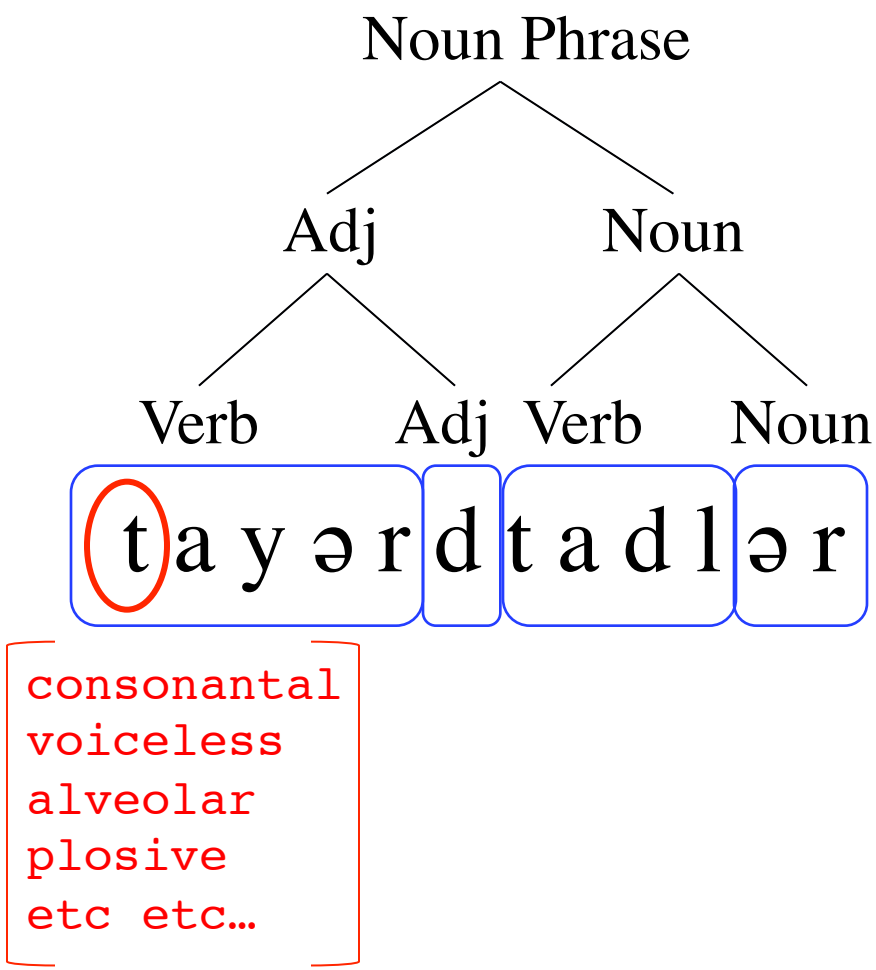
The human brain

The human brain

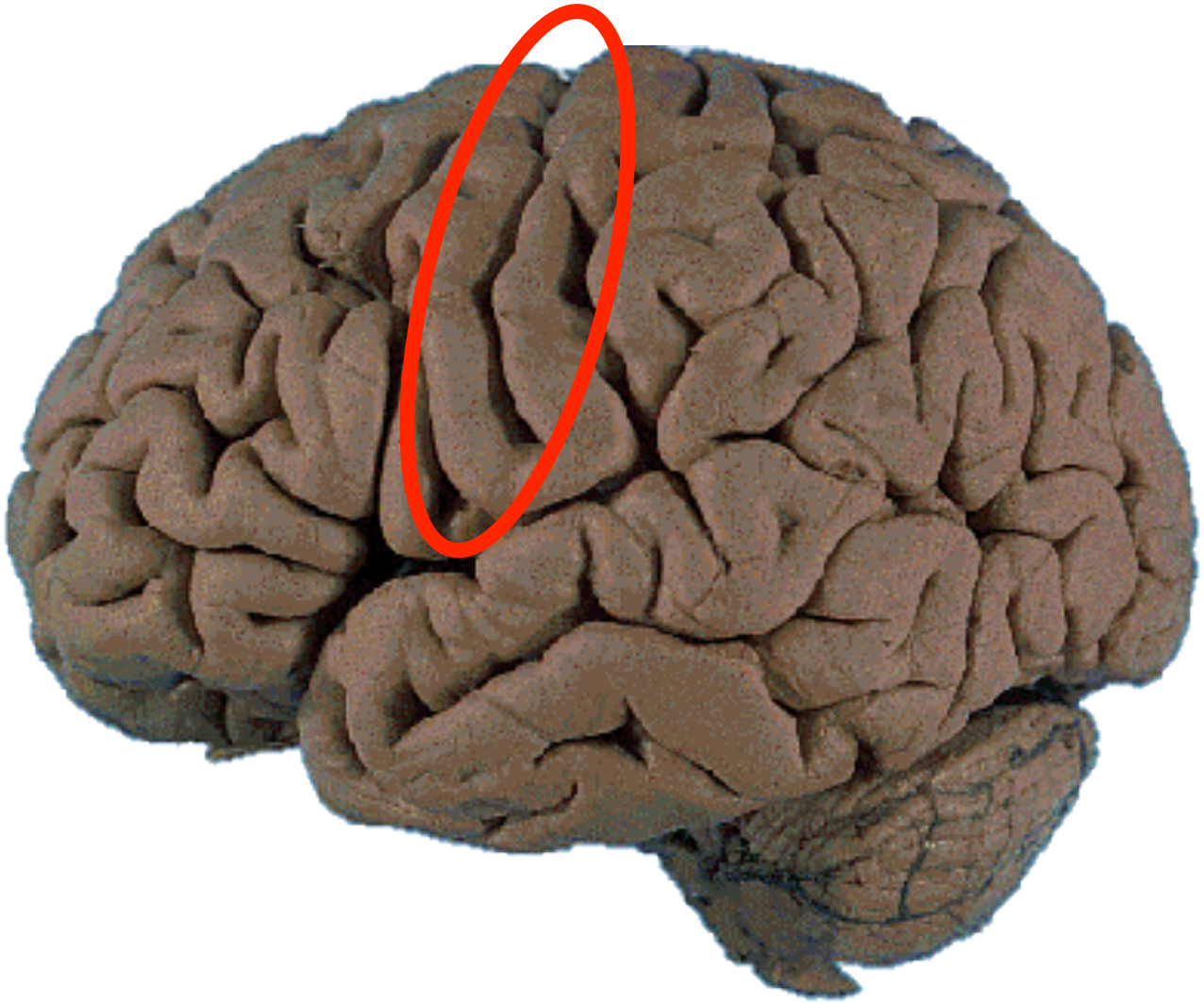
- What is the basic physiology of this organ?
- Understanding the parts of this organ provides a hypothesis space for its function – perhaps different parts perform different functions?
- Theories of the neurobiology of cognition need to make sense gives the structure of the brain (duh).

The parts list of language



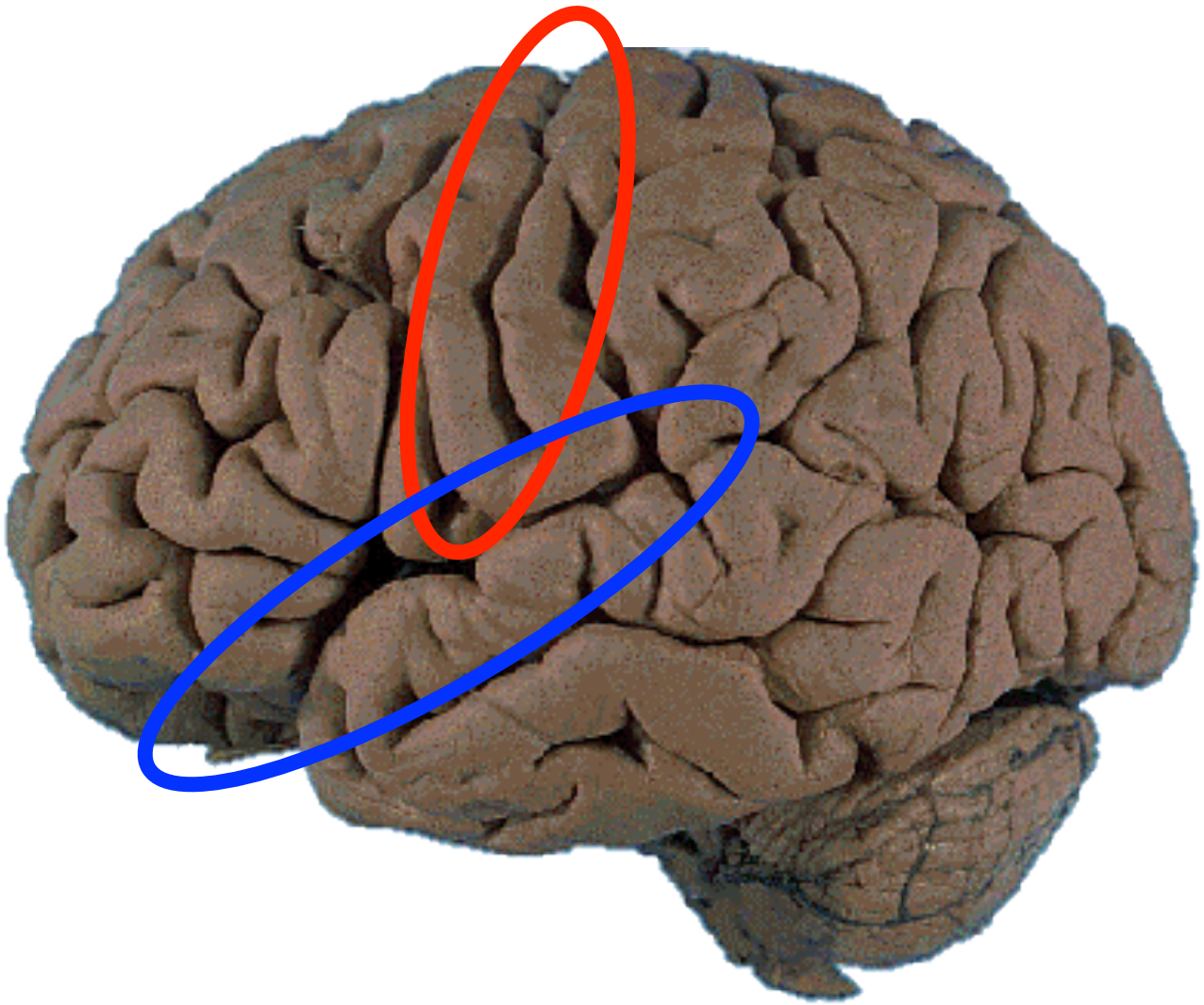
The parts list of the brain

Descriptive observations:
1. The brain is wrinkled



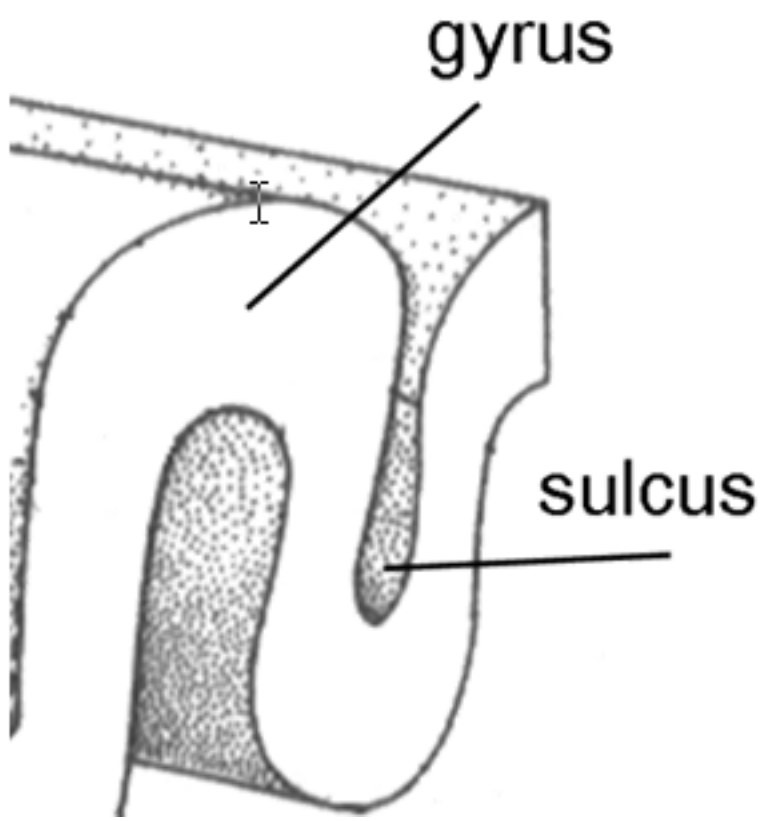
We can look for major anatomical features

