts of the body, the laws and rules of their developement.

OF THE SPINAL MARROW AND ITS CANAL, THE MEDULLA OBLONGATA, CORPORA OLIVARIA, AND PYRAMIDALIA.

During the period of the first month, and on the commencement of the second, the spinal marrow is formed of a membranous canal, containing a limpid and transparent fluid. Towards the end of the second month, this fluid is converted into a soft and pultaceous mass, similar to the white of egg. According as the tissue of the spinal marrow acquires consistence, its transparency diminishes. The walls of the canal which contain it are formed both by the dura mater, then thin and free from any fibrous appearance, and by the pia mater, which is traversed by numerous vessels. This latter dips into the pulp at the anterior surface of the canal, thus giving origin to the anterior longitudinal groove of the spinal marrow. It enters also posteriorly, where it forms a great longitudinal fold, constituting the canal of this organ.

If we plunge the embryo into alcohol, the soft and diffluent substance of the spinal marrow coagulates and acquires more consistence. At the end of the second month, and commencement of the third, we cannot yet distinguish any fibres, even by having recourse to previous immersion in spirits ; and on examining the spinal marrow with the microscope, we find it formed of small globules. Not until the commencement of the fourth month, can we distinguish on its anterior surface small parallel fibres, taking a longitudinal direction. Their number afterwards gradually augments, not only at the anterior part, but still on the sides of the two principal cords of the spinal marrow.

The spinal marrow represents a hollow cylinder, the thin walls of which are bent backwards, the posterior part presenting a longitudinal opening ; for it is hollowed by a groove, termed the canal of the spinal marrow. This canal exists through the whole cylinder, and communicates by the calamus scriptorius, with the fourth ventricle, which, rigorously speaking, is but a dilatation of it. During the first periods we can without difficulty separate the thin and flexed walls of the spinal marrow, and thus expose the canal which they contain. This canal is somewhat broader in the points where the spinal marrow sensibly enlarges exteriorly, as at the origin of the nerves for the pectoral and abdominal extremities. The mechanism of its formation is very simple; the pia mater, acquiring more extent, is folded longitudinally backwards, and dips into the substance of the spinal marrow, which, as we have seen, had been previously in a fluid state. It is very evident that, in the commencement of the second, third, and even fourth months, this canal has, in proportion to the thickness of the walls of the spinal marrow, a much greater capacity than it subsequently acquires. The contraction which it undergoes in the progress of developement of the embryo, arises from the pia mater depositing a new substance, the materials of which it derives from the blood sent by the heart, and which augmenting the volume of the walls of the cylinder, ought necessarily to diminish the calibre of the central canal. This substance is soft, reddish, and traversed by numerous small vessels, during the period of the two last months. We cannot then doubt that the cortical substance of the spinal marrow has an origin subsequent to that of the medullary fibrous substance, and that it is applied from within outwards on the surface of this latter. Consequently the opinion of M. Gall, that it is formed prior to the medullary, and is as it were the matrice, is absolutely false with regard to the spinal marrow; for we already perceive the roots of the spinal nerves on the second and third months, although at this period there is no cortical substance yet deposited in its canal.

It is very remarkable that the canal of the spinal marrow exists constantly, and during the entire life of the animal, in fishes, reptiles, and birds. I have met it in a great number of fishes, both of salt and fresh water; such as the ray (Raia), shark (Squalus), breme (Cyprinus brama), band-fish (Cepola), pike (Esox), salmon, carp, &c.; and I have always found its internal surface covered with a layer of grey substance. The observations of M. Arsaky agree perfectly with mine, in this respect.[1]

I have observed the same canal in question, in the hawks-bill tortoise (Testudo imbricata), common tortoise (Testudo græca), a young crocodile of the Nile, wall lizard (Lacerta agilis), ringed snake (Coluber natrix), land salamander (Lacerta

[1] Diss. de piscium cerebro et medulla spinali. Halle. 1813, p. 9.

salamandra), green frog (Rana esculenta), and the common toad (Rana bufo). In front it is continuous with the fourth ventricle, or rather, it dilates to give origin to this cavity, and its interior was covered with a thin layer of cortical substance.

Birds possess this canal, both in their embryo state,[1] and in adult age. In these it forms, at its inferior part, a remarkable excavation, which Steno, Perrault, Jacobæus, and some other authors, have described under the name of the rhomboidal sinus. In birds, also, the grey substance occupies the interior, and is no where in greater abundance than on the walls of this sinus.

The canal equally exists in the spinal marrow of the fœtus of mammiferous animals, as also in the young animals of this class. F. Meckel has found it in the embryo of the rabbit;[2] and G. Sewell, in young animals

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[1] T. G. J. Nicolai, Diss. de Medullâ Spinali avium ejusque Generatione in ovo incubato. Halle, 1811, in 4to. p. 39.—See my Treatise on Zoology, t. iii. p. 203.

[2] Beitræge zur Vergleichenden Anatomie, cah. ii. no. i. p. 32.

of the genus dog, sheep, ox, and horse.[1] This latter writer observes, that it was filled with a colourless fluid nearly opaque, and of the same nature as what existed in the ventricles. F. Meckel has even met a small canal full of fluid in the spinal marrow of some of the adult mammiferous class, such as the dog, cat, rabbit, sheep, and ox.[2] Blaes has met it also in many adult mammiferous animals.

Although we cannot find this canal in the spinal marrow of the human adult, in its normal state of developement, still it has undoubtedly been met with; we should then consider it as the result of a retardation in its developement. Charles Stephen[3] was the first who gave a de-

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[1] Philosophical Transactions for the year 1809, p. 146. —Reil's Archiv. für die Physiologie, t. xii. p. 119.

[2] Arsaky, Diss. de Piscium Cerebro, p. 11.

[3] De Dissectione Partium Corporis Humani, lib. 3, una cum Figuris, et Incisionum Declarationibus, à Steph. Riveno. Paris, 1545, in fol. p. 337. Cæterum quod ad interiora ipsius medullæ spectat, cavitatem in internum ejus substantiæ manifestam reperire licet, quæ seu quidam ipsius ventriculus esse conspicitur, in quo aquosa quidam humor sub-flavus continetur, paulo tamen liquidior quàm qui in anterioribus cerebri delitescit.

scription of it ; and Columbo,[1] Piccolhomini,[2] Bauhin,[3] Malpighi,[4] Lyser,[5] Golles,[6] Morgagni,[7]

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[1] De re Anatomicâ, lib. xv. Venice, 1559 ; p. 194.

[2] Anatomicæ Prælectiones, explicantes mirificam corporis humanis fabricam. Rome, 1586, in fol. p. 260.

[3] Theatrum Anatomicum. Francfort, 1605, in 8vo.

[4] De Cerebro, in his Opera Minora, t. ii. p. 119. In spinali medullâ oblongus sinus non in medullari sed cineritiâ excitatur substantiâ.

[5] Culter Anatomicus. Copenhagen, 1653, in 8vo. p. 88.

[6] Abrégè de l'Œconomie du Grand et du Petit Monde. Rouen, 1670, in 12mo.

[7] Adversaria Anatomica, vi. Animadvers. xiv. :—Præter fissuram anteriorem, altera quoque a tergo occurrit, in quam ipse calamus, ut vocant, scriptorius deorsùm producitur. Et alia quidem cadavera has fissuras longiores, altiores, et faciliùs deducendas exhibent ; alia contra ; alia autem sunt cursùs, in quibus præter has, exigua cavea, secundum longitudinem intra mediam supremæ medullæ substantiam insculpta, nullo negotio deprehenditur : quale imprimis piscatoris veneti cadaver fuit, cujus spinalem medullam transversâ sectione ab oblongatâ dividendo cum Cl. Santorino observavimus caveam, quæ minimi digito apicem prope modum admittebat, quinque autem transversorum digitorum spatii, et fortasse etiam longius (si quis tunc otium habuisset ulteriorem medullam è vertebris eximendi), ad inferiora producebatur. Et me-

Haller,[1] and M. Portal,[2] have since observed it. Many of these writers have even considered it as a constant and normal disposition; an hypothesis which Varoli, Monro, Sabatier, and some other anatomists, have justly opposed. Nymmann proceeded even further still, for he spoke of two canals prolonged into the spinal marrow.[3] Gall[4] pretends to have found,

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dullæ quidem medium, nisi quod posteriori parte propior erat, occupabat; fissura tamen, quod manifestè videre potuerim, ad ipsam caveam non pertingebat. Cæterum hujus superficies et vicina huic substantia erat cinerea; nec quidquam prorsus fuit quod non secundum naturam esse censuerim, præter ejus caveæ magnitudinem.

[1] Elem. Physiol. t. iv. p. 83.

[2] Observation sur un spina bifida, et sur le canal de la moelle épinière; dans les Mémoires de l'Academ. des Sc. 1770, p. 238. M. Portal has found the canal in the cervical portion of the spinal marrow of a man over thirty years of age.

[3] De Apoplexiâ, p. 114.

[4] Anat. et Physiol. du Système Nerveux, p. 51. M. Gall dit (p. 52): "On peut donc considérer chaque moitié de la moelle épinière comme une membrane plissée sur elle même." In this point he is right; but how to reconcile a similar disposition with the double range of enlargements, or ganglions, which he admits in the spinal marrow?

in the spinal marrow of new-born infants, in infants of a certain age, and even in certain adults, two canals free from all communication with the fourth ventricle, but which extended across the pons varolii, the common mass of the tubercula quadrigemina, and the arms of the medulla oblongata, into the interior of the optic chambers, where they formed a cavity sufficient to lodge an almond. These two supposed canals, with their termination in the optic chambers, do not exist; we must suppose that they were produced by a forced insufflation: I have never met them either in the adult, or in the fœtus; nor do we find them in animals, in which the canal of the spinal marrow always communicates with the fourth ventricle, by means of the calamus scriptorius.

The anatomy of the fœtus is by no means favourable to the hypothesis of Gall, who supposes that the spinal marrow of man and superior animals is composed of ganglia, or enlargements of grey substance, distinct, but adherent one to the other, and corresponding in number to the nerves which it furnishes. If the ganglia were the primary portions formed; if the spinal marrow itself resulted from their apposition, or their union, we should most unequivocally find them in the embryo, as in this case we observe the spinal marrow the least advanced in organization; but on early examination, we find nothing similar to these enlargements or ganglia. However, M. Gall justly observes, that in the adult, the points of the spinal marrow the most abundantly furnished with cortical substance, are those from whence emanate the largest nerves. The following may give an idea of what I have observed on this subject. We recognise, at a very early period, that the spinal marrow of the fœtus is broader where the large spinal trunks, which form the nerves of the pectoral and abdominal extremities, arise; its canal presents also dilatations in the same points. During the last months, when the walls of the spinal marrow are increased by the formation of new medullary fibres, and that the canal, at first contracted, is afterwards filled up gradually by the cortical substance deposited there, we find in these points a greater quantity of grey substance, traversed by numerous blood-vessels, which give it the rosy appearance. But still it is true, that this considerable mass of cortical substance belongs to a secondary formation, and forms no part of the primordial state.

The great quantity of grey substance in those parts of the spinal marrow, from whence issue the large nervous trunks, and which receives so many vessels, that Ruysch[1] imagined it entirely vascular, contributes certainly, during life, to increase and exalt the nervous action, according to this general law, that an organ possesses more force and energy, as it receives more arterial blood. M. Gall is deceived in saying, that the grey substance, which he terms the womb of the nerves, is the first formed, being the producer and nourisher of all the nerves. I allow with him, that it strengthens and fortifies the action of those parts of the brain and nerves which emanate from it, in as much as this effect is produced by the arterial blood which it contains, and by the greater rapidity with which it repairs the loss which the exercise of the vital action might produce. I admit then an intimate relation between the volume of the spinal nerves and the enlargements of the spinal marrow, in those points from whence these nerves issue. It is very easy to be convinced of this in fishes, where the origins

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[1] Thesaur. Anatom. iii. n. 9.

of the nerves produce particular ganglia, always when the nerves, and the organs to which they are distributed, have acquired a greater developement, or when there are particular organs not found in other fishes. The remarkable and regularly disposed enlargements observed immediately behind the cerebellum in the flying-fish (Trigla volitans),[1] are the origins of the nerves destined to the digitiform prolongations peculiar to these fishes, observed in front of the ventral fins, and provided with numerous muscles, serving at the same time as organs of touch and progression;[2] of this I have been convinced for some years. We find also in the torpedo (Raia torpedo), two large ganglia situated behind the cerebellum, the size of which they much surpass, and from whence issue the nerves analogous to the eighth pair, which furnish a great number of branches to the electrical organs of these fishes. The Raia clavata, Raia batis, Raia pastinaca, and other species of the skate properly called, present

[1] Samuel Collins has described and represented them, System of Anatomy, t. ii. tab. 70. fig. 3.

[2] This I have demonstrated in a Memoir addressed to the Academy of Sciences at Berlin.

but a very small swelling, giving origin to the eighth pair, which in these animals are only distributed to the gills. In the sheat-fish (Silurus), the origin of the fifth pair of nerves forms a very voluminous mass, because this pair sends large branches to the long barbules which cover the superior maxilla, and to the muscles of these appendages. We find similar enlargements along the spinal marrow of most fishes.[1] Thus, for example, in the carp, there are behind the cerebellum, two swellings, united together by a middle tubercle, and representing, in some degree, a second cerebellum. It is important to observe, that these enlargements are principally formed of cortical substance. We cannot then doubt, that the local augmentation of the mass of the spinal marrow, by the addition of a greater quantity of this substance, is to exalt the action or activity of the nerves which emanate from these ganglia.

The spinal marrow of the fœtus still resembles, in many other respects, that of animals of the inferior classes. In effect, during the first months

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[1] Arsaky. loc. cit. p. 16.—De posteriore gangliorum encephalum constituentium parte.

of uterine life, it fills the whole length of the vertebral canal, that is to say, it extends to the sacrum and coccyx ; an observation already made by Wrisberg, in a fœtus of six weeks.[1] The caudiform expansion does not exist in the beginning ; it only appears towards the end of the fourth month, and is owing to the elongation of the lumbar and sacral nerves at this period. If the spinal marrow descends lower in the vertebral canal in the fœtus, near the term of birth, than in that already born, I believe we may attribute it to the more rapid increase in length of the spinal column, than of the nervous cord, which it protects, so that the latter becomes shorter in relation to it, as the fœtus approaches nearer the term of birth ; for on the ninth month, the extremity of the spinal marrow has reached the upper part of the third lumbar vertebra.[2]

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[1] Descriptio Anatomica Embryonis, Gottingen, 1764, p. 23: Spinalis medulla tenuior in dorso, crassior in lumbis, ad apicem ossis sacri producta.

[2] There appears some difference in the opinion of authors on this most singular change which takes place in the spinal marrow and vertebral column during fœtal life. The researches of M. Serres have led him to con-

In fine, I have never met in the fœtus, the tubercles sometimes found in the adult, and which Vieussens, Tarin, Winslow, Huber, Frotscher, and different other anatomists have described and represented, the one as simple, the others as double. Monro and Heuffel have never observed them in the adult, nor have I frequently met with them myself; so that they appear not as one of the constant and normal characters of the organization of the spinal marrow.

In all respects the spinal marrow of the fœtus resembles that of animals. In most fishes, this organ is of considerable extent, and terminates

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ceive that there is a true displacement of the spinal marrow by a movement of ascension; and that in animals the diminution of extent of the tail of the embryo becomes proportioned, in the different species, to the degree of ascension of the spinal marrow in the vertebral canal. The opinion of Tiedemann with respect to the more rapid increase of the spinal column might be strengthened from a comparative examination of the relative size of the sacral artery, in the different species of vertebral animals. Besides, we find many animals, where the tail is composed of nearly thirty vertebræ, completely solid; consequently we may infer, that where they no longer contain the spinal marrow, their persistence is independent of this latter. (T.)

by a delicate extremity, without forming either a caudiform expansion or tubercles, in support of which I can cite the remarkable observations collected by Arsaky.[1] The spinal marrow extends through the whole length of the vertebral canal in reptiles and in birds,[2] and forms neither tubercles nor caudiform expansion, while the nerves which emanate from it come out directly by the foramina pierced in the sides of the vertebral column. The spinal marrow of mammiferous animals descends much lower down in the vertebral canal, than that of the human adult: in all indigenous animals, belonging to this class, which I have dissected, it was prolonged, without tubercles, into the cavity of the sacrum. J. F. Meckel has observed it extending nearly as far as the middle of this bone in the dog, cat, rabbit, and guinea pig;[3] Blaes[4] also, who had never

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[1] The sun-fish (Tetrodon mola) and fishing Ray are the only examples where the spinal marrow is very short; but it does not possess a caudiform expansion.

[2] Keuffel, De medullâ spinali. Halle, 1810, p. 29.—Nicolai, De medullâ spinali avium. Halle, 1811, p. 18.

[3] In the Dissertation of Arsaky, p. 4.

[4] Anatome medullæ spinalis et nervorum inde provenientium. Amsterdam, 1666, in 12mo.

studied this organ but in mammiferous animals, doubted the existence of the caudiform expansion.

It is an acknowledged fact, that the spinal marrow becomes more voluminous, in proportion to the brain, as we remove more from man through the series of mammiferous animals, birds, reptiles, and fishes. Thus Sœmmering has wisely laid down a principle, that of all animals man possesses the smallest spinal marrow, relative to the volume of his brain. But this proposition can only hold good in the adult; we cannot apply it to the fœtus; for anatomy demonstrates that the volume of the spinal marrow is more considerable, in relation to that of the brain, as the embryo is younger. It follows then that the proportion between these two organs is absolutely the same as in those animals already mentioned. To leave no doubt on the exactness of this assertion, I shall collect in a small table the different diameters of the spinal marrow and brain, taken from the first part of this work.

Age of the Fœtus.	BREADTH OF THE SPINAL MARROW: On a level with the medulla oblongata.	On a level with the enlargement from whence the nerves of the thoracic extremities emanate.	In the middle part.	On a level with the enlargement from whence the nerves of the pelvic extremities emanate.	BREADTH: Of the cerebellum.	Of the Brain.
2d Month.	1 Line.	$\frac{1}{2}$ Line.	$\frac{1}{2}$ Line.	$\frac{1}{2}$ Line.	$1\frac{2}{3}$ Line.	$1\frac{1}{4}$ Line.
3d Month.	$1\frac{1}{3}$	$\frac{2}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	4	5
4th Month.	$2\frac{1}{2}$	$1\frac{1}{4}$	$\frac{2}{3}$	$\frac{1}{3}$	$5\frac{1}{2}$	8
5th Month.	$2\frac{1}{2}$	$1\frac{1}{3}$	$\frac{3}{4}$	$1\frac{1}{3}$	7	12
6th Month.	3	$1\frac{1}{2}$	$\frac{3}{4}$	$1\frac{1}{3}$	8	15
7th Month.	$4\frac{1}{2}$	2	1	2	$9\frac{1}{2}$	$17\frac{2}{3}$
8th Month.	5	$2\frac{1}{2}$	$1\frac{1}{2}$	$2\frac{1}{2}$	$11\frac{1}{2}$	23
9th Month.	$5\frac{1}{2}$	3	2	3	16	31

We may judge from this table, that the primitive smallness of the brain is the sole cause of the great relative superiority which the spinal marrow possesses over it in the fœtus. During the five last months, in the course of which the encephalic mass augments with so much rapidity, the spinal marrow, not increasing in the same proportion, becomes consequently smaller in relation to it. In animals also, it appears voluminous, in comparison to the brain, on account of the very diminutive size of the latter. I have examined it in fishes which weighed nearly one hundred and fifty pounds, and I have observed that it equalled scarcely the sixth part of the spinal marrow of a human adult. We may then more justly express the relation between it and the brain, by saying, that, of all animals, man possesses a brain more voluminous in proportion to the mass of his spinal marrow, and that, in general, this viscus diminishes, in relation to the other, according as we descend in the degrees of animality. In the fœtus, where it is impossible to mistake a progression from the simple to the complex, the brain becomes more voluminous, in proportion to the spinal marrow, as it approaches nearer the term of complete developement. Here still we can only infer the relation of the brain to the spinal marrow, and not to the entire body; for, in the fœtus, the brain, compared to the body, is infinitely larger than in the adult.

The spinal marrow, more voluminous in the superior portion of the vertebral canal, represents in this point the medulla oblongata, whose inferior extremity, or origin, is at first merely indicated by a slight curvature of the cord forwards, of which we still perceive manifest traces, on the anterior part of this latter, in the fœtus of the seventh month. This curvature depends evidently on the flexion of the head on the chest. The pons varolii not existing before the third month, we can perceive the spinal marrow continuous with the crura cerebri, as in fishes, reptiles, and birds, which are equally destitute of this eminence. In the fourth month only, the period when the rudiments of the pons varolii have appeared, the limits of the medulla oblongata are marked by the transverse fibres of this protuberance, which unite together beneath the two hemispheres of the cerebellum.

The spinal marrow is divided into two cords by two grooves, the one anterior, the other posterior, which I have already described. Each of these two cords divide, in the medulla oblongata, into three smaller bundles, termed the pyramidal, olivary, and restiform fasciculi.

The two pyramidal fasciculi are situated on either side of the anterior longitudinal groove. Until the third month, they form a broad and plane surface, as in fishes, reptiles and birds,[1] because the pyramidal eminences are not yet developed on their surface. On the fifth month they commence to form a projection on the outer side, in consequence of their being reinforced by medullary fibres of new formation. On the seventh month, each pyramid measures three lines in length, and one in breadth; on the eighth month, four lines and a half in length, and one in breadth; lastly, on the commencement of the ninth month, the length is four lines and a half, and the breadth one and a half. The crossing of the pyramidal fasciculi, which Mistichelli[2] and Pourfour du Petit[3] have de-

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[1] Thus Willis remarks (Anat. cerebri, p. 34). In volucribus corpora pyramidalia planè desunt.

[2] Trattato dell' apoplessia. Rome, 1709, in 4to.

[3] Lettre d'un médecin des Hospices du Roi. Namur, 1710, in 4to. p. 12.

scribed; which Santorini,[1] Winslow,[2] Lieutand,[3] Sœmmering,[4] and Gall[5] have also observed, but which have escaped the researches of Haller, Vicq d'Azyr, Monro, and some others, and the existence of which these anatomists had doubted; this crossing, I say, is perceptible from the fourth and fifth week of fœtal life, at the point where the spinal marrow describes the curve forwards, corresponding to the inferior extremity of the pyramids. The two cords of the spinal marrow do not cross, but merely the middle or pyramidal fasciculi of each, which are composed of longitudinal fibres, and which give origin to the crura cerebri by expanding and becoming broader. Towards the third month, there is no difficulty in perceiving that these parts are really continuous, as the pons varolii does not yet exist; but at a later period their union, marked by the transverse fibres of the latter, becomes less ap-

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[1] Observationes Anatomicæ. Leyden, 1734, in 4to. p. 61: and in his Tab. Anatom. tab. 17.

[2] Traité de la Tête, n. 110.

[3] Anat. hist. et pract. t. i. p. 591.

[4] Bau des menschlichen Koerpers, t. v. part i. p. 68.

[5] Anat. et physiol. du système nerveux, p. 192, pl. 5.

parent as this protuberance acquires more volume and breadth. If we remove with precaution the transverse fibres of the pons varolii, we observe those which they cover taking a longitudinal direction, and becoming continuous with those of the crura cerebri. The ancient anatomists, such as Varoli,[1] Vieussens,[2] and Morgagni,[3] were all aware that the medullary fibres of the pyramids traversed the pons varolii, and united with those of the crura cerebri ; yet we cannot but acknowledge, that M. Gall has been the first

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[1] De nervis opticis nonnullisque aliis præter communem opinionem in humano capite observatis. Padua, 1573, in 8vo. p. 18. fig. 1, 2.

[2] Neurographia universalis, tab. 16.

[3] Adversaria anatomica, VI. p. 15. Certè enim nihil mihi ni plerisque cadaveribus facilius est, quam corporum pyramidalium summam partem, imam autem annularis protuberantiæ aut lentè, paulatimque abradendo, aut nonnunquam sine ullâ etiam abrasione suspensâ manu hanc ab illâ distrahendo, cæteris nexibus dissolutis, duos intùs medullares insignes fasces secundùm oblongatæ medullæ longitudinem porrectos, adhuc perstantes ostendere ; quos sursùm, deorsùmque persequendo, ex eorum crassitie, loco positu sæpè comperi, non differre ab iis qui in eâ Vieussenii tabulâ (16) medii inter litteras H. H. et G. G. secundum longitudinem feruntur.

to consider them as ascending from the spinal marrow towards the brain, while, before him, anatomists had supposed that they descended from the latter, and consequently looked on these as the origin of the spinal marrow. The latter part of this treatise will point out the degree of exactness and utility of the opinion of Gall.

The fasciculi situated on the side of the preceding, but smaller, to which I have given the epithet of olivary,[1] as the eminences of this name are formed on their surface, pass upwards into the pons varolii, or are covered by this protuberance; afterwards they remain in apposition with the pyramidal fasciculi. The greater number of their fibres, which are longitudinal, collect in the common mass of the tubercula quadrigemina, and bending upwards and inwards, uniting to those of the opposite side, form that portion which becomes the roof of the aqueduct of Sylvius. The others are directed forwards into the optic chambers, where they unite with those of the pyramidal fasciculi. The

[1] These cords correspond to what Reil has termed the loop or knot.—Archiv. für de Physiologie, t. ix. p. 505, tab. 11, v, w, x, y.

corpora olivaria, which are wanting in fishes, reptiles, and birds, are only formed towards the end of the sixth month, or on the commencement of the seventh; a period when the unfibrous substance which constitutes them is secreted by the pia mater, and deposited on the medullary substance of the olivary fasciculi. The tardy appearance of the corpora olivaria depends on the grey substance not being formed until after the white. On the seventh month, each measures two lines in length, and one in breadth ; on the eighth month, two lines and a half in length, and one and a fourth in breadth ; and lastly, on the commencement of the ninth month, each is three lines and a half in length, and one and a fourth in breadth. M. Gall[1] considers these bodies as ganglia from whence the olivary fasciculi emanate ; but, notwithstanding the description which this anatomist has given of the fasciculi themselves, in which he makes no mention of the medullary fibres, which are lost in the common mass of the tubercula quadrigemina, it is erroneous to suppose that they can come from

[1] Anat. et physiol. du cerveau, p. 198, pl. 12.

the corpora olivaria, as they appear in the fœtus long before the formation of these eminences. I do not however pretend to deny, that the cortical substance, so richly provided with vessels, which deposit it on the surface, does not contribute to increase their energy and activity.

The cerebellic fasciculi, termed also the restiform bodies, the peduncles or posterior crura of the cerebellum, are the most external and posterior of the three cords into which the spinal marrow is divided. They rise from the lateral and posterior parts of this organ, form the swellings which border the fourth ventricle, and pass afterwards into the cerebellum.

Lastly, we observe on either side, on the margin of the posterior longitudinal groove, or at the entry of the canal of the spinal marrow, a very thin and narrow fasciculus formed of longitudinal fibres. In the fœtus of the fifth month, I recognised, for the first time, the presence of this fasciculus, manifest traces of which had also appeared in the spinal marrow of fœtuses the most advanced. It contracts the fissure of the canal of the spinal marrow. On a level with the calamus scriptorius, it inclines aside and passes into the restiform fasciculus. We can also distinguish it in the adult, along the posterior longitudinal groove.

A problem here presents itself. Is the spinal marrow a continuation, a simple appendix of the brain? or rather, is it the brain which we should consider as the continuation of the spinal marrow? Galen, Achillini, Beranger de Carpi, Vesalius, Coiter, Spigelius, Riolan, Columbo, Fallopius, Veslingius, Willis, Vieussens, Verheyen, Winslow, Haller, Zinn, Portal, and other anatomists, have supported the first opinion, to which are attached the greater number of suffrages. M. Gall justly opposed this hypothesis, and skilfully defended the contrary assertion. He required, however, many arguments to show that the opinion of the brain being but an appendage of the spinal marrow was new. Platon, Praxagoras, Philotomius, Plistonicus, and some other Greek philosophers had already professed that opinion. Galen had combated it with the same energy which many physiologists of the present day employ against M. Gall.[1]

[1] De usu partium, lib. 8, cap. 12. Quo loco subit mihi admirari Praxagoram, et Philotimum, non modò propter dogmatum absurditatem, verùm etiam propter

Thonet Bartholin,[1] Malpighi,[2] and Fraccassati,[3] not content with adopting these, raised new arguments in its favour. However, though the opinion of M. Gall has not the merit of novelty, we must allow that this anatomist shares the honour of having attacked with advantage an erroneous doctrine, and of having re-established that of the ancients, of which he seems to be one of the most zealous defenders.

The researches which I have made on the brain of the fœtus, demonstrate that this viscus is produced by the superior part of the spinal marrow, that is to say, by the medulla oblongata, which increases and developes to give origin to it. I shall here collect the facts scattered in the first part of this work, in support of my opinion.

