ON THE RELATIONS OF THE INNER SURFACE OF THE CRANIUM TO THE CRANIAL ASPECT OF THE BRAIN.

The Sir John Struthers Anatomical Lecture Delivered at the Royal College of Surgeons of Edinburgh on the 16th December 1914.

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Mr. President and Fellows of the College,—My first and most pleasant duty is to thank your Council for the honour that it conferred upon me by offering me the Sir John Struthers Lectureship. I accept the post with feelings of gratitude to my old College for such a generous recognition of my work as an anatomist. About thirty-five years ago I gave a lecture, or rather a series of lecturettes, before the President and a select group of Fellows of the College, and after this trying ordeal I was granted recognition as a Lecturer on Anatomy. Once again I am called upon to lecture in this building, and if since that time confidence in my own knowledge and ability has diminished, belief in the sympathy and indulgence of my audience has increased.

Under the terms of Sir John Struthers' Bequest this lecture must be on normal anatomy, but within this department of science the greatest latitude is allowed. Thus the lecturer may deal with any problem on human and comparative anatomy within the vertebrate kingdom, whether macroscopic or microscopic, embryological or developed. He can present a critical digest of the works of others, or submit the result of his own researches. Knowing that my hearers would consist mainly of those interested in surgery, and in the belief that Sir John Struthers founded this lectureship for the encouragement of anatomical research, I felt that an account of some original work I have recently undertaken in human topographical anatomy might prove acceptable. With the approval of the President's Council I have chosen as my subject the relations between the inner wall of the cranium and the cranial surface of the brain, an aspect of cranio-cerebral topography which appears to me to have been somewhat overlooked, although it deals with structures of great medical and surgical importance.

A study of the extensive literature on cranio-cerebral topography will show that the attention of investigators has been directed mainly to the determination of the relations of the scalp and skull to the cerebral fissures and convolutions, with the special
object of affording surgeons reliable guides to operations on the cerebral cortex. One of the earliest investigators in this department of cranio-cerebral topography was our revered and venerable teacher, Principal Sir W. Turner, who published in 1874, or forty years ago, a paper entitled "On the Relations of the Convolutions of the Human Cerebrum to the Outer Surface of the Skull and Head."¹ Professor D. J. Cunningham, Turner's successor in the Chair of Anatomy in the University of Edinburgh, whose comparatively early death deprived anatomical science of one of its most brilliant representatives, wrote a classical memoir² on this subject, and enriched our museums with a very instructive series of models. Several observers have extended the study of cranio-cerebral topography to an examination of the relations of the deeper parts of the brain, such as the ventricles, basal ganglia, internal capsule and corpus callosum, to the surface. For some years past I have endeavoured, as time and suitable material were available, to improve upon the methods hitherto employed in the study of cranio-cerebral topography. In 1903³ I described a plan I had devised to illustrate the relations of the deeper parts of the brain to the surface, and recorded some of the results obtained. Again, at a meeting of the Anatomical Society, held in July 1905 in the Anatomical Department of the University of Edinburgh, I exhibited specimens showing modifications in and additions to my original methods, and prepared with the object of affording further data on this subject. Part of the results of this work was incorporated in the 11th edition of Quain’s Anatomy (see vol. iii. pt. i., figs. 316, 317, 318, and 305).

During the course of some work on the membranes of the brain I came to the conclusion that an interesting field of research regarding their topographical anatomy had been almost entirely ignored, for although the literature of cranio-cerebral topography is very extensive, and a large number of anatomists and surgeons have published the results of their observations, no systematic attempt has been made to examine the effect of the structures intervening between the bone and the brain in producing differences, or permitting harmony in the shape of the inner surface of the skull and the outer surface of the brain. This question has acquired considerable interest within the last few years, owing to certain deductions which have been made by several eminent anthropologists as to the form of the primitive human brain, based upon an examination of the casts of the cranial cavity of prehistoric skulls.
The Inner Surface of the Cranium

The structures to be examined for the elucidation of this problem are the meninges of the brain, numerous blood-vessels and the cerebro-spinal fluid, and the question naturally arises as to the most convenient method of illustrating their position and relations to the skull and brain. About ten years ago I made a few casts of the cranial cavity, with the dura mater in situ, which I have since used regularly for teaching purposes. The few casts obtained in this way were sufficient to convince me of their value in the investigation of various points in cranio-cerebral topography, and I decided to employ this method in the researches I have now to describe.