Descriptive observations:
1. The brain is wrinkled



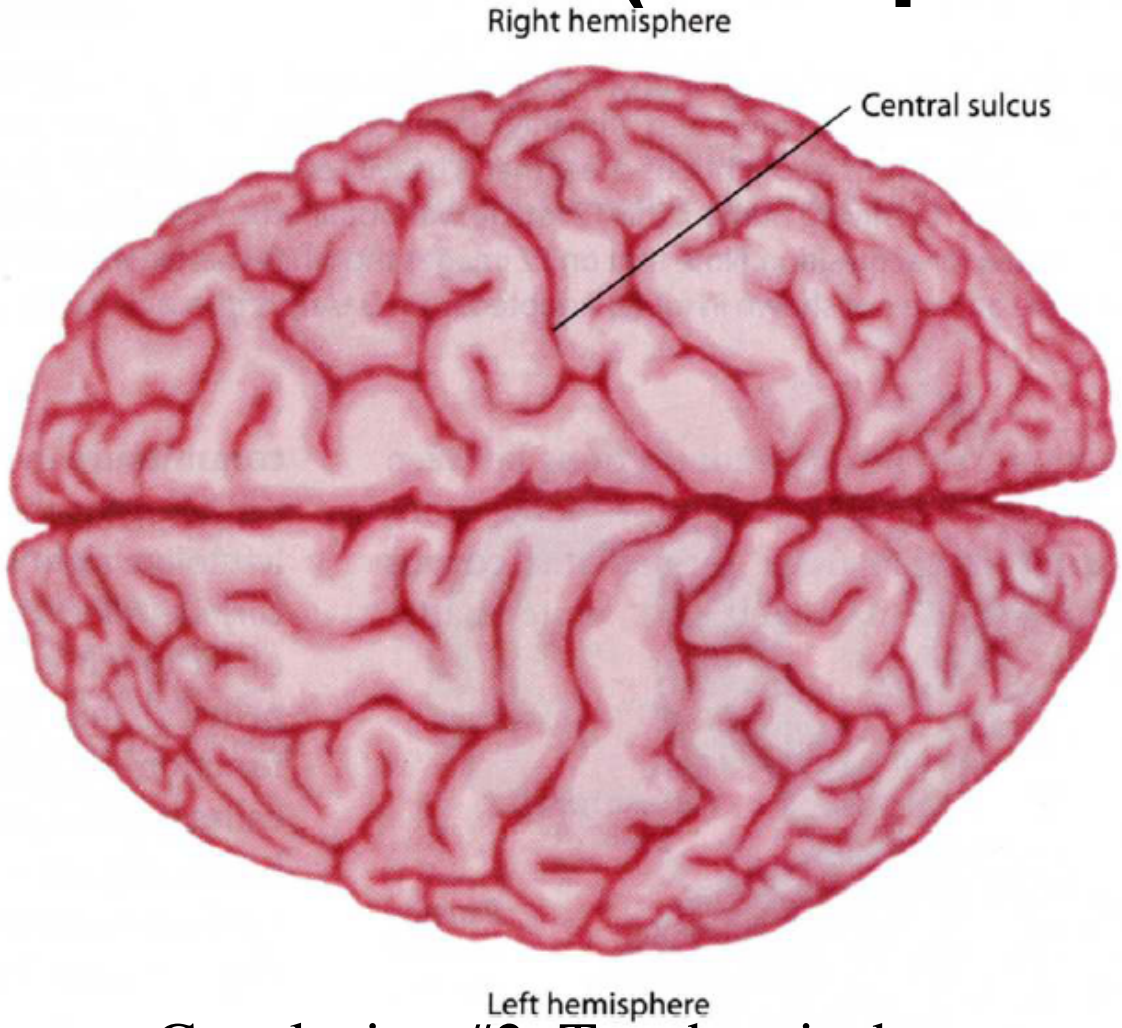
We can look for major anatomical features

Descriptive observations:
1. The brain is wrinkled



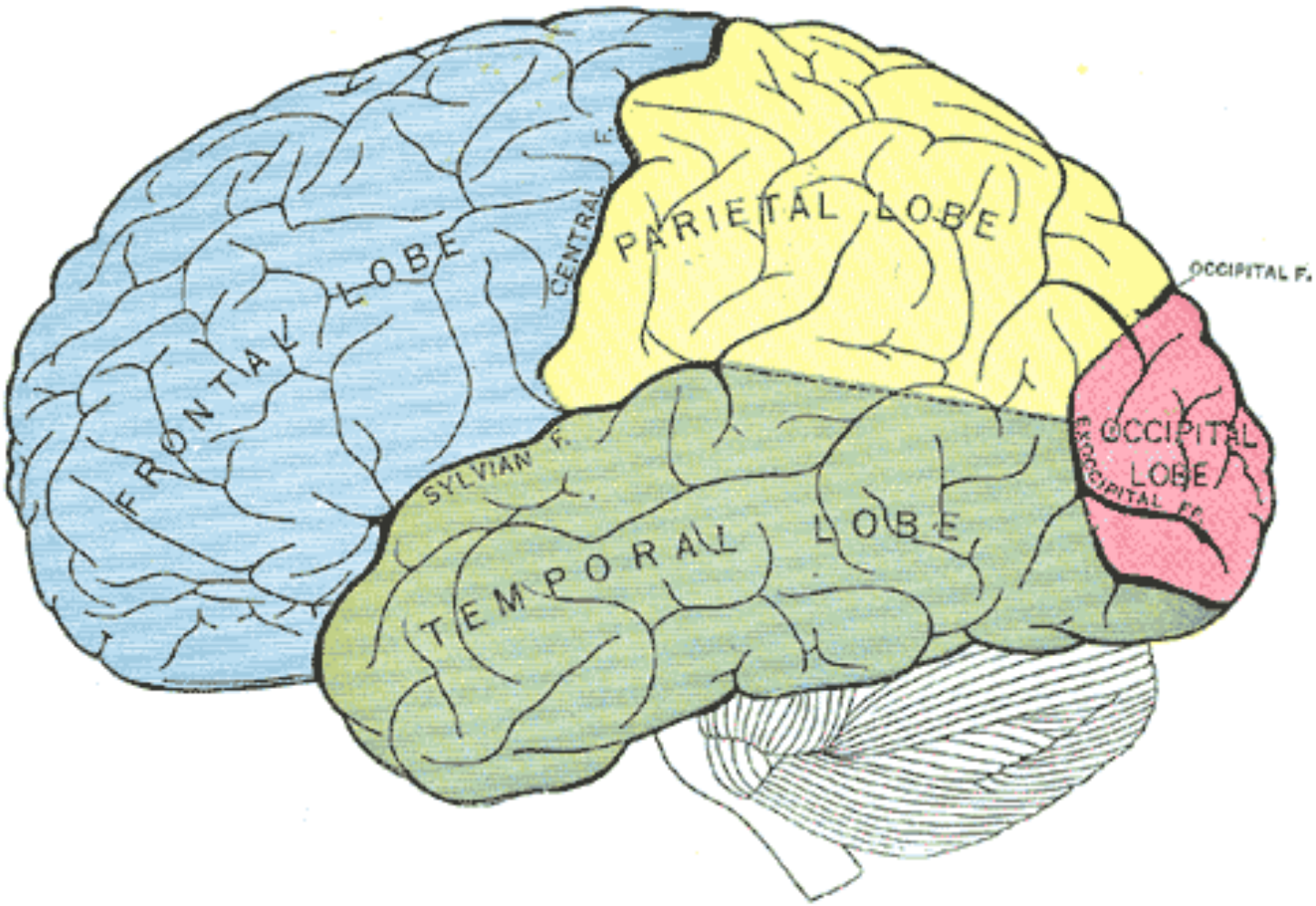
Conclusion #1: Folded surface, series of sulci and gyri

Descriptive observations:
2. Two halves that look like mirror images of each other (hemispheres)

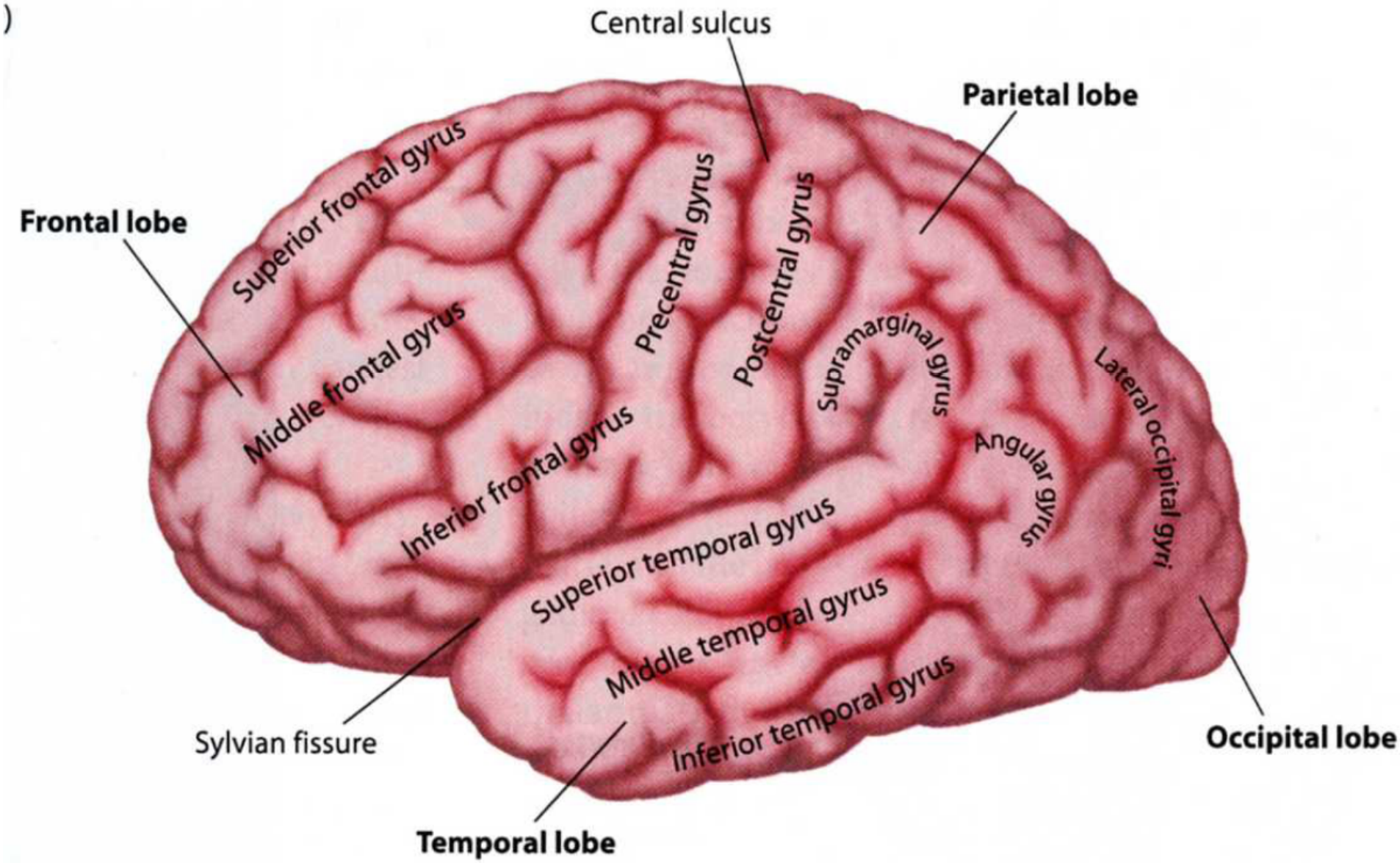


Conclusion #2: Two hemispheres

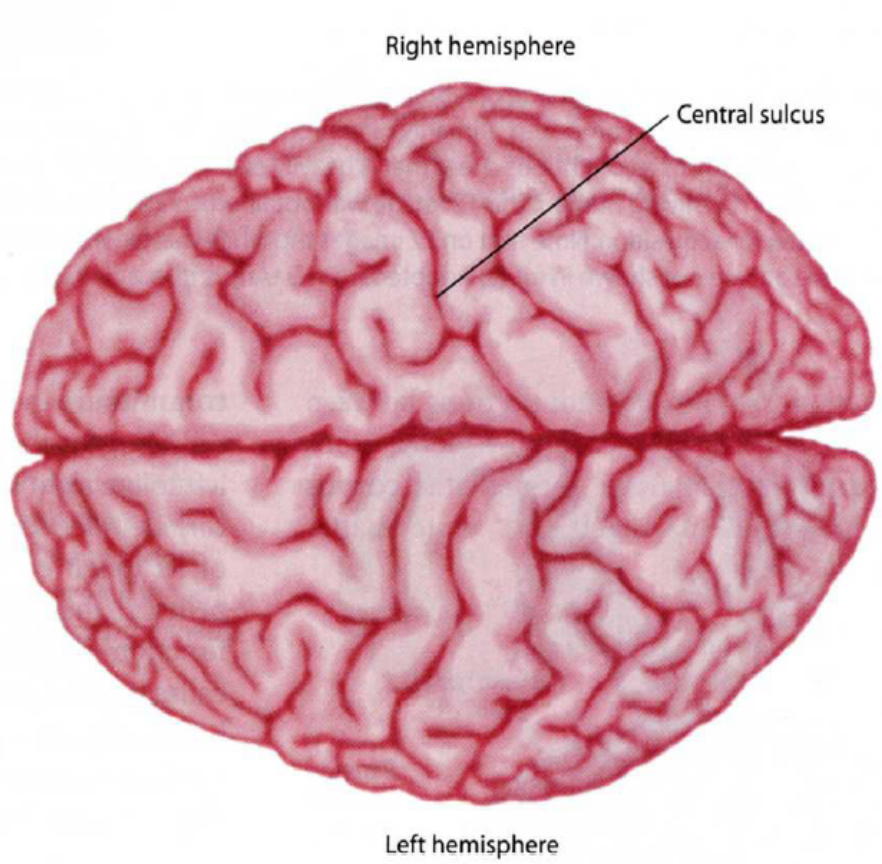
Each hemisphere is can be divided into 4 section, divided by big sulci: LOBES

