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2. On the Anatomical Relations of the Surfaces of the Tentorium to the Cerebrum and Cerebellum in Man and the lower Mammals.

William Turner

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them had compressed by its elastic force the substance of the mineral around the cavities, as shown by four sectors or quadrants of light which it polarises; and consequently the mineral must have been in a soft or plastic state by fusion when it thus yielded to the pressure of the included gas.

2. On the Anatomical Relations of the Surfaces of the Tentorium to the Cerebrum and Cerebellum in Man and the lower Mammals. By William Turner, M.B. (Lond.), Senior Demonstrator of Anatomy in the University of Edinburgh.

Comparative anatomists have of late directed considerable attention to the determination of the relations of the cerebrum and cerebellum. This has been in great measure due to the publication by Professor Owen of a system of classification of the Mammalia founded on their cerebral characters. The statement made by that eminent anatomist, that the posterior, or third, lobe of the cerebrum is peculiar and common to the genus *Homo*, and that equally peculiar are the "posterior horn of the lateral ventricle" and the "hippo-campus minor," which characterise the hind lobe, has led to much discussion. Various anatomists have published descriptions and drawings of dissections of the brains of many of the *Quadruman*a, especially of several of the higher apes. From these dissections, as well as from the older observations of Tiedemann and Cuvier, it may now be considered as fully proven, that in the *Quadruman*a the surface of the cerebellum corresponding to the superior surface of the human cerebellum is covered by the cerebrum; that posterior lobes, posterior cornua and hippocampi minores, are possessed by these animals.*

In the mammalia lower in the scale than the *Quadruman*a, it appears to be the general opinion of anatomists that the posterior cerebral lobes do not exist, and that, from this circumstance, there is always a greater or less amount of cerebellum projecting behind the

* See Professor Huxley, Dr Allen Thomson, Dr Rolleston, and Mr Marshall, in vol. i. of "Natural History Review," 1861; Professors Van der Kolk and Vrolik in January No. for 1862; Professor Huxley, "Proceedings Zoological Society," 1861; Mr Flower, "Proceedings Royal Society of London," 20th June 1861, and 9th January 1862.

cerebrum, and uncovered by it. Tiedemann* has, however, made an exception in favour of the seal, in which animal he says posterior lobes occur, although shorter than in the Simiæ. Cuvier† also recognises the exceptional arrangement in the seal, and places along with it the otter and the dolphins. Retzius‡ states, that in the mammalia lower than man, posterior lobes are found only in the apes, and that rudiments only are met with in the Cetacea and seals.

In the course of a series of observations which I have been making for some time back, on the crania of different mammals, my attention has been especially directed to the relative positions of the cerebrum and cerebellum. These observations have led me to come to the conclusion, that considerable misconception exists as to the relations of the two chief divisions of the encephalon.

If, relying on the published drawings, one may give an opinion of the method of examination of the brain which has been mostly adopted by anatomists, it would appear that the relation of the constituent parts of the brain has been determined after its removal from the cranial cavity, and with its base resting on a flat surface, such as a plate. By a procedure of this kind a very incorrect estimate is formed, for great displacement of parts ensues, especially in the lower mammals. The cerebrum slips forwards, the cerebellum backwards. The medulla, instead of being more or less oblique, is placed horizontally, and causes the cerebellum to be tilted upwards. The arched form of the base is almost entirely destroyed. The displacement is still greater if, at the same time, the membranes are removed.§ The observations which I have conducted have been, for the most part, made without removing the brain from the cavity of the skull. My dissections have been performed chiefly after two methods: 1st, By making vertical sections through both skull and brain, immediately on one side of the middle line, so as to preserve uninjured the falx cerebri, and the whole of one lateral half of the organ; 2d, By carefully removing with the bone-forceps the pos-

* *Icones Cerebri Simiarum*, p. 48.

† *Leçons d'Anatomie Comparée*, vol. iii., 1845.

‡ *Müller's Archivs*, 1846, p. 154.

§ Mr Marshall, in his description of the brain of a young chimpanzee (*Nat. Hist. Rev.*, vol. i. p. 298), has pointed out very clearly, in the brain of that animal, the changes which ensued after removal from the skull, and immersion for a time in spirit.

terior part of the skull. By this latter method, especially, a view may be obtained of the cerebellum and cerebrum as they lie *in situ*. Owing to the transparency of the dura mater in many of the lower mammals, the relations of these structures to each other may be studied, either with or without the removal of this membrane.

