Behavioral Neuroscience A
2: Anatomy

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https://youtu.be/6xG3b5eOt5s

Lecture Video at above link.

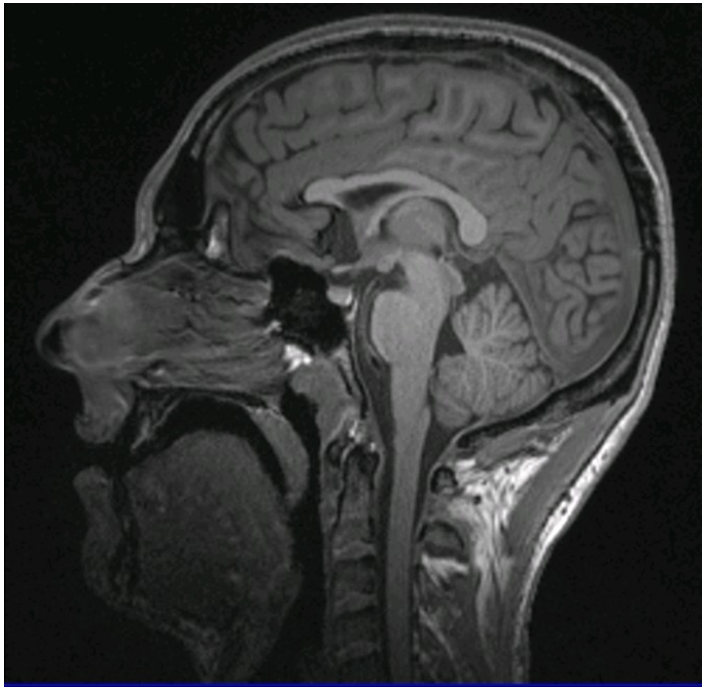
Coarse Anatomy

Today:
1) Learn major structures of (human) brain.
2) Learn about cerebro-spinal fluid and blood supply.

This is an MRI image of **my** brain (really)

-Taken when I was about 24 (when I was getting my Ph.D.)

You can see my big nose.

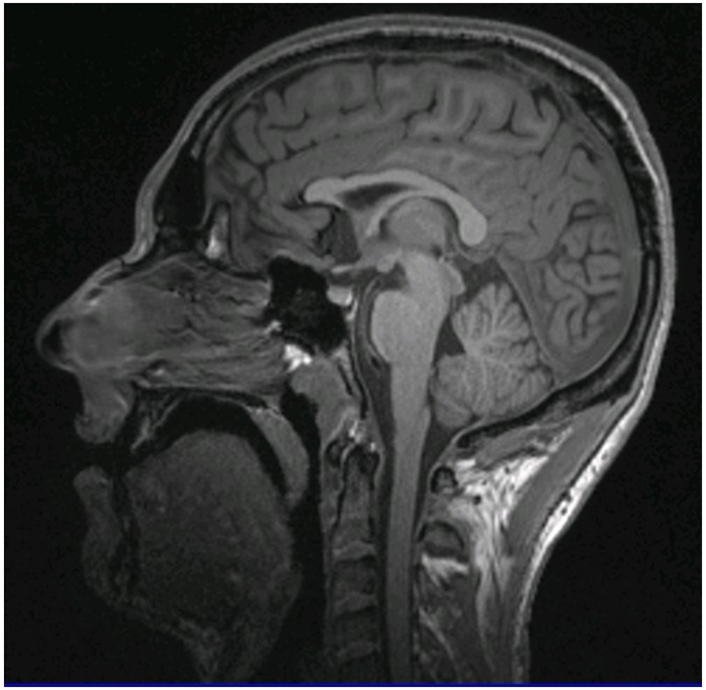


Coarse Anatomy

Today:
1) Learn major structures of (human) brain.
2) Learn about cerebro-spinal fluid and blood supply.

By the end of today, you should be able to easily do the following:

→ What type of view (slice) is this?
→ Point out *Corpus Callosum*
→ Point out *Cerebellum*
→ Point out *Brain stem*
→ Point out *Occipital Lobe*



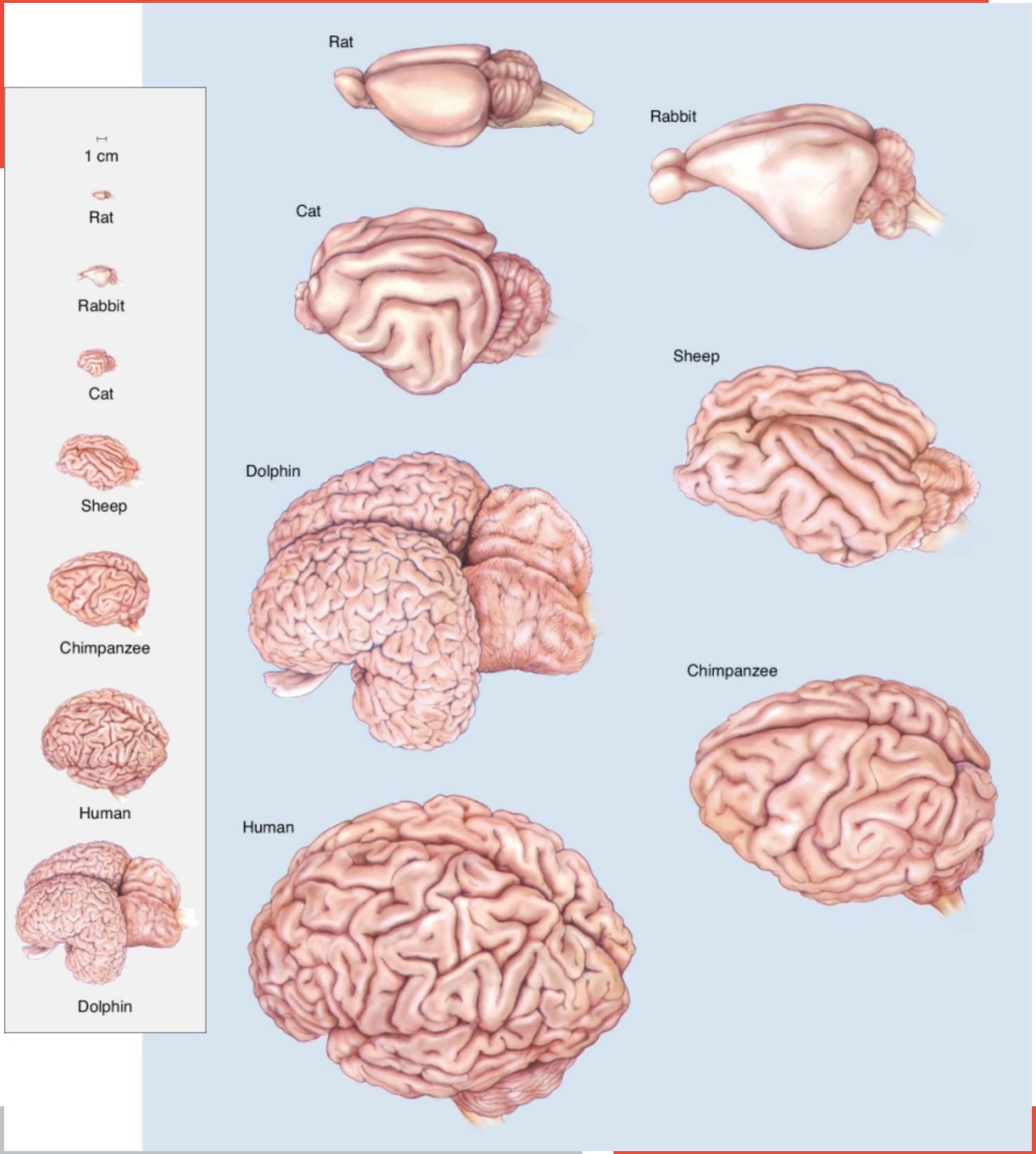
What brain areas do you know?

Brains across Species

Mammal brains vary widely in size and weight (rat:2g, cat: 30g, chimpanzee: 420g, dolphin: 1500-1600g, human: 1300-1400g).

The general structure is similar across mammal species.

→ Cerebral cortex becomes larger and more folded in dolphins and primates.



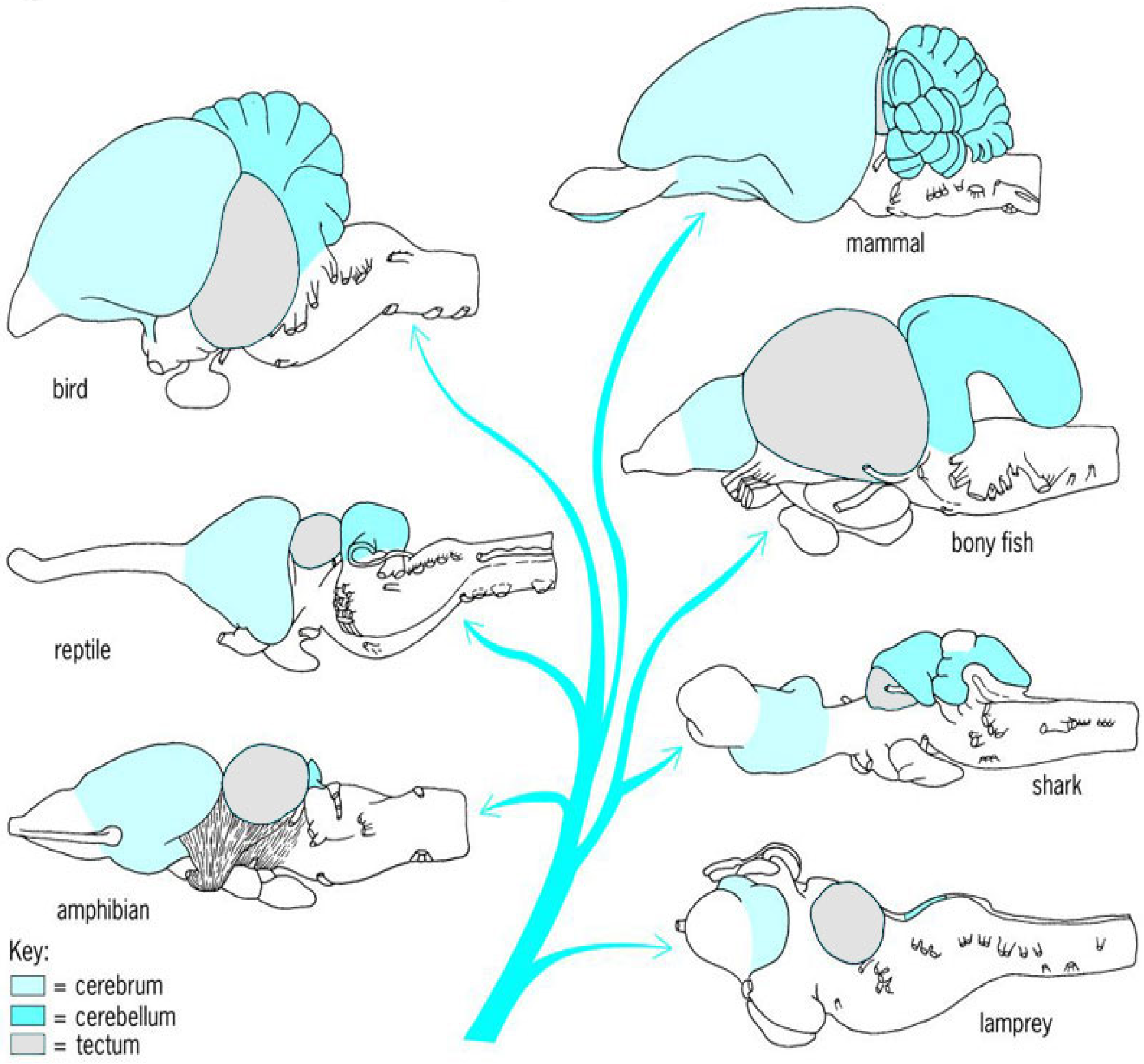
Brains across Species

What about non-mammals?

There are many similarities, but in general:

Reptiles, amphibians, and boneless fish (e.g. lamprey) have very little or no "cerebral cortex"

Birds are more similar to mammals (in complexity). But, structures evolved in parallel to mammals, to different ends.



McGraw-Hill Concise Encyclopedia of Bioscience, 2002

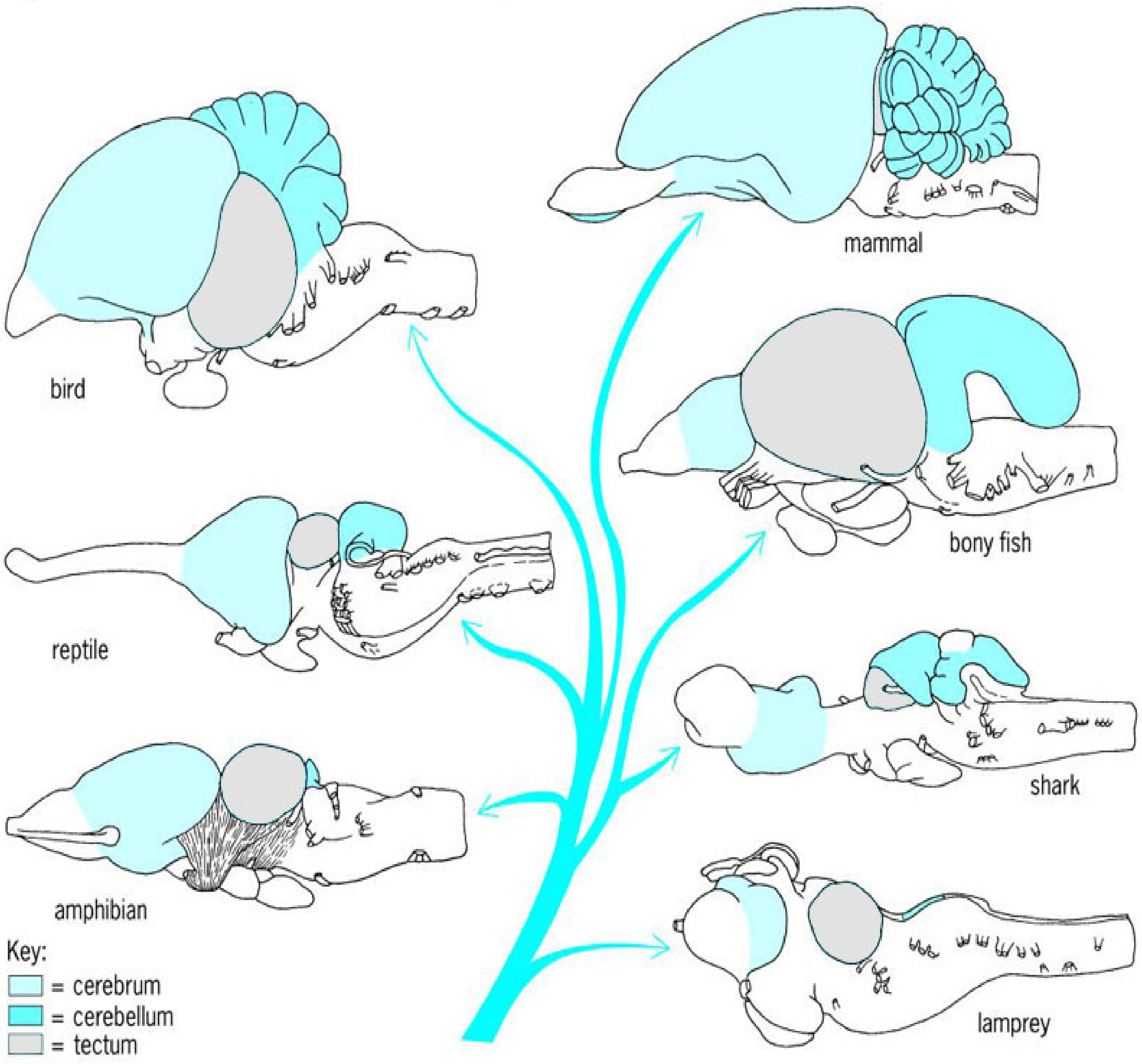
Brains across Species

What about non-mammals?

There are many similarities, but in general:

Photogenically "old" structures such as spinal cord, brainstem, even midbrain, are very similar!

It is said these structures are "conserved" in e.g. humans, i.e. the reptile/fish brain remains.



McGraw-Hill Concise Encyclopedia of Bioscience, 2002

How do we know the shape of the brain?

MRI/PET did not exist until a few decades ago.
→ Spatial resolution of MRI is *not good enough* to see cytoarchitectural (cell shape/connection) differences.

Scientists could accurately map brains more than 100 years ago!
→ How?

How do we know the shape of the brain?

First guess: **Dissection**.
→ Maybe you think we can dissect the brain.
→ Remove all blood and replace it with a fixing solution.
→ Keep it cold.
→ Carefully dissect the brain.

Do you think this will give us a good map of the brain?

How do we know the shape of the brain?

First guess: **Dissection**.
→ Maybe you think we can dissect the brain.
→ Remove all blood and replace it with a fixing solution.
→ Keep it cold.
→ Carefully dissect the brain.

Do you think this will give us a good map of the brain?
→ Brain is a 3-dimensional structure.

→ How do you go “inside” parts of the brain.

→ Some parts are totally contained within other parts...

How do we know the shape of the brain?

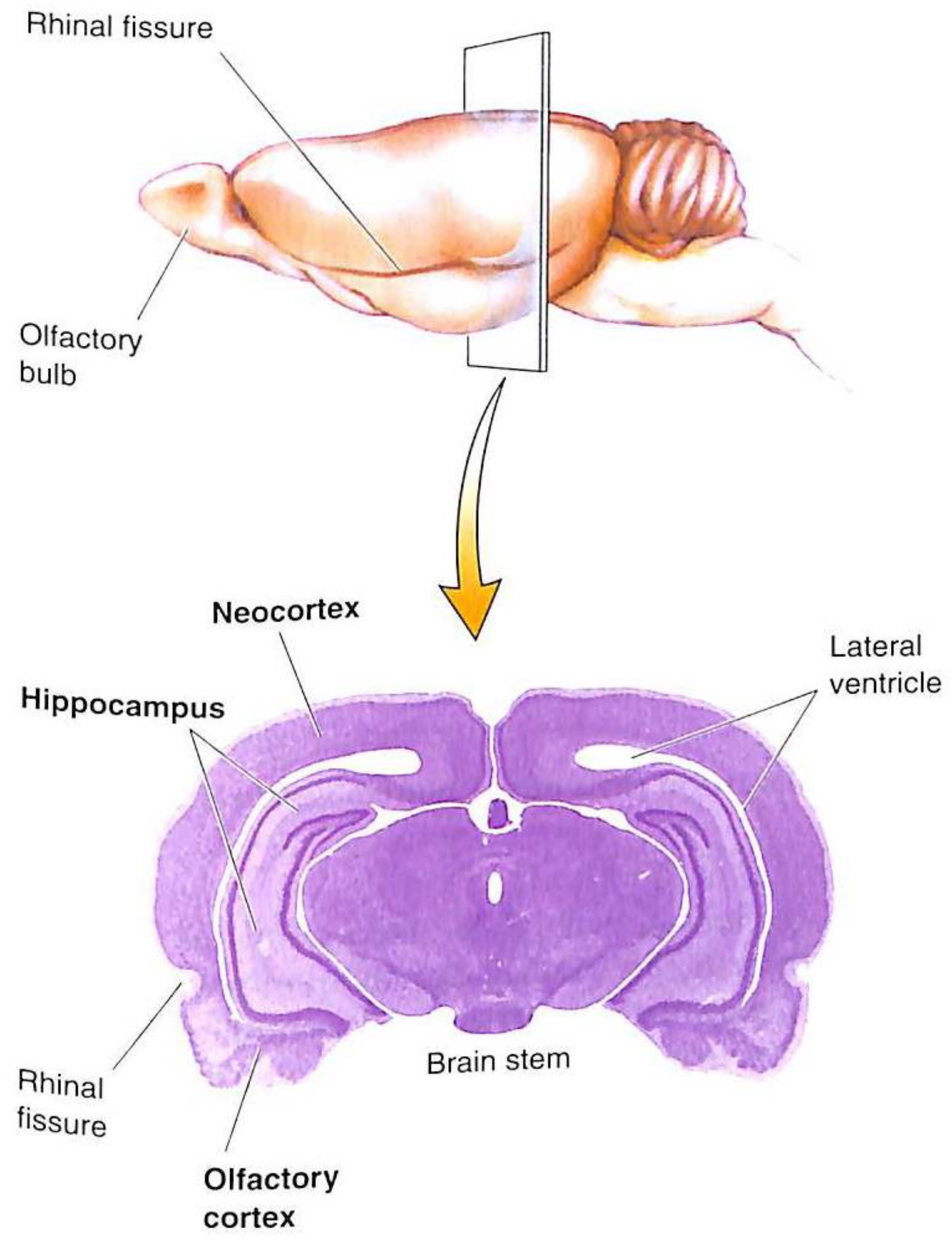
Second guess: **Slices**

Similar to dissection..
→ We fix and then freeze the brain
→ We *slice* the brain into very thin slices.
→ We look at the slices under a microscope.
→ Sometimes we *stain* the slices using chemicals that make certain parts (types of cells, areas containing certain neurotransmitters, fat) stand out.

Slicing and Staining

To investigate the structure and histology of the brain, brains of dead specimen are cut into slices and colored with different dyes.

Here for example a Nissl stain which marks the cell bodies of neurons. The intensely purple areas mark a high density of neurons.

