Surface anatomy

As stated above, only the hemispheres and diencephalon (or brain stricto sensu) are considered. The anatomy of the hind brain (brain stem and cerebellum), presented in a separate work [19], is omitted.

In spite of the important variations in sulcal and gyral anatomy from one brain to another as well as from one hemisphere to another, we give a synthetic view of what is most often encountered in our preparations or in the abundant literature [1–78]. So we leave aside the endless recording of variations to concentrate on general conformations which seem sufficient to illustrate cortical functional mapping.

For reasons of simplification, the hemispheres can be divided into lateral, inferomedial, and basal surfaces. The inferomedial surface is formed by the medial surfaces of the frontal, parietal, and occipital lobes and the inferior surfaces of the temporal and occipital lobes. Since the medial and inferior surfaces are continuous with each other with a very flat angle permitting an easy overall view, we decided to describe them as a whole rather than separately, as often done in other studies.

The basal surface includes the inferior surface (also called orbital lobe) of the frontal lobe, the anterior perforated substance, and the interpeduncular area.

1 The lateral surface

For a general view of the lateral surface refer to Fig. 1.
The lateral, central, parieto-occipital, and temporo-occipital fissures divide the lateral surface into frontal, temporal, parietal, and occipital lobes. The parts of these lobes which overlap the lateral surface and which can be seen on the inferomedial surface will be described later. The lateral surface of the hemisphere also comprises the insula hidden at the bottom of the lateral fissure.

1.1 The principal sulci on the lateral surface

1.1.1 **The lateral fissure** (fissure of Sylvius) is divided into two parts, the basal (Sect. 3.2) and the lateral part. The lateral part is in turn divided into anterior, middle, and posterior segments.

The anterior segment branches into two rami, which penetrate the frontal lobe: the horizontal ramus orally and the vertical one caudally.

The middle segment follows an almost horizontal course.

The posterior segment turns up vertically.

The lateral fissure forms a deep depression, the lateral fossa, whose sides overlap the insula and constitute the lateral operculum, divided into frontal, central, parietal, and temporal opercula. Each operculum will be described with the lobe it pertains to.

1.1.2 **The central sulcus** (or fissure of Rolando) separates the frontal and parietal lobes. It starts usually on the upper margin of the hemisphere, where it causes a significant notch curving

Fig. 1. Lateral aspect of the left hemisphere. The dotted lines show the theoretical boundaries between the different lobes. Fissures or sulci separating the lobes:

LFa lateral fissure, anterior segment
LFm lateral fissure, middle segment
LFp lateral fissure, posterior segment
CS central sulcus
PO parieto-occipital fissure
TO temporo-occipital incisure

Frontal lobe

F1 superior frontal gyrus
F2 middle frontal gyrus
F3 inferior frontal gyrus
PrG precentral gyrus
1 superior frontal sulcus
1′ superior precentral sulcus
2 middle frontal sulcus; when present, it divides the middle frontal gyrus into superior and inferior parts
3 inferior frontal sulcus
3′ inferior precentral sulcus
4 lateral orbital sulcus
4′ lateral orbital gyrus
5 frontomarginal sulcus
6 horizontal ramus of lateral fissure
7 vertical ramus of lateral fissure
8 inferior frontal gyrus, pars orbitalis
9 inferior frontal gyrus, pars triangularis
10 inferior frontal gyrus, pars opercularis
11 sulcus triangularis
12 sulcus diagonalis
13 subcentral gyrus; *a* anterior and *b* posterior subcentral sulci

Temporal lobe

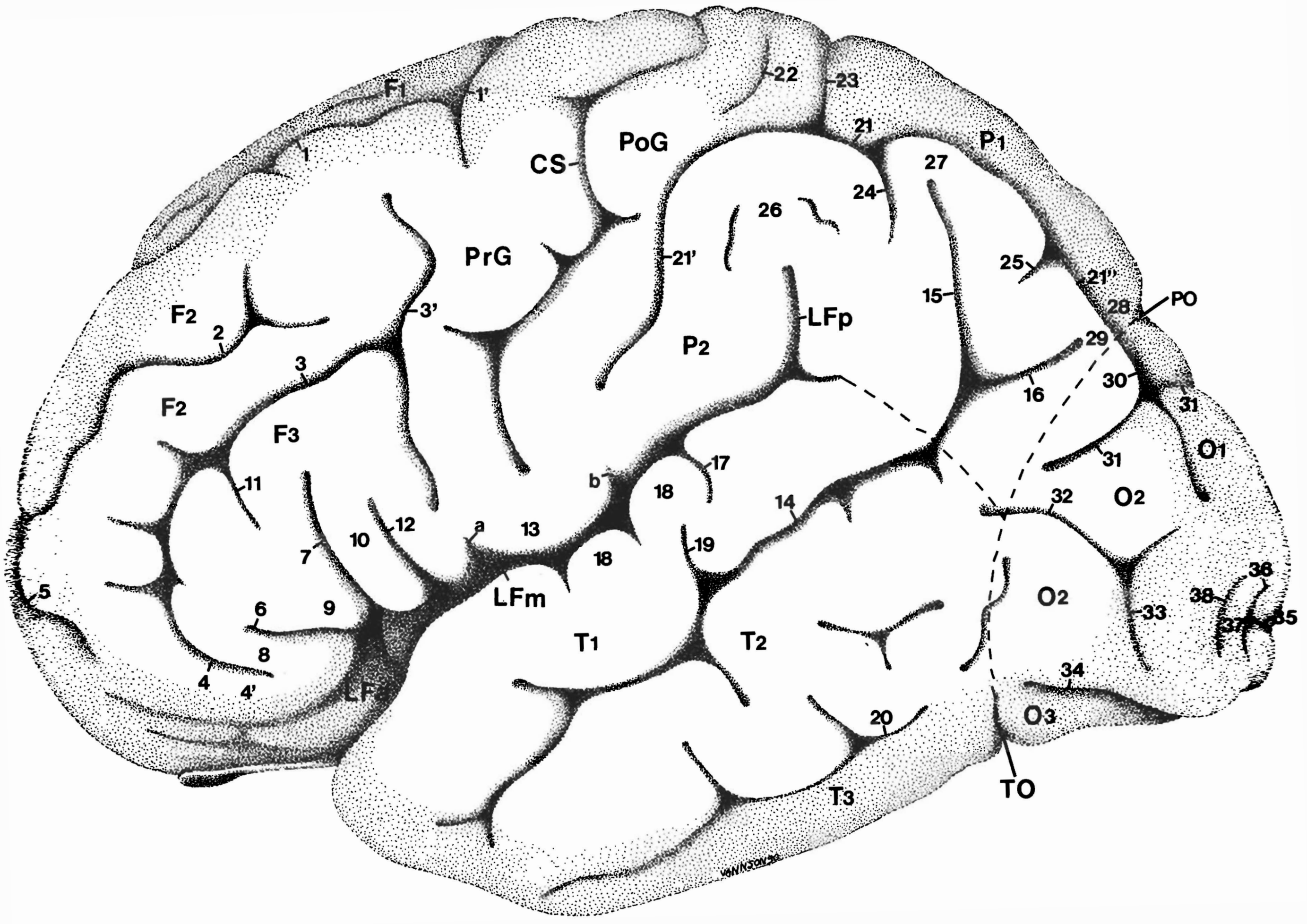
T1 superior temporal gyrus
T2 middle temporal gyrus
T3 inferior temporal gyrus
14 superior temporal sulcus, anterior segment
15 superior temporal sulcus, ascending posterior segment
16 superior temporal sulcus, horizontal posterior segment
17 transverse temporal sulcus
18 transverse temporal gyri
19 sulcus acousticus
20 inferior temporal sulcus

Parietal lobe

P1 superior parietal gyrus
P2 inferior parietal gyrus (parietal operculum)
PoG postcentral gyrus
21 intraparietal sulcus, horizontal segment
21′ intraparietal sulcus, ascending segment (inferior postcentral sulcus)
21″ intraparietal sulcus, descending segment
22 superior postcentral sulcus
23 transverse parietal sulcus
24 sulcus intermedius primus (of Jensen)
25 sulcus intermedius secundus
26 supramarginal gyrus
27 angular gyrus
28 arcus parieto-occipitalis, or first parieto-occipital “pli de passage” of Gratiolet
29 second parieto-occipital “pli de passage” of Gratiolet

Occipital lobe

O1 superior occipital gyrus
O2 middle or lateral occipital gyrus
O3 inferior occipital gyrus
30 intra-occipital sulcus or superior occipital sulcus
31 transverse occipital sulcus
32 lateral occipital sulcus (or middle occipital sulcus) when present, it divides the middle occipital gyrus into superior and inferior parts
33 sulcus lunatus
34 inferior occipital sulcus
35 calcarine sulcus
36 retrocalcarine sulcus
37 gyrus descendens
38 occipitopolar sulcus


F1
1'
1
CS
PoG
22
23
21
P1
27
24
26
PrG
21'
25
21''
F2
2
3'
15
LFp
28
PO
29
P2
3
F2
16
30
31
F3
O1
31
b
17
11
18
14
32
O2
a
13
12
10
19
7
18
LFm
O2
36
5
6
9
38
33
37
35
T1
T2
8
34
4
4'
20
O3
T3
TO

backward, and is visible on the medial surface. From this point of origin, the central sulcus goes down obliquely following a sinuous course: the upper and lower parts anteriorly convex and the middle one anteriorly concave. Sometimes the central sulcus is interrupted by a bridging gyrus linking the frontal and parietal lobes. The sulcus is thus separated into one superior and one inferior segment, a vestigial remnant of the foetal brain. The lower end of the central sulcus is separated from the lateral fissure by the subcentral gyrus.

1.1.3 **The parieto-occipital fissure** is not easily seen on the lateral surface. It is a notch on the upper edge of the hemisphere, between the parietal and occipital lobes.

1.1.4 **The temporo-occipital or pre-occipital incisure** is another notch between the occipital and temporal lobes, situated on the inferior margin of the hemisphere, and it sometimes extends into a vertical sulcus, the anterior occipital sulcus (Figs. 3 and 123).

1.2 The frontal lobe (lateral surface)

The frontal lobe is the only one on the lateral surface to be clearly separated from the other lobes. It is bounded inferiorly by the lateral fissure and caudally by the central sulcus.

Three sulci – superior frontal, inferior frontal, and precentral – divide it into four frontal gyri: precentral, superior, middle, and inferior.

1.2.1 **Frontal sulci** on the lateral surface. The superior and inferior frontal sulci assume a horizontal orientation: at their caudal ends they branch into two rami, ascending and descending, which form superior and inferior precentral sulci. Those two sulci often remain independent or merge to create one single precentral sulcus.

1.2.2 **The precentral gyrus** is set apart from the other frontal gyri by the precentral sulcus, and from the parietal lobe by the central sulcus, whose lower end does not usually reach the lateral fissure. In that case a small, subcentral gyrus, bounded by two short, anterior and posterior, subcentral sulci, links the precentral and postcentral gyri. Those parts of the precentral, postcentral, and subcentral gyri which line the lateral fissure form the central, or rolandic, operculum (Figs. 54–57 and 59).

1.2.3 **The superior frontal gyrus** (F1) lies on the superior margin and overlaps the medial surface of the hemisphere (Fig. 13); the lateral surface of the superior frontal gyrus is often divided by an additional, and occasionally discontinuous, longitudinal sulcus.

1.2.4 **The middle frontal gyrus** (F2) is in most cases the largest; it is situated between the superior and inferior frontal sulci. It is often divided by an additional, middle frontal sulcus into one superior and one inferior part. This sulcus reaches the frontal pole where it sometimes merges into the frontomarginal sulcus (of Wernicke). The frontomarginal sulcus (Fig. 6) may also stem from the superior frontal sulcus, or be totally independent, and in any case crosses the frontal pole transversally (Sect. 1.2.6).

1.2.5 **The inferior frontal gyrus** (F3) is bounded in its upper part by the inferior frontal sulcus: it normally bypasses the lower edge of the frontal lobe and merges into the orbital lobe. However, there sometimes appears a lateral orbital sulcus between the frontal and orbital lobes. It was found that this sulcus may be either independent, or stemming from the frontomarginal sulcus (Fig. 30), or again curving backward from the inferior frontal sulcus (Fig. 4). The two, horizontal and vertical, rami issueing from the lateral fissure define three parts in the inferior frontal gyrus: the pars orbitalis orally, the pars triangularis centrally, and the pars opercularis caudally. A small groove, the sulcus triangularis, stemming from the inferior frontal sulcus, often cuts into the pars triangularis. A vertical groove, the sulcus diagonalis, is often to be found on the pars opercularis. The pars triangularis and the pars opercularis combine to form the frontal operculum (see Figs. 47–53).

1.2.6 **The frontal pole** (Figs. 4 and 6) is a transitional area between the lateral, medial, and orbital surfaces of the frontal lobe. Its anatomy is complex because when they reach the frontal pole the longitudinally oriented frontal gyri are interrupted by transversal folds: the transverse frontopolar gyri.

There can be found two, superior and inferior, transverse frontopolar gyri, and possibly a third, middle one. The frontomarginal sulcus extends between the transverse frontopolar gyri dorsally and the frontomarginal gyrus ventrally. At the level of the frontal pole this gyrus marks the boundary between the frontal and orbital lobes.

1.3 The temporal lobe

On the lateral surface of the hemisphere the temporal lobe caudally joins the parietal and occipital lobes, without any clearly defined boundary, except the inconspicuous temporo-occipital incisure. Two, superior and inferior, temporal sulci divide the lateral surface of the temporal lobe into three, superior, middle, and inferior, temporal gyri.

1.3.1 **The temporal sulci** on the lateral surface. The superior temporal sulcus, sometimes called parallel sulcus because it runs parallel to the lateral fissure, may be described as two segments, one anterior and one posterior. The anterior segment reaches the temporal pole, where it is sometimes termed the anterior temporal sulcus. The posterior segment may assume two different aspects. In some cases it is formed by one sulcus only, but in most cases it branches out posteriorly into one ascending posterior segment (sulcus angularis) and one horizontal posterior segment.

The inferior temporal sulcus is usually not continuous and does not provide easy identification. In the vicinity of the occipital lobe, its posterior end may occasionally run upward and be called the anterior occipital sulcus (Fig. 3).

1.3.2 **The superior temporal gyrus** (T1) runs parallel to the lateral fissure. Its ascending posterior part lies between the ascending segments of the lateral fissure orally and of the superior temporal sulcus caudally. Its anterior end is a part of the temporal pole (Sect. 1.3.5).

The upper margin of the superior temporal gyrus forms the temporal operculum (Fig. 9). It continues into the lateral fissure by a large cortical area, sometimes called the superior surface of the temporal lobe. This surface can only be observed when the superior overlying margin of the lateral fissure has been removed. From front to back the superior surface of the temporal lobe is divided into three parts: the planum polare, the transverse temporal gyri, and the planum temporale (Fig. 9).

The planum polare, with an uneven aspect, is separated from the insula by the inferior circular sulcus.

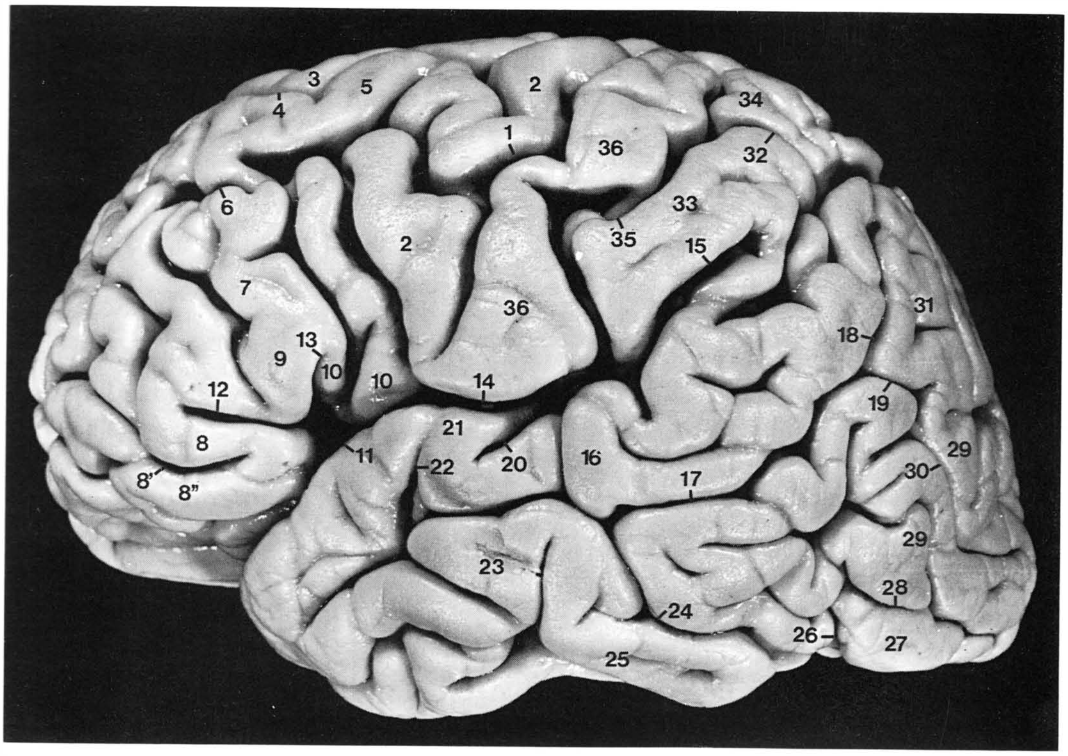


Fig. 2. Lateral aspect of left hemisphere (× 0.85).