Comparative anatomists, in describing these relations, are in the habit of employing such terms as overlapping, covering, exposure, denudation, to express their extent. Such terms are not, however, sufficiently precise, because they do not convey distinctly which surface of the cerebellum it is which is thus overlapped, covered, exposed, or denuded. Indeed, it is seldom that the attempt has been made, in the lower mammals, to give an accurate definition of these surfaces, so as to distinguish them from each other. Before a close and accurate comparison can be instituted between the relations of the cerebrum to the cerebellum in man and other mammals, it is necessary that such a definition be attempted. It has appeared to me that the septum lying between the cerebrum and cerebellum, commonly termed the tentorium cerebelli, furnishes us with a basis for arriving at a precise conclusion.

If we turn to the descriptions of the cerebellum of man, given in our standard text-books of human descriptive anatomy, we shall find it stated that the cerebellum consists of a central median part—the vermiform process, or worm; and of two lateral lobes—the hemispheres. Of these, the hemispheres preponderate greatly in size. The cerebellum presents an upper and lower surface, and a circumference. The upper surface corresponds to the tentorium cerebelli; the lower is lodged in the concavity of the inferior occipital fossæ, to which it is accurately adapted. The circumference of the cerebellum corresponds to the line of junction of the upper and lower surfaces with each other, and along it a deep fissure, the great horizontal fissure, extends. The circumference—called also the posterior margin—corresponds, therefore, to the line of attachment of the tentorium to the transverse line of the occipital bone, and marks with great precision the divergence of the two surfaces of the cerebellum from each other. Of these surfaces, that which is superior, and in contact with the tentorium, which we may therefore appropriately term tentorial, is the only one related to the cerebrum, the posterior lobes of which not only cover, but even project beyond it. The inferior surface, in contact with the occipital bone,

which may therefore be termed occipital, never possesses any relation whatsoever to the cerebrum.

An examination of several members of most of the great orders of the class Mammalia has satisfied me, that it is quite possible to arrive in them at as correct a conception of the relations of the cerebrum to the cerebellum as in man. In every animal which I have examined, I have found the cerebellum to possess two surfaces. One of these is in contact with the tentorium, and, through the intervention of that membrane, is in relation to the cerebrum. The other is in contact with the wall of the occipital fossa. The surfaces are distinguished from each other by looking in different directions. The tentorial, corresponding to the superior in man, looks, as a rule, more or less forwards. The occipital, corresponding to the inferior in man, looks, as a rule, more or less backwards. These surfaces along their line of junction form an angle, more or less marked in different animals. This angle corresponds to the circumference, or posterior margin, of the human cerebellum, and is in contact with the line of attachment of the tentorium to the occipital bone. The tentorial aspect of the cerebellum, therefore, is that which is in constant relation to the cerebrum, and, not only in man, but in all the mammalia, is covered by it.

That this is the case with regard to the Quadrumana, has been so completely proven by the observations of the various anatomists already referred to, that it appears almost unnecessary to enter again into this question. As I have had an opportunity of dissecting *in situ* the brain of a young and recently dead Cercopithecus, which was given me by my friend Dr M'Bain, I may mention that in it the posterior cerebral lobes not merely covered the tentorial surface of the cerebellum, but projected decidedly beyond its posterior margin. Through the liberality also of Professor Goodsir, I have obtained permission to examine several quadrumanous brains in his possession. All these had been removed from the cranial cavity, and had been lying for some time in spirit.

In a Chimpanzee, the tentorial surface of the cerebellum was directed upwards, and was evidently flatter than the corresponding surface in man. The occipital surface was directed downwards. The posterior margin was clearly marked. The posterior lobes of the cerebrum corresponded to the whole of the tentorial surface, and extended as far as the posterior margin of the cerebellum, beyond

which they might even be stated slightly to project. The inferior vermiform process was lodged in a slight furrow between the two cerebellar hemispheres.

In the brains of several specimens of *Cercopithec*i, the tentorial and occipital surfaces, with the posterior margin of the cerebellum, were distinctly marked. In all, the posterior cerebral lobes extended over the tentorial surface as far as the posterior margin. In two of the brains, it might be stated that the cerebral lobes projected backwards beyond that margin. The comparatively greater development of the inferior vermiform process, over the lateral hemispheres of the cerebellum, was indicated by the absence of that fossa between the hemispheres in which it lies in the more highly developed human cerebellum.