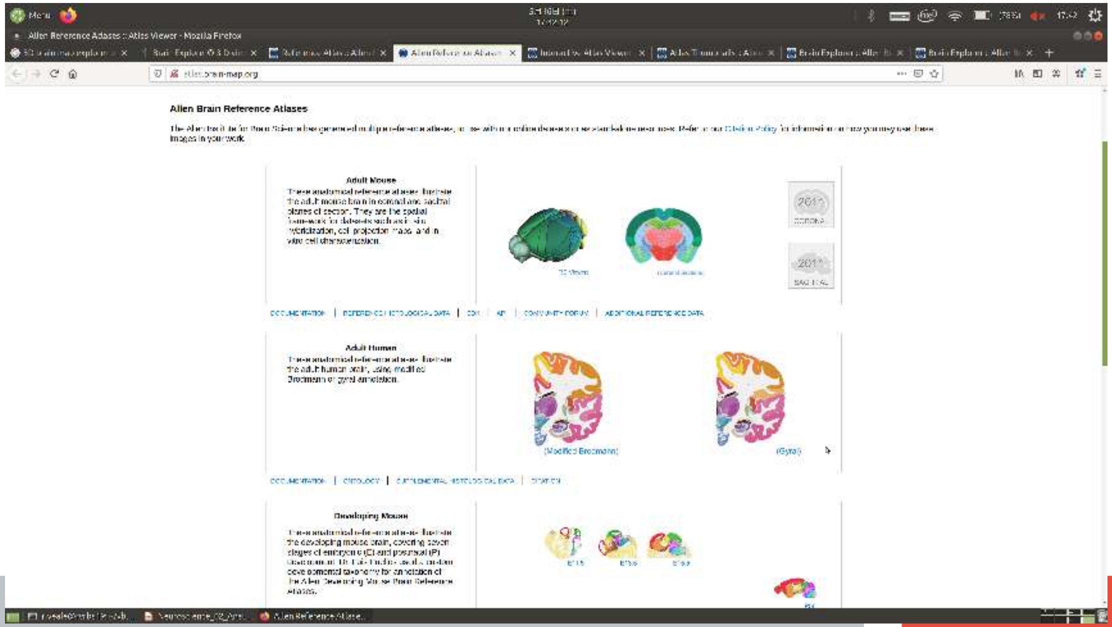


Slicing and Staining

Then, you put the slices back together to make a 3-D image.

http://atlas.brain-map.org/

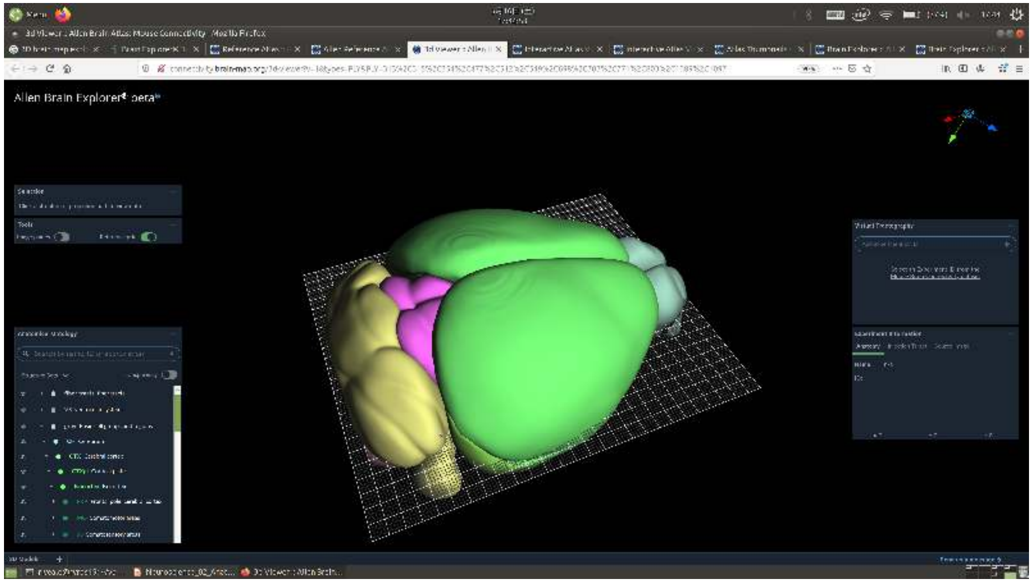
You can play around with the Allan Brian Atlas (Made by the Allen Institute for Brain Science)

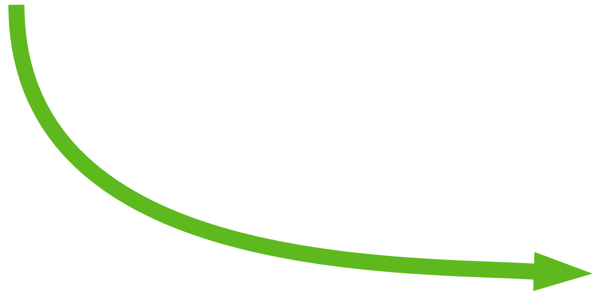


Slicing and Staining

Slices are combined into 3D reconstruction.

→ Anatomists classify different “regions” of the brain based on different properties (cell shapes, densities, location, connections...)



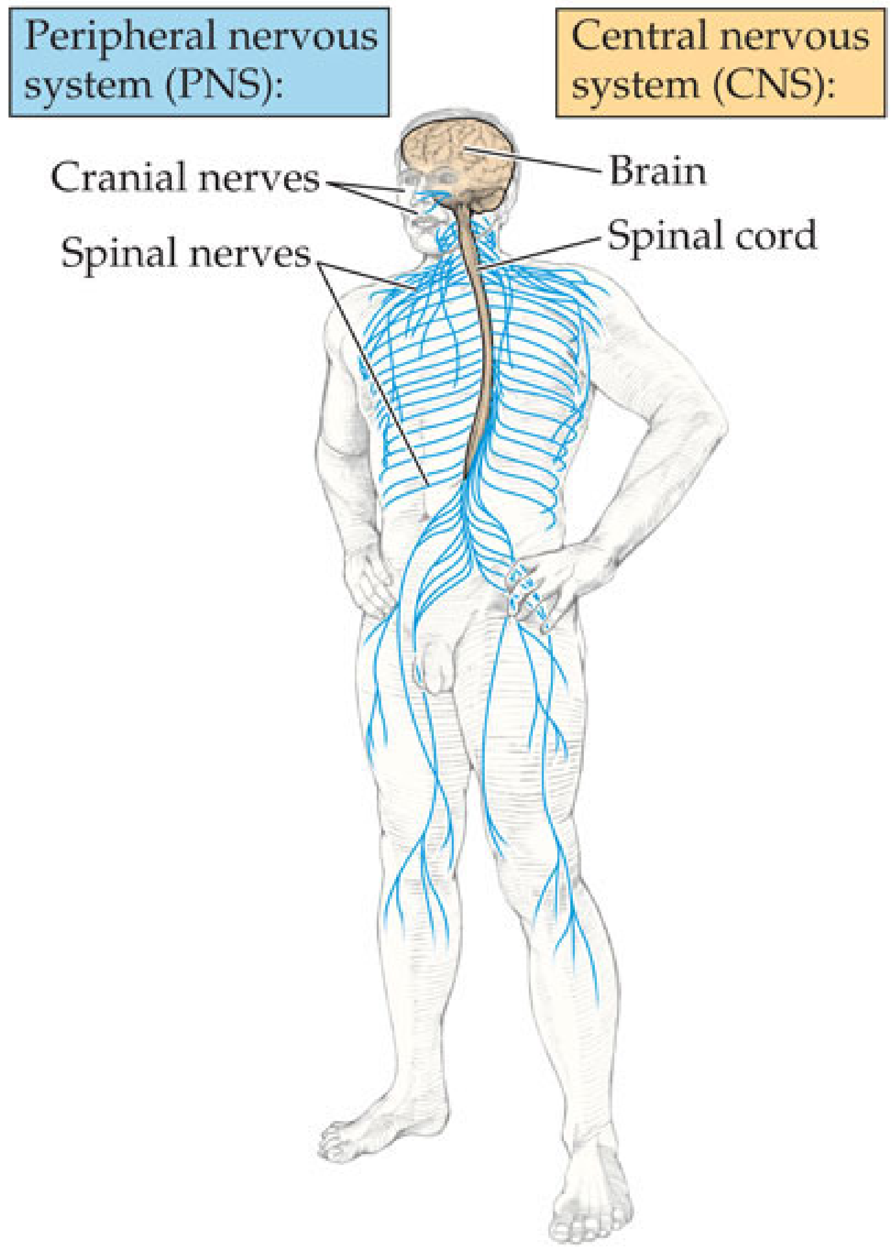


Definitions

The nervous system consists of the

1) <u>central nervous system</u>

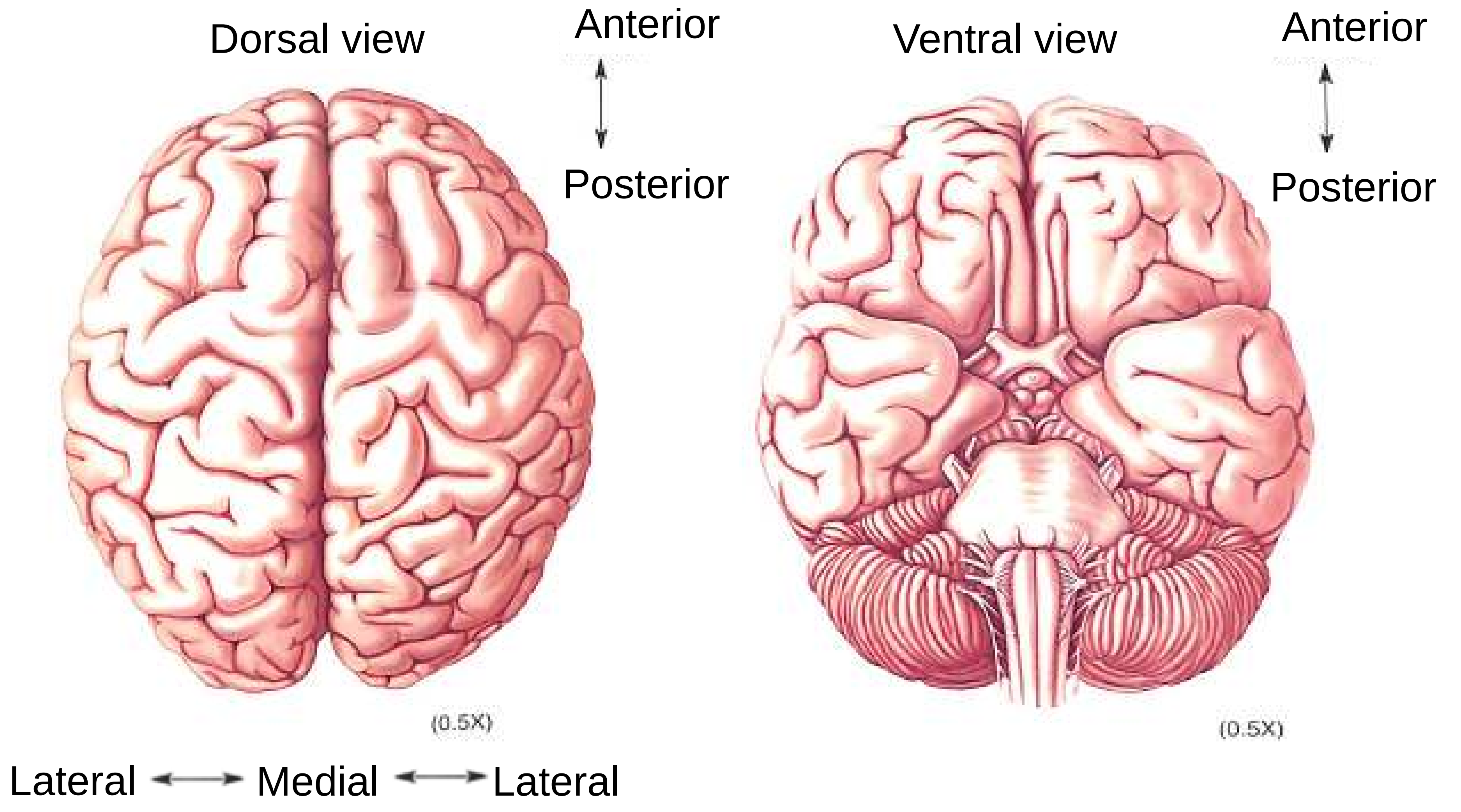
2) <u>peripheral nervous system.</u>



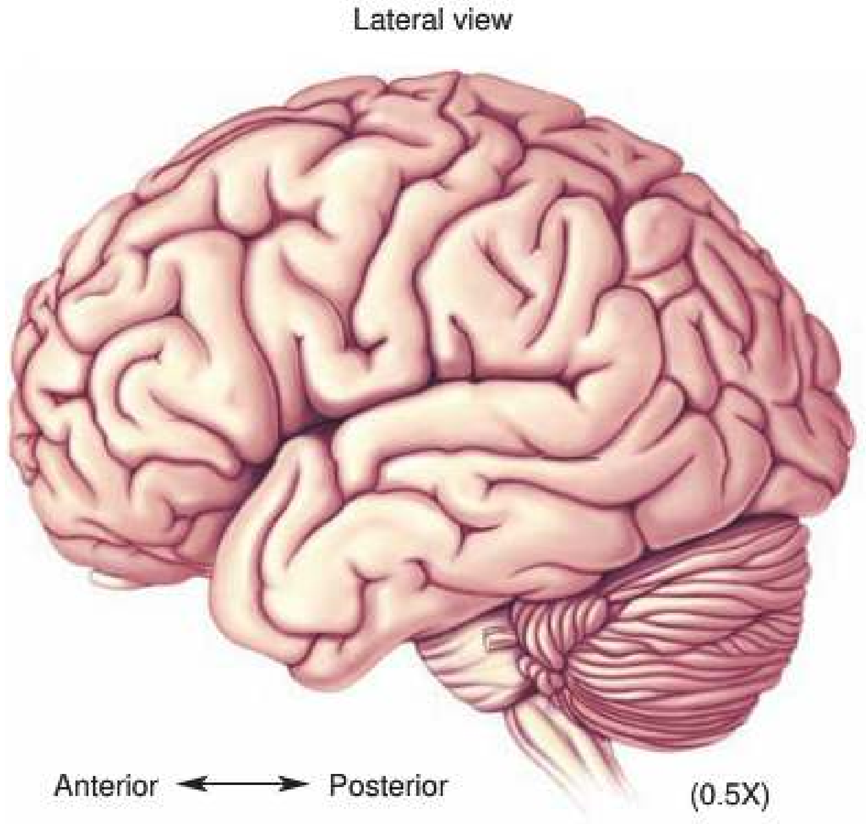
<u>Efferent</u> nerve fibers / axons
carry information <u>from CNS</u> to periphery.

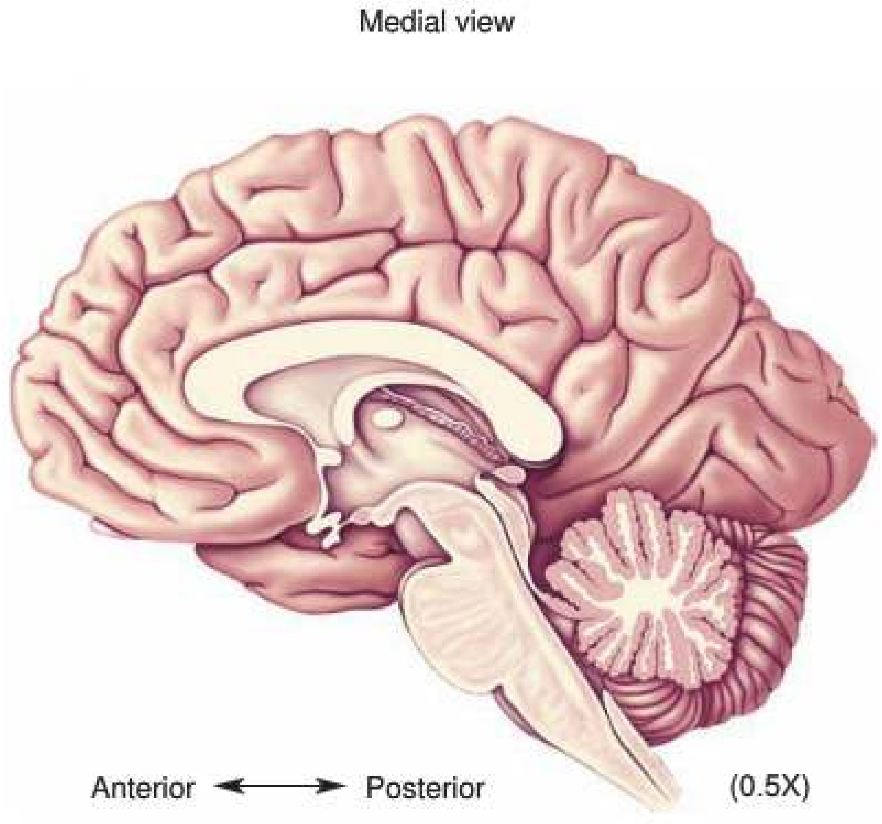
<u>Afferent</u> nerve fibers / axons
carry information from periphery <u>to CNS</u>.

Orientation (Up-Down)

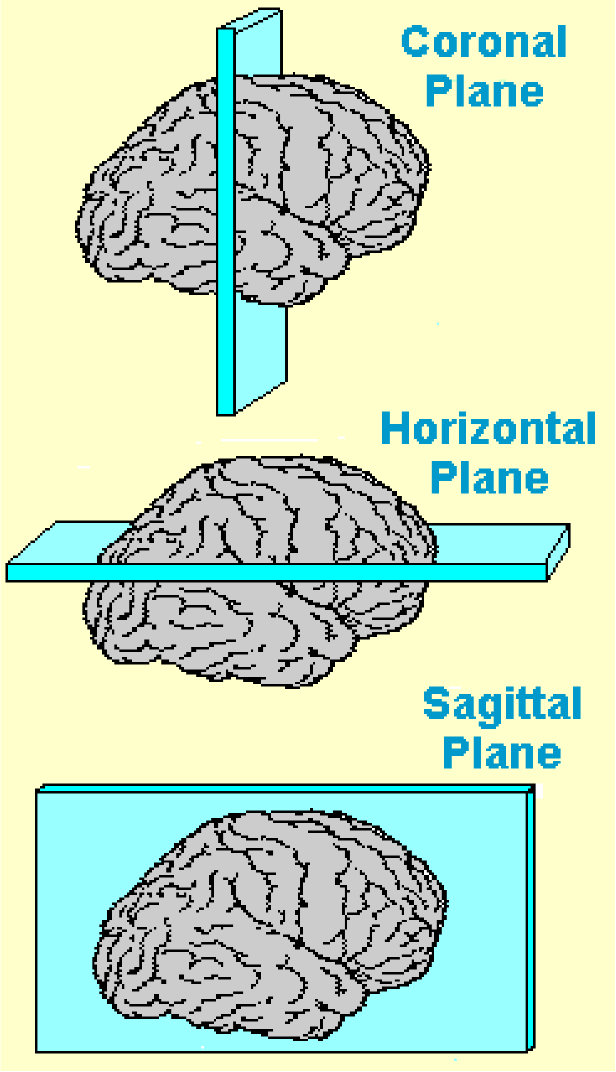


Orientation (Left-Right)





Slicing the Brain (Planes)

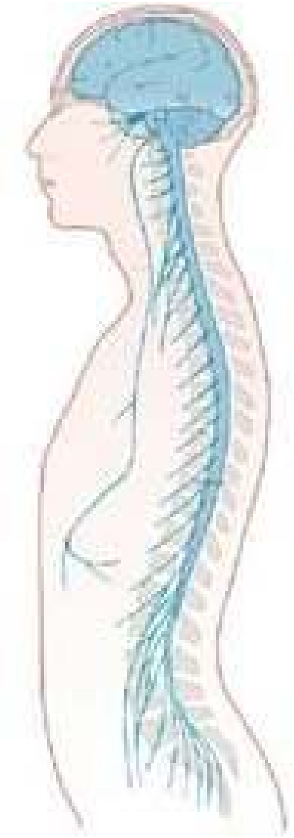


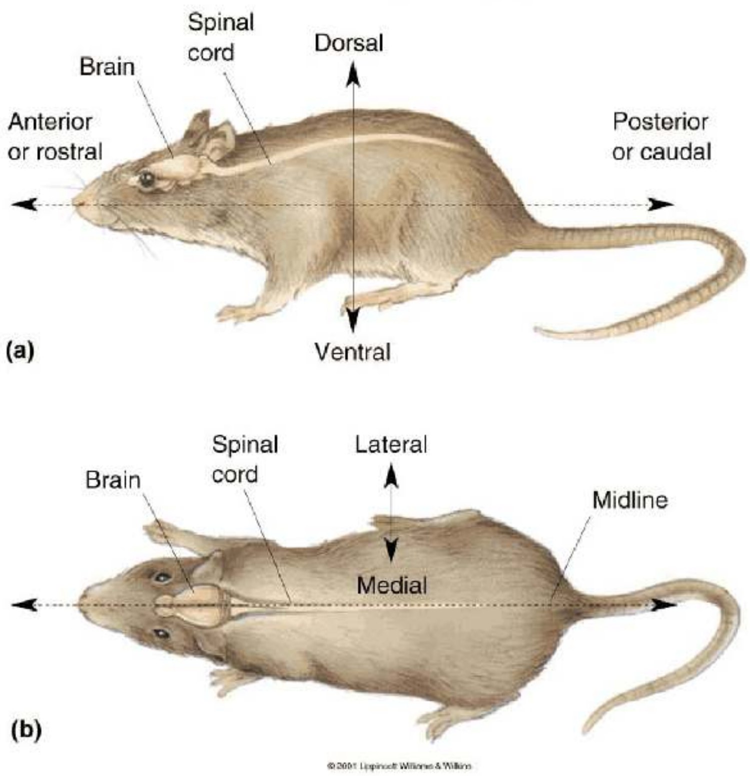
The (mammal) brain is only symmetric in one direction: left-right.

So, often we will say “(mid-) sagittal to mean down the middle, and (para-) sagittal to mean parallel to that.

Species orientation differences

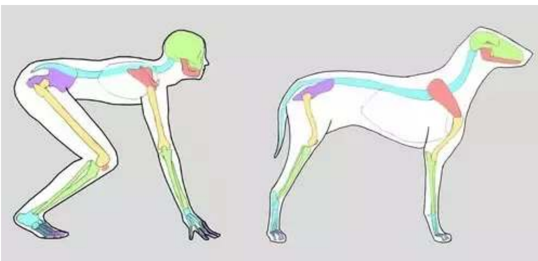
Notice something different?