1 central sulcus
2 precentral gyrus
3 superior frontal gyrus (F1)
4 superior frontal sulcus
5 middle frontal gyrus (F2)
6 inferior frontal sulcus
7 inferior frontal gyrus (F3): in this case the inferior frontal gyrus is large and the middle frontal gyrus small
8 pars orbitalis
8′ lateral orbital sulcus
8″ lateral orbital gyrus
9 pars triangularis
10 pars opercularis
11 lateral fissure, anterior segment
12 horizontal ramus of lateral fissure
13 vertical ramus of lateral fissure
14 lateral fissure, middle segment
15 lateral fissure, posterior segment
16 superior temporal gyrus (T1)
17 anterior segment of superior temporal sulcus
18 ascending posterior segment of superior temporal sulcus
19 horizontal posterior segment of superior temporal sulcus
20 transverse temporal sulcus
21 transverse temporal gyrus
22 sulcus acousticus
23 middle temporal gyrus (T2)
24 inferior temporal sulcus
25 inferior temporal gyrus (T3)
26 temporo-occipital incisure
27 inferior occipital gyrus (O3)
28 inferior occipital sulcus
29 middle occipital gyrus (O2)
30 lateral occipital sulcus merging into the superior temporal sulcus (19)
31 angular gyrus
32 intraparietal sulcus
33 supramarginal gyrus
34 superior parietal gyrus (P1)
35 inferior postcentral sulcus (ascending segment of intraparietal sulcus)
36 postcentral gyrus

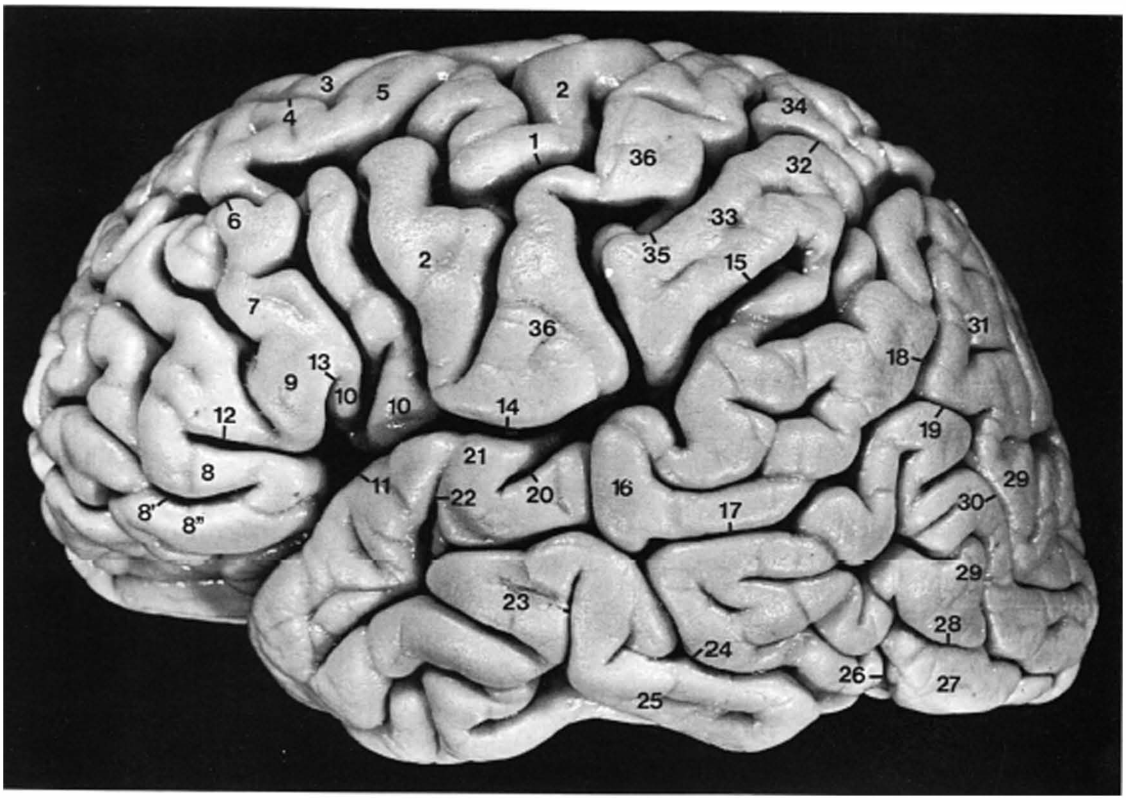


Fig. 3. Lateral aspect of left hemisphere (× 0.80).

1 anterior segment of the lateral fissure; *a* horizontal and *b* vertical ramus
2 middle segment of the lateral fissure
3 posterior segment of the lateral fissure, contrary to its usual vertical orientation, it appears horizontally oriented
4 central sulcus
5 precentral gyrus
6 superior frontal gyrus (F1)
7 superior frontal sulcus
7′ superior precentral sulcus
8, 8′ middle frontal gyrus (F2), superior and inferior parts
9 middle frontal sulcus
10 inferior frontal sulcus
10′ inferior precentral sulcus
11 inferior frontal gyrus (F3), pars orbitalis
12 inferior frontal gyrus (F3), pars triangularis
13 inferior frontal gyrus (F3), pars opercularis
14 superior temporal gyrus (T1)
15 sulcus acousticus
16 transverse temporal gyrus
17 transverse temporal sulcus
18 planum temporale
19 superior temporal sulcus
20 middle temporal gyrus (T2)
21 inferior temporal sulcus
22 inferior temporal gyrus (T3)
23 anterior occipital sulcus (branch of inferior temporal sulcus)
24 temporo-occipital incisure
25 inferior occipital gyrus (O3)
26 inferior occipital sulcus
27, 27′ middle occipital gyrus, superior and inferior parts
28 lateral occipital sulcus
29 transverse occipital sulcus
30 angular gyrus
31 sulcus intermedius secundus
32 ascending posterior segment of superior temporal sulcus
33 sulcus intermedius primus (of Jensen)
34 intraparietal sulcus
35 supramarginal gyrus
36 inferior postcentral sulcus (ascending segment of intraparietal sulcus)
37 postcentral gyrus

The transverse temporal gyri (or Heschl's gyri) are sometimes reduced to only one gyrus. But most commonly there are one anterior transverse temporal gyrus and one posterior transverse temporal gyrus, separated by an intermediate transverse temporal sulcus. They originate from the retro-insular area of the lateral fossa. They then follow an oblique oral course and reach laterally the outward aspect of the superior temporal gyrus, where they often assume the shape of one or two lobules partially grooved by the sulcus acousticus branching from the superior temporal sulcus. Those transverse temporal gyri are caudally separated from the planum temporale by the transverse temporal sulcus which can usually be described on the lateral surface of the superior temporal gyrus.

The planum temporale varies eminently in size. It may be short if the ascending posterior segment of the lateral fissure stems out close to the transverse gyri, or conversely quite spacious if the said segment is caudally stretched out, or even nonexistent.

1.3.3 **The middle temporal gyrus** (T2) reaches to the temporal pole orally and the occipital lobe caudally, without any clear-cut boundary.

1.3.4 **The inferior temporal gyrus** (T3) is not very visible on the lateral surface, but more so on the inferior temporal surface (see Fig. 13). This gyrus is caudally separated from the occipital lobe by the temporo-occipital incisure.

1.3.5 **The temporal pole** is formed by the combination of the superior, middle, and inferior temporal gyri, which overlap the inferior surface of the temporal lobe (Figs. 6 and 17).

1.4 The parietal lobe (lateral surface)

It is clearly separated from the frontal lobe by the central sulcus, but it stretches caudally over the posterior end of the lateral fissure and merges into the temporal and occipital lobes. The parieto-occipital fissure, small on the lateral surface, is the only sign of a boundary with the occipital lobe.

1.4.1 **The parietal sulci** on the lateral surface. On the lateral surface of the parietal lobe, only one sulcus is clearly visible, the intraparietal (or interparietal) sulcus. Its general course is ventrally concave. The intraparietal sulcus is, in most cases, composed of three segments, the anterior segment follows an ascending course, the intermediate segment is horizontal, and the posterior segment follows a descending route.

The ascending segment, or inferior postcentral sulcus, runs parallel to the central sulcus. (There is also an independent superior postcentral sulcus which is not sharply defined.)

The horizontal segment is an acutely angled continuation of the anterior segment. As it courses backward, it gradually turns into the descending segment.

As the descending segment crosses the theoretical boundary of the parietal lobe, it changes name and becomes the intra-occipital sulcus.

The intraparietal sulcus divides the parietal lobe into the postcentral and the superior and inferior parietal gyri.

1.4.2 **The postcentral gyrus** is often narrower than its frontal homologue from which it is separated by the central sulcus. The subcentral gyrus – ventrally – and the paracentral lobule – dorsally – (see Fig. 13) represent a superficial link between precentral and postcentral gyrus.

1.4.3 **The superior parietal gyrus** (P1) lies on the superior margin of the hemisphere and overlaps its medial surface (Sect. 2.3). It is often crossed by the transverse parietal sulcus branching out from the intraparietal sulcus. At the level of the parieto-occipital fissure, the superior parietal gyrus is linked to the superior occipital gyrus by a transitional area called arcus parieto-occipitalis (or first parieto-occipital "pli de passage" of Gratiolet). The superior parietal gyrus may be connected with the inferior parietal gyrus by bridging lobules which cross over the intraparietal sulcus.

1.4.4 **The inferior parietal gyrus** (P2) is situated above the lateral fissure. The lower margin of the inferior parietal gyrus forms the parietal operculum (Figs. 70–77). It is divided by the sulcus intermedius primus of Jensen, which is a descending ramus of the intraparietal sulcus, into two parts, the supramarginal and the angular gyrus.

The supramarginal gyrus, rostrally situated, is an arched lobule surrounding the end of the lateral fissure.

The angular gyrus, caudally situated, is a narrow lobule bypassing the ascending posterior segment (sulcus angularis) of the superior temporal sulcus. There is sometimes a sulcus intermedius secundus which bounds posteriorly the angular gyrus. Actually this angular gyrus may be extended to a whole triangularly shaped cortical region lying between the ascending and horizontal segments of the superior temporal sulcus. As it turns round the above mentioned horizontal segment, the angular gyrus is connected to the middle occipital gyrus by a small bridging lobule, the second parieto-occipital "pli de passage" of Gratiolet (Figs. 1 and 102).

1.5 The occipital lobe (lateral surface)

No clear-cut boundary distinguishes the occipital lobe from the neighbouring parietal and temporal lobes, although a controversial anterior occipital sulcus (Figs. 3 and 123) was sometimes quoted as protracting the inferior temporal sulcus, or originating from the temporo-occipital incisure. The occipital lobe is therefore separated from the other lobes by a theoretical line starting from the parieto-occipital fissure to the temporo-occipital incisure.

The occipital-lobe anatomy is so intricate and variable that the classic anatomy textbooks shirk from precise descriptions. It seems that such a description is possible by trying to establish some kind of analogy between the occipital lobe and the other lobes, in particular the frontal lobe. It is thus possible to describe two, superior and inferior, occipital sulci on the lateral surface of the lobe, forming three, superior, middle, and inferior, occipital gyri.

1.5.1 **The occipital sulci** on the lateral surface. The superior, or intra-occipital, sulcus is usually the continuation of the intraparietal sulcus. On its course toward the occipital pole (which is only occasionally reached) it crosses at a right angle the transverse occipital sulcus. This sulcus forms two segments, one is anteriorly oriented and extends variably on the lateral surface, the other is posteriorly situated and reaches the superior margin of the lobe (Figs. 104–106).

The inferior occipital sulcus, as a rule, is variable and difficult to identify: it is located near the inferior margin of the lobe.

1.5.2 **The superior occipital gyrus** (O1) is the only one which is clearly defined. It follows the superior edge of the lobe and merges with the cuneus on the medial surface of the occipital lobe (Fig. 13).

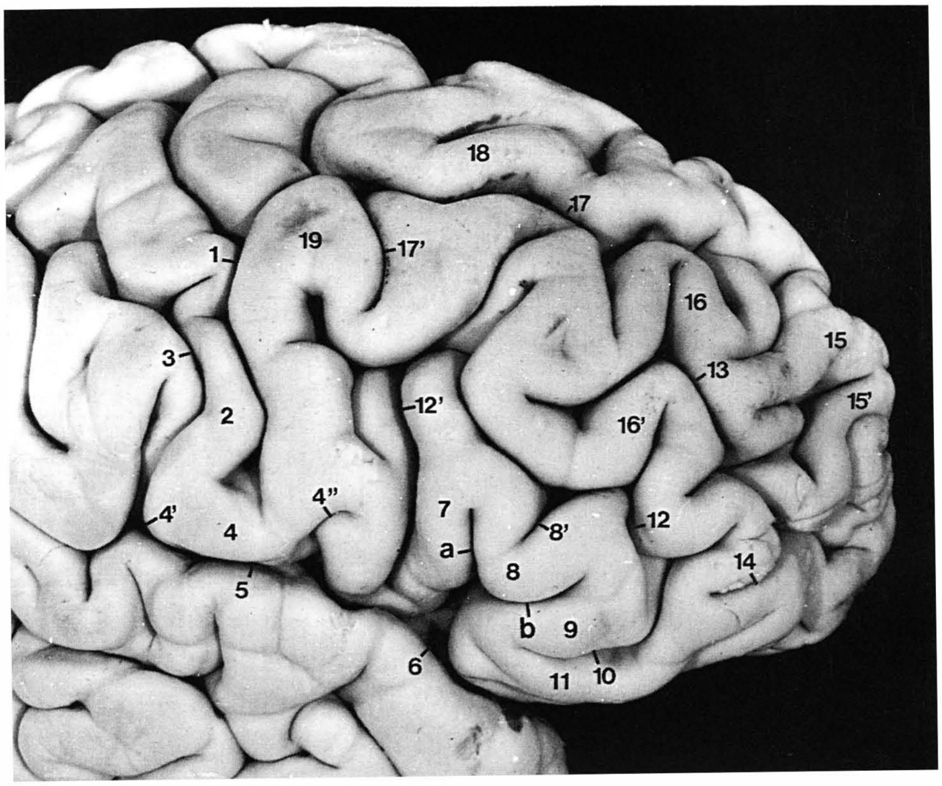


Fig. 4. Lateral aspect of the right frontal lobe (× 1).