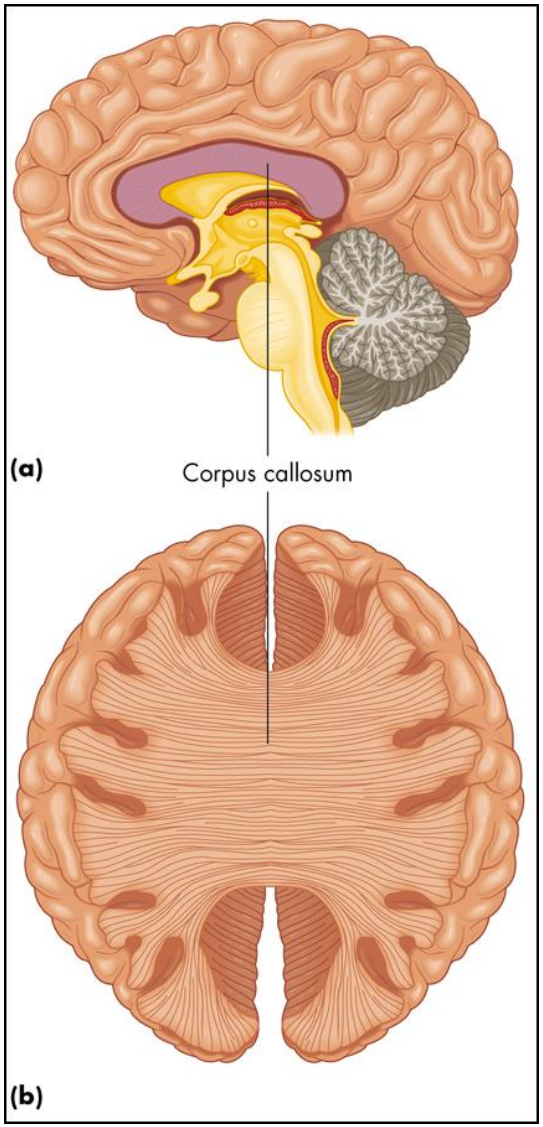


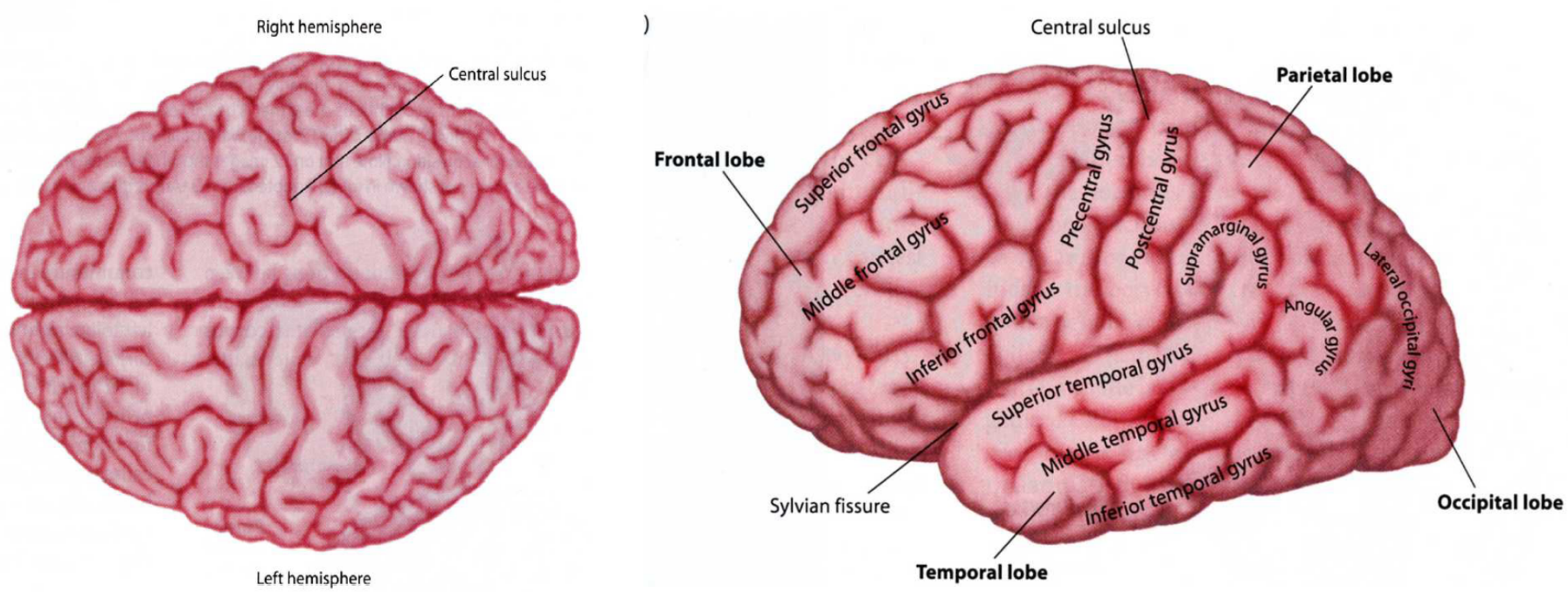
Consistent gyri and sulci across individuals within the lobes



The corpus collossum connects the two hemispheres.



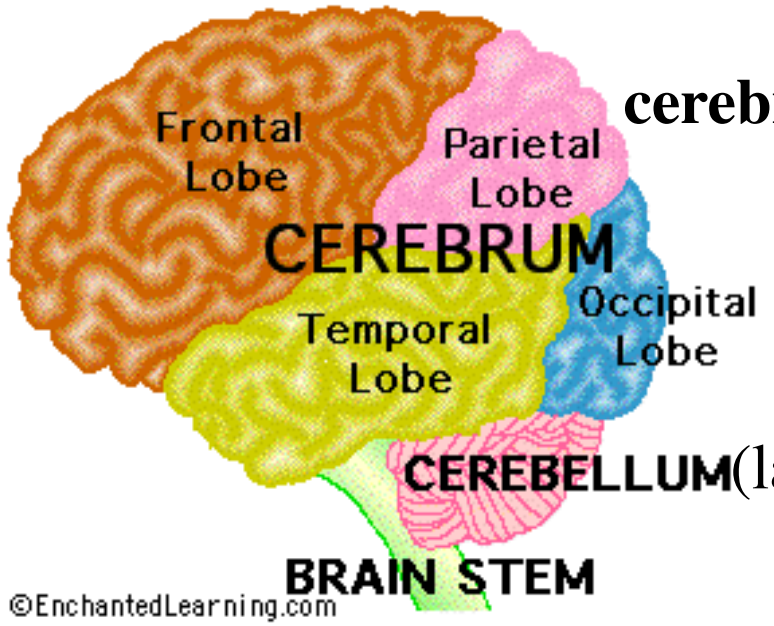




So now we know that brains can be characterized in terms of their major visible anatomical features:

a) Sulci (or fissures) and gyri can be used as boundaries for areas

b) The brain has two hemispheres, connected by a massive bundle of neural tissue



cerebrum (latin for brain)

(latin for 'little brain')

So now we know that brains can be characterized in terms of their major visible anatomical features:

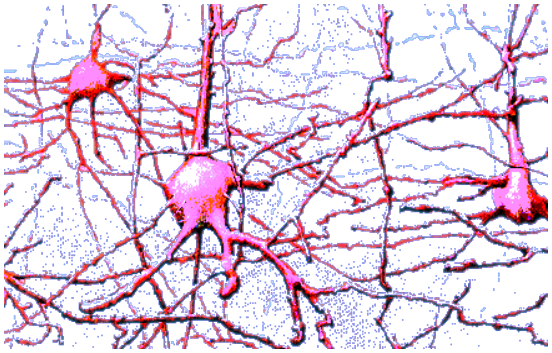
a) Sulci (or fissures) and gyri can be used as boundaries for areas

b) The brain has two hemispheres, connected by a massive bundle of neural tissue

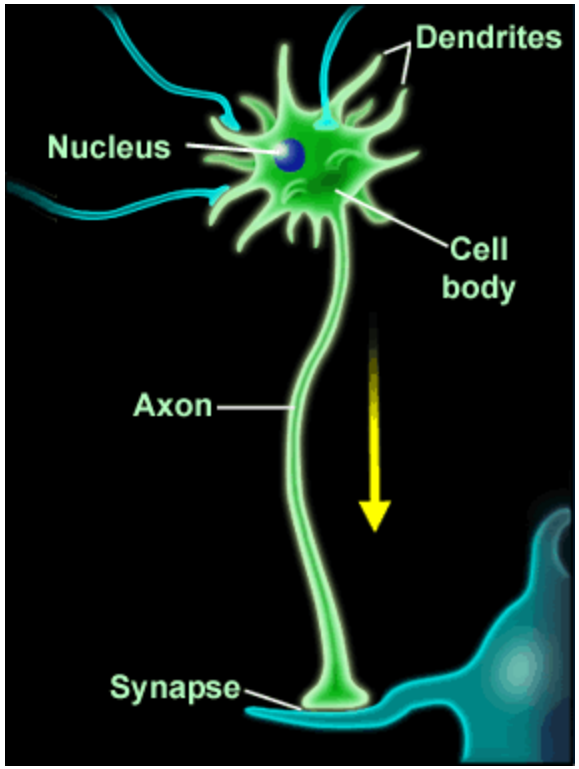
c) There are some other anatomically distinct areas, like the cerebellum and the brain stem

What are the brain areas made of?

Neurons

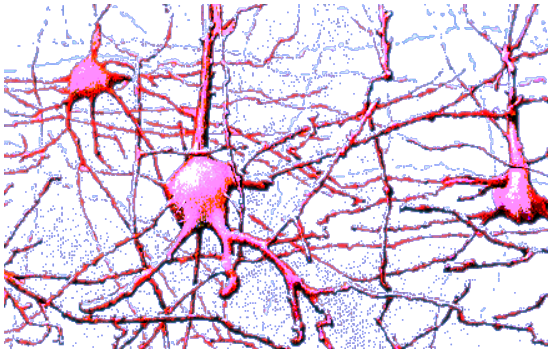


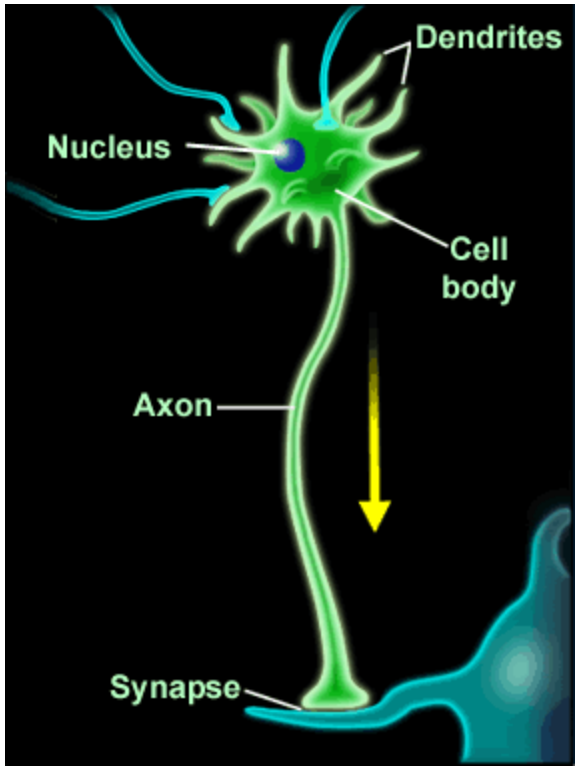
- Central nervous system is made up of about 100 billion neurons.
- Unlike other cells in that they can both receive and send out signals to neighboring neurons in the form of electrical pulses.



Neurons

- Typically a given neuron is connected to about ten thousand other neurons.
- The specific point of contact between the axon of one cell and a dendrite of another is called a synapse.