1°, We have seen that, in the beginning, the

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eorum, quæ in anatomis appareat, ignorantiam. Superabundantiam enim quamdam seu spinalis medullæ propaginem, existimant esse cerebrum.

[1] Anatome quintum renovata. Leyden, 1686, in 8vo. p. 428.

[2] De cerebro, in his Opera omnia. Leyden, 1687, in 4to. tom. ii. p. 116.

[3] De cerebro, in Malpighi opera, tom ii. p. 134.

brain is very small in proportion to the spinal marrow, and even bears the type of this latter. In effect, it results from the prolongation upwards and forwards of its two principal cords: it is completely open superiorly, and the canal of the spinal marrow extends to the fourth and third ventricle; the cerebellum, and the common mass of the tubercula quadrigemina, consist but of two plates proceeding from the spinal marrow, mutually inclining, but not yet united.

2°, The cerebellum evidently proceeds from the spinal marrow, its two peduncles arising from the surface of the latter; they unite afterwards over the fourth ventricle, and then only do the stems, branches, and leaflets appear.

3°, We have seen the rudiments of the common mass of the tubercula quadrigemina, primarily membranes, formed by the olivary fasciculi of the spinal marrow; these membranes mutually unite, are gradually enlarged by new additions of substance, and thus insensibly acquire the disposition observed in the adult.

4°, I have shown that the pyramidal fasciculi of the spinal marrow, proceeding towards the antero-superior part, produced the enlargements termed the optic chambers and corpora striata;

each then terminating in a thin plate, reflected from before backwards and from without inwards, formed the commencement of the cerebral hemispheres. These membranous hemispheres were still so short on the second month, as scarcely to cover the corpora striata. According as they developed, they extended farther backwards, so as to cover, on the third month, the optic chambers, on the fourth and fifth, the tubercula quadrigemina, and on the sixth and seventh, the cerebellum. Their inflection on themselves gave origin to the lateral ventricles.

5°, I have demonstrated that the medullary fibres of the pyramidal fasciculi are directly continuous with those of the peduncles of the brain; that they pass from hence into the optic chambers, as also into the corpora striata, and that they terminate in expanding in the hemispheres.

6°, And lastly, we have seen that the new layers of cerebral substance are gradually deposited on the surface of the membranous hemispheres ; that the walls of these latter gradually augment in thickness, and that only during the latter months do we perceive the convolutions.

All these particulars united, prove evidently that the cerebellum and brain are produced by the spinal marrow, and, to use the expression of Reil, are an efflorescence of this part. To these we may add the data furnished by the anatomy of the spinal marrow in the different classes of the animal kingdom; for the organization of the brain becomes more and more complicated as we ascend the scale from fishes up to man. In order to support the contrary opinion, that is to say, that the spinal marrow was a continuation, an appendage of the brain, the parts which we observe the first formed in the fœtus should necessarily give origin to this organ; we should consequently meet the brain and cerebellum before it; this is not the case. Besides, in reviewing the scale of the animal kingdom, where we see so evident a gradation in the formation and expansion of the organs, we should meet with a perfect brain before meeting a spinal marrow. We observe precisely the contrary, that is to say, that the spinal marrow of inferior animals is very voluminous, while their brain, forming really but an appendage, is very small; and we find this organ acquiring a greater volume and developement, according as we ascend the scale from fishes to mammiferous animals, a progress absolutely similar to what it follows when formed in the head of the human fœtus.

I could furnish still many other proofs in support of the principles which I establish; but it seems unnecessary, as nothing could persuade him who has not been already convinced by the arguments mentioned.

OF THE CEREBELLUM.

On reviewing the descriptions which I have given of the structure of the cerebellum in the fœtus, and examining the plates which refer to it, it is impossible not to recognise the many degrees of increasing complication which this organ passes through. I shall now unite together the facts relative to its formation, deducing some results, and establishing a comparison between its successive degrees of complication, and the gradation which its organization pursues in animals.

At the end of the first month, and on the commencement of the second, a soft and fluid substance occupies the place of the cerebellum. Towards the end of the second month, after having plunged the embryo in alcohol, we perceive, on either side, a small thin plate or a very narrow fasciculus, rising from the spinal marrow, along the fourth ventricle, turning inwards, and resting against that of the opposite side, without uniting to it. On the third month, these fasciculi have evidently augmented in volume, and represent then the corpora restiformia, termed the peduncles of the cerebellum by Willis, and the crura by other anatomists. Uniting on the middle line, they form a small narrow mass, extended like a bridge over the fourth ventricle. At this period the cerebellum is three or four lines in breadth: smooth and convex on the outer side, concave within, no appearance on its surface, of grooves, nor yet of lobes or leaflets. Its anterior surface is continuous with the membrane of the tubercula quadrigemina, and its posterior border inclined inwards.

On the fourth month, the cerebellum was five lines and a half in breadth, and one line and a half in length, in its middle part. It enclosed in a semicircle the common mass of the tubercula quadrigemina. On the inferior surface of the restiform fasciculi, appeared a small swelling, the rudiment of the ciliary body (corpus dentatum) or what has been termed by Reil the great medullary nucleus. In front of the peduncles of the cerebellum descend those fibres which wind round the olivary and pyramidal fasciculi of the spinal marrow, those of the right side uniting with those of the left, and forming thus the pons varolii, which was yet but one line in its longitudinal diameter.

On the fifth month, the cerebellum seemed to have increased in its transverse direction, and was a little flattened, its breadth being seven lines. At this period only, four transverse grooves are observed, deeper on the middle line than elsewhere, and gradually disappearing on the lateral parts. These grooves divided the organ into five lobes, which represented, in a perpendicular section, exactly five stems; the branches or leaflets had not yet existed. The excavation of the internal surface of this organ formed the roof of the fourth ventricle; the commissure which formed the pons varolii was two lines in length. The fibres distributed to the common mass of the tubercula quadrigemina, and the valve of Vieussens, had already existed. On the sixth month, the breadth of the cerebellum was eight lines; its lateral parts had acquired a greater developement, and an elevation a little above the middle portion, which represented the processus vermiformis. The posterior notch of Reil was perceptible. The surface of the organ presented both deep and superficial grooves, which divided the lobes into lobules. In a longitudinal section, the stems, as also the branches, were apparent, and the ciliary bodies had acquired some volume. The pons varolii was two lines and a half in length.

On the seventh month, the breadth of the cerebellum was nine lines and a half; the lobes were separated by very deep transverse grooves; others more superficial were placed between the branches. The vermiform process was more sunk, in relation to the hemispheres; and the nodule, the pyramid, the short cross-bands, and the spigot, were discernible. The posterior edge, which enters a little inwards, formed the small valve, or small posterior medullary velum,[1] as also the peculiar appendages, termed by Reil the flocks. In a longitudinal section of the cerebellum appeared the stems, branches, and ramifications; but the last divi-

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[1] See Mayo's Anatomical and Physiological Commentaries, part i. p. 25.

sions or leaflets were not yet visible. The fasciculi of the spinal marrow, which plunged into the hemispheres, formed large swellings, the ciliary bodies, from which some fibres rose into the stems, branches, and ramifications, and radiated towards the periphery. Some fibres, proceeding forwards, formed the prolongations of the cerebellum towards the tubercula quadrigemina; while others descending, produced the pons varolii, now three lines in length, and four and three quarters in breadth.

On the eighth month, the cerebellum was eleven lines in breadth; the hemispheres having acquired their developement, the vermiform process appeared more sunk. The longitudinal diameter was four lines and a half in the middle part, and six and a half on the sides. The soft substance which is deposited from without inwards on the ramifications, and which forms the leaflets, remained adherent to the folds of the pia mater, when this membrane was elevated.

On the ninth month, the breadth of the cerebellum was one inch four lines; its longitudinal diameter six lines and a half at the vermiform process, and nine on the hemispheres. All the parts were developed, and the leaflets had already appeared.

After this view, it is incontestable that the cerebellum proceeds from the two restiform fasciculi, emanating from the spinal marrow; an opinion which Fraccassati[1] had already supported. In effect, these parts are the first formed, and give origin to all those which are observed on the periphery of the organ. The ulterior developement and formation of the cerebellum are owing to new cerebral substance secreted by the vessels which the pia mater sends into its interior, and which surrounds it on all sides. The successive depositions of this substance are formed, the one on the surface, by the formation of the lobes, stems, branches, ramifications, and leaflets; the others, from below upwards, and from within outwards, by the formation of the ciliary bodies.[2] These bodies, termed by M. Gall the ganglia of the cerebellum, are visible from the fourth month, as I

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[1] Epistola de Cerebro, in Malpighi Op. t. ii. p. 125.

[2] Termed the festooned or denticulated bodies by Vicq d'Azyr, who has represented them, pl. xxxi. figs. 3, 4.

have already mentioned, and are produced by the numerous vessels sent from the choroid plexus of the fourth ventricle to the cerebellum. On their surface, as also on that of the corpora restiformia, the new substance is deposited, secreted by the internal surface of the pia mater. This membrane, augmenting gradually in extent, forms folds, which dip into the soft and diffluent cerebral matter of the new deposition: hence arise the transverse grooves and lobes observed on the fifth month, as also the divisions of the cerebellum into stems resting on the medullary nuclei. These depositions continuing, and the pia mater extending, the latter produces again new folds; the transverse grooves become more numerous, and the stems divide into branches, towards the sixth month. On the seventh and eighth, the cerebral matter is secreted in greater quantity, the pia mater still continues to form both deep and superficial folds, and not only the stems and branches appear, but also ramifications and leaflets.[1] Lastly, on the ninth

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[1] Reil has already conjectured so (Archiv. für die Physiologie, t. viii. p. 278). He thus observes: "We might imagine, that the formation of fissures, or grooves,

month, an exterior layer of vascular cerebral substance is deposited on the surface of the medullary leaflets. Consequently the cortical substance is applied from without inwards on the surface of the cerebellum, and is the last production of the pia mater, as Reil has also conjectured.[1]

The separation of the cerebellum into two lateral parts, or hemispheres, and into a middle portion, the processus vermiformis, the commissure of the two preceding, only becomes apparent on the fifth month, after the formation of

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is effected from without inwards: the most superficial forming leaflets, while the deepest give origin to lobules and lobes."

[1] Archiv. für die Physiologie, t. viii. p. 393. The cortical substance is only applied on the surface of the medullary; it is separated, and consequently has no direct communication with it. P. 394. The cortical substance appears to be a precipitate furnished by the internal surface of the pia mater, and which gradually acquires a greater degree of density. Perhaps the brain is a series of similar precipitates, furnished successively by this membrane. At least it is certain, that, in the fœtus, this latter membrane is of extraordinary thickness, and we cannot perceive any distinction between the cortical and medullary substance.

the medullary nuclei. In effect, according as the restiform fasciculi, which arise from the spinal marrow, augment laterally, by the production of these two nuclei, and enlarge by the increase of their proper mass, their volume and extent become more considerable, in proportion to that of the vermiform process ; in this manner they give origin to the hemispheres of the cerebellum, and thus the posterior notch is also formed. The augmentation of the lateral parts gradually follows that of the ciliary bodies, a necessary result of the great number of blood-vessels which penetrate both these bodies and the hemispheres. Consequently, according as the hemispheres enlarge, the vermiform process not increasing in the same proportion, appears diminished in volume, seeming not only condensed, and more sunk, but still adding an apparent increase to the depth and breadth of the posterior notch, as the cerebellum approaches nearer the term of complete developement. To render this more evident, I shall state the comparative extent of the longitudinal diameter of the hemispheres, and of the processus vermiformis, during the different periods of fœtal life.

Age of the Fœtus.	LONGITUDINAL DIAMETER	
	Of the Vermiform Process.	Of the Hemispheres.
Fourth Month, . . .	$1\frac{1}{2}$ Line.	$1\frac{1}{2}$ Line.
Fifth Month, ...	2	$2\frac{1}{2}$
Sixth Month, ...	$2\frac{1}{3}$	3
Seventh Month, . .	4	$4\frac{2}{3}$
Eighth Month, . . .	$4\frac{1}{2}$	$6\frac{1}{3}$
Ninth Month, ...	$6\frac{1}{2}$	9

I could not very distinctly perceive, until the seventh month, the parts in the vermiform process, termed by Reil the nodule, pyramid, spigot, and short cross-bands.

At the same time that the medullary nuclei were formed, so were the cords which joined the cerebellum to the tubercula quadrigemina, and those destined to form the pons varolii. This latter, composed of transverse fibres,[1] gave

[1] Willis has already remarked this, (Anat. Cerebri, p. 32.)

origin to the middle lateral cords, which surround the olivary and pyramidal fasciculi of the spinal marrow, beneath which they unite on the mesial line. These middle cords proceeded from the rhomboidal bodies, and from the white substance of the cerebellum, appearing as soon as the formation of the medullary nuclei, that is to say, on the fourth month. M. Gall[1] pretends that they are formed by particular fibres, which he has termed, *Les fibres rentrantes*, which, according to him, arise from the grey substance extended over the leaflets, and pro-

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[1] Anatomie et Physiologie du Système Nerveux, p. 182. Des filamens nerveux rentrans ou divergens, ou de la réunion (commissure) du cervelet. " Nous avons vu jusqu'a présent que les filets nerveux du cervelet, avant d'entrer dans le ganglion, et après en être sortis, s'écartent davantage les uns des autres, et s'épanouissent graduellement en couches et en feuilles; que, par conséquent, ils occupent une circonférence toujours plus grande. Mais il y a encore un autre ordre de fibres nerveuses, qui n'ont pas de connexion immédiate avec le faisceau primitif, ni avec le ganglion ou l'appareil de renforcement. Ces fibres sortent de la substance grise de leur surface, se portent dans diverses directions, entre les filets divergens, vers le bord interne antérieur et forment ainsi une couche fibreuse, large et épaisse."

ceeding from the cerebellum, unite and form the great commissure, or pons varolii. These fibres are imaginary, for the pons varolii, and the medullary fibres which constitute it, exist in the fœtus on the fourth month, that is to say, at a period when we find neither stems, branches, nor even leaflets, covered with cortical substance; he has given them an origin from parts which only exist at a subsequent period. The pons varolii, thin and narrow at first, augments in breadth and thickness, according as the ciliary bodies and hemispheres of the cerebellum increase. Of this we may be convinced by the following table, which shews the extent of its diameter each month.

Age of the Fœtus.	Length of the Cerebellum.	Breadth of the Cerebellum.
Fourth Month, . . .	1 Line.	
Fifth Month, ...	2	
Sixth Month, ...	$2\frac{1}{3}$	
Seventh Month, . .	3	$4\frac{3}{4}$ Lines.
Eighth Month, . . .	4	5
Ninth Month, ...	$5\frac{1}{3}$	$6\frac{1}{3}$

We shall shortly see that the pons varolii increases also in animals, according as the hemispheres of the cerebellum become more voluminous. I should remark here, that I have observed in the fœtus of six months, the groove which lodges the basilar artery, so well marked in adults, along the inferior surface of the pons varolii. As this artery exists prior to the pons varolii, and as it furnishes branches to the pia mater charged with the secretion of the substance which is to form it, it is evident that the groove now mentioned depends on the manner in which the cerebral pulp is deposited around the vessel.

The prolongations of the cerebellum towards the tubercula quadrigemina and valve of Vieussens, appear from the end of the third month, in the form of a small plate, which, detached from the anterior thin border of the cerebellum, gains the posterior margin of the membranes which are subsequently to form the common mass of the tubercula quadrigemina. According as the ciliary bodies are developed, these prolongations become more voluminous ; and on the seventh, eighth, and ninth months, we can distinctly perceive the longitudinal fibres of the white substance which compose them.

The posterior valve, or valve of Tarin, termed the posterior medullary velum by Reil, is formed by the posterior border of the cerebellum, reflected downwards and inwards. This, as well as the flocks, is not observed until the seventh month.

After having thus given a history of the formation of the cerebellum in the human fœtus, I shall now state the principal characters of the developement of this organ in animals.

The degree of evolution in which we find the cerebellum in the fœtus of the third month, is similar to the permanent state observed in osseous fishes, in many of the cartilaginous, and in the greater part of reptiles. In all the species of the salmon genus which I have dissected, in the carp, pike, pearch, haddock, mullet, mackrel, gudgeon, pipe-fish (Sygnathus), dorey (Zeus-faber), band-fish (Cepola), star-gazer (Uranoscopus), flounder, &c. amongst the osseous fishes ; and of the genus sturgeon, amongst the cartilaginous, the cerebellum is composed of two fasciculi rising from the spinal marrow, and uniting over the fourth ventricle. We can perceive neither grooves, lobes, nor leaflets. The pons varolii and valve of Tarin are also wanting; nor is the cerebellum susceptible of a division into a central portion, or vermiform process, and into lateral hemispheres. It presents a few peculiarities in respect to its exterior configuration. It is sometimes composed of two thin cords, mutually inclining and uniting on the middle line, as in the sturgeon; at other times, it is formed of a small rounded prominent tubercle, as in the star-gazer (Uranoscopus), and some other species. In the salmon, pike, gar-pike (Esox belone), burbot (Gadus lota), dorey, band-fish, and many others, it is a round mass reflected backwards. Sometimes inclining forwards, it then turns back, as in the Murena conger and Anguilla, species of the eel.

This organ is also composed, in the greater number of reptiles, of two thin cords or plates, which rise from the spinal marrow, and uniting, give origin to a medullary arch extended over the fourth ventricle. In the frog and toad, it forms a thin, narrow, transverse plate; in the land salamander (Lacerta salamander), ringed snake (Coluber natrix), and common grey lizard, it forms a rounded prominence. In the hawks-bill tortoise (Testudo imbricata), and common tortoise, it is a small plate convex above, concave below, and extended across the fourth ventricle.

The cerebellum of the ray and shark is a little more developed; though still hollow, it presents on the exterior many unequal grooves, into which dip folds of the pia mater. In the young Nilotic crocodile, and in the Cayman or alligator, which I have dissected, it is a little inclined backwards, and divided by a transverse groove into two leaves or plates.

The pyramidal cerebellum of birds, the peduncles of which rest on the spinal marrow, presents a more complicated organization than that of the animals already mentioned. Transverse grooves, hollowed on its external surface, divide it into many folds or plates, the number of which varies according to the species of the bird in which we examine it. The two fasciculi rising from the spinal marrow to form it, unite over the fourth ventricle; and from the point of junction, the medullary substance divides into many branches, which are generally subdivided into two stems or leaflets. The stems and medullary leaves are covered exteriorly by grey substance. Two elevations, scarcely observable, represent the lateral portions or hemispheres of the cerebellum. The prolongations, destined to form the pons varolii, are totally wanting. It is necessary to remark, that in birds, as in man, the organization of the cerebellum is simpler in the fœtal state than in adult age, and that it becomes complicated in proportion to the developement of the individual. Having carefully observed the cerebellum of the chick in ovo, I could perceive neither grooves nor leaflets as far as the eleventh day ; the former only became visible on the twelfth and thirteenth.

The cerebellum of mammiferous animals presents a more perfect developement than that of birds, reptiles, or fishes. The simple pyramid which represents it in birds, gradually becomes complicated in the mammiferous class, according as we examine it in the orders of the gnawing, (Rodentia), ruminating (Ruminantia), hoofed (Solipeda), carnivorous (Carnivora), and four-handed (Quadrumana) animals ; and this in such a manner as to present on the circumference new stems, branches, ramifications, and leaflets. The hemispheres, scarcely perceptible in birds, become gradually more voluminous. Even in this respect, the increasing progression is effected in a successive manner. In the rodentia, and particularly in the mouse, rat, squirrel, hare, rabbit, marmotte, guinea-pig, and beaver, the vermiform process is very considerable in proportion to the hemispheres; I have observed that it occupies the entire length, breadth, and height of the cerebellum, and that the hemispheres are on the contrary very small. The number of stems, branches, ramifications, and leaflets, is inconsiderable. The hemispheres of the ox, sheep, goat, and hind, among the ruminantia; of the horse among the solipeda; of the dog, fox, marten, and cat, among the carnivora, are much more developed than those of the rodentia, in comparison to the processus vermiformis, and contain many more branches, ramifications, and leaflets. The proportional volume of the hemispheres has appeared to me more considerable still in the dolphin which I dissected at Trieste, and the number of leaflets greater. The hemispheres, in relation to the processus vermiformis, increase somewhat in the human fœtus, during the three last months of gestation, and the number of branches, ramifications, and leaflets, augment also according as the embryo advances. Reil has made a very just remark, that the number of stems of the cerebellum, and of their divisions or subdivisions, increase in proportion to the progress of the animal organization towards complete perfection. We may add to these different particulars, the observations of Malacarne on the intimate relation between the number of leaflets of the cerebellum, and the energy or extent of the intellectual faculties of the individual, in the human species. This physician has found them less numerous in idiots and fatuous persons, than in many who were distinguished by the force and brilliancy of their mind.

The volume of the two ciliary bodies correspond exactly in mammiferous animals to the bulk of the lateral parts of the cerebellum.[1] They are very small in those animals where the hemispheres are but little developed, and they augment in the same proportion as these latter become more considerable; in the human fœtus,

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[1] Vicq d'Azyr had been deceived in denying them to these animals.—Vide Les Mémoires de l'Académie des Sciences, 1783. p. 47.

also, they undergo the same progressive formation.

We find in all mammiferous animals, at least as far as I am acquainted, the pons varolii, a commissure produced by the two middle cords. The volume and thickness of this protuberance, examined successively in the different species, are in a direct proportion to the developement of the hemispheres and ciliary bodies; the rodentia, whose hemispheres attain the least dimensions, possess the smallest pons varolii: Such at least is what I have observed in the animals of this order previously mentioned. In these, the pons varolii forms a very narrow thin ribbon-like portion, slightly prominent, and surrounding the medulla oblongata. In the ruminantia, in the horse, in the carnivora, as also in the dolphin, this part exceeds that in the rodentia, but is still less voluminous than in man, who cannot be compared to any of the mammiferous animals in relation to the developement of the rhomboidal bodies, hemispheres, and pons varolii, as Willis has already remarked.[1] The

[1] Anatomia Cerebri, p. 26.

brain of the fœtus presents the same gradation in the formation of the pons varolii, which does not exist before the fourth month of uterine life, as we also see in fishes, reptiles, and birds; and it only commences to appear at this period in the form of a narrow band, similar to what we observed in the rodentia; afterwards it gradually augments, according as the mass of the hemispheres and ciliary bodies increase.

The anterior prolongations of the cerebellum, or those proceeding to the tubercula quadrigemina and great cerebral valve, exist in all mammiferous animals; but the valve of Tarin does not present the same regularity. In the hare, rabbit, beaver, &c. this valve is merely indicated by a prominent line or margin; in the sheep, ox, dog, cat, horse, &c. it forms a small membrane, slightly connected to the appendages of the flocks. As in the human fœtus, we cannot distinguish it before the seventh month.

Thus it results, that nature follows a fundamental type in the production of the cerebellum, and that not only the successive formation of this organ in animals, from fishes up to man, but still its gradual formation or developement in the fœtus, are performed according to the same laws, and in the same order.

OF THE FOURTH VENTRICLE.

In the fœtus of the second month, the fourth ventricle is but a simple dilatation of the canal of the spinal marrow, extending to the third ventricle, passing under the unconnected plates of the cerebellum, and under those which correspond to the tubercula quadrigemina. On the third month, when the pyramidal and olivary fasciculi have much augmented in size, and formed the medulla oblongata; the corpora restiformia, having also become more voluminous, are turned more aside. Hence the canal of the spinal marrow is found open at the back part, and the calamus scriptorius, the commencement of the dilatation, and the fourth ventricle, are the necessary results of these changes. The pia mater, introduced into this cavity, forms a choroid plexus, which lines it, and directs the blood to the inferior surface of the cerebellum. On the fourth and fifth month, we perceive, in the bottom of the fourth ventricle, two small oblong eminences, composed of a vascular unfibrous substance; these are the grey bands (Tœniæ griseæ) of the Wenzells,[1] from whence the acoustic nerves take their origin. We may at this period inflate the canal of the spinal marrow through the calamus scriptorius. During the following months, the fourth ventricle augments in capacity, while its extent is still diminishing, in relation to the volume of the brain and cerebellum, the periphery of which is increased to a considerable degree. The grey bands are also developed. Neither I nor the Wenzells could discover in the fœtus the white medullary striæ implanted on the base of the ventricle, which we generally observe in the brain of the adult, and which Piccolhomini, Willis, and most of the modern anatomists regard as the roots of the auditory nerves.

The fourth ventricle exists constantly in fishes, reptiles, birds, and mammiferous animals. In fishes it always communicates with the canal of the medulla oblongata, and we can only consider it as a dilatation of this canal, becoming more

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[1] De penitiori structurâ cerebri, p. 183. The Wenzells had perceived the first traces of these bands in the brain of a fœtus of the third month.

ample at its superior portion. In all these animals it is continuous with the third ventricle, passing under the cerebellum, valve of Vieussens, and tubercula quadrigemina. Besides, it occupies a greater portion of the cerebellum, in proportion as this latter is thinner, or even converted into a simple membranous plate, as in fishes and in reptiles. In animals, as well as in the fœtus, its capacity is greater in proportion to the cerebellum and brain, according as these latter are less developed. I have found on its base, in the mammiferous animals and birds of this country, the grey bands which give origin to the auditory nerves, and which were even proportionally more voluminous in most of the mammiferous animals than in man, thus agreeing with the observations of the Wenzells.[1] I have not succeeded better than these latter anatomists[2] in discovering any medullary striæ at the bottom or base of the ventricle; hence I conclude that these striæ fail in the brain of animals, as in that of the fœtus.

As the fourth ventricle is much sooner formed than the lateral ventricles, or than that of the

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[1] Loc. cit. p. 180. [2] Loc. cit. p. 182.

septum lucidum, in the brain of the fœtus, and as also we meet it in all animals, while the lateral ventricles fail in osseous fishes, and that of the septum in all fishes, reptiles, and birds, I propose to call it the first ventricle, in place of terming it the fifth, as the Wenzells have done. Galen termed it the ventricle of the cerebellum ; and Thomas Bartholini, the noble ventricle of the spinal marrow. Its use is to furnish to the pia mater and to the choroid plexus, a surface sufficient to receive the vessels of the cords of the spinal marrow, those of such nerves as take their origin in this place, and those from the internal surface of the cerebellum, bringing the blood which supplies the nutrition of these parts, and which exalts their action when required. In general the manuals of anatomy do not mention the choroid plexus of this ventricle, though very voluminous in the fœtus, and found both in the human adult and in animals, as described by Willis, Vieussens, Tarin, Haller, Vicq d'Azyr, and the Wenzells.

OF THE TUBERCULA QUADRIGEMINA.

The parts corresponding to the tubercula quadrigemina represent, in the embryo of the second month, two uncovered plates, inclining upwards and inwards. These plates cover the prolongation of the fourth ventricle in front, without, however, being united, for their borders are yet but in apposition on the mesial line, and easily separated from one another. At this period they are one line in length, and as much in breadth. On the commencement of the third month, their form is that of an elongated oval, smooth and convex on the outside, and still very distinct from one another, for not until the end of this month are they united, forming thus a sort of bridge over the aqueduct of Sylvius. As they are hollow, they contain a true cerebral ventricle. They measure two lines and a half in length, and two lines in breadth. On the fourth month, their volume and convexity are more considerable; their length is now three lines and a half, and their breadth three lines. A slight longitudinal groove, on the middle line, is the only trace of the fissure which had previously divided them into two lateral halves. The hemispheres of the brain, which had much increased, and extended backwards, commenced now to cover their anterior part. Their walls, hollow and membranous, were three quarters of a line thick on the sides, and but one-half of a line in the middle, that is to say, at the junction of the two portions. We now commence to distinguish the fibres which proceed from the spinal marrow, between the pyramidal fasciculi and the corpora restiformia, and consequently coming from the middle or pyramidal fasciculi. These fibres ascend, on either side, into the walls of the tubercula quadrigemina, and unite. On the fifth month, the posterior part alone of the tubercles appears uncovered, protected only by the pia mater, between the cerebellum and hemispheres of the brain, for their anterior portion is now concealed by these latter. They are four lines in length, and three in breadth. On the sixth month, they are totally covered by the cerebral hemispheres, so that we can perceive but the cerebellum and hemispheres of the brain. If we separate these latter, the tubercula quadrigemina immediately come to view, and are smooth and convex on their upper surface ; a longitudinal depression dividing them into two halves. The fibres which rise from the olivary fasciculi of the spinal marrow penetrate their walls, and mutually unite on the middle line; the anterior fibres of these fasciculi pass into the optic chambers. All these fibres become apparent on scraping off the exterior layer of unfibrous substance. Beneath the fibres which come from the olivary fasciculi, lie the superior crura cerebelli, of a texture equally fibrous. The walls of the tubercula quadrigemina are at this period much thicker than before, being in front one line and three quarters. This augmentation of volume diminishes the relative extent of the ventricle which they contain.