1	central sulcus
2	postcentral gyrus
3	inferior postcentral sulcus (ascending segment of the intraparietal sulcus)
4	subcentral gyrus
4′	posterior subcentral sulcus
4″	anterior subcentral sulcus
5	lateral fissure, middle segment
6	lateral fissure, anterior segment; *a* vertical and *b* horizontal ramus
7	inferior frontal gyrus (F3), pars opercularis
8	inferior frontal gyrus (F3), pars triangularis
8′	sulcus triangularis
9	inferior frontal gyrus (F3), pars orbitalis
10	lateral orbital sulcus
11	lateral orbital gyrus
12	inferior frontal sulcus
12′	inferior precentral sulcus
13	middle frontal sulcus reaching 14
14	frontomarginal sulcus
15	superior frontopolar gyrus
15′	inferior frontopolar gyrus
16, 16′	middle frontal gyrus (F2), superior and inferior parts
17	superior frontal sulcus
17′	superior precentral sulcus
18	superior frontal gyrus
19	precentral gyrus

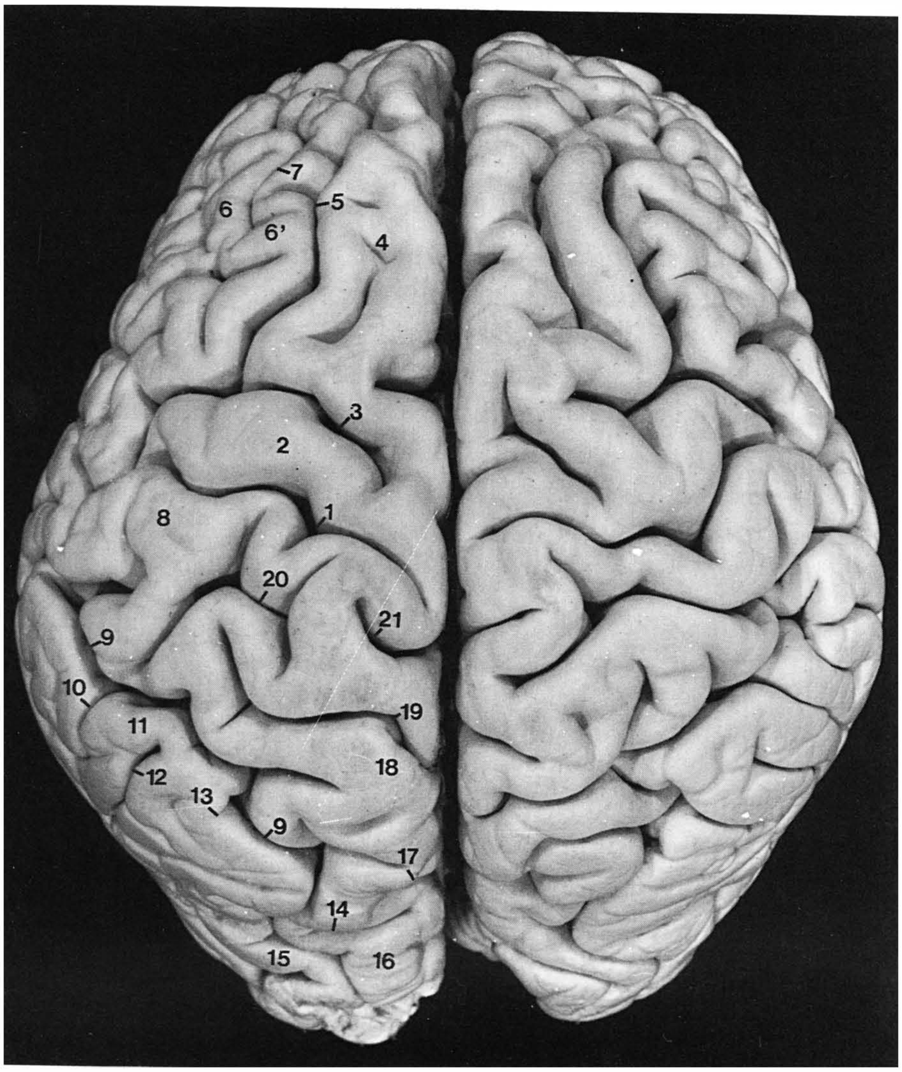


Fig. 5. Superior aspect of left and right hemispheres ($\times 0.75$).

1 central sulcus (note its typical backwardly curved aspect on the superior margin of the hemisphere)
2 precentral gyrus
3 superior precentral sulcus
4 superior frontal gyrus (F1)
5 superior frontal sulcus
6, 6′ middle frontal gyrus (F2), superior and inferior parts
7 middle frontal sulcus
8 postcentral gyrus
9 intraparietal sulcus
10 sulcus intermedius primus (Jensen)
11 angular gyrus
12 superior temporal sulcus, ascending posterior segment
13 sulcus intermedius secundus
14 transverse occipital sulcus
15 middle occipital gyrus (O2)
16 superior occipital gyrus (O1)
17 parieto-occipital fissure
18 superior parietal gyrus (P1)
19 transverse parietal sulcus
20 superior postcentral sulcus
21 cingulate sulcus, marginal segment

1.5.3 **The middle occipital gyrus** (O2) stretching between the superior and inferior occipital sulci offers a more complex aspect. It covers the major part of the lateral surface: this is the reason why it is often termed the lateral occipital gyrus.

An intermediate sulcus, the lateral occipital sulcus (or prelunatus) – which by analogy with the frontal-lobe terminology might be called middle occipital sulcus – divides the middle occipital gyrus into one superior and one inferior part. The anterior end of the lateral occipital sulcus sometimes reaches the temporal lobe, where it may merge into the superior temporal sulcus (Fig. 2). Its posterior end joins a backwardly curved sulcus, which may be identified as a vestigial sulcus lunatus or *Affenspalte* (Fig. 7). In monkeys and apes, the sulcus lunatus separates the occipital lobe from the other lobes and marks the boundary of a large visual striate area, which in these species covers the whole of the lateral surface of this lobe. In man, the striate area is restricted to the occipital pole itself. It seems that the sulcus lunatus only partially followed that regression, since it lies at some distance from the occipital pole.

The presence of the sulcus lunatus is controversial; it may be absent, or may stem from the transverse occipital sulcus, or assumes a contrary anteriorly concave curvature.

1.5.4 **The inferior occipital gyrus** (O3) forms the inferior margin of the occipital lobe. This indistinct gyrus is sometimes part of the middle occipital gyrus, when, as is often the case, the inferior occipital sulcus is absent.

1.5.5 **The occipital pole** (Fig. 7). When the three occipital gyri reach the occipital pole, they can no longer be identified and are merged together. At level of the occipital pole, we can sometimes see on the lateral surface the posterior end of the calcarine sulcus, reaching over from the medial surface. The calcarine sulcus is often terminated by the retrocalcarine sulcus. A small gyrus – the gyrus descendens of Ecker (Fig. 8) – is posteriorly bounded by the retrocalcarine sulcus and anteriorly by the variable occipitopolar sulcus. On the lateral surface, the boundary of the striate area is delineated by the gyrus descendens.

1.6 The insula

The insula (Fig. 10) is hidden at the bottom of the lateral fossa and can only be observed after the lateral operculum has been removed.

The lateral operculum is a cortical lamina which stretches from the lips of the lateral fissure until it reaches inside to the adjoining insula. Several segments are described: the frontal (Sect. 1.2.5), central or rolandic (Sect. 1.2.2), parietal (Sect. 1.4.4), and temporal (Sect. 1.3.2) opercula.

The insula is shaped as an inverted triangle with the base on top and the apex at bottom. This apex is cut by a conspicuous notch, or falciform fold, which marks the boundary between the lateral and basal segments of the lateral fissure (Sect. 1.1.1). The insula is separated from the cortex of the lateral operculum by the circular insular sulcus. The insula is divided into anterior and posterior areas by a central insular sulcus. The anterior area is itself divided into three short insular gyri, while the posterior area is formed by one or two long insular gyri.

1.7 Cortical asymmetry

Between the right and left hemispheres there are several cases of asymmetry which have been especially observed on the lateral surface. We limit ourselves here to some salient facts [see 79–96] . The planum temporale is mostly more developed on the left. It is the same with the lateral fissure, longer in the left hemisphere and often deprived of its ascending posterior segment (Fig. 3). As a rule, the right frontal lobe and the left occipital lobe are bigger. Moreover, it is likely that sexual dimorphism may be present in the human brain.

2 The inferomedial surface of the hemisphere

For a general view of the inferomedial surface refer to Fig. 13.
The constituents of the inferomedial surface are: the medial surface formed by the frontal, parietal, and occipital lobes, and the inferior surface comprising the inferior part of the temporal and occipital lobes. The medial and inferior surfaces of the hemisphere are separated by so flat an angle that they can be studied as a whole.

The inferomedial surface can be functionally as well as anatomically divided into two distinct regions: the limbic lobe, and the frontal, temporal, parietal, and occipital lobes.

2.1 The limbic lobe

The limbic lobe (Figs. 13 and 14) is separated from the surrounding structure by the limbic fissure and may be divided into limbic and intralimbic gyri.

2.1.1 **The limbic fissure.** The description of the limbic fissure is not easy because this fissure is formed by a succession of different and discontinuous sulci. Moreover, these sulci participate in the constitution of the limbic fissure only on segments of their courses. Those sulci are in succession: subcallosal, cingulate, subparietal, anterior calcarine, collateral, and rhinal.

The subcallosal or anterior para-olfactory sulcus is situated under the genu of the corpus callosum. This small forward concave sulcus is either independent, or joins the cingulate sulcus, or again joins the supraorbital sulcus (Sect. 2.2).

The cingulate (callosomarginal) sulcus begins in the subcallosal area, follows the curvature of the corpus callosum on its pericallosal segment, and then curves up along its marginal segment to reach the superior margin of the hemisphere, behind the superior end of the central sulcus.

The subparietal sulcus is set apart from the cingulate sulcus and is not easy to identify. It forms the inferior boundary of the precuneus.

The description of the anterior calcarine sulcus calls for the mention of two clearly definite fissures of the medial surface of the hemisphere: the parieto-occipital fissure and the calcarine sulcus.

The parieto-occipital fissure cuts deep into the medial surface, and separates the parietal from the occipital lobes. Its superior end reaches over to the lateral surface (Sect. 1.1.3). Its inferior end joins the calcarine sulcus.

The calcarine sulcus belongs to the occipital lobe. In spite of its variable anatomical aspect, three segments may be described, a middle segment – the calcarine sulcus proper –, an anterior segment – the anterior calcarine sulcus –, and a posterior segment – the retrocalcarine sulcus (Figs. 13, 16, and 17).

The calcarine sulcus proper separates the cuneus from the lingual gyrus: it usually has a sinuous aspect.

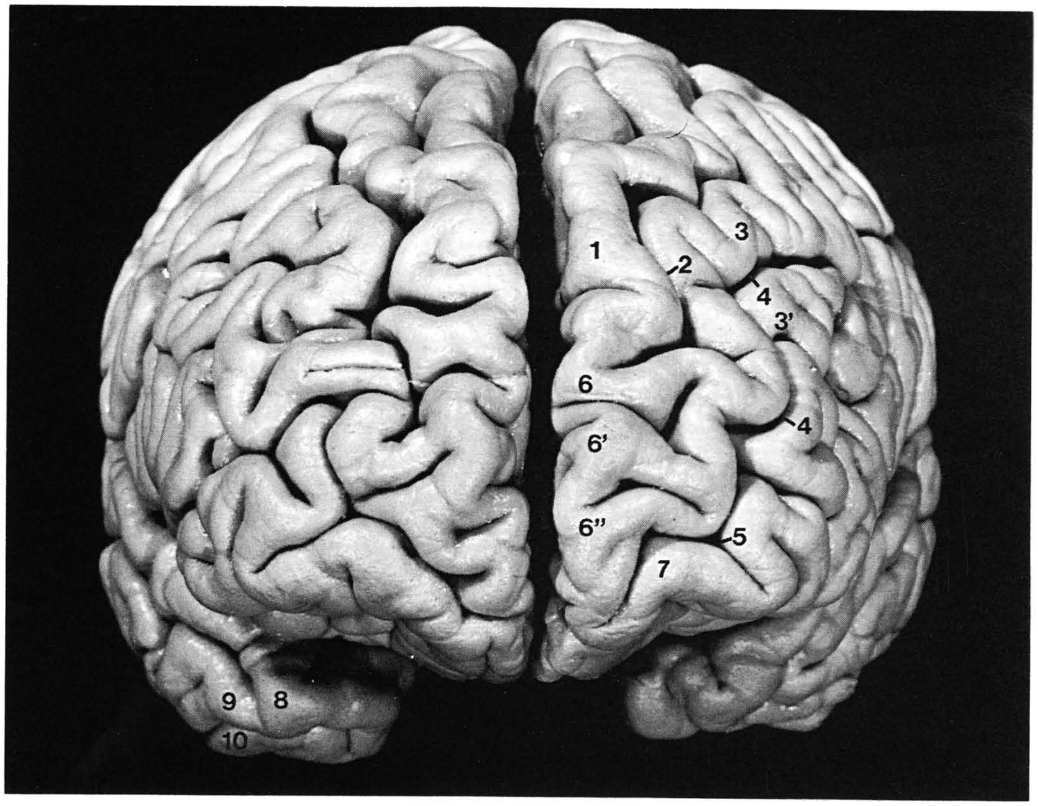
The retrocalcarine sulcus is formed by the calcarine sulcus when it branches off caudally into two rami, ascending and descending. It is sometimes found that the ascending ramus (Fig. 116), or even the whole of the retrocalcarine sulcus, is absent.

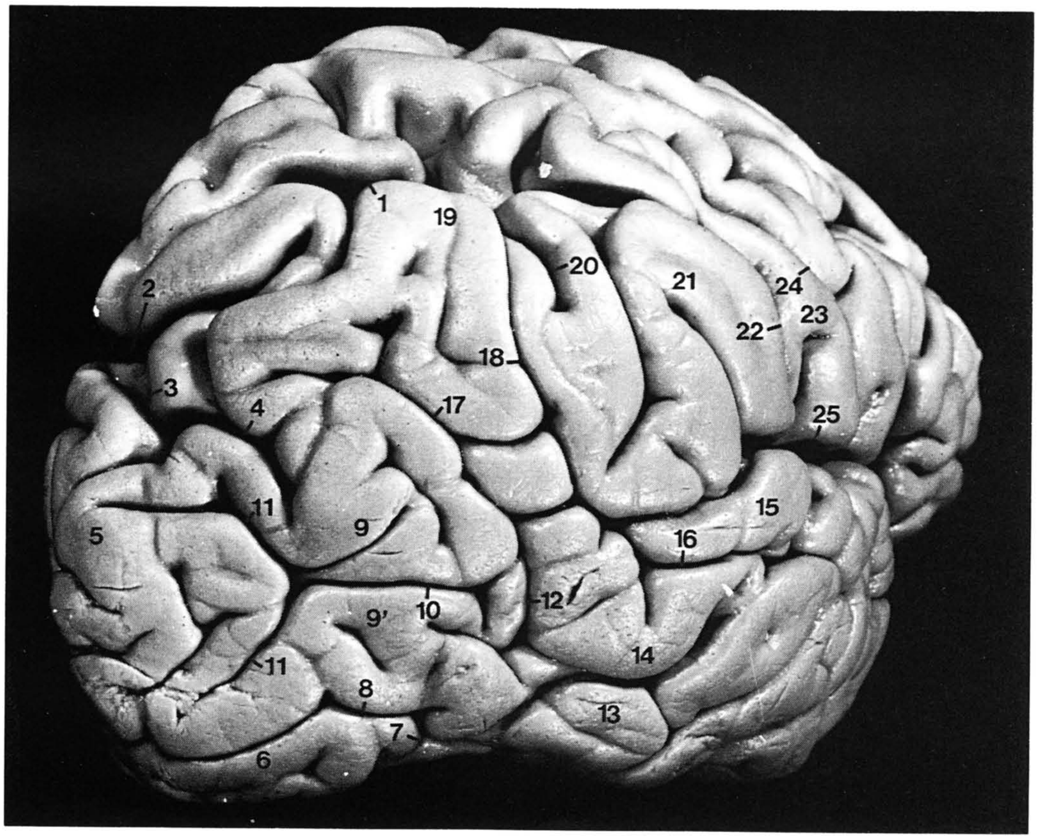
Fig. 6. Frontal pole, anterior aspect (× 0.65).

1 superior frontal gyrus (F1)
2 superior frontal sulcus
3, 3′ middle frontal gyrus (F2), superior and inferior parts
4 middle frontal sulcus reaching 5
5 frontomarginal sulcus
6, 6′, 6″ superior, middle, and inferior transverse frontopolar gyri
7 frontomarginal gyrus
8 superior temporal gyrus (T1)
9 middle temporal gyrus (T2)
10 inferior temporal gyrus (T3)

Fig. 7. Occipital pole, right hemisphere, lateral aspect (× 1).