In a *Macacus*, a vertical section through the skull and brain of which animal I examined, the cerebrum corresponded to the tentorial aspect of the cerebellum; the posterior lobes of the one and the superior surface of the other extended as far as the margin of attachment of the tentorium to the transverse line of the occiput.

In two specimens of *Cynocephali*, the same relation of the posterior lobes of the cerebrum to the tentorial aspect of the cerebellum was observed. In neither of these brains was the inferior vermiform process lodged in a depression between the hemispheres, but formed an almost continuous surface with them.*

In three brains, from animals of the genus *Ateles*, the posterior cerebral lobes extended quite up to the posterior margin, separating the tentorial from the occipital surface of the cerebellum. In all the lateral hemispheres projected slightly beyond the inferior vermiform process, which was lodged in a shallow depression between them.

In a lion monkey (*Midas leoninus*) the occipital surface of the cerebellum was separated from the tentorial by a very clearly defined

* Since this paper was read before the Society, I have dissected *in situ* the brain of a young *Shacma*, and have found that the cerebrum projected beyond the cerebellum, both laterally and posteriorly. The vermiform process protruded slightly beyond the cerebellar hemispheres. The projection of the cerebral hemispheres backwards beyond the worm was rather less than $\frac{3}{10}$ ths of an inch, whilst on each side of the worm it extended to rather more than $\frac{3}{10}$ ths of an inch behind the cerebellar hemispheres. The cerebellar and posterior cerebral fossæ in the cranium exhibited an arrangement in conformity with this disposition of the encephalon. (March 27th.)

posterior margin, as far as which the posterior cerebral lobes extended. The inferior vermiform process projected beyond the cerebellar hemispheres, which were comparatively feebly developed.

The Cetacea possess, not only in their great mass of brain, but in the number and complexity of the convolutions of their hemispheres, very decided evidences of a high degree of cerebral organisation. Professor Goodsir has allowed me to examine the brains of a porpoise, a bottle-nosed dolphin (*D. Tursio*), and a rorqual (*Balænoptera*), either in his possession, or in the Anatomical Museum. In all, in accordance with the peculiar antero-posterior compression of the cranial cavity, the corresponding diameter of the cerebral hemispheres was very much shortened, so that the brain was widened out, and heightened greatly in its vertical diameter. In all, the distinction between the tentorial and occipital surfaces of the cerebellum was very clearly marked. The cerebrum passed backwards as far as the posterior margin of the cerebellum. The cerebellum in them was a cerebellum inferius; for, as far as could be judged from an inspection of the brains, as they lay out of their cavities, the cerebellum was not exposed when looked at from above. The cerebrum possessed very decided posterior lobes; for, on account of the great extent of the tentorial surface of the cerebellum, and the heaping up of the cerebral convolutions in the vertical diameter, a large proportion of the cerebral hemispheres was placed above the cerebellum.* The brain of the bottle-nosed dolphin had been lying for many years in spirit in the Anatomical Museum. A section had been made into the lateral ventricle on the right side, from which it appeared as if there were indications of a prolongation of the ventricle in the direction of the posterior lobe. When the dissection was extended, so as to obtain a more complete view of the arrangement, it was seen that the lateral ventricle was continued backwards and outwards, sweeping along the posterior part of the optic thalamus. It then changed its direction, and passed downwards and forwards, so as to form the inferior horn. At, or about, the spot where this change took place, a recess, extending backwards in the substance of the cerebral mass was met

* Each hemisphere of *Delphinus Tursio*, measured 5 inches and $\frac{9}{10}$ ths in its antero-posterior diameter. The cerebrum extended 2 inches and $\frac{4}{10}$ ths behind the posterior end of the corpus callosum, the inferior surface of which mass of cerebrum was in relation to the tentorial surface of the cerebellum.

with. This recess, from its position and curvature, must, I think, be regarded as a rudimentary posterior cornu. As the soaking of a brain in spirit, for a series of years, has a tendency to render the examination of the ventricular arrangements more difficult, than would be the case in a recent brain, I hope, in the course of the summer, to supplement this observation, by an examination of the brain of the common porpoise.