The material used consisted of a number of entire heads which were injected with a 5 per cent. solution of formol and immersed in the fluid until the brain was thoroughly hardened in situ. This can be done without any appreciable contraction of the brain (see Figs. 1 and 2, with legends). The heads were then divided in a horizontal, coronal, or sagittal direction with a saw and a large flat knife. The exposed portions of the brain were carefully removed with the arachnoid and pia mater, and placed in a solution of formol. Casts were then taken of the parts of the cranial cavities thus emptied, while the dura mater was still in position. This membrane was afterwards detached from the skull and preserved in formol, and a cast taken of the bony cranial cavity, the various foramina having previously been closed with plasticine. The portions of the brain which were removed before taking the dural and bone casts were placed with their cut surfaces on sheets of glass, and moulds made of their cranial surfaces. Two moulds of each piece of the brain were taken, the first with the arachnoid and pia mater in position, and the second after the removal of these membranes and their blood-vessels. From these moulds casts were obtained. By this means we secured a series of four casts from each subject, viz.: the inner surface of the (1) cranial wall, and of the (2) dura mater; of the cranial aspect of the brain covered by the (3) arachnoid and pia mater, and (4) destitute of these membranes. To facilitate the study of the superficial relations of the brain and its membranes casts were also made of the outer aspect of the cranial wall.

The technique employed in the preparation of such casts is comparatively simple, although before it is mastered some loss of both time and specimens may occur. I was fortunate in having the valuable assistance and advice in this work of my friend Mr. J. J. Andrew, L.D.S., to whom I wish to express my warmest thanks.
The exact procedure adopted and the material used for taking the moulds or casts naturally varied according to the form and structure of the object dealt with. A plaster cast of the interior of the cranial vault can generally be shelled out by tapping the bone firmly with a hammer. If, however, the bone is sawn through too near the base the calvaria must be divided before the cast can be removed. Plaster casts of the occipital end of the skull can also be easily extracted by tapping, provided that the coronal section through the skull is not made anterior to the posterior edge of the foramen magnum. When dealing with larger and more irregular spaces, such as one half of the cranial cavity, gelatine is preferable to plaster, as the gelatine cast can be taken in one piece, whereas a plaster one cannot be extracted unless made in several blocks. From the gelatine cast a plaster mould is made from which casts can be reproduced. In my hands gelatine did not give satisfactory results for the dural casts, owing to its tendency to adhere in places to the dura mater, and I found it necessary in the lateral halves of the skull to make plaster casts in several pieces, which were subsequently joined together. The brain is easily cast with plaster of Paris, but in order to avoid injury to the brain during its removal from the mould this organ should be taken in two pieces. Gelatine is not suitable, as it is very apt to adhere to the brain, especially if any formol be left in the specimen.

In the selection of a method for any research in cranio-cerebral topography there is a great advantage in adopting one by which the various structures to be examined are preserved in as perfect a state as possible, so that should any difficulty arise in the interpretation of the photographs, reconstructions, or casts, the actual specimens from which they were obtained are still available for further examination.

By the plan I have followed in making my series of casts I have been able to keep the cranial wall, the dura mater, and the brain from which each cast was taken, but the arachnoid and pia mater had to be removed piecemeal, to expose the surface of the brain, and consequently the original specimen from which No. 3 of each series of casts was obtained had to be dissected before No. 4 could be made.

It might reasonably have been expected that series of casts such as those just mentioned would abound in our museums and anatomical and surgical departments, for their utility in the study of cranio-cerebral topography is obvious. Further, the preparation
and examination of such series constitute an essential preliminary research in order to obtain reliable data from which estimates of the cortical development of the brain of prehistoric man can be made from endocranial casts of prehistoric skulls. I have made inquiries amongst my anatomical colleagues and the curators of a number of museums, and have been unable to discover the existence of a single set of such series of casts. There are a number of plaster casts of the cranial cavity of recent man in the Hunterian Museum in London, nearly all of which were made many years ago, but the brains corresponding to these endocranial casts are not preserved. I have failed to find in any museum casts of the cranial cavity with the bone lined by the dura mater.

