DEPARTMENT OF ANATOMY AND CELL BIOLOGY,

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Practical instructions for the dissection of the brain

(Revised, February 2008)

This is a series of numbered instructions for 8 to 12 hours of practical work. If you are already some way into the course, are behind in your reading, and are finding the subject difficult, read ***Instructions 143-145*** now.

The first version of these notes was issued to medical students when the time for dissection was reduced in the early 1990s. Since the mid-1990s, human brains for dissection have been in short supply, and it is now necessary to conduct practical classes almost entirely with preserved (plastinated) specimens. Curricular changes at UWO have led to the elimination of practical work in Neuroanatomy for medical students, but laboratory classes are still held for students in Physical Therapy and Occupational Therapy, and for graduate students.

This version of the lab notes is intended for use by graduate students taking Anatomy 535b (Anatomical Foundations of Neuroscience). It includes notes on the human and rat central nervous systems. The brains of the two species should be examined together, to see the similarities and differences.

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General remarks on technique.

The **human** specimens include intact and pre-dissected brains, stained sections mounted on glass slides, and various specimens from the Department's museum. The brains should have no abnormalities other than occasional anatomical variations and changes attributable to ageing. Depending on availability of material, it may be necessary to deviate from the printed instructions. For example, you may find that a certain piece of dissection has already been done. A pre-dissected specimen may not yet be available, in which case you may be provided with an intact part with dissecting instructions, or you may have to share with another group of students. Please remember that the brains we dissect belonged to people, and treat the material with due respect. Put your specimens back in their containers when not in use. Small scraps of tissue that are not needed for study should be put in the plastic bags provided at the ends of some of the benches.

The **wet specimens** were fixed for several months in aqueous formaldehyde solution, and then transferred to 35% alcohol. There should be only a slight odour of formaldehyde, and there is no risk of catching infectious diseases from these specimens. There is a real risk of cutting yourself

and getting alcohol in the wound - a painful experience - so be careful. University regulations state that safety glasses are to be worn in teaching laboratories. No food or drinks are allowed in the laboratory. The wearing of a lab. coat is compulsory, and some students like to wear disposable latex or plastic gloves as well.

Plastinated specimens have been dehydrated and infiltrated with a rubber-like silicone polymer. This causes shrinkage to 75-80% of the original size. Handle these dry specimens with great care because they are easily damaged.

The **rat** specimens are preserved in dilute formaldehyde.

INSTRUMENTS. You need the following:

1. For blunt dissection: a scalpel handle, without a blade, and/or a spatula about 5 mm wide, with a rounded end. A lollipop stick is also suitable.

2. Stout forceps, at least one pair. A pair of smaller forceps is needed for the rat's and occasionally also for the human brain.

3. Scissors. Blades 3 cm or longer, and sharp enough to cut paper and string.

4. Some kind of blunt probe, more than 5 cm long, preferably with an angled or curved tip. The pauper's version is fashioned with pliers from a large paper-clip or from stripped domestic electric wire. File off any sharp points or rough edges.

5. A scalpel blade (No. 12 is the best size & shape). Use a new one, and keep it in a safe place. You won't need to fix it to the scalpel handle. A smaller, pointed blade (No. 11) is preferable for the rat's brain.

6. A ruler (15 cm) is useful because measurements are included in some of the dissecting instructions.

Stainless steel trays are provided, and a number of long "brain knives" are available for the few occasions they are needed. Coloured pencils are needed if you want to illuminate the outline drawings in these notes.

TEXTBOOKS.

In these notes, references are made to pages and figure numbers in the 8th edition (2005) of BARR'S THE HUMAN NERVOUS SYSTEM, by J. A. Kiernan (Philadelphia, Lippincott Williams & Wilkins). A citation like, "*Barr* 11-2," refers to the photo on Page 196, which is in Chapter 11. If you don't like this book, any Neuroanatomy text with labelled photographs or other realistic pictures may be used instead. If you wish to do the dissection more thoroughly, get THE HUMAN BRAIN IN DISSECTION, by D. G. Montemurro & J. E. Bruni (Philadelphia, Saunders; 2nd edn, 1988), which has detailed descriptions, many large photographs, and also an atlas for comparing anatomical slices with images made by computerized tomography and nuclear magnetic resonance imaging. The order of dissection followed in these notes is approximately the same as in Montemurro & Bruni, but the procedure is less complete, and you are not expected to identify

as many of the visible structures.

An inexperienced student takes about 16 hours to do a careful dissection of a human brain and to examine a set of stained sections of the brain stem. Your course allows less time, and you are also expected to examine the rat's brain, so don't expect to see everything.

A set of labelled pictures of the rat's brain is available on the web site for Anatomy 535b (**ratpix.pdf**). In addition, several textbooks and atlases of human neuroanatomy are available in the practical classes.

SPECIMENS NEEDED.

Availability will vary. Certain instructions for dissection must be skipped when pre-dissected or plastinated specimens are provided. The numbered instructions are based on the assumption that a intact brain will be examined and dissected.

One whole brain with meninges and blood vessels in place. Ideally this should include a cap of dura mater over the top of the cerebral hemispheres.

One whole brain with the dura and arachnoid removed. This one will be dissected. The cerebral hemispheres and brain stem may already have been separated when you receive this specimen.

Plastinated and wet pre-dissected specimens, as available. Wet specimens must be returned to their containers when not being examined. Plastinated specimens have been infiltrated a rubbery polymer. They are dry, but have a texture similar to that of wet, fixed tissue. Don't put plastinated specimens into the containers of 35% alcohol!

Intact and partly dissected wet specimens of rats' brains.

Stained sections of the human brain stem and diencephalon.

Large slices of human cerebral hemispheres, stained to distinguish grey matter from white matter.

In the fresh state, central nervous tissue is too soft to be dissected or cut into slices. Before fixation the white matter is white but the grey matter is pink because it contains more capillary blood vessels.

Class 1 MENINGES AND EXTERNAL BLOOD VESSELS.

1. Examine the whole brain with intact meninges and blood vessels. If your specimen does not include any dura, look at someone else's for that part of the procedure.

2. Recall (from Gross Anatomy) the arrangement of dural reflections in the cranial cavity (*Barr* 26-2). Find the **dura**, some branches of the **middle meningeal artery**, and the **superior sagittal sinus**. The middle meningeal artery may be damaged in a head injury, especially if there is a

fracture of the squamous temporal bone. The blood escapes quickly, forming an extradural mass that presses on the cerebral hemisphere.

3. Identify the **cerebral hemispheres**, the **cerebellum** and the **brain stem**. Observe that the **tentorium cerebelli** (never present in these specimens) is below the **occipital lobes** of the cerebrum, above the cerebellum, and level with the **midbrain**, which is only partly visible in this intact specimen (*Barr* 1-3, 26-4).

4. Look at the **superior sagittal sinus**, which contains some clotted blood. Open the roof of the sinus with a longitudinal cut. Note its generally triangular cross-sectional shape and the shallow **lateral lacunae**.

5. Lift up the dura, and look at the surface of a cerebral hemisphere. You see a membrane, the **arachnoid**, and many blood vessels, nearly all of which are veins. The **superior cerebral veins** (described in *Barr*, Ch. 25) pierce the dura and empty into the superior sagittal sinus or its lateral lacunae. You can explore this continuity with a blunt probe, inserted from the lumen of the sinus.

6. Look for some **arachnoid granulations** (*Barr* 26-1, 26-7) alongside the superior sagittal sinus. Most of them project into the lateral lacunae. Arachnoid granulations are easy to see, whether the dura is present or not. In man they are the principal route of absorption of cerebrospinal fluid from the subarachnoid space into the blood.

7. The **subarachnoid space**, which in life contained cerebrospinal fluid, is collapsed. To appreciate the existence of the space, lift up the arachnoid (with forceps), over the convexity of a cerebral hemisphere. Notice also that the arachnoid is quite a substantial membrane, 1 - 2 mm thick.

8. Make a hole in the arachnoid, or look through one that's already there, and see the surface of the underlying cerebral cortex. The shining surface of the cortex is due to the closely adherent **pia mater**, a very thin membrane that can be seen clearly only with a microscope. The pia follows the contours of all the convolutions of the surface of the brain, whereas the arachnoid bridges over all but the largest indentations. Consequently the width of the subarachnoid space varies from place to place. The widest parts are named as **cisterns**. One of these will be examined later (***Instruction 121***). For the others, consult a textbook (*Barr* Ch. 26; 26-4). The cisterns are important radiological landmarks.

9. Look at the shape of a cerebral hemisphere. Details cannot be made out when the arachnoid is present, but the **frontal, temporal and occipital poles** are easily discerned.

10. Most of the blood vessels that cover the surface of the cerebral hemisphere are veins. The **superior cerebral veins** drain upwards, into the superior sagittal sinus. Each vein pierces the arachnoid, runs for a short distances in the subdural space (which normally is completely occluded by contact of the dura with the arachnoid), and then pierces the dura to enter the sinus or one of its lacunae. **Subdural haemorrhage**, a common, serious and treatable consequence of closed head injury, is due to tearing of the fragile vein by the tough dura at the point of penetration. Bleeding into the subdural space may be fast or quite slow.