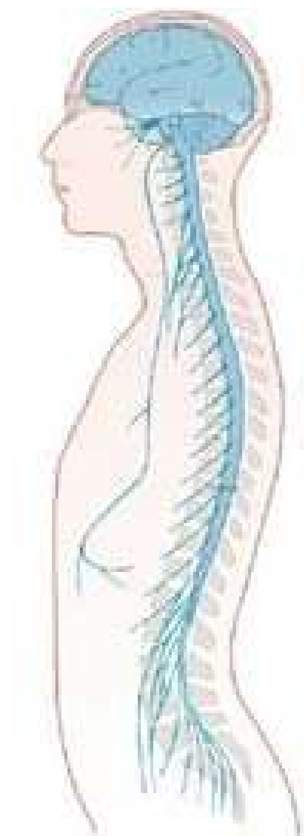




Species orientation differences

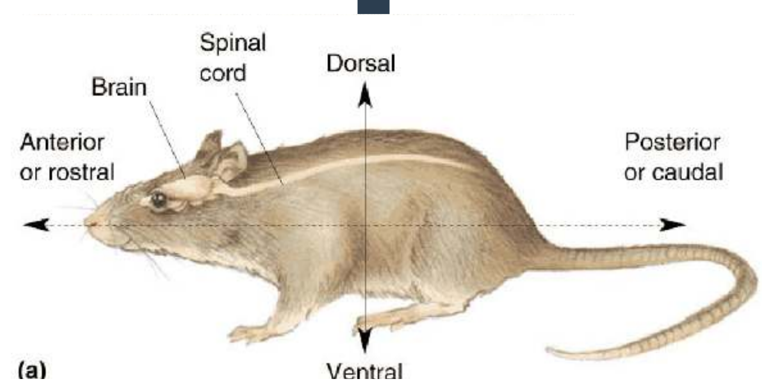
One issue: humans walk "unnaturally"





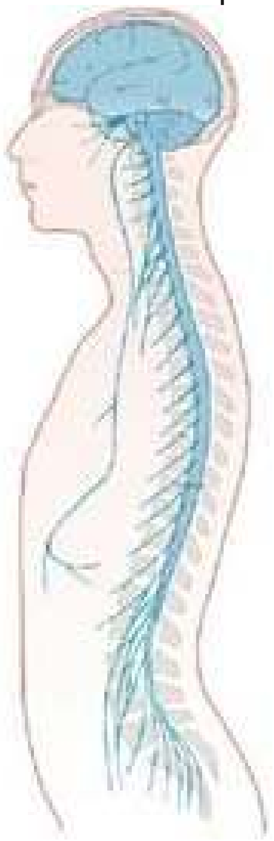
Dorsal?

Dorsal



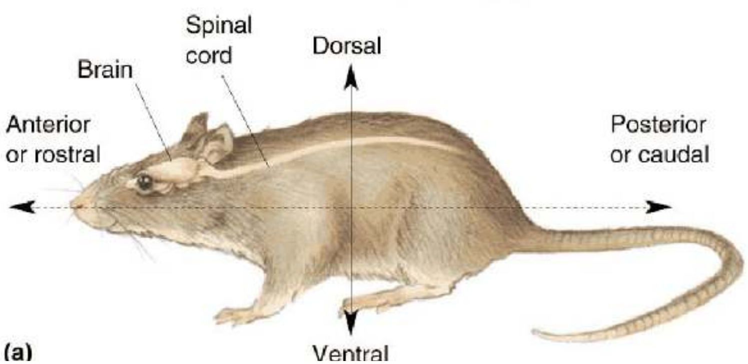
Species orientation differences

Humans (and some other upright-walking primates) have a “natural position” with brain bent 90 degrees…



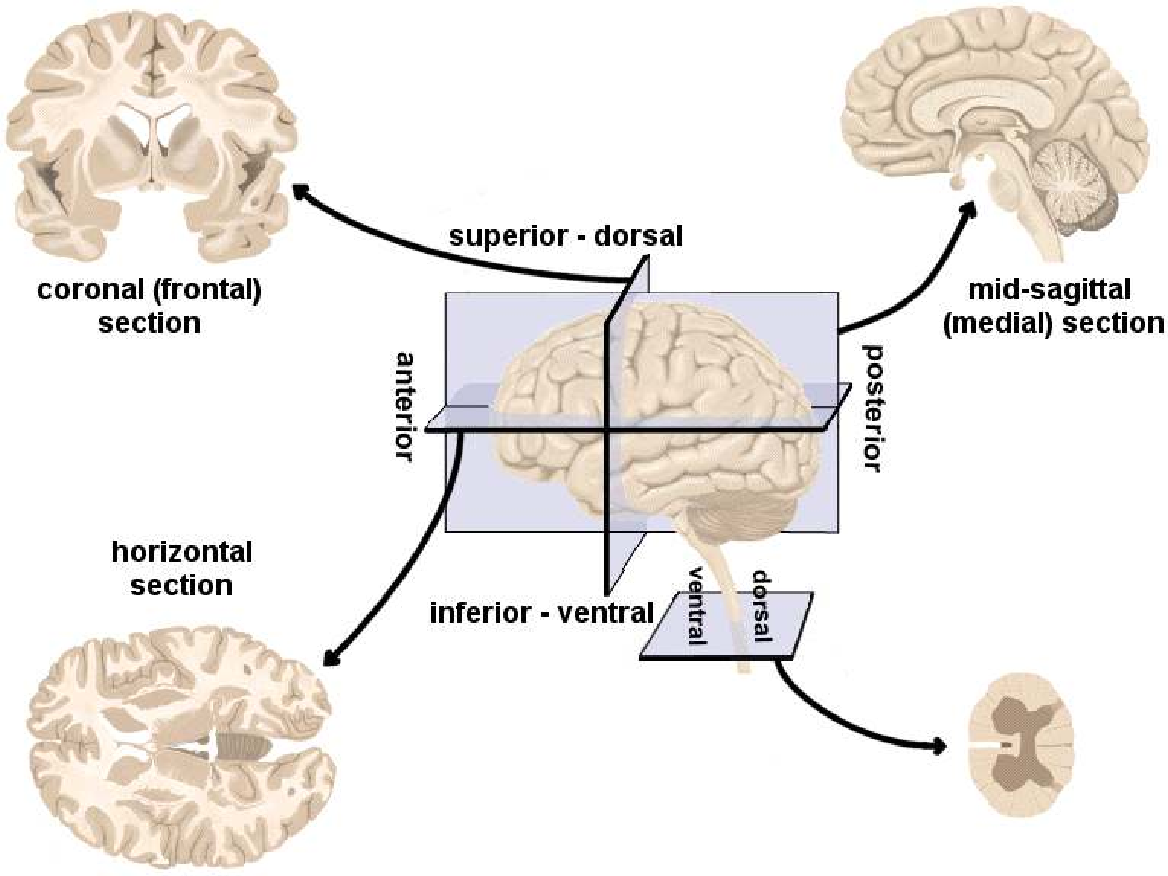
Dorsal?

Dorsal



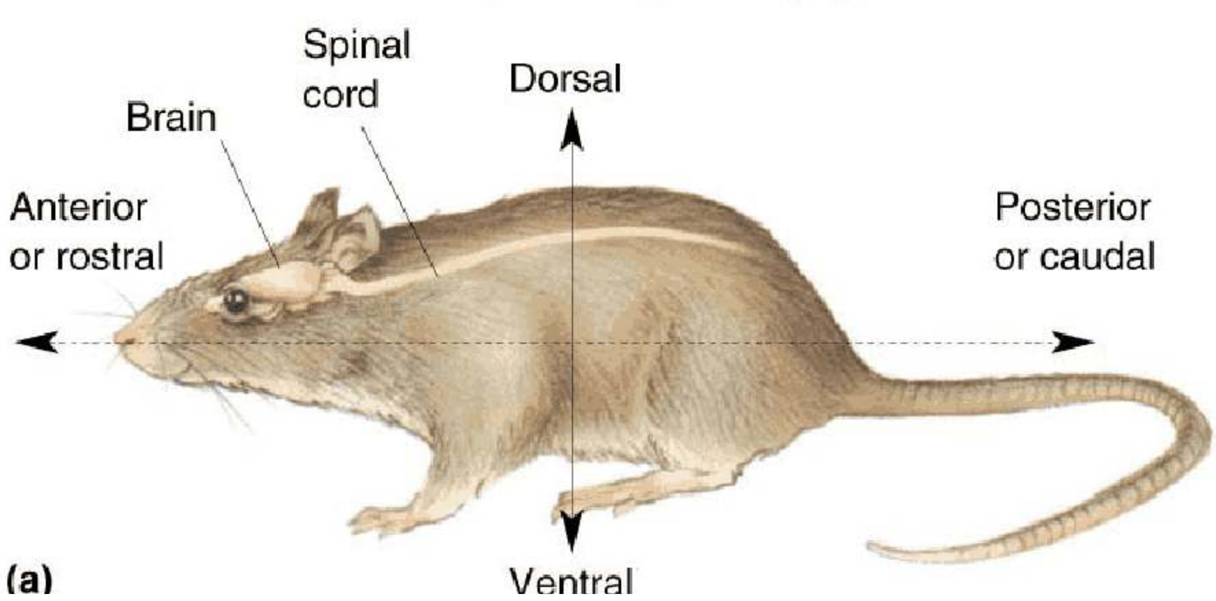
Species orientation differences

So, in humans and upright walking primates, dorsal/ventral “flips” 90 degrees at the head.

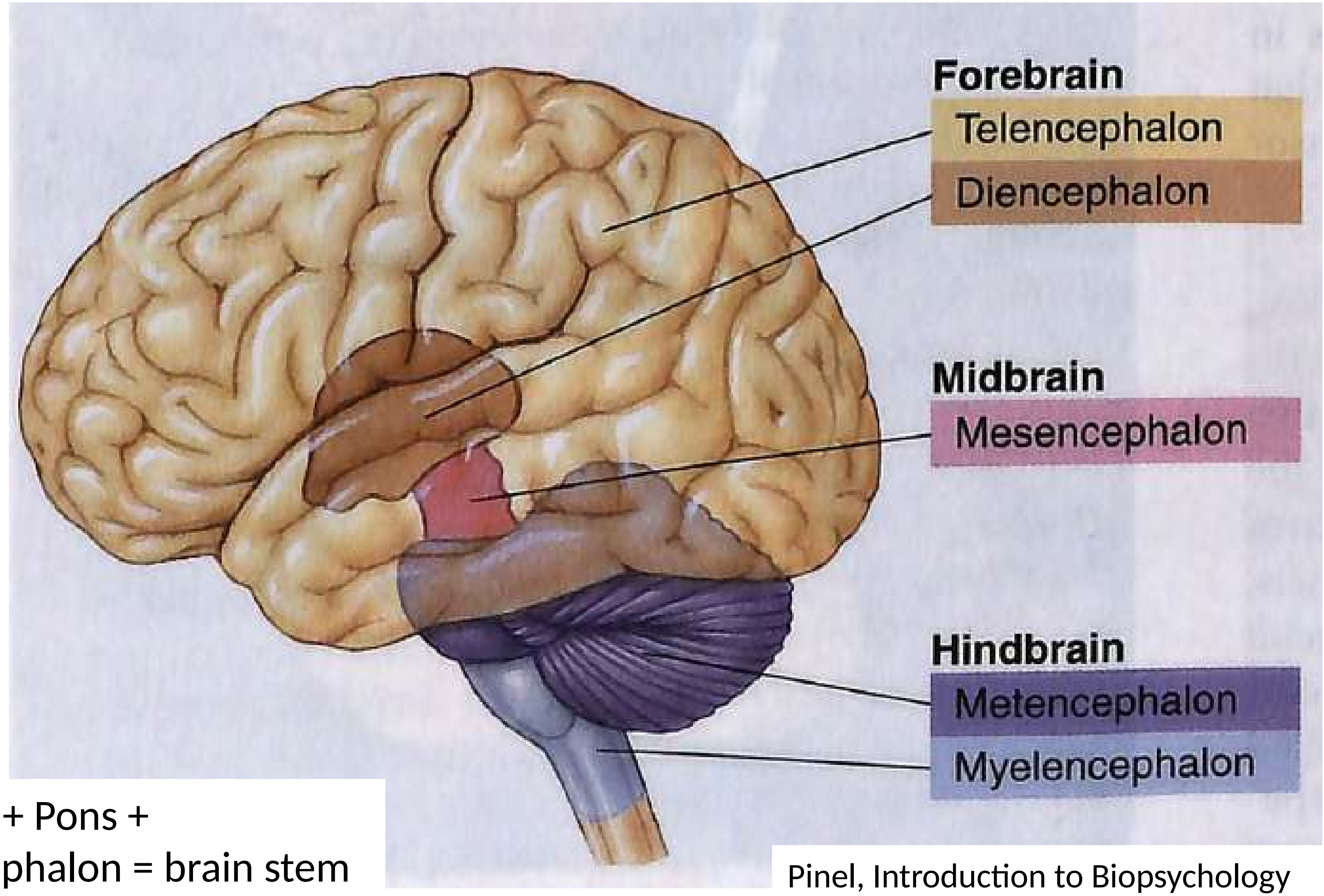


Species orientation differences

In rats, cats, dogs, dolphins, etc., it stays the same.
(note “rostral” meaning towards *beak* and “caudal” meaning towards *tail*)



Major Divisions

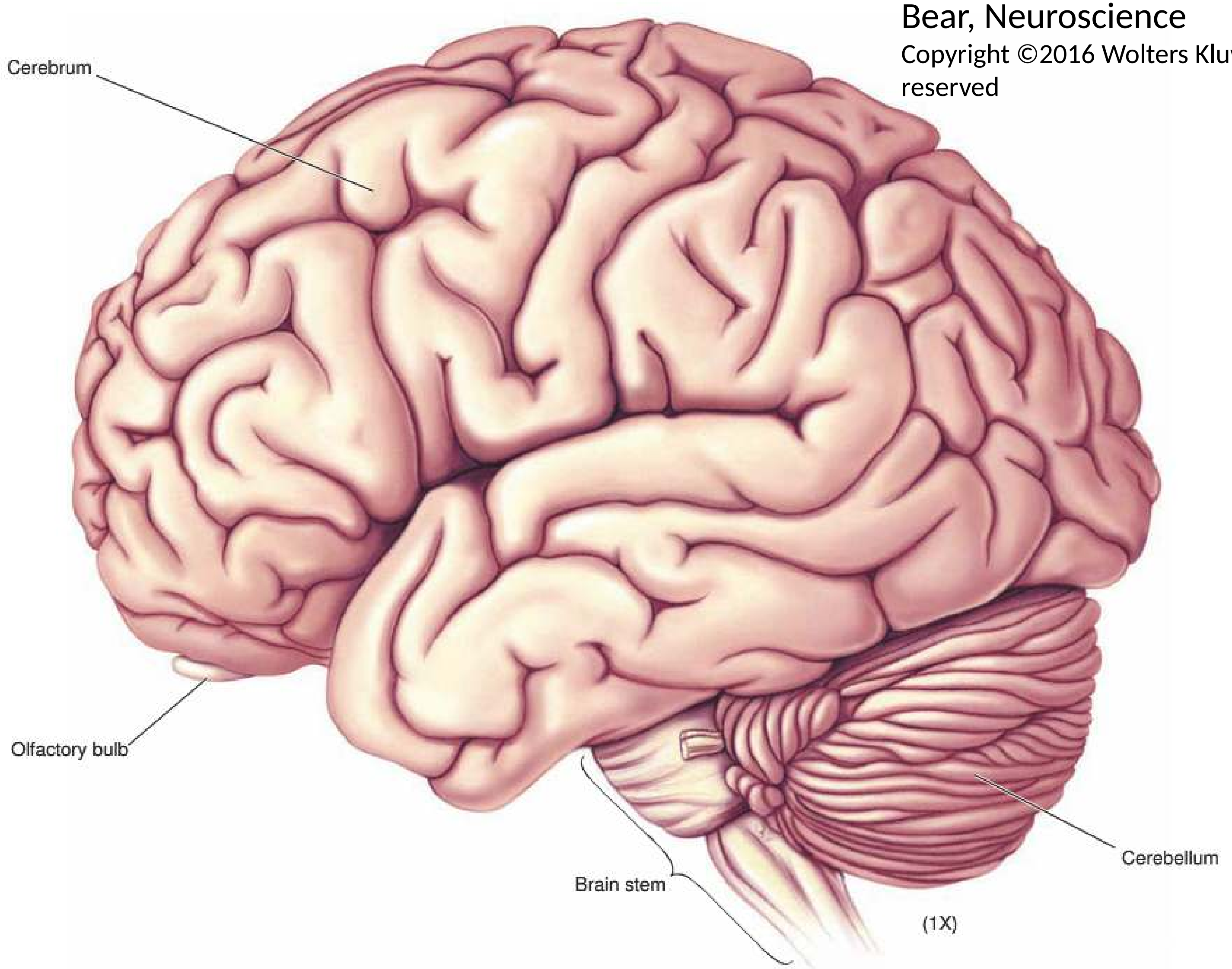


Midbrain + Pons + myelencephalon = brain stem

Pinel, Introduction to Biopsychology

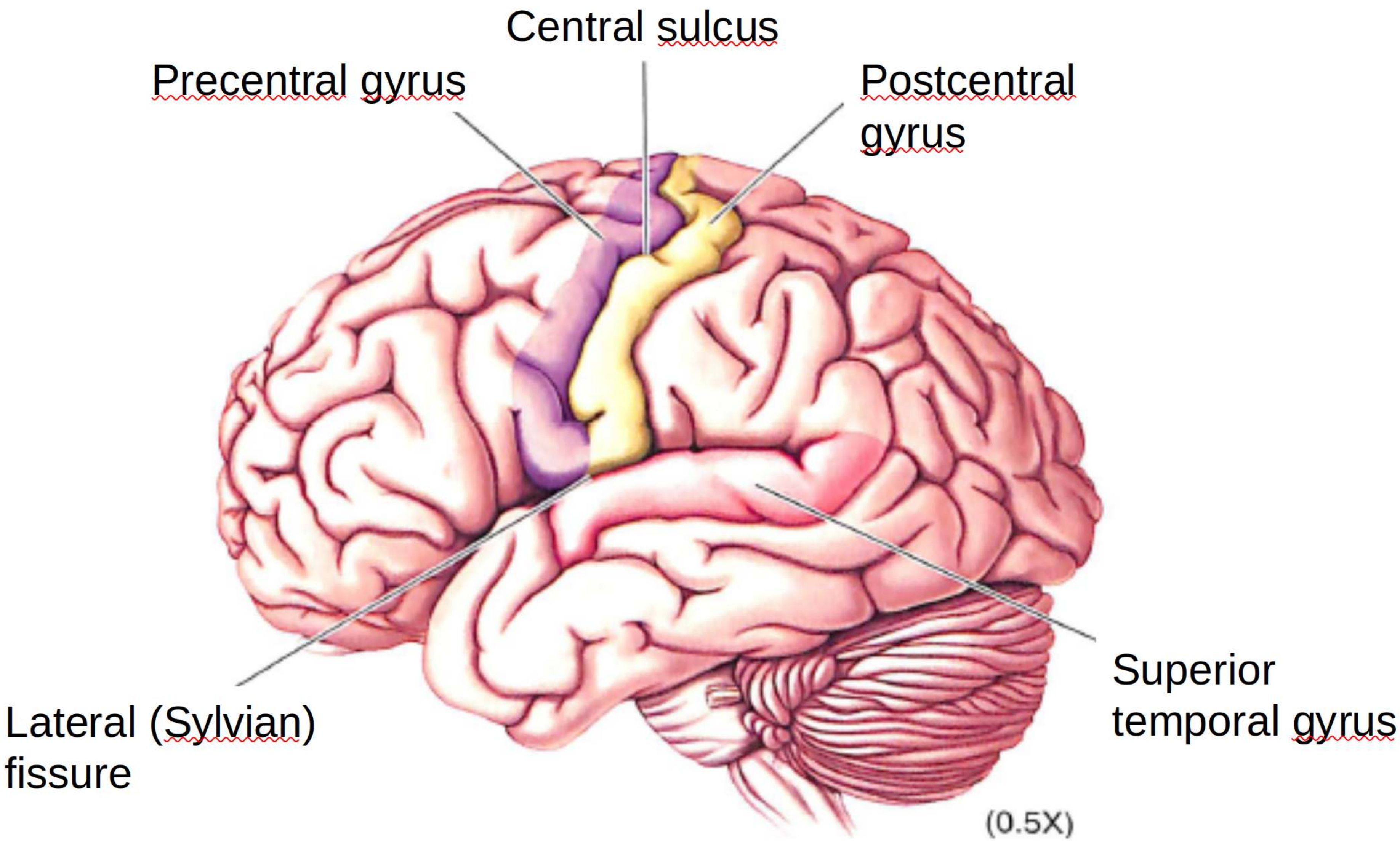
Human Brain

Bear, Neuroscience

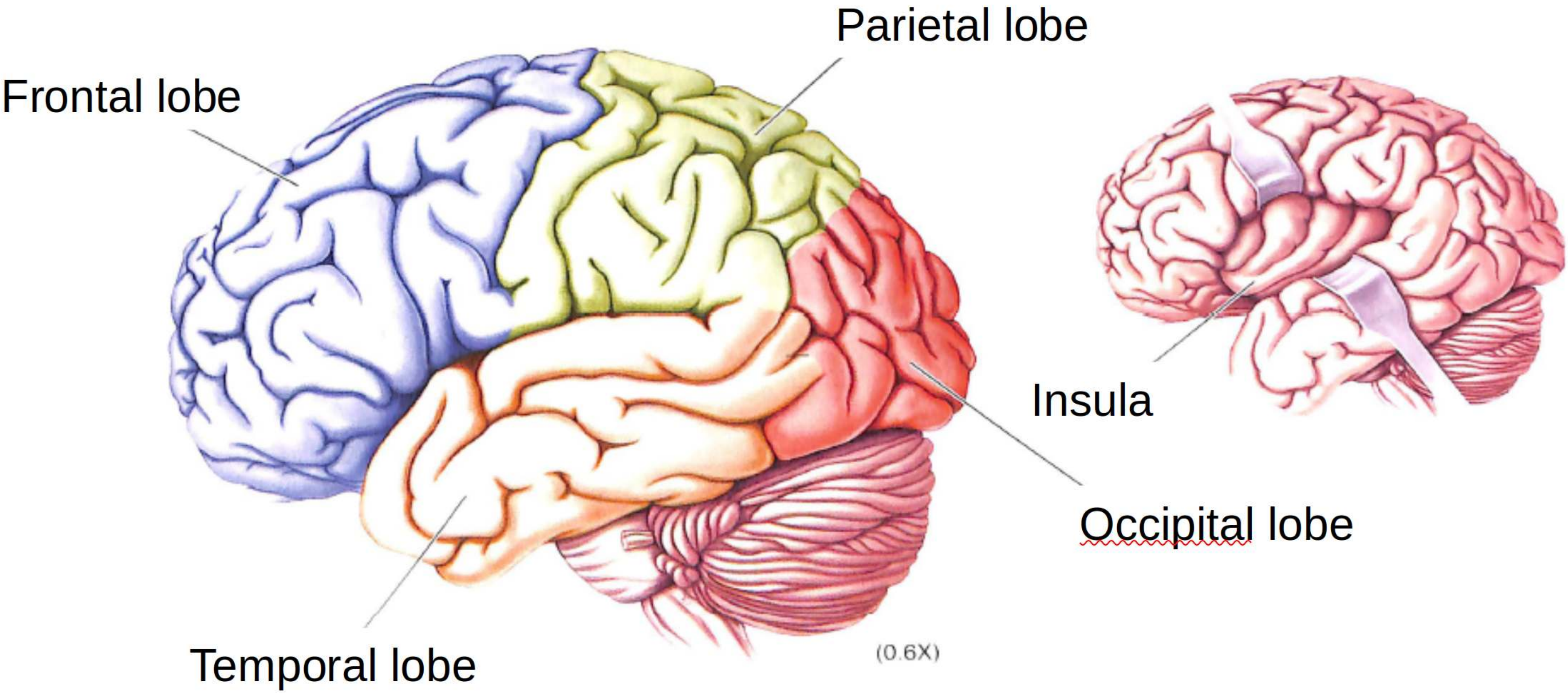


Gyrii and Sulci

Gyrus: “Bump”
Sulcus: “Valley”