1 intraparietal sulcus
2 parieto-occipital fissure
3 intra-occipital sulcus (superior occipital sulcus)
4 transverse occipital sulcus
5 superior occipital gyrus (O1)
6 inferior occipital gyrus (O3)
7 temporo-occipital incisure
8 inferior occipital sulcus
9, 9′ middle (or lateral) occipital gyrus (O2), superior and inferior parts
10 lateral occipital sulcus
11 sulcus lunatus
12 anterior occipital sulcus
13 inferior temporal gyrus (T3)
14 middle temporal gyrus (T2)
15 superior temporal gyrus(T1)
16 superior temporal sulcus
17 superior temporal sulcus, horizontal posterior segment
18 superior temporal sulcus, ascending posterior segment
19 angular gyrus
20 sulcus intermedius primus (Jensen)
21 supramarginal gyrus
22 inferior postcentral sulcus (ascending segment of intraparietal sulcus)
23 postcentral gyrus
24 central sulcus
25 lateral fissure


1
2
3
4
3'
6
4
6'
6''
5
7
9
8
10


1
19
2
20
21
24
23
22
18
3
17
4
25
15
11
5
9'
16
10
9'
12
14
11
8
13
7
6

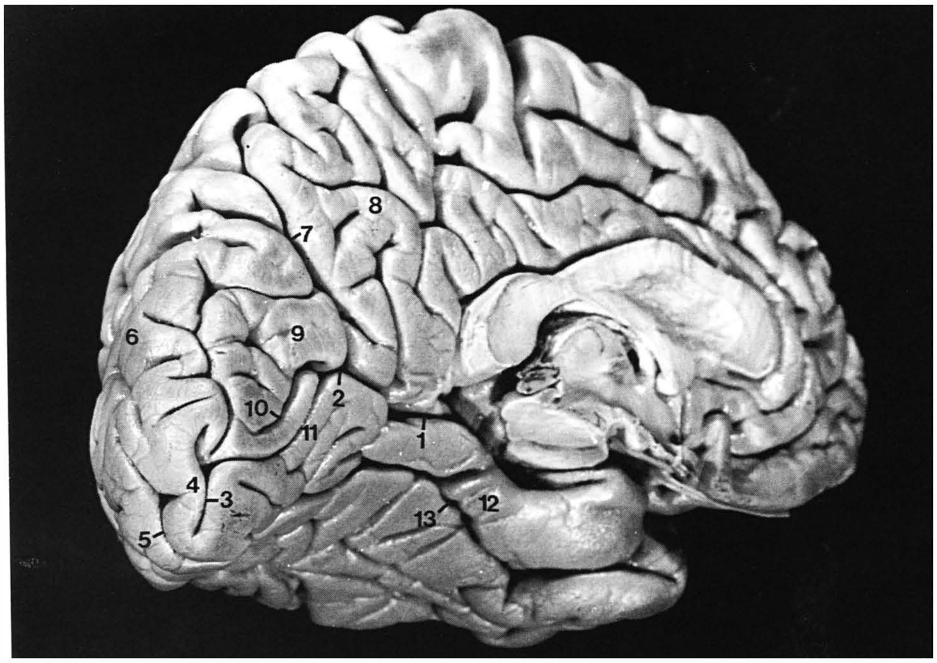


Fig. 8. Occipital pole, left hemisphere, medial aspect (× 0.85).

1 anterior calcarine sulcus
2 calcarine sulcus
3 retrocalcarine sulcus
4 gyrus descendens of Ecker
5 occipitopolar sulcus
6 superior occipital gyrus (O1)
7 parieto-occipital fissure
8 precuneus
9 cuneus (O6)
10 paracalcarine sulcus
11 lingual gyrus (O5)
12 parahippocampal gyrus (T5)
13 collateral sulcus

The anterior calcarine sulcus is that segment of the calcarine sulcus situated beyond the junction with the parieto-occipital fissure; it extends forward under the splenium and bounds the isthmus. Its deeper part forms a protrusion in the occipital horn: the calcar avis (Figs. 88–93 and 196). The anterior calcarine sulcus is the only segment of the calcarine sulcus to be part of the limbic fissure.

The collateral or medial occipitotemporal sulcus lies on the inferior surface of the temporal and occipital lobes. One temporal and one occipital segment are usually described.

The temporal segment of the collateral sulcus is the only one to belong to the limbic fissure. The deeper part of the sulcus creates a cortical fold whose protrusion into the temporal horn of the lateral ventricle is called the collateral eminence (Figs. 186–193).

The occipital segment of the collateral sulcus separates the 4th and 5th occipital gyri.

The anterior and posterior ends of the collateral sulcus often branch out into transverse sulci, called anterior and posterior transverse collateral sulci (Figs. 13 and 17). It is generally noted that such bifurcations are the rule with many other sulci: for instance the frontal sulci branch off into the precentral sulci, the intra-occipital sulcus into the transverse occipital sulcus, the calcarine sulcus into the retrocalcarine sulcus, the lateral occipital sulcus into the sulcus lunatus, etc.

The rhinal sulcus, the last element of the limbic fissure, forms on the temporal lobe the rostral boundary of the limbic lobe. It is sometimes continuous with the collateral sulcus.

2.1.2 **The limbic gyrus** (see [20], for more details). It is made up of several parts: the subcallosal gyrus, cingulate gyrus, isthmus, and parahippocampal gyrus (Figs. 13 and 14).

The subcallosal gyrus is set between the anterior para-olfactory (or subcallosal) sulcus and the posterior para-olfactory sulcus, which marks the boundary with the paraterminal gyrus. There is some confusion as to the terminology concerning those two small gyri: the subcallosal gyrus is called area adolfactoria by some researchers, in which case the paraterminal gyrus is termed subcallosal.

The cingulate gyrus circles around the corpus callosum from which it is separated by the pericallosal sulcus. It may show on its course several vertical sulci.

The isthmus is a narrow cortical bridge which links the cingulate gyrus to the parahippocampal gyrus, under the splenium of the corpus callosum.

The parahippocampal gyrus (T5) and the lingual gyrus (itself part of the occipital lobe) together form the medial occipitotemporal gyrus. The parahippocampal gyrus is separated from the fusiform gyrus by the collateral sulcus. It can be divided into two segments.

The posterior segment is narrow; its flat superior surface – or subiculum – is separated from the hippocampus by the hippocampal sulcus.

The anterior segment is more voluminous; it is called the piriform lobe, comprising the anterior part of the uncus and the entorhinal area.

The uncus curves posteriorly to rest on the parahippocampal gyrus itself, separated from the latter by the uncal sulcus. The uncus is functionally divided into two parts: one anterior and one posterior.

The posterior part of the uncus which belongs to the intralimbic gyrus (Sect. 2.1.3) is formed by the gyrus uncinatus, the band of Giacomini, and the uncal apex.

The anterior part of the uncus belongs to the piriform lobe. Its surface is uneven and displays two protrusions: the semilunar gyrus and the gyrus ambiens, both covering the amygdala (Figs. 58–62 and 129–131).

The entorhinal area is the lower part of the piriform lobe and encroaches (especially in man) upon the posterior segment of the parahippocampal gyrus (Figs. 128–135).

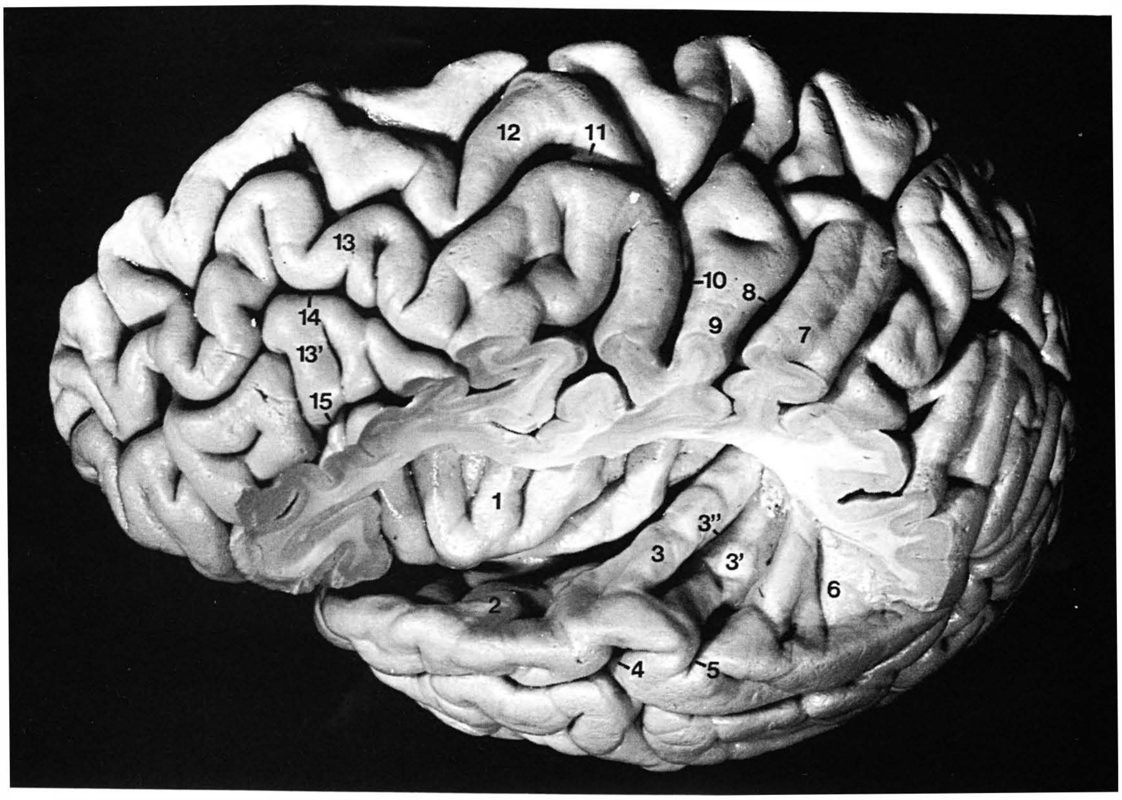


Fig. 9. Superior aspect (temporal operculum) of left superior temporal gyrus after ablation of the lower part of the frontal and parietal lobes (× 0.95).

1	insula
2	planum polare
3, 3′	anterior and posterior transverse temporal gyri (of Heschl) or retro-insular gyri
3″	intermediate transverse temporal sulcus
4	sulcus acousticus
5	transverse temporal sulcus
6	planum temporale
7	postcentral gyrus
8	central sulcus
9	precentral gyrus
10	superior precentral sulcus
11	superior frontal sulcus
12	superior frontal gyrus (F1)
13, 13′	middle frontal gyrus (F2), superior and inferior parts
14	middle frontal sulcus
15	inferior frontal sulcus

Fig. 10. Lateral aspect of the right insula after ablation of frontal, parietal, and temporal opercula ($\times$ 1.4).

1 circular insular sulcus
2 central insular sulcus
3 falciform fold
4, 4′, 4″ short insular gyri
5, 5′ long insular gyri

2.1.3 **The intralimbic gyrus** (Figs. 14, 14′, and 15). It arches within the limbic gyrus. It is divided into three parts: anterior, superior, and inferior.

The anterior part is called the prehippocampal rudiment. Its controversial situation is said to be between the posterior para-olfactory sulcus and the paraterminal gyrus (Fig. 14).

The superior part comes next. It rests on the superior surface of the corpus callosum and forms a thin cellular layer: the indusium griseum, itself covered on each side with the medial and lateral longitudinal striae.

The inferior part, the only one which is well developed, is called the hippocampus.

The hippocampus is bilaminar: one lamina rolled up inside the other: the cornu ammonis and the gyrus dentatus (Fig. 14′). According to different aspects of the pyramidal neurons forming the cornu ammonis, this layer may be subdivided into four fields: CA1, CA2, CA3, and CA4 which may have specific functions and pathology. The cornu ammonis and the gyrus dentatus are separated from the parahippocampal gyrus by a narrow hippocampal sulcus. The hippocampus is mainly intraventricular and accordingly externally inconspicuous. It is divided into body, head, and tail.

The hippocampal body (or middle part) is hidden by the fimbria which stems from the crus fornicis. Sometimes the dentes of the gyrus dentatus are superficially visible and compose the margo denticulatus.

The hippocampal head (or anterior part): its intraventricular part is composed of “digitationes hippocampi”; its extraventricular part is visible on the uncal surface and comprises the gyrus uncinatus, the band of Giacomini, and the uncal apex. The latter term seems better fitted than the other name, the intralimbic gyrus, which may lead to some confusion with the intralimbic gyrus proper.

The hippocampal tail (or posterior part) is also partially visible on the surface (Figs. 14, 77–80, and 138): one part is the continuation of the gyrus dentatus as fasciola cinerea, and the other part is the continuation of the cornu ammonis as gyrus fasciolaris. Some protrusions of the hippocampus, called the gyri of Andreas Retzius, are sometimes visible in the subsplenial area. (For more details on the hippocampal anatomy, refer to [20, 32, 43, 56, 71].)

2.2 The frontal lobe (medial surface)

The medial surface of the frontal lobe (Figs. 13 and 16) is separated from the limbic lobe by the cingulate sulcus.

In the subcallosal region, one or two supraorbital sulci (sulci rostrales) separate the medial surface of the frontal lobe from the gyrus rectus, itself a part of the orbital lobe. Most of the medial surface of the frontal lobe corresponds to the superior frontal gyrus (F1). It is bounded posteriorly by a small paracentral sulcus. Caudally to this sulcus, the paracentral lobule belongs both to the frontal and parietal lobes. It forms the upper parts of the postcentral and precentral gyri on either side of the central sulcus superior end.

2.3 The parietal lobe (medial surface)

The medial surface of the parietal lobe (Figs. 13 and 16) is essentially formed by the precuneus, itself part of the superior parietal gyrus (P1). The precuneus is separated anteriorly from the paracentral lobule by the marginal segment of the cingulate sulcus, and posteriorly from the occipital lobe by the parieto-occipital fissure. The subparietal sulcus forms an imperfect boundary between precuneus and cingulate gyrus.

2.4 The temporal lobe (inferior surface)

The temporal lobe displays three gyri: the inferior temporal, fusiform, and parahippocampal gyri (Figs. 13, 17, and 18).

2.4.1 **The inferior temporal gyrus** (T3). Its boundaries are the inferior temporal sulcus on the lateral surface of the hemisphere (Fig. 1) and the lateral occipitotemporal sulcus on the inferior surface. It thus constitutes the inferior margin of the temporal lobe and stretches backward to the temporo-occipital incisure.

2.4.2 **The fusiform gyrus** (T4). Its boundaries are clearly defined. We find: the lateral occipitotemporal sulcus laterally, the collateral or medial occipitotemporal sulcus medially, and the anterior and posterior transverse collateral sulci rostrally and caudally. The fusiform gyrus does not extend to the temporal pole.

2.4.3 **The parahippocampal gyrus** (T5) is part of the limbic lobe and was studied in Sect. 2.1.2.

2.5 The occipital lobe (inferior and medial surfaces)

On the medial surface of the hemisphere, the occipital lobe is clearly distinguished from the neighbouring parietal lobe by the parieto-occipital fissure. On the contrary, the inferior surfaces of the occipital and temporal lobes do not show any anatomical boundaries. This is why they are often described together (Figs. 13 and 16–18).

On the inferior surface of the occipital lobe we propose a somewhat arbitrary division into three occipital gyri: O3, O4, and O5, whereas on the medial surface, the cuneus (O6) is clearly defined.

2.5.1 **O3 or inferior occipital gyrus** extends from the inferior occipital sulcus on the lateral surface (Fig. 1), to the lateral occipitotemporal sulcus on the inferior surface. The inferior occipital gyrus as well as the adjoining inferior temporal gyrus compose the inferior margin of the hemisphere: they are sometimes separated by the temporo-occipital incisure.

2.5.2 **O4 and O5,** the next two gyri, are continuous with their temporal homologues, T4 and T5, and are sometimes described pairwise together with them as strict anatomical entities.

The 4th occipital (O4) and temporal (T4) gyri together compose the lateral occipitotemporal, or fusiform, gyrus.

The lingual (O5) gyrus and the parahippocampal (T5) gyrus together compose the medial occipitotemporal gyrus. The lingual gyrus lies at the junction of the inferior and medial surfaces, where sometimes an intermediate or lingual sulcus is found, which then creates two, superior and inferior, parts.

On the inferior surface of the occipital pole, the three occipital gyri O3, O4, and O5 are no longer identifiable and merge into a common cortical region.

2.5.3 **O6 or cuneus** is the only occipital gyrus to provide a precise description, as it lies between two clearly defined sulci: the parieto-occipital fissure and the calcarine sulcus.

The calcarine sulcus (Sect. 2.1.1) is sometimes spanned by a bridging lobule: the cuneolingual gyrus, which links the cuneus and the lingual gyrus (Figs. 104–107). On the occipital pole, the calcarine sulcus proper branches off and creates the retrocalcarine sulcus. At the back of this sulcus, a small lobule, the gyrus descendens of Ecker, sometimes bounded by the occipitopolar sulcus, constitutes the caudal boundary of the striate cortex. It has been stated above (Sect. 1.5.5) that the gyrus of Ecker may sometimes be situated on the lateral surface of the occipital lobe. The striate cortex is situated in the gyrus of Ecker as well as on the superior and inferior edges of the calcarine sulcus proper; it extends rostrally along the inferior edge of the anterior calcarine sulcus, without reaching its end (Figs. 91–114, 116–124, 164–173, and 183–200).

3 The basal surface of the brain

For a general view of the basal surface refer to Fig. 22.

The base of the brain is anatomically divided from front to back into right and left orbital lobes, right and left anterior perforated substances, and an interpeduncular area which, for obvious reasons, will be studied as a whole.

Fig. 11. Medial aspect of the left hemisphere observed after sagittal section of commissures and third ventricle (× 0.8); for more details, see Fig. 12. The inferior aspects of temporal and occipital lobes are hidden by brainstem and cerebellum which must be removed following the dotted line.