11. The position of the **lateral sulcus**, which separates the frontal from the temporal lobe, is marked by the **superficial middle cerebral vein**. The external veins of the cerebrum are variable, but two other named vessels are often prominent. The **superior anastomotic vein** (of Trolard) courses across the frontal lobe, connecting the superficial middle cerebral vein with the superior sagittal sinus. The **inferior anastomotic vein** (of Labbe) runs across the temporal and occipital lobes, connecting the superficial middle cerebral vein to the transverse sinus.

12a. Other external **veins of the brain** are most easily studied from a textbook (*Barr* Ch. 25). Some internal veins, and the great cerebral vein (of Galen) will be seen when the brain is dissected. Turn the specimen over and examine its ventral or inferior surface. Despite the presence of the arachnoid, several major parts of the brain are easily recognized.

12b. Identify the **brain stem**, consisting of the **medulla, pons and midbrain** (*Barr* 1-3, 6-1). The midbrain is not easily seen at this time. Please don't damage the specimen by trying too hard. The whole medulla may be present, or its caudal part may be missing from your specimen. Notice how the large **cerebellum** forms a kind of open collar around all three divisions of the brain stem. The ventral part of the pons continues laterally into the **middle cerebellar peduncle**. **Cranial nerves** can be seen emerging from the brain stem; they will be studied later.

13. On the ventral surface of each **frontal lobe**, identify the **olfactory bulb**, **olfactory tract** and **anterior perforated substance** (*Barr* 17-3). Identify also the **optic nerves**, **optic chiasma**, and **optic tracts** (*Barr* 11-1). Behind the chiasma is the **tuber cinereum**, from which emerges the **pituitary stalk**. (The occasional specimen includes the whole pituitary gland and the diaphragma sellae.) The two **mamillary bodies** are posterior to the tuber cinereum.

14. The most medial part of the ventral (inferior) surface of the **temporal lobe** is the **uncus**. The two unci partly obscure your view of the parts of the diencephalon mentioned in the previous paragraph. The neural structures are also partly concealed by **blood vessels**, which must now be examined.

15. The grossly visible vessels on the inferior surface of the brain are **arteries**, but their walls are as thin as those of veins in other parts of the body. Arteries contract after death, so the vessels you seen in the specimen are narrower than they were in life. You will probably see conspicuous yellow deposits of atheroma in the arteries at the base of the brain.

16. The brain is supplied by the left & right internal carotid arteries and the left & right vertebral arteries, each of the latter being a branch of the thyrocervical trunk of the subclavian artery. Anastomoses between the vertebral and carotid systems and between the arteries of the left and right sides constitute the **circle of Willis**. Deviations from the typical arrangement of vessels are common.

17. On the ventral surface of the medulla, identify the two **vertebral arteries** and observe that they unite to form the **basilar artery** (*Barr* 25-1).

18. At the level of the caudal part of the medulla each vertebral artery has a medially directed branch that joins its fellow of the opposite side to form the caudally directed **anterior spinal artery**. This small median vessel supplies the ventral parts of only the first few cervical segments of the spinal cord. Further caudally it is reinforced by **radicular arteries**. The **posterior spinal arteries** are dorsolaterally directed branches of the vertebrals. These too are joined by radicular arteries along the length of the spinal cord.

19. The largest branch of the vertebral artery is the **posterior inferior cerebellar artery**, known in clinical circles as PICA. It has branches that supply the lateral part of the medulla, and then supplies the posterior, inferior parts of the cerebellum. Ischaemia in the territory of this artery causes Wallenberg's lateral medullary syndrome, a constellation of clinical signs that can be explained in terms of the destruction of specific nuclei and tracts in the medulla.

20. Shift your gaze rostrally to the **basilar artery**, which lies in a sulcus in the ventral midline of the pons. The **anterior inferior cerebellar artery** (AICA) arises soon after the formation of its parent vessel. It supplies the anterior, inferior part of the cerebellum (including the flocculonodular lobe or vestibulocerebellum). In most people this artery gives rise to the **labyrinthine artery**, which accompanies the 8th cranial nerve and supplies the inner ear. Occlusion of AICA causes vertigo and ipsilateral deafness. The labyrinthine artery is sometimes a branch of the basilar artery (*Barr* 25-1).

21. The basilar artery has many small branches, the **pontine arteries**. Short pontine arteries supply the medial and ventral parts of the pons. Long pontine arteries supply lateral and dorsal parts.

22. At the rostral border of the pons, the basilar artery appears to end in four branches. The penultimate branches are the left & right **superior cerebellar arteries**, and the final bifurcation is into the two **posterior cerebral arteries**. On at least one side you should see the **oculomotor nerve** (which emerges from the ventral aspect of the midbrain) passing between the superior cerebellar and the posterior cerebral artery.

23. Now look closely at the area immediately anterior (rostral) to the terminal bifurcation of the basilar artery. The **posterior cerebral arteries** have small branches that go up into the hard-too-see ventral surface of the midbrain, posterior to the mamillary bodies. This region will be easier to see in dissected specimens. It is called the **interpeduncular fossa** because it's between the cerebral peduncles (which constitute most of the midbrain). The floor of the fossa is called the **posterior perforated substance** because numerous small branches of the basilar and posterior cerebral arteries enter the brain here. The small vessels are known as **posteromedial central arteries**. They supply the ventral and medial parts of the midbrain, and various parts of the diencephalon.

24. The only branch of the **posterior cerebral artery** easily visible on the inferior surface of the brain is the **posterior communicating artery**, which is lateral to the mamillary bodies and joins the **internal carotid artery** (*Barr* 25-1). In the embryo the posterior cerebral artery developed as a branch of the internal carotid, but it was later "captured" by the vertebro-basilar circulation. The posterior communicating artery is therefore a vestige of the original first part of the posterior

cerebral artery. In one of the commonest variations the "capture" does not occur on one side: the posterior cerebral artery arises from the internal carotid, there is no posterior communicating artery, and the last branch of the basilar is the superior cerebellar artery.

25. Carefully widen the fissure between the cerebrum and cerebellum, and observe the course of the posterior cerebral artery as it passes posteriorly across the lateral aspect of the **midbrain**. This segment of the artery gives off **posterolateral central branches** (often called thalamo-perforating arteries by radiologists). They supply the posterior part of the thalamus (including geniculate bodies), and the lateral and dorsal parts of the midbrain. The **posterior choroidal artery** (which you won't be able to see) is another branch of this part of the posterior cerebral artery.

26. The most conspicuous branches of the posterior cerebral artery are those to the cortex of the **occipital lobe** and the inferior surface of the **temporal lobe** (*Barr* 25-3). They will be seen later.

27. Returning to the middle of the inferior surface of the specimen, find the left and right **internal carotid arteries**, lateral to the optic chiasma. The first large branch, the ophthalmic artery, was left behind when the brain was removed (as were the small posterior hypophysial arteries). The first visible branch is therefore the **posterior communicating artery** (already seen), and the next is the **anterior choroidal artery**, which runs along the lateral edge of the optic tract and is then concealed by the medial part of the temporal lobe. The anterior choroidal artery has branches that supply several important internal structures of the cerebral hemisphere (including parts of the temporal lobe, internal capsule and thalamus). It ends by supplying the choroid plexus of the lateral ventricle, where its terminal branches anastomose with those of the posterior choroidal artery. (Arterial anastomoses are unusual among end-arteries in the brain. Veins, as you can see on the surface of the hemisphere, anastomose freely.)

28. The terminal bifurcation of the internal carotid, into the **anterior and middle cerebral arteries**, is lateral to the optic nerve. At this level numerous small branches, the **anteromedial and anterolateral central arteries** (also called lenticulostriate arteries) pass from all three vessels into the **anterior perforated substance**. They supply the inside of the cerebral hemisphere, including the corpus striatum and much of the internal capsule. The recurrent artery of Heubner (medial striate artery) is a large individual vessel of the anteromedial group.

29. Observe the **middle cerebral artery**, entering the depths of the lateral sulcus. Using your fingers and coarse forceps, pull away the arachnoid and superficial veins, starting in front of the temporal pole and extending along the lateral sulcus, until you have exposed the pale, shining pial surfaces of most of the inferior and lateral aspects of the frontal, temporal and parietal lobes. Do this for the left and right cerebral hemispheres. Notice that the sulci and gyri of the surface of the brain to not generally correspond to the pattern of superficial veins.

30. Using the thumbs of both your hands, carefully widen the lateral sulcus, so that you can see the **middle cerebral artery** and its branches. As it enters the sulcus, the artery gives off some **anterolateral central** (= lenticulostriate) branches. The conspicuous branches, however, are those that begin in the depths of the lateral sulcus, curve around the **opercula**, and supply the cortex of the lateral surfaces of the **frontal, parietal and temporal lobes** (*Barr* 25-2). The

frontal, parietal and temporal opercula (singular: operculum = Latin for cover or lid) are the parts of the three named lobes that form the sides or banks of the lateral sulcus. These cortical regions conceal the cortex of the **insular lobe** (= insula, or island of Reil), which forms most of the floor of the lateral sulcus. The insula will be more closely examined, and then dissected, later (***Instruction 59***).