It is the seventh month before we perceive the nates and testes. These eminences are separated from one another not only by the longitudinal groove, but still by a transverse one; the anterior pair being a little more voluminous than the posterior. Taken together they measure four lines and a half in length, and as many in breadth. The walls of the mass which support them have so much increased in thickness, that there scarcely remains a vestige of the vast cavity which they previously contained, and the communication of the fourth ventricle with the third is reduced to a mere canal, constituting the aqueduct of Sylvius. Their exterior layer is composed of a soft vascular unfibrous substance, which forms the eminences properly so called. When we scrape it externally with the flat handle of a knife, we expose the ascending fibres of the olivary fasciculi, which, spreading obliquely into the common mass, mutually unite. Beneath these fibres are situated those of the superior prolongations of the cerebellum, which proceed forwards, that is to say, taking the same direction as the aqueduct of Sylvius, and partly crossing with the oblique ascending fibres of the olivary fasciculi. These and the anterior fibres of the same fasciculi pass into the optic chambers, where they unite with those of the pyramidal fasciculi, or crura cerebri. On the eighth month, the tubercula quadrigemina are five lines in length, and as many in breadth ; on the ninth, their longitudinal diameter is five lines, and their transverse six. In other respects, their structure is the same at this period as on the seventh month.

These details demonstrate that the tubercula quadrigemina arise principally from the spinal marrow, and proceed from these middle fasciculi which I have termed the olivary bundles. These fasciculi represent at first two plates directed upwards and reflected inwards, and uniting like an arch over the continuation of the fourth ventricle with the third. As the plates are hollow, they form two cavities in apposition with this continuation, and which we may term the ventricle of the tubercula quadrigemina, the walls of which gradually thicken, both by the increase of the cords which proceed from the cerebellum, and by the accumulation of new cerebral substance on the exterior of the olivary fasciculi. The pia mater, dipping into this soft unfibrous substance, produces the four eminences from whence the entire mass derives its name.

Anatomists in general have mistaken the true structure of these bodies; to Reil we owe the most accurate description of them.[1] The portion which he has termed the loop, or knot, and which he has represented as proceeding

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[1] Archiv. für die Physiologie, t. ix. p. 505 et 514, tab. ii. v, w, x, y.

from the medulla oblongata, partly from the pyramidal, and partly from the olivary bodies, corresponds to the prolongation of the olivary fasciculi. He justly observes, that this loop, or knot, ascends obliquely, and expands on the upper part of the tubercula quadrigemina.

The tubercula quadrigemina are formed of medullary and cortical substance in the brain of the human adult; the medullary substance which they contain is composed of the oblique ascending fibres of the olivary fasciculi, and of those of the superior prolongations of the cerebellum. These two orders of fibres mix and cross, but in such a manner, that those of the olivary fasciculi are situated more superficially than the others. The grey or cortical substance is deposited on the surface of the superficial fibres, and receives some very delicate vascular ramifications, which the pia mater furnishes.[1] The cavities which previously existed

[1] Reil observes (Loc. cit. p. 215), that the tubercles are four rounded masses of grey substance, applied on the radiation of the loop which expands beneath them.

gradually diminish, and at length disappear: the diminution accompanies the increase of their walls, and continues, until there no longer remains, between the fourth and third ventricle, but a narrow canal of communication, constituting the aqueduct of Sylvius.

M. Gall[1] imagines, that the anterior pair of tubercles are the origins or ganglia of the optic nerves, because he was enabled to trace these latter into their interior. Prior to him, different anatomists had already placed a part of the roots of the visual nerves in these bodies; such as Morgagni, Winslow,[2] Zinn,[3] Santorini,[4] Girardi,[5] and Sœmmering.[6] The facts which I

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[1] Anatom. et Physiol. du Système Nerveux, p. 86, pl. xv.

[2] Exposition Anatomique, Traitè de la Tête, No. cxxxvi. " Les nerfs optiques, outre leur origine des grosses éminences, ont une espèce de communication avec les tubercules quadri-jumeaux antérieurs, par des filets très déliés, dont une extrémité se confond avec ces tubercules."

[3] Descript. Anat. Oculi Humani, p. 1711.

[4] Observationes Anatomicæ, p. 63.

[5] Santorini Tabulæ Anatomicæ.

[6] Vom Bane des Menschlichen Koerpers, t. v. pl. i. p. 148.

have collected support this opinion. On dissecting the brain of a fœtus of the latter end of the third month, I discovered the optic nerves, and succeeded in tracing them into the interior of the tubercula quadrigemina, as also to the surface of the optic chambers. I have frequently repeated the same observations in fœtuses of four and five months. At this period the corpus geniculatum externum did not exist ; this production only appeared evident on the sixth month, in the form of a soft vascular unfibrous mass, covered by the pia mater ; it afterwards gradually augmented in volume during the course of the following months. I therefore consider the tubercula quadrigemina and corpus geniculatum as the principal roots of the optic nerves, without, however, asserting that they are the only ones, while it is possible to trace some of their fibres as far as the surface of the optic chambers, both in the brain of the fœtus and of the adult.

I now proceed to the consideration of those parts which, in the brain of animals, correspond to the tubercula quadrigemina in man ; and we shall see how far the resemblance may hold between these and the corresponding parts at the different periods of their formation in the fœtus. But I shall follow a different path from that which I have hitherto traced ; that is to say, in place of proceeding from animals the most simple to the more complex, I shall descend from the latter to the former, passing from the compound to the simple.

So far as we can judge from the observations hitherto collected, the tubercula quadrigemina exist in the brain of all mammiferous animals. In the European species which I have dissected, they possess the same structure as in man, that is to say, are composed of a layer of grey or cortical substance, beneath which is the medullary portion. This latter is partly composed of fibres, which rise from the olivary fasciculi, and unite on the middle line, and partly too of other fibres proceeding from the cerebellum. In all mammiferous animals, the greater number of the roots of the optic nerves arise from the tubercula quadrigemina, principally from the anterior pair, as M. Gall has demonstrated,[1] and which the committee appointed by the Institute to exa-

[1] Loc. cit. p. 80.

mine his work have admitted.[1] The common mass of the tubercula quadrigemina contains small cavities or depressions, described and represented for the first time by the Wenzells.[2] As these cavities are more ample in young mammiferous animals than in those which have attained an adult age, we may consider them as the remains of what were observed in the brain of the fœtus. The tubercula quadrigemina are covered by the hemispheres of the brain in the Quadrumana, Carnivora, Ruminantia, and Solipeda; but in the Rodentia, such as the beaver, hare, marmotte, squirrel, cavia, rat, and mouse, they are not quite covered, and appear between the cerebellum and brain, as in the human fœtus of the fourth and fifth months.

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[1] "Rapport fait à l'Institute sur un Mémoire de MM. les Docteurs Gall et Spurzheim, par MM. Cuvier, Tenon, Portal, Sabatiér, et Pinel, dans les Annales du Muséum d'Histoire Naturelle, t. ii. p. 353." Il est certain que, dans tous les quadrupèdes, le faisceau principal du nerf optique vient des nates et du corpus geniculatum externum.

[2] De Penitori Structurâ Cerebri, p. 166. Scrobiculi in canali corporum quadrigeminorum tam in homine quam in mammalibus.

Such also is the case with the bat, whose cerebral organization approaches in many respects to that of inferior animals, as he possesses a brain without convolutions. The volume of the tubercula quadrigemina is more considerable in proportion to that of the brain, as the latter possesses a more simple structure. It is in man, and in the Quadrumana, that these parts present the least relative volume ; next in order are the Carnivora, then the Ruminantia and Solipeda ; while, on the contrary, in the Rodentia and Bat genus, the greatest relative volume occurs. The relation between these parts and the brain is absolutely the same in the human fœtus ; that is to say, they are more voluminous, in proportion as the embryo is younger ; and become much smaller still, in proportion to the encephalic mass, as the fœtus advances nearer the term of its perfect organization. With regard to the respective volume of the eminences, there exists much variety. The two pair are both nearly of the same size in man and in the Quadrumana ; however, in man, we find sometimes the anterior tubercles more developed than the posterior, while sometimes we find the contrary take place. The posterior pair is always more voluminous than the anterior in the Carnivora; but the anterior pair present the greater volume in the Ruminantia, Solipeda, and Rodentia, according to the observations of Sœmmering,[1] Cuvier, and Gall, in support of which I add my own observations. We are still ignorant on what these differences depend. Although I regard, with MM. Cuvier and Gall, the tubercula quadrigemina, particularly the nates, as the principal roots of the optic nerves, still I cannot adopt the opinion which they offered, as a simple conjecture however, and according to which the testes should be the roots of the olfactory nerves; neither anatomy nor physiology furnish any fact in support of this hypothesis.

Much discussion has arisen on the existence of parts analogous to the tubercula quadrigemina of man and the mammiferæ, in the brain of birds. Willis[2] first asserted that birds were destitute of them; indeed, if we take the term

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[1] Vom Hirn und Rückenmark. Mayence, 1788, in 8vo. p. 91.

[2] Anatomia Cerebri, p. 23.

tubercula quadrigemina in its rigorous acceptation, he was correct; yet we shall find that birds possess really this cerebral organ, but under a different form from that observed in man and mammiferous animals arrived to an adult age. Anatomists are aware, that immediately in front of the cerebellum in birds, are two large, smooth, round, or oval eminences, separated above by a longitudinal depression. As the optic nerves arise from these eminences, a fact of which there is no doubt, they have been compared to the optic chambers of man and mammiferous animals, and hence have received their name: as Collins,[1] Haller,[2] Vicq d'Azyr,[3] Ebel,[4] Malacarne,[5] Cuvier,[6] and some others have termed them. M. Gall[7] first pointed out

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[1] System of Anatomy, t. ii.

[2] De Cerebro Avium, in his Opera Minora, t. iii. p. 191.

[3] Mémoires de l'Acad. des Sciences, 1783.

[4] Observationes Neurologicæ, t. i. fig. 12, 13.

[5] Esposizione delle parti relative all'encefalo degli uccelli: Memoire di Verona, t. i. p. 6.

[6] Anatomie Comparée, t. ii. p. 162.

[7] Untersuchungen über die Anatomie des Nervensystems. Paris, 1809, in 8vo. p. 40; Anatomie et Phy-

the error of considering them analogous to the optic chambers, and asserted that they corresponded to the anterior part of the tubercula quadrigemina. Although different anatomists, and very recently M. Frank,[1] a pupil of Reil's, opposed this opinion, M. Cuvier[2] has

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siologie du Système Nerveux. Paris, 1810, in 8vo. p. 36.

[1] Diss. de Avium Encephali Anatome. Berlin, 1812, in 8vo. p. 36; Reil's Archiv. für die Physiologie, t. xi. p. 226.

[2] Rapport, p. 337. " On faisait à l'origine que nos anatomistes attribuent au nerf optique, une forte objection, tirée de la structure des oiseaux, qui manquent, disait-on, de nates, quoique leur œil et leur nerf optique soient énormes; mais leur réponse est victorieuse. Ce que Willis, Collins, Haller, et les autres anatomistes après eux, ont nommés couches optiques dans les oiseaux n'est autre chose que les nates eux-mêmes. Les vraies couches optiques sont en avant, avec leur troisième ventricule, leurs pédicules de la glande pinéale, les deux commissures à la place ordinaire, en un mot, semblables en tout à celles des quadrupédes, à la grandeur relative près; les pretendues couches de Haller sont, au contraire, entre la commissure postérieur et la valvula de Vieussens: l'aqueduct de Sylvius passe entre elles; c'est avec lui que communiquent les ventricules qui leur sont propres dans cette classe. Nous avons vérifié cette remarque impor-

since recognised the justice of it, and pronounced in its favour. I also adopt this opinion, but with some restrictions; that is to say, that the eminences now in question do not correspond to the nates only, but are analogous to the entire mass of the tubercula quadrigemina. The following are the arguments in favour of this opinion:—

1°, The supposed optic chambers of birds correspond evidently, with regard to their situation, to the tubercula quadrigemina, such as we observe in the human fœtus; they are completely exposed, a peculiarity also to be met in the latter until the fifth month.

2°, They are very voluminous, rounded, and smooth, as in the fœtus of the first periods of gestation.

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tante; elle ne souffre pas de réplique. Il est d'autant plus du devoir du rapporteur de le reconnaître, qu'il avait adopté l'erreur commune dans ses ouvrages.

" Or, comme les tubercules en question donnent evidemment naissance aux nerfs optiques, dans les oiseaux, ils confirment l'origine qu'on donne à ces nerfs dans les mammifères et dans l'homme au lieu de l'infirmer."

3°, They contain a cavity communicating with the aqueduct of Sylvius, as in the fœtus.

4°, They are formed of medullary fibres, which arise from the lateral parts of the spinal marrow, and which turning inwards, unite by means of a thin medullary plate. A layer of grey substance is mixed with the medullary fibres.

5°, and lastly, We find immediately in front of these eminences, two small swellings situated on the crura cerebri, united together by a commissure, and between which exists the third ventricle. These swellings are then analogous to those termed the optic chambers in man and mammiferous animals.

The optic nerves arise principally from these masses analogous to the tubercula quadrigemina of the human fœtus ; yet I have succeeded in tracing some fibres, particularly the anterior, into the eminences corresponding to the optic chambers. The volume of these masses being proportional, in different birds, to that of the eyes and optic nerves, is a further illustration of their being the principal origins or ganglia of the visual nerves. Thus, in birds which have large eyes, as, for example, the falcon and owl, they are more voluminous than in those which have smaller ones, as in the chicken, duck, goose, and coot, &c.

The details into which I have entered demonstrate very clearly the analogy between the structure of the brain in the fœtus, and that of this organ in the different degrees of the animal scale. We have seen, that there are still true tubercula quadrigemina in the Rodentia, but, as in the human embryo, they are not covered by the hemispheres of the brain. In birds, they are not only exposed, but also hollow, and represent smooth and polished masses, without eminences.

Let us now turn our attention to the parts which correspond to these tubercles in the class of reptiles. In all the animals of this class which I have dissected, particularly in the common tortoise, the hawk's-bill tortoise, very many species of lizards, in the Nilotic crocodile, ringed snake, frog, and toad, we find, in front of the cerebellum, as in birds, two rounded protuberances, oval, and smooth, to which anatomists have also given the name of optic chambers, because they give origin to the visual nerves. These protuberances are hollow, and communicate with the aqueduct of Sylvius. Their thin walls, reflected upwards and inwards, are composed of medullary substance. On examining the brains of very many reptiles, for example, that of the hawk's-bill tortoise, which was preserved for some time in alcohol, I perceived some medullary fibres rising from the lateral parts of the cords formed by the prolongation of the spinal marrow forwards, and spreading into the hollow walls of the eminences in question. These hollow masses, resting on the cords of the spinal marrow, are then analogous to the tubercula quadrigemina. They cannot be the optic chambers, as in all the reptiles mentioned, we find two other small protuberances in front of them, as in birds, which resemble the optic chambers of man and mammiferous animals, and from whence issue some of the roots of the visual nerves. The volume of these masses is also in a direct relation with that of the eyes and optic nerves, so that I have found them larger in the lizard and dragon, than in the tortoise. They resemble still, in another point of view, the tubercula quadrigemina of the fœtus during the first months of uterine life, as they are not united, as in birds; but, on the contrary, are separated in their entire extent, while the margins of their walls touch without uniting together. We are now arrived to a degree still more simple and inferior in the organization of this portion of the brain.

It remains now to consider these tubercles in fishes. Willis first asserted that these animals were destitute of them; and many writers have still followed this author in that erroneous opinion. Anatomists are aware, that in fishes, we find, in front of the cerebellum, two smooth protuberances, round or oval, varying according to the species, and parted by a longitudinal depression. The greater number of authors, as Collins, A. Monro, Camper,[1] Ebel,[2] and Cuvier, have taken these eminences for the hemispheres; Haller[3] and Vicq d'Azyr[4] considered them as corresponding to the optic chambers. Scarpa[5] sometimes termed them the tubercula

[1] See first volume of his works.

[2] Loc. cit. tab. ii. iii. iv.

[3] Loc. cit. vol. ii. p. 166, Du Cerveau des Poissons.

[4] Opera Minora, t. iii. p. 198.

[5] Anat. Disquisitiones de Auditu et Olfactu. Pavia, 1789, folio.

majora cerebri, at other times the corpora, or tubercula olivaria, without explaining the uses which he attributed to them. M. Arsaky[1] named them the tubercula optica, still, however, considering them as analogous to the tubercula quadrigemina. This latter opinion I adopt, many motives inducing me to do so. The protuberances already mentioned are not the hemispheres of the brain, because these latter are found more anteriorly giving origin to the olfactory nerves, as I shall hereafter demonstrate with all the necessary detail. Although the visual nerves proceed from these, I cannot, however, consider them as the optic chambers, while the latter never contain a cavity in their interior. With regard to their situation immediately in front of the cerebellum, they resemble perfectly in this respect the tubercula quadrigemina of birds or reptiles; they arise from the lateral parts of the cords which are continued from the spinal marrow forwards and downwards, and expanding into a sort of membrane, are reflected in-

[1] De Piscium Cerebro, p. 23.

wards to give origin to two cavities, which communicate with the anterior prolongation of the fourth ventricle. They are composed of two layers, the one medullary substance, the other cortical; their borders, reflected inwards, as in reptiles, are in apposition without uniting; and lastly, their volume is proportional to that of the optic nerves and eyes. In effect, in fishes which have small eyes, they are but little marked, and scarcely as large as the eminences from whence the olfactory nerves arise; a disposition which the conger eel, and barbot (Gadus lota), furnish examples of. They are, on the contrary, of moderate volume in the ray and shark; and very large, much more considerable even than the protuberances which furnish the olfactory nerves, in the trout, grayling (Salmo-thymallus), pike, garpike, dorey, stargazer, mullet, carp, barbet, and many species of the genus mullet, sea-breme, (Sparus), and perch. The cavities formed by the reflection inwards of these membranes, contain in most fishes, the ray and shark excepted, small eminences or folds, which rest on the anterior prolongations of the spinal marrow, and which Haller, Vicq d'Azyr, and Cuvier have termed the tubercula quadrigemina, although, properly speaking, they possess no analogy to these. These eminences vary much in form, volume, and number, as we may judge after the minute description given by M. Arsaky. They are peculiarly well developed in the carp, in which we effectively perceive, under each membrane of the tubercula quadrigemina, a large protuberance, slightly bent on itself, convex on the outer side, concave within, the posterior part of which adheres to the anterior prolongations of the spinal marrow. On the internal side of these protuberances, are two other lesser ones, which rise behind from a small round and double eminence, the use of which we are still ignorant of; in the sturgeon, and in very many fishes, they communicate with the cerebellum.

OF THE OPTIC CHAMBERS.

On the second month we perceive, immediately in front of the tubercula quadrigemina, two smooth protuberances, completely exposed, two-thirds of a line in length, and mere enlargements of the peduncles of the brain. Towards the commencement of the third month, their length is one line and a half, and their breadth one line and three-fourths; the hemispheres of the brain do not yet cover them. At the end of this month, they measure two lines and a half in length, and the membranous hemispheres are extended over them. These protuberances, the interior of which is full and massive, are now united by a small transverse band, representing the posterior commissure. On the fourth month, each of these eminences measures three lines in length, and one and a third in breadth; on the fifth, three lines and a half in length, and two and a half in breadth. They are evidently enlargements of the peduncles of the brain; for, on scraping the layer of soft unfibrous substance which covers their superior and external part, and which adheres to the pia mater lying over them, we can perceive the fibres of these peduncles, being the continuation of those of the pyramidal fasciculi across the pons varolii. To these are united those exterior fibres of the olivary fasciculi which do not pass into the tubercula quadrigemina. The unfibrous substance covering them is highly vascular, deriving its blood-vessels from the internal surface of the pia mater. The fibres then continue on their course beneath and across the corpora striata, to penetrate into the hemispheres of the brain. From the soft substance spread on their surface, some of the small roots of the optic nerves arise, which unite to some of more considerable size proceeding from the tubercula quadrigemina. The pedicles of the pineal gland take also their origin from this substance. Lastly, from each optic chamber arises a small cord, which descends into the mammillary eminences, and reflected in their interior from below upwards, forms the commencement of the anterior pillar of the fornix, to which I shall hereafter return. The mass and volume of the optic chambers augment, during the course of the following months, in proportion to the progressive developement of the hemispheres. They measure each three lines and a half in length, and three in breadth, on the sixth month; six lines and a half in length, and three in breadth, on the eighth; and nine lines in length, and five and a half in breadth, on the ninth. According as they enlarge, the volume of the crura cerebri, which traverse them, becomes more considerable, the exterior layer of unfibrous substance augments, and the number and calibre of the blood-vessels increase also. The posterior commissure, apparent towards the end of the third month, increases too ; transverse fibres are evidently seen in its tissue, and it becomes a true means of union between the two chambers. I did not perceive until the ninth month the commissura mollis,[1] which unites the internal surfaces of the optic chambers, and which is extended like a bridge over the third ventricle.

Anatomists in general have erroneously considered the eminences in question as the origins of the optic nerves, as the name implies. The comparison established between them and the parts from whence the visual nerves arise in birds, has contributed much to credit this error. In truth, Willis, Collins, Haller, and many of the successors of the latter, without even excepting Frank, supposed the hollow protuberances of birds analogous to the optic chambers of man. I have already shown the motives which necessitate the denial of such a comparison, and which require our considering these parts as

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[1] The Wenzells are said to have met this commissure once on the fifth month, and again on the seventh.—De Penitiori Structurâ Cerebri, p. 128.

organs corresponding to the tubercula quadrigemina. The most important motive, however, is deduced from the following fact; that, in front of the masses which produce the optic nerves, we still find, in the brain of birds, two other very small eminences, constituting the true enlargements of the peduncles of the brain. The fibres of the arms of the medulla oblongata traverse these second masses and pass into the hemispheres, where they are covered above by a layer of grey unfibrous vascular substance. These two protuberances are united by a very delicate commissure, and comprise between them the third ventricle. They are then distributed absolutely in the same manner as the optic chambers in the brain of man. The structure of the brain of reptiles is also in support of this opinion. I have found in that of the frog and toad, in front of the hollow protuberances analogous to the tubercula quadrigemina, from whence arise the optic nerves, two other small massive eminences, which were not covered by the hemispheres, as was observed in the human fœtus. These masses constitute the two enlargements of the anterior part of the peduncles of the brain, and are united by a commissure.

I have perceived two similar ones, equally small and massive, in the brain of the ringed snake and grey lizard, in front of the hollow protuberances which give origin to the optic nerves; in these animals they were united by a commissure, and their posterior part was not covered by the hemispheres. I also observed them in the brain of the testudo imbricata and common tortoise; but in both these reptiles, they were covered by the hemispheres. Fishes have hitherto presented nothing which could be compared to these bodies.

M. Gall,[1] who has justly supposed that the visual nerves arise from the tubercula quadrigemina, considers the optic chambers as the organs of reinforcement of the peduncles of the brain; he terms them the great cerebral ganglia, to distinguish them from the corpora striata, which he names the lesser ganglia. According to him, they augment the volume of the pyramidal fasciculi, which traverse them, furnishing cortical substance and new medullary fibres. Reil[2] likened them to a sort of button applied on the

[1] Anatomie du Cerveau, p. 198.

[2] Archiv. für die Physiologie, t. ix. p. 159.

internal side of the crura cerebri, serving as a point of concentration for the fibres of these latter, from whence they afterwards expand in the whole cerebral mass. Concluding therefore that they were erroneously termed the optic chambers, he has styled them the system of the cerebral peduncles. They appeared to him as organs effecting the radiating expansion of the fibres of these cords into the posterior lobes ; that is to say, he assigned to them the office of effecting a retrograde radiation, and considered them as the focus of organization of the crura cerebri, the central point of the general expansion. He supposed that the optic nerves, in arising from their substance, were merely placed in immediate relation with the principal centre of the brain.

We cannot but assent to the opinion of Reil, when we consider that the crura cerebri, formed in great part by the pyramidal fasciculi of the spinal marrow, have really acquired an increase in volume in traversing the optic chambers, on their exit from which they spread into the hemispheres of the brain a greater number of fibres than composed them before their entry there. The increase of these two cords is a consequence of the numerous blood-vessels which the optic chambers receive, and the result of a great deposition of cerebral substance, by which new medullary fibres are formed. The abundance of the cortical substance found in the optic chambers accounts for the multiplicity of blood-vessels there, as all anatomists agree in considering the cortical more vascular than the medullary. This great afflux of blood augments the mass of these eminences, and communicates a greater degree of activity, supplying more abundantly their nutrition. Although the anterior roots of the visual nerves arise from the optic chambers in man, mammiferous animals, birds, and reptiles, this circumstance seems not sufficient to authorize the supposition, that they are their sole and single origin, as the anatomy of animals apprizes us, that their volume is not in a direct relation with that of the optic nerves, but that they are much larger according as the hemispheres have acquired a greater degree of developement. In effect, in amphibious animals whose hemispheres are small, the traces of them are so slight, as to have induced anatomists to have totally overlooked them ; but they are larger in the Rodentia, as also in the hedgehog and bat, and more prominent still in proportion in the

Carnivora and Ruminantia; and lastly, in the brain of man they present the greatest dimensions. In the fœtus, too, we have seen their volume augment in the same proportion as that of the hemispheres. All these circumstances lead to the conclusion, that the optic chambers are enlargements of the crura cerebri, destined to afford greater energy to their nutrition, and to the formation of the mass which constitutes them; so that we should consider them as the principal focus of vitality of the crura and hemispheres of the brain.

OF THE PINEAL GLAND.

The pineal gland was not perceptible in the brain of fœtuses two and three months old, nor did I recognise it until the fourth, when it appeared in the form of a small and flat body, the pedicles of which, extremely delicate, arose from the internal border of the superior surface of the optic chambers.[1] It gradually augmented

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[1] The Wenzells have seen it for the first time in a fœtus of the fifth month (Loc. cit. p. 313). Conarium em-

in volume during the course of the following months, but always continued round and flat. Its tissue was so soft as to prevent the examination of its structure. It adhered constantly to the pia mater by delicate blood-vessels. The Wenzells have never met concretions in its interior,[1] nor have I been more successful.

Fishes are destitute of this body, at least I have not met it in any species which I have dissected. Haller[2] did not observe it in the pike nor trout, but he pretended to have seen it in the carp and tench. Camper neither found it in the cod-fish nor haddock, nor have Vicq d'Azyr, Cuvier, or Arsaky made any mention of it: it appears not to exist in fishes, nor during the first periods of life of the human fœtus. But reptiles possess it, at least I have observed it in the hawk's-bill tortoise, wall lizard, and ringed snake. It is situated immediately behind the hemispheres of the brain, where it appears in the form of a small round soft body.

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bryonis quinque mensium reperiebamus acûs capituli minoris magnitudinem adæquans; rotundum prætereà erat multùmque pallidum.

[1] Loc. cit. p. 313.

[2] Opera Minora, t. iii. p. 216.

Its pedicles, which are very delicate, arise evidently, as in the human brain, from the superior surface of the enlargements of the crura cerebri situated in front of the tubercula quadrigemina. These two pedicles unite behind, and form a small mass, which is the gland itself. It is also found in birds, which Haller erroneously denied, although Borrich and Harder had already found it in the eagle, and Perrault in the ostrich. Vicq d'Azyr, Cuvier, and Malacarne have also observed it in birds. It is situated behind the hemispheres of the brain, immediately under the pia mater, united to it by delicate vessels, and of the form of a small elongated or pyramidal body. Its pedicles proceed from the surface and internal border of the enlargements of the crura cerebri. As we always find it in reptiles and birds in front of these enlargements, and not in front of the tubercula quadrigemina, it is a new proof of the error into which anatomists have fallen, in considering the hollow protuberances, from whence the optic nerves arise in these animals, as analogous to the optic chambers of man. I have not observed any concretions in the pineal gland of reptiles or fishes, no more than in that of the fœtus.

We find this gland in the brain of mammiferous animals; but it varies in size, figure, and structure. It is small, and of a round form, in the Carnivora, as the dog, fox, cat, marten, &c.; voluminous, oblong, and nearly conical, in some of the Rodentia, for example, in the beaver and marmot; but small and round in other Rodentia, as the hare, rabbit, &c. Its volume is much more considerable, in proportion to that of the brain, in the Ruminantia than in man; but it differs in its form, according to the species; it is nearly round in the sheep, elongated and cylindrical in the ox, and very nearly cordiform in the hind. In the horse it is large, oblong, and very hard; in the pig, voluminous, elongated, and somewhat thicker in the centre than at either extremity. In all mammiferous animals its medullary pedicles arise from the superior surface of the optic chambers, and even a little from the nates; they are united together by a mass of reddish-grey substance, which constitutes the gland itself. This latter is hollow in the hind and sheep.[1] I have never found

[1] Thus as Vicq d'Azyr has already remarked (Loc. cit. p. 484.

concretions in that of any mammiferous animal, nor have the Wenzells either.[1] Sœmmering, however, has observed some in the fallow-deer (Cervus dama),[2] and Malacarne[3] in the goat. M. Gall[4] regards the pineal gland as a ganglion, giving origin to nervous or medullary cords; however, I should be more inclined to consider it as a commissure of the two optic chambers, increased by a deposition of grey vascular substance.

OF THE CORPORA STRIATA.