1 medial aspect of frontal lobe
2 medial aspect of parietal lobe
3 medial aspect of occipital lobe
4 corpus callosum
5 fornix
6 third ventricle
7 mesencephalon
8 pons
9 medulla
10 fourth ventricle
11 vermis
12 left cerebellar hemisphere
13 inferior aspect of left temporal lobe

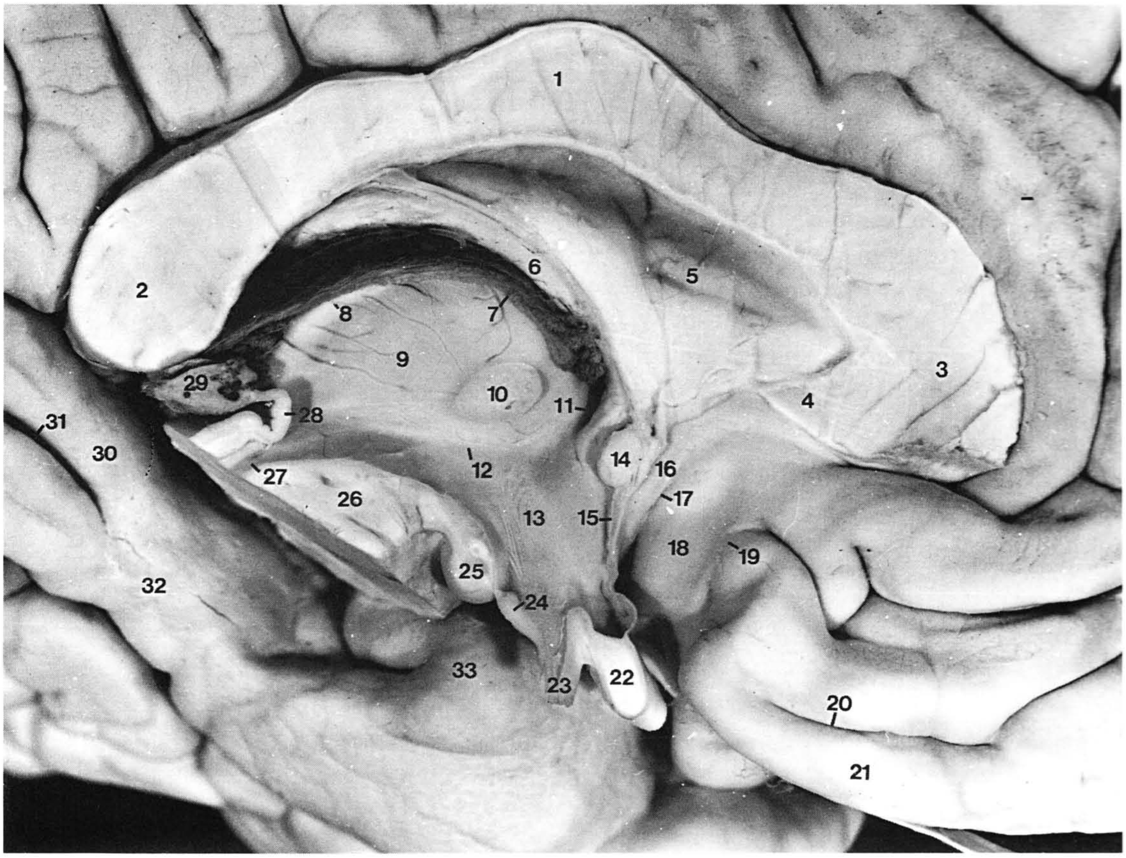


Fig. 12. Median sagittal section of third ventricle, left hemisphere (× 1.6).

1 corpus callosum, body
2 corpus callosum, splenium
3 corpus callosum, genu
4 corpus callosum, rostrum
5 septum pellucidum
6 fornix
7 choroid plexus of third ventricle
8 stria medullaris
9 thalamus
10 interthalamic adhesion
11 interventricular foramen
12 hypothalamic sulcus
13 hypothalamus
14 anterior commissure
15 lamina terminalis
16 paraterminal gyrus overlaying the septal nuclei
17 posterior para-olfactory sulcus
18 subcallosal area
19 anterior para-olfactory sulcus
20 supraorbital sulcus
21 gyrus rectus
22 optic chiasma
23 median eminence and infundibular recess
24 posterior tuber
25 mamillary body
26 mesencephalon
27 cerebral aqueduct
28 posterior commissure
29 pineal gland
30 isthmus
31 anterior calcarine sulcus
32 parahippocampal gyrus (T5)
33 uncus

Fig. 13. Inferomedial aspect of the right hemisphere.

Limbic fissure, composed successively of

1 anterior para-olfactory sulcus (subcallosal sulcus)
2 cingulate sulcus
2′ marginal segment of cingulate sulcus
3 subparietal sulcus
4 anterior calcarine sulcus
5 collateral sulcus (medial occipitotemporal sulcus)
5′ anterior transverse collateral sulcus
5″ posterior transverse collateral sulcus
6 rhinal sulcus

Limbic lobe, composed successively of

7 subcallosa area
 8 posterior para-olfactory sulcus
 9 paraterminal gyrus
10 cingulate gyrus
11 isthmus
T5 parahippocampal gyrus
 12 gyrus dentatus
 13 piriform lobe
  14 gyrus ambiens
  15 semilunar gyrus
  16 band of Giacomini

Medial aspect of the frontal lobe

17 gyrus rectus
18 supraorbital sulcus
F1 medial aspect of superior frontal gyrus
19 paracentral sulcus
20 paracentral lobule
CS superior end of central sulcus

Medial aspect of the parietal lobe

P1 medial aspect of superior parietal gyrus: precuneus
21 transverse parietal sulcus

Inferomedial aspect of the temporal lobe

T3 inferior temporal gyrus
22 lateral occipitotemporal sulcus
T4 fusiform gyrus
TO temporo-occipital incisure

Inferomedial aspect of the occipital lobe
The dashed line shows the arbitrary boundary between the occipital and temporal lobes.

O3 inferior occipital gyrus
O4 fourth occipital gyrus which forms together with the fourth temporal gyrus (T4) the fusiform gyrus, or lateral occipitotemporal gyrus
O5 lingual gyrus which forms together with the parahippocampal gyrus the medial occipitotemporal gyrus
23 lingual sulcus; when present, it divides the lingual gyrus into a superior and a inferior part
O3′, O4′, O5′ on the inferior aspect of the occipital pole, the caudal parts of these three occipital gyri merge into a common occipital cortex
24 calcarine sulcus
24′ retrocalcarine sulcus
25 gyrus descendens
26 occipitopolar sulcus
O6 cuneus
27 paracalcarine sulcus

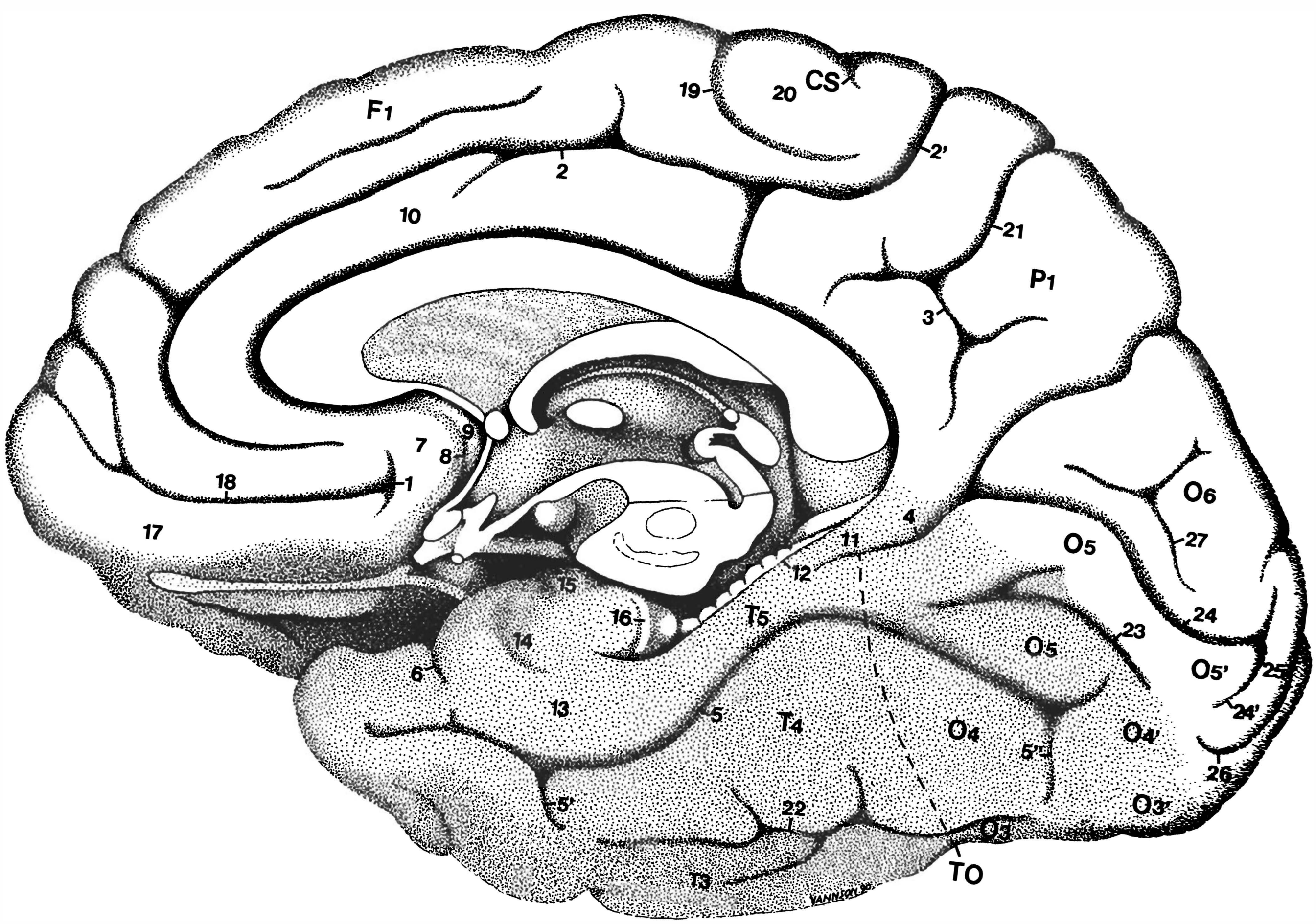

F1
19
20
CS
2
2'
10
21
P1
3
9
7
8
18
1
17
4
11
12
15
T5
16
14
6
13
5
T4
O4
O5
O6
27
24
23
O5'
25
24'
O4'
5''
26
5'
22
O3'
T3
TO

Fig. 14. Sagittal section of the brain; right hemisphere, limbic lobe

Limbic fissure

1 anterior paraolfactory sulcus (subcallosal sulcus)
2 cingulate sulcus
3 subparietal sulcus
4 anterior calcarine sulcus
5 collateral sulcus
6 rhinal sulcus

Limbic gyrus

7 subcallosal area
8 posterior paraolfactory sulcus
9 cingulate gyrus
10 isthmus
11 parahippocampal gyrus, posterior part
11′ parahippocampal gyrus, anterior part: piriform lobe

Piriform lobe, divided into

12 entorhinal area
13 gyrus ambiens
14 semilunar gyrus
15 prepiriform cortex

Intralimbic gyrus

16 prehippocampal rudiment
16′ paraterminal gyrus
17 indusium griseum

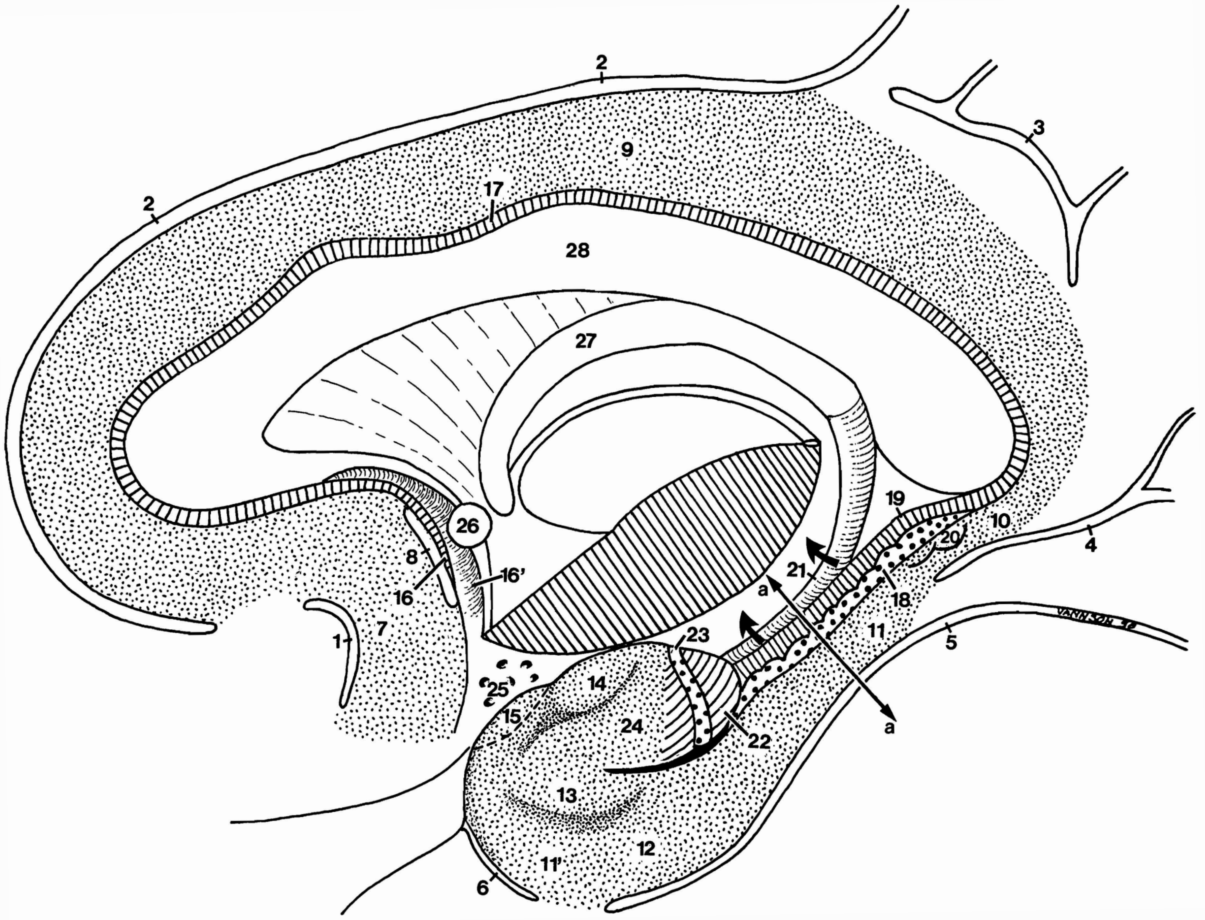
Hippocampus, composed of

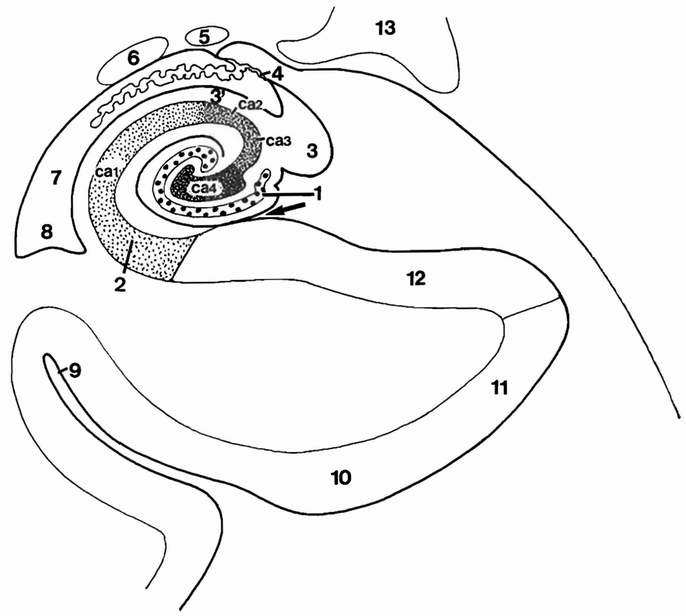
18 gyrus dentatus
19 cornu ammonis
20 gyri of Andreas Retzius
21 fimbria (displaced upwards; arrows)
22 apex of uncus
23 band of Giacomini
24 gyrus uncinatus
25 anterior perforated substance
26 anterior commissure
27 fornix
28 corpus callosum

The a–a line indicates the plane of the section on Fig. 14′.