31. Look again at the ventral or inferior surface of the brain, and find the **anterior cerebral artery**. It is directed first medially and the dorsally (= up) into the **interhemispheric fissure**. The left and right anterior cerebral arteries are connected by the **anterior communicating artery**, anterior and dorsal to the optic chiasma. The further course of the anterior cerebral artery cannot be followed yet. This vessel supplies the medial surface of the cerebral hemisphere as far as the parieto-occipital sulcus. Its territory extends laterally to include the top (superior surface) of the frontal and parietal lobes, for about 2 cm lateral to the midline.

32. If you **look at a functional map** of the primary motor and somatosensory cortical areas, and read the associated text (*Barr* 15-1, 15-2), you will notice that the anterior cerebral artery supplies cortical areas that serve the lower limb, whereas the middle cerebral artery supplies corresponding areas for the upper limb, trunk, neck and head. The **supplementary motor area** (*Barr* 15-2), essential for initiation of voluntary movements, is also supplied by the anterior cerebral artery, but the functions of this important cortex are largely duplicated in the contralateral hemisphere. Bilateral destructive lesions of the supplementary motor areas cause profound paralysis and mutism, but they are not caused by unilateral arterial occlusions.

33. The area of **cortex supplied by the middle cerebral artery** (*Barr* 25-2) includes all the speech and language areas (*Barr* 15-6) in the cerebral hemisphere dominant for these functions. (In most people, including most lefty writers, this is the left hemisphere.)

34. On the inferior surface of the brain, find again the terminal bifurcation of the **basilar artery** and the two **posterior cerebral arteries**. You have already looked for their less conspicuous branches, the posteromedial central (thalamo-perforating) and posterior choroidal arteries. Now strip the arachnoid and superficial veins from the cortex of the **inferior surface of the temporal lobe and the whole occipital lobe**. The posterior cerebral artery supplies these cortical areas. The smaller branches will be removed along with the meningeal tissue and superficial veins.

35. **In preparation for later dissection,** remove all remaining arachnoid and superficial veins from the cerebral hemispheres, including the orbital surfaces of the frontal lobes and the easily accessible parts of the medial surfaces of the frontal and parietal lobes.

36. **REMOVAL OF BRAIN STEM AND CEREBELLUM**. Read through ***Instructions 37-40*** before you do anything.

37. Using scissors, cut through the **basilar artery** at the level of the rostral end of the pons.

38. Widen the fissure that separates inferior surfaces of the occipital lobes from the superior surface of the cerebellum. At the base of this fissure, in the midline, is a mass of tissue that contains the **great cerebral vein** (a median structure) and the **pineal gland**. Using a long pair of

forceps, pull away the arachnoid from these structures, and from the inferior surfaces of the occipital lobes, until the pineal gland is clearly visible. Below the pineal gland are the four lumps (**superior and inferior colliculi**) that constitute the tectum or dorsal surface of the **midbrain**.

39. Taking care not to tear or crack the midbrain, follow the surface of this part of the brain stem ventrally, on each side, until you can see the ventral surfaces of the left and right **cerebral peduncles**, just posterior to the mamillary bodies (*Barr* 11-1). Observe the **oculomotor nerves**, which emerge from the medial surfaces of the peduncles.

40. **Using a sharp scalpel blade,** cut through the superior end of the cerebral peduncle on each side. The ventral end of the cut must be caudal to the mamillary bodies and rostral to the oculomotor nerves. The dorsal end of the cut must be caudal to the pineal gland. It does not matter if a small part of the superior colliculus remains with the cerebral hemispheres - better too low than too high. Put the caudal part of your specimen (brain stem with attached cerebellum) back in its container.

41. **BISECTION OF THE CEREBRUM.** Read through ***Instructions 42-44*** before you do anything. Make sure you have seen all the arteries of the **circle of Willis** at the base of the brain (*Barr* 25-1) because they will never look the same again.

42. **Using scissors,** cut through the anterior communicating artery and through the left posterior cerebral artery, so that the bifurcation of the basilar artery will remain with the right cerebral hemisphere.

43. Obtain a long "brain knife." (A blade less than 30 cm long will not do the job properly.) Be careful! The blade is or should be extremely sharp. Make sure it's firmly attached to the handle, and don't wave it around. Using a sawing motion, **cut in the midline** to divide the cerebrum into left and right halves. Watch the blade as you cut. If the inferior surface is split symmetrically (orbital surfaces of frontal lobes, optic chiasma, mamillary bodies, pineal gland) the rest will probably be O.K.

44. Put the left cerebral hemisphere back into the container. It will be used later to display the anatomy in horizontal sections. The right hemisphere will be dissected.

45. (At this point the present *Instructions* differ significantly from the procedure in Montemurro & Bruni's *Human Brain in Dissection*. In that work the brain is not bisected: the dissection begins in the right hemisphere and moves over to the left. This provides a much more instructive presentation of midline structures, especially the fornix and third ventricle, than the simpler method followed here. Nevertheless, all the stages of the present simplified dissection are shown in the illustrations of Montemurro & Bruni.)

46. Identify the **corpus callosum** (*Barr* 1-3; 11-2), a large body of white matter composed of fibres that interconnect the cortices of the left and right cerebral hemispheres. Examine the arteries on the medial surface of the cerebral hemisphere (*Barr* 25-3).

47. The **anterior cerebral artery** has two large branches, which are conspicuous in carotid

angiograms (*Barr* 25-5,25-6). The **pericallosal artery** follows the dorsum (superior surface) of the corpus callosum. It supplies the medial and superior surfaces of the posterior part of the parietal lobe. The **callosomarginal artery** follows the **cingulate sulcus** (*Barr* 13-5) and supplies the medial and superior surfaces of the frontal lobe and of the anterior part of the parietal lobe.

48. The branches of the **posterior cerebral artery** are more difficult to trace. They supply the occipital lobe and most of the inferior surface of the temporal lobe (*Barr* 25-3).

49. **In preparation for later dissection,** remove all remaining arachnoid and superficial veins from the medial surface of the right cerebral hemisphere, so that the sulci and gyri can be seen. With care the larger branches of the arteries can be preserved. However, all the superficial blood vessels will be removed when the internal parts of the hemisphere are dissected. Before leaving the laboratory, make sure all specimens are fully submerged in their container, and that all unwanted bits and scraps have been put into plastic bags.

Class 2 TOPOGRAPHICAL ANATOMY OF THE CEREBRAL CORTEX.

50. Gather your specimen(s) of the **right cerebral hemisphere** that have been largely stripped of meninges and blood vessels. No further dissection is done in this class. If you think the number of names of cortical sulci and gyri is excessive, you are right. Nobody needs to know them all. **The ones worth remembering are (a) those corresponding to cortical areas with known and important functions, and (b) those that are so conspicuous that they serve as major anatomical landmarks.** Landmarks are needed to identify functional areas of cortex and for correspondence with large structures inside the cerebral hemisphere. Happily, there are some sulci and gyri that have important functions as well as being major anatomical landmarks.

51. Look at the lateral surface of the right cerebral hemisphere. The sulci (singular: sulcus) are the grooves and cracks. The gyri (singular: gyrus) are the convexities. Find again the **lateral sulcus**. It is also called the sylvian fissure, in honour of Francis Sylvius (1614-1672), the French anatomist who wrote the first decent description of this important cleft. Clinicians often refer to "perisylvian" cortex when describing the site of a lesion that impairs the production and/or comprehension of spoken words.

52. Find the **central sulcus** (*Barr* 13-3). Its superior end extends for a few mm onto the medial surface of the hemisphere. Its inferior end does not quite join the lateral sulcus. The inferior end of the central sulcus is 5 cm posterior to the temporal pole. **The central sulcus is important** because (a) it separates the frontal from the parietal lobe, and (b) it separates the primary motor area from the first somatosensory area.

53. Find the **parietooccipital sulcus**, which is largely confined to the medial surface of the hemisphere (*Barr* 13-5).

54. Delineate the **frontal, parietal, occipital and temporal lobes** (*Barr* 13-1 & 13-2). Notice that their boundaries are not all formed by conspicuous sulci. The fifth (insular) lobe is in the floor of the lateral sulcus. It will be revealed when you remove the opercula, at a later stage of the dissection.

55. **Look ahead a few pages** and read ***Instruction 56***. **Then** find the following sulci and gyri.

Frontal lobe:

Lateral surface (*Barr* 13-3):

Precentral gyrus, which corresponds to the primary motor area.

Precentral sulcus (often discontinuous).

Superior, middle and inferior frontal gyri (often indistinct, but note that the sulci of the anterior part of the frontal lobe run mainly in an anteroposterior direction).

Anterior and ascending rami of the lateral sulcus (also *Barr* 13-1), which delineate the orbital, triangular and opercular parts of the inferior frontal gyrus. In the left hemisphere, the triangular and opercular parts correspond to Broca's expressive speech area.