Neurons

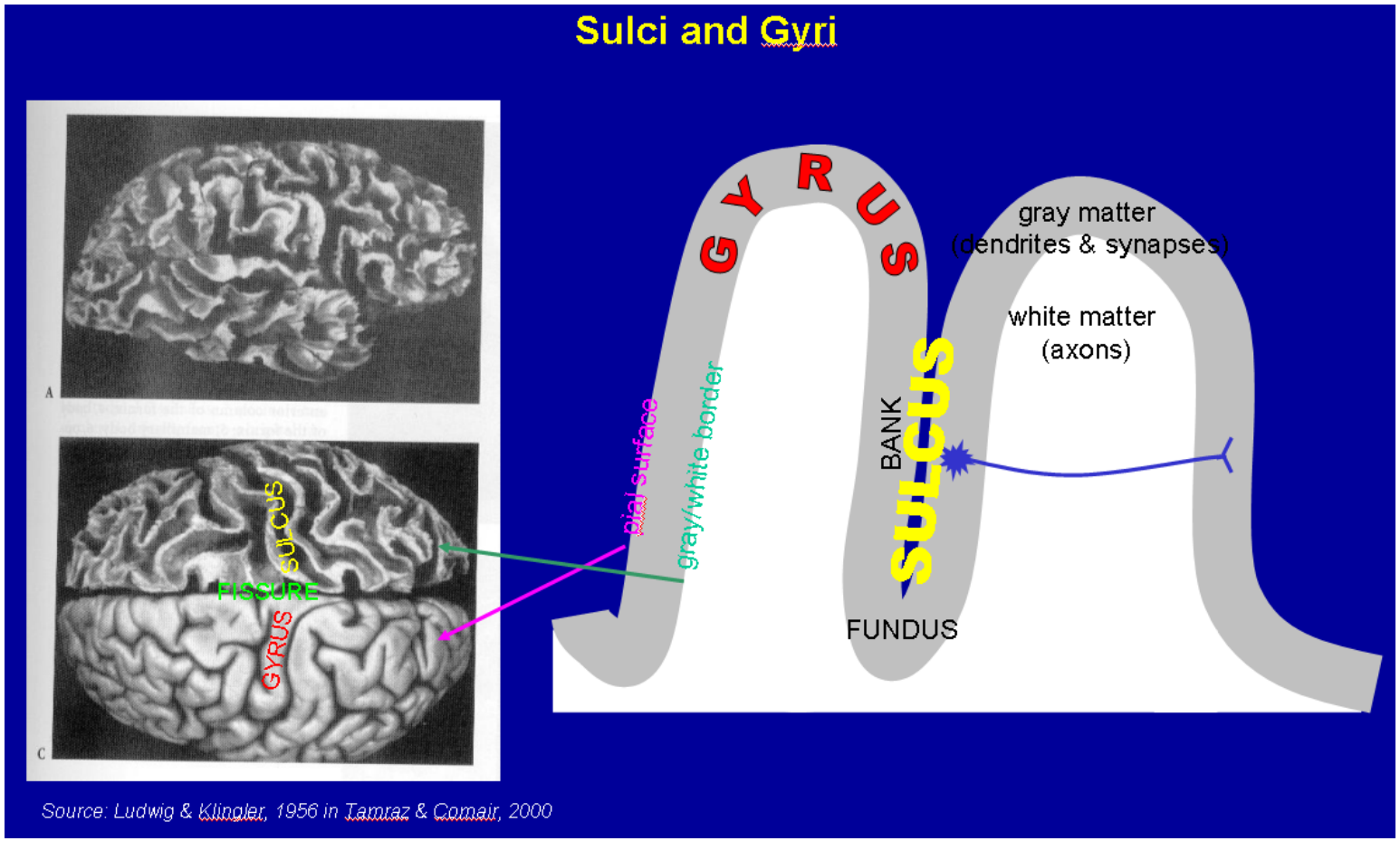
- We are born with a complete set of neurons.
- What changes in maturation is the connections between the neurons.
- On average, we lose about 20% of our neurons by the time we die.

Neurons

http://www.dnatube.com/video/1107/Neurons-and-How-They-Work

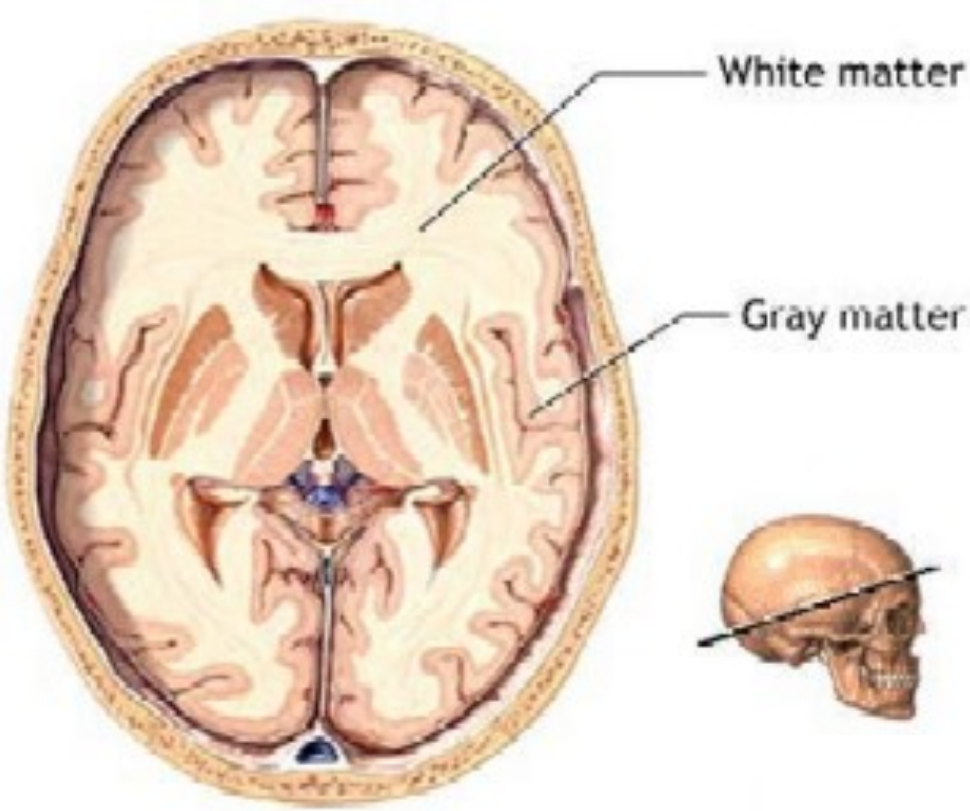
Cortex

- about two millimeters thick and has a total surface area of about 1.5 square-meters



Grey and white matter

- Grey matter
  - **cortex**
  - **unmyelinated nerve cells**
- White matter
  - **myelinated nerve fibers**
  - **the tissue through which messages pass between different area of grey matter**



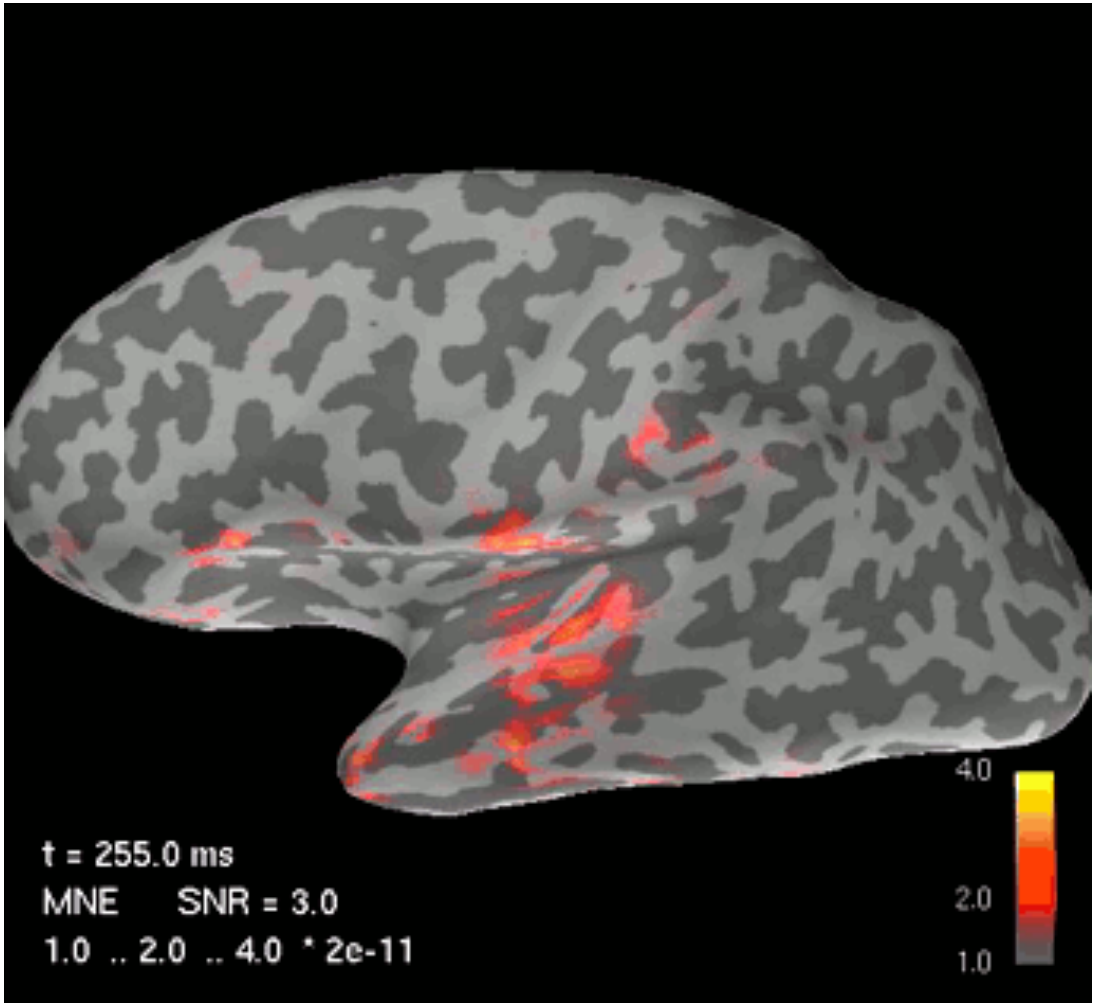
- More specifically: Myelination is most abundant in white matter but significant amounts of myelinated fibers are also present in the cortical gray matter.

How fast is the brain?

- After a neuron has fired, it takes it about one millisecond to return to its normal state.
- Much slower than your computer!
- The secret of the brain lies in the vast number of neurons (tens of billions) and the complicated way they are connected.