Fig. 14′. Transverse section of the hippocampus. The hippocampus is composed of two cortical layers: the gyrus dentatus (1) and the cornu ammonis (2) separated by the hippocampal sulcus (arrow) and covered with fimbria (3) and alveus (3′). (See [20], for more information.)

ca1, ca2, ca3, ca4 fields of cornu ammonis
4 tela choroidea of temporal horn
5 stria terminalis
6 tail of caudate nucleus
7 temporal horn of lateral ventricle
8 collateral eminence
9 collateral sulcus
10 parahippocampal gyrus
11 entorhinal area
12 subiculum
13 lateral geniculate body


2
3
2
9
17
28
27
26
8
16
16'
7
1
19
10
20
4
21
a
18
11
5
23
25
14
15
24
22
a
13
12
11'
6


13
6
5
4
3'
ca2
ca3
3
7
ca1
ca4
1
8
2
12
9
11
10

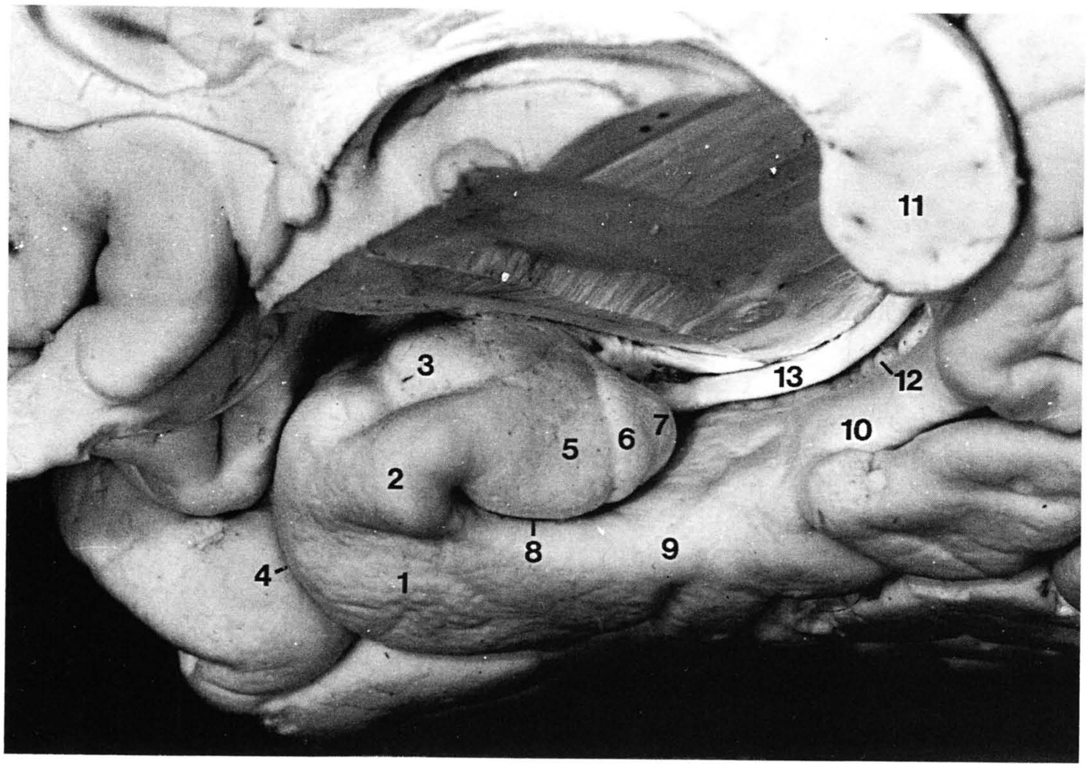


Fig. 15. Medial aspect of the right hemisphere, showing the uncus ($\times 1.8$). The uncus is composed of an anterior part belonging to the parahippocampal gyrus and a posterior part belonging to the hippocampus.

Anterior part of uncus

1 entorhinal area
2 gyrus ambiens
3 semilunar gyrus
4 rhinal sulcus

Posterior part of uncus

5 gyrus uncinatus
6 band of Giacomini
7 apex of uncus (intralimbic gyrus, see p. 23)
8 uncal sulcus

9 parahippocampal gyrus
10 isthmus
11 splenium
12 gyrus dentatus (margo denticulatus)
13 fimbria

Fig. 16. Medial aspect of the right cerebral hemisphere (× 0.9).

1	corpus callosum
2	septum pellucidum
3	fornix
4	thalamus
5	hypothalamus
6	gyrus rectus
7, 7′	supraorbital sulci
8	anterior para-olfactory sulcus (subcallosal sulcus)
9	subcallosal gyrus
10	cingulate sulcus
10′	marginal segment of cingulate sulcus
11	cingulate gyrus
12	medial aspect of superior frontal gyrus (F1)
13	paracentral sulcus
14	paracentral lobule
15	central sulcus
16	subparietal sulcus
17	precuneus
18	parieto-occipital fissure
19	cuneus
20	calcarine sulcus
20′	retrocalcarine sulcus
20″	anterior calcarine sulcus
21	lingual gyrus
22	isthmus
23	parahippocampal gyrus
24	uncus
25	collateral sulcus

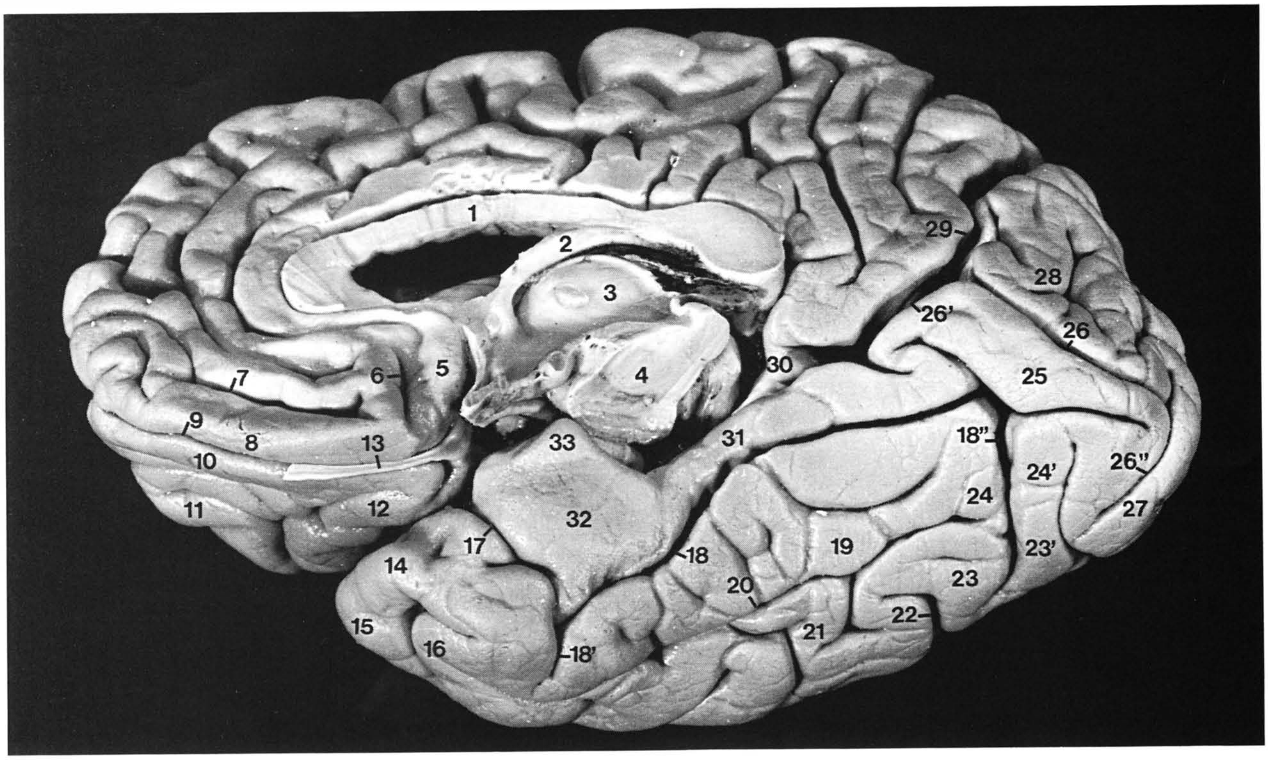


Fig. 17. Inferomedial aspect of the right cerebral hemisphere (×0.9).

1 corpus callosum
2 fornix
3 third ventricle
4 cut surface of mesencephalon
5 subcallosal gyrus
6 anterior para-olfactory sulcus (subcallosal sulcus)
7 supraorbital sulcus
8 gyrus rectus
9 medial orbital sulcus (olfactory sulcus)
10 medial orbital gyrus
11 anterior orbital gyrus
12 posterior orbital gyrus
13 olfactory tract
14 temporal pole, superior temporal gyrus (T1)
15 temporal pole, medial temporal gyrus (T2)
16 temporalpole, inferiortemporal gyrus (T3)
17 rhinal sulcus
18 collateral sulcus (medial occipitotemporal sulcus)
18′ anterior transverse collateral sulcus
18″ posterior transverse collateral sulcus
19 fusiform gyrus (T4)
20 lateral occipitotemporal sulcus
21 inferior temporal gyrus (T3)
22 temporo-occipital incisure
23, 23′ inferior occipital gyrus (O3)
24, 24′ fourth occipital gyrus (O4)
25 lingual gyrus (O5)
26 calcarine sulcus
26′ anterior calcarine sulcus
26″ retrocalcarine sulcus
27 gyrus descendens
28 cuneus (O6)
29 parieto-occipital fissure
30 isthmus
31 parahippocampal gyrus (T5)
32 piriform lobe (entorhinal area)
33 gyrus ambiens

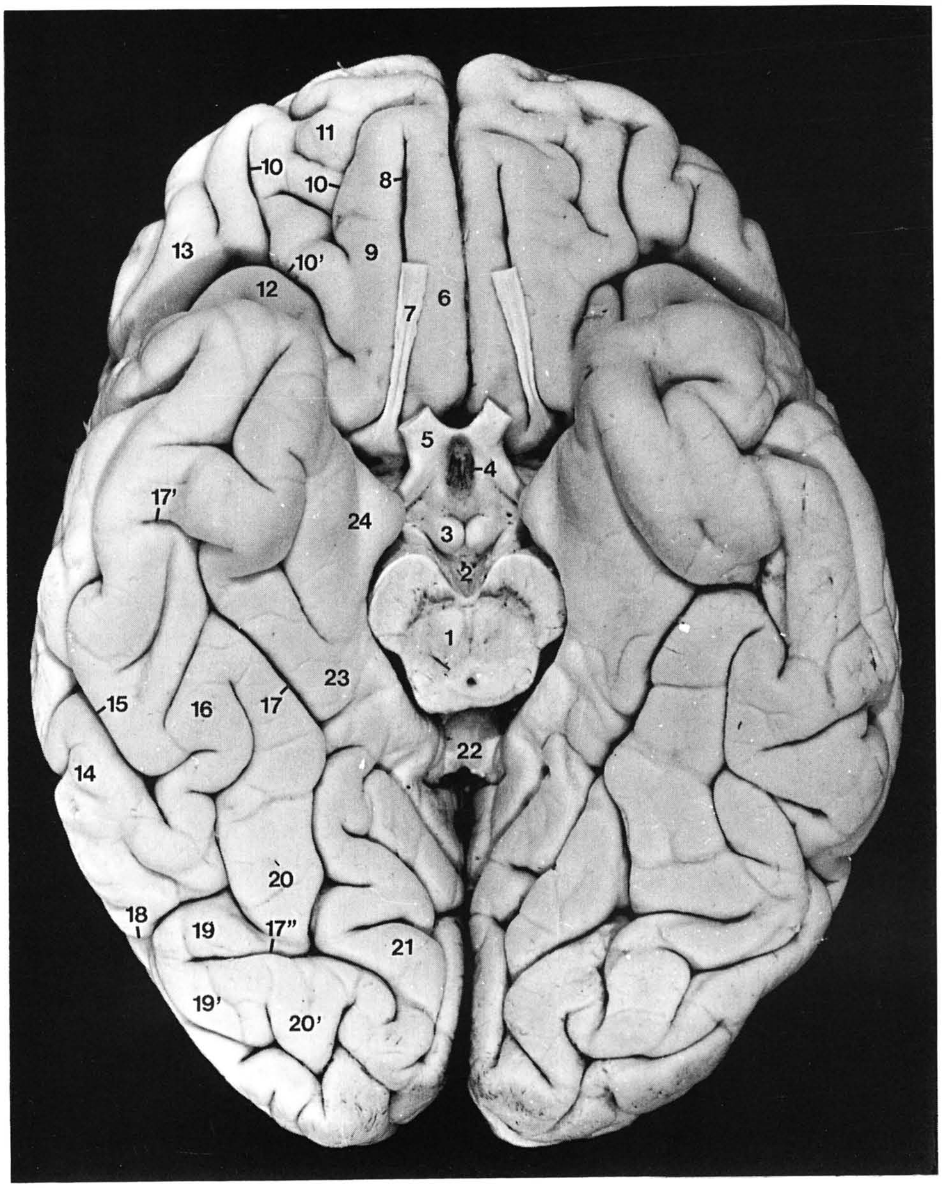


Fig. 18. Inferior aspect of the brain; cerebellum and brain stem removed ($\times 0.85$).

1	cut surface of mesencephalon
2	interpeduncular fossa
3	mamillary body
4	hypophysial stalk and median eminence
5	optic chiasma
6	gyrus rectus
7	olfactory tract
8	medial orbital sulcus (olfactory sulcus)
9	medial orbital gyrus
10	H-shaped orbital sulcus
10′	arcuate orbital sulcus
11	anterior orbital gyrus
12	posterior orbital gyrus
13	lateral orbital gyrus
14	inferior temporal gyrus (T3)
15	lateral occipitotemporal sulcus
16	fusiform gyrus (T4)
17	collateral sulcus (medial occipitotemporal sulcus)
17′	anterior transverse collateral sulcus
17″	posterior transverse collateral sulcus
18	temporo-occipital incisure
19, 19′	inferior occipital gyrus (O3)
20, 20′	fourth occipital gyrus (O4)
21	lingual gyrus (O5)
22	splenium
23	parahippocampal gyrus
24	uncus

3.1 The orbital lobe or inferior surface of the frontal lobe

3.1.1 **Orbital sulci.** Three sulci can be described on the orbital lobe.

The lateral orbital sulcus separates the orbital lobe from the lateral surface of the frontal lobe (Fig. 1). It is often difficult to recognize and has already been described (Sect. 1.1.1).

The H-shaped sulcus is formed by two longitudinal rami, linked by a transversal, often caudally concave ramus (arcuate orbital, or transverse orbital, sulcus). Actually this typical shape is rather exceptional and this name is indiscriminately given to the complex sulci situated in the central region of the orbital lobe.

The medial orbital sulcus, or olfactory sulcus, contains the olfactory tract.

3.1.2 **Orbital gyri.** The orbital sulci form five gyri.

The lateral orbital gyrus is situated between the lateral orbital sulcus and the H-shaped sulcus.

The anterior and posterior orbital gyri, respectively, are situated on each side of the transverse orbital sulcus.

The medial orbital gyrus is situated between the H-shaped and the medial orbital sulci.

The gyrus rectus lies along the medial margin of the orbital lobe and extends over the medial surface of the frontal lobe.

It is generally admitted that both, medial orbital and rectus, gyri belong to the superior frontal gyrus. Likewise, the anterior orbital gyrus and the rostral part of the lateral orbital gyrus are part of the middle frontal gyrus. Lastly, the posterior orbital gyrus and the caudal part of the lateral orbital gyrus are referred to the inferior frontal gyrus. In fact, the continuation of the frontal gyri in the orbital lobe appears arbitrary, especially as regards the middle and superior frontal gyri, which are separated from their orbital homologues by the frontomarginal and transverse frontopolar gyri.

3.2 Anterior perforated substance

The anterior perforated substance (Figs. 20–23) can only be studied after removing the temporal pole. It is triangular in shape, bounded rostrally by the medial and lateral olfactory striae (diverging from the olfactory tract), caudally by the optic tract, and laterally by the endorhinal sulcus, formed by the junction of the uncus into the anterior perforated substance.

The anterior perforated substance is a layer of grey matter of telencephalic origin. It shows a number of perforations: large ones for the lateral striate blood vessels, and small ones for the medial striate blood vessels.

The junction of the olfactory tract with the two olfactory striae forms the olfactory trigone, which delineates an often inconspicuous olfactory tubercle. It is sometimes possible to observe the surface aspect of Broca's diagonal band along the optic tract.

Laterally the anterior perforated substance is continuous with the limen insulae, a deep sulcus linking the temporal and orbital lobes, and forming the floor of the basal segment of the lateral fissure. The limen insulae reaches into the insula through the narrow falciform fold. The lateral olfactory stria leads into the uncal amygdala through the limen insulae: on its course, the lateral stria is covered by a thin grey-matter lamina which combines with the adjacent area of the uncus to form the rudimentary prepiriform cortex (Fig. 14).