Medial and inferior surfaces (*Barr* 13-5 & 13-6):

Cingulate gyrus (very conspicuous, and involved with memory and affect; extends into the parietal lobe).

Orbital gyri, which constitute a major part of the region known as the prefrontal cortex, involved in judgement and foresight. The **gyrus rectus** is the most medial one in this group, lying alongside the **olfactory tract** and **olfactory bulb** (*Barr* 17-3).

Temporal lobe:

Lateral surface (*Barr* 13-3):

Superior temporal sulcus.

Superior temporal gyrus. Observe that most of the cortex of this gyrus faces upward, forming the inferior bank of the lateral sulcus, which is also the **temporal operculum**. The anterior part of the upward-facing surface of the superior temporal gyrus includes the **anterior transverse temporal gyri** (Heschl's convolutions), which are the site of the primary auditory area. The posterior part of this upward-facing surface is called the **planum temporale**, which is auditory association cortex. In the left hemisphere it is also part of the receptive language area (Wernicke's area).

Middle and inferior temporal gyri account for the remainder of the lateral surface of the temporal lobe.

Inferior and medial surfaces (*Barr* 13-6 & 13-5):

Lateral occipitotemporal gyrus (the same thing as the **inferior temporal gyrus**; it extends into the occipital lobe). The inferior temporal cortex is anatomically placed between the occipital cortex (vision) and the parahippocampal gyrus (memory), and clinical studies indicate that it probably constitutes a repository for complex **visual memories**.

Parahippocampal gyrus. This contains cortical areas concerned with olfaction and memory. Its lateral boundary is the **collateral sulcus**. The anterior end of the collateral sulcus is called the **rhinal sulcus**, and the cortex medial to this is called the **entorhinal area**. The most medial part of the parahippocampal gyrus is a slightly hook-like lump called the **uncus** (Latin for hook). The medial boundary of the parahippocampal gyrus is the **hippocampal sulcus**, which will be seen later when you dissect the temporal lobe. The posterior end of the parahippocampal gyrus is continuous with the posterior end of the cingulate gyrus, in a region known as the **isthmus or retrosplenial cortex**. Between the parahippocampal and lateral occipitotemporal gyri is the **medial occipitotemporal gyrus**, also called the **fusiform gyrus**. The posterior part of this gyrus is necessary for recognizing people's faces. [Sorry about all these names, but most represent major parts of functional systems.]

Parietal lobe:

Lateral surface (*Barr* 13-3):

Postcentral gyrus, which corresponds to the first somatosensory area.

The **intraparietal sulcus** (often indefinite) formally divides the parietal lobe into superior and inferior parietal lobules. Two gyri of the inferior parietal lobule form (in the left hemisphere) part of the receptive language area. These are the angular and supramarginal gyri.

To find the **angular gyrus**, follow the superior temporal sulcus into the parietal lobe. The angular gyrus surrounds the end of the sulcus.

To find the **supramarginal gyrus**, follow the lateral sulcus into the parietal lobe. Its end is surrounded by the supramarginal gyrus. The anterior part of the supramarginal gyrus is immediately posterior to the postcentral gyrus.

Medial surface (*Barr* 13-5):

Central sulcus and **parieto-occipital sulcus** (for orientation).

Paracentral lobule. This is the cortex around the central sulcus. The anterior part of the paracentral lobule is in the frontal lobe (primary motor cortex for the contralateral foot and lower leg). The posterior part of the paracentral lobule is in the parietal lobe (first somatic sensory area for contralateral lower leg, foot and perineum).

Cingulate gyrus. The posterior part of this gyrus is formally a part of the parietal lobe.

Precuneus. Not worth remembering, but it's the name for the large area of cortex anterior to the parieto-occipital sulcus.

Occipital lobe (*Barr* 13-5):

Lateral surface:

No named sulci or gyri worth bothering with. This is **visual association cortex**, and it extends into the adjacent parts of the parietal and temporal lobes.

Medial surface:

Calcarine sulcus. This is the landmark for the primary visual area. It is a deep indentation, so most of the primary visual cortex is in the walls of the calcarine sulcus.

Cortex between the calcarine sulcus and the parieto-occipital sulcus constitutes the **cuneus** (Latin for wedge; aptly describes the shape). The cortex inferior to the calcarine sulcus is named the **lingual gyrus**, from its fancifully tongue-like shape. You probably won't encounter these anatomical names again, but they accommodate cortical areas that recognize important **features contained in visual images**, including vertical and horizontal lines, right-angles, and colours.

56. **Many students find it helpful to use a "colouring book" approach to learning parts of the brain.** The incomplete drawings that accompany these notes can be used to fill in things you see now, or for revision at a later stage. You may want to use a colour scheme: a colour for each lobe; different colours for sulci and gyri; colours peculiar to functional systems.

57. **Remember!** The practical work comes early in the course, to provide an anatomical framework for the functional pathways of the nervous system. The cerebral cortex is the "highest" level of the nervous system, easily imagined as the final recipient of sensory input and the source of motor commands. **Association areas** are the large regions of the cerebral cortex that receive input from the "primary" sensory areas and are connected with the parts of the brain concerned with memory and the generation of movements. All cortical areas are interconnected, but not in a random manner. The grossly visible bundles of **cortico-cortical fibres** will be examined when you dissect the subcortical white matter.

Class 3 INTERNAL STRUCTURE OF THE CEREBRAL HEMISPHERE - 1. Major bundles of association, commissural and projection fibres, and the corpus striatum.

58. **A NOTE ON TECHNIQUE.** You will need the instruments listed at the beginning of these Notes. "Blunt" dissection displays the larger bundles (fasciculi) and layers ("capsules") of nerve fibres in the cerebrum. Regions containing axons with a particular orientation are exposed by pulling away successive layers of brain tissue, with traction in the direction of the fibres to be exposed. The first step is to tear off some cortex to reveal the short association bundles that

connect adjacent sulci and gyri. Larger lumps of cortex may then be pulled away, to show the longer fibre bundles that go from one lobe to another. Successive layers of white matter are peeled off to display the more deeply placed fasciculi and capsules. **You have to know what to look for** (*Barr* 16-1), or the white matter in your dissection will quickly become a ragged mess. It is always possible, however, to clean up a damaged dissection and move on to the next stage. Ask a demonstrator for assistance if you are uncertain about what you see.

The **blunt dissection technique** consists of repetitions of the following sequence of movements:

(a) Stick the spatula (or scalpel handle) obliquely into the brain, undercutting the piece to be removed, and aligned with the direction of the nerve fibres to be displayed. Typically, you might insert the instrument for 1 - 2 cm beneath a gyrus, at an angle of 30E to the surface.

(b) Lever up the piece of brain. Put a thumb on the deep side of the spatula, and the index finger of the same hand on the upper or outer surface of the piece of tissue to be removed.

(c) PULL in the direction of the fibres until the piece comes away. **Don't rub or scrape the white matter**; it is tempting to do so, but this will obliterate the fibrous texture of the fasciculi and capsules.

If you think you are removing a piece that is too big, stop pulling and use scissors or a blade to cut off the piece you intended to remove. Do this if you accidentally enter the lateral ventricle when dissecting the white matter of the hemisphere.

As the dissection proceeds, you will collect many small bits of brain on the tray. Put these in the plastic bag provided. From time to time, take your specimen to a sink and wash it under the running tap. This nearly always improves the appearance and instructive value of the dissection.

59. **The dissection begins with a deliberate cut.** You will remove the frontal and parietal opercula, exposing the insula and some of the white matter of the frontal and temporal lobes. **Use the RIGHT cerebral hemisphere.**

60. **Measure** 3 cm along the lateral sulcus from the temporal pole. Insert a scalpel blade into the inferior frontal gyrus to a depth of 2 cm, at an angle of about 70E to the cortical surface. **Make a semicircular cut** with a radius of about 3 cm in the cortex and subcortical white matter of the frontal and parietal lobes. This cut should end in the posterior end of the posterior ramus of the lateral sulcus.

61. **Remove the curved wedge of cortex** isolated by the cut you have just made, by pulling in an antero-posterior direction. If it doesn't come away easily, deepen the original cut. You should now be able to see the **insula** and the **superior surface of the temporal lobe** (*Barr* 15-4; also 13-4).

62. The **insula** is surrounded by the **circular sulcus**. The cortex of the insula is marked by short (anterior) and long (posterior) gyri. The insula is a landmark for important structures inside the hemisphere, as you will soon see.

63. Find the **anterior transverse temporal gyri** (Heschl's convolutions) on the upward-facing surface of the superior temporal gyrus (*Barr* 15-4). These constitute the primary auditory cortex. The auditory association cortex is posterior to Heschl's convolutions, in the planum temporale and extending into the parietal lobe.

64. The exposed white matter above the insula may already show many longitudinally aligned bundles of fibres. By blunt dissection, remove cortex and white matter anterior and posterior to this region, exposing the **superior longitudinal fasciculus** (*Barr* 16-3). This large association bundle interconnects cortical areas in the frontal, parietal and occipital lobes. It is most easily seen above the insula, where there are not too many intersecting fibres running in other directions.