Blown-up cortex

Blown-up cortex



Cortical layers

- Cytoarchitectonics: the arrangement of nerve cells in the cerebral cortex

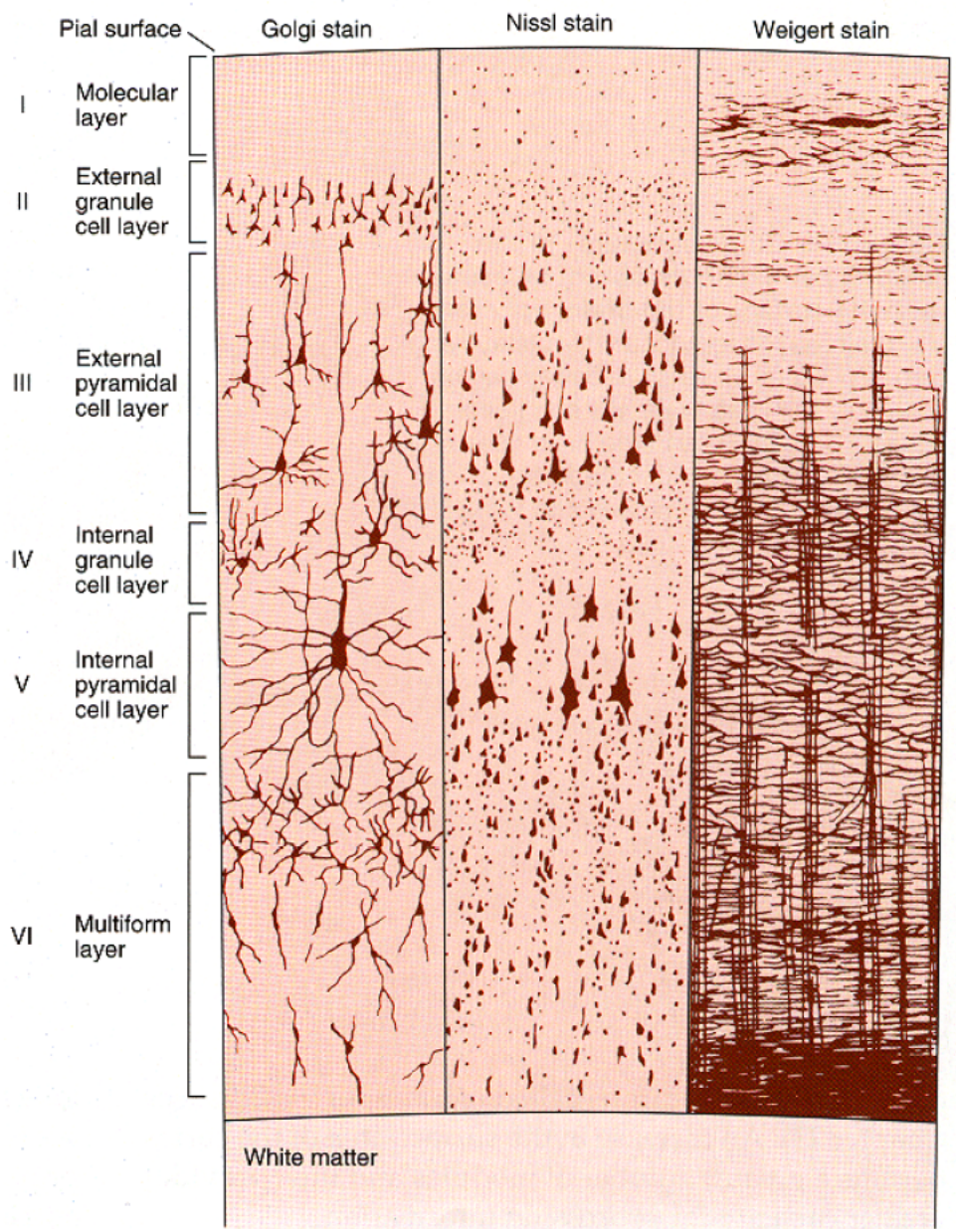
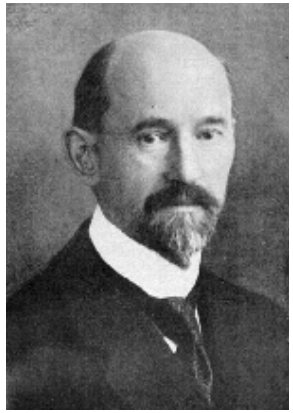


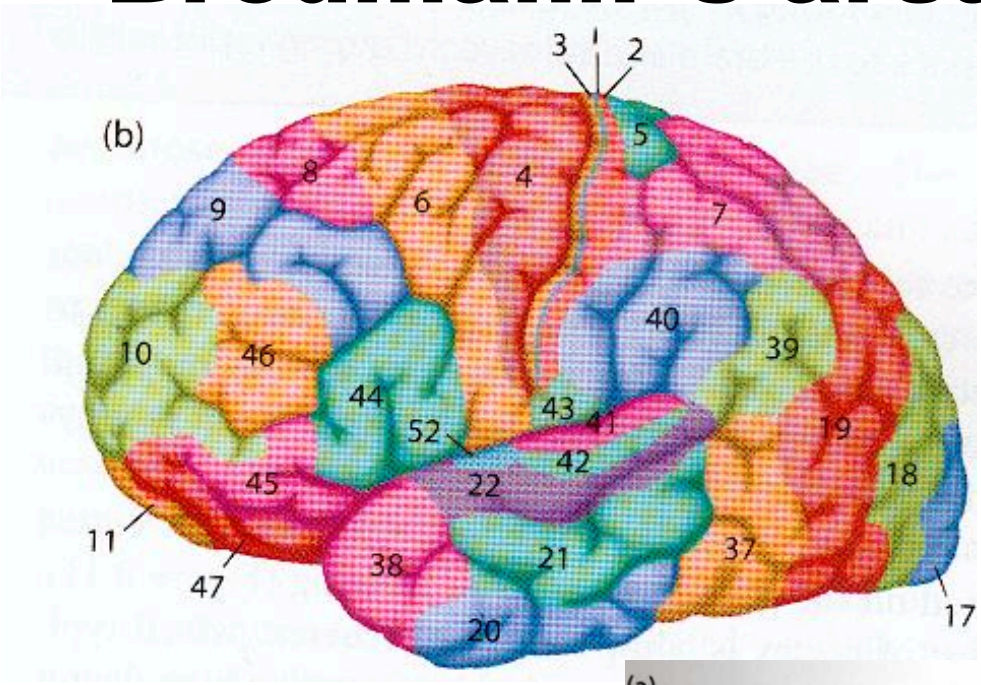
Figure 3. Layers in the neocortex as revealed by different staining methods. The Golgi stain reveals neuronal cell bodies and dendritic trees. The Nissl stain shows cell bodies and proximal dendrites. The Weigert stain reveals patterns of axonal distribution.

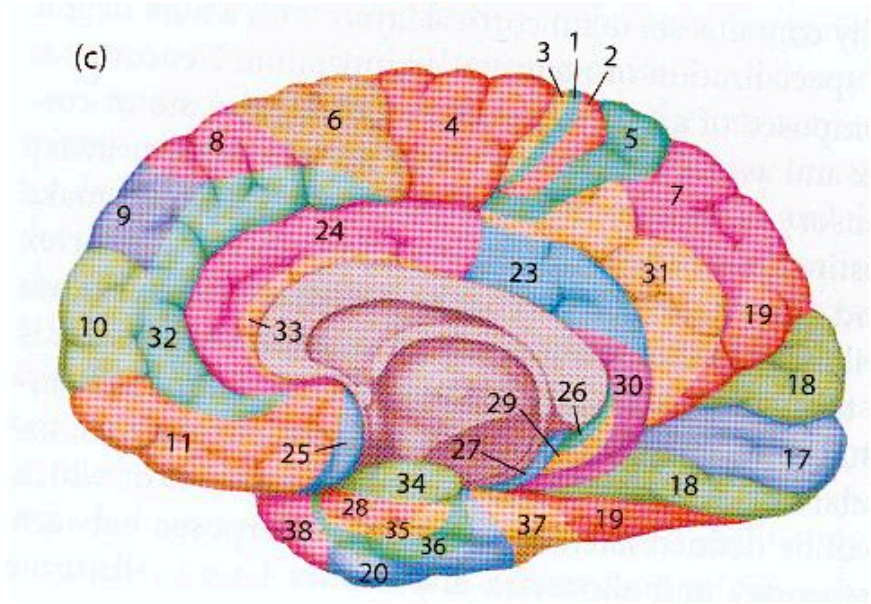
Korbinian Brodmann, (1868 - 1918)

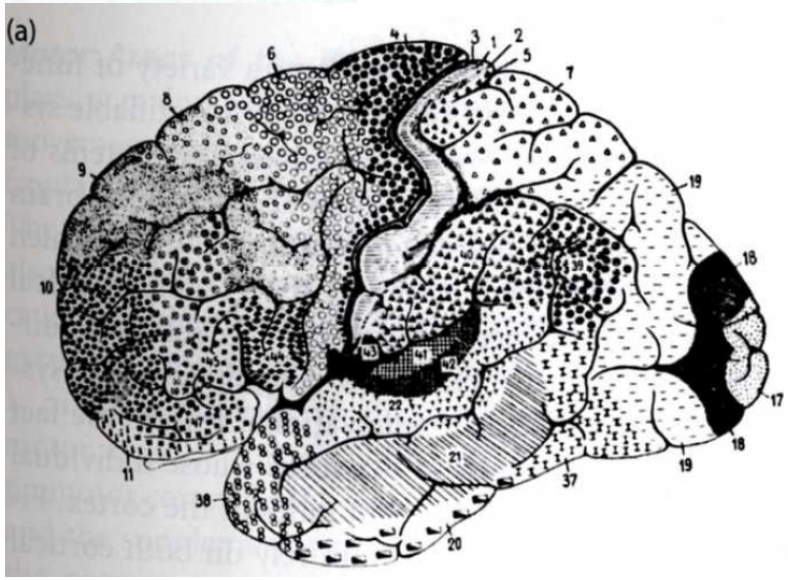


- Defined the cerebral cortex into 52 distinct regions on the basis of their cytoarchitectonic characteristics.