Medially, the anterior perforated substance and the medial olfactory stria together continue into the paraterminal and subcallosal gyri, situated on the medial aspect of the hemisphere (Fig. 13).

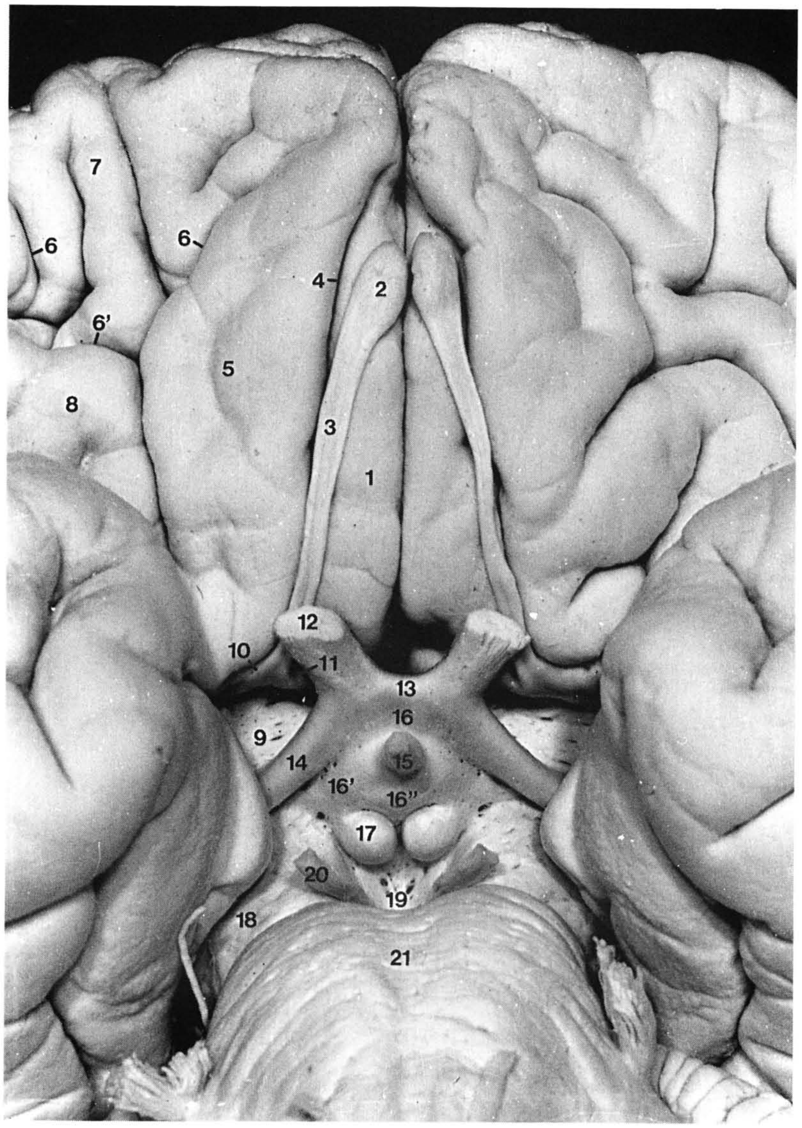


Fig. 19. Basal surface of the brain (× 1.65).

Orbital lobe

1 gyrus rectus
2 olfactory bulb
3 olfactory tract
4 medial orbital sulcus (olfactory sulcus)
5 medial orbital gyrus
6 H-shaped orbital sulcus
6′ arcuate orbital sulcus
7 anterior orbital gyrus
8 posterior orbital gyrus

9 Anterior perforated substance

10 lateral olfactory stria
11 medial olfactory stria
12 optic nerve

Interpeduncular area

13 optic chiasma
14 optic tract
15 hypophysial stalk
16 anterior tuber
16′ lateral tuber
16″ posterior tuber
17 mamillary body
18 crus cerebri
19 interpeduncular fossa (posterior perforated substance)
20 oculomotor nerve
21 pons

Fig. 20. Tuberal region (× 6.2).

1 optic chiasma
2 optic tract
3 infundibulum (median eminence of hypophysis)
3′ hypophysial stalk covered by portal vessels
4 posterior tuber (postinfundibular eminence)
5 lateral tuber with lateral eminence (5′)
6 lateral perforated substance
7 mamillary body
8 cut surface of crus cerebri
9 anterior perforated substance

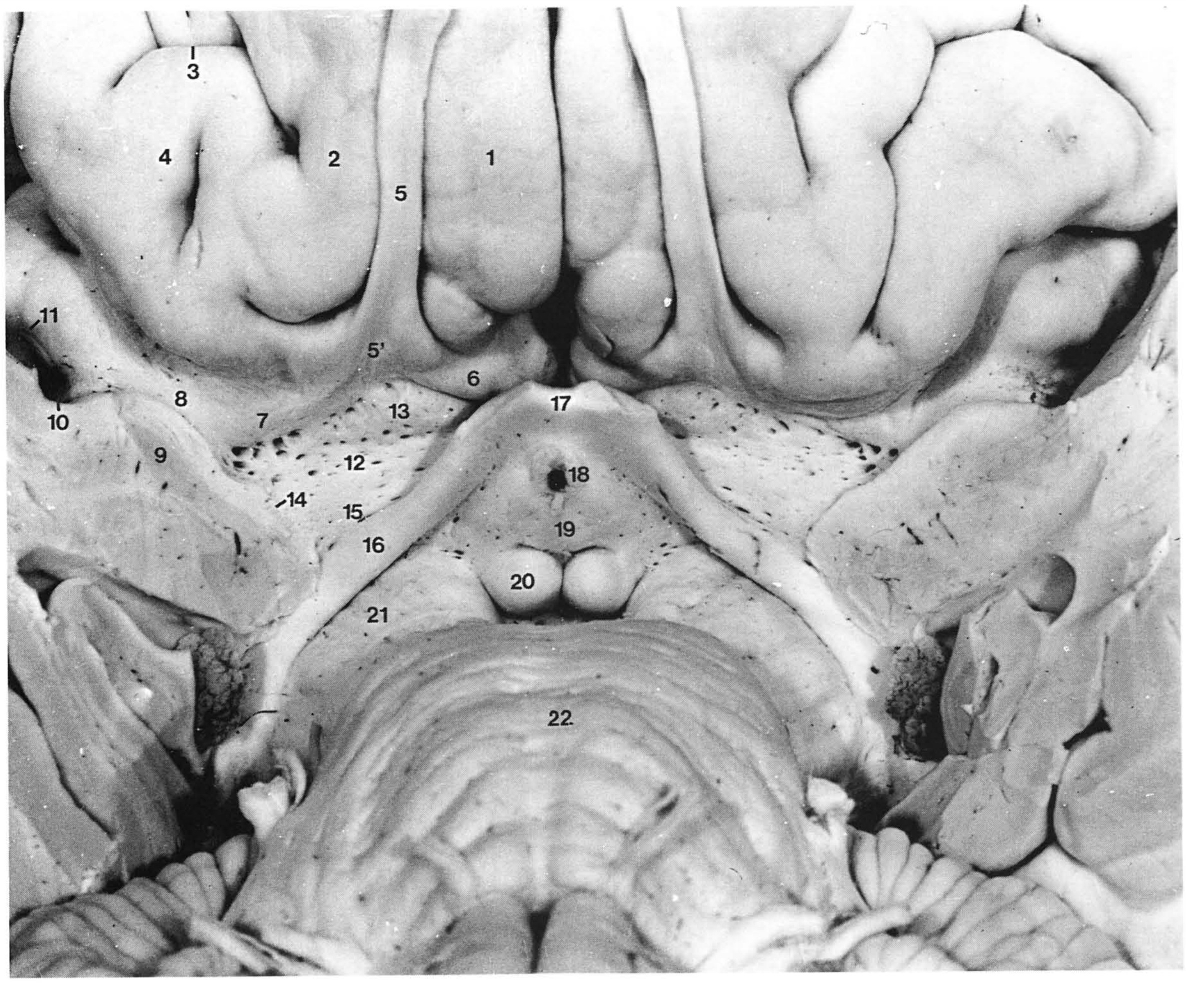
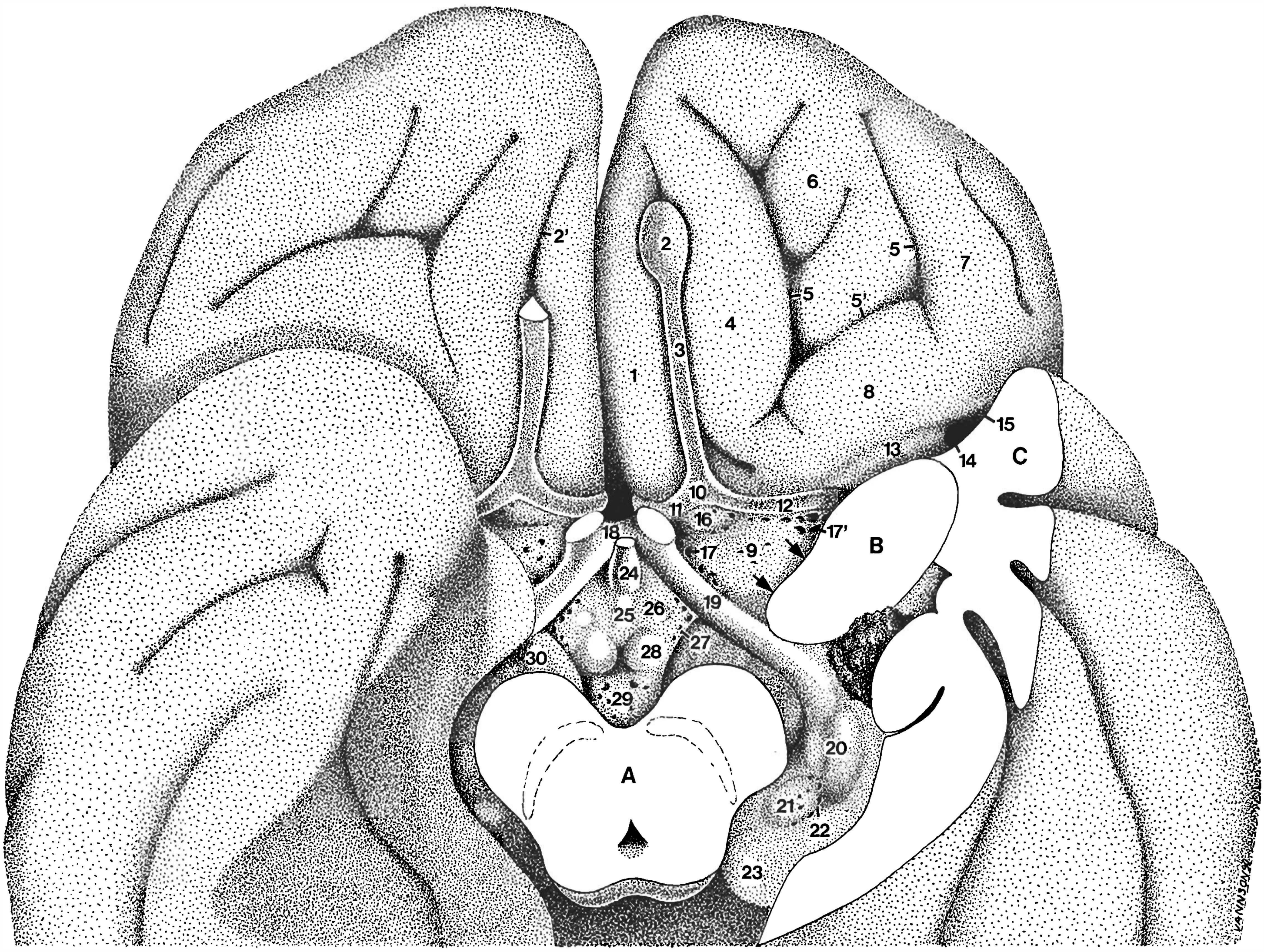


Fig. 21. Basal surface of the brain; uncus and temporal pole removed (×2.1).

1 gyrus rectus
2 medial orbital gyrus
3 H-shaped sulcus (arcuate orbital sulcus)
4 posterior orbital gyrus
5 olfactory tract
5′ olfactory trigone
6 medial olfactory stria
7 lateral olfactory stria covered with prepiriform cortex
8 limen insulae (floor of basal part of lateral fissure)
9 cut surface of semilunar gyrus
10 falciform fold
11 lateral fissure, lateral part
12 anterior perforated substance
13 olfactory tubercle
14 endorhinal sulcus
15 Broca's diagonal band
16 optic tract
17 optic chiasma
18 infundibulum
19 tuber
20 mamillary body
21 crus cerebri
22 pons



Figs. 22 and 23. Basal surface of the brain. The diagram in Fig. 22 is partially illustrated by the photograph in Fig. 23 ($\times 22$). The brainstem (*A*), uncus (*B*), and temporal pole (*C*), have been removed.

Orbital lobe

1 gyrus rectus
2 olfactory bulb
2′ medial orbital sulcus (olfactory sulcus)
3 olfactory tract
4 medial orbital gyrus
5 H-shaped sulcus
5′ arcuate orbital sulcus
6 anterior orbital gyrus
7 lateral orbital gyrus
8 posterior orbital gyrus

Anterior perforated substance (9)

10 olfactory trigone
11 medial olfactory stria
12 lateral olfactory stria
  13 limen insulae (floor of basal part of lateral fissure)
14 falciform fold
15 lateral fissure, lateral part
16 olfactory tubercle
17, 17′ penetration point of medial and lateral striate blood vessels

Arrows indicate the endorhinal sulcus.

Interpeduncular region

18 optic chiasma
19 optic tract
  20 lateral geniculate body
  21 medial geniculate body
  22 penetration point of thalamo-geniculate blood vessels
  23 pulvinar
24 infundibulum (median eminence)
25 posterior tuber (postinfundibular eminence)
26 lateral tuber and lateral eminence
27 lateral perforated substance and penetration point of tuberothalamic and tuberohypothalamic blood vessels
28 mamillary body
29 interpeduncular fossa and posterior perforated substance (penetration point of thalamoperforating blood vessels)
30 crus cerebri

3.3 The interpeduncular region

The interpeduncular area (Figs. 19–23) is a diamond-shaped structure bordered caudally by the superior margin of the pons and by the right and left crura cerebri, each one diverging into the corresponding hemisphere. It is bounded rostrally by the optic chiasma and the right and left optic tracts. Each optic tract turns round the crus cerebri and reaches into the lateral geniculate body. The lateral geniculate body and its adjacent homologue, the medial geniculate body, are pierced by a number of small apertures allowing passage for the thalamogeniculate vessels.

The two mamillary bodies divide the interpeduncular area into anterior and posterior parts.

3.3.1 **The interpeduncular or intercrural fossa,** the posterior part, caudal to the mamillary bodies, is a deep depression. The oculomotor nerve emerges on its walls (Fig. 19). On its floor, or posterior perforated substance, there appear numerous apertures: larger rostral ones for the thalamoperforating blood vessels and smaller caudal ones for the mesencephalic and pontine blood vessels (see [220]).

3.3.2 **The tuber cinereum** or tuberal region, the anterior part of the interpeduncular region, rostral to the mamillary bodies, is divided by the insertion of the infundibulum (median eminence of the hypophysis) into four areas: anterior, posterior, and right and left lateral.

The anterior tuber is small in size as the infundibulum is situated very close to the chiasma.

The posterior tuber, or postinfundibular eminence, on the contrary is clearly defined and forms a median ridge, extending caudally to the mamillary bodies.

Each lateral tuber is bounded by the adjacent corresponding optic tract. Retzius [57] describes several protrusions, the lateral eminences, as well as small vascular apertures for the hypothalamic vessels, mostly situated along the optic tract and crus cerebri (lateral perforated substance).

Here ends our attempt to sum up the surface anatomy of the human brain, which should provide sufficient explanation for the following chapters about sectional anatomy.

Functional localizations of the human cortex in relation to frontal, temporal, parietal, and occipital lobes

1 Preliminary remarks

It should be presumptuous to attempt giving in a few lines an account of the cortical functions of the brain. Only a general survey will be found here [97–155].

The cytoarchitectonic map of Brodmann only shows the different areas on the outer part of cortex. We must, however, remember that the cortical surface in the depth of the sulci represents two thirds of the total cortical surface.

The classical localizations of cortical functions in relation to cortical areas now appear less clearly defined; in particular, the new methods of investigation, as positron emission tomography (PET) and functional MRI, show that cognitive tasks are performed by a large number of areas which seem to work together.

As seen previously (Sect. 1.5), on the lateral aspect of the hemisphere a distinct anatomical boundary between parietal, occipital, and temporal lobes is absent; thus, there is a wide transitional zone between these lobes and it is difficult to assign the different areas forming this zone to a specific lobe (e.g., areas 42, 22, 39, 40, 37).