65. As you remove pieces of cortex, look at the **short association fasciculi** that connect adjacent gyri. Notice that the dissection has also exposed small bundles and tufts of fibres that connected with the cortex you have removed. The cerebral white matter contains fibres running in all directions. **Association fibres** connect cortical areas within the hemisphere. **Commissural fibers** go from the cortex of one hemisphere to that of the contralateral hemisphere. **Projection fibres**, which may be ascending or descending, connect the cortex with subcortical parts of the central nervous system.

66. **Extend the blunt dissection** of the superior longitudinal fasciculus from the parietal into the temporal lobe. This dissection involves removal of most of the superior temporal gyrus, almost to the temporal pole. You should see fibres of the superior longitudinal fasciculus curving round into the temporal lobe, constituting the **arcuate fasciculus** (*Barr* 16-3). This bundle includes fibres that connect the auditory association area with the expressive speech area. A lesion that transects the arcuate fasciculus causes a speech defect known as disconnection aphasia.

67. Turn the specimen over, and find the **cingulate gyrus** on its medial surface. Lift off the cortex of this gyrus to display the longitudinally running fibres of the **cingulum**.

68. Next, **remove most of the cortex of the frontal and parietal lobes**, by pulling the pieces upwards and laterally, until the cingulum can be seen from above (*Barr* 16-2). There should now be a crest of white matter lateral to the cingulum and medial to the superior longitudinal fasciculus, and the only remaining cortex should be that of the occipital lobe, most of the temporal lobe, the anterior one third of the frontal lobe, and the whole of the insula (*Barr* 16-3). **Make sure the specimen is clean and free of debris** before continuing the dissection.

69. Remove the cortex of the **insula**, starting in the centre and working towards the circular sulcus. Remember that the cortex is only 1 - 2 mm thick. While carrying out this instruction and the ones that follow, you must be aware of the **layers of white and grey matter** that you will encounter. These are best seen in a horizontal section (*Barr* 16-8). The thin subcortical white matter of the insula is called the **extreme capsule**. Deep to it is another layer of grey matter, the **claustrum**. These layers will not be revealed completely by blunt dissection, but you should be aware that you are passing through layers of both white and grey matter.

70. Remove the extreme capsule and claustrum by blunt dissection. Pull away the tissue in a

longitudinal (antero-posterior) direction along the lower border of the insula, and in a radial (largely upward) direction elsewhere. The **external capsule** will be revealed as a distinctive convex surface, and the **inferior occipitofrontal fasciculus** will be seen along the lower (inferior) border of the convexity (*Barr* 16-4).

71. Remove the cortex of the parts of the frontal and temporal lobes adjacent to the lateral sulcus, to display the fibres of the **uncinate fasciculus**, which interconnect the cortices of the frontal and temporal poles.

72. The **external capsule** is 1 - 2 mm thick. Remove it by peeling little bundles of fibres upwards. Continue the pulling beyond the convexity of the external capsule, into the crest of white matter that remained after removal of the parietal and most of the frontal cortex. The peeling reveals grey matter (the **putamen**) beneath the external capsule, and the crest of white matter consists largely of radially directed projection fibres: an appearance called the **corona radiata** (*Barr* 16-5).

73. The **putamen** is the outer (lateral) part of the **lentiform nucleus**. The inner part of this nucleus is the **globus pallidus** (*Barr* 16-8). The lentiform nucleus and the **caudate nucleus** (not yet seen) make up the **corpus striatum**, which is the central grey matter of the telencephalon. The anterior end of the putamen is continuous with the head of the caudate nucleus (*Barr* 12-1 & 12-2), a fact that will be appreciated as the dissection proceeds.

74. The **lentiform nucleus** has the size and shape of a Brazil nut, with the narrow side directed medially. Remove the nucleus by scooping out grey matter until you encounter the underlying white matter of the internal capsule. The grey/white distinction is not very clear anteriorly because in this region there are strands of grey matter that traverse the **internal capsule**, joining the putamen with the caudate nucleus.

75. It is now revealed that the fibres of the corona radiata are the same as those of the **internal capsule**. The deepest concavity of the internal capsule (indented by the narrow edge of the "Brazil nut" shape of the lentiform nucleus) is the **genu**, named from its knee-like appearance in horizontal sections (*Barr* 16-8). Anterior to the genu is the **anterior limb** of the internal capsule, consisting largely of fibres going from the thalamus to the cortex of the anterior part of the frontal lobe. The **posterior limb** contains thalamocortical fibres that end in the precentral, parietal and occipital cortex, and also most of the descending fibres that pass from the frontal, parietal and temporal lobes to the brain stem and spinal cord.

76. A prominent component of the posterior limb of the internal capsule is the **geniculocalcarine tract** (visual radiation). These fibers originate in the lateral geniculate body of the thalamus (***Instruction 101***) and then pass behind (posterior to) the lentiform nucleus and through the deep parietal white matter, on their way to the primary visual cortex on the medial surface of the occipital lobe (*Barr* 20-7). Some geniculocalcarine fibres loop forward into the temporal lobe (**Meyer's loop**), but this clinically important fasciculus is rarely exposed by blunt dissection.

77. With the tip of a finger, press upon the region of the geniculocalcarine tract. In most brains it will be evident that there is an underlying hollow cavity, the **occipital horn of the lateral**

ventricle. Quite often the occipital horn is absent or very small.

78. The **auditory radiation** (fibres on their way from the medial geniculate body (***Instruction 101***) to the cortex of Heschl's convolutions) passes along the inferior surface of the lentiform nucleus, as the **sublentiform part** of the internal capsule. It is not seen in the present dissection because the superior temporal gyrus has been removed.

79. Now it's time to look at the telencephalic **commissural fibres**. These interconnect cortical areas on the left and right sides. The **anterior commissure** interconnects parts of the temporal lobes. Other cortical areas are connected through the **corpus callosum**, which is the most conspicuous object in a mid-sagittal section through the brain.

80. Look at the medial surface of the right cerebral hemisphere (*Barr* 13-2; also 13-5 and 16-7). Find the **splenium, genu and rostrum of the corpus callosum**. The **anterior commissure** is a little less obvious. You will find it by following the rostrum towards the optic chiasma. The **lamina terminalis**, which is the rostral (anterior) wall of the third ventricle, is a thin layer of grey matter that extends from the chiasma to the anterior commissure (*Barr* 11-2).

81. Two other "commissures" (really, they are decussations) should be sought at this time, on the medial surface. Find the **pineal gland**, and notice that its stalk is attached dorsally to the diencephalon and ventrally to the midbrain, above the superior colliculi (*Barr* 11-2). The tiny **habenular commissure** is in the dorsal wall of the pineal stalk. The somewhat larger **posterior commissure** is in the ventral wall of the stalk. The **fornix** (***Instructions 91-101***) also contains small numbers of decussating and commissural fibers (*Barr* 11-2; 18-3).

82. Now look at the superior surface of the **corpus callosum**. If necessary, lift away some of the fibres of the cingulum. This surface is covered by a layer of grey matter, the **indusium griseum**, which is usually too thin to be visible to the unaided eye. Embedded in the indusium are two visible ridges, the superior **longitudinal striae** (of Lancisi), which are small association fasciculi of the limbic system.

83. Pull away cortex and white matter dorsal to the splenium of the corpus callosum. See how the callosal fibres spread out laterally and then turn in a posterior direction (*Barr* 16-6). This formation is called the **forceps occipitalis** or forceps major.

84. Do a similar dissection to show fibres radiating from the genu of the corpus callosum to the anterior cortex of the frontal lobe. The **forceps frontalis** is also called the forceps minor, because it is smaller than the forceps occipitalis.

85. With a finger, press on the top of the corpus callosum. The hollow feeling is due to the underlying **lateral ventricle**.

Class 4 INTERNAL STRUCTURE OF THE CEREBRAL HEMISPHERE - 2. The lateral and third ventricles and associated structures.

86. Before beginning to dissect, review the structures that make up the roofs, walls and floors of

the **lateral and third ventricles** (*Barr* Ch. 11; 16).

87. Part of the medial wall of the lateral ventricle, the **septum pellucidum**, may be present on the medial surface of the dissected right cerebral hemisphere. Otherwise it will be with the left hemisphere (*Barr* 11-2). This membrane is attached anterodorsally to the corpus callosum, and posteroventrally to the fornix.

88. Using a scalpel blade, cut a rectangular window in the corpus callosum, about 2 cm posterior to the genu. The hole should be big enough to admit the tip of your little finger. Look into the window and observe the convexity of the **head of the caudate nucleus**, which forms the lateral wall of the ventricle. Place the tip of your little finger on the caudate head, and the tip of another finger on the anterior limb of the internal capsule, in the hollow that was occupied by the lentiform nucleus. By palpation, you will appreciate that (a) the head of the caudate nucleus is lateral to the anterior limb of the internal capsule, and (b) the caudate head and the putamen (***Instruction 73***) were continuous through and anterior to the anterior limb (*Barr* 12-2).