Brodmann's areas

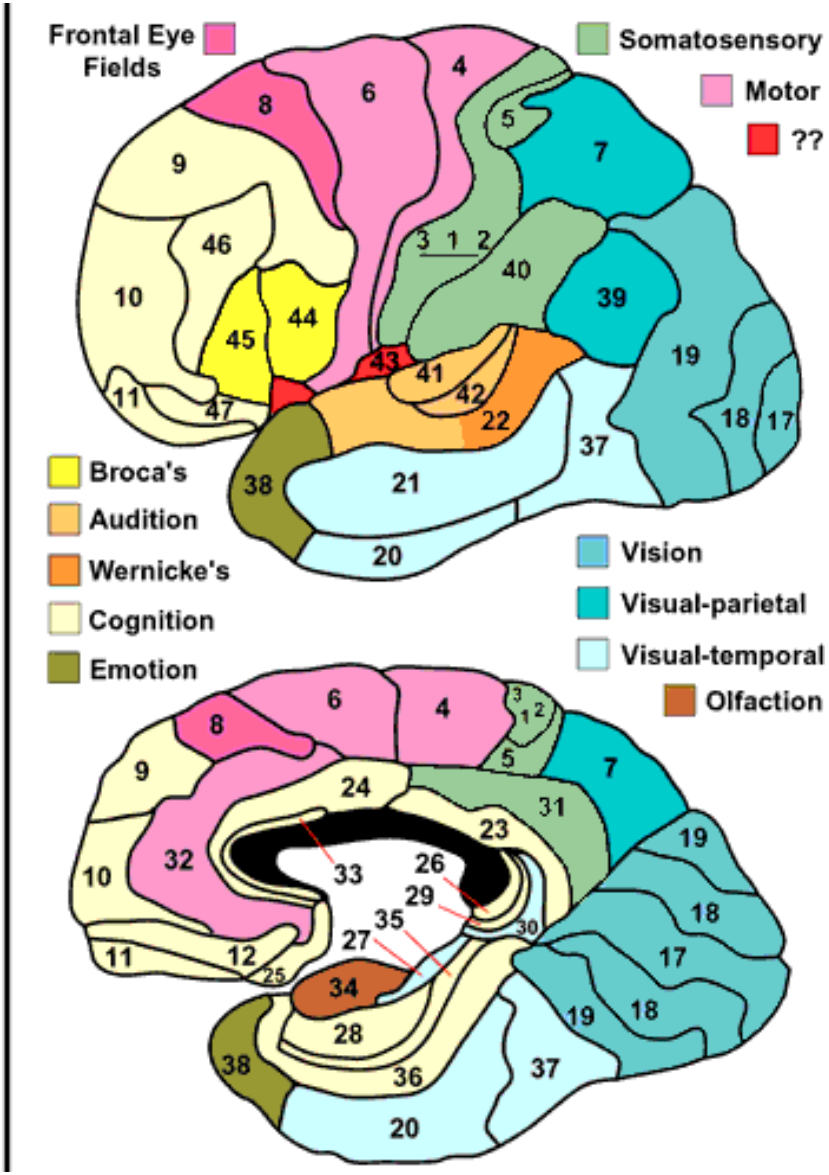




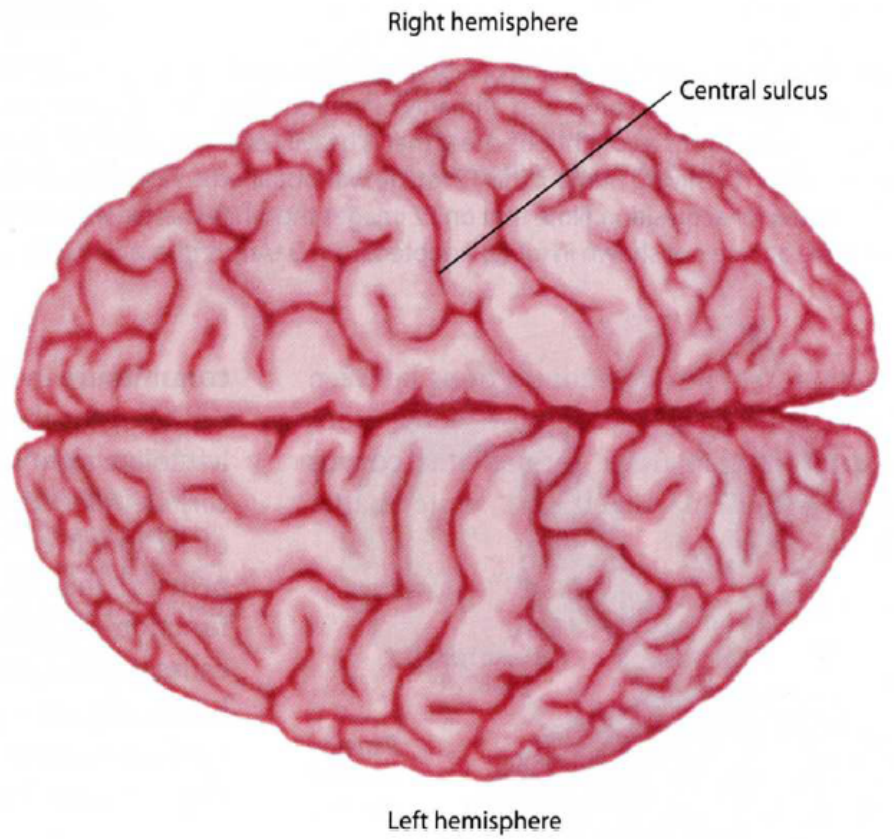


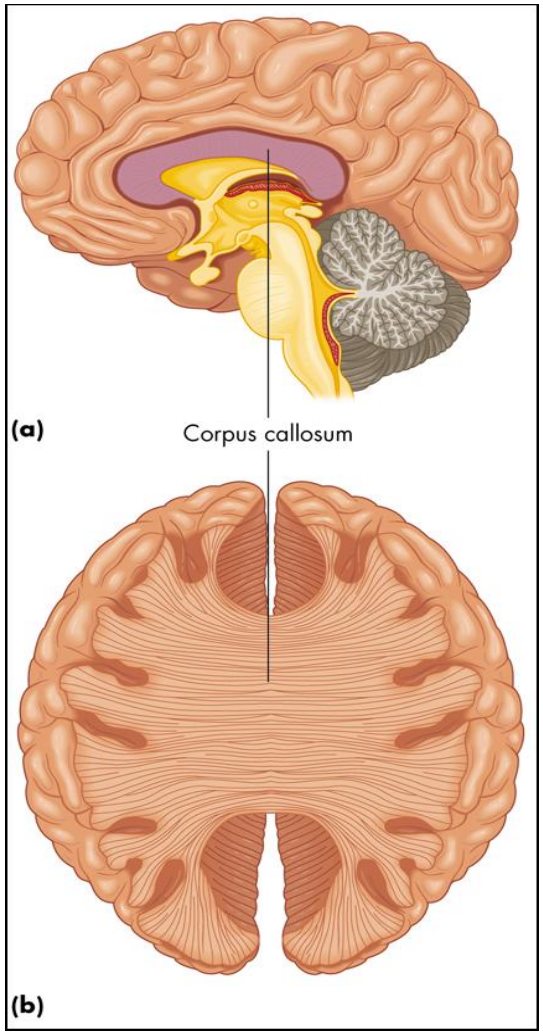
Broad functional divisions

Brodmann's areas



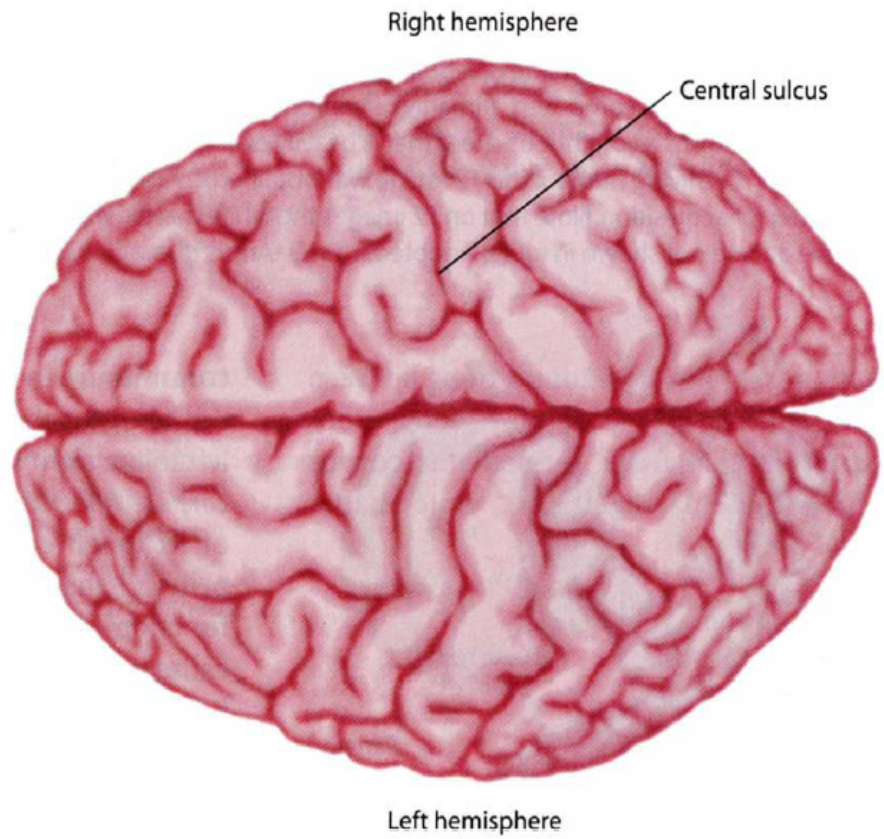
Cerebral hemispheres

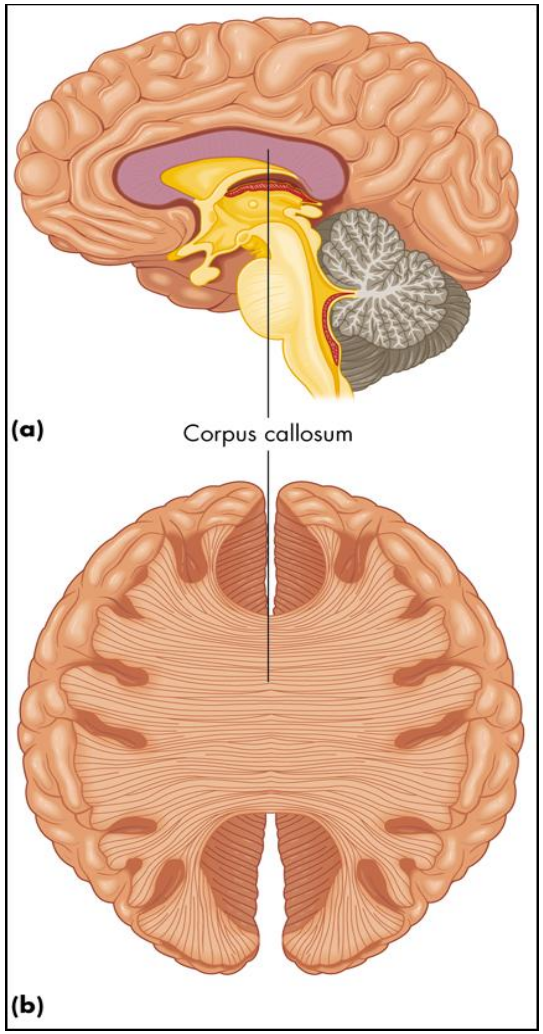




What happens when the two hemispheres are physically separated?
Brain lesion (tumor, etc)
Epilepsy treatment

Cerebral hemispheres





What happens when the two hemispheres are physically separated?

Brain lesion (tumor, etc)

Epilepsy treatment

short video: http://www.youtube.com/watch?v=aCv4K5aStdU

longer video: http://www.youtube.com/watch?v=lfGwsAdS9Dc

Homunculus

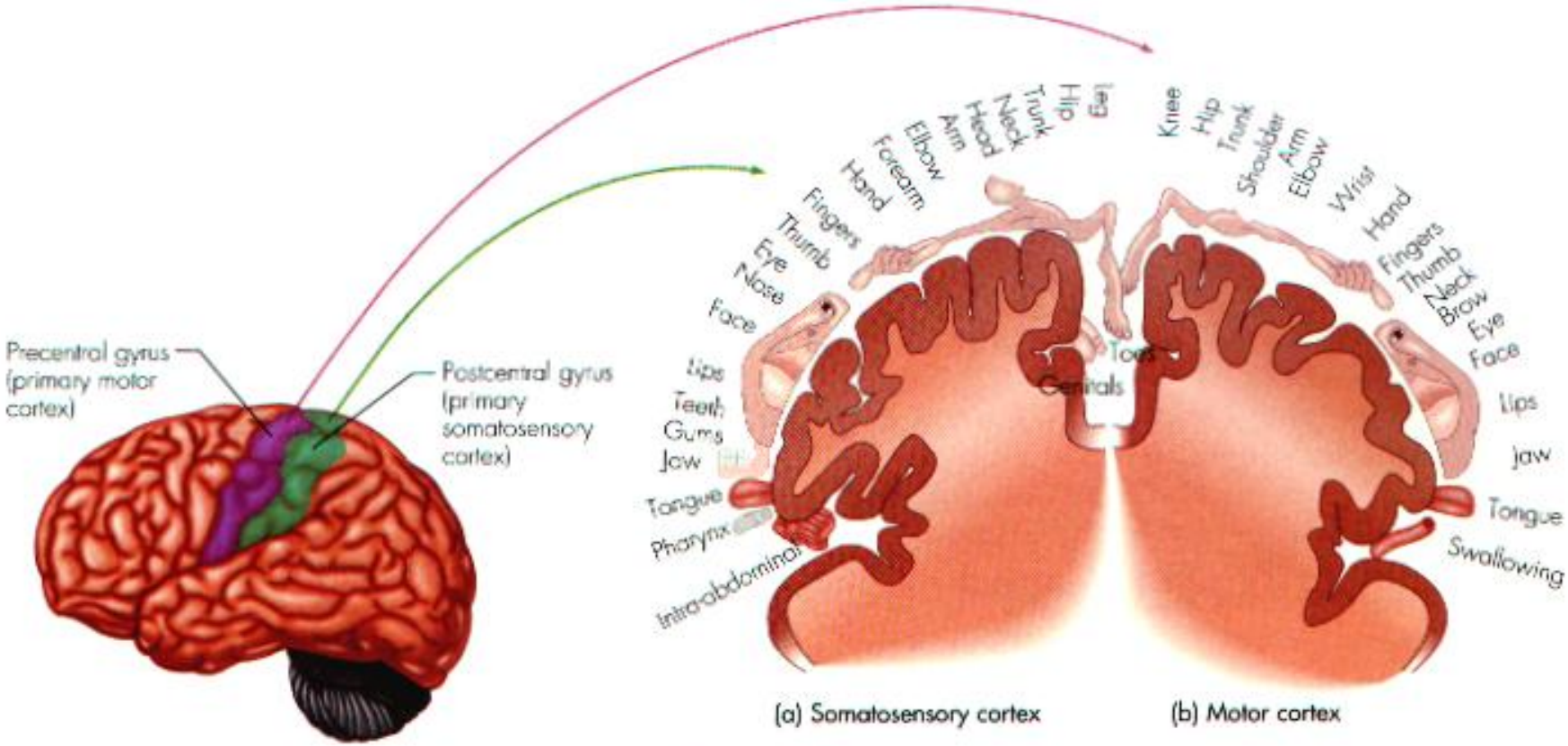
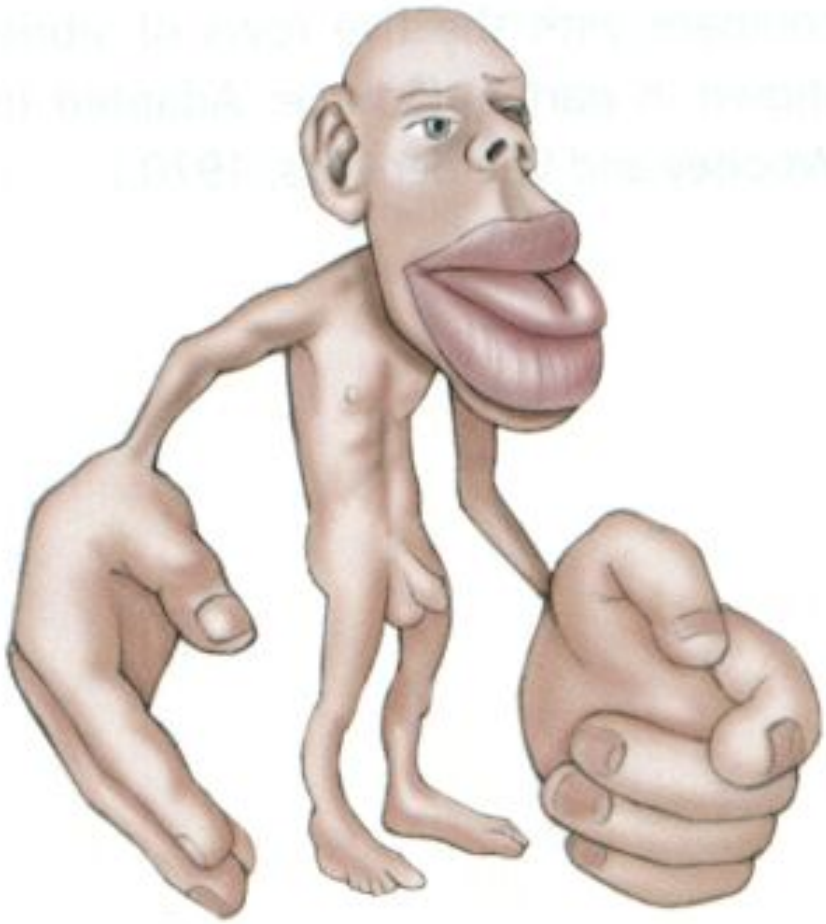
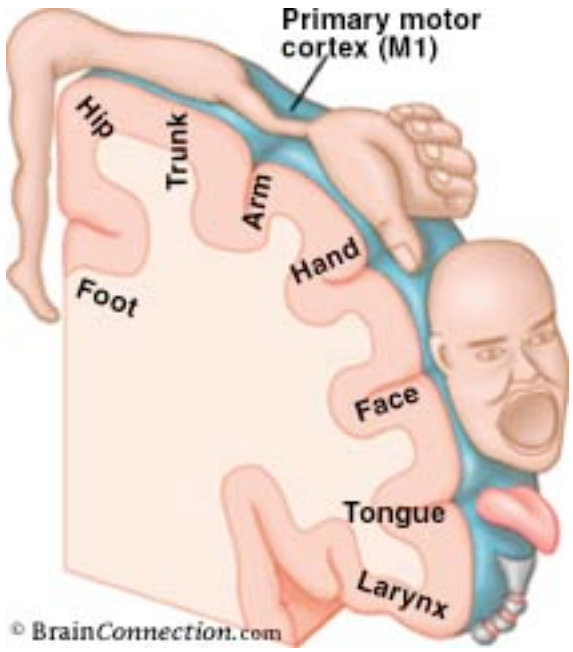