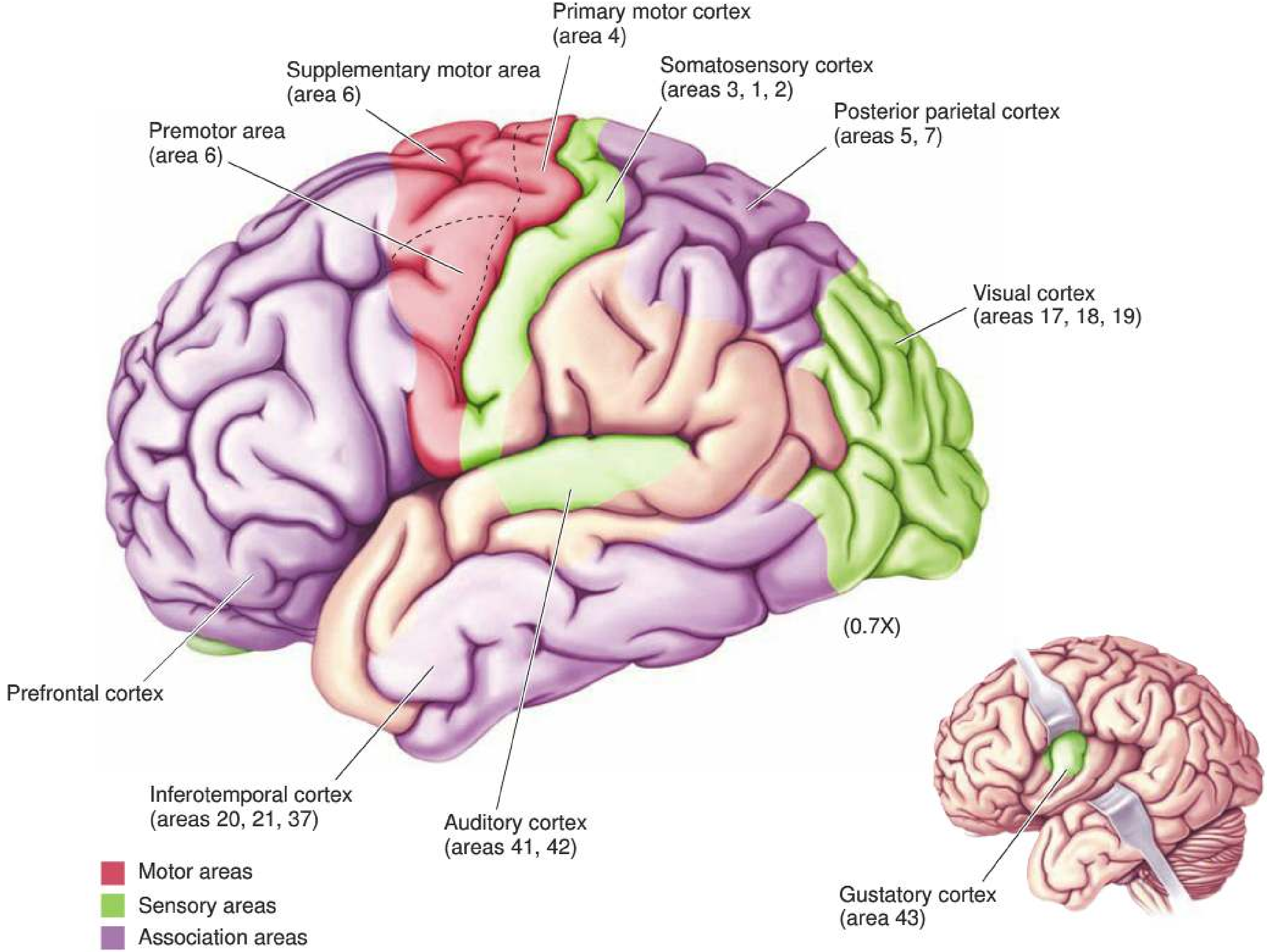
Major Cerebral Lobes



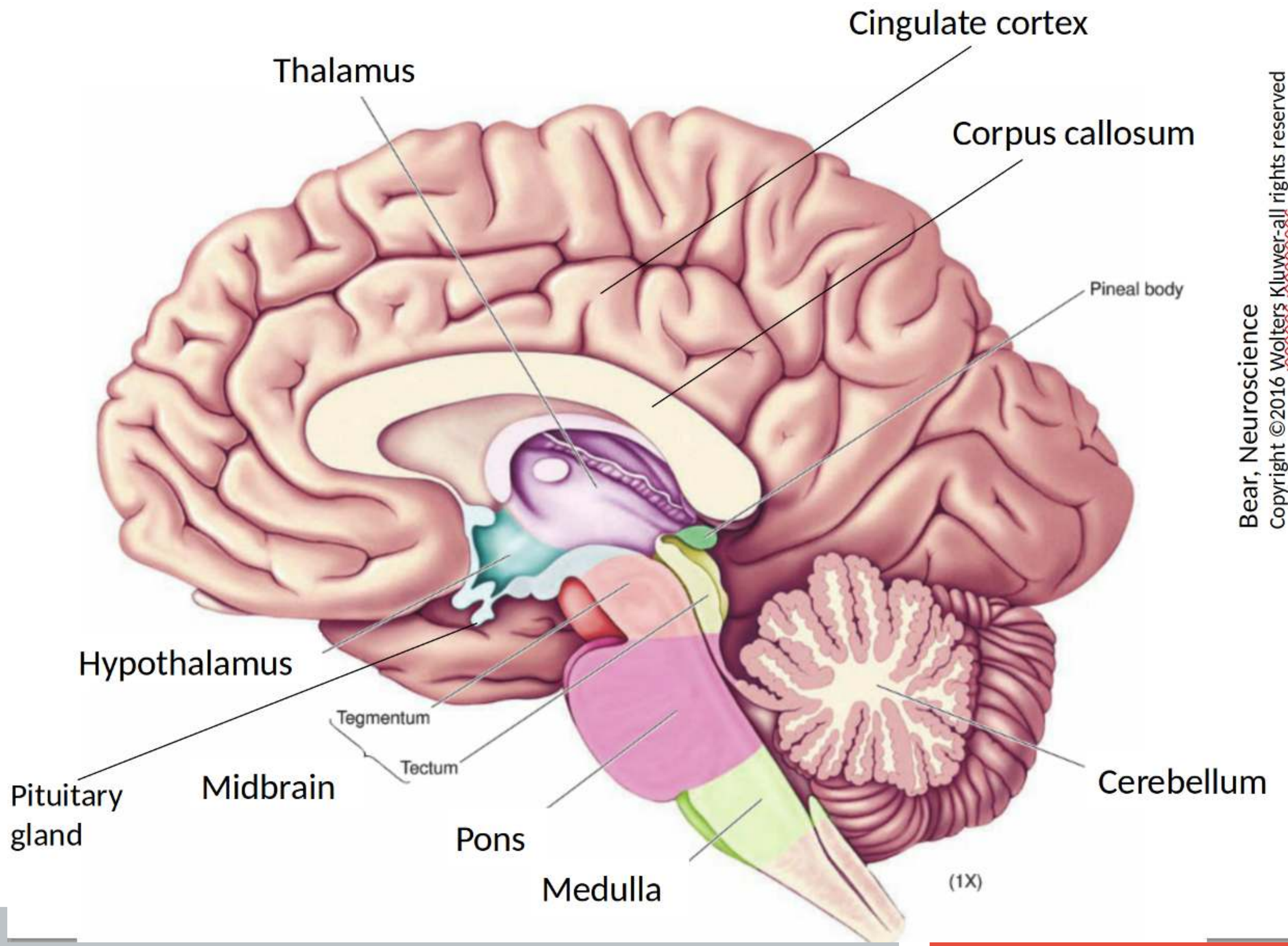
Functional **brain areas**

Separate based on what *behaviors* or *sensations* they are related to.

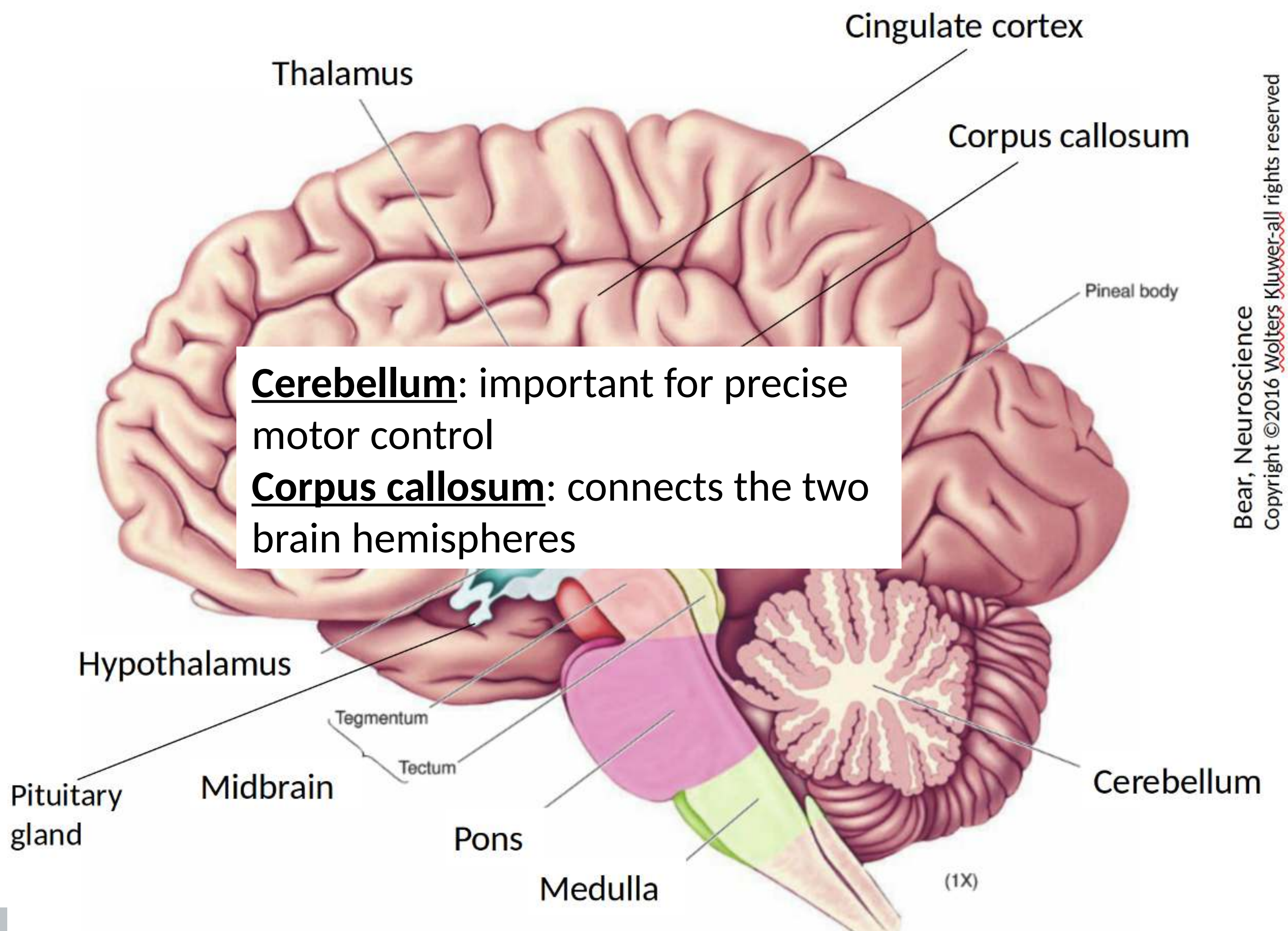
(Usually based on what is lost when damaged…)



Saggital View



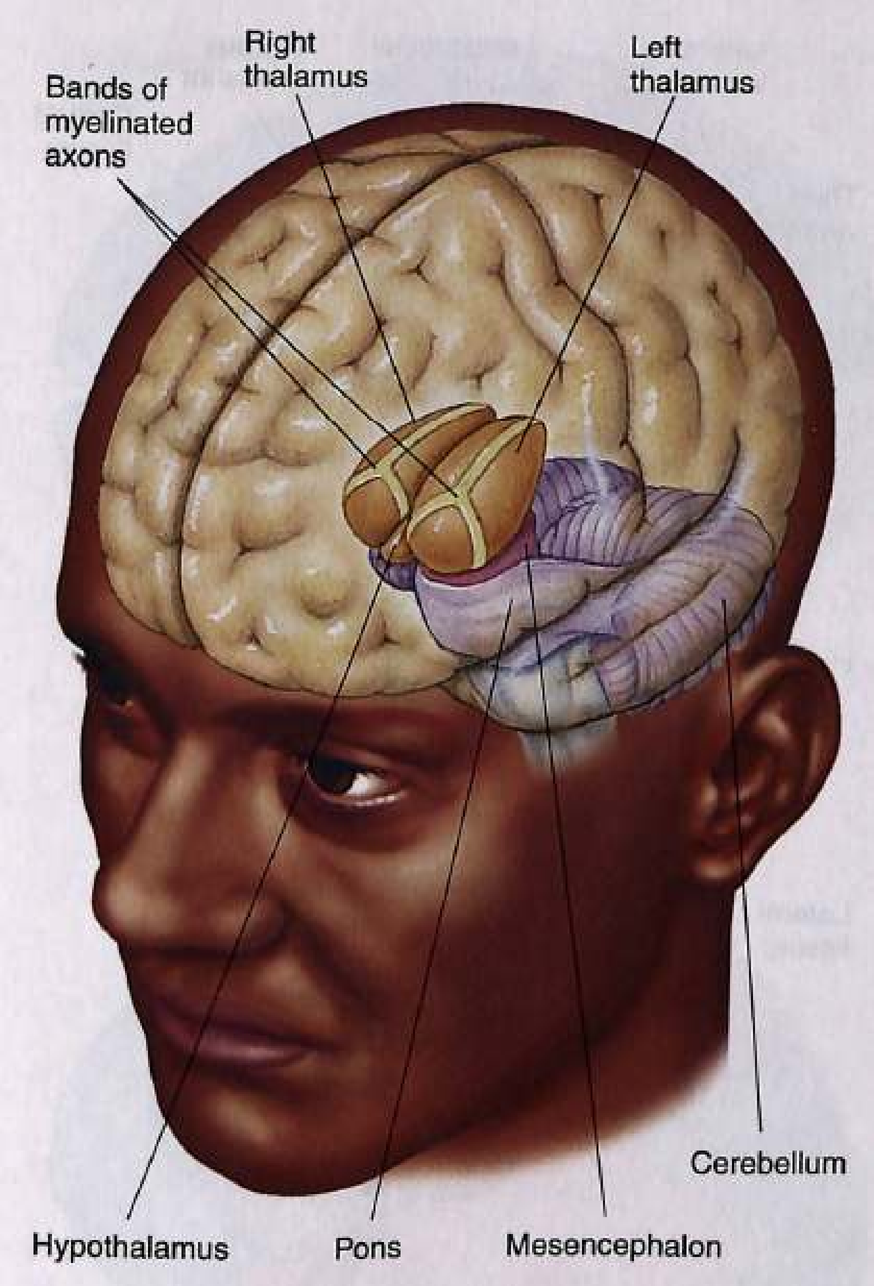
Saggital View



Cerebellum: important for precise motor control

Corpus callosum: connects the two brain hemispheres

Diencephalon



Thalamus: Important "relay station" for sensory information reaching the brain.

Hypothalamus: Important for homeostasis (eating, drinking, sleeping, mating). Also important for regulating hormone secretion of the pituitary gland.

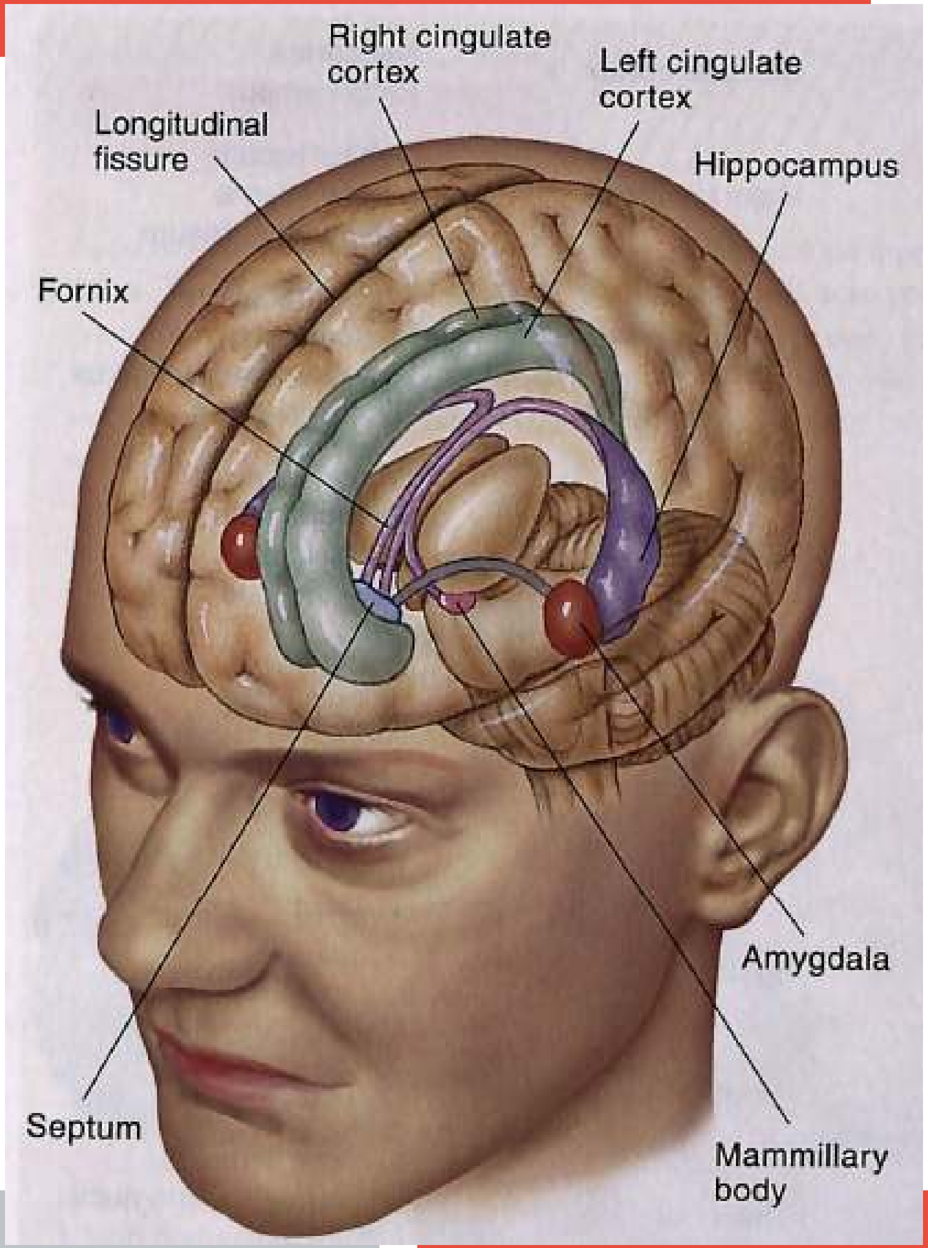
Pituitary gland (see slide before): Important for secreting several hormones into the blood stream (e.g., releasing stress hormones, growth hormones, hormones that regulate metabolism and ovulation).

Limbic System

The **limbic system** is in general involved in motivated behavior (feeding, flight, fight, sexual behavior), but also memory and learning.

Hippocampus: Important for memory formation and spatial memory (place cells).

Amygdala: Important for emotion and fear response.