89. Insert a blunt probe through the window you have made, and guide its tip towards the splenium of the **corpus callosum**. Cut down onto the probe, in a line parallel to the midline. (The probe should prevent the blade from damaging the floor of the lateral ventricle.) Widen the opening laterally, using a scalpel blade or scissors to remove callosal and other white matter. Preserve the splenium and genu of the corpus callosum.

90. Looking into the opening in the roof of the lateral ventricle, identify the **caudate nucleus**, the **choroid plexus**, and the dorsal surface of the **thalamus**. These structures will be examined more closely after the next piece of dissection.

91. Continue the removal of the roof of the lateral ventricle, by inserting a probe and cutting away the overlying white matter, including much of the forceps occipitalis and geniculocalcarine tract. When the posterior part of the ventricle is laid open, pass the probe forwards into the temporal lobe. Again, cut down onto the probe and remove the roof of the temporal horn. The whole lateral ventricle is now opened, and can be seen to be C-shaped (*Barr* 16-9). The **frontal horn** of the ventricle extends from the central part of the ventricle into the frontal lobe. The **temporal horn** extends into the temporal lobe. In most brains there is also an **occipital horn**, though its size is variable.

91. **Find the following** (*Barr* 16-9; 16-10).

<u>Frontal horn</u>:

Head of caudate nucleus, narrowing caudally into the **tail**, which follows the curve of the ventricle into the temporal horn.

Septum pellucidum.

<u>Temporal horn</u>:

The **hippocampus**. This looks like a white sausage, forming the floor and medial wall of the inferior horn. It is importantly involved in memory. Follow the hippocampus back towards the central part of the ventricle, where it continues into the **fornix**. (The hippocampal formation will be more closely examined later.) The **amygdaloid body (amygdala)** bulges into the medial side of the inferior horn, near the tip of the temporal lobe. The **uncus** is a surface landmark for the position of the amygdala.

Central part:

The floor is partly covered by the **choroid plexus**, which also extends into the temporal horn. Resist the temptation to rip out the choroid plexus at this time.

Gently lift the choroid plexus to see the **floor of the central part of the ventricle**. It consists of the superior surface of the **thalamus** laterally, and the **fornix** medially. Trace the fornix forwards, until it curves ventrally and disappears into the grey matter of the diencephalon. Immediately posterior to the fornix at this point there is a space, not occupied by choroid plexus, between the fornix and the anterior tubercle of the thalamus. Insert a probe into the space, and see where it emerges on the medial side of the hemisphere. You have demonstrated the **interventricular foramen** (foramen of Monro).

Return to the region of transition of the hippocampus and fornix. Posterior to the fornix is a convex area called the **collateral trigone**. It is raised by the collateral sulcus (lateral to the parahippocampal gyrus. Remember ***Instruction 55***?). A substantial mass of choroid plexus rests on the collateral trigone, and can often be seen in CT images because it usually contains granules of calcified material.

The **choroid plexus**. See how the choroid plexus enters the ventricle through the **choroid fissure**, which is the cleft between the fornix and the thalamus.

The **stria terminalis** (*Barr*16-9). This slender bundle of fibres (most are going from the amygdala to the septal area) is in the groove between the thalamus and the caudate nucleus. It is accompanied by the **terminal vein** (*Barr* 25-4).

Posterior horn:

If the posterior horn is present, its medial surface is a prominent ridge, **the calcar avis**. This is raised by the deep calcarine sulcus, on the medial surface of the occipital lobe.

92. Make a clean cut in a coronal plane to remove the temporal pole at the level of the uncus. The cut surface shows the **hippocampus** and the **amygdaloid body** indenting the **temporal horn of the lateral ventricle**. Note that the cavity of the temporal horn is very small. It does not show on a normal CT scan, and visible temporal horns are a radiological sign of dilation of the lateral ventricle.

93. This is a good stage at which to review the **internal veins** of the cerebrum (*Barr* 25-4). Not

many of these veins are likely to be visible in your dissected specimen. The next part of the dissection is a closer examination of the hippocampus and fornix, followed by an examination of the third ventricle.

94. In the dissected right cerebral hemisphere, find the **parahippocampal gyrus**. Widen the deep sulcus that separates the medial side of the gyrus from the midbrain and thalamus. A ridge or flange of white matter, the **fimbria**, can be seen lying alongside the hippocampus. The **dentate gyrus**, a narrow band of grey matter with a crenated edge, is visible in the floor of the sulcus between the hippocampus and the fimbria (*Barr* 18-1 & 18-2).

95. Turn the specimen over, and see how the **fimbria** becomes larger towards the posterior end of the hippocampus, and eventually is continuous with the posterior part (crus) of the **fornix** (*Barr* 18-3). The ventricular surface of the hippocampus consists of a layer of white matter known as the **alveus**. The fibres of the alveus join the fimbria, and leave the hippocampus by way of the fornix.

96. Follow the curve of the **fornix** over the dorsal aspect of the **thalamus**. Anterior to the **interventricular foramen**, a small bundle branches off and passes anterior to the anterior commissure. These fibres (the precommissural fornix) end mainly in the septal area. The great majority of fibres dive into the grey matter of the diencephalon, just below the **anterior tubercle of the thalamus** (*Barr* 11-2). Their course through the hypothalamus to the mamillary body will be dissected after the third ventricle has been examined.

97. Take the undissected left cerebral hemisphere out of its container, and examine the medial surfaces of the two sides together. The **third ventricle** is slit-like, with a large lateral wall in each hemisphere. The roof and floor are formed by median structures.

98. **Find the following landmarks** (*Barr* 11-2).

Stria medullaris thalami. This ridge (consisting of fibres going from the septal and preoptic areas to the habenular nuclei) marks the junction between the wall of the third ventricle and the floor of the lateral ventricle. The ependyma of the third ventricle is reflected from the stria medullaris onto the choroid plexus, which dangles from the roof of the third ventricle.

Habenula and habenular commissure.

Pineal gland.

Posterior commissure. (The stria medullaris thalami, habenula, pineal and posterior commissure constitute the **epithalamus**.)

Confluence of **third ventricle** with **cerebral aqueduct** of midbrain.

Hypothalamic sulcus (junction between thalamus above and hypothalamus below).

Mamillary body.

Tuber cinereum.

Optic chiasma.

Lamina terminalis.

Anterior commissure.

Fornix. Note that the middle parts of the left and right fornices are united in the midline, immediately above the choroid plexus that forms the roof of the third ventricle.

The **tela choroidea** (blood vessels and associated connective tissue of the choroid plexus) is derived from vascular pial tissue that passes beneath the splenium and the fornix to enter the ventricular system. The choroid plexus intrudes into the lateral ventricle by passing between the fornix and the thalamus.

The **anterior tubercle of the thalamus**, which forms the posterior wall of the crescent-shaped **interventricular foramen**.

99. By blunt dissection, at a depth of 1 - 3 mm, remove grey matter from the **right wall of the third ventricle**, starting just behind the anterior commissure and working towards the mamillary body. This will show that most of the fibers of the **fornix** end in this part of the hypothalamus (*Barr* 11-15).

100. Demonstrate the **mamillothalamic fasciculus**, by blunt dissection from the mamillary body towards the anterior tubercle of the thalamus (*Barr* 11-15).

101. Find those parts of the diencephalon that can be seen in the dissected right cerebral hemisphere. You should have seen most of them already.

Thalamus:

Anterior tubercle.

Pulvinar (the posterior convexity of the thalamus).

Lateral geniculate body (found by tracing the **optic tract** to its termination).

Medial geniculate body (medial to the lateral one). The geniculate bodies are underneath the pulvinar.

Interthalamic adhesion or massa intermedia (A fusion of the left and right thalami that forms a bridge of grey matter across the third ventricle in about 70% of brains).

Hypothalamus:

Tuber cinereum.

Mamillary bodies.

Epithalamus:

Posterior commissure.

Pineal gland.

Habenula (habenular nuclei).

Stria medullaris thalami.

(The components of the **subthalamus**, which is lateral to the hypothalamus, cannot be seen in this dissection, but are visible in sections through the diencephalon.)

102. Put the dissected right hemisphere and the intact left hemisphere back into their container. Even if you don't look at them again, they may serve as prosected specimens for later generations of students.

Class 5. THE CEREBRAL HEMISPHERE IN HORIZONTAL SECTIONS.

103. Some or all of the dissection for this class may have been done already. If you started with an intact brain, proceed as follows. Strip off all the arachnoid and superficial blood vessels from the undissected left cerebral hemisphere. Review the positions of **major sulci and gyri**, and find the **anterior and posterior commissures**. Using a long "brain knife" cut this hemisphere into horizontal slices, each about 1 cm thick. The plane of the slices should be parallel to a line that passes through the anterior and posterior commissures. This is one of the planes in which nuclear magnetic resonance images (NMRI) are usually displayed for purposes of clinical diagnosis. (**Note**. The "axial" plane of images prepared by computerized X-ray tomography (CT) is different. An oblique plane somewhat nearer to horizontal than coronal is chosen, to minimize irradiation of the eyes.)