Figure 4.21 Approximate representation of sensory and motor information in the cortex
(**a**) Each location in the somatosensory cortex represents sensation from a different body part. (**b**) Each location in the motor cortex regulates movement of a different body part. *(Source: After Penfield & Rasmussen, 1950)*

The mind/brain view of the body

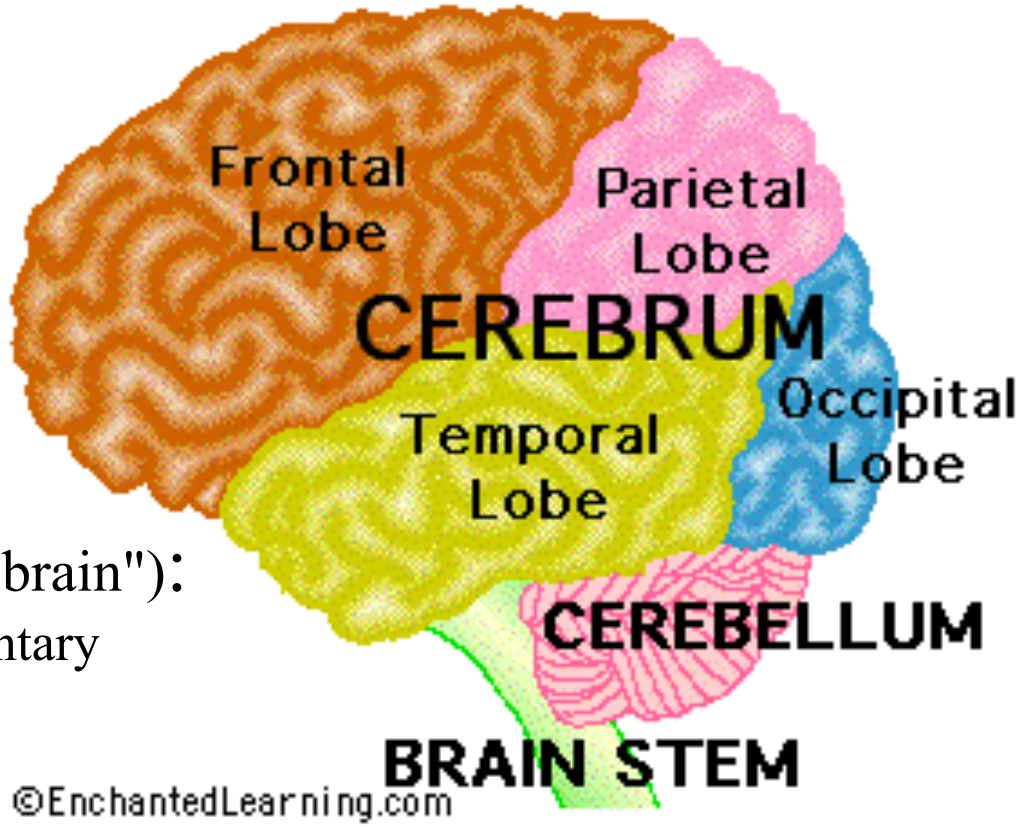




What counts as evidence for this type of mapping?

A video on pre-surgical brain mapping:

http://www.youtube.com/watch?v=l1SAC1HcAzc



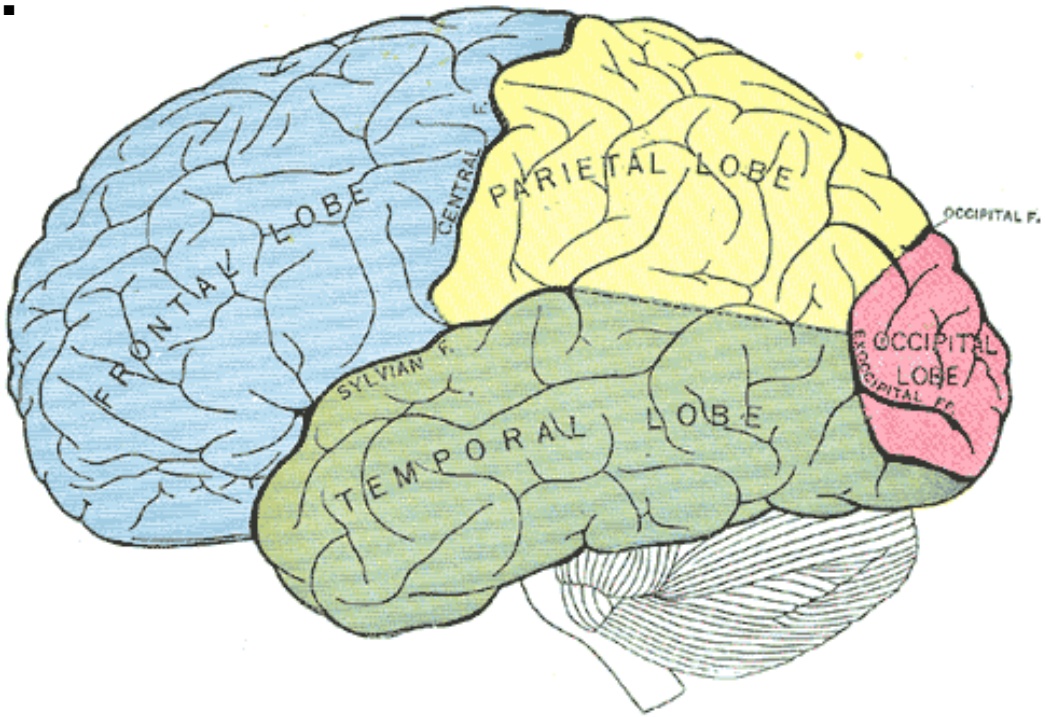
- Cerebellum (Latin: "little brain"): Coordination and control of voluntary movement

- Brain stem:

  breathing, heartbeat, and blood pressure

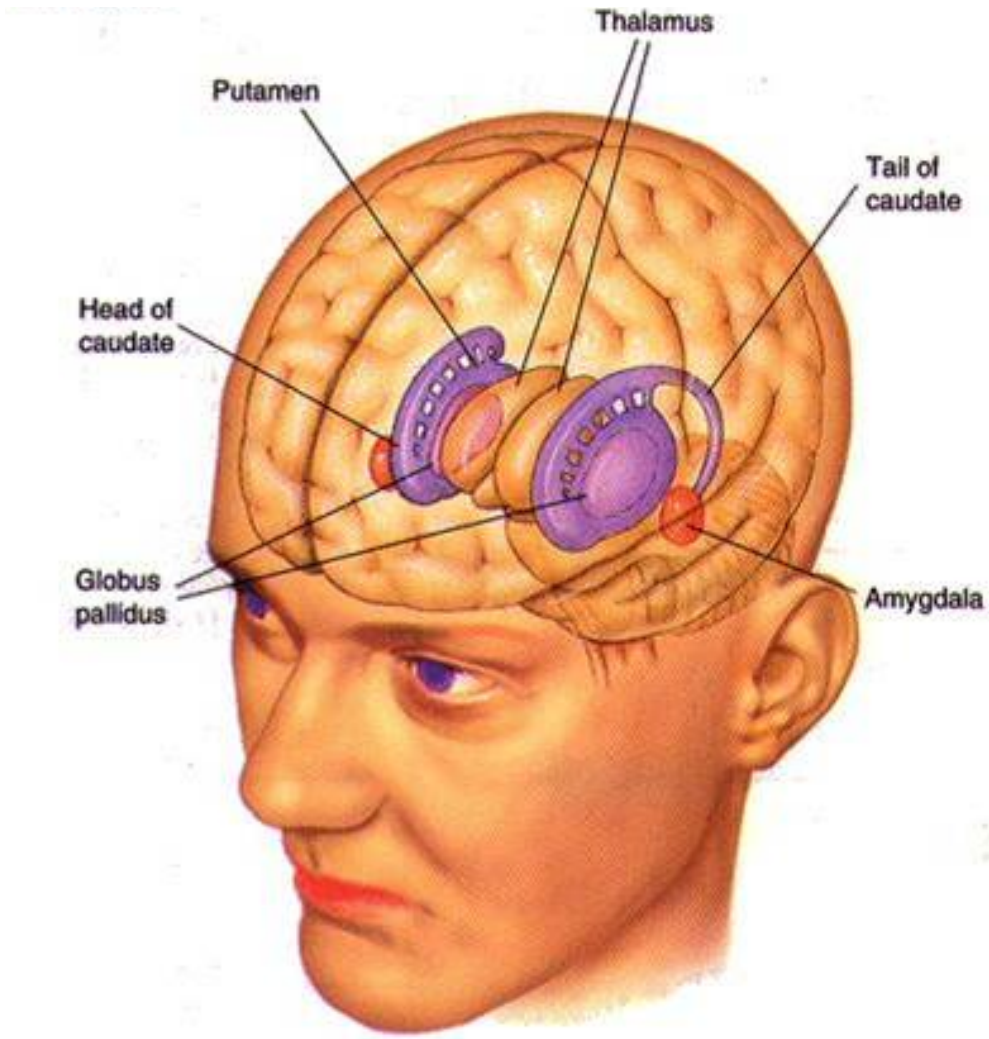
Gross generalizations about function

- Frontal lobe:
  - **decisions, judgments, problem solving, emotions.**
- Temporal lobe:
  - **perception, recognition, many aspects of language**
- Parietal lobe:
  - **movement, orientation, recognition, perception of stimuli**
- Occipital lobe:
  - **vision at large**



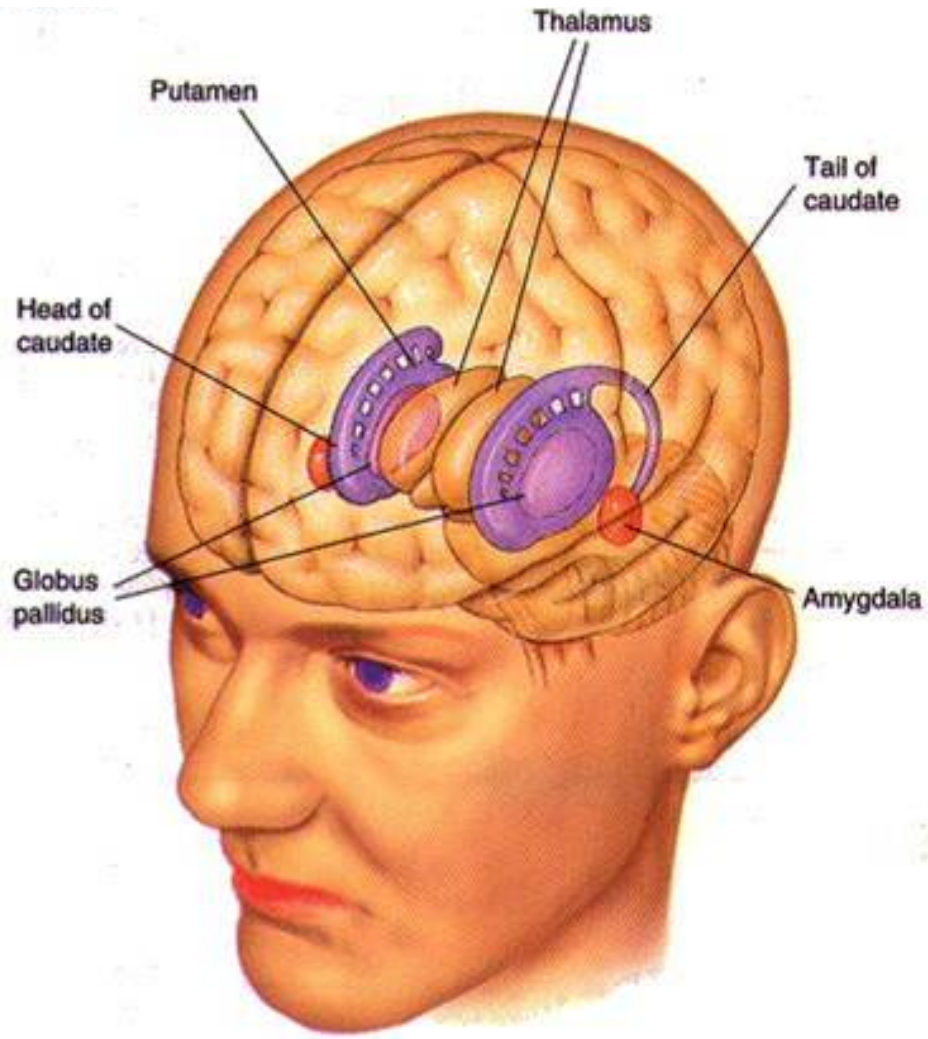
Subcortical structures: basal ganglia, the limbic system and the thalamus

- Thalamus:
  - **A relay site between sensory organs and the cortex (except for olfaction); receives and organizes sensory information from the sensory organs**
  - **Regulates sleep and wakefulness** (during sleep the thalamus is closed. i.e., does not take input from sensory organs).