Professor A. Ecker, in the course of an investigation of some artificially distorted skulls of North American Indians, made endocranial casts of several dried skulls with the view of determining the alterations produced in the form of the brain. He figured (Plate III.) a cast of the interior of the skull of a child 7 to 10 years old, in whom the head had been greatly flattened over the frontal and occipital regions while over the parietals the vault was very prominent. The general outline of the cast showed the very obvious changes in the general shape of the cranial cavity which had resulted from the pressure applied to the surface of the head. The casts also exhibited markings indicating the position of certain convolutions and fissures of the cerebral hemispheres. These were especially distinct over the temporal lobe; the superior, middle, and inferior temporal convolutions and their related fissures being readily recognised. In the parietal region the cast was smooth, but Ecker thought he could recognise the position of the central fissure, and he also figures the parieto-occipital. He marked on this endocranial cast the position of the cranial sutures, and for purposes of comparison investigated the relation of these sutures to the brain in a normal adult male. Although he made endocranial casts of each half of the skull he did not attempt any comparison between these casts and the brain.

Professor G. Schwalbe prepared numerous endocranial casts for his important researches on the juga cerebralia and impressiones digitatae, but he makes no reference to the brains belonging to the skulls from which his casts were taken, although he admits that a comparison of the juga cerebralia in a number of skulls with the fissures of the corresponding brains is very desirable.

It has frequently been assumed that the general arrangement
of the cerebral fissures and convolutions can be determined from endocranial casts, and indeed even asserted that such casts possess the advantage of indicating the main fissures without obscuring them by secondary ones, although no systematic attempt has been made to determine the points of agreement and the differences between endocranial casts and the surface of the corresponding brains.

Casts of the cranial cavity are usually made by dividing the skull in the median plane, taking casts of each half and then joining them together. Such casts give, on the whole, the most instructive and complete illustrations of the form of the endocranial surface, but the division of the skull in the median plane and the imperfection of the cast at the union of its two halves are apt to destroy or impair certain important markings in the plane of the section, and they require to be supplemented by casts of the cranial cavity when opened by horizontal or coronal sections of the skull, as by this means we can obtain views of the exact form of the median part of the endocranial wall. I have made casts of five portions of the cranial wall, viz. the vault, the frontal end, the occipital end, and the right and left lateral halves. In my collection of casts those of the vault are the most numerous, because they are easily obtained during the ordinary course of the dissection of the head and neck. After the skull-cap was sawn through horizontally for the removal of the brain, this organ and its membranes were cut across with a large flat knife at the same level as the bone. For the casts of the frontal and occipital ends of the cranial cavity coronal sections were made through the head a little in front of the bregma and some little distance anterior to the lambda. In order to make casts of the lateral halves the bone was divided in the median plane and the two halves of the skull were slightly separated, and an attempt made to cut the cranial contents just to one or other side of the falx cerebri. On each half the cerebral hemisphere was removed and a dural cast taken of the space above the level of the tentorium before the portions of the brain below this dural fold were taken out and the cavity below it cast.

Huxley asserted that it should become “an opprobrium to an ethnological collection to possess a single skull which is not bisected longitudinally.” Experience has shown that the curators of our museums will not follow the advice of this great morphologist, but surely it would not detract seriously from the impressive
Fig. 1.—From a photograph of the left lateral aspect of the skull of a man aged fifty-six years, and upon this a photograph of the same aspect of the corresponding left cerebral hemisphere. The original photographs were both life-size. In the figure they are reduced to one-half.

Fig. 2.—Photograph of the median aspect of the right half of a sagittal section of the head of a man aged fifty-nine years. After this section had been made the mid-brain was divided by a horizontal cut and the upper part of the brain removed from the cranial cavity and divided by six coronal sections into seven slabs. After being photographed these slabs were replaced in the cranial cavity and a photograph was taken of the median surface. The lines indicating the position of the coronal sections were just visible in the life-sized photograph, and to indicate their situation more distinctly dots have been placed at intervals along their course. This figure is one-half natural size.
Fig. 3.—Photograph of an endocranial cast of the vault of the skull, from a female aged twenty-seven years, viewed from above.

Fig. 4.—Photograph of the corresponding endocranial cast.

Fig. 5.—Photograph of a cast of the corresponding part of the brain covered by the arachnoid and pia mater.

Fig. 6.—Photograph of a cast of the same brain after these membranes had been removed. G. C. A., gyrus centralis anterior; G. C. P., gyrus centralis posterior.
Fig. 7.—Photograph of an endocranial cast of the occipital end of the skull, from a male aged seventy years, viewed from behind. L., lambda; L. S., lambdoidal suture; S. T., sinus transversus.