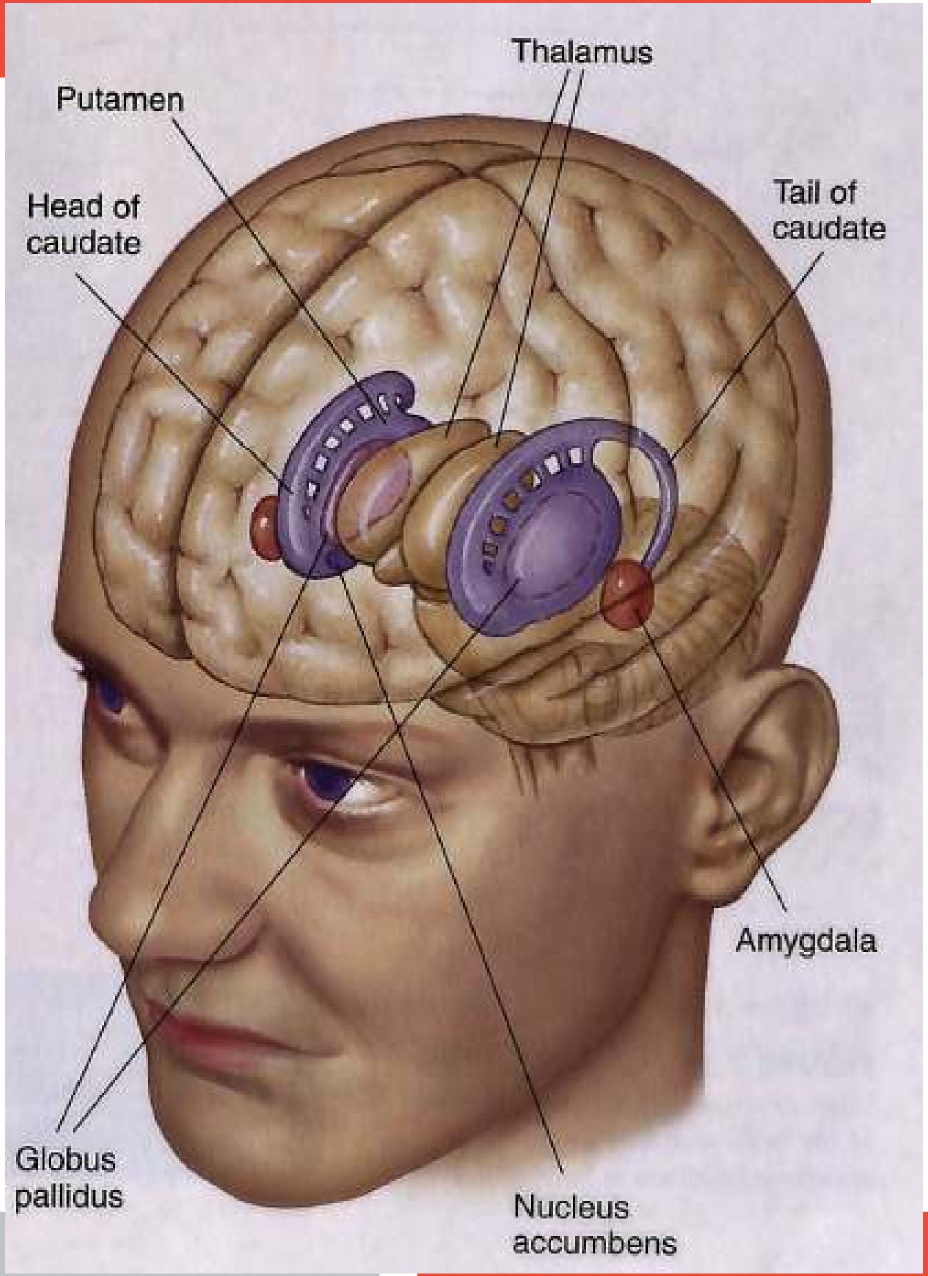
Pinel, Introduction to Biopsychology

Basal Ganglia

The **basal ganglia** are important for voluntary movement. Parkinson's disease is linked with cell damage in this circuit.

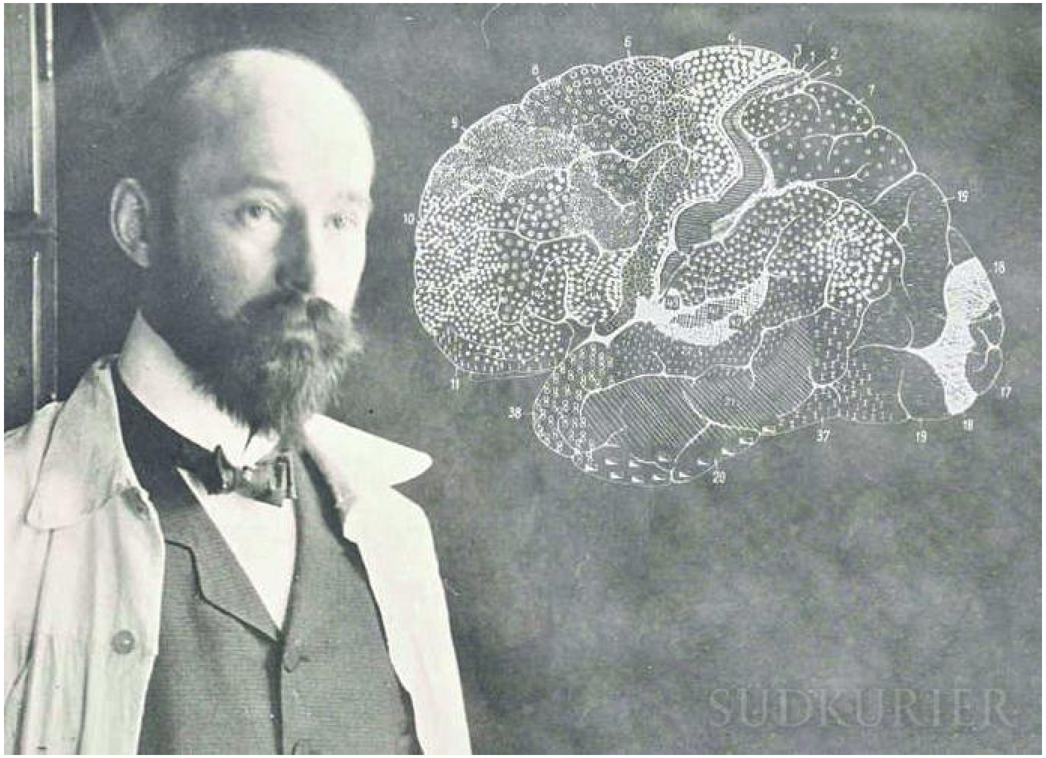
Nucleus accumbens: part of the reward system (important for the addictive effects of drugs).

Basal ganglia:
Caudate
Putamen
Globus pallidus



Broadmann areas (BA)

Korbinian Brodmann (1868-1918)



Brodmann investigated the cytoarchitecture (arrangement of cells) of the cerebral cortex and classified brain areas according to this.

He assumed different functions for these areas – but that was not known in his time.

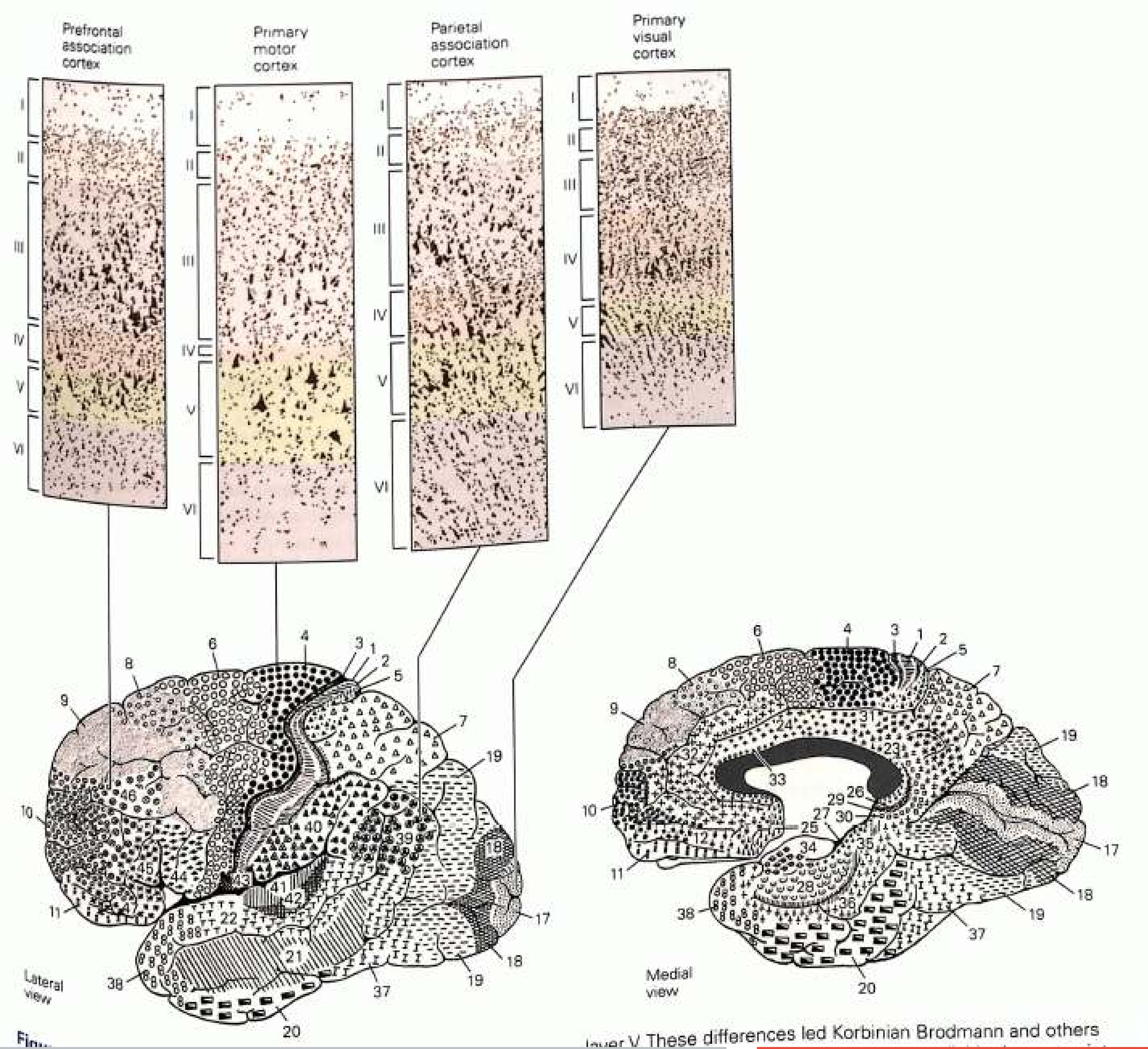
Broadmann

1) Prefrontal association cortex

2) Primary motor cortex

3) Parietal association cortex

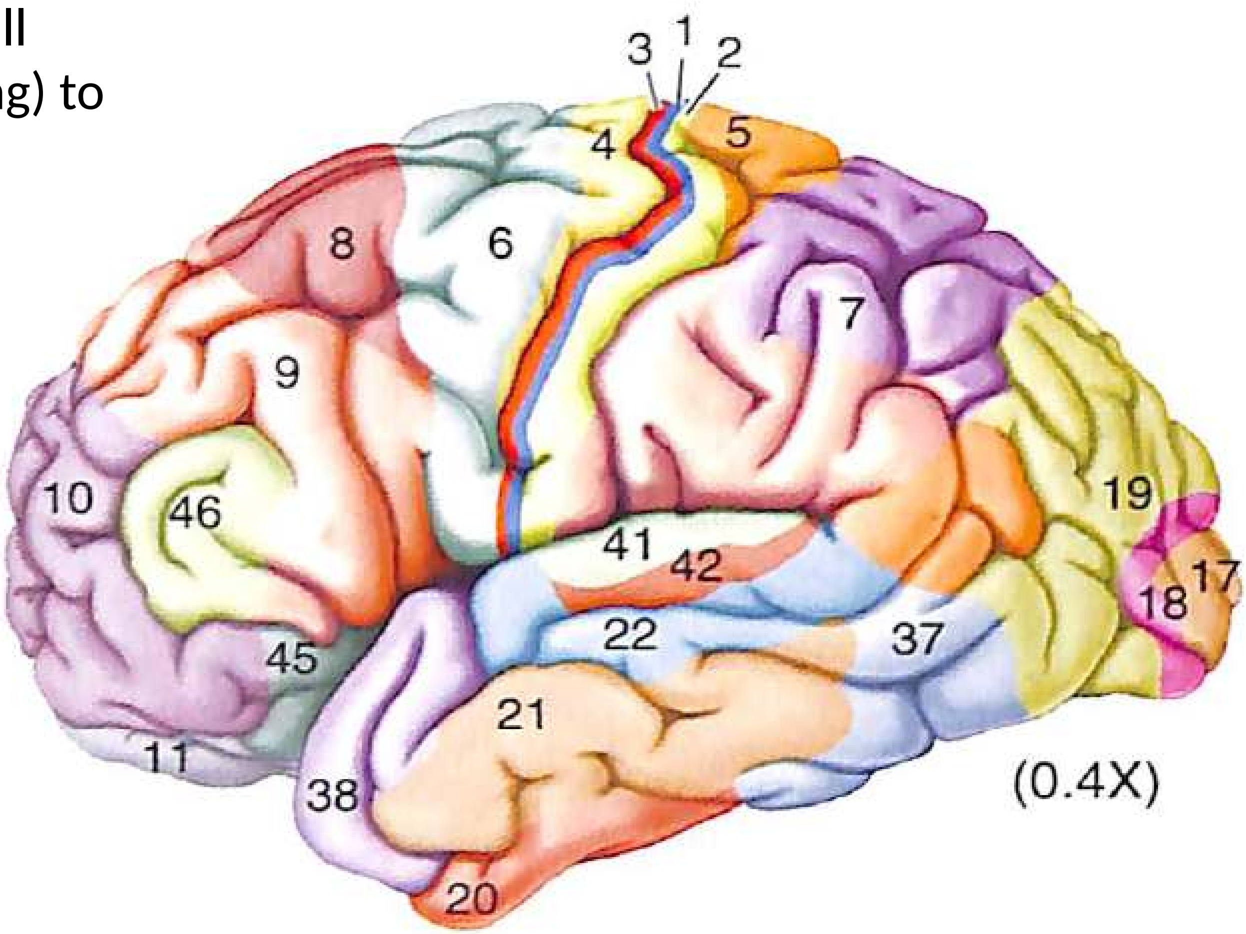
4) Primary visual cortex



Kandel, Principles of Neural Science

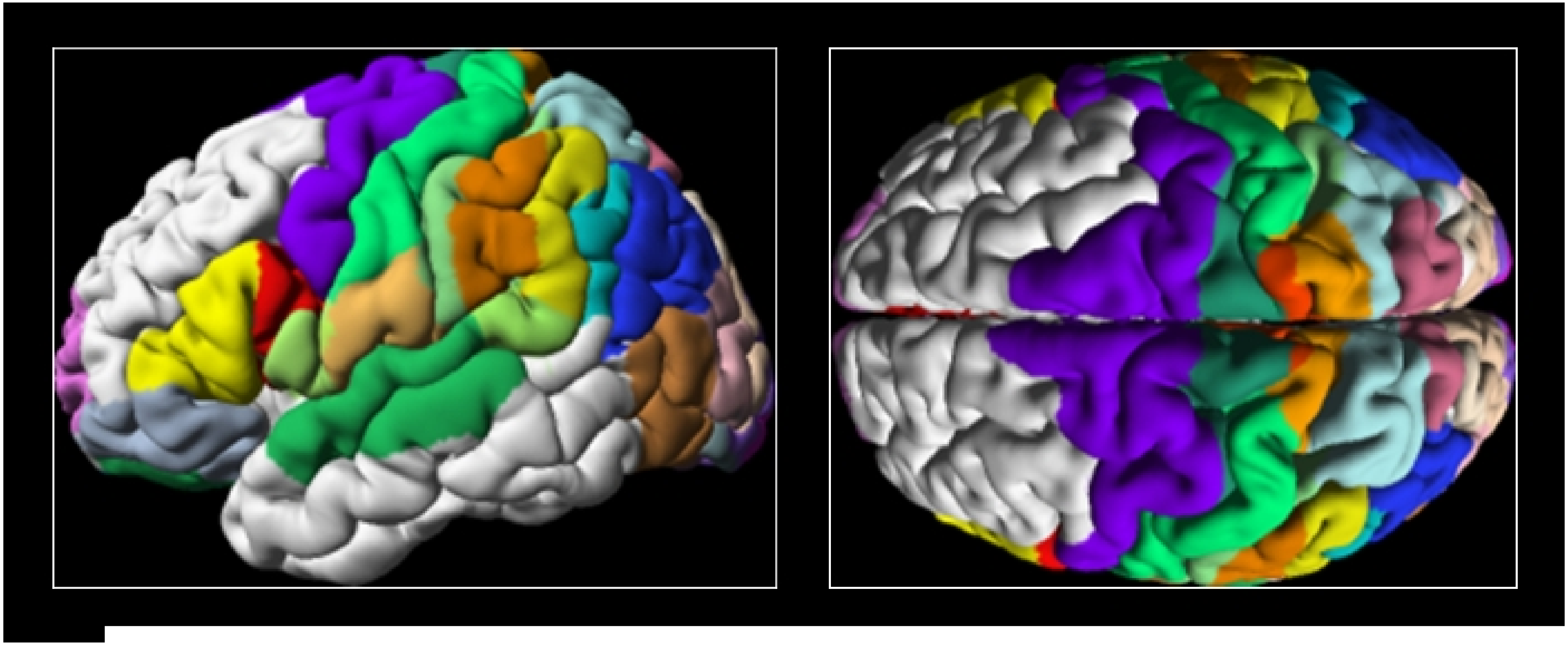
Broadmann's Areas

The Brodmann areas do indeed relate to different structures, and are still widely used (e.g., in neuro imaging) to characterize anatomical location.



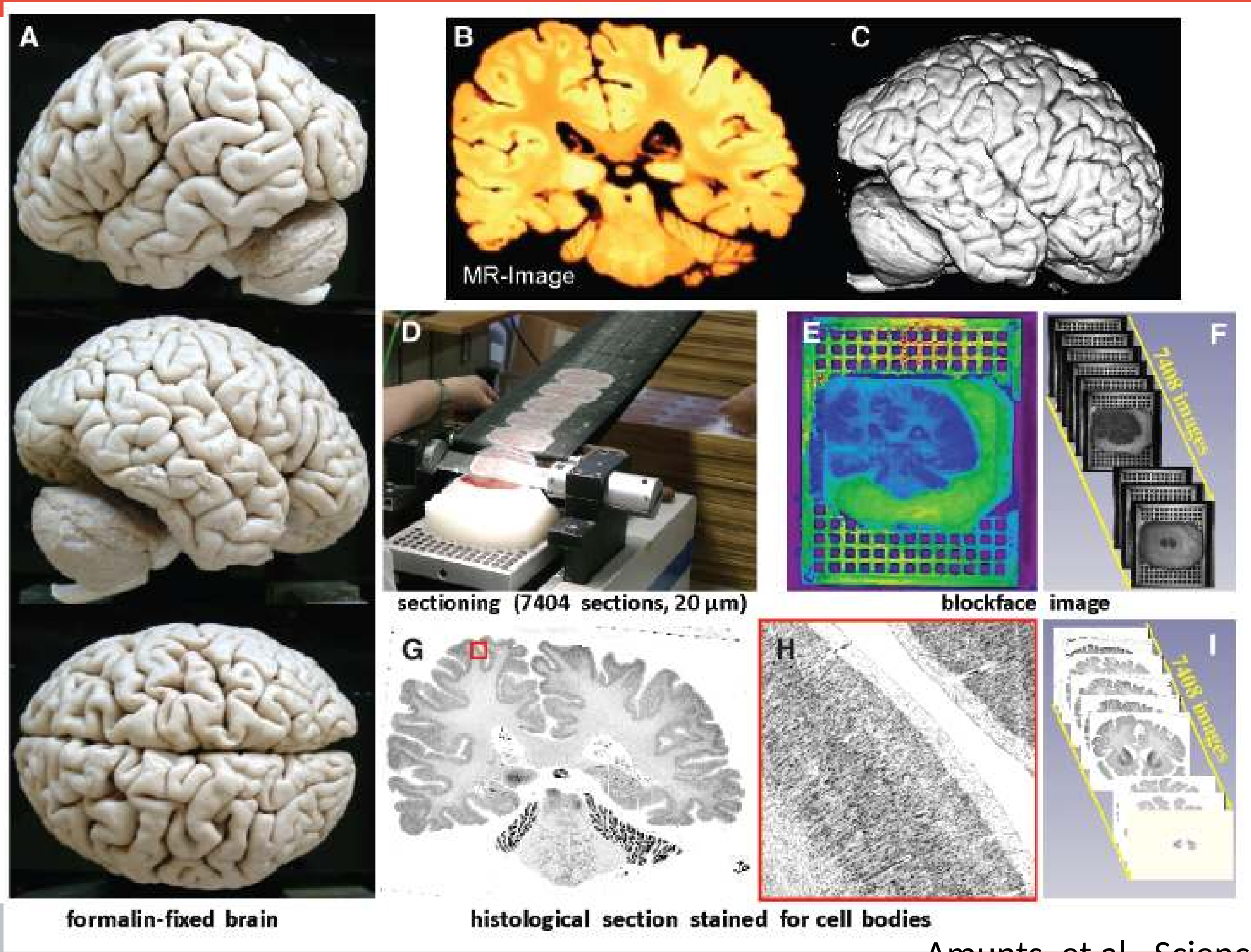
Brodmann's map

Jülich Brain: http://www.fz-juelich.de/



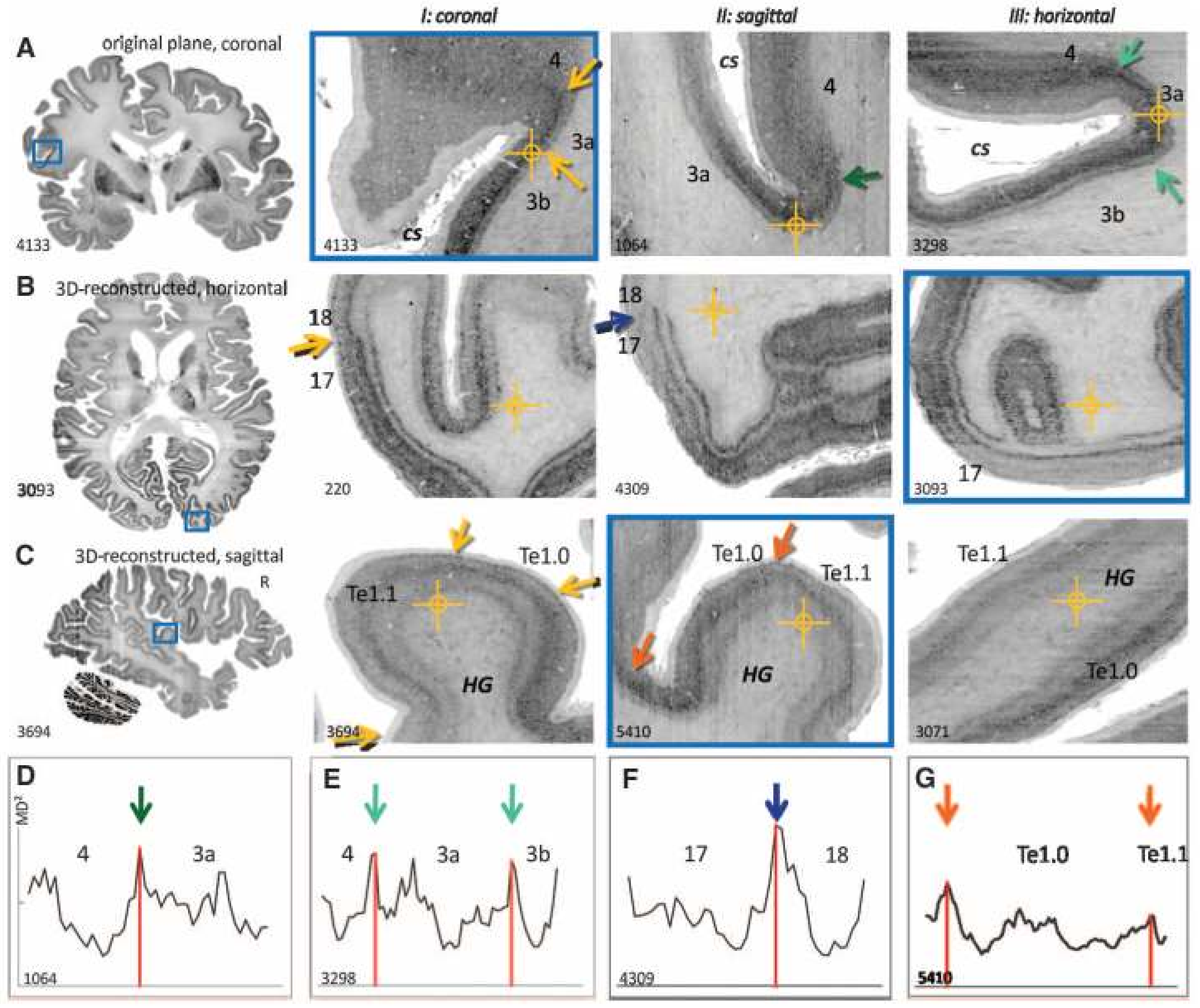
However, the Brodmann areas do not cover the entire brain (in particular not the sulci) and so recent research updates this map in 3D and with various cytoarchitectonic descriptions.