104. The exercise of identifying structures in slices is closely similar to the systematic examination of a series of clinical NMR images, but abnormalities are unlikely to be seen in your set of sections. The accompanying outlines contain the structures you should be able to find in the sliced cerebral hemisphere. It is important to keep your series of slices in order. Don't let them dry out (unless you have a plastinated set). Return them to their container when you have finished.

105. Ideally you should be able to find in the slices all the structures that you found when you dissected the contralateral cerebral hemisphere, and also a few features that you have not yet

seen. The accompanying drawings show you what to look for. Annotate the drawings as you examine the horizontal sections of the left cerebral hemisphere. Lead lines or arrows can be put in to connect names to parts, and colours may be used to distinguish tracts and fasciculi from nuclei, cortex, other regions of grey matter, and parts of the ventricular system.

The printed lines in the drawings represent (a) the pia mater and (b) the outlines of nuclei and of other structures such as parts of the ventricular system. The cerebral cortex is not shown, but could be added as a coloured line inside the appropriate parts of the pia. Only a few sulci and gyri are mentioned. Identify them by fitting all the slices together, locating the sulcus or gyrus on the surface, and then seeing where it is in each section.

Class 6. BRAIN STEM AND CEREBELLUM.

106. Take out the specimen consisting of the brain stem with attached cerebellum. Identify the **ventral (basal, basilar) part of the pons** (see ***Instruction 12*** of these Notes). If the length of the medulla caudal to the lower border of the pons, is less than 4 cm, it probably will not include the pyramidal decussation and the caudal end of the olive. Look at the top end of the specimen. The cut surface of the midbrain is probably somewhat chisel-shaped. If the superior colliculi cannot be found, or if neither oculomotor nerve can be seen in the interpeduncular fossa (see ***Instruction 22***), the cut was made too far caudally. If your specimen is incomplete you will need to look at someone else's to see the missing structures.

107. Examine the **ventral and lateral aspects of the brain stem** (*Barr* 6-1; 6-2). Most of the dorsal surface is concealed by the cerebellum, which has not yet been removed.

108. Find the **anatomical landmarks of the surface** of the brain stem, working from caudal to rostral (***Instructions 109-121***).

109. There is a deep groove (**ventral median fissure**) in the ventral midline of the medulla, with a prominent longitudinal ridge, the **pyramid**, on each side. The pyramid consists of fibres of the **corticospinal (pyramidal) tract**, descending from the ipsilateral cerebral cortex. This tract provides direct cortical control of skilled movements.

110. At the caudal end of the medulla most of the corticospinal fibres cross the midline in the **decussation of the pyramids**, which obliterates the ventral median fissure at this level.

111. In the rostral half of the medulla there is an elliptical eminence, the **olive**, lateral to the pyramid.

112. Lateral and dorsal to the olive is a large ridge of white matter, the **inferior cerebellar peduncle**.

113. The dorsal surface of the most caudal part of the medulla is not hidden by the cerebellum (*Barr* 6-3). The ridge next to the **dorsal median sulcus** is the **gracile fasciculus**, which expands

rostrally as the **gracile tubercle** (containing the **gracile nucleus**).

114. The **cuneate fasciculus and tubercle (nucleus)** are lateral to their gracile counterparts, and dorsomedial to the inferior cerebellar peduncle. The gracile and cuneate fasciculi and nuclei are components of an ascending pathway concerned with discriminative touch and proprioceptive sensations.

115. The **ventral or basilar part of the pons** is a mass of white matter in which are embedded numerous nuclei of neurons. The axons of the neurons in these **pontine nuclei** cross the midline and then compose the **middle cerebellar peduncles**. Small bundles of descending fibres (corticopontine, corticobulbar, corticoreticular and corticospinal) are present among the more prominent transverse pontine fibres.

116. The dorsal aspect of the pons will be examined when the cerebellum has been removed (***Instruction 122***).

117. Look at the cut surface of the midbrain, and identify the **tectum** (consisting, at this level, of the **superior colliculi**), the **cerebral aqueduct**, and the **cerebral peduncles**. Within the transected cerebral peduncle, identify the **basis pedunculi**, the **substantia nigra**, and the **red nucleus**. Stained sections (*Barr* 7-14 & 7-15) will guide you to the positions of these structures.

118. Retract the superior edge of the cerebellum and examine the lateral surface of the **cerebral peduncle**. Find the **inferior colliculi** and the **superior cerebellar peduncles** (*Barr* 6-2).

119. Remove about 1 cm from the superior edge of the left side of the cerebellum, by dissecting bluntly, away from the midbrain. This will improve the exposure of the **left inferior colliculus** and **superior cerebellar peduncle**, and will demonstrate the continuity of the latter structure with the white matter of the cerebellum.

120. Find the **superficial origins of cranial nerves III-XII**. (A "superficial origin" is the site at which a cranial nerve enters or leaves the brain stem. The superficial origins of the cranial nerves are shown in *Barr* 6-1, 6-2 & 6-3. You should be able to envisage and describe each superficial origin with reference to landmarks you have already identified. For example, "The rootlets of the hypoglossal nerve arise from the sulcus between the pyramid and the olive." There are several types of intracranial lesion that damage nerves at or near their superficial origins.

The old term "deep origin" is seldom used nowadays. It refers to nuclei within the brain stem that either send axons into cranial nerves or receive axons from sensory ganglia of cranial nerves. If you are going to practise medicine you can't know too much about the cranial nerves, and you should have a good working knowledge of the contents of *Barr* Chapter 8. This chapter also covers the neural connections that control eye movements.

121. Find the apertures (foramina) through which cerebrospinal fluid (CSF) passes from the fourth ventricle into the subarachnoid space.

Median aperture (foramen of Magendie) - Locate the inferior cerebellar peduncles. Hold the specimen by the cerebellum and gently press down (ventrally) on the medulla. There will probably be a web of arachnoid (the **roof of the cerebellomedullary cistern or cisterna magna**) that bridges the space between the cerebellar hemispheres dorsal to the medulla. Remove this arachnoid by cutting with scissors or peeling with forceps. Look up into the cleft between the medulla and cerebellum (*Barr* 6-4). The left and right sides of the **inferior medullary velum** will be seen, each attached to an **inferior cerebellar peduncle** ventrally and to the midline of the cerebellum (**inferior vermis**) dorsally. The median aperture is the space between the left and right sides of the inferior medullary velum. In most individuals it is quite a large hole, through which the floor of the fourth ventricle is visible. Notice the granular texture of the **choroid plexus of the fourth ventricle**, which arises from the inside of the inferior medullary velum.

Lateral aperture (foramen of Luschka) - Look into the **cerebellopontine angle** and locate the superficial origins of the vestibulocochlear and glossopharyngeal nerves. Near this site a tuft of choroid plexus, looking like a minuscule fragment of cauliflower, protrudes through the lateral aperture. Pass a blunt probe alongside the tuft of choroid plexus, around the dorsal aspect of the inferior cerebellar peduncle, and into the ventricle. Look at the tip of the probe by peeping into the median aperture. It is immediately obvious that the median aperture is the largest of the three channels through which CSF passes from the ventricular system into the subarachnoid space. (The bits of choroid plexus that hang out of the lateral apertures may bring newly secreted CSF into contact with chemosensitive neurons that are superficially located in the ventrolateral medulla.)

122. **Remove the cerebellum**. Take a scalpel blade and cut through the superior, middle and inferior cerebellar peduncles on the left and right sides. The cerebellum should come off quite tidily, revealing the floor of the fourth ventricle. Put the cerebellum away for later study, and turn your attention to the **dorsal aspect of the brain stem**.

123. Most of the thin **roof of the fourth ventricle** was removed with the cerebellum, but part of the **superior medullary velum** should remain with the brain stem. Look for a membrane of white matter that joins the left and right superior cerebellar peduncles. Inspect the rostral cut surface of the midbrain and insert a probe into the **cerebral aqueduct**. The tip of the probe enters the **fourth ventricle** in the midline, between the superior cerebellar peduncles and ventral to the superior medullary velum.

124. Examine the **walls and floor** of the diamond-shaped (rhomboid) fourth ventricle. The rostral sides of the diamond are the superior cerebellar peduncles, and the caudal sides are the inferior cerebellar peduncles. The floor of the ventricle is sometimes called the **rhomboid fossa**.

125. Find these landmarks in the floor of the fourth ventricle (*Barr* 6-3). **Dorsal median sulcus**, **sulcus limitans**, **striae medullares**, **vestibular area**, **facial colliculus**, **obex**. Note the positions of the rostral halves of the **hypoglossal nucleus** and the **dorsal nucleus of the vagus nerve**. (The striae medullares are transverse ridges composed of fibres that enter the cerebellum by way of its inferior peduncle. These fibres, which arise in the contralateral arcuate nuclei of the medulla (*Barr* Ch. 7) are probably functionally equivalent to pontocerebellar fibres. Don't

confuse the striae medullares of the medulla with the stria medullaris of the diencephalon - see ***Instructions 98 and 101***.)