Fig. 8.—Photograph of the corresponding endodural cast.

Fig. 9.—Photograph of a cast of the corresponding part of the brain covered by the arachnoid and pia mater.

Fig. 10.—Photograph of a cast of the same brain after these membranes had been removed. P. O., parieto-occipital fissure.
Fig. 11.—Photograph of an endocranial cast of the right half of the skull of a female aged sixty-one years, viewed from the lateral aspect. S. T., sinus transversus.

Fig. 12.—Photograph of the corresponding endodural cast.

Fig. 13.—Photograph of a cast of the corresponding part of the brain covered by the arachnoid and pia mater.

Fig. 14.—Photograph of a cast of the same brain after the membranes had been removed. G. T. S., gyrus temporal superior; G. T. M., gyrus temporalis medius; G. T. I, gyrus temporalis inferior; G. C. A., gyrus centralis anterior; G. C. P., gyrus centralis posterior; Rp. F. C. L., posterior ramus of fissura cerebri lateralis.

(Owing to a mistake the casts from which the photographs for Figs. 11 to 14 were made were incorrectly labelled male.)
Photograph of an endocranial cast of the right half of the skull of a man aged fifty-six years, viewed from the lateral aspect. S. T., sinus transversus.

Photograph of an endodural cast of the right half of the skull of a newly-born infant.

Photograph of the dura mater removed from the left half of the skull, viewed from the lateral aspect. The transverse venous sinus had been opened.

Photograph of endodural cast of the left half of the skull of an infant nine months old.
Fig. 19.—Photograph of the dura mater of the vault of the skull, viewed from below.

Fig. 20.—Photograph of the occipital part of the dura mater, viewed from the front.

Fig. 21.—Photograph of the left hemisphere of the brain of a man aged fifty-six years, viewed from the lateral aspect. The brain was covered by the arachnoid and pia mater.
appearance of long rows of entire skulls to have at least one skull of each series exhibited in this condition, and I would venture to suggest that in addition casts should be shown of each half of the cranial cavity, for the form of this cavity is, in some respects, of more importance than the external aspect, and it is certainly advisable to be able to compare the two.

**Endocranial Casts.**—I have prepared endocranial casts of the vault of the skull from 13 adults, of 4 lateral halves, viz.: both halves of a man aged 56 years; the left half of a man aged 59, and the right half of a female aged 61; and three casts of the occipital end of the skull from a female aged 76, and two males 57 and 70, and one of the frontal end of a man 57. Photographs of some of these casts are seen in Figs. 3, 7, 11, and 15.

This collection of endocranial casts, besides demonstrating the general form of different parts of the cranial cavity, presents special markings due to the meningeal vessels, the Pacchionian bodies, the venous sinuses of the dura mater, the impressiones digitatae and juga cerebralia.

The casts of the vault and of the occipital end of the skull resemble in general form the norma verticalis and the norma occipitalis of the skull, but a side view of a cast of one half of the cranial cavity presents some striking differences from that of the norma lateralis of the skull. Thus the cast shows well the shape of the anterior, middle, and posterior fossae of the base of the skull and the sharply-defined boundaries between them. The posterior part of the lateral aspect of the anterior fossa forms a rounded projection which corresponds to a depression on the frontal bone external to its orbital plate, while a well-defined groove marks the position of the lesser wing of the sphenoid bone and separates the cavities of the anterior and middle fossae. A deep excavation bounded posteriorly by the sigmoid part of the transverse sinus, and below and in front by the middle fossa, indicates the position occupied by the petrous part of the temporal bone.

**Meningeal Vessels.**—The markings showing the course of the middle meningeal vessels are too well known to require any detailed description, but I do not consider that their terminal branches afford a reliable guide to the median line of the skull, for while in some cases they appear, as described by Keith, to end in very fine twigs a little external to the median plane, in other instances they can be seen extending inwards, probably as venous grooves, to the level of the superior longitudinal sinus. Various
anatomists have directed attention to a broad deep groove passing upwards near to and almost parallel with the coronal suture. Several of my casts show a ridge corresponding to this groove, which is so deep that the cranial wall is translucent in this position.