BigBrain Project



Amunts, et al., Science, 2013

BigBrain Project



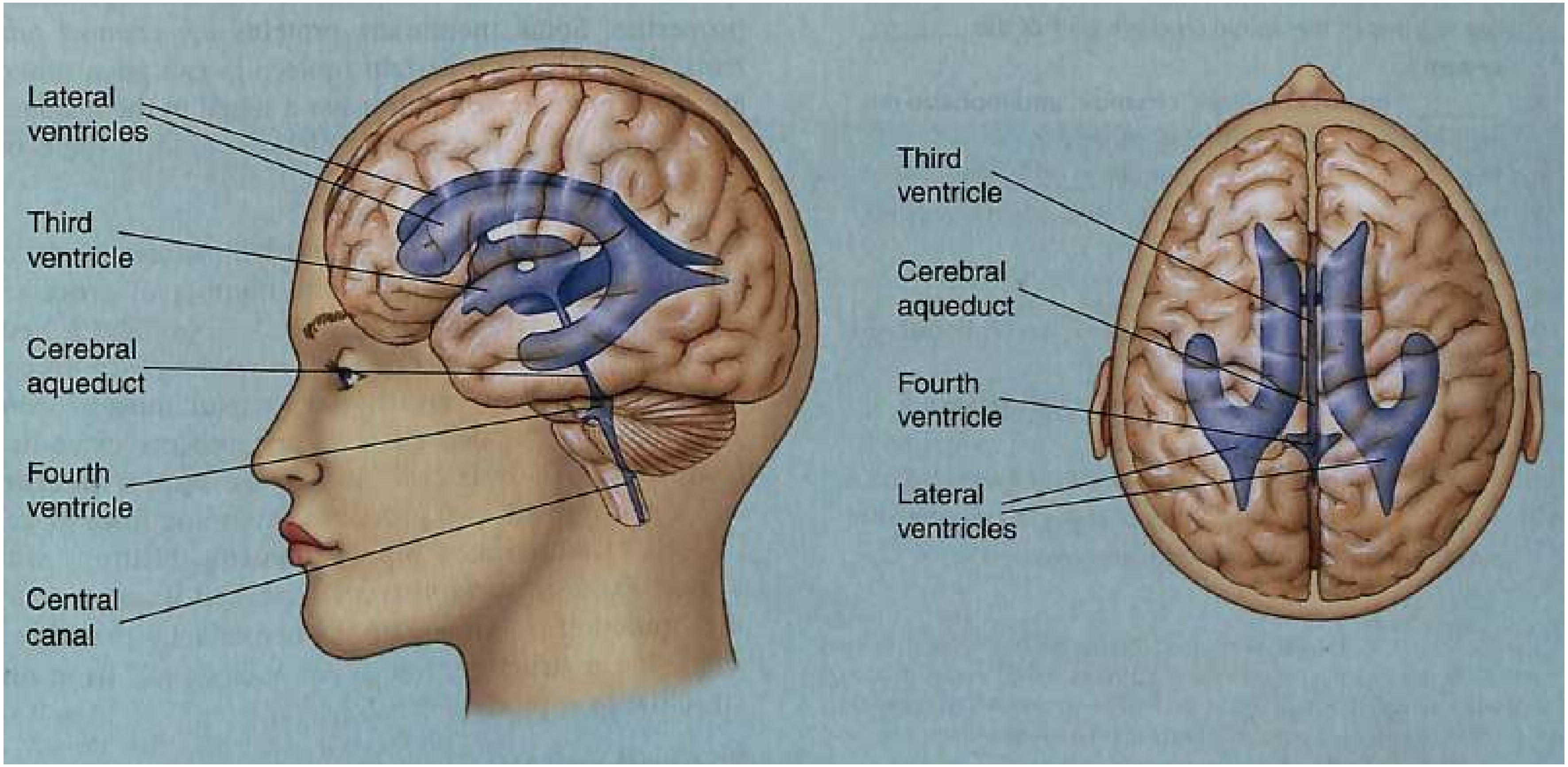
Somato-
sensory
Cortex

Visual
Cortex

Auditory
Cortex

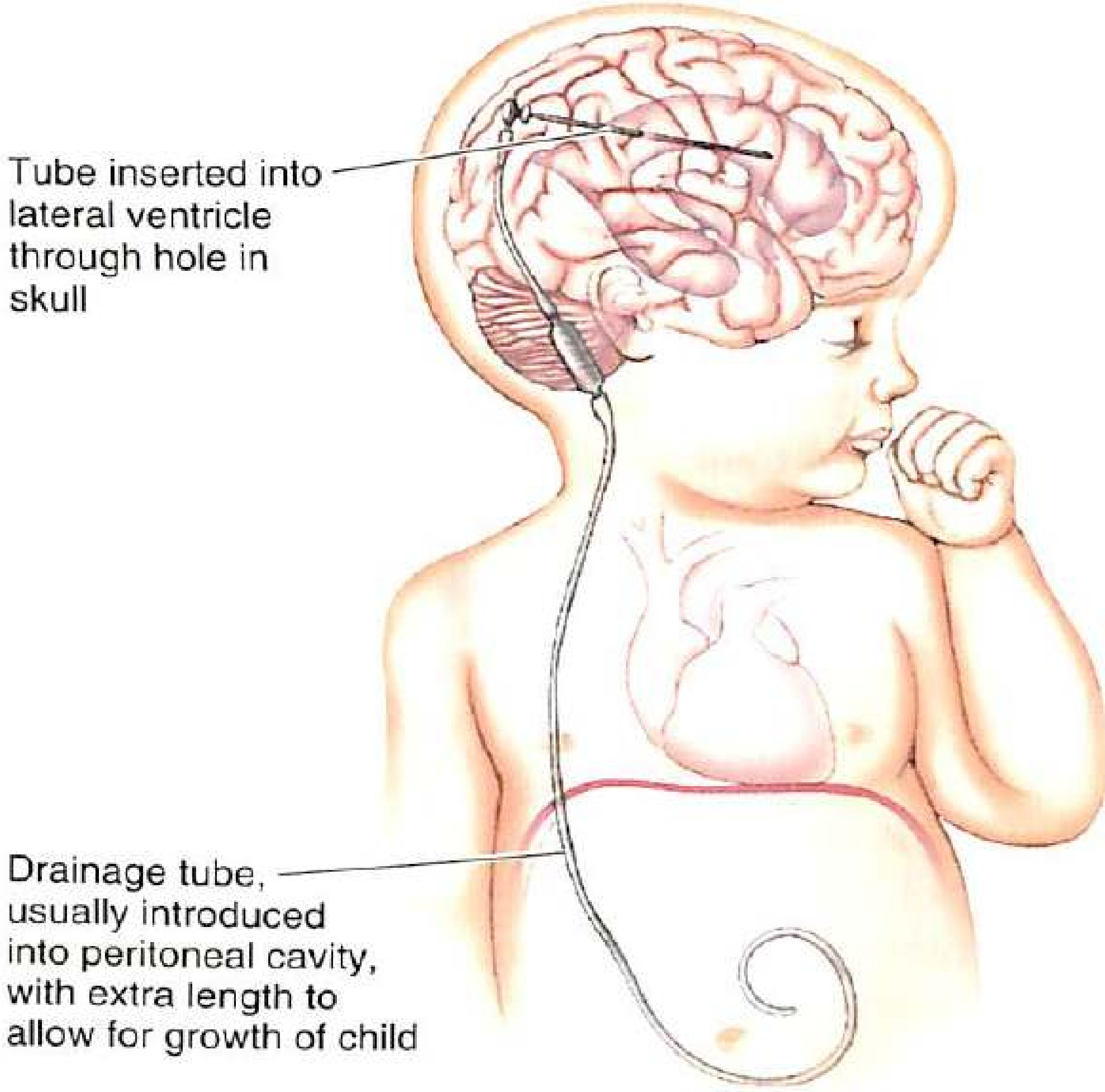
Ventricles and CSF

The brain is protected by the cerebrospinal fluid (CSF) which is around the brain and also fills cavities called ventricles.



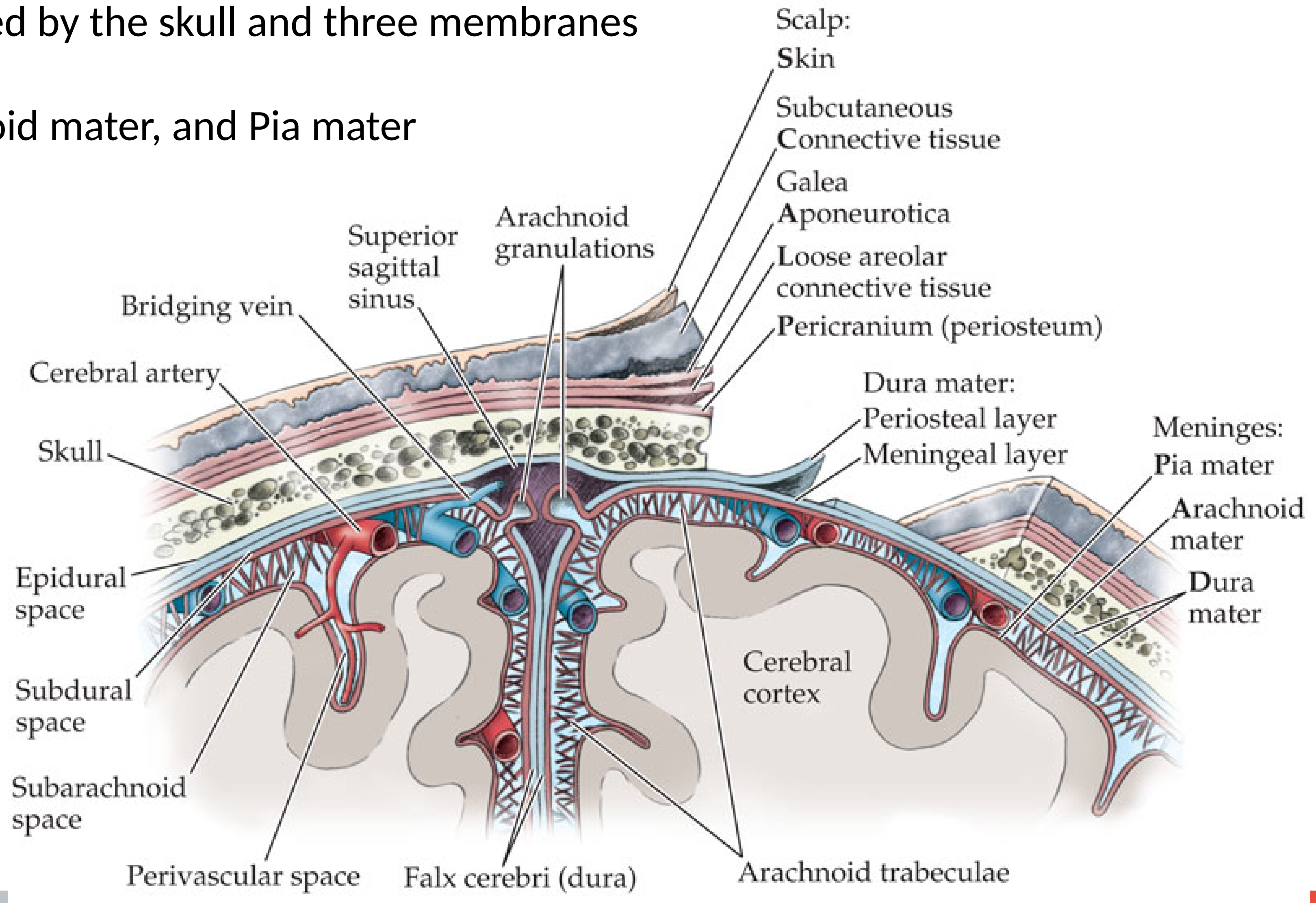
Hydrocephalus

Sometimes, CSF is blocked and builds up, increasing cephalic pressure. This needs drainage to avoid brain damage.

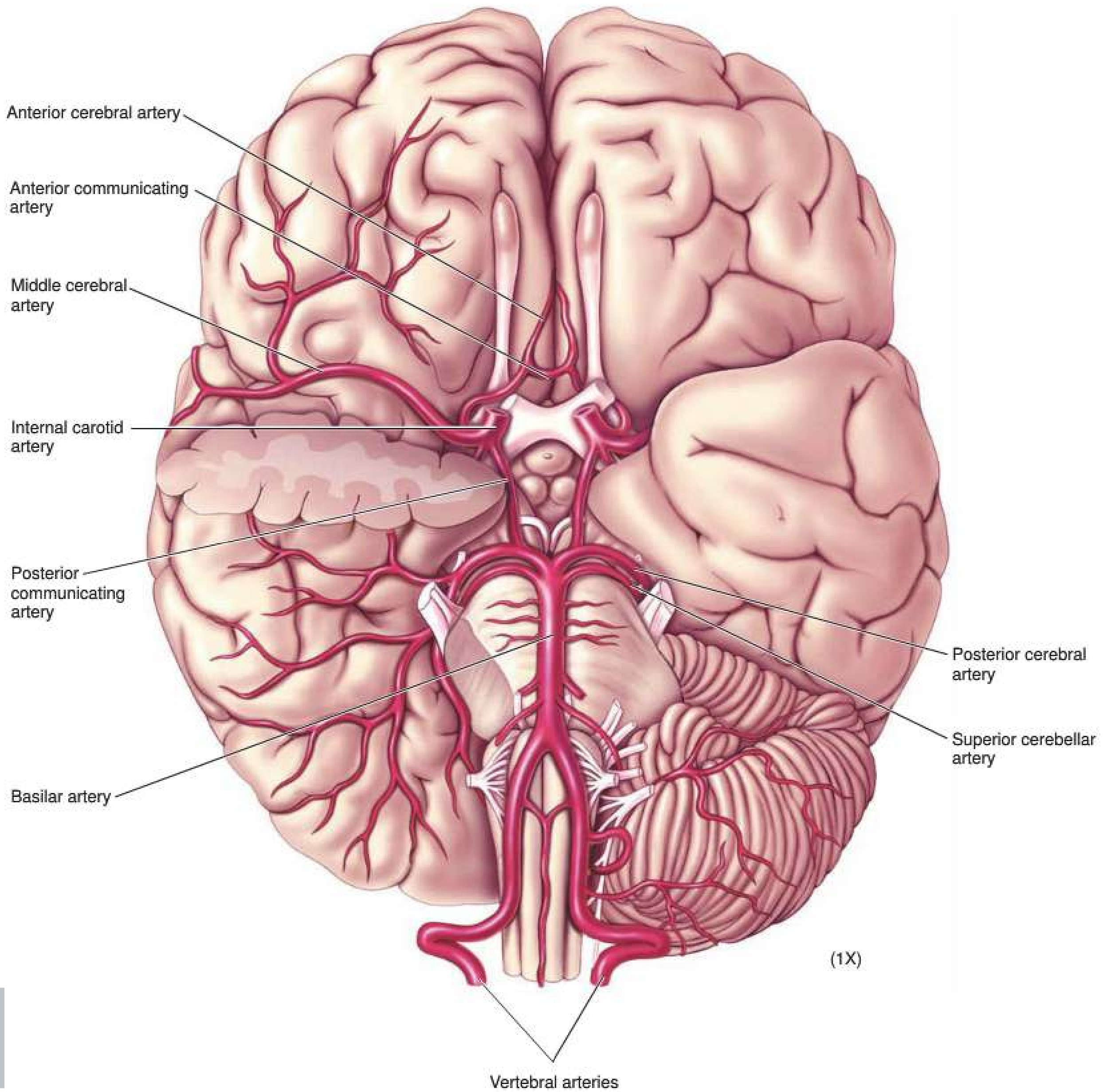


Between brain and scalp

The brain is protected by the skull and three membranes (meninges):
Dura mater, Arachnoid mater, and Pia mater