On examining the brain of a fœtus of two months, we perceive, in front and on the side of the enlargements of the crura cerebri, or optic chambers, two small narrow protuberances, one line in length, completely exposed, and evidently the rudiments of the corpora striata. On the

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[1] Loc. cit. p. 151.

[2] Vom Hirn und Rückenmark. Mayence, 1788, in 8vo. p. 92.

[3] Encefalotomia di Alcuni Quadrupedi. Mantone, 1795, in 4to. p. 31.

[4] Loc. cit. p. 222.

commencement of the third month, the protuberances have become a little more voluminous, and are partly covered by the hemispheres of the brain reflected inwards from their external border. Towards the end of the same month, they are both two lines and a half in length, and one in breadth; they appear as crowning or constituting a veritable enlargement of these parts. The crus cerebri commences along its external border to expand into the hemisphere, which, reflected inwards over this protuberance, forms thus the lateral ventricle, comprised between its summit and the internal surface of the hemisphere. Its superior surface, the floor of this ventricle, is smooth and convex, a depression separating it from the optic chamber. In the course of the following months, the corpora striata, winding round the crura cerebri at the point where their fibres radiate in the hemispheres, gradually augment, and increase in the same proportion as these latter acquire thickness and a greater developement. Their anterior portion, the broader, dips into the anterior cornu of the lateral ventricle; and the posterior, the narrower, plunges into the descending cornu of the same cavity. On the sixth month, they both measure seven lines in length, and three and a half in breadth in front, and one line and a half behind. Between these bodies and the optic chambers exists a depression lodging a small blood-vessel, for the tœnia semicircularis is not yet in existence. If we make an incision into the posterior part of the corpora striata, and detach them from the crura cerebri, on which they rest, reflecting them inwards, we may distinguish perfectly the radiation of the fibres of the peduncles, which on their exit from the optic chambers expand into the hemispheres. Many of these fibres proceed upwards, into the corpora striata, covered on their superior surface by a soft unfibrous substance, which dips in between them. Numerous blood-vessels penetrate the corpora striata, coming from the superior surface and from the choroid plexus, as also from the inferior and external part of the fissure of Sylvius, and from the artery lodged in this groove.

On the seventh month, these bodies, which are then voluminous, smooth, and convex above, are nine lines in length; and lastly, on the ninth month, they have attained fifteen lines. At this period, they no longer form a well-defined eminence, but appear more sunk in the external wall of the hemisphere, which has itself become thicker. Between these bodies and the optic chambers we observe a soft vascular mass, filling the depression which had previously existed in this point. It rests upon a small vessel, and represents the horny plate, or tœnia semicircularis. On examining a recent brain of this age, we recognise that the difference between the white and grey substance of the corpora striata is not so striking as in the brain of the adult, and that these bodies are formed by an uniform and reddish vascular mass.[1] The term corpora striata is not applicable to these bodies in the fœtus.

If we turn to the consideration of such parts as correspond to these bodies in the brain of animals, we shall find, at least in essential points, the same successive formation as in the human fœtus. There are no corpora striata, properly called, in fishes, as Haller has already well observed; to admit them indeed in these

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[1] The observations of the Wenzells agree perfectly with mine. (Loc. cit. p. 306.)

animals, it would be necessary to suppose that the masses from whence the olfactory nerves arise, and which are considered as analogous to the hemispheres, represent these latter, and the corpora striata. We shall see hereafter if there exist sufficient motives for adopting such an hypothesis.

The corpora striata exist indubitably in reptiles. On making a longitudinal incision into the small pouches which constitute the hemispheres of their brain, and removing aside the thin wall of the ventricle thus opened, we perceive laterally, on the floor of the ventricle, an oblong protuberance, smooth above, and partly covered by the choroid plexus. It lies anterior to, and on the side of the enlargement of the cerebral peduncle, analogous to the optic chamber of mammiferous animals, from which it is separated by a depression or groove, as in the brain of the younger fœtuses. It is composed of unfibrous substance, of a reddish-white colour, into which dip, from above downwards, the blood-vessels coming from the choroid plexus. This substance rests on the fibres of the crus cerebri, at their exit from the enlargement, that is to say, at the point where they turn outwards, to constitute the thin and membranous wall of the hemisphere. We cannot then doubt that this protuberance is analogous to the corpus striatum of fœtuses of the third and fourth months. Its volume varies according to the species, always, however, proportional to the extent and size of the hemispheres. In the frog, toad, and land-salamander, which among reptiles possess the smallest hemispheres, the corpora striata are very thin. They appear better developed in the ringed snake and grey lizard, where the hemispheres are larger than those of the preceding reptiles. In the hawk's-bill and common tortoise, Nilotic crocodile, and Guana (Lacerta iguana), I have found them the most voluminous, as these animals possess hemispheres of considerable size.

The protuberances analogous to the corpora striata are very prominent in birds, as Vicq d'Azyr, Cuvier, and other anatomists have well remarked; they form two large masses, which constitute the greatest part of the hemispheres of the brain. Their convex and smooth surface, perceptible in the lateral ventricle, is covered by the choroid plexus, from which vessels pass into their substance. They are parted by a slight depression, from the small swellings of the cerebral peduncles, or optic chambers; consequently the tœnia semicircularis exists neither in birds nor reptiles, nor also during the first periods of uterine life of the fœtus. The superior part of the corpora striata is composed of a reddish-grey vascular substance, but the mixture of grey and medullary matter is perceptible at their base. The crura cerebri, after having formed the enlargements already mentioned in the preceding chapter, pass into the corpora striata, and afterwards expand into the thin membranes of the hemispheres, which bending upwards, inwards, and backwards, produce the lateral ventricles, and cover in these cavities.

These bodies exist in the brain of mammiferous animals; Willis has observed them in the sheep, Collins in the cat, and Stukeley in the elephant. These three writers have described and represented them. In the hare, rabbit, beaver, squirrel, and hedgehog, they form, as in birds, the greater part of the hemispheres of the brain, and are separated from the optic chambers by a superficial groove. These animals possess a very narrow tœnia. The corpora striata are small in proportion to the brain, in the dog, cat, fox, ox, sheep, and horse ; but this apparent defect of relation evidently depends on the greater augmentation of the hemispheres, by the addition of superior encephalic layers, in which the convolutions are hollowed. In the Rodentia and hedgehog, these layers and convolutions do not exist. In the Carnivora, Ruminantia, and Solipeda, the corpora striata represent oblong protuberances, smooth and convex above, arising from the floor of the lateral ventricles, and uniting to the optic chambers by the tœniæ. Their superior surface consists of a grey unfibrous substance, penetrated by vascular ramifications from the choroid plexus ; the middle layer, of a mixture of grey and medullary substance; and the inferior, of medullary alone. The fibres of the crura cerebri, after having traversed the optic chambers, penetrate the corpora striata, and afterwards expand, from without inwards, and from below upwards, into the hemispheres.

These details prove, that in reptiles, birds, and mammiferous animals, the crura cerebri, after having quitted the optic chambers, pass into the corpora striata, where their mass is considerably increased by a mixture of grey substance. Surely the numerous arteries with which this substance is provided, impress a more energetical activity on the phenomena of its nutrition ; while it is very evident that the fibrous fasciculi which radiate in the external wall of the hemispheres, are more voluminous on their exit from the corpora striata, than before their entry there. Such also is the observation of Reil and Gall : while the former has termed the corpora striata, the great superior cerebral ganglia ; and the latter, the great, or anterior cerebral ones.

OF THE ANTERIOR COMMISSURE.

The anterior commissure does not exist on the second month ; I did not perceive it until the third. It was at first thin and delicate, but gradually augmented, in the course of the following months, according as the hemispheres and corpora striata were developed. It consisted of a cord of medullary fibres, closely connected together, and incased by the pia mater. This cord, situated transversely, and uniting the two hemispheres together, passed into the corpora striata, and was reflected backwards, dipping into the middle lobes of the brain. Here it expanded into a great number of delicate fibres, which united with those coming from the crura cerebri, and ultimately passed into the corpora striata. The anterior commissure arises in the following manner : the crura cerebri, after having penetrated the corpora striata, expand their numerous medullary fibres into the hemispheres, very many of which, inclining from behind forwards, and from without inwards, mutually approach and unite to those of the opposite side.

The anterior commissure forms the union between the radiations of the crura cerebri, corpora striata, and the two middle lobes of the cerebral hemispheres. Willis was the first anatomist who considered it as a commissure of the corpora striata. Varolius, Vieussens, Santorini, Vicq d'Azyr, and many others, have described it without mentioning the manner of its formation. M. Chaussier has been well aware of its origin ; he has described it as proceeding from the fibres which constitute the crura cerebri. M. Gall[1] regards it as belonging, with the posterior commissure and corpus callosum, to a

[1] Anatomie du Cerveau, p. 20.

system of organs, composed of converging fibres, which he supposes to arise from the grey substance of the convolutions of the brain. These re-entrant fibres are imaginary objects, and do not naturally exist, as I shall hereafter show. He observes,[1] that the anterior commissure is formed by the re-entrant fibres arising from the anterior convolutions of the middle lobes, and from some of those near the fissure of Sylvius, and that these fibres proceed inwards in order to form it by their union. The following facts show that he is equally wrong in this point. The anterior commissure exists in the brain of fœtuses of three and four months, consequently at a period when there are no convolutions, for these latter only appear at a subsequent period. It cannot then be formed by the converging fibres of parts which are not yet in existence. Reil[2] had a more correct idea of the structure of this part, for he observes, it unites the two middle lobes (the radiations of the two cerebral peduncles), and resembles much the eminences by which the fornix terminates in the lateral ven-

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[1] Loc. cit. p. 204.

[2] Archiv. für die Physiologie, t. xi. p. 94.

tricles ; but the origin and formation of this body had escaped his sagacity.

In fishes, the two protuberances from which the olfactory nerves arise, are united by a white and medullary commissure. This body exists in all reptiles and birds. On cautiously separating the superior part of the hemispheres of the brain of the frog, toad, lizard, snake, tortoise, and that of birds, we observe that they are nearly separated by a groove, and merely connected together by a small transverse cord of medullary substance, which dips into each hemisphere. This cord having passed under the protuberances analogous to the corpora striata, expands into a certain number of fibres which are lost in the substance of the hemispheres, and anastomose with those of the crura cerebri. As there are no convolutions on the brain of these animals, and as they possess an anterior commissure, we perceive that M. Gall has been deceived in supposing this latter to arise from the convolutions, observing, that it is composed of re-entrant fibres. The anterior commissure is also met with in mammiferous animals ; here it forms a transverse white cord, situated in front of the anterior pillars of the fornix, uniting the two hemispheres together, and resulting from an assemblage of medullary fibres, which take very nearly the same direction with the same connexions as those which are sent by the crura cerebri into the hemispheres. In such of the mammiferous animals (in particular among the Carnivora, as the dog, and among the Ruminantia and Rodentia,) as possess the olfactory nerves well developed, the anterior commissure unites also the two enlargements of these nerves; a remark which has already been made by Cuvier.[1]

OF THE EXTERIOR PARTS OF THE HEMISPHERES OF THE BRAIN.

In the fœtus of the second month we perceive, on either side, in front and along the small tubercles corresponding to the corpora striata, a thin delicate membrane, which scarcely covers them, and formed of medullary substance, reflected backwards and inwards, and covered by the pia mater. This is the rudiment

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[1] Rapport, p. 368. " La commissure antérieure du cerveau s'unit évidemment aux nerfs olfactifs dans les animaux."

of the hemispheres of the brain. The diminutive size of these latter accounts for the optic chambers, tubercula quadrigemina, and cerebellum being exposed at this period. On the commencement of the third month, the membranous hemispheres completely cover the corpora striata, and are three lines in breadth. Towards the end of the same month they have acquired more considerable dimensions, and are then four lines in length, five in breadth, and three deep: they cover not only the corpora striata, but even the optic chambers; but do not yet extend over the tubercula quadrigemina. Each hemisphere is only composed of an anterior lobe, for the middle and posterior form but a small rounded appendage.

On the fourth month the hemispheres are ten lines in length, five in breadth in front, and eight behind. They are prolonged considerably backwards, so as not only to cover the corpora striata and optic chambers, but also the anterior part of the tubercula quadrigemina. Their superior surface is smooth, presenting here and there a few slight depressions, into which the pia mater sinks. Laterally and beneath we find them divided by a groove (the fissure of Sylvius), into an anterior large lobe, and into another small mass corresponding both to the middle and posterior lobes. From this fissure, which lodges the lateral artery of the brain, arises the olfactory nerve, very large, hollow, and directed upwards and forwards. The hemispheres are two large membranous sacs, into which the choroid plexus penetrates by their internal part, above the optic chambers; the thicker portion of their walls corresponding inwards, to the level of the corpora striata, and the thinner portion inwards and backwards. On the fifth month, the hemispheres are one inch three lines in length, and about one inch broad behind. Although they are much elongated in this latter direction, still they do not cover altogether the tubercula quadrigemina.

On the sixth month, they are one inch six lines and a half in length, and one inch in breadth in front, and one inch three lines behind. At this period, they cover not only the entire of the tubercula quadrigemina, but still the greater part of the cerebellum. On their internal or commutual surface we can already perceive many grooves, the rudiments of the convolutions; while their superior and lateral surfaces are smooth. Underneath we observe the anterior, middle, and posterior lobes. The two great anterior lobes are parted from the middle by the fissures of Sylvius, which lodge the middle arteries of the brain, the continuation of the trunks of the internal carotids. From the walls of these lobes arise the olfactory nerves, very voluminous, proceeding inwards and forwards, and terminating by an enlargement or swelling. The middle lobes, which form a round prominence, are separated from the posterior by a slight depression.

On the seventh month, the brain is one inch ten lines in length, one inch two lines in breadth before, and one inch five lines behind. It has so augmented in volume, that it not only covers the tubercula quadrigemina and cerebellum, but extends even a little beyond this latter organ. Depressions appear here and there, the rudiments of the convolutions and anfractuosities, and into which folds of the pia mater sink. The fissures of Sylvius are deep, and ascend high up into the substance of the brain, inclining a little backwards; they lodge the middle arteries of the brain, which send into the substance of this organ a number of ramifications, for the nutrition of the corpora striata.

On the eighth month, the hemispheres which cover the cerebellum, and are prolonged even beyond its posterior border, are two inches eleven lines in length, two inches one line in breadth, and one inch ten lines deep. On examining their inferior surface, we perceive the anterior, middle, and posterior lobes, the respective limits of which are well defined. Grooves and depressions appear in different places, lined by folds of the pia mater; these are more numerous on the surface of the anterior and middle lobes, than on the posterior.

On the ninth month, the hemispheres are three inches four lines in length, and two inches seven lines in breadth. They now present exactly the form observed in the adult, and are covered with convolutions and anfractuosities.

After this view, it is evident that the hemispheres of the brain are formed on the sides and from before backwards ; that they constitute at first but a thin and medullary membrane, reflected inwards and forwards; that they augment gradually in volume and thickness; and that according as they increase, they extend over the corpora striata, optic chambers, tubercula quadrigemina, and cerebellum, so as at length to cover all these parts. We observe precisely the same manner of formation in the hemispheres of the brain of animals, except that they are arrested, in the different species, in different degrees of developement, which those of the fœtus pass through in their successive evolution. Proofs, in support of this fact, are furnished by the examination of the brain of animals.

In all osseous fishes, and in the cartilaginous of the genus sturgeon, we find, anterior to the protuberances from whence the optic nerves arise, and which correspond consequently to the tubercula quadrigemina, two full and massive eminences, which give origin to the olfactory nerves. Haller termed them the superior tubercles of the olfactory nerves. Vicq d'Azyr, Cuvier, and some anatomists, called them the protuberances or ganglia of the brain from whence the olfactory nerves arose; and M. Arsaky represented them as the tubercles of the olfactory nerves, and considered them as analogous to the hemispheres. They are in general of an oval form; sometimes smooth, sometimes covered with slight depressions and prominences resembling small convolutions. Camper has observed these anfractuosities and prominences in the brain of the cod-fish; and Vicq d'Azyr[1] perceived them in very many other fishes. I have seen them in the ray, the flying-fish (Trigla volitans), which inhabit the mediterranean, in the star-gazer, dorey, gudgeon, burbot, trout, grayling, and common salmon, &c.

The volume of these protuberances varies according to the species. Thus I have found them infinitely larger than those from whence the optic nerves arise, in the burbot and accipenser stellaris. However, they are in general less voluminous, as we observe in the genus star-gazer, dorey, pike, salmon, and breme, &c. They are composed of a grey or reddish-white substance, united together by a small anterior medullary commissure. Some fibres of the crura cerebri pass into their interior, and are lost in the olfactory nerves, to which they give origin. I consider them as analogous to the corpora striata, on the external borders of which the membranous hemispheres are not yet elevated. The analogy which exists between them and

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[1] Mémoires de l'Acad. des Sc. ann. 1783, p. 473. "Les tubercules antérieurs offrent dans quelques-uns des incisions ou petites circonvolutions."

these bodies in the fœtus, during the first periods of developement, is much in favour of this opinion, as also the presence of the anterior commissure, and their giving origin to the olfactory nerves. The other small eminences, anterior to these, vary in number, and should be considered as simple enlargements of the olfactory nerves. We find four of these swellings in the eel, two in the sturgeon, flounder, and pike, and none in the haddock or breme.

The brain of cartilaginous fishes, particularly of the ray and shark, present two voluminous masses, united together, from whence the olfactory nerves arise; they are hollow, as M. Arsaky observes, and their cavity is prolonged into these nerves. Properly speaking, the superior wall of these masses (that which covers the ventricle) is formed by a membrane of a greyish-white colour, reflected inwards and backwards, and into which the fibres of the crura cerebri expand; the pia mater, which covers it on the outer side, passes by the posterior part into the cavity, which it also lines. Thus we perceive the first rudiments of the hemispheres of the brain.

These hemispheres exist in all reptiles which

I have hitherto dissected. Vicq d'Azyr has improperly termed them the ganglia of the olfactory nerves. Anterior to the two masses, analogous to the tubercula quadrigemina, and which produce the optic nerves, we observe two others, rather voluminous, perfectly smooth, and covered by the pia mater ; from the anterior part of these the olfactory nerves arise. These masses, always comparatively larger than the protuberances from whence the optic nerves arise, represent the hemispheres. In the frog, toad, and salamander, their volume is inconsiderable ; they are larger in the tortoise, and in none so well developed as in the lizard, dragon, lacerta iguana, and crocodile. Their form varies somewhat ; they are oval, elongated, and nearly cylindrical, in the salamander ; oblong, and united in front, in the frog and toad ; oval in the grey lizard, hawk's-bill and common tortoise ; and nearly triangular, broad behind, and terminating by a delicate extremity, which becomes the olfactory nerve, in the ringed snake, guan, and crocodile. In the two latter animals they resemble somewhat the hemispheres of birds. On separating their superior surfaces, we observe, in front of the tubercula quadrigemina, the two small optic chambers, supporting the pineal gland, and we thus bring into view the third ventricle and anterior commissure, uniting the hemispheres anteriorly; and, lastly, on each hemisphere, behind and on the inner side, we recognise the opening by which the pia mater enters to form the choroid plexus of the lateral ventricles. If we open into the flattened hemispheres, we expose the lateral ventricles, filled by the choroid plexuses; beneath and on the internal side of which are situated the oblong eminences corresponding to the corpora striata. Each hemisphere represents a membranous sac. The thin medullary membrane rising from the anterior and lateral parts of the corpora striata, is reflected backwards and inwards, and thus constitutes the wall of the ventricle. In this state the hemispheres of the brain of reptiles resemble evidently those of the fœtus of the third month, which present the same inflection, and the same extent posteriorly, covering the corpora striata and optic chambers; leaving however the tubercula quadrigemina exposed, a peculiarity also observable in reptiles.

The olfactory nerves, which arise from the hemispheres, form in the tortoise a small oblong hollow swelling, their cavity being formed by a prolongation of the lateral ventricle. I have observed nothing similar in any other reptile.

The hemispheres of the brain of birds are much more voluminous, more elevated, and more convex, than those of reptiles. However, they do not cover the masses analogous to the tubercula quadrigemina, for we observe them still exposed, as in fœtuses of the first periods of gestation. They represent a heart, their anterior extremities being continuous with the olfactory nerves; no convolutions or anfractuosities are observed on their surface; nor are they divided into lobes, for the fissures of Sylvius do not exist. They are composed of two large prominences, analogous to the corpora striata, which give origin to two medullary plates, reflected backwards and outwards, and which form the lateral ventricles. They are united together by the anterior commissure. The corpus callosum fails, as we have also observed, in the human fœtus, during the first periods of its formation.

The brain of mammiferous animals gradually approaches that of man, in passing through various degrees of organization, which establish some resemblance between it and the brain of the fœtus; but the latter passes with rapidity through the degrees of its developement: the Rodentia and bat genus occupy the lowest degree in this respect. The hemispheres of the Rodentia, particularly of the mouse, rat, marmot, beaver, hare, rabbit, and squirrel, &c. have neither grooves nor convolutions, as Willis had first remarked, but are smooth and flattened. Such also is the case with the bat of this country, the opossum, according to Tyson,[1] the phalangista of Cuvier, and the two-toed ant-eater (Marymecophaga didactyla), according to Daubenton.[2] On the surface of the hemispheres of the hare, rabbit, and squirrel, we observe a few grooves, into which the pia mater sinks. In the Rodentia, and more particularly in the genus rat, in the marmot, beaver, and even in the bat, they extend so little backwards, that the tubercula quadrigemina are partly exposed, as in fœtuses of the fourth and fifth months. We find them also, as in these fœtuses, divided into anterior and middle lobes, by a delicate fissure of Sylvius, which had not until this period appeared.

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[1] Philos. Trans. No. 290.

[2] Buffon, Hist. Nat. t. xiii. p. 94.

In the Carnivora, as the marten, fox, dog, cat;[1] in the Ruminantia, as the sheep,[2] goat, ox,[3] hind; and, lastly, in the pig[4] and horse,[5] the hemispheres are much more voluminous, more elevated, and more convex, and more thickly covered with convolutions and anfractuosities. They cover not only the entire surface of the tubercula quadrigemina, but still a portion of the anterior surface of the cerebellum, as in the fœtus of the sixth and seventh months. A fissure of Sylvius parts the anterior from the middle lobe, with which latter the posterior is found still confounded.

Lastly, in the ape[6] the brain is larger and more convex, and covers even the cerebellum. We observe, as in the full grown fœtus, anterior, middle, and posterior lobes; the convolutions and

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[1] Collins, loc. cit. tab. 55, fig. 2.

[2] Vicq d'Azyr, loc. cit. tab. 8, fig. 1.

[3] Vicq d'Azyr, loc. cit. tab. 8, fig. 2.

[4] Collins, loc. cit. tab. 54.

[5] Vicq d'Azyr, loc. cit. tab. 7.

[6] Blumenbach, de generis humani varietate nativâ. Guttingen, 1778, in 8vo. tab. 1. Basis cerebri papionis mandrill.

anfractuosities are much more numerous than in the animals already mentioned. However, M. Cuvier[1] asserts, that in most of the Quadrumana, with the exception of the chimpansee[2] (Simia troglodites) and Gibbon (Simia lar), we find no convolutions on the posterior lobes. Their developement on these lobes in the human fœtus is much posterior to that on the others.

All these facts establish that the hemispheres in the fœtus, as well as in animals, are developed laterally and from before backwards; that they extend successively in the latter of these directions, over the corpora striata, optic chambers, tubercula quadrigemina, and at length over the cerebellum; that these portions of the brain become gradually more elevated, and more convex; that the convolutions and anfractuosities are gradually developed; and that by their progressive increase the brain becomes eliptical, or nearly globular. Thus the brain of the human adult is distinguished from that of animals, by the volume and depth of the hemispheres, as also by

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[1] Anat. Comp. t. ii. p. 157.

[2] Tyson, Anatomy of a Pigmy, fig. 13, 14.

the greater number of anfractuosities and convolutions. Let us now see how these latter are formed, and the manner of distribution of the fibres of the crura cerebri in the hemispheres.

OF THE CRURA CEREBRI, AND OF THEIR EXPANSION IN THE HEMISPHERES.

On the second month, the fasciculi of the spinal marrow, prolonged into the brain, are curved downwards, underneath the tubercula quadrigemina; this flexion is very apparent in the brain of fœtuses of three months. If at this period we extend this organ, with its enlargements and spinal marrow, on a plane surface, we shall perceive that the two organs present a striking analogy to those of fishes and reptiles, which immediately recalls the ingenious idea of Camper,[1] who endeavoured to explain the mode of conversion of the brain and cranium of a four-footed into a biped animal, or man. The continuity of the middle fasciculi of the spinal marrow with the crura cerebri is perfectly evident

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[1] Vide Monro on Fishes.

in fœtuses of this age, because the pons varolii is not yet in existence. The crura cerebri passing beneath the tubercula quadrigemina, penetrate the optic chambers, which are composed of a mass of unfibrous vascular substance deposited on their surface ; and having become more voluminous, they then pass into the corpora striata, where they are mixed a second time with a similar substance. Lastly, they are converted into a membrane exteriorly, which is reflected backwards and inwards. This reflected membrane represents the hemispheres of the brain, and covers the corpora striata and optic chambers, serving as a coverlet to the enlargement situated interiorly. The space comprised between the enlargements and the membrane constitutes the lateral ventricle. Its thickness is scarcely a quarter of a line, and we can easily reflect it outwards. The pia mater covers it exteriorly, and, passing from thence to its internal surface, forms the choroid plexus in the lateral ventricle.

On the fourth month, the middle and ascending fasciculi of the spinal marrow, continuous with the crura cerebri, are covered by the pons varolii apparent at this period, but its dimensions are inconsiderable; however, it establishes the limits between the pyramids and arms of the medulla oblongata. The two crura separate a little in ascending, while the curvature which they formed on the second and third months is not so apparent, owing to their increase in volume, and to the additional new substance filling up the concavity of this curve. They are evidently composed of fibres continued from the pyramidal fasciculi of the spinal marrow, passing into the optic chambers, where a vascular unfibrous substance is deposited on their superior surface. On scraping this substance, we perceive, without difficulty, the ascending fibres. From the internal and inferior side of the optic chamber, some fibres proceed from each crus, descend into the corpora mammillaria, where, reflected on themselves, they re-ascend to form the anterior pillars of the fornix. All the other fibres of the crura, being very numerous, proceed forwards and outwards, pass under the corpora striata, and expand like a fan in the thin membranous hemispheres. We may perceive this radiating expansion, on detaching and elevating these latter bodies from the crura cerebri; at the same time we observe many fibres ascending to these bodies, where they are covered with an unfibrous vascular substance. Those fibres expanding in the membranous hemispheres, on the external side of the corpora striata, proceed upwards, and are reflected inwards, to form the superior wall or roof of the lateral ventricle; then re-descending along the internal surface of the hemispheres, gain the posterior pillars of the fornix, with which they unite posteriorly. By their union with these pillars, they form the cornu ammonis, appearing at first as a prominent fold on the internal surface of the lateral ventricle. Anteriorly, where the pillars of the fornix arise, the fibres of the two hemispheres unite together, and give origin to the corpus callosum, at this period small and narrow. A horizontal incision into the membranous hemispheres penetrates into the vast cavity of the lateral ventricles, the walls of which are nearly half a line in thickness on the outer side, along the corpus striatum, but scarcely a quarter of a line on the inner side. This difference arises evidently from the fibres of the crura cerebri being in close apposition on the outer side, while within they occupy a greater surface, on account of their radiating expansion. Frequently the membranous hemispheres, at this period, are covered here and there with prominences, or species of folds, the rudiments of the convolutions.

On the fifth month, the crura cerebri, being the continuation of the pyramidal fasciculi across the pons varolii, have acquired a greater developement, and penetrate the optic chambers and corpora striata, augmenting in volume in traversing these ganglia, and at length expand in the hemispheres. The fibres of the two hemispheres unite in front, and on the inner side, where they form the corpus callosum. By a horizontal section of their superior surface, we expose the lateral ventricles, whose membranous walls are a little more than one line in thickness on the outer side, near the corpora striata, their diameter being at farthest one line on the inner side. The internal walls present, on their outer surface, some depressions, corresponding to as many prominences internally.

On the sixth month, the crura cerebri, still more voluminous than during the preceding periods, follow the same route across the optic chambers and corpora striata. If we remove these latter bodies by a horizontal section, from the crura, and reflect them backwards, the expansion of the fibres of each crus in the hemispheres becomes very distinct. They radiate from the lateral parts forwards, backwards, and upwards; while those bending inwards, to form the roof of the lateral ventricle, unite afterwards at the anterior part, to give origin to the corpus callosum, now well marked. The walls of the lateral ventricles have augmented much in thickness. The fibres of the crura radiate not only in the direction indicated, that is to say, upwards and inwards, but also toward the periphery, that is, from within outwards. This is effected by new fibrous layers deposited on the external surface of those previously formed, while their disposition becomes very apparent on breaking the substance of the brain. Exteriorly we observe, on the fibres, a layer of unfibrous vascular substance adhering to the internal surface of the pia mater. The layer of this substance remaining attached to the membrane, and the portion of brain from whence it had been removed, present a flocculent and velvety appearance, and when examined with a magnifying glass, appear formed of small globules. The pia mater, covering the brain on the outer side, produces folds which sink into the grooves on the external surface of the organ.