In the brains of those Carnivora which I have been able to examine, the cerebellum has been seen to possess tentorial and occipital surfaces, separated by a slight, yet definite, ridge, which corresponded to the line of attachment of the tentorium to the occipital bone. The cerebellum is not, however, so decidedly a "cerebellum inferius" as in the examples already described. The surfaces of the cerebellum consequently look more or less forwards and backwards. Thus, if we look from above upon the brain of a dog or cat, we see the cerebellum projecting slightly behind the cerebrum, or exposed, as it is usually stated. From the description which has been given by Tiedemann* of these relations, not only in the Carnivora, but in the Ruminantia, Solipeds and Pachydermata, it is evident that he considered a portion, at least, of this exposed surface belonged to the anterior aspect of the cerebellum. But if we examine the brain *in situ*, we shall see that the posterior end of the cerebrum passes as far as the posterior margin of the anterior (tentorial) surface of the cerebellum, so as to cover it. The exposed surface is, therefore, the occipital, or that which corresponds to the inferior surface of the human cerebellum. In the dog, both the tentorial and occipital surfaces of the cerebellum are well developed and about equal in extent. The amount of cerebral hemispheres in relation, through the tentorium, to the corresponding cerebellar surface, is therefore considerable, and warrants us, I think, in regarding them as posterior lobes. The lateral ventricles do not possess any proper posterior cornua; but a slight indentation, continuous with the ventricular cavity, in the substance of each posterior lobe, appears to me to present a rudiment of the posterior horn. In the cat, the tentorial is smaller than the occipital surface of the cerebellum, and the extent of cerebrum in relation with it is proportionally smaller than in the dog, so that the size of its posterior lobes is smaller; for the area of

* Anatomie und Bildungs-geschichte des Gehirns, &c. Nürnberg, 1816. P. 147.

the tentorial surface of the cerebellum may be taken as a measure of the amount of the posterior part of the cerebrum by which it is covered. Its lateral ventricles possess no traces of posterior horns.

I have already mentioned that both Tiedemann and Cuvier have noted that the seal possesses more largely developed cerebral hemispheres than the Carnivora generally; and Cuvier places, along with the seal, the otter. I have, as yet, had no opportunity of examining the brains of these animals, but the accompanying casts of the interior of their cranial cavities will give some conception of the relations of the cerebellum and cerebrum.*

In the otter, the cerebrum not merely covered the tentorial aspect of the cerebellum, but even projected beyond it in a very striking manner. Thus, when the brain was looked at from above, no part of the cerebellum was exposed. From the cast, it would appear as if the occipital surface of the cerebellum looked almost directly backwards. The cerebral hemispheres possessed considerable width posteriorly. In the seal, nearly the same relations prevailed as in the otter; the posterior projection of the cerebral hemispheres was more strongly marked laterally than in the middle line. This was due partly to the ossification of the tentorium and falx cerebri, and partly to the posterior cerebral fossæ not passing quite so far back in the middle line as they did somewhat further outwards.

An inspection of the interior of the cavity of a cranium, in my possession, of a walrus (*Trichecus*), an animal closely allied to the seal, led me to suppose that, if a cast of the cavity were taken, relations of a similar nature would be met with. I, accordingly, made such a cast, and found that the cerebral hemispheres projected backwards beyond those of the cerebellum; this projection, as in the seal, and from the same cause, being more strongly marked laterally than in the middle line. The occipital surface of the cerebellum was almost flat, and directed backwards, with but a slight upward inclination. Both the seal and the walrus may be considered to possess brains of large size, so that the cerebellar hemispheres were concealed by the cerebral lobes when the brain was looked at from above. In them as well as in the otter the cerebellum was inferior.

* Most anatomists, I think, will admit that a very correct general conception of these relations may be obtained in those cases where it is difficult to procure the brains themselves, by making casts of the cranial cavity. The accuracy of this method is ensured, even more absolutely, when the tentorium is ossified.

If one might form an opinion, from the casts of the cranial cavities of these animals, of the size of their posterior cerebral lobes, it is not improbable that they might be found to possess indications of posterior horns to the ventricles. I shall certainly avail myself of the first opportunity which may present itself, to inquire into this point. Besides, I find that Tiedemann in his "Icones," p. 19, in a description of the brain of a *Phoca vitulina*, states, "præteræa cornu posterioris vestigium occurrit."