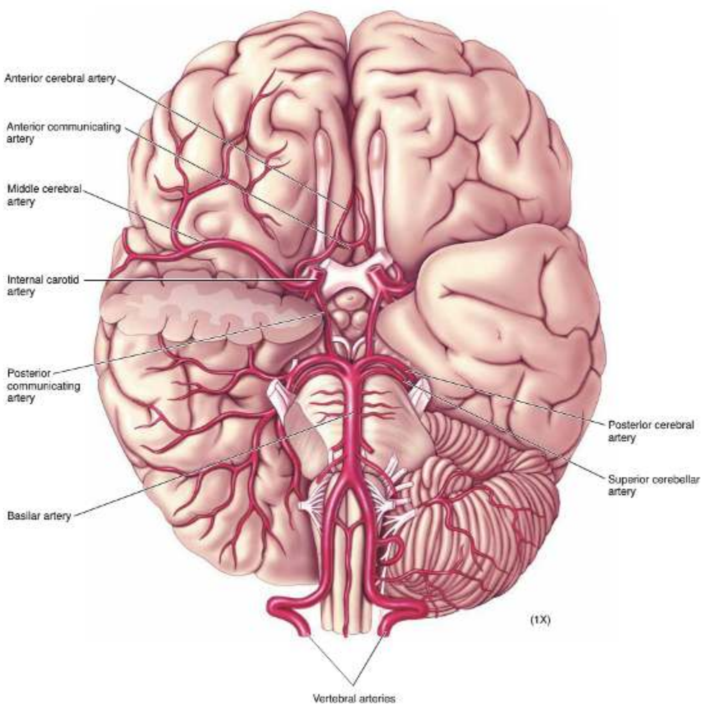


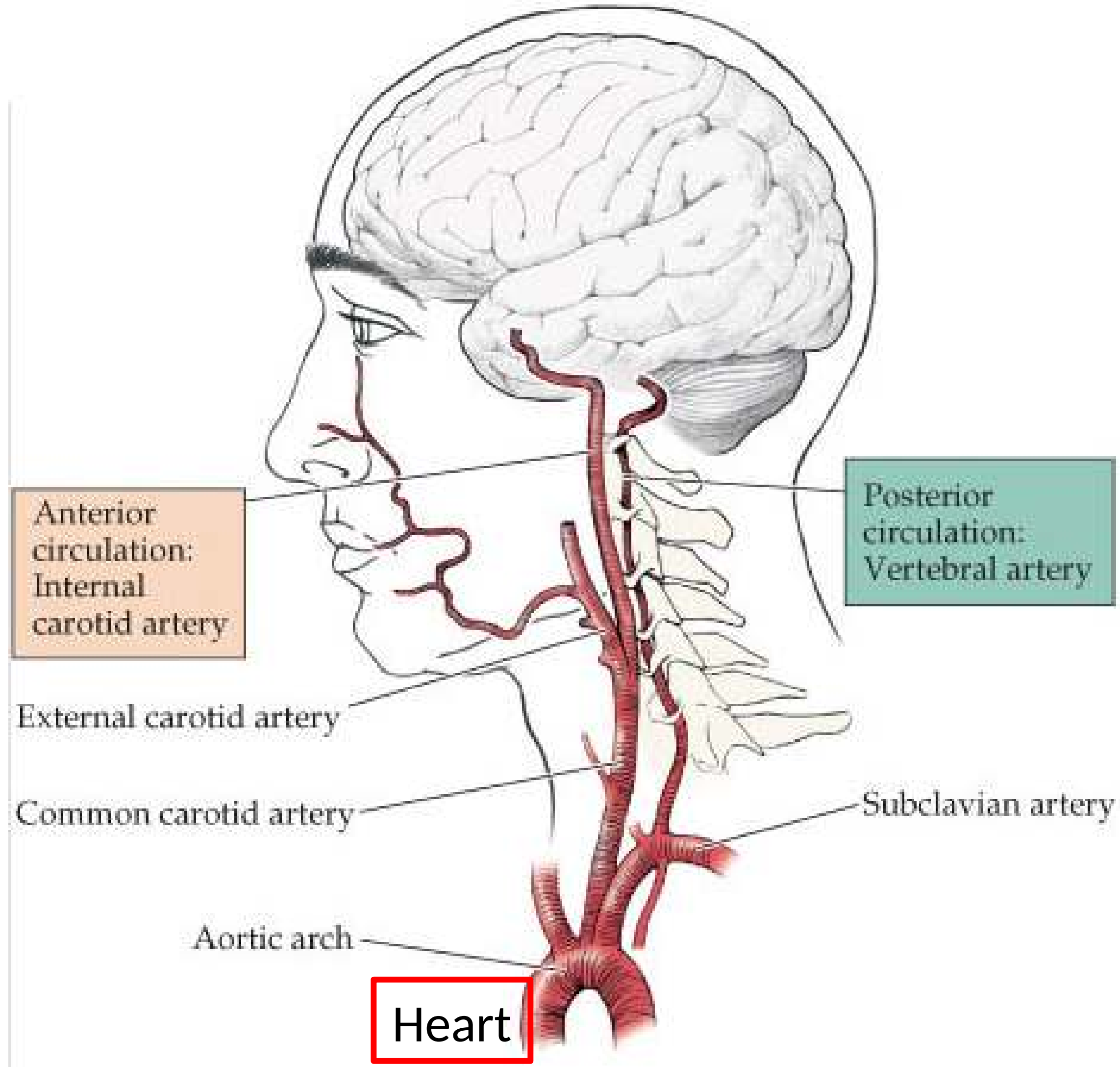
Arterial Blood Supply



Blood to the brain

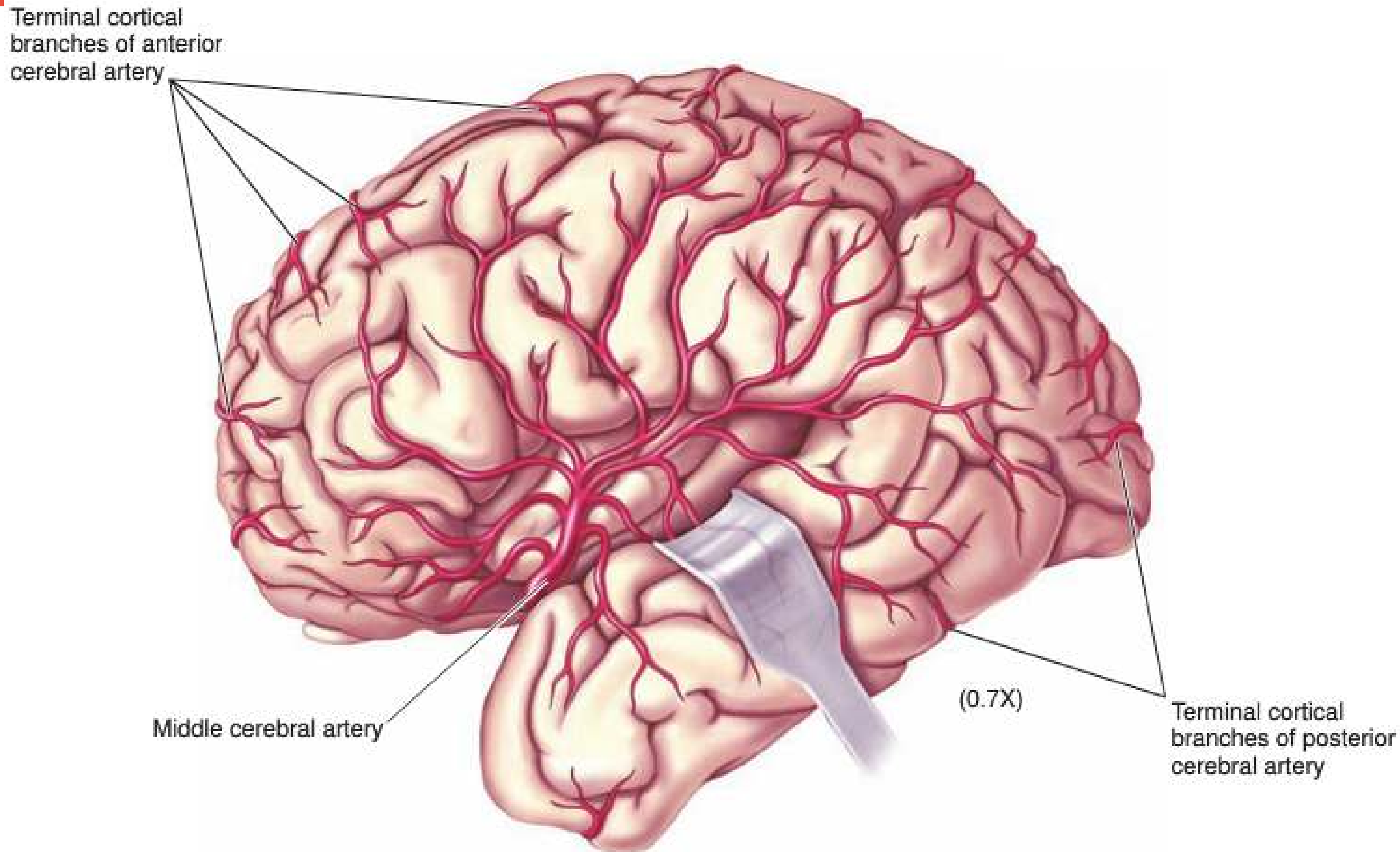
The brain is supplied with blood by the internal carotid and the vertebral arteries.





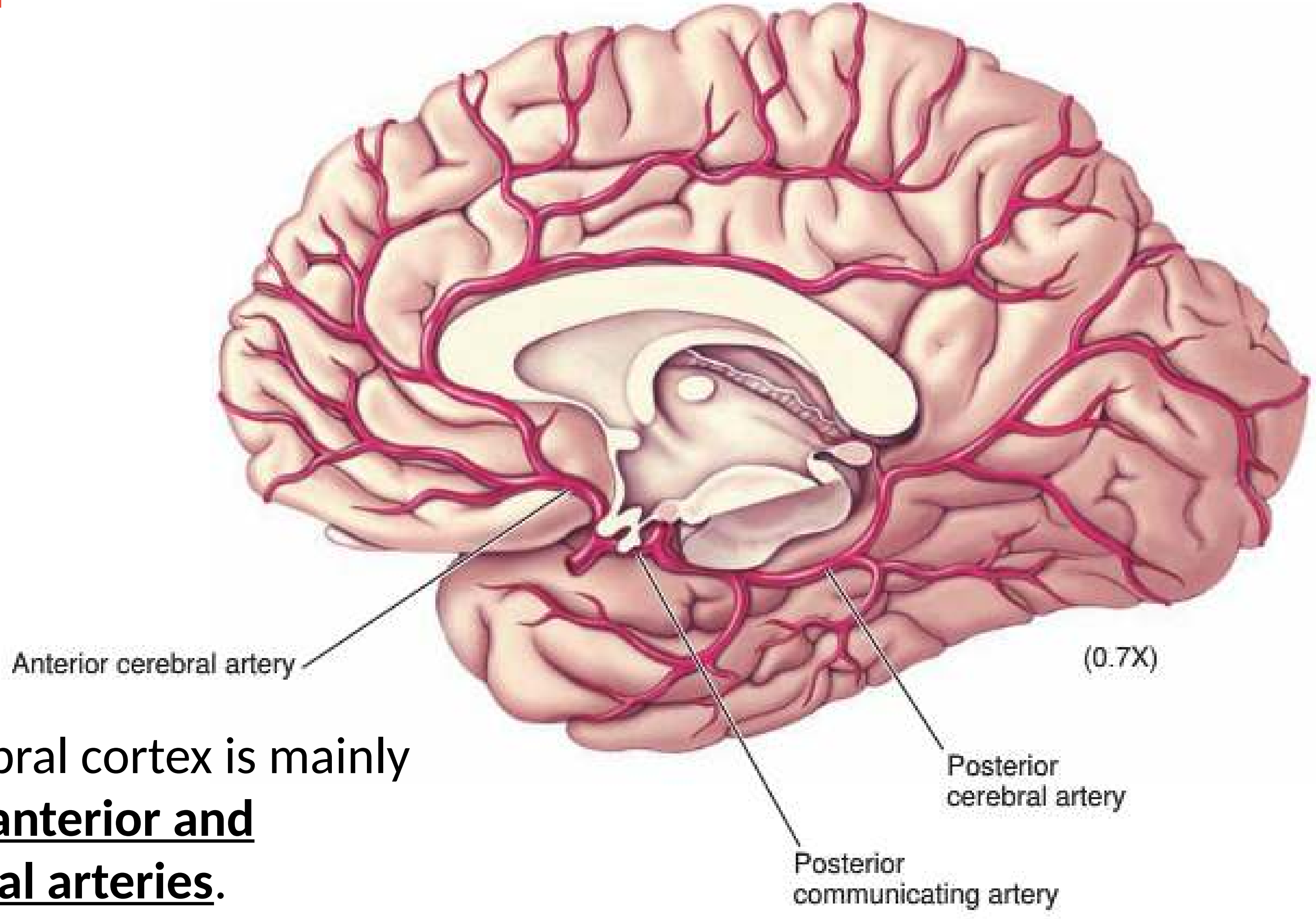
Blumenfeld, Neuroanatomy through Clinical Cases

Blood on the side of the brain



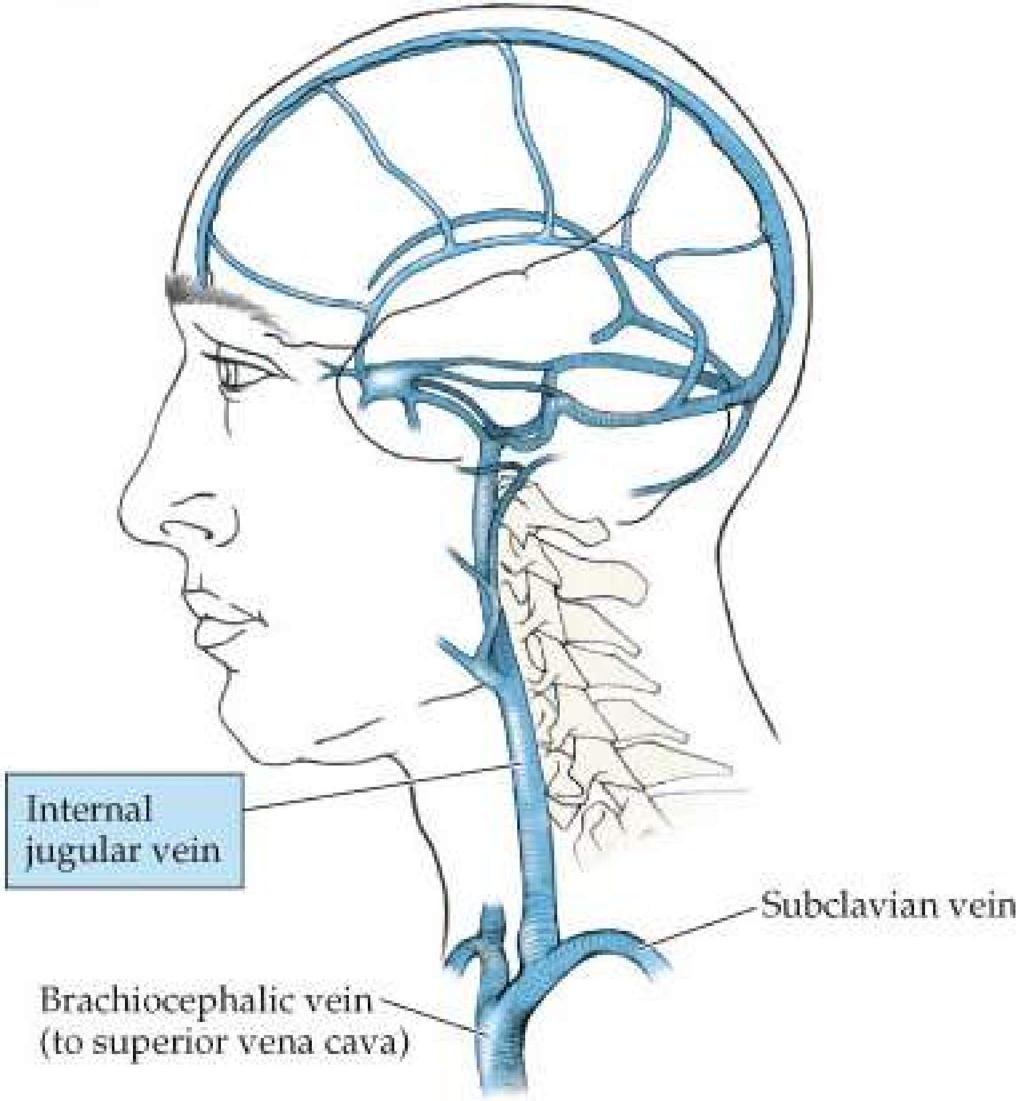
The lateral cerebral cortex is mainly supplied by the **middle cerebral artery**.

Blood in the middle of the brain



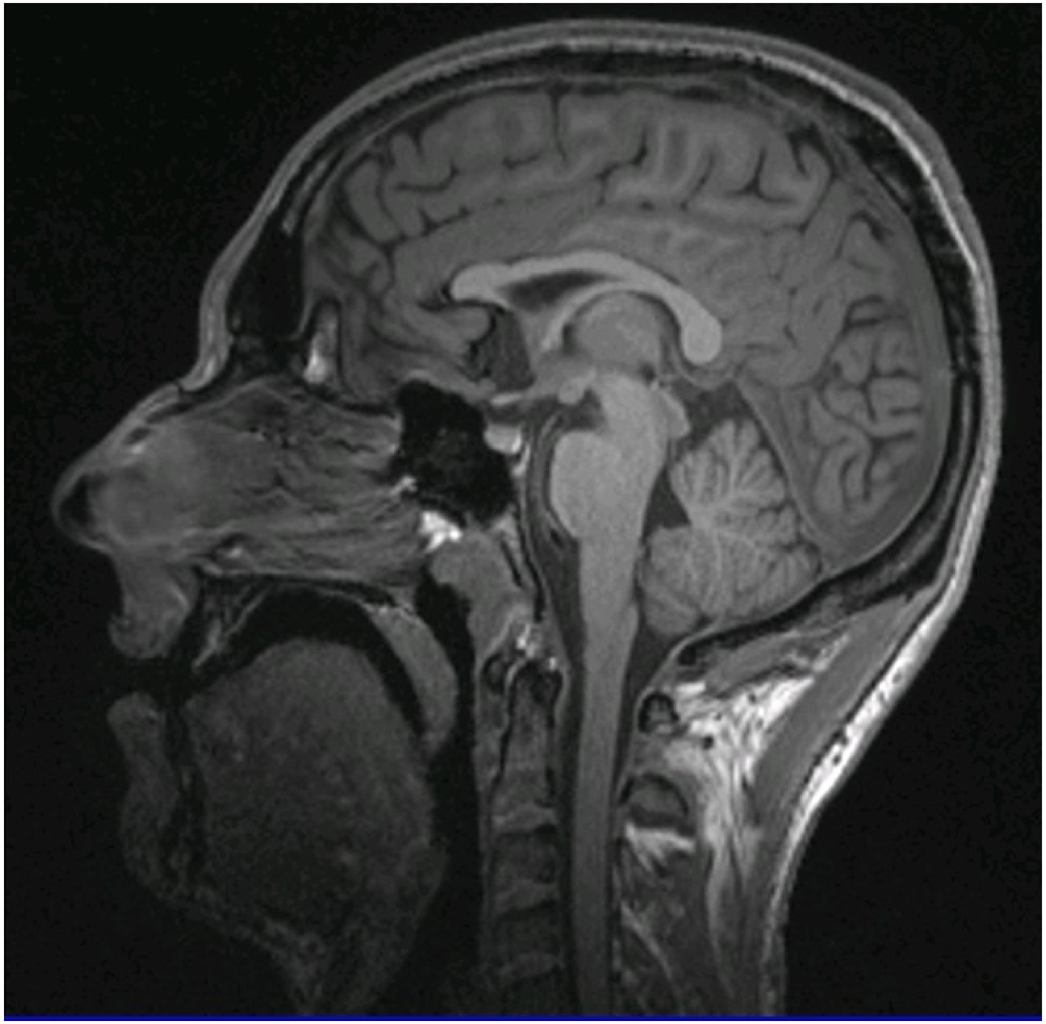
The medial cerebral cortex is mainly supplied by the **<u>anterior and posterior cerebral arteries</u>**.

Veins
Blood going away from the brain



Can you do the following?

- → What type of view (slice) is this?
- → Point out *Corpus Callosum*
- → Point out *Cerebellum*
- → Point out *Brain stem*
- → Point out *Occipital Lobe*

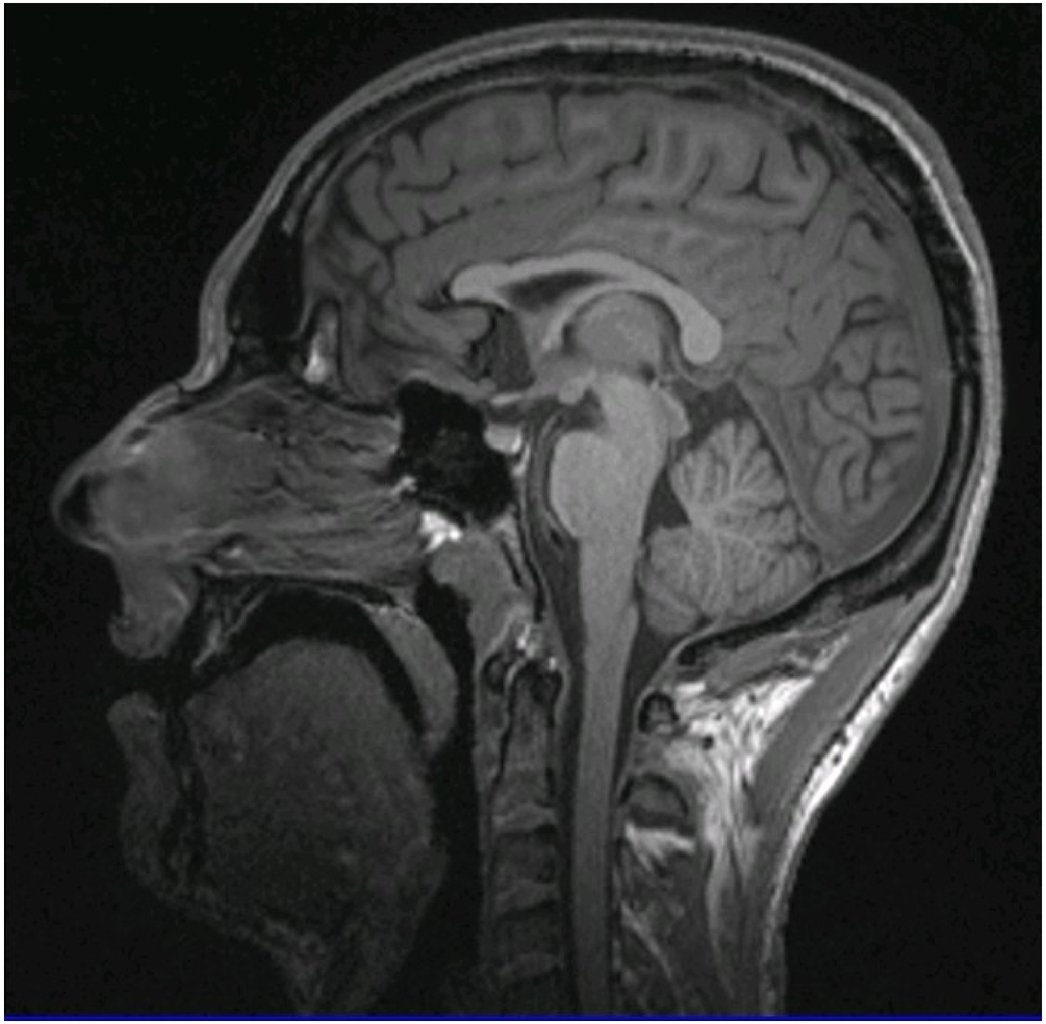


Coarse Anatomy

→ What type of view (slice) is this?

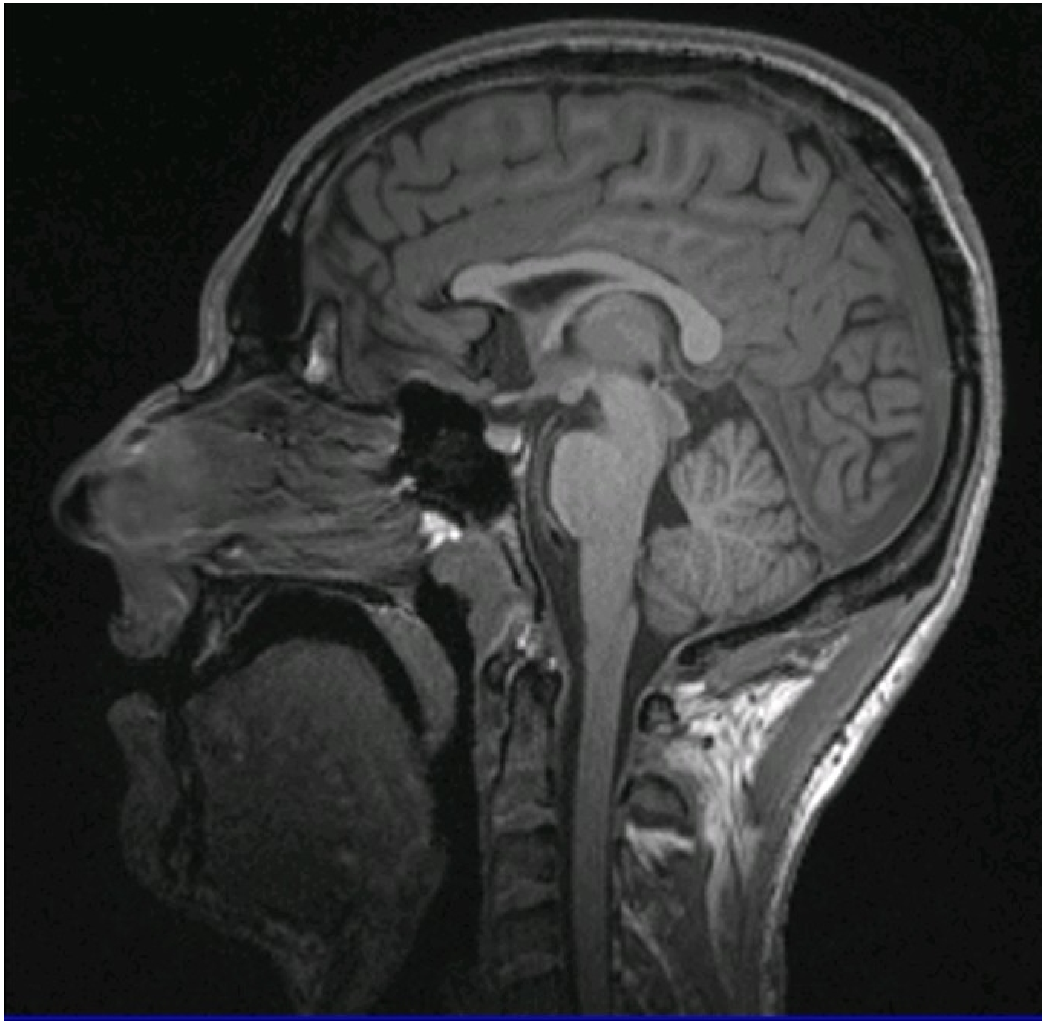
(Para-) sagittal

-It must be near the center because we can see the corpus callosum, but it couldn’t be at exactly the center because then it would be in between the left and right hemispheres and we wouldn’t see much cortex!