On the seventh month the mass of the hemispheres is considerably increased by the addition of new layers of cerebral substance, so that a transverse section of the walls of each hemisphere presents four lines three-fourths in thickness on the outer side, on a level with the corpora striata; three lines in front; two lines and a half behind; and one and a fourth on the inner side, towards the middle part. The fibres of the crura pursue their usual direction. The pia mater sends into the soft unfibrous substance, numerous folds, which form superficial grooves.

On the eighth and ninth months, the hemispheres, very large and convex, present numerous convolutions and anfractuosities, the depth of which is considerably less on the eighth than on the ninth month. The crura cerebri are very voluminous, and have much enlarged; they traverse, in the usual manner, the optic chambers and corpora striata, in the interior of which they are covered by an unfibrous vascular substance. Having thus considerably augmented, they proceed toward the external part of the hemispheres, in which the fibres expand like a fan; the middle cerebral artery supplies them with numerous ramifications. By a horizontal section of the external part of the fissure of Sylvius, and by removing the external layers of cerebral substance (in a direction from below upwards) in which the anfractuosities and convolutions are situated, the radiating expansion of the fibres of the crura become perfectly evident. They proceed upwards, forwards, and backwards, and are also reflected from without inwards. Some fibres, appearing to be implanted, as it were, on the preceding, or rather to be a continuation of them, penetrate each convolution, and are covered externally by a very thin layer of unfibrous substance analogous to the grey matter of the brain.

The expansion of the crura cerebri in the hemispheres is effected in the same manner, in reptiles, birds, and mammiferous animals, as in the human fœtus. Of this we may be convinced on examining the brain of these animals. In reptiles and birds, the fibres of these two cords proceed forwards, penetrate the protuberances analogous to the optic chambers of man, as also the corpora striata, and passing outwards and upwards, expand into the thin membranous plates which represent the hemispheres of the brain, covering both these tubercles and the lateral ventricles. The crura cerebri of mammiferous animals are distributed precisely in the same manner. In the Rodentia, which possess neither anfractuosities nor convolutions, the expansion destined to form the hemispheres is merely composed of fibres reflected inwards, which, uniting on the middle line, form the corpus callosum, the surface of which is covered by a thin layer of grey substance. In the Carnivora, Solipeda, and Ruminantia, where the anfractuosities and convolutions are quite apparent, and whose hemispheres are thicker and more convex, we observe some medullary fibres radiating toward the periphery, that is to say, rising from the fasciculus of those which formed the roof of the ventricles, and ascending into the convolutions, where they are covered exteriorly by a layer of grey substance.

Thus the hemispheres of the brain, which are primarily membranous, both during the first periods of uterine life of the fœtus, and in inferior animals, appear after the formation of the spinal marrow, crura cerebri, and their vascular enlargements, the optic chambers and corpora striata; thus clearly proving that they are the product of an expansion of the pyramidal fasciculi of the spinal marrow. In traversing the pons varolii, optic chambers, and corpora striata, these fasciculi augment in volume by the addition of new fibres, and by the deposition of grey substance on their surface. The membranous hemispheres cover successively, in the fœtus, the corpora striata, optic chambers, tubercula quadrigemina, and lastly, the cerebellum. According to their elongation backwards, their mass augments, by new layers of cerebral substance furnished by the vessels of the pia mater. The radiating fibres which constitute their base increase also, while others are applied on their surface, which in place of inclining inwards, proceed, on the contrary, outwards, and tend towards the periphery. The rudiments of convolutions and anfractuosities, observed in fœtuses of the fourth month, are formed by the foldings of the membranous hemispheres. The greater number of these grooves and convolutions are developed during the latter months of gestation, in consequence of the increase of the pia mater, the folds of which sink into the soft cerebral substance covering the exterior of the hemispheres. Such of the fibres of the crura as radiate outwards, pass into the convolutions, on the summit of which they are covered by a soft reddish-grey substance, penetrated by the delicate ramifications of the pia mater, in the form of fasciculi or flocculent pencillæ.

My researches confirm the results which M. Gall[1] has drawn from the progress of the crura cerebri across the optic chambers and corpora striata, into the hemispheres and convolutions; but they refute all what this anatomist has said on his supposed system of re-entrant fibres, as I shall prove in the following chapter, where I shall describe the formation of the corpus callosum. M. Gall[2] has also erred in admitting that the convolutions of the brain are the result of the folding of the original membranous hemispheres. The process which he has employed to demonstrate this folding, and by this means reduce the hemispheres to the condition of a membrane, always produces the rupture of the

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[1] Anat. et Physiol. du Système Nerveux, p. 197, pl. 5. 10. 12.

[2] Loc. cit. p. 209. De la structure des circonvolutions du cerveau, et de leur déploiement où déplissement.

internal layers of fibres of the crura cerebri ; this is clearly quite conclusive.

The description which I have given of the crura cerebri, and of the expansion of their fibres in the hemispheres, agrees perfectly with the observations published by Reil. The prolongation of the pyramidal fasciculi into the crura cerebri, as also their expansion in the hemispheres, after having traversed the optic chambers and corpora striata, have been termed by him[1] the system, or organization of the cerebral peduncles ; that is to say, he justly regards the fibres of this system as forming but one and the same organ. The system of the crura cerebri, he observes, is intermixed and covered with grey substance and vessels, from the pyramids to its termination in the capsule of the brain. The optic chambers possess such intimate connexions with it, that we may consider them as forming a part of it, and these two sets as really portions inseparable from one and the same organization. From the optic chambers the crura cerebri de-

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[1] Archiv. für die Physiologie, t. ix. p. 147.

rive their increase and the radiating direction of their fibres. They form two species of ganglia or buttons on their internal side, where their fibres are united into a common centre, from whence they spread out into an immense circle, whose radii occupy the entire brain, and which Reil has termed the radiating crown. The rays of these crowns traverse the corpora striata, capsules composed of grey substance; they are as it were the sources of the hemispheres, and are well supplied with arterial blood, sent from the middle artery of the brain across the cribriform plate of the fissure of Sylvius. These crowns gradually diverge, in traversing the corpora striata, and appear nearly perfect circles, expanding during their ascension into the lobes of the brain, and forming thus the external and superior wall of the trigiditated cavities or lateral ventricles. So far Reil has been exact in his description; but he is deceived in supposing that the corpus callosum constitutes a peculiar system, imagining that the transverse fibres of this system descend between the radiating crowns, forming a sort of coverlet for them; while the corpus callosum is evidently produced by the extremities of the fibres of the two crura cerebri uniting on the mesial line. [1] *

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[1] Loc. cit. p. 172.

* The formation of the convolutions of the hemispheres, according to the views and researches of M. Serres, possess the highest interest; I shall therefore take the liberty of inserting from his work, the particulars of his researches on this point, and thus run no risk of mistaking the ideas of the author on the formation of these parts of the brain, the description of which he acknowledges to be attended with no little difficulty. "Jusqu'au milieu de la formation des embryons de l'homme, des singes, du veau, du cheval, du lion, du mouton, et du cochon, la surface extérieure de l'encéphale est lisse; on n'y voit que les scissures qui correspondent à la scissure de Sylvius et au contour postérieur des lobes de la base du cerveau. Je fus d'autant plus frappé de cette disposition, qu'en ouvrant l'intérieur des hémisphères, j'aperçus les circonvolutions, très-bien formées en dedans, sur des embryons du commencement du troisième mois de l'homme, du cheval, du veau; sur la fin du deuxième mois, du cochon, et du mouton; je reconnus en même temps qu'il existait, entre ces circonvolutions intérieures et la partie interne de la lame externe des hémisphères, un intervalle d'autant plus étendu que j'observais des embryons plus jeunes. En cherchant quelle pouvait être la cause de ces circonvolutions précoces, je m'aperçus qu'il se détachait, des parties latérales des pédoncules cérébraux qui correspondaient aux couches

OF THE CORPUS CALLOSUM.

The corpus callosum does not exist in the brain of the fœtus on the second month, nor

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optiques et aux corps striés, des feuillets hémisphèriques internes ; ces feuillets étaient plissés dans toute leur étendue, surtout à leur bord libre, qui était flottant dans la cavité des hémisphères ; je comptai cinq feuillets chez l'embryon humain, trois chez les embryons des carnassiers et des ruminans, et deux chez ceux des rongeurs ; ces feuillets étaient plies sur eux-mêmes et ondulés à leur superficie, notamment à leur partie antérieure et postérieure, et à leur partie interne ; ces lames internes étaient enveloppées par le feuillet hémisphèrique extérieur, qui, n'étant pas appliqué encore sur les feuillets internes, ne partageait pas leurs ondulations : cette circonstance expliquait ainsi l'absence extérieure des circonvolutions. En étudiant avec soin cette disposition nouvelle, je rencontrai les branches des artères striées et choroïdiennês serpentant le long de ces lames hémisphèriques ; plus tard, je rencontrai ces lames réunies par leur base, formant un grand faisceau unique, dans les interstices du quel je rencontrai toujours les principaux troncs artériels. Cet effet coïncidait avec l'accroissement des couches optiques et du corps strié. En même temps que les lames s'étaient réunies par leur base, et avaient formé par cette jonction le plateau medullaire, connu sous even on the commencement of the third; towards the end of this second period, however, we find the two membranous hemispheres united ante-

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le nom de demi-centre ovale des hémisphères, je les trouvai beaucoup plus développées en hauteur ; l'intervalle qui les séparait de la lame externe avait disparu ; les ondulations intérieures s'étaient appliquées contre la paroi interne de la lame extérieure ; les saillies des circonvolutions intérieures avaient produit un enfoncement sur la partie interne de la lame externe ; à cet enfoncement intérieur correspondait une élévation extérieure sur la superficie de l'hémisphère. La lame externe s'était enfoncée, en outre, dans les anfractuosités qui séparaient les ondulations des lames hémisphériques internes, ces enfoncemens avaient détermine des proéminences, des bosselures, en dedans de la lame interne ; à l'extérieur de ces bosselures correspondaient des enfoncemens, qui dessinaient, à la superficie des hémisphères, les ondulations qu'on remarquait sur les lames internes. Plus les ondulations intérieures étaient prononcées, plus les circonvolutions extérieures étaient marquées, plus leurs anfractuosités étaient profondes.—Anatomie Comparée du Cerveau, p. 179, &c.—This manner of formation, according to M. Serres, explains why the external convolutions, which are so precocious in the embryo, only become apparent on the external plate, when the optic chambers and corpora striata, into which the internal undulated plates are inserted, have acquired a great developement. (T.)

riorly by a small narrow commissure, nearly perpendicular ; while they are completely separated behind, so that the optic chambers and third ventricle may still be seen. On the fourth and fifth month it is even yet very small, and perpendicular, thus leaving the parts just mentioned still uncovered. On the sixth month, it measures three lines two-thirds in length, and one line and a fourth in breadth. At this period, when the hemispheres of the brain are extended considerably backwards, the corpus callosum takes a horizontal direction, and covers the anterior part of the optic chambers. It is formed of transverse fibres, the immediate continuation of those of the crura cerebri which have traversed the hemispheres, and, being the result of union of fibres of opposite sides, it constitutes the true commissure of the hemispheres. On the seventh month its direction is horizontal ; it measures nine lines and a half in length, and is sufficiently extended backwards to cover the optic chambers and third ventricle. We may also trace its transverse fibres as far as the ascending fibres of the crura cerebri, of which they are the continuation. On the eighth month it is fifteen lines in length, on the ninth eighteen lines. It now covers not only the optic chambers, but extends as far as the anterior pair of the tubercula quadrigemina. I succeeded in tracing the fibres of the crura into this medullary production, where they united on the middle line with those of the opposite side.

We may conclude, from this rapid sketch, that the corpus callosum is formed from before backwards in the brain of the fœtus; that it gradually bends upwards, so as to form what Reil has termed the knee, and shoots backwards, according as the hemispheres are developed over the tubercula quadrigemina and cerebellum. We conclude also, that it results from the union of the fibres of the crura cerebri, after their expansion to form the hemispheres. The re-entrant fibres, by which M. Gall[1] explains its formation, and that of the anterior commissure, are merely imaginary. This anatomist supposes that the medullary re-entrant fibres arise from the grey substance of the convolutions, and proceeding backwards, cross the ascending and radiating fibres of the crura cerebri, and converging towards the middle line, form the corpus callosum.

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[1] Anat. et Physiol. du Système Nerveux, p. 201.

But all these assertions are merely hypothetical; for the corpus callosum exists in the fœtus of the fourth and fifth months, a period when there are neither convolutions nor layers of cortical substance on the superficies of the brain. But a direct proof of the falsity of his ideas on this subject, is furnished by the uninterrupted continuity which I have observed between the medullary fibres of the crura and those of the corpus callosum.

Reil[1] has equally erred in considering the transverse fasciculi of the great cerebral commissure, or of that which he terms the system or organization of the corpus callosum, as an assemblage of particular fibres, and altogether different from those of the crura cerebri; while they are evidently a prolongation of them. In answer to this problem, viz. What are the mutual relations between the system of the crura cerebri and that of the corpus callosum? he proceeds:[2] "We must not attach too much importance to the continuity of the fibres, in the

[1] Archiv. für die Physiologie, t. ix. p. 272; t. xi. p. 347.
[2] Tom. ix. p. 182.

anatomy of the brain, for their contiguity is sufficient to guide us. The two systems expand in a radiating manner, and meet. The crura cerebri come from the inferior part, and form a reflected cone. The system of the corpus callosum, on the contrary, comes from the superior part, passes between the fibres of the preceding, and forms a sort of coverlid." Still, however, Reil did not altogether mistake the continuity of the medullary fibres of the crura cerebri ; for on examining the brain of an adult, which was distended to an enormous degree by a serous effusion into the ventricles, he observed that the fasciculi of the corpus callosum and crura cerebri met in a straight line on the external border of the anterior portion of the corpora striata, and united together by direct anastomosis.[1]

If we examine the corpus callosum in the brain of animals, we find that fishes, reptiles, and birds are destitute of it, as also very young fœtuses. This peculiarity did not escape Haller, Vicq d'Azyr, Cuvier, and some other anatomists. Consequently, on separating the hemis-

[1] Archiv. für die Physiologie, tom. xi. p. 557.

pheres of the brain in reptiles and birds, we find them completely parted from one another superiorly, and merely united beneath by two commissures, the anterior and posterior, as also by the pineal gland. The corpus callosum exists in the brain of mammiferous animals; but in the Rodentia and Bat genus, where the brain, properly called, is flattened and extended but little backwards, this body is very narrow and short, as in the fœtus of the sixth month. It is infinitely larger and longer in the Carnivora, Ruminantia, and Solipeda, whose hemispheres are of a greater size, and extend farther backwards, than those of the preceding animals. In all these mammiferous animals, the radiation of the medullary fibres in the hemispheres, and their inflection inwards to unite and form the corpus callosum, are exceedingly evident. This is very easily seen in the Rodentia, whose hemispheres are very flattened. If we remove from the brain of a hare, rabbit, or beaver, after its having been immersed some time in alcohol, an extremely thin layer of the hemispheres which cover the transverse fibres of the corpus callosum, we immediately perceive the fibres proceeding outwards, and continuous with those of the crura cerebri. Willis has accurately demonstrated these transverse medullary fibres in the brain of the sheep.

I believe it necessary to remark here, that the brain of man is subject to an imperfect developement of the corpus callosum, and is liable to be arrested in one of the degrees of evolution through which it passes in the successive series. Reil has reported an example of this monstrosity. A woman about thirty years of age, an idiot, of a good constitution, and frequently employed by the inhabitants of her village in trifling commissions, fell suddenly backwards, and died from an attack of apoplexy. On opening the head, independently of a slight serous congestion in the ventricles, the corpus callosum presented a solution of continuity in the whole length of its middle portion, or rather this middle portion was altogether wanting; so that the optic chambers were completely exposed, and the two hemispheres solely united by the commissura mollis, the anterior commissure, and by the tubercula quadrigemina. Neither the knee nor thigh of the corpus callosum existed; and consequently, the septum lucidum was wanting, as it is situated in the interior of the knee. The anterior lobes of the brain were completely separated from one another in front, as far as the junction of the optic nerves and the anterior commissure; and the portion of their internal or commutual surfaces, where the knee and beak of the corpus callosum usually penetrate, was covered with convolutions as the rest of the brain. The middle and posterior part did not exist. The fornix arose, as usual, from the optic chambers, descended into the corpora mammillaria, rose again to form the anterior pillars, ascended behind the anterior commissure, and, uniting on either side with the walls of the lateral ventricles, situated immediately under the longitudinal convolutions, formed a smooth round border. Then winding round the posterior parts of the optic chambers, it plunged into the descending cornu of the lateral ventricles. Reil presumed that this defect in the corpus callosum was the result of a retardation in the developement of the brain; the details into which I have entered on the formation of the great cerebral commissure in the brain of the fœtus, fully assert the truth of his opinion.

OF THE LATERAL VENTRICLES.

In the fœtus of the second month, the hemispheres of the brain represent a thin membrane, reflected inwards and backwards, and scarcely covering the corpora striata. The lateral ventricles are yet very small, because they merely comprise the space existing between these bodies and the membrane. On the commencement of the third month, they have acquired a little greater capacity, while the membranous hemispheres completely cover the corpora striata. Towards the end of the same month, when the membrane not only covers these two latter bodies, but also the optic chambers, the lateral ventricles have acquired a greater capacity in proportion to the thickness of their walls, than in the adult brain, the walls of the latter being scarcely a fourth of a line in thickness. They dip a little in front of the corpora striata, and form the anterior cornua, which are prolonged into the interior of the olfactory nerves, then very voluminous, short, and swelled, and which are merely hollow appendages of the hemispheres. The lateral ventricles descend, posterior to the corpus callosum, into the short appendage constituting the rudiment of the middle lobe, and thus form the commencement of the middle or descending cornua. In each ventricle, we observe a large choroid plexus, produced by the folding of the pia mater in consequence of the reflection of the hemispheres backwards. These plexuses send numerous vessels, as well into the corpora striata as to the internal and concave surface of the hemispheres.

On the fourth and fifth months, a period when the hemispheres have acquired a more considerable volume and greater extent backwards, the lateral ventricles have also become more capacious. The anterior cornu is continuous with the hollow cavity in the interior of the olfactory nerves, and the middle or descending cornu presents a fold of the membranous wall of the hemispheres, which is the rudiment of the cornu ammonis. The lateral ventricle is prolonged backwards into the appendage of the hemispheres, which forms the posterior lobe, and which represents the posterior cornu; we also perceive in this latter cavity a slight prominence, announcing the origin of the unciform eminence.

On the sixth and seventh months, when the posterior lobes are more extended over the cerebellum, and the walls of the hemispheres have augmented remarkably in thickness, the lateral ventricles gradually contract, and approach that form which at a subsequent period they are to preserve. The anterior cornu communicates still with the cavity of the olfactory nerve; and in the descending cornu, we observe the cornu ammonis, with the corpus fimbriatum; and in the posterior cornu, the fold commonly termed the hippocampus minor.

On the eighth and ninth months, the lateral ventricles of the fœtus resemble perfectly those of the adult in their configuration.

To the different temporary states of the ventricles in the human embryo, correspond permanent ones in the different animals. We find no trace of them in the osseous fishes, which are destitute of membranous hemispheres. The first animals in which they are observed are the ray and shark, where we find them in the anterior masses of the brain, from whence they are prolonged into the interior of the olfactory nerves. In reptiles and birds, they are very capacious, in proportion to the thickness of their walls, as in the fœtus of the third month; but their interior is not yet divided into cornua. In the tortoise and in birds, their anterior part extends to the swelling of the olfactory nerves. In mammiferous animals they are not so broad, in proportion to the thickness of their walls, and we observe both the anterior and descending cornua. The former are continuous, in the Carnivora, Rodentia, Ruminantia, and Solipeda, as in the fœtus, with the enlargements of the olfactory nerves, which are generally termed mammillary eminences. In the Quadrumana,[1] we perceive, besides the posterior lobes of the brain, the posterior cornua of the lateral ventricles, which are also the latest parts developed in the brain of the fœtus.

The lateral ventricles are then formed at a later period than the canal of the spinal marrow, and than the third and fourth ventricles, in the human fœtus, as also in animals; they result from the reflection of the membranous hemispheres inwards and backwards. This reflection causes a folding of the cerebral pia mater,

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[1] Cuvier, Anat. Compar. t. ii. p. 155.

from whence results the choroid plexus, which we find in all animals provided with lateral ventricles. The lateral ventricles are destined, as all those of the brain, and as the canal of the spinal marrow, to present to the pia mater a more extensive surface for the expansion of blood-vessels, and of furnishing a serous exhalation.

OF THE CORPORA MAMMILLARIA.

The corpora mammillaria do not appear until the end of the third month, in the form of a common mass, simple and of considerable size ; and not until the commencement of the seventh month is this mass, hitherto simple and homogeneous, divided into two eminences by a slight longitudinal groove. This groove lodges a fold of the pia mater, which sends vascular ramifications into the substance of the eminences. I shall continue the history of these bodies, when treating of the pillars of the fornix.

Vicq d'Azyr[1] and Sœmmering[2] have already

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[1] Loc. cit. p. 470.

[2] Vom Hirn und Rückenmarck, p. 103.

remarked that there exists two mammillary eminences in the Carnivora, for example in the dog, fox, cat, badger ; but in the Ruminantia, as the ox,[1] hind, sheep, and goat, and in the squirrel, &c. these eminences form but a single voluminous mass, as during the first periods of fœtal life. In birds they constitute a small simple mass. I have not met them at all well marked in reptiles ; nor can I presume to decide, whether the very voluminous tubercles observed near the pituitary gland in fishes, termed by Haller the inferior protuberances of the olfactory nerves, and considered by Vicq d'Azyr and Arsaky as analogous to the mammillary eminences, correspond to them really or not ; the hypothesis of Arsaky and Vicq d'Azyr appears, however, the most probable, if we may judge after the situation and form of these bodies.[2]

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[1] M. Gall has represented the mammillary eminences of the calf, loc. cit. pl. 3.

[2] M. Serres considers it as an appendage of the optic nerves, and analogous, not to the corpora mammillaria, but to the grey matter (Tuber cinereum) placed behind the junction of the visual nerves. (T.)

OF THE FORNIX AND SEPTUM LUCIDUM.

Neither fornix nor septum lucidum exist in the brain of the fœtus on the second month, nor even on the commencement of the third; and not until the end of this latter period can we perceive, arising from the common mass of the mammillary eminences, two very thin and narrow ribands, representing the anterior pillars of the fornix. These two riband-like portions proceed upwards behind the corpus callosum, which is at this period small and perpendicular; and afterwards bend backwards, to unite with the internal thin border of the membranous hemispheres, which are reflected inwards and backwards. As the pillars are not yet united together, the fornix, properly speaking, does not exist. On the fourth month, the ascending cords are slightly connected, but, immediately behind this narrow commissure, they separate again in the form of two thin plates, proceeding backwards, and winding round the optic chambers, behind and near which they plunge into the middle lobes of the hemispheres. These productions constitute the posterior pillars of the fornix, and concur in forming the cornua ammonis; their free, thin border represents the corpus fimbriatum. Between this body and the optic chamber, we perceive the opening by which the choroid plexus penetrates into the lateral ventricles.

On the fifth month, we recognise, without difficulty, what had been already visible on the fourth, that the roots of the anterior pillars of the fornix come from the optic chambers; that these pillars dip into the corpora mammillaria; and that after being reflected there, they re-ascend behind the corpus callosum, and in front of the optic chambers. United together, the two pillars form the fornix, which bending backwards, covers a little the anterior part of the third ventricle. On passing behind and under the corpus callosum, they send off to this latter two thin plates, constituting the septum lucidum. In the interval of these plates we perceive the prolongation of the third ventricle, proceeding forwards through a small triangular space, situated between the anterior pillars of the fornix, and above the anterior commissure, and forming by this disposition the ventricle of the septum lucidum. After the union of these pillars with the corpus callosum by means of the plates of the septum, they separate again, and proceeding backwards round the optic chambers, plunge into the middle lobes of the hemispheres. In this point they represent the posterior pillars; and their inferior thin border, turned towards the optic chambers, corresponds to the corpus fimbriatum. That part of the internal wall of the hemispheres with which they are united, is hollowed by a deep fossa or depression, taking the direction of each pillar, and forms an eminence in the middle cornu of the lateral ventricle, which, together with the posterior pillar, produces the cornu ammonis. The pia mater lines this depression completely.

On the sixth and seventh months, the fibrous fasciculi which descend from the optic chambers into the corpora mammillaria, become more voluminous; they form a turn in the interior of these eminences, and afterwards ascend to become anterior pillars of the fornix. The plates of the septum lucidum, rising from the pillars after their junction, and uniting to the inferior surface of the corpus callosum, are considerably increased in developement; and the space comprised between them, that is to say, the ventricle of the septum, has acquired a greater capacity. To date from this period, the fornix gradually approaches the horizontal direction, and covers the third ventricle. Its pillars separate posteriorly, and descend into the middle lobes of the brain, together with the fold which forms a prominence on the surface of the descending cornu. On the seventh month, some transverse fibres appear uniting the posterior pillars, like a commissure; these fibres represent the lyre. The entire fornix, from the mammillary eminences, is composed of longitudinal fibres, taking the same direction with the pillars, that is to say, from below upwards, and bending backwards, at length dip into the middle lobes. The medullary plates which form the septum lucidum, are composed of delicate ascending radiating fibres, which unite with the inferior surface of the corpus callosum. The fibrous fasciculi of the posterior pillars, descending into the middle lobes, interlace with the expanding fibres of the crura cerebri; their point of termination is not well defined.

On the eighth and ninth months, the fornix has extended farther back, covering entirely the third ventricle, its mass has augmented much, as also the volume of its different parts ; but the direction of the fibres continues the same.

From what has been said, we may conclude that the fornix is formed from below upwards, and from before backwards ; that its anterior pillars arise from the fibrous fasciculi, which proceed from the optic chambers, and descending into the corpora mammillaria, are there reflected upon themselves. These fasciculi constitute then the anterior pillars, which inclining backwards, unite to form the fornix, and separating again posteriorly, descend into the middle lobes of the brain. Thus the fornix shoots backwards as the hemispheres are developed and extend in the same direction ; and together with the corpus callosum, gradually proceeds horizontally, according as the mass of the hemispheres elongates to cover the cerebellum. The medullary plates proceeding from the pillars of the fornix to the inferior surface of the corpus callosum, and which constitute the septum lucidum, become larger and longer as these two bodies approach the horizontal direction. The ventricle of the septum necessarily increases in capacity, according as the plates enlarge.

Let us now take a view of the origin and formation of the fornix and septum lucidum, in the brain of animals, with the intention of determining if there exists, or not, in this respect, any analogy between these latter and the human fœtus. We find neither fornix nor septum lucidum, properly called, in fishes, reptiles, or birds, as in the embryo of the second and third months. However, I have observed in the hawk's-bill tortoise, a part analogous to the fornix of a fœtus of the third month, that is to say, a small fasciculus of medullary fibres, arising from the optic chambers. This fasciculus proceeding downwards, was reflected behind the anterior commissure, and at length rose in a radiating manner in the form of a thin membrane, which, uniting with that of the hemispheres, was reflected inwards. This state of parts, resembling that in the first periods of the fœtus, is still better marked in the brain of birds. From each optic chamber a fasciculus of medullary fibres descends, which, reflected behind the pituitary gland, forms the mammillary eminences; and afterwards rising along the anterior commissure, expands its radiating fibres on the internal wall of the hemispheres, where they unite to those coming from the crura cerebri. This internal radiated wall of the hemispheres, which Haller,[1] Vicq d'Azyr,[2] Cuvier,[3] and Frank,[4] have described, bears some analogy to the pillars of the fornix, which are not yet, on the end of the third month, in the fœtus, united together to form the fornix itself.

In mammiferous animals we always meet the fornix, septum lucidum, and its ventricle. But these parts are shorter and smaller, according to the extent of the hemispheres, and more particularly so in the Rodentia, than in other mammiferous animals, as their brain does not cover even the tubercula quadrigemina. In all these animals, we may elevate and nearly entirely reflect forwards the hemispheres, cornu ammonis, and fornix. The fornix and its appendages are infinitely larger and longer in the

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[1] Opera Minora, t. iii. p. 193. Haller termed this radiated wall the fornix.

[2] Loc. cit. p. 495. Medullary expansions which form the internal wall of the lateral ventricles. Pl. iii. fig. 3, d, d, c, c, c, c.

[3] Anat. Comp. t. ii. p. 161.