**Pacchionian Bodies.**—My casts show, as one would expect, considerable variations in the number, size, and position of the Pacchionian bodies. In only one out of thirteen casts of the vault were distinct markings for these structures absent.

**The Venous Sinuses.**—The venous sinuses of the dura mater are generally described as grooving the bones, but this is by no means the case in the whole of their course. In front an endocranial cast of the vault shows a distinct median groove which may be subdivided by a slight ridge. As this groove approaches the region of the bregma it tends to become very shallow or even replaced by a convexity, while opposite about the posterior half of the sagittal suture the groove generally becomes distinct again but marked along the middle line by a narrow ridge (see Fig. 3). These markings on an endocranial cast are of interest in connection with the determination of the median line of the vault of the skull in prehistoric fragments. Thus in the reconstruction of the Piltdown skull considerable differences of opinion exist as to whether or not a large piece of the left half of the frontal and parietal portions of the vault should be so placed that certain parts of it cross the median plane on to the right side. Dr. Smith Woodward, in his original description of this fragment, stated that the sagittal suture was entirely obliterated. Since then Professor Elliot Smith has discovered a suture which he believes represents its anterior end, but no trace of the posterior part has been detected, consequently other markings have to be looked for which might serve as a guide to the relation of the posterior part of the fragment to the median line. Professor A. Keith states that "In the skull of all the higher primates the longitudinal sinus near the hinder end of the adjacent margins of the right and left parietal bones is marked by a narrow deep groove with distinct edges; on the margin of the upper angle of the Piltdown fragment the edge or margin of this groove can be clearly recognised." Hence Keith, in his reconstruction, placed the fragment so that the posterior part of its inner edge came close to, but did not cross, the median plane. I have 15 endocranial casts of this region of the skull-cap, and out of these 9 show a distinct ridge corresponding to the groove on the bone described by Keith; in most of the others it was present but only faintly marked. This
deep narrow groove is therefore not constant in man, although it appears to occur in a distinct majority of skulls.

The posterior end of the superior sagittal (longitudinal) sinus is deeply embedded in the interval between the two cerebral hemispheres, so that the latter project backwards about 2 cm. further than the sinus.

The position of the median part of the transverse or lateral sinus is indicated on an endocranial cast by a distinct depression between the prominences due to the cerebrum and cerebellum there. The sinus only faintly grooves the bone, but as it gains the lateral aspect of the skull it tends to project beyond these organs, and at the sigmoid part of the sinus produces a marked prominence on an endocranial cast (Figs. 11 and 15).

Impressiones Digitatae and Juga Cerebralia.—These are the only markings on an endocranial cast from which we can obtain any details as to the arrangement of the cerebral convolutions and fissures. My own observations on these depressions and ridges are in close agreement with those of Schwalbe, and I have but little to add to his excellent account of their distribution. Except in rare cases they are very feebly marked on the vault. They tend to increase in distinctness from the vault towards the base and are best developed in the anterior and middle fossae. The cause of this distribution is somewhat doubtful, but it is probably due to gravity, the brain, having a distinctly higher specific gravity than its investing cerebro-spinal fluid, tends to sink in this fluid. Owing to the most frequent position of the head being the erect one the bony base is most markedly impressed by the brain, then as the horizontal posture is less frequently assumed, the lateral, anterior, and posterior walls are not so distinctly marked, while their absence at the vault is dependent on the accumulation of a more or less continuous layer of fluid in this situation separating the convolutions from close proximity to the bone.