Of the Pachydermata and Ruminantia, I have examined *in situ* the brains of the pig and sheep. In both these animals the tentorial and occipital surfaces of the cerebellum were clearly indicated by the line of attachment of the tentorium to the occipital bone. In both, the cerebral hemispheres extended backwards as far as that line, so that the tentorial surface of the cerebellar hemispheres was completely covered by it. In the pig, the tentorial surface of the cerebellum was larger proportionally than in the sheep, so that the extent of cerebrum in relation to the cerebellum was greater. When the brain of either animal was examined from above, a partial projection of the cerebellum behind the cerebrum might be seen; but the exposed surface was the occipital, and not the tentorial. From an examination of the brains, preserved in spirit, of the Warthog (*Phasco-chæres*) and Peccari (*Dycoteles*) in the possession of Professor Goodsir, it would appear, that in them, as in the common pig, the tentorial surface is covered by the cerebrum.

In the Rodentia, Insectivora, Cheiroptera, and Marsupialia, the cerebellum is no longer placed below the cerebrum, but behind it, so that it becomes really a cerebellum posterius. From the statements which have been made in the works of several anatomists of great distinction, it would appear to be their opinion that the cerebrum has, in these orders, so slight a relation to the cerebellum, that the *corpora quadrigemina* are more or less exposed between the two.* From an examination which I have conducted *in situ*, of the brains of several members of these important groups, I think it very doubtful whether such a general statement is correct. Of the Rodentia, I have examined the rabbit, guinea-pig (*Cavia cobaia*), and rat. In all these animals it was quite possible to distinguish a tentorial and occipital surface in the cerebellum. The area of the

* Tiedemann, Anatomie des Gehirns, p. 146; Icones, p. 48. Cruveilhier, Descriptive Anatomy, p. 1013. Stannius, Lehrbuch, pp. 389, 390.

former was small, and possessed a forward direction. The latter was much larger, and at first sight appeared to be the only surface which the cerebellum possessed. It was directed more or less upwards and backwards. The separation between the two surfaces was indicated by a slight ridge which corresponded to the line of attachment of the tentorium to the occipital bone. As far as this line the cerebrum extended posteriorly. The anterior surface of the cerebellum was thus in relation, through the tentorium, with the cerebrum. Owing to the limited area of this surface, the amount of cerebrum in relation to it was necessarily extremely small, and might be considered as little more than the posterior edge of the cerebral hemispheres. Neither in the rabbit nor guinea-pig could the *corpora quadrigemina* be seen, until the cerebral hemispheres were drawn on one side, or the cerebellum pushed back. In the rat, the hemispheres of the cerebrum were in relation to those of the cerebellum; but, in the middle line, owing to their divergence from each other at the posterior end of the great longitudinal fissure, the upper aspect of the *corpora quadrigemina* could be seen. When a bird's-eye view of the brain was made, a large proportion of cerebellum was exposed lying behind the cerebrum, but this exposed surface was the occipital. Tiedemann, in his "Icones," has illustrated the anatomy of the brain of the Rodentia, by figures of the brains of the agouti (*Cavia agouti*), porcupine, and beaver. In every instance he has represented the cerebrum lying so far in front of the cerebellum as not to be in contact with it. Thus, exposure of the *corpora quadrigemina* is occasioned. From my dissections I am satisfied that this mode of depiction does not give a faithful representation of the relation of the structures. The error has evidently arisen from studying the parts after removal from the cavity, and without taking properly into consideration the relations which they bore to each other *in situ*.

Of the Insectivora, I have dissected *in situ* the brains of the mole and hedgehog. Of the Cheiroptera, I have dissected but one species. In these animals the surfaces of the cerebellum had about the same relation, as regards direction and size, as in the Rodentia. In all, the small tentorial surface was in apposition with little more than the posterior edge of the cerebrum. In none of the animals examined could the *corpora quadrigemina* be seen until the cerebral hemispheres were turned on one side.

Of the Edentata and Monotremata I have, as yet, had no opportunity of dissecting any specimens.

Of the Marsupialia, through Professor Goodsir's kindness, I have been enabled to examine two brains of the kangaroo (*Macropus*). Although these brains had been for some time in spirit, and had evidently to some extent lost their original form, yet it was possible to distinguish in them the tentorial and occipital surfaces of the cerebellum, and to note that the cerebrum had to the former a relation corresponding to that which had been noted in the mammals already described. In the kangaroo, therefore, the exposed surface of the cerebellum is the occipital. The *corpora quadrigemina* could not be seen until the cerebral hemispheres were drawn to one side.

(The paper was illustrated by crania, casts, photographs, and drawings. The drawings were made by Dr Henry S. Wilson, and, to ensure accuracy of form, proportion, and relation, their outlines were taken with the assistance of a camera.)

3. On the Connection between Organic Force and Crystalline Force. By H. F. Baxter, Esq.

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