[4] Reil's Archiv. für die Physiologie, t. xi. p. 223.

brain of the Carnivora and Solipeda, whose hemispheres extend farther back, than in the Rodentia. This explains why the fornix of these latter, and the different parts of which it is composed, resemble what has been observed in the brain of the fœtus on the sixth month ; while, in the Carnivora, Ruminantia, and Solipeda, they resemble more the fœtus of the seventh and eighth months. Further, the fornix presents no difference, in all these animals, with regard to the manner of its formation ; it is always a medullary fasciculus, descending from the optic chambers into the corpora mammillaria, and reflecting there, passes upwards behind the anterior commissure. Inclining backwards, it sends off to the inferior surface of the corpus callosum a radiated medullary plate, which forms the septum lucidum, and at length separates, from that of the opposite side, posteriorly, dipping into the hemispheres, and forming the cornu ammonis.

Few anatomists have well understood the structure and progress of the fornix. Vieussens, Tarin, Lieutaud, and some others, supposed that the anterior pillars of the brain were united with the medullary substance of the crura cerebri, or with the anterior commissure. Sanctorini[1] first demonstrated that they arose from the corpora mammillaria.[2] Günz, who made the same remark, termed these eminences the bulbs of the fornix. The researches of Vicq d'Azyr[3] and Sœmmering have removed all doubt on the connexions of these bodies. These anatomists have also observed that the fornix is formed by longitudinal and ascending fibres, which proceed backwards; they also proved that the corpora fimbriata and cornua ammonis, were prolongations of the fornix, a fact already admitted by Eustachius, Ridley, Winslow, Marchette, Lieutaud, Duverney, and very many other anatomists. M. Gall[4] has entirely mistaken the structure of the fornix, as he ranges it among the commissures of the brain, and which he supposes to be formed by re-entrant fibres, although he has been aware of and described[5] the

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[1] Observat. Anatomicæ, cap. iii. De Cerebro, p. 60.

[2] Prolusio Observationes Anatomicas De Cerebro Continens Altera, p. 11.

[3] Anatomie du Cerveau, pl. xxv. fig. 2.

[4] Anatomie du Cerveau, p. 204.

[5] Loc. cit. pl. xiii.; pl. xiv. xvii. p. 222.

fasciculi of fibres which descend from the optic chambers into the corpora mammillaria, as also their inflection and ascension into the anterior pillars. Reil has most accurately described the fornix, which he terms the twain-band. He observes, that the roots, which are turned outwards, arise from the optic chambers; and he has shewn how they descend into the corpora mammillaria, and there turn to form the anterior pillars; and lastly, he has described the union of the cylindrical pillar with the lamellated fornix, as also the separation of the two cords posteriorly, and their connexion with the cornu ammonis.[1]

Nor have anatomists been fully acquainted with the structure and manner of formation of the septum lucidum. They have in general considered the two plates of this septum as parts descending from the inferior surface of the corpus callosum to the superior surface of the fornix. This idea is evidently erroneous, for the two plates rise from the anterior pillars

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[1] Archiv. für die Physiologie, t. xi. p. 106. The fornix is represented in plate ix. t. ix.

of the fornix, and proceed upwards to gain the inferior surface of the corpus callosum, with which they unite. This is evidently proved by the direction and radiation of the medullary fibres, which always proceed from the pillars towards the corpus callosum, expanding and inclining backwards.[1] Malpighi[2] first asserted that there existed, in the septum lucidum, some fibres proceeding from before backwards. Still M. Gall,[3] who has accurately described these fibres, has mistaken the true structure of the septum lucidum, as he ranges it among the parts of the brain, whose connections and use are very little known. Reil[4] has also mistaken its formation.

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[1] With regard to the formation of the septum lucidum, M. Serres expresses himself in the following terms:— " Le septum lucidum est donc formé de quatre lames primitives : deux inférieures, provenant des piliers antérieurs et ayant une direction ascendante de bas en haut : et deux supérieures, se dirigeant en sens inverse de la base du corps calleux, &c. Anat. Comp. du Cerveau, p. 156. T.

[2] Epistola de Cerebro ad Fracassatum. Bon. 1665, 12mo.

[3] Loc. cit. p. 220.

[4] Archiv. für die Physiologie, t. xi. p. 101.

The cavity which separates the two plates of this septum communicates posteriorly, in the brain of the fœtus, with the third ventricle, by means of a small triangular opening existing between the anterior pillars of the fornix and anterior commissure, and by which the pia mater penetrates. I have sometimes found this communication open in the adult. Hence we may conclude that the ventricle of the septum lucidum is not so entirely free from connexions with the cerebral cavities as anatomists have supposed.

OF THE CORNU AMMONIS.

The cornu ammonis does not exist in the brain of the fœtus on the second and third months; and not until the fourth do we perceive, on the outer side, near the posterior pillar of the fornix, and in the point where this latter unites with the hemispheres, a depression bent in the same direction with the pillars. To this depression corresponds an eminence, with which the posterior pillar here united, and representing the corpus fimbriatum, plunges into the descending cornu of the ventricle. A fold of the pia mater lines the exterior depression. The prominent fold of cerebral substance in the descending cornu of the lateral ventricle, by its union with the posterior pillar of the fornix, represents the cornu ammonis. On the fifth, sixth, and seventh months, this eminence presents evidently the form of a fold, though considerably augmented in volume. On disengaging the pia mater from the cerebral substance, we perceive the slight depression formed in the fold, and lined by this membrane. This fold, united to the posterior pillar of the fornix, juts outward, according as the brain is prolonged backwards, and forms thus a protuberance, the prominence of which corresponds to the developement of the middle lobe. We can easily distinguish the fibres which come from the fornix, and which descend along the posterior pillar with the cornu ammonis. On the eighth and ninth months, the cornu loses its resemblance to a simple fold of cerebral substance, because the mass of the brain has much increased, and the convolutions, now very numerous, prevent our perceiving the depression corresponding on the outer side to the interior fold, as distinctly as during the first months, a period when no other depressions but it and the one corresponding to the unciform eminence had existed. Not until the ninth month can we evidently perceive the enlarged extremity of the cornu ammonis in the descending cornu of the ventricle, as also the small digitiform tubercles.

The cornu ammonis being one of the latest parts developed in the brain of the fœtus, we consequently find it appearing very late in the series of animals, for it is only in the mammiferous class that we commence to observe it. The fishes, reptiles, or birds, which I have dissected, have never presented any thing which bore the most remote analogy to this protuberance. In all the mammiferous animals which I have examined, it results from a fold of cerebral substance formed in the descending cornu of the lateral ventricle, and accompanying the posterior pillar of the fornix, constituting the species of border termed the corpus fimbriatum. On the outer side exists a deep depression, into which the pia mater sinks. On examining the substance of the cornu ammonis, we observe that its swelled and prominent part in the cornu of the ventricle is composed, as in the brain of the adult, of medullary substance, in the interior of which we perceive some grey portions, covered exteriorly by the pia mater. This explains the appearance of the alternate layers of white and grey substance observed in a section of this protuberance, and which Vicq d'Azyr has most faithfully represented. The cornu ammonis is evidently more voluminous in proportion to the mass of the brain properly called, in mammiferous animals than in man, as Vicq d'Azyr, Sœmmering and the Wenzells have well remarked; but this circumstance depends on the cerebral hemispheres of animals being less voluminous than those of man.

We may now conclude that the cornu ammonis is formed by a fold of the hemispheres of the brain, proceeding inwards, a particularity to which the Wenzells[1] first called the attention of anatomists; and that this fold is united to the posterior pillar of the fornix constituting the corpus fimbriatum. I am then inclined to consider it as a mass for the re-enforcement of the posterior pillars, while a thick layer of grey vascular substance is applied on the descending medullary fasciculi of these pillars.

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[1] Loc. cit. p. 151.

OF THE UNCIFORM EMINENCE.

The unciform eminence, or hippocampus minor, termed also by anatomists the Ergot, does not appear until the end of the fourth month, in the form of a slight fold of the membranous hemispheres, reflected inwards on itself. The pia mater dips into the exterior depression, which communicates with the cavity corresponding to the cornu ammonis. During the following months, this fold gradually augments in mass and in extent, so slowly however that we may perceive it, not only in the brain of the fœtus, but still in that of the adult, arising from a fold, as the Wenzells have observed.[1] This protuberance sometimes fails in the adult; we may consider this circumstance as a defect of conformation produced by a retardation in the developement of the encephalic organ.

I am not aware that the unciform eminence exists in any animal, because all animals, even the mammiferous, with the exception of the

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[1] Loc. cit. p. 144.

Quadrumana, are destitute of the posterior lobes of the brain, and of the posterior cornu of the lateral ventricle. I am not positive if it exists in the Simia ; yet I have not met with any observation on this subject in the writings of anatomists, who have had the opportunity of dissecting the brains of these animals.

OF THE PITUITARY GLAND.

The pituitary gland is not in existence on the second month of the fœtus, nor even on the commencement of the third; but it appears towards the end of this second period, forming a large soft mass. On the fourth, fifth, and sixth months, it augments considerably in size, and represents a pyramidal hollow body, for the third ventricle is prolonged into its interior. In the course of the following months, it nearly resembles that of the adult ; however, its posterior lobe, the exact description of which we owe to the Wenzells, is infinitely smaller than the anterior. I could not observe any peculiar difference in its substance ; it was composed of a reddish, soft, unfibrous mass, well supplied with blood-vessels.

This body exists, according to my observations, in fishes, reptiles, birds, and mammiferous animals. In fishes, it is of an enormous size in proportion to that of the brain; it is conical, as in the shark and ray, or rounded and pedicular, as in most of the osseous fishes, and in the pike, carp, gudgeon, &c. I have never observed it hollow. In reptiles and birds it represents a hollow pyramidal eminence. It presents also the two same characters in mammiferous animals, where we find it of a more considerable size than in adult man, in proportion to that of the brain, as Vicq d'Azyr, Sœmmering, and the Wenzells have already remarked; it is analogous to the pituitary gland of the human fœtus.

ADDENDA.

ADDENDA.

HAVING thus laid before the reader the facts and observations contained in the work of Tiedemann, I believe it would not be the least uninteresting part of the subject, to present him with a short sketch of some conclusions drawn by M. Serres, from his extensive researches on the comparative anatomy of the brain. It was originally my intention to place these facts in the body of the work, but I was apprehensive that any deviation from the plain accurate description of the particulars observed by the German author, would probably confuse and disunite the various parts of the subject. It is scarcely necessary for me to enter into a discussion relative to the idea of Gall, viz. that the grey or cortical substance was the matrice or womb of the medullary. To those who have perused the previous pages, the falsity of this opinion is sufficiently apparent.

But a subject of no less importance, and which has for past ages been the cause of long and ardent discussion, here presents itself. Does the brain produce the spinal marrow, or is the former an expansion or product of the latter? The ancient philosophers adopted the latter opinion, without, however, being able to assign sufficient reasons for drawing such a conclusion. Physiologists, on the contrary, considering that the centre of action of the nervous system resided in the brain, derived the spinal marrow from this organ. Malpighi, with the idea that animals were developed from the centre to the circumference, considered the brain and all the nerves as derived from the spinal marrow; which latter opinion Gall and Spurzheim have adopted. The influence of the sanguineous system over the developement of the nervous system in general, had not been previously studied with sufficient attention; and hence arose the great discordance of the opinions of physiologists with regard to the formation of the brain and spinal marrow.

The following are the interesting observations, or rather the laws of the nervous system, deduced by M. Serres from his extensive researches. The spinal marrow is produced by the intercostal arteries, the cerebellum by the vertebral, and the brain by the carotids. These arteries possess distinct conditions of existence, different and remote periods of origin, and limited distributions; or, if we admit that the sanguineous system possesses any influence over the formation of the different organs, it is also necessary to admit distinct origins for each of the parts to which these arteries are principally distributed. This being established, the question of the pre-existence of the different parts of the nervous system is contained in that of their different arteries.

Of the three orders of arteries which surround the spinal marrow and brain, the arteries of the spinal marrow are the first formed; the rudiments of this organ are also the first developed.

The crura cerebri and tubercula quadrigemina follow the formation of the spinal marrow, the cervical region of which is primitively formed by the branch of the superior intercostal artery, which enters the vertebral canal.

In fine, the vertebral artery arrives the last into the cranium; the cerebellum is also the last organ apparent in the formation of the encephalic organ of all classes.

Thus then we perceive three distinct centres of formation, three different sources of developement of the central part of the nervous system. If we adopt the idea of Willis, we suppose that the nervous system proceeds successively from the periphery of the cerebral hemispheres and cerebellum towards the spinal marrow. If that of Malpighi and Gall, we must imagine that the brain radiates from the spinal marrow, as the branches of a tree from the parent trunk. But these opinions are not exact. The principal parts of the brain take very different directions in their progress of developement; the cerebellum is formed from behind forwards, and the cerebral hemispheres, on the contrary, from before backwards.

When we examine the arteries which embrace the brain and give rise to its production, we can perceive the cause of this peculiarity of direction; for we observe that the vertebral artery enters at the posterior part, and is directed from behind forwards, according to the manner of formation of the cerebellum. If, on the contrary, we follow the direction of the internal carotid, we observe that, after its having formed those double turns along the cavernous sinus, it gains the anterior part of the brain, and proceeds from before backwards, agreeable to the mode of developement of the cerebral hemispheres.

Thus the developement of the crebellum follows the direction of the vertebral artery, and that of the brain the course of the internal carotid. Hence it follows that the corpus callosum is developed from before backwards, according to the gradual progress of the artery of this part. Hence, also, the anterior part of the fornix follows the same direction, while the posterior part, which is developed under the influence of the posterior cerebral artery coming from the vertebral, proceeds in its formation from behind forwards.

From this union of the vertebral and carotid arteries, results the general relation observed in the vertebral animals, between the developement of the cerebellum and that of the cerebral hemispheres.

One of the most important general facts of the comparative anatomy of the nervous system, is the antagonism observed between the developement of its different parts.

Thus, the size of the spinal marrow and brain follows an inverse ratio in their formation, as Haller, Sœmmering, and Cuvier have already established. What is the cause of this antagonism? We cannot look for it in the proportion of the substances which compose the cerebro-spinal axis of the nervous system, as the grey matter of the spinal marrow decreases in a direct ratio with its developement. But we may consider the respective balancing of the calibre of the arteries which form these parts, as affording us an explanation of this peculiarity.

The more voluminous the spinal arteries coming from the intercostals, the more the spinal marrow is developed.

The greater the size of these arteries, the more the vertebral and internal carotids are atrophied; consequently, the greater is the diminution of developement of the cerebellum and brain. On the contrary, the more the vertebral and internal carotid arteries increase in volume, the more the spinal arteries are reduced in their respective calibre; consequently, the greater is the increase of the brain, as also the greater is the diminution of the spinal marrow.

This general principle of the formation of the organs is applicable to all the parts of the nervous system, consequently to all parts of the animal.

The great sympathetic nerve diminishes in a direct ratio with the decrease of the sanguineous system.

The volume of the caudal prolongation of animals is rigorously adjusted to the volume of the calibre of the middle sacral artery. In the human embryo, also, the rudiment of its caudal prolongation diminishes according as the middle sacral artery atrophies.

Likewise, the appearance of the extremities and their nerves coincides with the appearance of the corresponding arteries; and from the volume of these latter we can infer that of the nerves and extremities.

In the Bimana, amongst reptiles, and in the Cetacea, which are the Bimana in the mammiferous class, we only observe the axillary arteries: the femoral are wanting. On the contrary, in the biped reptiles, the axillary artery is wanting, while the femoral attains its full developement.

In the application of this principle to the head, we find the external and internal carotid arteries developed in inverse proportions. Hence we may deduce the causes of the antagonism observed in the developement of the face and of the brain. The greater the volume of the external carotid artery, the more marked is the external form of the face, and the more voluminous are the nerves of sense; the greater the diminution of the internal carotid, the more is the brain reduced in its dimensions.

The developement of the external carotid is proportioned to that of the intercostal and spinal arteries; hence we may explain the proportional developement of the trunk, spinal marrow, face, and nerves of sense, in animals. On the contrary, the greater the increase of volume of the internal carotid, the more the external diminishes, the more the face and nerves of sense are atrophied, and the more the brain is developed.

But the ophthalmic artery does not continue in the same relation; it is always in proportion to the developement of the external carotid; hence the volume of the eye is always proportioned to that of the face and to the extent of the organs of smell and taste.

Such are the principal conclusions drawn by M. Serres, with regard to the influence of the sanguineous system over the developement of the nervous system in general. They are interesting in many points of view, and afford us strong grounds for rejecting the opinions of Malpighi, Gall, and other no less celebrated anatomists, on the formation of the brain and spinal marrow. The narrow limits of this work prevent me from entering more fully into other interesting facts related by M. Serres: for a particular account of these, I must refer the reader to his extensive work on the comparative anatomy of the brain.

FINIS.

EXPLANATION

OF

THE PLATES.

PLATE I.

Fig. 1.—*Fœtus of Seven Weeks.*

a, Tubercle of the neck.

Fig. 2.—*Side View of the Brain and Spinal Marrow of the same Fœtus.*

a, Spinal marrow
b, Enlargement of the spinal marrow, with its inflection forwards
c, Cerebellum
d, Mass of the tubercula quadrigemina
e, Optic chambers
f, Membranous hemispheres of the brain
g, Protuberance analogous to the corpus striatum.

Fig. 3.—*Posterior View of the same Brain, slit open in its whole length.*

a, a, Spinal marrow
b, Orifice of the canal of the spinal marrow
c, Enlargement of the spinal marrow
d, d, Cerebellum, slit on the middle line, and extended like a bridge over the fourth ventricle
e, e, The masses of the tubercula quadrigemina, separated on the middle line.

Fig. 4.—*Brain of an Embryo of Nine Weeks.*

a, a, The two principal cords of the spinal marrow, separated by a longitudinal groove
b, b, Cerebellum
c, Parts which give origin to the tubercula quadrigemina
d, Optic chambers
e, Membranous hemispheres, reflected backwards and inwards.

Fig. 5.—*Brain of an Embryo of Twelve Weeks.*

a, a, The reverted flaps of the cranium
b, The spinal marrow
c, Enlargement of the spinal marrow, with its curve forwards
d, Cerebellum

e, Prolonged and ascending cord of the spinal marrow

f, The elevation which gives origin to the tubercula quadrigemina

g, Crus cerebri, or cord of the spinal marrow, re-descending and directed forwards

h, Membranous hemisphere of the brain, not yet covering the eminences destined to form the tubercula quadrigemina

i, Left optic nerve

k, Left olfactory nerve

l, Nervus accessorius of Willis, arising from the lateral part of the medulla oblongata.

Fig. 6.—Posterior View of the Brain and Spinal Marrow of the same Fœtus.

a, a, Spinal marrow, with its posterior longitudinal fissure

b, Cerebellum, and beneath it the fourth ventricle

c, c, Hemispheres of the brain

d, The eminences which become the tubercula quadrigemina, with the longitudinal groove which they present.

Fig. 7.—Inferior surface of the Brain of the same Fœtus.

a, a, Spinal marrow, with its anterior longitudinal groove

b, b, Enlargement of the spinal marrow, with its curvature forwards
c, c, Peduncles of the cerebellum, arising from the spinal marrow
d, d, Cerebellum
e, e, Cerebral peduncles
f, Corpora mammillaria
g, Pituitary gland
h, h, Anterior lobes of the brain
i, i, Posterior rounded appendages, representing the middle and posterior lobes
k, Olfactory nerves
l, l, Nerves arising from the fissure of Sylvius.

PLATE II.

Fig. 1.—*Superior View of the Brain of the same Fœtus; the Membranous Hemispheres are separated from one another, and removed aside.*

a, a, The two principal cords of the spinal marrow
b, Posterior longitudinal groove
c, c, Cerebellum
d, d, Masses destined to form the tubercula quadrigemina
e, e, Optic chambers

f, f, g, g, g, g, Membranous hemispheres separated from one another

h, h, Corpora striata, somewhat broader in front, and divided by a slight depression

i, Commissure of the two hemispheres, or commencement of the corpus callosum

k, k, Lateral ventricles, with the radiated folds of the internal surface of the hemispheres.

Fig. 2.—Spinal Marrow of the same Fœtus, with its Canal.

a, a, a, a, a, The two very thin walls of the spinal marrow, separated from one another, so as to leave open the canal, which is continuous, superiorly, with the fourth ventricle

b, b, Peduncles of the cerebellum, mutually inclining.

Fig. 3.—Cavity of the Mass common to the Tubercula Quadrigemina, opened obliquely from above downwards, and from right to left, after the excision of the superior wall.

a, a, Principal cords of the spinal marrow

b, b, Cerebellum

c, Thin and membranous wall of the tubercula quadrigemina on the right side

d, e, Left wall of the tubercula quadrigemina.

Fig. 4.—*Superior surface of the Brain of the same Fœtus.*

a, a, Spinal marrow
b, b, Cerebellum
c, Fourth ventricle
d, d, Membranous plates destined to form the tubercula quadrigemina, with the longitudinal groove indicating their point of union
e, Third ventricle, situated between the optic chambers, which are separated and turned aside
f, f, Internal smooth and polished surface of the optic chambers
g, Posterior commissure
h, h, Corpora striata, curved round the crura cerebri, which give origin to the membranous hemispheres, by the radiation of their fibres
i, i, Lateral section of the membranous hemispheres.

Fig. 5.—*Perpendicular Section of the Brain of the same Embryo.*

a, Anterior view of the spinal marrow
b, Membrane of the spinal marrow, turned backwards
c, Canal of the spinal marrow resulting from this disposition
d, Inflection of the spinal marrow forwards

e, Small enlargement of the margin of the spinal marrow
f, Second inflection of the spinal marrow upwards
g, Perpendicular section of the cerebellum
h, Thin plate uniting the cerebellum to the membrane of the tubercula quadrigemina, or great cerebral valve
i, i, Spinal marrow having become thicker, and constituting the peduncles of the brain
k, k, Perpendicular section of the membrane of the tubercula quadrigemina
l, Cavity of the tubercula quadrigemina
m, Third ventricle
n, Pituitary gland
o, Optic chamber
p, Olfactory nerves
q, Perpendicular section of the corpus callosum, which at this period is yet perpendicular
r, Anterior pillar of the fornix
s, s, Cerebral hemispheres, still very small.

PLATE III.

Fig. 1.—*Superior Surface of the Brain of a Fœtus, aged Fourteen to Fifteen Weeks.*

a, a, Spinal marrow
b, Peduncles of the cerebellum, separated from one another

c, Cerebellum, still without grooves
d, d, The right hemisphere of the brain, not yet covering the mass of the tubercula quadrigemina
e, Depression of the membranous hemisphere.

Fig. 2.—*Inferior surface of the same Brain.*

a, a, Spinal marrow
b, Anterior longitudinal groove of the spinal marrow
c, c, Pyramids, or pyramidal fasciculi of the spinal marrow
d, d, Corpora restiformia, or peduncles of the cerebellum
e, e, Olivary fasciculi of the spinal marrow, on which the corpora olivaria are not yet developed
f, f, Cerebellum
g, g, Ventricle of the cerebellum
h, Annular protuberance
i, i, Cerebral peduncles
k, k, Fifth pair of nerves
l, Corpora mammillaria
m, Pituitary gland
n, Optic nerves
o, o, Olfactory nerves
p, p, Fissures of Sylvius
q, q, Middle lobes of the brain
r, r, Posterior lobes
s, s, Anterior lobes.

Fig 3.—*Side View of the same Brain.*

a, Spinal marrow
b, Curvature of the spinal marrow forwards
c, Enlargement of the spinal marrow
d, Corpus restiforme
e, Fifth pair of nerves
f, Entry to the fourth ventricle
g, Cerebellum
h, Mass of the tubercula quadrigemina
i, Peduncle of the brain
k, Posterior lobe of the brain
l, Anterior lobe
m, Optic nerve
n, Olfactory nerve
o, Fissure of Sylvius.

PLATE IV.

Fig. 1.—*Perpendicular Section of the Brain.*

a, Spinal marrow
b, Canal of the spinal marrow
c, Fourth ventricle
d, Small enlargement of spinal marrow

e, Cerebellum
f, Enlargement of the spinal marrow
g, Cavity of the tubercula quadrigemina
h, Superior membranous wall of same
i, Optic chamber
k, Third ventricle
l, Pituitary gland
m, Corpus mammillare
n, Optic nerve
o, Olfactory nerve
p, Corpus callosum
q, q, Anterior pillar of the fornix reflected on the optic chamber
r, r, Internal surface of the cerebral hemisphere.

Fig. 5.—Lateral Ventricles opened.

a, a, Spinal marrow
b, b, Cerebellum
c, Fourth ventricle
d, d, Mass of the tubercula quadrigemina
e, e, e, Margin of the superior wall of the lateral ventricle
f, Choroid plexus
g, Anterior part of inferior wall of lateral ventricle
h, Posterior part of same
i, Corpus striatum
k, Cornu ammonis
l, Pes hippocampi

m, m, The thicker portion of the membrane of the hemispheres elevated above the corpus striatum.

Fig. 6.—*Superior Surface of the Hemispheres separated from one another.*

a, a, Spinal marrow
b, b, Principal cords of spinal marrow, separated laterally from one another
c, c, Cerebellum
d, Middle part of same
e, Fourth ventricle
f, f, Masses of the tubercula quadrigemina, with their longitudinal groove
g, g, Optic chambers
h, Pineal gland
i, i, Pedicles of the pineal gland
k, Third ventricle
l, l, Anterior pillars of the fornix
m, Corpus callosum
n, n, Pillars of fornix, curving backwards, where they form the cornua ammonis, with their bands
o, o, Depressions of the cerebral membrane, which form on the inside the cornua ammonis
p, p, p, p, Cerebral hemispheres
q, q, Depressions of the cerebral membrane, forming the pes hippocampi.

PLATE V.

Fig. 1.—*Posterior View of the Brain and Spinal Marrow.*

a, a, The two principal cords of the spinal marrow
b, b, Points where they separate to form the fourth ventricle
c, Fourth ventricle
d, d, Cerebellum, with its transverse grooves
e, e, Mass of the tubercula quadrigemina, yet partly uncovered
f, f, Cerebral hemispheres.

Fig. 2.—*Superior Surface of the Brain, the Hemispheres are separated from one another.*

a, a, Spinal marrow
b, Point where the canal of the spinal marrow communicates with the fourth ventricle
c, Posterior extremity of the fourth ventricle
d, d, Cerebellum
e, e, Masses of the tubercula quadrigemina, with their longitudinal groove, slightly marked
f, f, f, f, Hemispheres of the brain separated from one another
g, Lateral ventricle laid open

h, Corpus striatum
i, i, Depressions of the grooves on the internal wall of the hemisphere
k, k, Optic chambers
l, l, Pedicles of the pineal gland
m, Pineal gland
o, Third ventricle
p, p, Anterior pillars of the fornix
q, Corpus callosum
r, Anterior commissure
s, Groove, or depression, situated near the posterior pillar of the fornix
t, t, Posterior pillars of the fornix, winding round the optic chambers.

PLATE VI.

Fig. 1.—*Perpendicular Section of the same Brain.*

a, Spinal marrow, with its canal
b, Point of its lateral flexion
c, Enlargement analogous to the grey band of the Wenzells
d, Curvature of the spinal marrow forwards
e, Section of the pons varolii
f, Cerebral peduncle
g, Cerebellum, composed of five stems and lobes

h, Fourth ventricle
i, Cavity of the tubercula quadrigemina
k, Walls of same
l, Optic chamber
m, n, Corpus callosum
o, Anterior commissure
p, Pituitary gland
q, Corpus mammillare
r, Anterior pillar of the fornix
s, t, Posterior pillar of same
u, Third ventricle
v, v, v, v, v, Grooves
w, Olfactory nerves.

Fig. 2.—Superior Surface of the Brain of a Fœtus of Twenty-one Weeks.

a, Spinal marrow, cut across
b, Enlargement of same
c, Cerebellum, with its transverse grooves
d, d, d, d, Cerebral hemispheres.

Fig. 3.—Inferior Surface of same Brain.

a, a, Principal cords of the spinal marrow
b, Curvature of the same
c, c, Pyramids
d, d, Olivary fasciculi of the spinal marrow
e, e, Annular protuberance

f, f, Orifice of the fourth ventricle, by which the pia mater enters
g, g, Cerebral hemispheres
i, i, Fissures of Sylvius
k, k, Anterior lobes
l, l, Middle lobes
m, m, Crura cerebri
n, Corpora mammillaria
o, Pituitary gland
p, Optic nerves
q, Olfactory nerves.

PLATE VII.

Fig. 1.—*Superior Surface of the same Brain, the Hemispheres separated, and the Lateral Ventricle exposed.*

a, a, Spinal marrow
b, b, Enlargement of same
c, Middle part of cerebellum, or vermiform process, with the small posterior groove
d, d, Tubercula quadrigemina
e, Optic chambers
f, Pineal gland, with its pedicles
g, Corpus callosum
h, h, h, Margins of the section of the hemispheres

i, Corpus fimbriatum
k, k, Pes hippocampi majoris
l, Pes hippocampi minoris
m, Depression existing between the optic chamber and corpus striatum, the tœnia semicircularis not being yet formed
n, Eminence analogous to the corpus striatum
o, Anterior cornu of lateral ventricle
p, Middle, or descending cornu
q, Posterior cornu
r, r, r, Cerebral hemisphere.