Schwalbe directed attention to the fact that in many subjects the prominence formed by the free posterior border of the lesser wing of the sphenoid and lodged in the main stem of the Sylvian fissure is continued backwards and upwards on the lateral wall of the skull by an elevation which he terms crista Sylvii ossis parietalis. The lower border of this elevation is formed by the inferior border of the inner aspect of the parietal bone, and it usually corresponds with the anterior portion of the superior temporal sulcus. The inner surface of the squamous portion of the temporal bone almost invariably shows depressions directed obliquely
downwards and forwards, which mark the position of the middle and inferior temporal convolutions. The portion of the cranial wall above the inner line of the parieto-squamous suture is thicker than that below this suture, and it forms a prominence opposite the rather narrow and somewhat depressed superior temporal convolution. This prominence may be represented on the lateral surface of the bone by a depression directed from the region of the pterion backwards and upwards. In skulls in which the digital impressions are well marked (see Fig. 15), a series of depressions may indicate the direction of the superior temporal convolutions, and another the convolutions situated above the posterior limb of the Sylvian fissure, so that the course of this fissure, except at its posterior end, may be clearly defined on an endocranial cast. In other cases the digital impressions bounding the posterior limb of the Sylvian fissure may be quite indistinct (see Fig. 11). On the lower portion of the outer aspect of the inferior frontal convolution there is a rounded prominence which lies in a distinct fossa on the temporal part of the squamous portion of the frontal bone. This fossa is represented on the lateral aspect of the cranial wall by the protuberentia gyri frontalis inferior of Schwalbe, which, with those opposite the middle and inferior temporal convolutions, are of special interest as being elevations of the outer aspect of the cranial wall corresponding to convolutionary prominences of the brain. Although these cranial "bumps" are covered by the temporal muscle they can often be felt in the living body. The convexity on an endocranial cast corresponding to the fossa for the lodgment of the elevation on the inferior frontal convolution is usually smooth, but may be marked by one or more grooves due to cerebral sulci. The digital impressions and cerebral ridges on the orbital plates of the frontal bone are never absent, and, as a rule, clearly map out the convolutions and fissures on the orbital aspect of the frontal lobe of the brain. The elevations on an endocranial cast opposite the frontal and parietal eminences on the skull-cap are usually rather more distinct than the latter, owing to a slight thinning of the frontal and parietal bones in these places, and a similar condition obtains at the cerebral fossae of the squamous part of the occipital bone.

Viewed from the lateral aspect an endocranial cast shows a very distinct hollow in front of the sigmoid part of the transverse sinus, which is due to the elevation of the petrous part of the temporal bone as compared with the floor of the middle fossa of the base of the skull in front of it.
ENDODURAL CASTS (see Figs, 4, 8, 12, 17, and 18).—The dura mater, although generally regarded as one of the membranes of the brain, may from a morphological and surgical point of view be considered a part of the cranial wall, since it forms the internal periosteum for the cranial bones. Its blood-vessels, very inappropriately termed meningeal, are mainly distributed to these bones, and are completely separated by the subdural space and the arachnoid from the vessels that supply the brain. As the meningeal vessels ramify over the outer aspect of the dura mater and this membrane contains a number of venous sinuses and forms various folds which project towards the cranial cavity, it is evident that casts of the cranial wall with and without dura must differ from one another in various respects. The branched elevations due to the meningeal vessels, which constitute such a characteristic feature of an endocranial cast, are entirely absent on an endodural one, the cranial surface of the dura mater opposite these vessels being smooth. It is true that over a large part of the endocranial surface the dura mater is thin and closely applied to the bone, so that the digital impressions on the bone are duplicated in relief on both the endocranial and endodural casts, but in the position of the superior sagittal and transverse sinuses and their immediate neighbourhood there is no such harmony.

As the superior sagittal sinus projects downwards between the two cerebral hemispheres and gives attachment to the falx cerebri, and as the horizontal portion of the two transverse sinuses is lodged in the groove between the cerebrum and the cerebellum and is continuous with the tentorium cerebelli, their effect on the form of endodural casts (Figs. 4, 8, and 12) as compared with those of the bone itself (Figs. 3, 7 and 11) needs only to be mentioned to be appreciated. The sigmoid part of each transverse sinus, on the other hand, grooves deeply the bone and does not project internally, so that its position is only faintly indicated on a cast of the inner surface of the dura mater.

The relations of the dura mater and the appearances of its cerebral surface in the immediate neighbourhood of the superior sagittal and the transverse sinuses require a more detailed consideration, as they have been either entirely ignored or imperfectly described in our anatomical and surgical text-books. When the vault of the skull with its contents is removed by a horizontal section, and an attempt is made to take out the upper part of the cerebral hemispheres along with the arachnoid and pia mater, the
subdural space is found to be interrupted near the medium plane by the passage of the arachnoid and a number of subarachnoid blood-vessels into the dura mater. If these structures be torn and the brain removed, the cerebral surface of the dura mater is seen to be broken up into a number of fasciculi the clefts between which serve for the passage of the structures already mentioned as crossing the subdural space. The superior cerebral veins pass into the venous channels known as the lacunæ laterales, or sometimes directly into the sagittal sinus, while the small arteries of the pia, pushing the arachnoid before them, project into the venous spaces and form the capillary tufts of the Pacchionian bodies.