Notwithstanding these remarks, an overview of the cortical functions will be described as follows (Figs. 24, 25, and 25′).

2 The frontal lobe

Functionally, the frontal lobe may be divided into precentral and prefrontal cortex.

2.1 **The precentral cortex.** Two functional zones may be considered.

The primary motor cortex (area 4, M1), situated in the precentral gyrus, is involved in the execution of movement via the corticospinal and corticonuclear tracts. There is a precise representation of different controlateral muscular regions of the body in area 4; for instance, muscles of the lower part of the body are dependent upon superior area 4 (paracentral lobule) and those of the upper part are controlled by inferior area 4 as shown by the classical motor homunculus of Penfield.

The premotor cortex, situated in the superior and middle frontal gyri (areas 6 und 8), is involved in the coordination of synergistic movements in collaboration with the cerebellum. Belonging to the premotor cortex but having more precise functions are: the frontal eye field (lower part of area 8), in particular concerned with directing the gaze; Broca's speech area (inferior frontal gyrus, areas 44 and 45), for motor functions of language; the supplementary

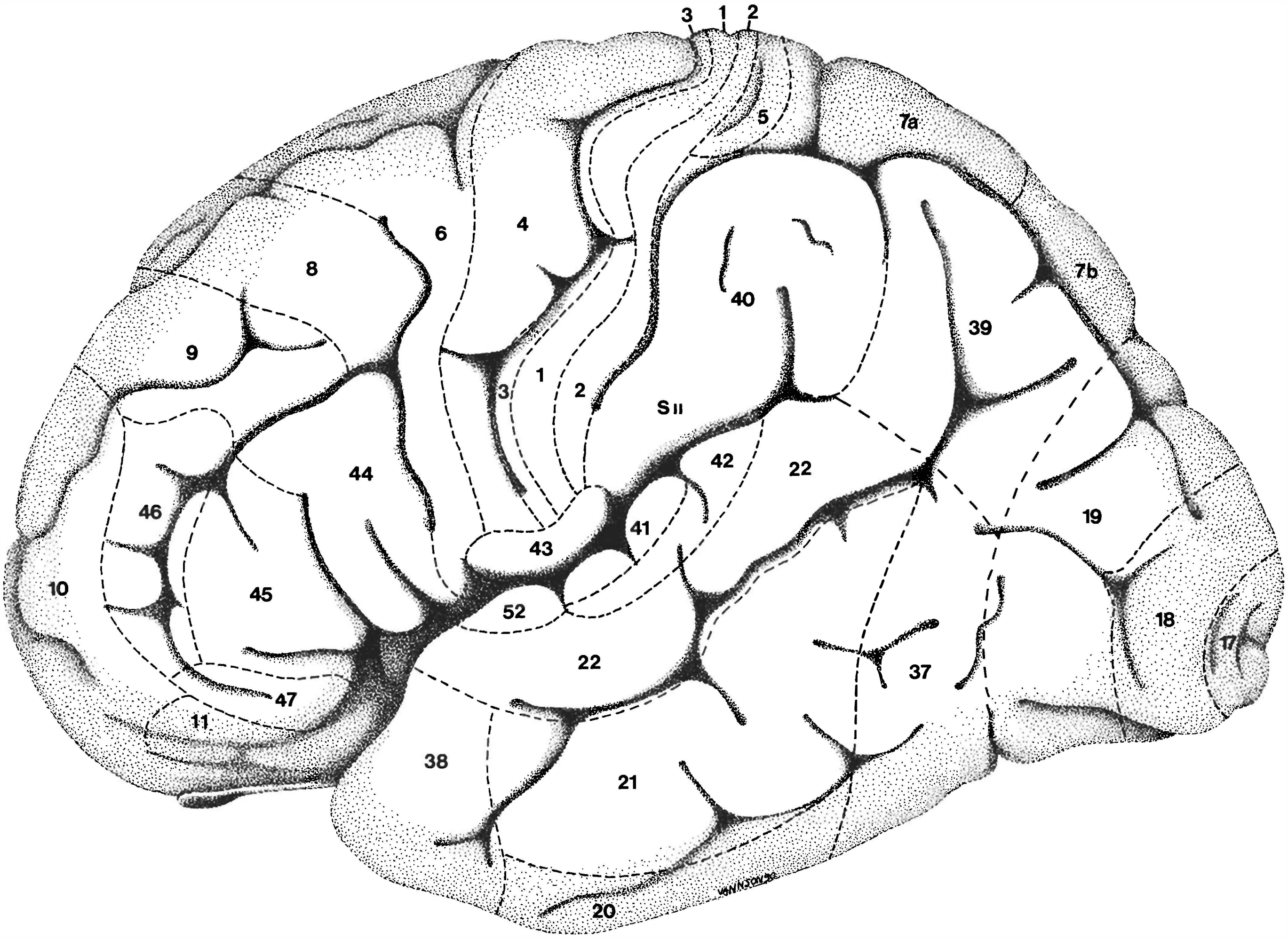
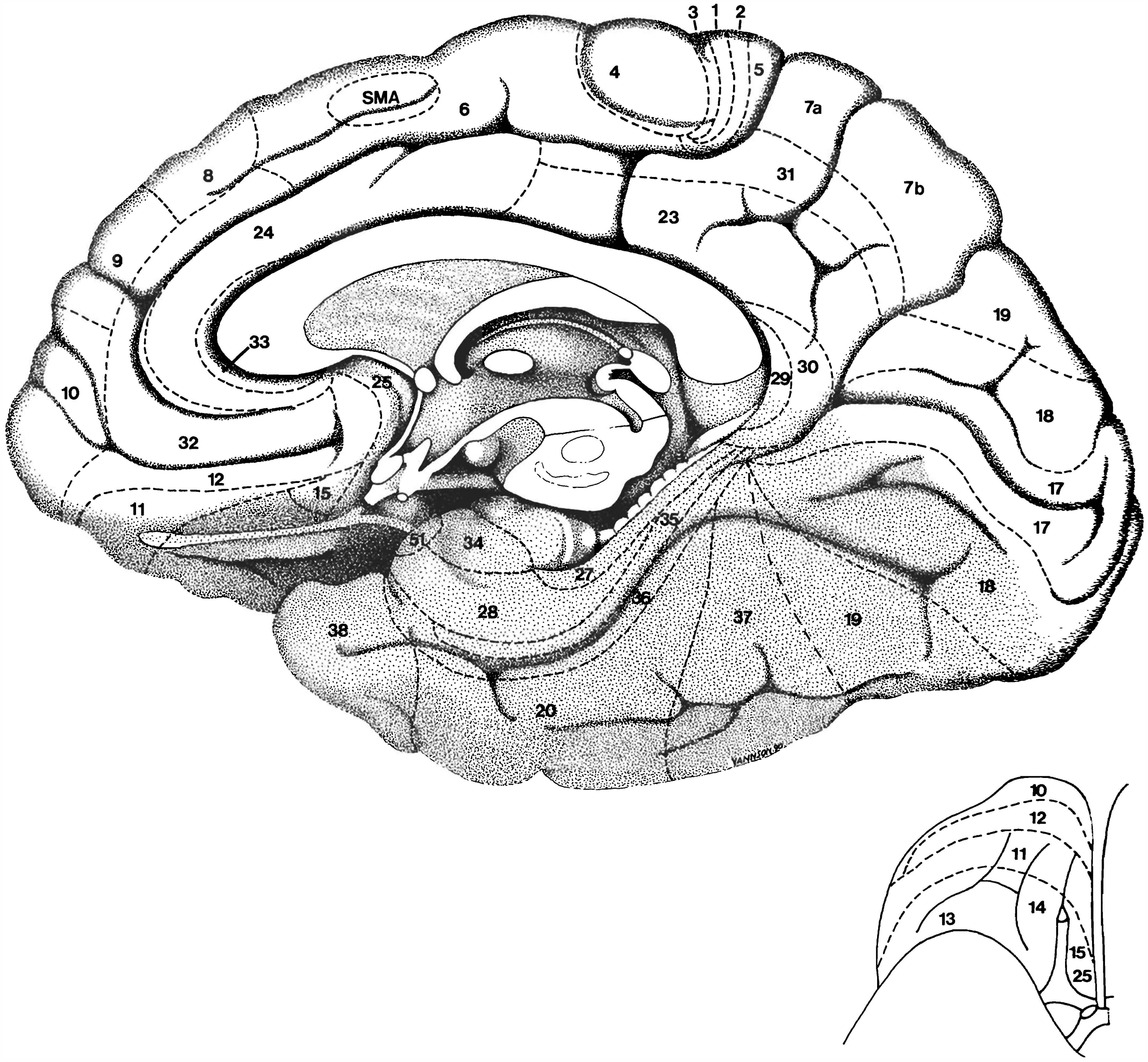


Fig. 24. Cytoarchitectonic areas according to Brodmann, lateral surface of the left hemisphere.



Figs. 25 and 25′. Cytoarchitectonic areas according to Brodmann; inferomedial surface of the right hemisphere (Fig. 25), orbital surface of the right hemisphere (Fig. 25′).

motor area (SMA) (medial aspect of area 6 anterior to paracentral lobule), involved in the initiation of movement and postural adjustments during movement in collaboration with the basal ganglia.

2.2 **The prefrontal cortex.** Areas 9–11, 46, and 47 on the lateral surface and 10–15 on the orbital surface; this prefrontal cortex regulates the neocortical control of behavior in collaboration with the limbic system via the mediodorsal thalamic nucleus. Moreover, some visceral centers may be situated in the prefrontal cortex.

The new functional methods of investigations quoted above show that the frontal cortex is actually involved in more general and expanded cognitive functions.

3 The temporal lobe

The temporal lobe may be divided into three functional zones.

3.1 **The auditory cortex.** This cortex comprises the primary auditory cortex (A1), mainly situated in the transverse temporal gyri (area 41), and the auditory association cortex (A2): area 52 anterior to the primary auditory cortex, and partially covering the planum polare; areas 22 and 42, including most of the superior temporal gyrus and the planum temporale, taking part in the Wernicke speech area (Sect. 4.2).

In fact the precise localization of the auditory cortex seems difficult to define.

3.2 **The temporal association cortex.** It has a great development in man. It includes areas 21, 20, and 37 on the lateral aspect of the lobe and areas 20, 37, and 36 on its inferior aspect (middle and inferior temporal gyri and fusiform gyrus).

This cortex seems especially concerned with memory in relation with the mechanism of language (memory of names of persons, places, etc.).

The inferotemporal visual areas (areas 20, 21, and 37) are involved together with the occipital cortex in recognizing visual stimuli such as the shape of an object (inferior visual system; Sect. 5.2).

3.3 **The limbic centers** (see Sect. 6).

4 The parietal lobe

The parietal lobe is divided into somatosensory cortex and parietal association cortex.

4.1 **The somatosensory cortex.** The primary somatosensory cortex (SI) is situated in the postcentral gyrus; together with its frontal homologue, the primary motor cortex in the precentral gyrus, it is sometimes named “rolandic” or “central” area. The primary somatosensory cortex is divided into narrow cytoarchitectonic areas 3b, 1, and 2. Area 3a is a transitional cortex between the frontal and parietal lobes at the bottom of the central sulcus. As in the primary motor cortex, the somatosensory cortex is somatotopically organized so that various regions of the controlateral body have a precise representation (sensory homunculus).

The secondary somatosensory cortex (SII) is located in the parietal operculum (inferior parietal gyrus).

The gustatory cortex seems to be situated in the subcentral gyrus (area 43).

4.2 **The parietal association cortex.** It includes both the superior and inferior parietal gyri (areas 5, 7a and b, 39, and 40) which are sometimes described together as the posterior parietal association cortex. Important cortical functions are attributed to this region: three-dimensional interpretation of the nature of an object by tactile stimuli (stereognosis, area 7); visual localization of objects, elaboration of motor program necessary to reach these objects, spatial perception and spatial memory in collaboration with the visual association cortex (superior visual system); auditory functions especially in supramarginal gyrus in collaboration with the auditory association cortex.

A vast cortical zone belonging to parietal, occipital, and temporal lobes, includes association cortex involved with speech in relation to vision and audition. This cortical zone, the Wernicke speech area, is formed by the supramarginal (area 40) and angular (area 39) gyri associated with the adjacent temporal cortex (areas 42 and 22).

5 The occipital lobe

The occipital lobe is divided into primary visual cortex and visual association cortex.

5.1 **The primary visual cortex** (striate cortex, area 17 or V1). It is situated in relation to the calcarine sulcus and may be macroscopically identified by a white line of myelinated fibers bisecting the internal granular layer (stria of Gennari).

5.2 **Visual association cortex** (parastriate, 18 or V2, and peristriate, 19 or V3, V4, and V5 areas). Two main functional systems are attributed to this cortex.

The superior visual system in relation to the parietal association cortex (occipitoparietal system) is concerned with spatial perception such as localization and movements of an object.

The inferior visual system in relation to the temporal association cortex (occipitotemporal system) is involved in visual identification of an object and color perception (in the lingual cortex).

Furthermore, the visual association cortex (areas 18 and 19) plays a role similar to the frontal eye field (area 8) in controlling eye movements.

6 The limbic lobe

Functionally the limbic lobe is divided into limbic cortex and paralimbic association cortex.

6.1 **The limbic cortex.** It is composed of hippocampus, subiculum (area 27), prepiriform (area 51), and periamygdaloid (area 34) cortex. The amygdala is joined to this formation and is divided into lateral, basal, accessory basal, medial, central, cortical – covered by the semilunar gyrus – nuclei. For more information about limbic functions, see [20].

6.2 **The paralimbic association cortex.** It includes the subcallosal and cingulate gyri (areas 23–25 and 32), the retrosplenial cortex (areas 29 and 30) and the parahippocampal gyrus (entorhinal area, area 28) and perirhinal area (areas 35 and 36). Also sometimes linked to the paralimbic cortex is the insula.

There are two main functional systems in the limbic lobe: the olfactory system and the limbic system.

In man, the olfactory cortical centers are controversial and difficult to localize. According to literature are quoted the semilunar gyrus, the prepiriform (area 51), and entorhinal (area 28) cortices, but also the subcallosal area (area 25) and the posterior orbital gyrus (area 13).

The limbic system is divided into a basolateral and a medial limbic system.

The basolateral limbic system includes different structures such as amygdala (central, basal, and lateral nuclei), mediodorsal thalamic nucleus, prefrontal cortex (areas 9–15, 46, and 47) and temporal pole cortex (area 38). This system is mainly concerned in control of behavior; it has also vegetative functions.

The medial limbic system (of Papez) is constituted by the hippocampus, anterior and mediodorsal thalamic nuclei, and certain cortical areas such as subiculum (area 27), entorhinal area (area 28), perirhinal area (area 35), and cingulate cortex (areas 23, 24, 29, and 30). The medial limbic system is mainly involved in memorization and regulation of emotional behavior.

\+ postinfundibular and premamillary anastomoses between the right and left tuber arteries
12 arteries of the mamillary body
13 anterior choroidal artery
14 anterior cerebral artery
15 anterior communicating artery

Veins of the tuberal region

16 longitudinal tuberal veins, often of plexiform appearance, the principal veins in this region. They receive 17, 18 and 19 and are drained into 20; left and right veins are linked by 21 and 22.
17 veins of optic tract and optic chiasma
18 medial tuberal veins draining the posterior tuber
19 mamillary veins
20 interpeduncular vein
21 pre-infundibular (retrochiasmatic) venous arch
22 premamillary venous arch (here discontinuous)

Fig. 263. Vascularization of the tuberal region. Drawing, distinguishing arteries *(red)* and veins *(black)*, and intravascular india ink injection (bar: 3.3 mm).

1 optic chiasma
2 optic tract
3 infundibulum (median eminence of the hypophysis) covered by the primary plexus of the hypophysial portal system
3′ hypophysial stalk and portal vessels
4 posterior tuber (postinfundibular eminence) covered by an extension of the primary plexus of the portal system
5 lateral tuber and lateral perforated substance
6 mamillary body
7 cut surface of crus cerebri
8 interpeduncular fossa and thalamoperforating arteries

Arteries of the tuberal region, divided into three groups (9–11)

9 superior hypophysial arteries, arising from the internal carotid artery (9′), vascularize the primary plexus of the hypophysial portal system, covering the infundibulum (9″ pre-infundibular or retrochiasmatic arterial plexus)
10 tuberohypothalamic (tuberoinfundibular) arteries supply the middle group of hypothalamic nuclei and the posterior tuber
11 tuberothalamic (premamillary) arteries, often restricted to one or two main trunks, reach the posterior group of the hypothalamic nuclei and the thalamic anterior pole. The tuberohypothalamic and tuberothalamic arteries arise usually from the posterior communicating artery (11′) and mainly penetrate the tuber in the lateral perforated substance (11″ posterior cerebral artery).