Fig. 2.—Perpendicular Section of the same Brain.

a, Spinal marrow
b, Small eminence analogous to the grey band of the the Wenzells
c, Extremity of the fourth ventricle, or calamus scriptorius
d, Fourth ventricle
e, Commencing branches and stems of cerebellum
f, Exterior grooves of the cerebellum
g, Medulla oblongata
h, Pons varolii
i, Crus cerebri
k, Cavity of tubercula quadrigemina
l, Thick wall of the mass of the same
m, Great cerebral valve
n, Passage from the cavity of the tubercula quadrigemina into the third ventricle

o, Optic chamber
p, Third ventricle
q, Pituitary gland
r, Corpus mammillare
s, Anterior pillar of fornix
t, Corpus callosum
u, Septum lucidum
v, Point of the third ventricle, where the pillar of the fornix remounts
w, Olfactory nerve
x, Depression corresponding to the foot of the pes hippocampi
y, y, y, y, Commencing convolutions
z, Anterior commissure.

PLATE VIII.

Fig. 1.—*A portion of a Hemisphere, with its exterior Depressions.*

a, a, a, a, External surface of the posterior and middle lobe
b, b, Margin of the corpus fimbriatum
c, c, Corpus fimbriatum
d, d, Posterior pillar of the fornix
e, e, e, Depression corresponding to the pes hippocampi majoris

f, Depression corresponding to the pes hippocampi minoris.

Fig. 2.—Right Hemisphere of same Brain, on which we perceive the radiation of the Fibres of the Crus Cerebri in the Corpus Striatum and Wall of the Hemisphere.

a, Spinal marrow
b, Enlargement of same
c, d, Cerebellum, with its transverse grooves
e, Optic chamber
f, f, Radiation of the fibres of the crus cerebri, the corpus striatum reverted
g, g, Inferior surface of the corpus striatum, on which we perceive the fibres entering this body
h, h, h, Progress of the radiating fibres of the crus cerebri on the internal surface of the hemisphere
i, i, i, Radiation of the fibres exteriorly, in the thickness of the wall of the hemisphere
k, k, Same radiation in the anterior and posterior wall
l, l, The same in the internal and inferior wall.

Fig. 2.—Portion of the Superior Wall of a Hemisphere.

a, a, Superior surface of this portion, deprived of the pia mater ; it is covered with a layer of soft substance, appearing formed of small globules b, b, Internal surface of the pia mater detached from this portion, and reverted; a thin layer of this soft unfibrous substance adheres to it

c, Point where a thicker portion of this substance is detached

d, This portion which adheres to the pia mater

e, e, Fibres appearing on the surface of a small portion of this mass

f, f, Layer of soft substance formed of globules resting on the fibres.

PLATE IX.

Fig. 1.—Inferior Surface of the Brain of a Fœtus of Twenty-Seven Weeks.

a, One of the principal cords of the spinal marrow

b, Transverse section of spinal marrow, showing its canal

c, Corpora pyramidalia

d, Corpora olivaria

e, Corpora restiformia

f, Inferior surface of cerebellum

g, h, The flocks

i, Pons varolii

k, k, Crura cerebri, the continuation of the pyramidal fasciculi, with their longitudinal fibres

l, l, Corpora mammillaria
m, Pituitary gland
n, Union of the optic nerves
o, o, Posterior lobes of the brain overlapping the cerebellum
p, p, Middle lobes
q, q, Anterior lobes
r, r, Olfactory nerves, coming from the fissures of Sylvius
s, Ganglion of the olfactory nerve
t, t, t, t, Commencing convolutions
1, First pair of nerves arising from the fissure of Sylvius, and from the inferior radiating fibres coming out from the corpus striatum
2, Second pair of nerves, arising from the anterior part of the tubercula quadrigemina, from the corpus geniculatum, and from the superior part of the optic chamber
3, Third pair, arising from the crus cerebri
4, Fourth pair, arising from the great cerebral valve
5, Fifth pair, arising between the olivary and restiform fasciculi, and traversing the pons varolii
6, Sixth pair, arising between the pyramidal and olivary fasciculi
7, Seventh pair, emanating from the medulla oblongata
8, Eighth pair, arising from the grey band
9, Ninth pair
10, Tenth pair
11, Twelfth pair.

Fig. 2.—Superior Surface of the same Brain. One of the Hemispheres is removed, and the Lateral Ventricle thus exposed.

a, Spinal marrow
b, Cerebellum
c, Tubercula quadrigemina
d, Corpus callosum
e, Right hemisphere removed aside, to show the corpus callosum
f, f, f, Depressions in the cerebral substance, the commencement of convolutions
g, g, Exterior broad wall of the lateral ventricle, showing the radiation and superposition of the fibres
h, h, Anterior and posterior wall of the same ventricle
i, i, The internal thinnest wall
k, k, Transverse section of the commencing convolutions
l, Corpus striatum
m, Anterior cornu of the lateral ventricle
n, Descending cornu of same
o, Posterior cornu
p, Pes hippocampi majoris
q, Tœnia semicircularis
r, Optic chamber
s, Pes hippocampi minoris.

PLATE X.

Fig. 1.—*Side View of the same Brain.*

a, Spinal marrow
b, Corpus restiforme
c, Corpus pyramidale
d, Corpus olivare
e, Cerebellum
f, Curvature of spinal marrow
g, The flock
h, Pons varolii
i, Middle lobe of the brain
k, Posterior lobe
l, Anterior ditto
m, m, Fissures of Sylvius, lodging the middle cerebral arteries
n, Olfactory nerve
o, o, o, Depressions, or commencing convolutions.

Fig. 2.—*Fourth Ventricle and Cerebellum, when viewed underneath.*

a, a, Spinal marrow
b, b, Corpora restiformia
c, c, Grey bands of the Wenzells
d, Fourth ventricle
e, e, Posterior superior lobes of the cerebellum

f, f, Posterior inferior lobes
g, g, Digastric lobes
h, h, Posterior thin border of cerebellum, forming the valve of Tarin
i, i, The flocks
k, Pyramid of the lesser vermiform eminence
l, Spigot.

PLATE XI.

Fig. 1.—*Superior View of the Brain of the same Fœtus.*

a, Spinal marrow
b, Posterior longitudinal groove
c, c, Corpora restiformia, with the thin posterior cords of the spinal marrow
d, Central lobes of cerebellum
e, e, Four-sided lobes
f, f, Posterior superior lobes
g, g, Olivary fasciculi
h, h, Anterior pair of tubercula quadrigemina
i, i, Posterior pair
k, Posterior commissure
l, Transverse section of pineal gland
m, m, Its pedicles

n, n, Superior surface of optic chambers
o, o, Their inferior surface
p, Third ventricle
q, Corpus striatum
r, Its anterior and internal part
s, Its anterior and external part
t, t, The fibres of the crus cerebri, radiating outwards, on their exit from the corpus striatum
u, Transverse section of the anterior commissure
v, Transverse section of corpus callosum
w, One of the plates of the septum, directed from the fornix to the corpus callosum
x, Hippocampus major
y, Tœnia semicircularis
z, Depression near the cornu ammonis, where the pia mater sinks
* * Depression opposite the cornu ammonis, visible in the posterior cornu of the lateral ventricle.

PLATE XII.

Perpendicular Section of the same Brain.

a, Spinal marrow
b, Medulla oblongata
c, Pons varolii

d, Grey band of the Wenzells
e, Fourth ventricle
f, Aqueduct of Sylvius
g, Valve of Vieussens
h, i, Vertical stem of cerebellum, according to Reil
k, l, m, Horizontal stem of same
n, Tubercula quadrigemina
o, Optic chambers
p, Third ventricle
q, Crus cerebri
r, Corpus mammillare
s, Fibres proceeding from this eminence to the corpus callosum
t, Anterior commissure
u, Infundibulum
v, Optic nerve
w, w, Plates and ventricle of the septum lucidum
x, Tœnia semicircularis
y, Fornix
z, z, Corpus callosum
* * * *, Depressions and grooves, the commencing convolutions.

PLATE XIII.

Fig. 1.—*One of the Hemispheres of the same Brain.*

a, a, Corpora mammillaria
b, b, b, Fibres which rise from these eminences to form the fornix
c, Fibres directed upwards and backwards, and unite with the cornu ammonis
d, Cornu ammonis, terminating in the middle lobe
e, Depressions on the side of this cornu
f, Corpus callosum
g, Plate of the septum lucidum
h, Fibres of the crus cerebri,. after the removal of the optic chamber, which penetrate into the corpus striatum
i, i, i, Corpus striatum, curved round the crus cerebri
k, Depression
l, Olfactory nerve
m, Optic nerve
n, Descending pillar of fornix, forming the cornu ammonis.

Fig. 2.—*Left Hemisphere of the Brain, with the radiation of the Fibres appearing after the removal of the Exterior Layer.*

a, Point of radiation
b, b, b, b, Fibres of the crus cerebri, radiating forwards, upwards, and backwards

c, Fibres radiating from the periphery, implanted on the preceding, and covered with a layer of soft substance

d, Fissure of Sylvius.

PLATE XIV.

a, Transverse section of spinal marrow

b, Point of crossing of the pyramidal fasciculi

c, c, The pyramids directed upwards and forwards

d, Passage of the pyramidal fasciculus across the pons varolii, and junction of its longitudinal fibres with the transverse fibres of this latter

e, e, e, e, Pyramidal fasciculi, on their exit from the pons varolii, forming the crura cerebri; their continuation into the optic chambers and corpora striata

f, Reflected portion of the pons varolii

g, Its other half

h, h, Corpora olivaria

i, i, Corpora restiformia

k, k, The flocks

l, l, The two hemispheres of the cerebellum

m, m, Fasciculus of fibres descending from the optic chambers to the corpora mammillaria

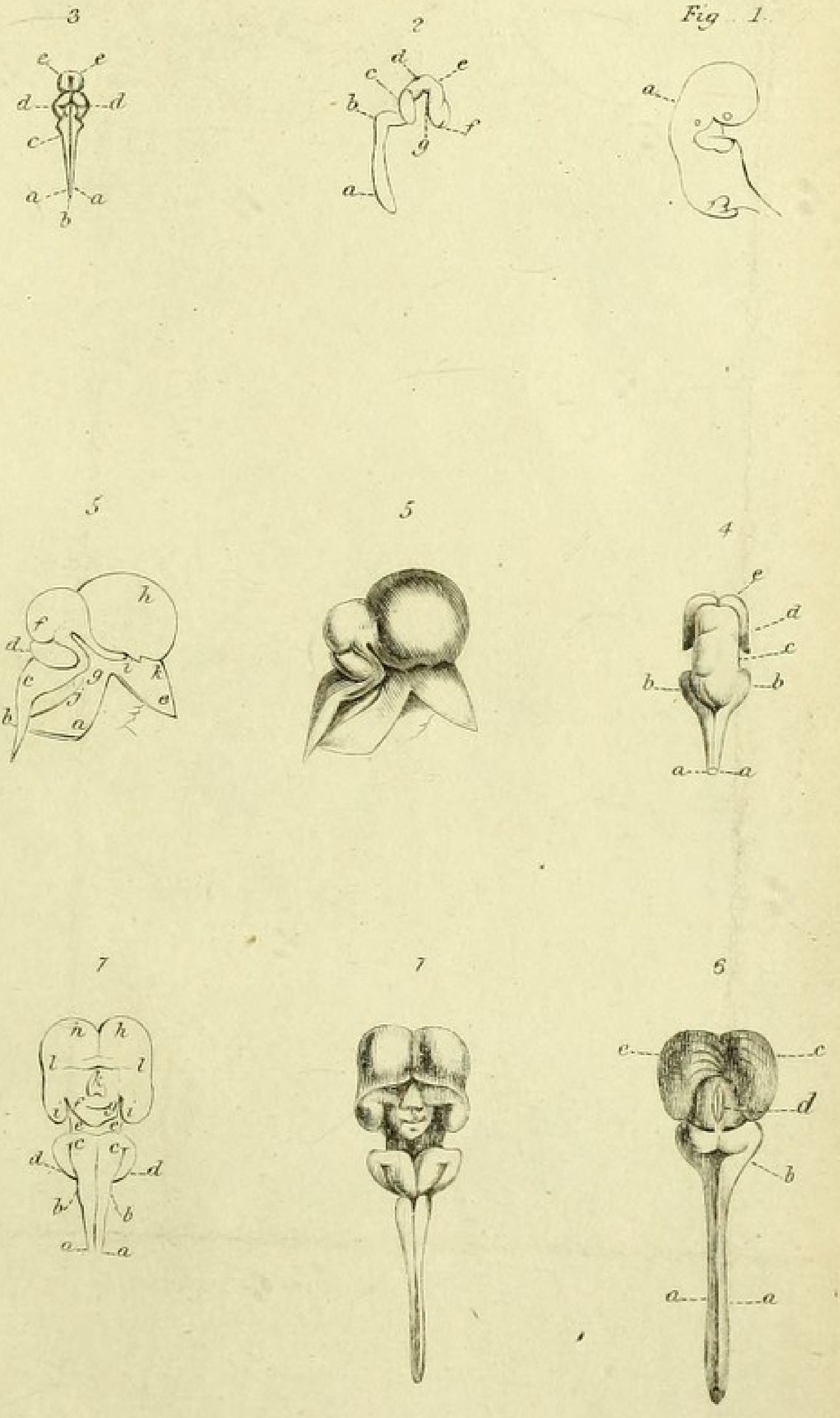
n, Point of inflection of this fasciculus
o, Its continuation with the anterior pillar of the the fornix.

Fig. 2.—a, Side view of the spinal marrow.
b, Pyramidal fasciculus
c, Its passage across the pons varolii, and its continuation into the crura cerebri
d, Transverse section of pons varolii
e, Corpus olivare
f, Olivary fasciculus exposed on removing the half of the pons varolii
g, Course of the olivary fasciculus towards the tubercula quadrigemina
h, Corpus restiforme
i, Transverse section of the corpus restiforme, where it penetrates the cerebellum
k, Oblique section of the corpus dentatum
l, Fasciculus sent by the cerebellum to the tubercula quadrigemina
m, m, Branches of the cerebellum, cut obliquely, and resting upon the corpus dentatum
n, Superior layer of the tubercula quadrigemina removed
o, Inferior fibres of the olivary fasciculus, directed towards the optic chamber.

ERRATUM.

In page 287, line 3, *for* uninteresting, *read* interesting.

PLATE I.



W.H. Lizars sc

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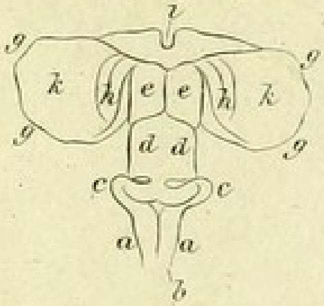

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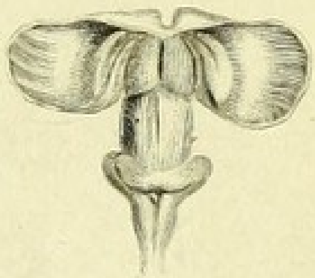

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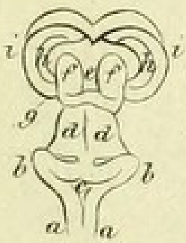

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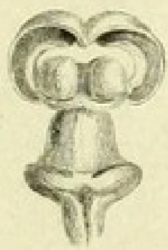

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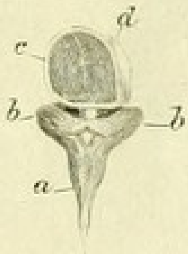

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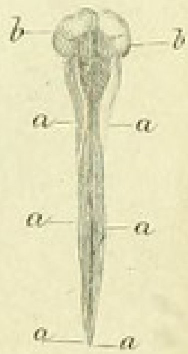

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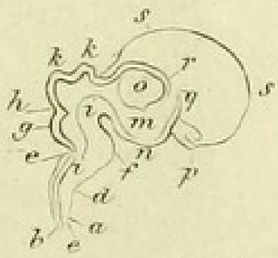

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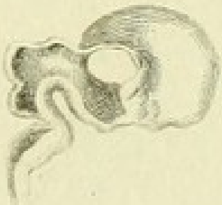

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PLATE III.

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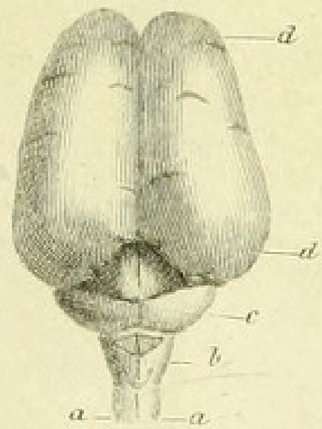

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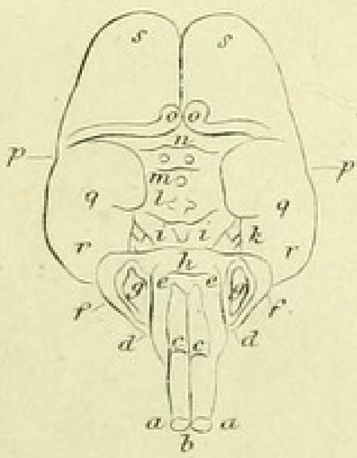

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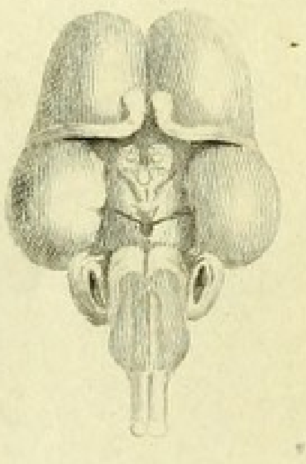

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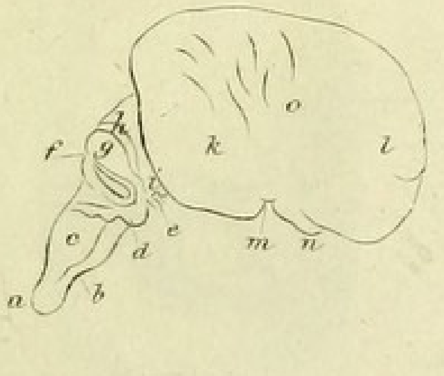

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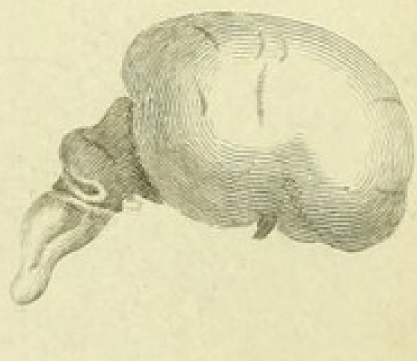

W. H. Lizars sc.

PLATE IV.

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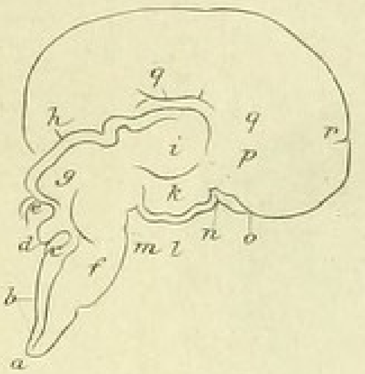

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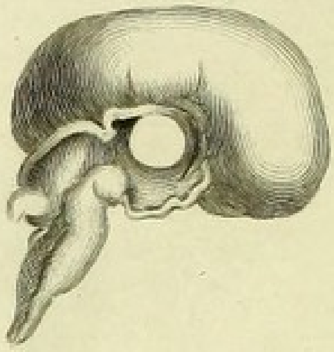

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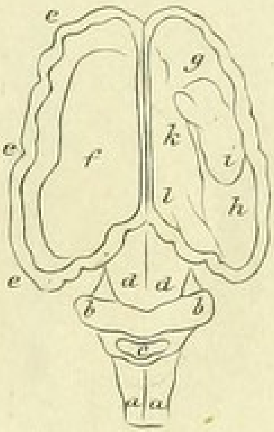

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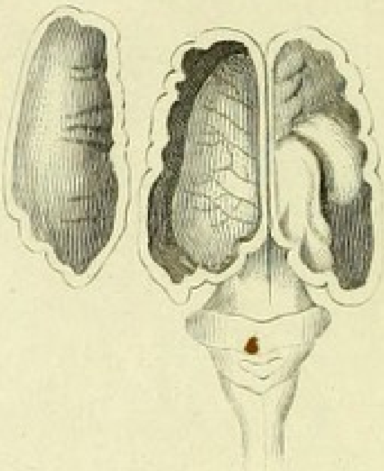

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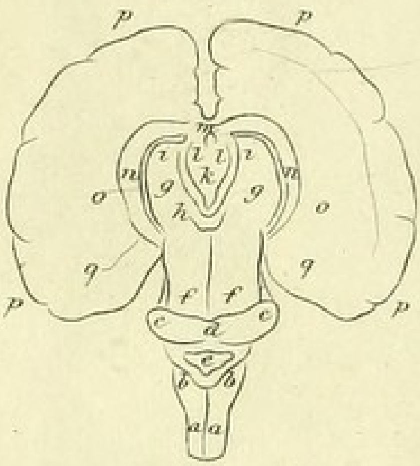

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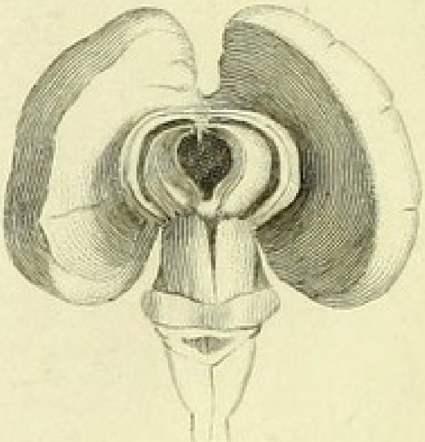

W. H. Lizars sc.

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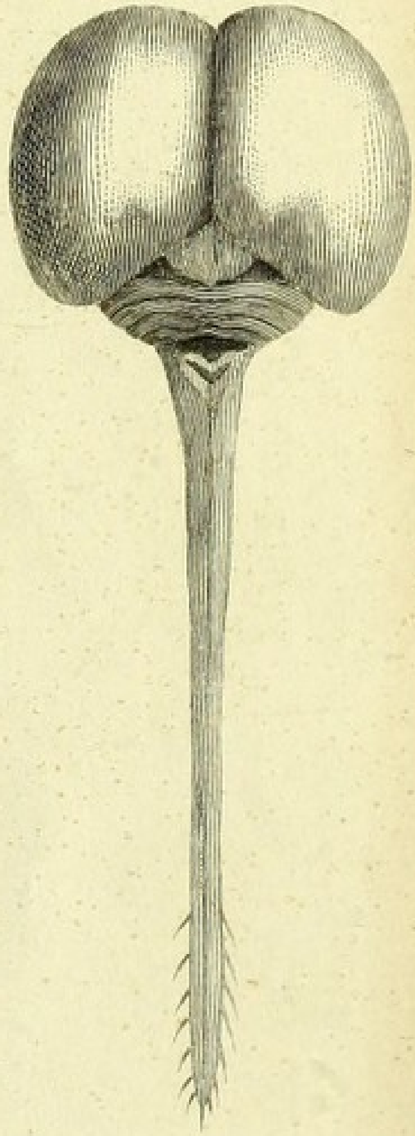

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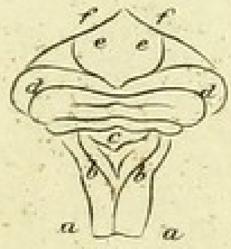

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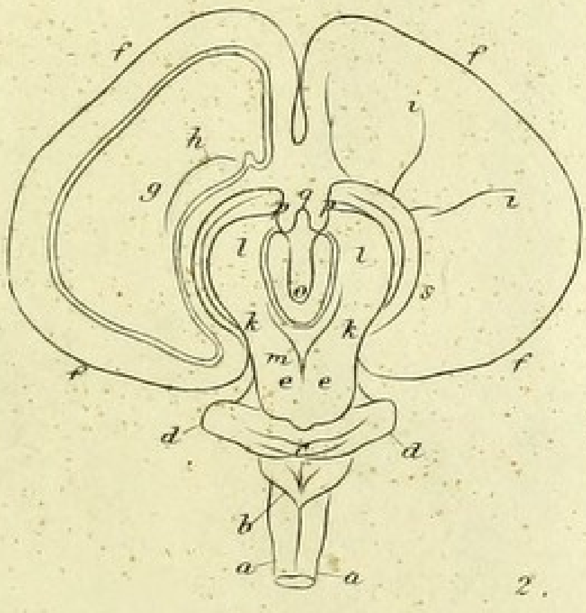

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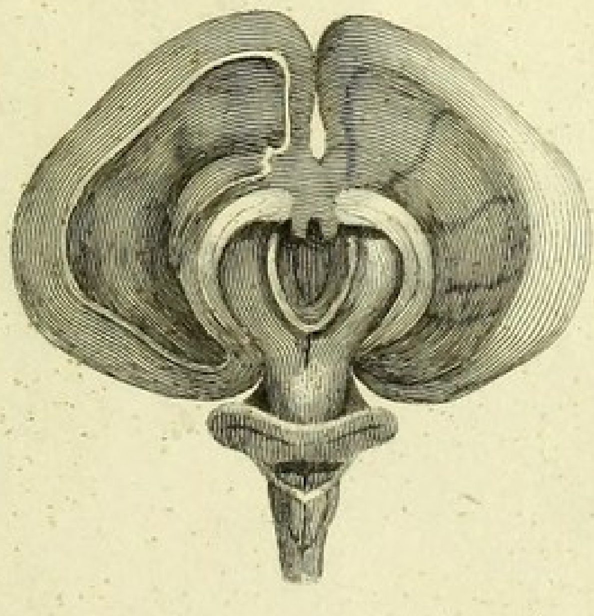

W. H. Lizars sc.

PLATE VI.

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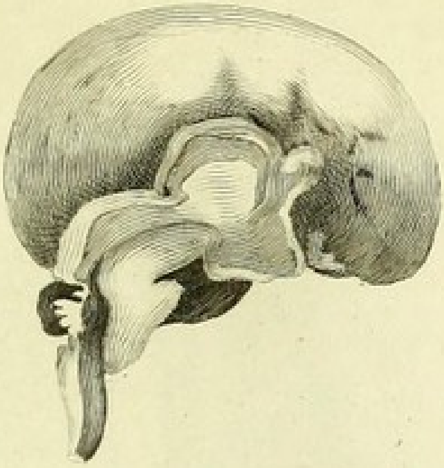

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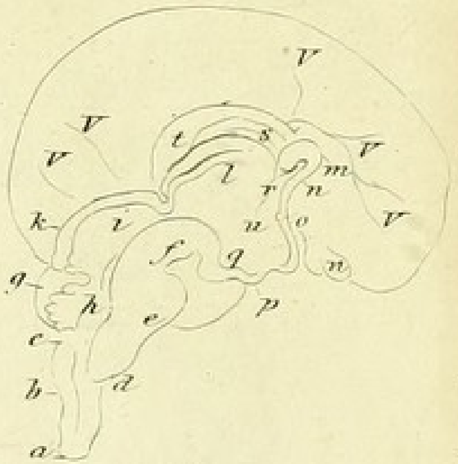

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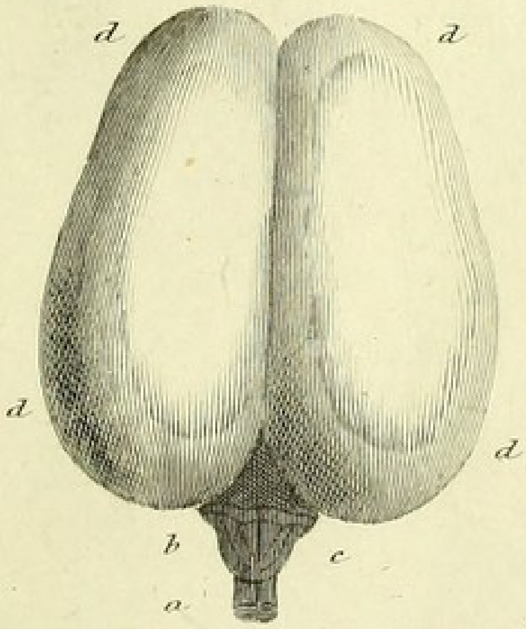

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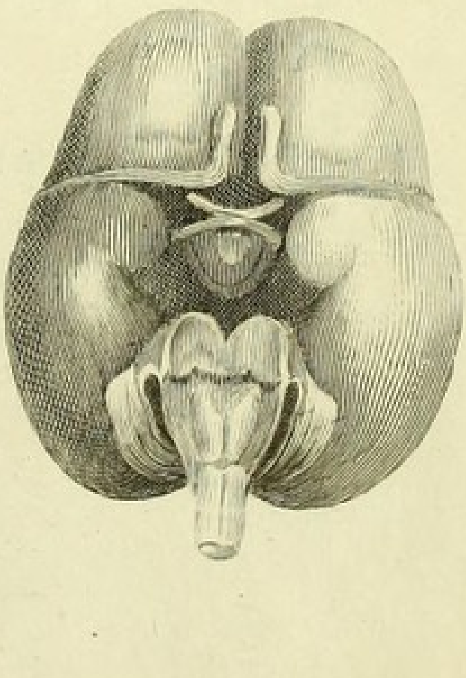

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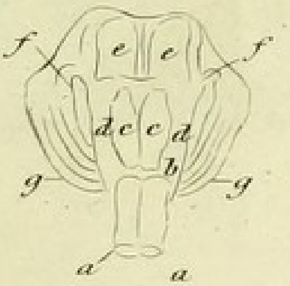
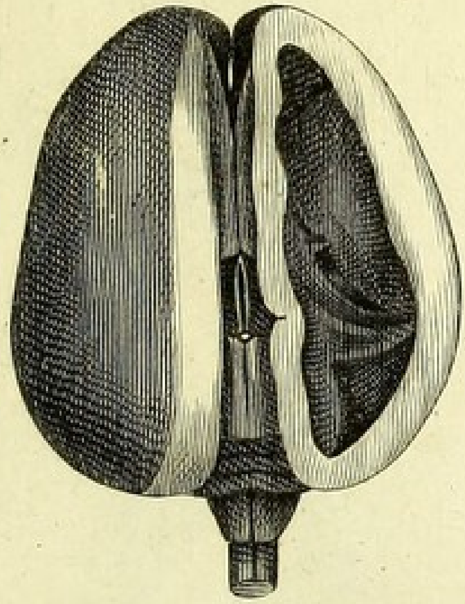


W.H. Lizars Sc.