Mr. P. Sargent has recently directed attention to the surgical importance of the lateral lacunæ, as they may render the upper end of the cortical motor area relatively inaccessible to the surgeon. In one case he found that each parietal lateral lacuna measured 15 cm. in length and 2·5 cm. in breadth at its widest part.

Fig. 19 is a photograph of the dura mater of the vault viewed from the cerebral aspect in a man aged 60 years. The dura mater was suspended by threads in front of a good light. At the sides it is seen to be smooth and translucent, while near the longitudinal sinus it is rough and opaque, owing to irregular projections of the dura mater and the presence in its substance of venous lacunæ and Pacchionian bodies. In this specimen the lacunæ form a more or less continuous series from about halfway between the nasion anteriorly backwards on the frontal and parietal bones as far as the level of the parietal foramina. They are broadest towards the anterior part of the interparietal suture, where the two lateral lacunæ and the sagittal sinus have a breadth of about 3·5 cm. The corresponding subdural cast presents a number of broad grooves running mainly inwards and forwards which lodged the superior cerebral veins, and numerous fine transverse or oblique depressions which were occupied by fasciculi of the dura mater.

Fig. 20 is a photograph, taken from the front, of the inner surface of the dura mater in the occipital part of the skull. The tent-like tentorium is seen to divide the cranial cavity into an upper and a lower portion for the lodgment respectively of the cerebral hemispheres and the cerebellum. Below the posterior attachment of the tentorium on each side of the falx cerebelli the dura mater presents a distinctly rough fasciculated area. The clefts between
these fasciculi serve for the passage into the dura mater of the arachnoid and pia mater covering the opposed portion of the lateral lobes of the cerebellum. This peculiar appearance of the dura mater has been generally overlooked, although it was figured many years ago by Kay and Retzius. The grooves in an endodural cast due to these fasciculi are seen in Fig. 8.

This coronal section of the skull divided the base just in front of the posterior edge of the foramen magnum, and it will be seen that the median fold of the dura mater forming the falx cerebelli terminates some distance behind the foramen magnum. Between the foramen and the falx the dura covers a flat triangular area which was termed by Schwalbe the trigonum vermianum, although it must be remembered that it is not in contact with the vermis of the cerebellum, being separated from it by the cerebro-spinal fluid contained in the cisterna magna.

**Arachnoid Casts.** — There are no large cisterna for the cerebro-spinal fluid over the cranial aspect of the convoluted surface of the cerebral hemispheres, still there is sufficient fluid with the arachnoid, the pia mater, and the cerebral vessels covering the cerebral cortex to obscure the course of many of the cerebral fissures. The larger amount of the cerebro-spinal fluid at the vault as compared with the base is mainly responsible for the imprint of the convolutions at the base in the form of digital impressions and their practical absence at the vault. These facts are readily demonstrated by an examination of the series of casts in which the form of the bone, the dura mater, the arachnoid and the brain itself are represented.

The appearance of the arachnoidal surface is seen in Fig. 21, made from a photograph of the left cerebral hemisphere of a man 59 years old, viewed from the lateral aspect. This photograph shows that the arachnoid is reflected at the vault from one convolution to another without any marked depression opposite the fissures, while at the base and in the region of the frontal and occipital poles it makes a distinct dip inwards and the fissures are consequently more sharply defined. In the neighbourhood of the Sylvian point, however, it bridges across the fissure to form a small cisterna.

As a rule the cranial surface of the lateral lobes of the cerebellum is moulded pretty closely to the bone so that the position of the great horizontal sulcus can usually be detected in an endocranial cast of the cerebellar fossa of the occipital bone, but opposite the pyramid of the inferior vermiform process and the
adjacent portion of the lateral lobes, the large collection of cerebro-spinal fluid which is contained in the cisterna magna causes a distinct separation between the cerebellum and the bone.