Put the specimens (brain stem & cerebellum) back in their container of 35% alcohol (unless you have plastinated specimens).

126. At this stage you are in a position to study **TRANSVERSE SECTIONS OF THE BRAIN STEM**, but this unpopular exercise is not included in your scheduled practical classes. Real sections (on slides) are available, and any student interested in examining such material may contact Dr J. A. Kiernan in the Department of Anatomy, at any time.

In order to see the positions of the major nuclei and tracts, examine pictures of sections stained by the Weigert method, in which myelin is a dark blue-black colour and cell bodies are unstained. Such sections are shown in *Barr*, 7-1 to 7-15 (Chapter 7), and they are also explained in a videotape, "The Human Brain in Section," prepared in the Department of Anatomy and available in the Learning Resources Centre and in the Sciences Library.

The need to learn about the internal structure of the brain stem has given Neuroanatomy a bad name for a century, but THE TASK CAN BE GREATLY SIMPLIFIED IF IT IS DONE BY APPLYING RULES AND PRINCIPLES RATHER THAN BY MEMORIZING LABELLED PICTURES.

The exact localization of lesions in or near the brain stem is often possible on the basis of simple clinical data but this is generally a matter for the neurosurgeon or clinical neurologist. The general practitioner must, however, be able to recognize symptoms and signs indicative of brain stem lesions. Such lesions are often life-threatening and are sometimes treatable, especially when the cause of the trouble is external to the central nervous tissue.

127. THE BEGINNERS RULES FOR LEARNING BRAIN STEM SECTIONS ARE:

1. Identify the approximate level by finding major surface landmarks.

Medulla: Pyramids ventrally; decussation of pyramids at most caudal level.

Olive ("crumpled purse" shape of inferior olivary nucleus).

Inferior cerebellar peduncle laterally.

Central canal in caudal half of medulla ("closed medulla")

Floor of 4th ventricle in rostral half; widest rostrally.

Pons: Transverse pontine fibres at all levels.

Floor of 4th ventricle at all levels; widest at pontomedullary junction.

Middle cerebellar peduncles in middle part.

Superior cerebellar peduncles in rostral part.

Midbrain: Colliculi, cerebral peduncles and cerebral aqueduct at all levels. Substantia nigra (pigmented) at all levels.

Inferior colliculus has a capsule of myelinated fibres (from lateral lemniscus).

Conspicuous decussation of superior cerebellar peduncles at level of inferior colliculi.

Conspicuous red nucleus dorsal to substantia nigra at level of superior colliculi.

2. Having decided on the level of the section, locate cranial nerves, their nuclei and any associated tracts: **nuclei of cranial nerves III-XII, fibres of III, V, VI, VII & XII within the brain stem, spinal and mesencephalic trigeminal tracts and nuclei, solitary tract and its nucleus**.

3. Note the position of the **corticospinal tract** in the section.

4. Note the positions of the nuclei and tracts concerned with general somatic sensation from parts of the body below the neck . These are the **gracile & cuneate fasciculi, gracile & cuneate nuclei, internal arcuate fibres, medial lemniscus, and spinothalamic tract**.

5. Note the positions of the larger nuclei and tracts concerned with other senses: **tractus solitarius, spinal trigeminal tract, cochlear and vestibular nuclei, lateral lemniscus, medial longitudinal fasciculus**.

128. Examine the removed **cerebellum**. The cerebellum has a superficial **cortex** of grey matter, separated by white **matter** from deeply located **cerebellar nuclei**. Most of the gyri of the cerebellum, which are called **folia**, are aligned transversely. The parts of the cortex in the midline are collectively known as the **vermis**. The lateral parts are the **cerebellar hemispheres**.

129. Fit the cerebellum to the brain stem to identify the **superior and inferior cortical surfaces**. Note that the cerebellum is curled ventrally, so that the most rostral and the most caudal parts of the vermis are quite close together, dorsal to the 4th ventricle (*Barr* 10-1 & 10-2).

133. The deeper sulci of the cerebellum are named as fissures. Find the **primary fissure** on the superior surface of the cerebellum (*Barr* 10-1), and the more conspicuous **horizontal fissure** near the posterior margin of the superior surface. All the cortex rostral to the primary fissure constitutes the **anterior lobe** of the cerebellum. Most of the cerebellum caudal to the primary fissure belongs to the **posterior lobe**.

134. On the inferior and ventral surfaces of the cerebellum, find the **tonsils**, the **flocculi** and the **nodule** (which is the most caudal part of the vermis. The **dorsolateral fissure** separates the

nodule and flocculi from the remainder of the cerebellum, delineating the **flocculonodular lobe**.

135. Fit the cerebellum to the brain stem again, and notice that the medulla is located between the two tonsils. If the brain stem and cerebellum are displaced caudally into the foramen magnum (medullary coning or tonsillar herniation) the medulla can be squeezed between the tonsils, with fatal results.

136. Identify the cortical components of the three functional divisions of the cerebellum (*Barr* 10-12). The **vestibulocerebellum** is the flocculonodular lobe. The **spinocerebellum** consists of most of the vermis and adjacent parts of the hemispheres (paravermal cortex), except for the nodule, the flocculus, and part of the posterior lobe. The **pontocerebellum**, which is the largest division, consists of the lateral parts of the hemispheres and part of the posterior lobe vermis.

137. The cerebellar cortex, especially that of the vermis, is classified into many named parts (*Barr* 10-3). Don't bother learning any names other than those already mentioned in ***Instructions 128-136***.

138. Dissect one cerebellar hemisphere as follows. Use a long bladed knife to make a horizontal cut in a plane about 3 mm inferior to the horizontal fissure. This incision should extend only to the midline. Make another cut in the midline of the superior vermis. When the second cut meets the first, lift out the isolated superior part of one cerebellar hemisphere.

139. Look at the cut surfaces. In the sagittal plane observe the **tree-like pattern of folia** responsible for the ancient term "arbor vitae cerebelli." Confirm or correct your earlier identification of the **primary fissure**. It is the deepest one seen in the sagittal section.

140. In the horizontal cut surface, appreciate the depth of the arrangement of fissures and folia, which provide a large area of **cerebellar cortex**. In the central white matter identify the **dentate nucleus**, which has a "crumpled purse" shape similar to that of the inferior olivary nucleus of the medulla (*Barr* 10-10). The dentate nucleus receives the output of the cortex of the pontocerebellum. If you cannot see the dentate nucleus, cut slices 2 mm thick from the removed piece of cerebellar hemisphere or from the horizontal surface of the larger part of the specimen.

141. The smaller cerebellar nuclei, which can rarely be seen in simple dissections, are the **fastigial nucleus** for the vestibulocerebellum and the **interposed (globose & emboliform) nuclei** for the spinocerebellum (*Barr* 10-8).

142. Put the brain stem and both parts of the cerebellum back into the container provided, and make sure that all "wet" specimens are fully immersed in the 35% alcohol. Plastinated specimens are kept dry.

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143. Don't commit suicide if you have failed to find one or two of the structures mentioned in these numbered instructions.

144. Please don't whine to one of the University's harassment persecutors if a basic science or clinical lecturer uses an anatomical term not included in these dissection notes. Bear in mind that,

(a) A few important pathways are too inconspicuous to be grossly visible. They are covered in the lectures.

(b) Some obsolete and confusing terms (notably the word "extrapyramidal") are still used by people reluctant to read a textbook published more recently than 1968. There are also unsatisfactory but unavoidable words (like "limbic" and "basal ganglia") that mean different things to different people.

(c) Some useful clinical terms (like "upper motor neuron lesion" and "pseudobulbar affect") are academically wrong. They nevertheless identify disordered functions that cannot be confidently explained in terms of the interruption of known neuronal pathways. Some clinical neurological diagnoses (such as multiple sclerosis and encephalitis) are made largely on the basis of information other than the anatomical sites of the lesions that cause the disordered function.

(d) Many eponyms are used for syndromes encountered in clinical neurology, and many anatomical structures have alternative eponymous names. These provide an extra burden to the average student, who will probably not become a neurologist, neurosurgeon or neuroscientist. It would be a pity, however, if the names of people who made anatomical and clinical discoveries were to be forgotten. For explanations of the more common neuroanatomical eponyms, download **neuroglos.htm** from the course web page, or visit **http://www.whonamedit.com**. In neuroanatomical exam questions, all synonyms likely to have been encountered by students are clearly indicated for every structure that has more than one name.

145. **If you are having difficulties or if you want to study the CNS in greater depth**, remember that the neuroanatomists in the Department of Anatomy are there to help you. Don't hesitate to ask for advice, but please come more than a week before the exam if possible. Numerous videotapes and a few computer programmes, prepared in the Department of Anatomy, are available in the Taylor Sciences Library and in the Valberg Learning Resources Centre of the Faculty of Medicine. The **videotapes** cover all the topographical anatomy and several of the functional systems of the CNS. Some are "self-testing," with pauses for you to answer pertinent questions. The **Anatomy Museum** (DSB Room 4002-4003) also contains many specimens and models that are helpful for learning Neuroanatomy.