PLATE .VII.

Fig. 1.



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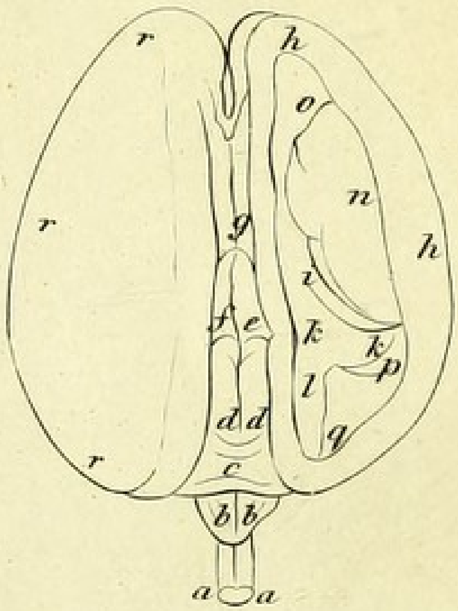

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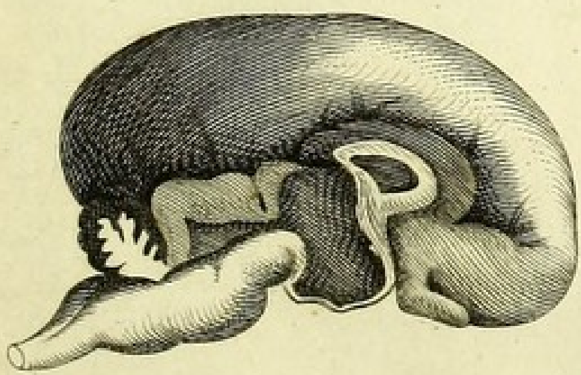

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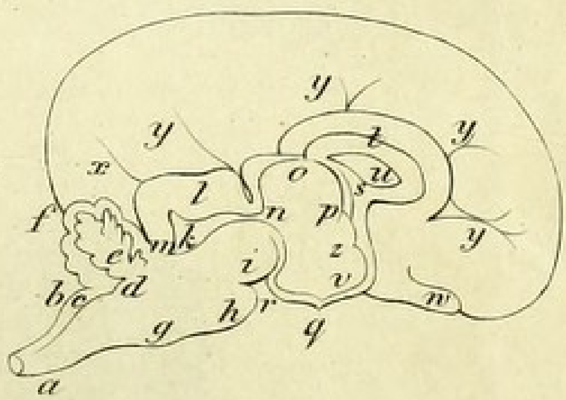

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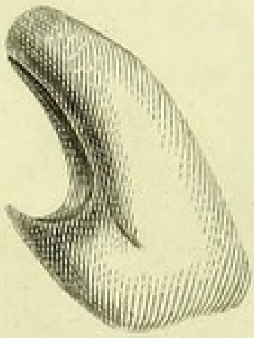

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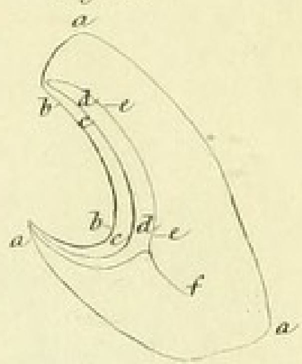

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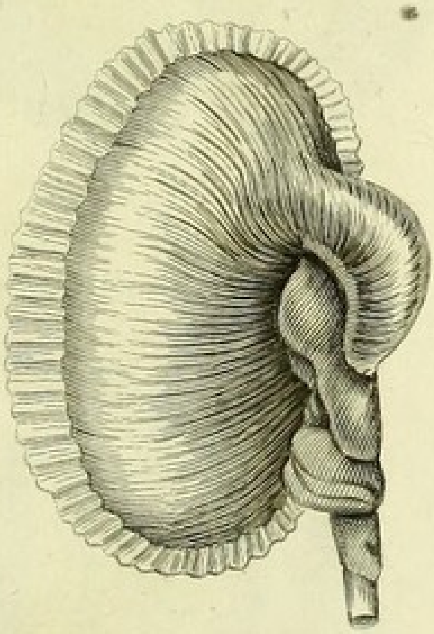

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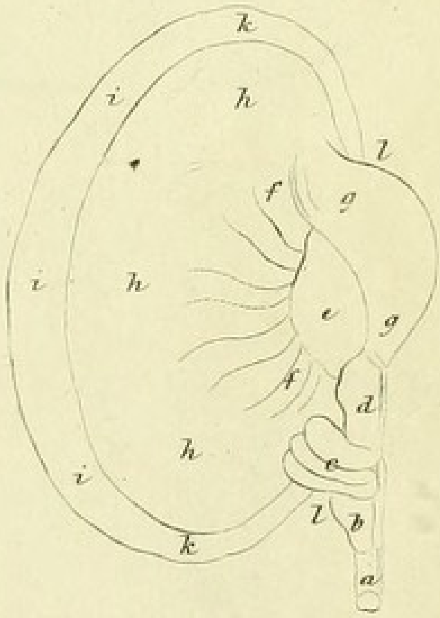

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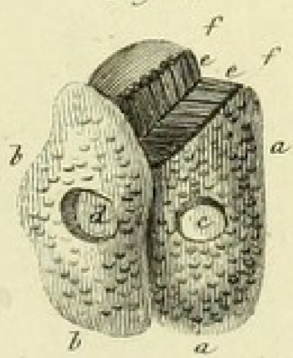
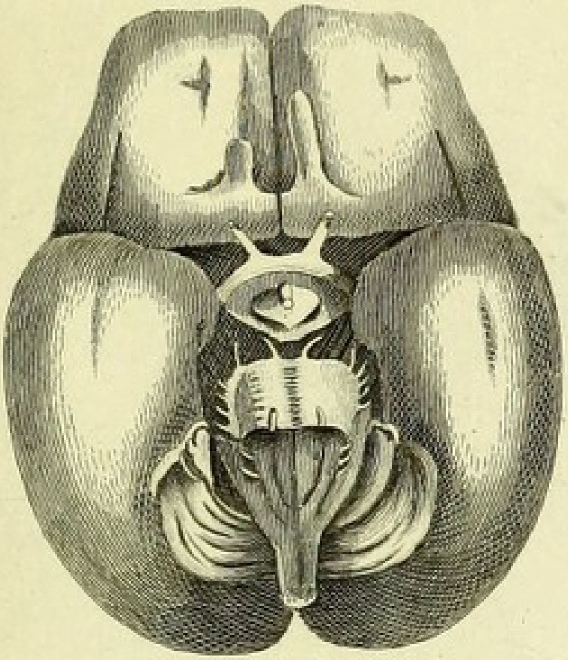


W.H. Lizars Sc.

PLATE IX.

Fig. 1.



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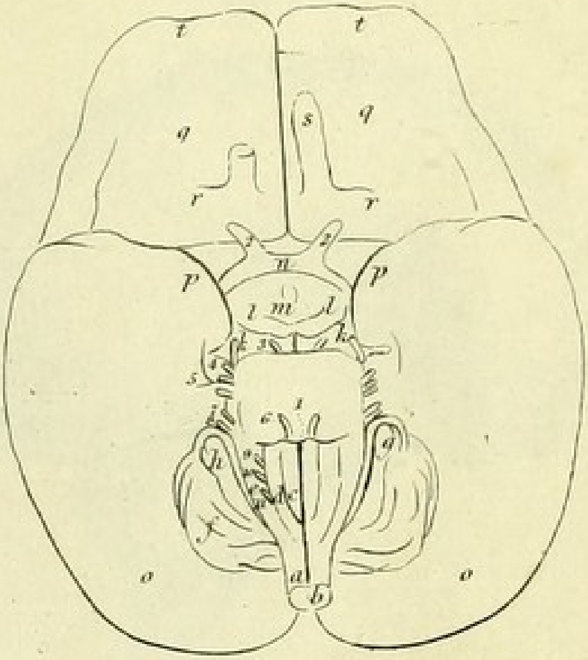

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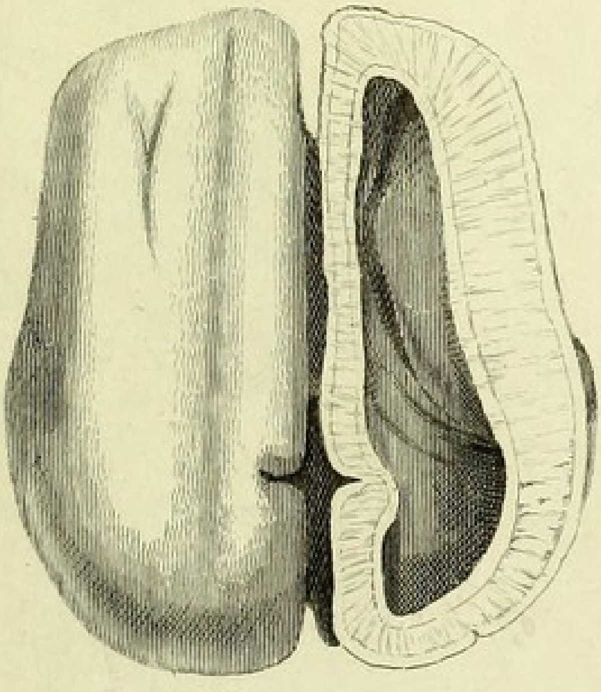

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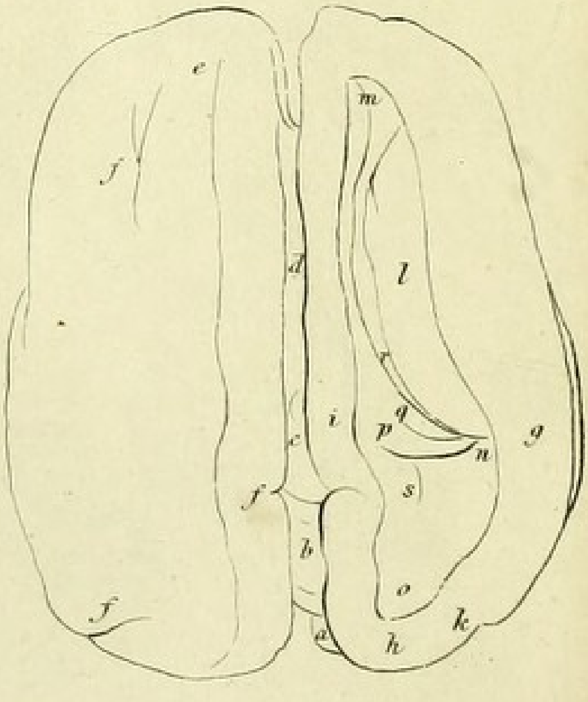
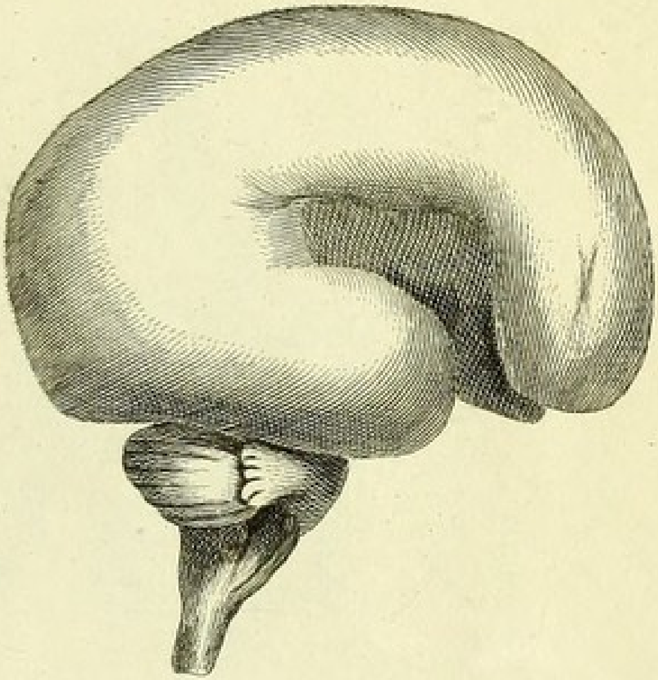


W. H. Lizars sc

PLATE X.

Fig. 1.



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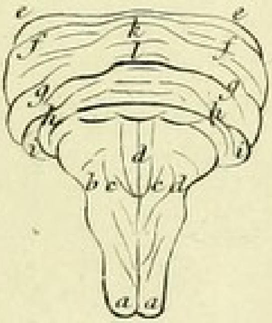

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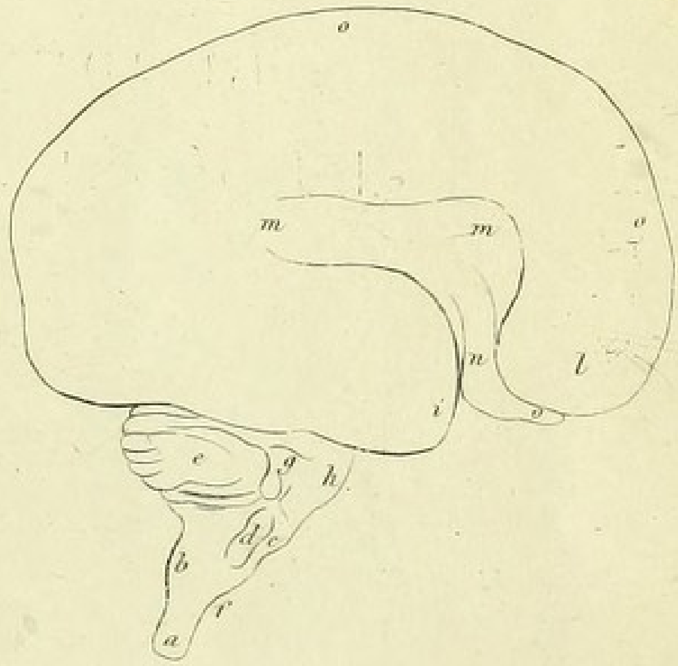
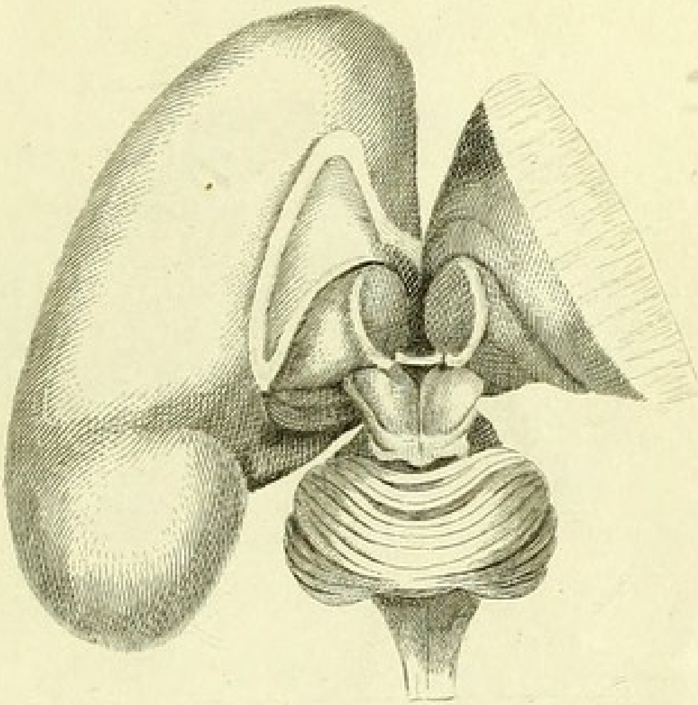


W.H.Lizars sc.

PLATE XI.

Fig. 1.



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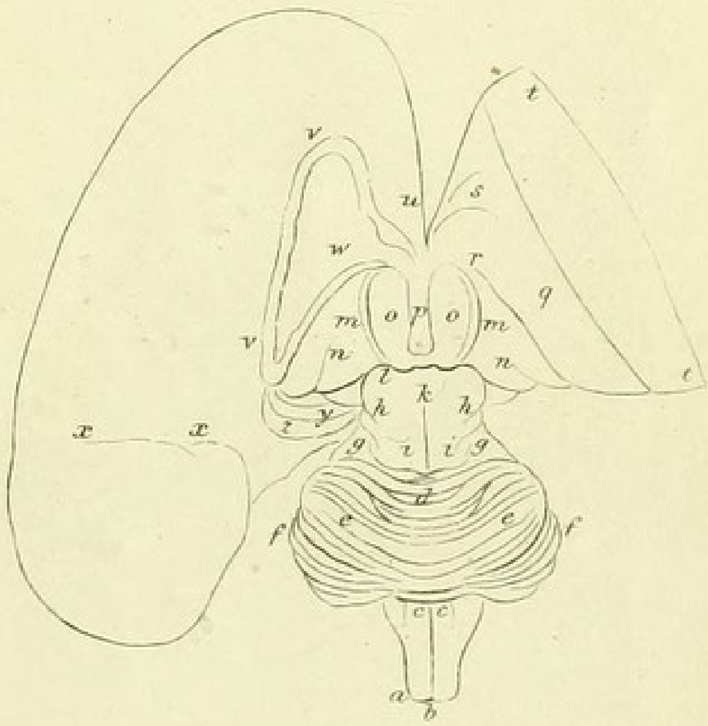
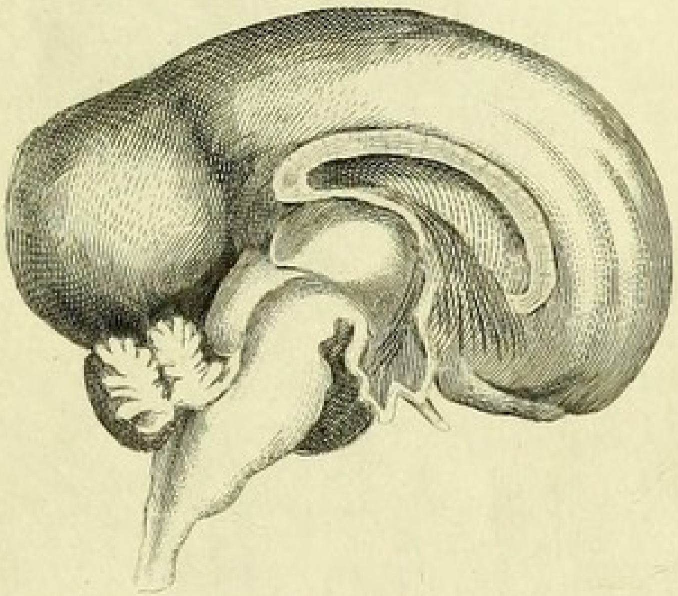


W. H. Lizars sc.

PLATE XII.

Fig. 1.



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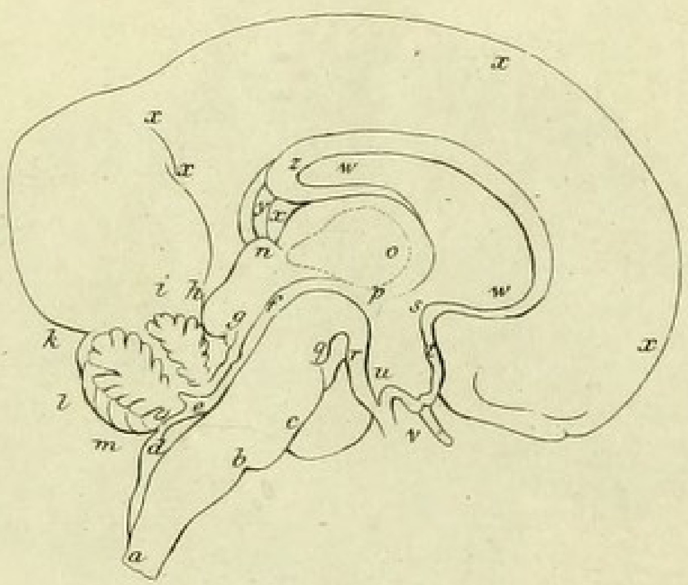
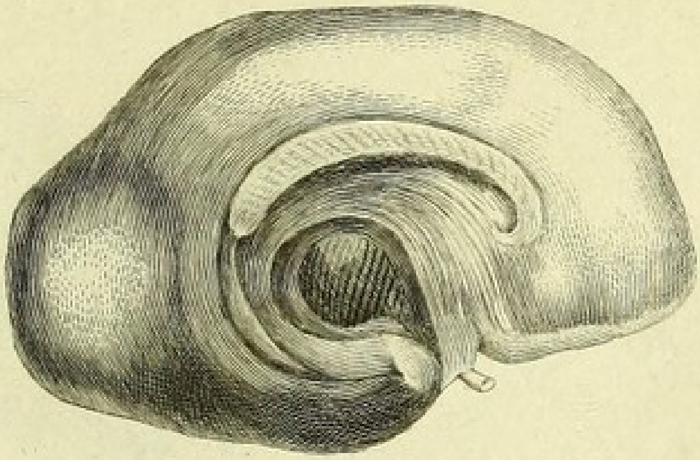


W. H. Lizars sc.

PLATE XIII.

Fig. 1.



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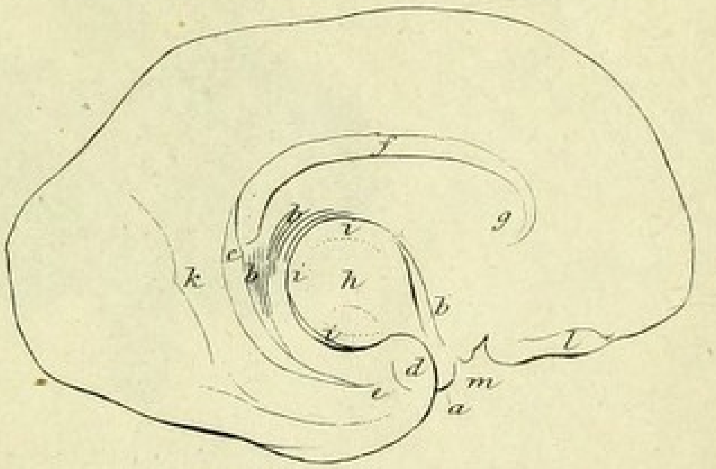

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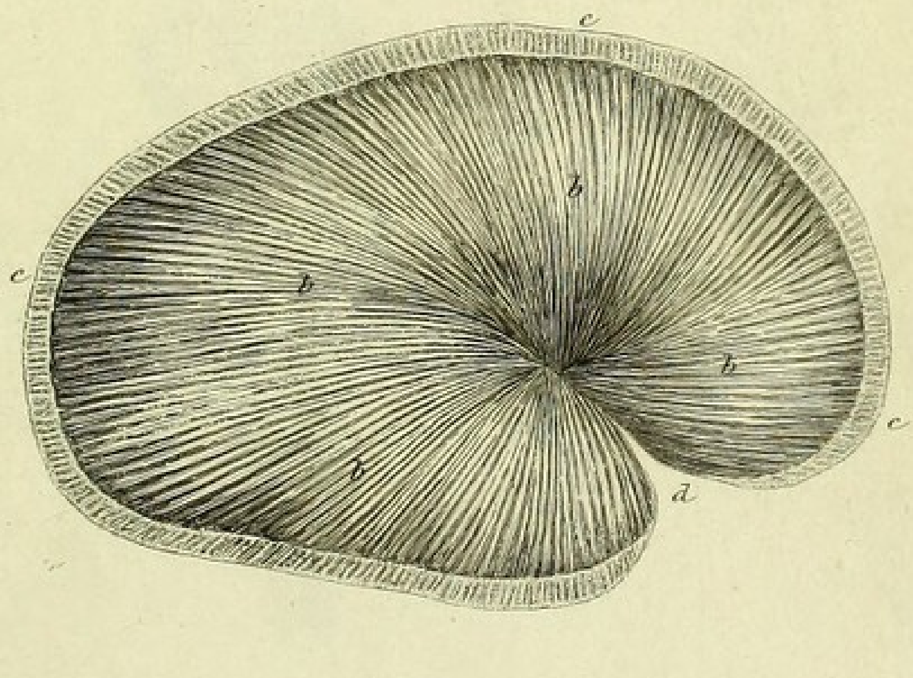

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PLATE XIV.

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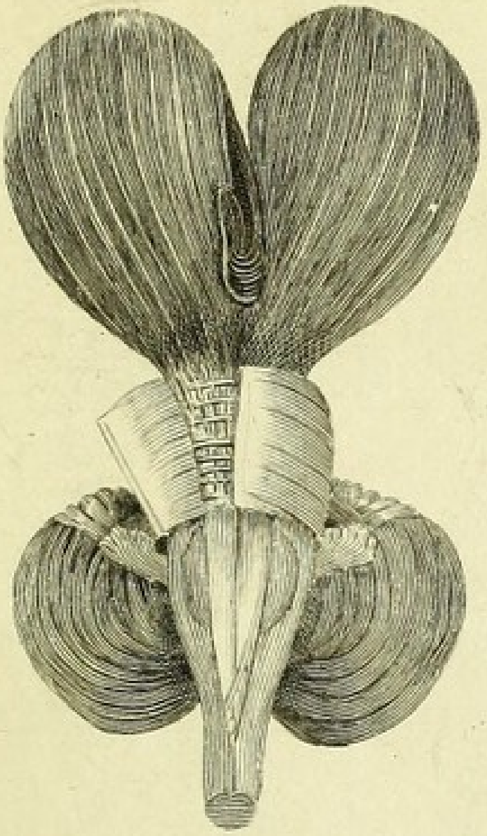

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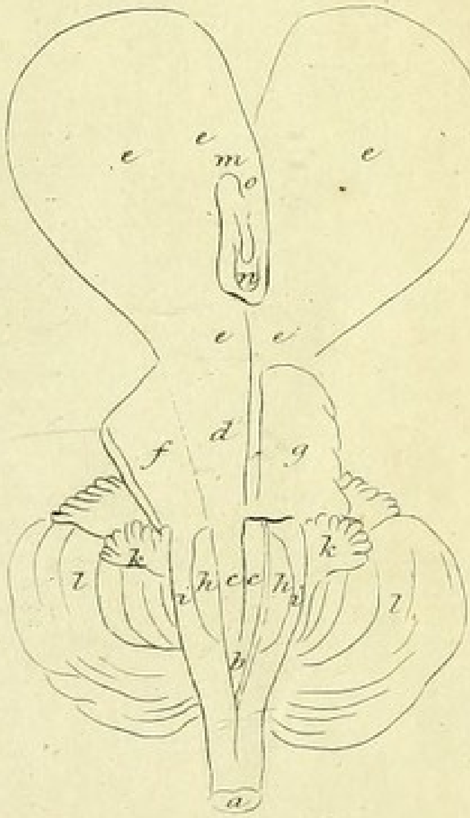

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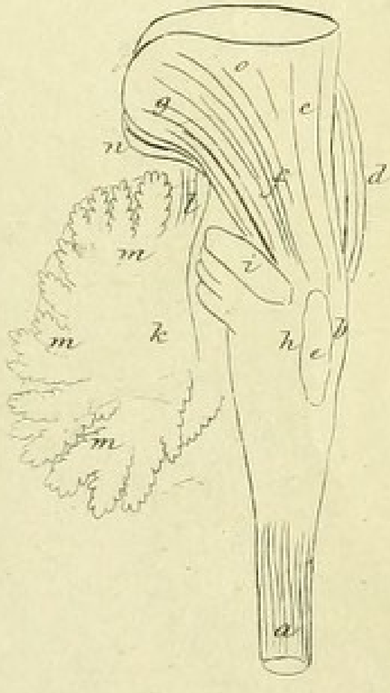

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