**Brain Casts.**—When the cranial aspect of the cerebral convolutions of a well-hardened brain is examined both before and after the removal of the arachnoid and pia mater it will be found that the larger cerebral vessels by no means invariably occupy the sulci, but frequently lie superficial to and groove the convolutions. Further, the convolutions do not present a uniform flat surface, but exhibit elevated and depressed portions, the latter being generally bridged over by the arachnoid, beneath which are small pools of cerebro-spinal fluid. It must also be remembered that in order to identify fissures with certainty it may be necessary to open them up to ascertain their relations to the "concealed" convoluted surface of the hemisphere. This is especially the case with the branches of the Sylvian fissure and the associated insular opercula, as the latter are bounded by fissures which extend into the limiting sulcus of the island of Reil. It is evident from these facts and from the relations of the arachnoid and dura mater already described, that great caution must be exercised in attempting to determine the fissural and convolutionary pattern of the brain from an endocranial cast. If all the membranes of the brain were uniformly thin, the cerebro-spinal fluid very small in amount, and there were no cisterns in which this fluid could accumulate, an endocranial cast would give a fair pattern of the superficial convolutions and the fissures bounding them, but we know that such conditions are non-existent, except over limited areas. It has been supposed that an estimate of the degree of simplicity or complexity of the convolutions and fissures could be formed from the number and arrangement of the impressions digitatae and juga cerebralia, but unfortunately for this hypothesis few and feebly marked digital impressions may exist with a well-convoluted brain. If the endocranial cast of the lateral half of the skull of a man 56 years of age (see Fig. 15) be compared with that of a female 61 years of age (Fig. 11), it will be found that the imprints of the digital impressions differ very markedly, yet in these two subjects there was no essential difference in the complexity of the convolutionary pattern.

The only cerebral fissures which can, as a rule, be identified on an endocranial cast are the main stems of the Sylvian fissure and its posterior branch, the superior and middle temporal sulci and
those on the orbital surface of the frontal bone. Those fissures which cut into the superior border of the cerebral hemisphere, such as the central and parieto-occipital, are not indicated on an endocranial cast owing to their being separated from the bone by some of the following structures, viz.: the superior sagittal sinus and the lacunae laterales embedded in the dura mater, the superior cerebral veins, the arachnoid and cerebro-spinal fluid, and the Pacchionian bodies. The course of these fissures outwards on the superior aspect of the hemisphere cannot be followed, mainly owing to the accumulation of the cerebro-spinal fluid on the vault.

In skulls in which the digital impressions and intervening ridges are well marked, an endocranial cast shows, of course, corresponding markings, but except at the base the ridges, even when superficial to cerebral fissures, are interrupted too frequently to permit of the latter being mapped out except in a vague and uncertain manner. We have already referred to the elevation on the lateral aspect of the frontal lobe occupying a depression on the part of the frontal bone which enters into the formation of the floor of the temporal fossa. In this region of the brain is placed the inferior frontal convolution, and it is marked by a number of fissures (see Fig. 14). The anterior branch of the Sylvian fissure cuts into it and divides into two sulci (anterior ascending and anterior horizontal) bounding the cap of Broca, pars triangularis, or frontal operculum (PT, PT, on Fig. 14). The frontal operculum is related medially to the orbital operculum and behind to the fronto-parietal operculum. In addition to the two anterior branches of the Sylvian fissure other sulci, such as the diagonal and branches of the inferior frontal and inferior precentral, may be found in this region. On none of my four endocranial casts of the lateral half of the skull can these fissures be identified, and in two of them the whole area forms a nearly smooth rounded elevation.

From the endocranial casts of La Chapelle, La Quina, and Piltdown paleolithic skulls, Professors Boule, Anthony, and Elliot Smith have described the arrangement of a number of the cerebral fissures and convolutions, and upon this basis have constructed theories regarding the evolution of the brain of ancient man.

It is only from the size and form of the cranial cavity that we can form any opinion as to the degree of cerebral development of the prehistoric races of mankind since their brains have not been
preserved. So far as I am able to judge, the endocranial casts of the prehistoric skulls which have been found up to the present do not yield any more information regarding the convolutionary pattern of the cerebral cortex than those of existing man. It is unfortunate that the facts they reveal are so few in number and so lacking in precision, but it is surely better to admit frankly the limitations of our knowledge than to reconstruct primitive brains upon such slender data.

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ON THE VALUE OF EMULSIONS OF LIQUID PARAFFIN AND CASTOR-OIL IN THE TREATMENT OF CERTAIN TYPES OF CHRONIC DYSEPSIA IN CHILDHOOD.

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This paper deals with the treatment of various forms of chronic dyspepsia in children over one year by emulsions of liquid paraffin or of castor-oil. It is based on the notes of about 120 cases which I have observed in the Out-patient Department of the Children's Hospital during the last three years. For the-