Coarse Anatomy

→ Point out *Corpus Callosum*

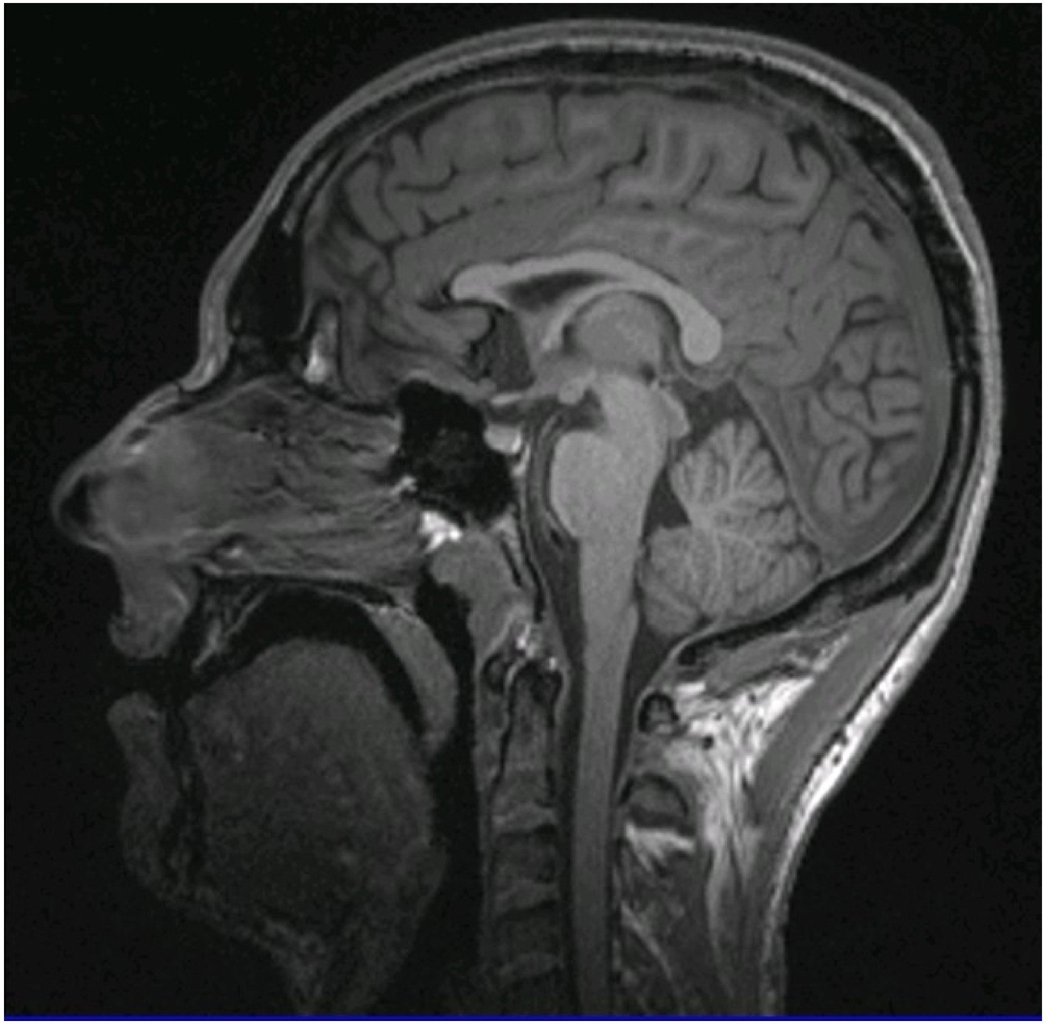


Coarse Anatomy

→ Point out *Corpus Callosum*

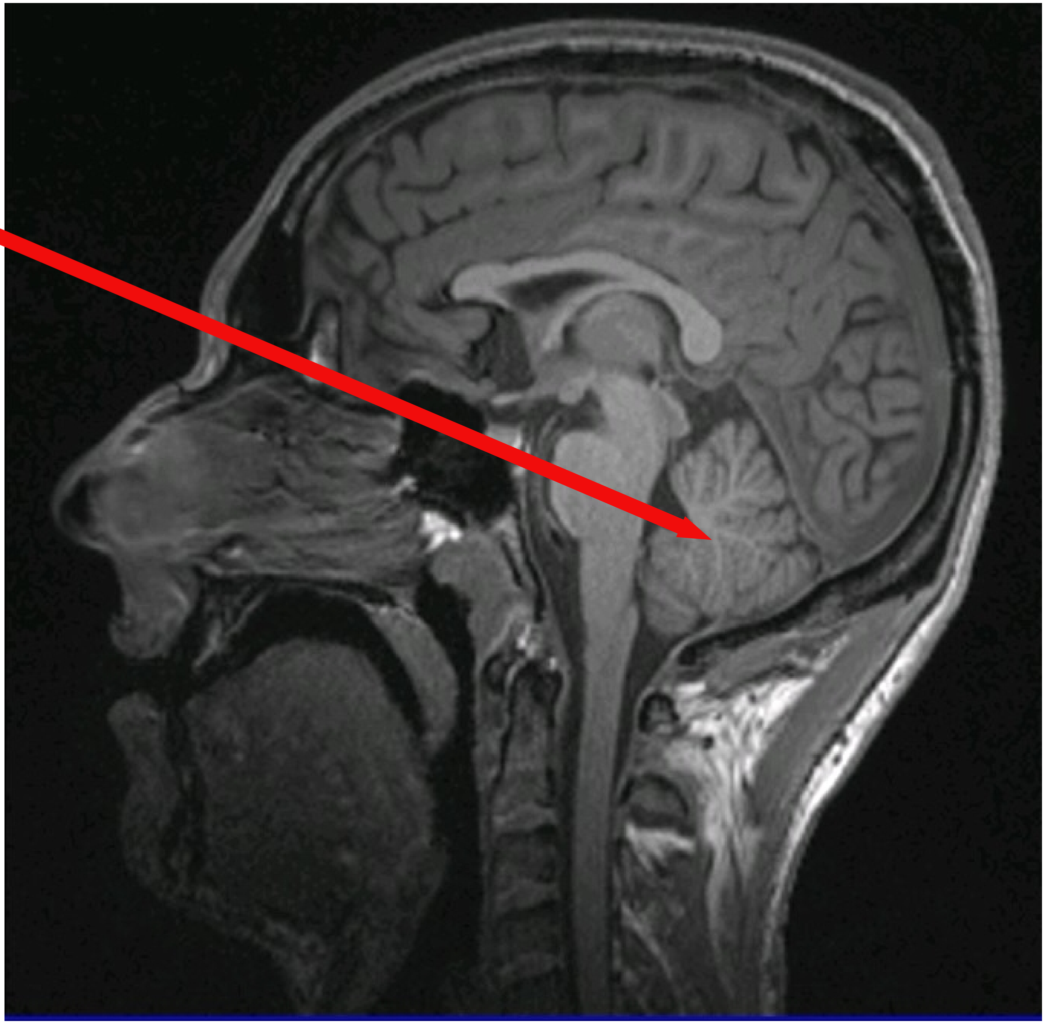
Coarse Anatomy

→ Point out *Cerebellum*



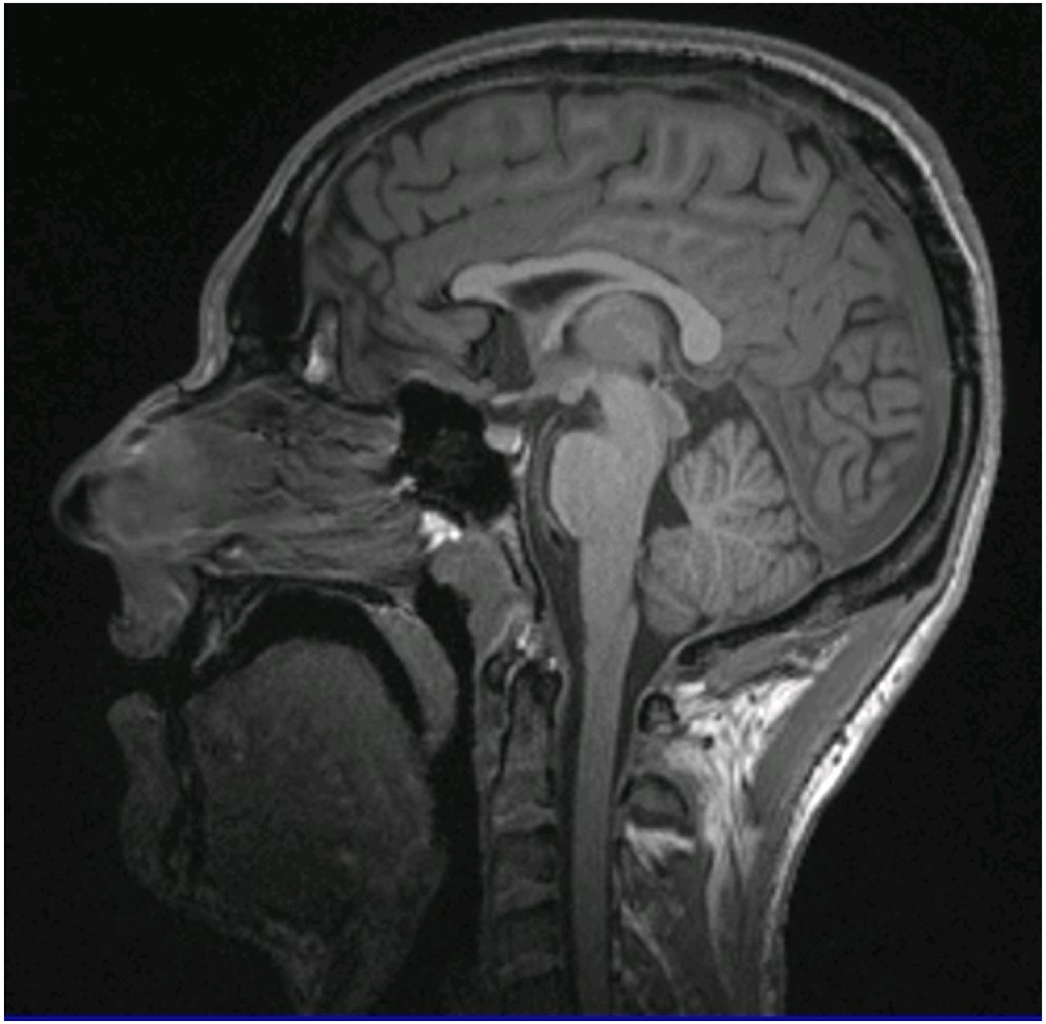
Coarse Anatomy

→ Point out *Cerebellum*



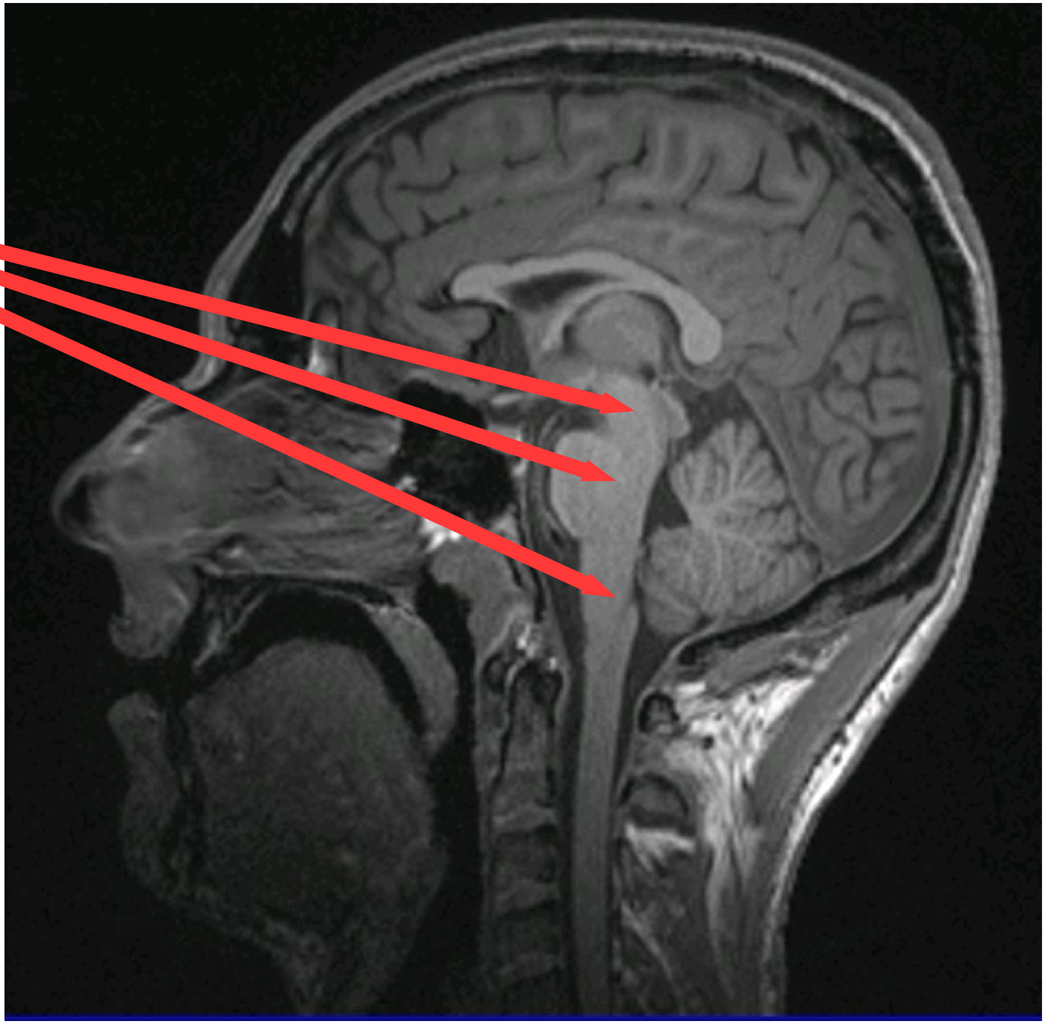
Coarse Anatomy

→ Point out *Brain stem*



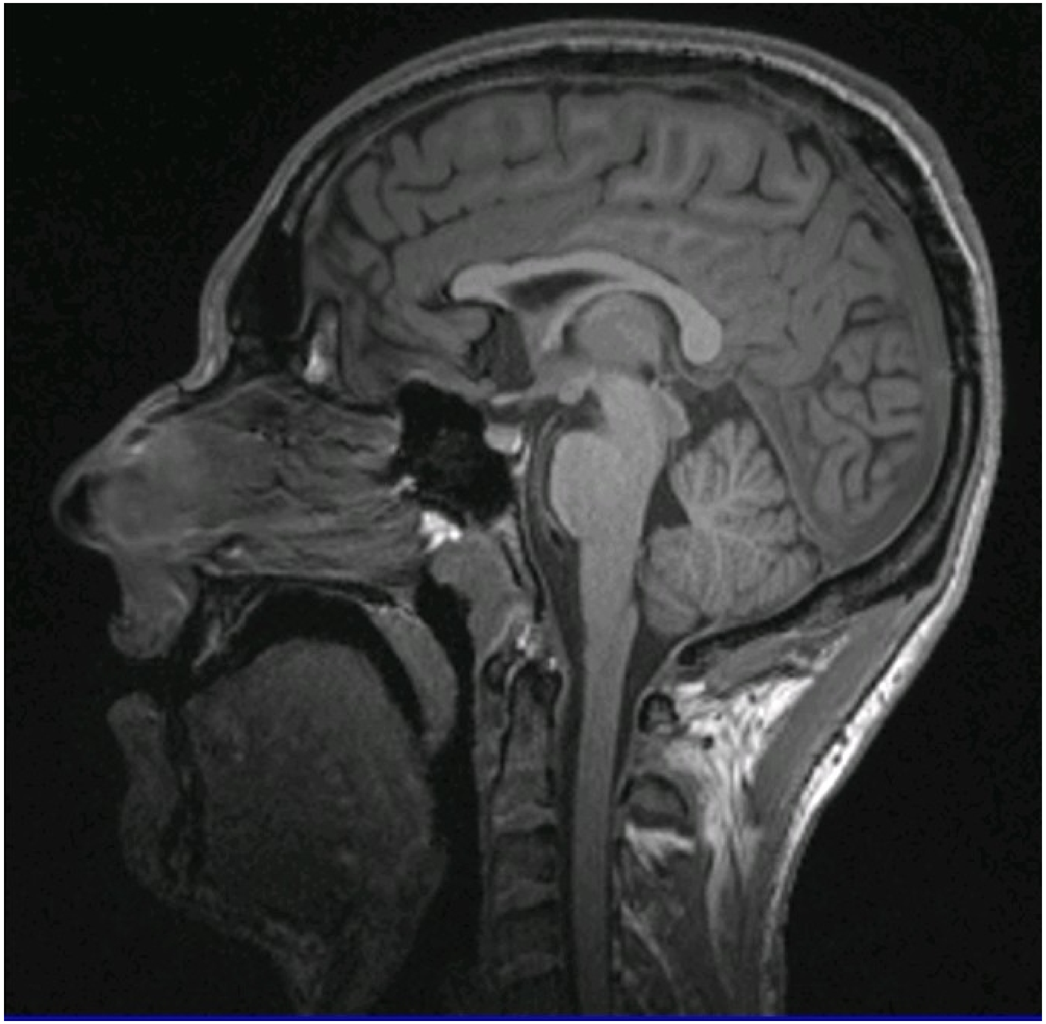
Coarse Anatomy

→ Point out *Brain stem*



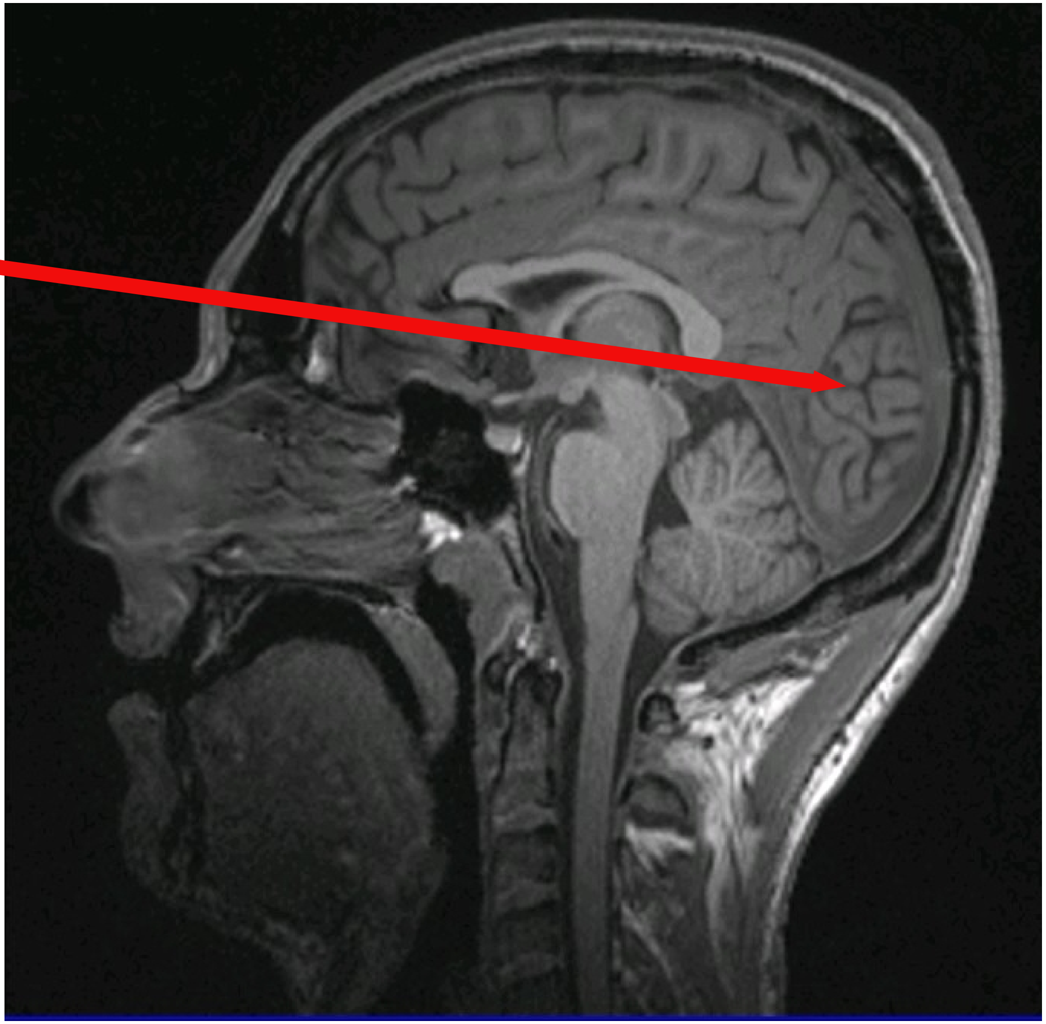
Coarse Anatomy

→ Point out *Occipital Lobe*



Coarse Anatomy

→ Point out *Occipital Lobe*



Coarse Anatomy

Today:

1) Learn major structures of (human) brain.
2) Learn about cerebro-spinal fluid and blood supply.