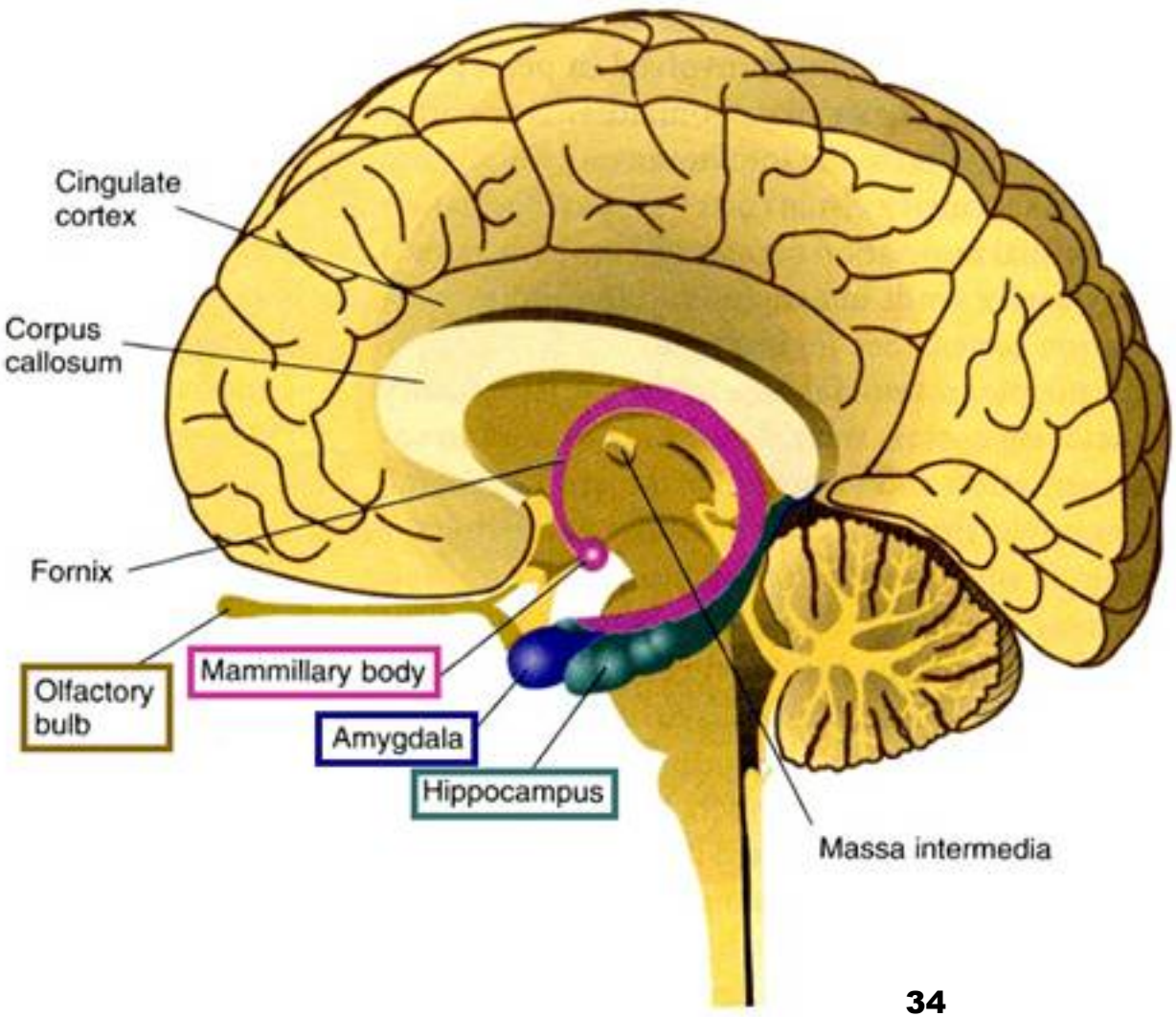
Subcortical structures: basal ganglia, the limbic system and the thalamus

- Basal ganglia:
  - Caudate nucleus
  - Putamen
  - Globus pallidus
  - Many functions: control of voluntary motor movements, procedural learning, routine behaviors or "habits" …
- Damage to these structures can cause
  - movement diseases like: Parkinson's, Huntington's
  - some neuropsychiatric disorders, like: Tourette's, OCD, etc.



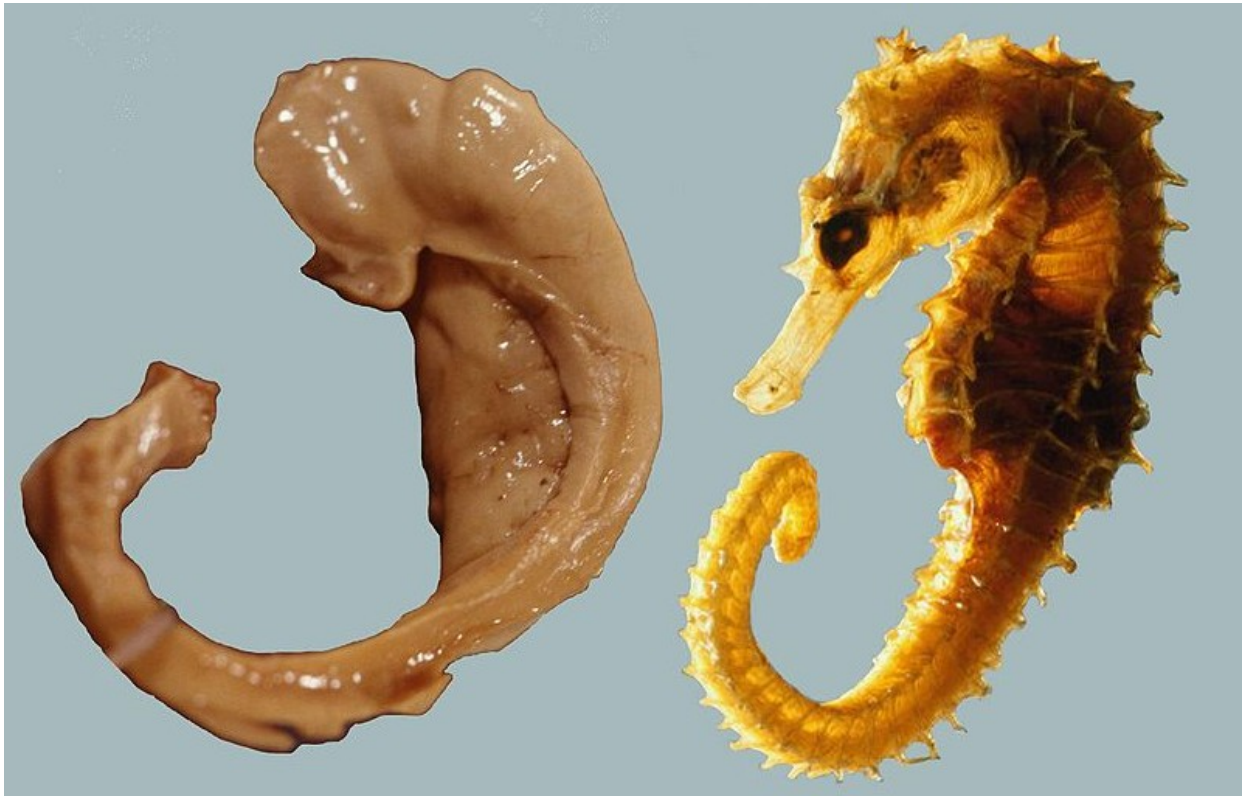
Subcortical structures: basal ganglia, the limbic system and the thalamus

- Limbic System
  - Hippocampus
  - Amygdala
- **emotion, memory**



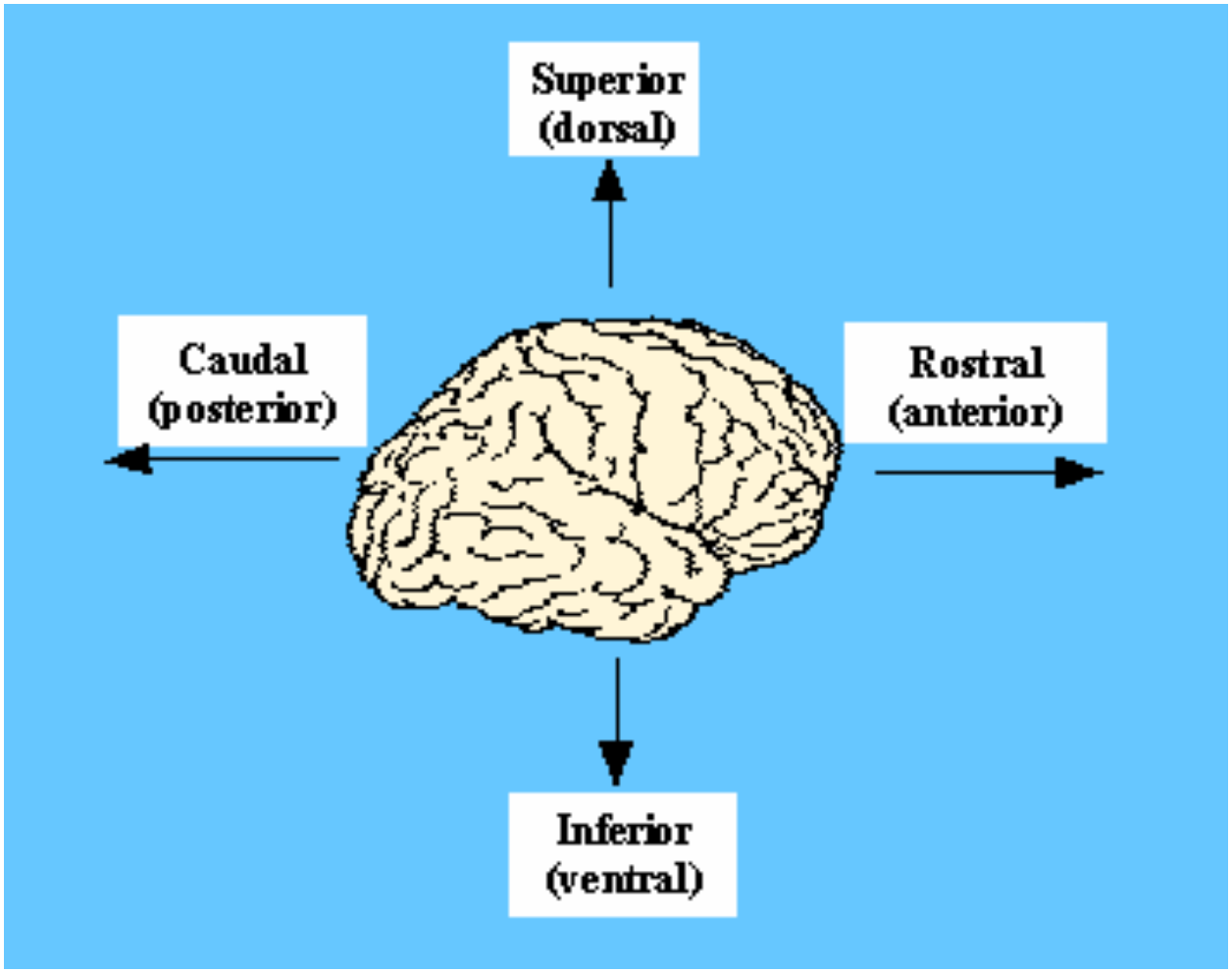
Subcortical structures: basal ganglia, the limbic system and the thalamus

- Limbic System
  - Hippocampus
  - Amygdala
- **emotion, memory**

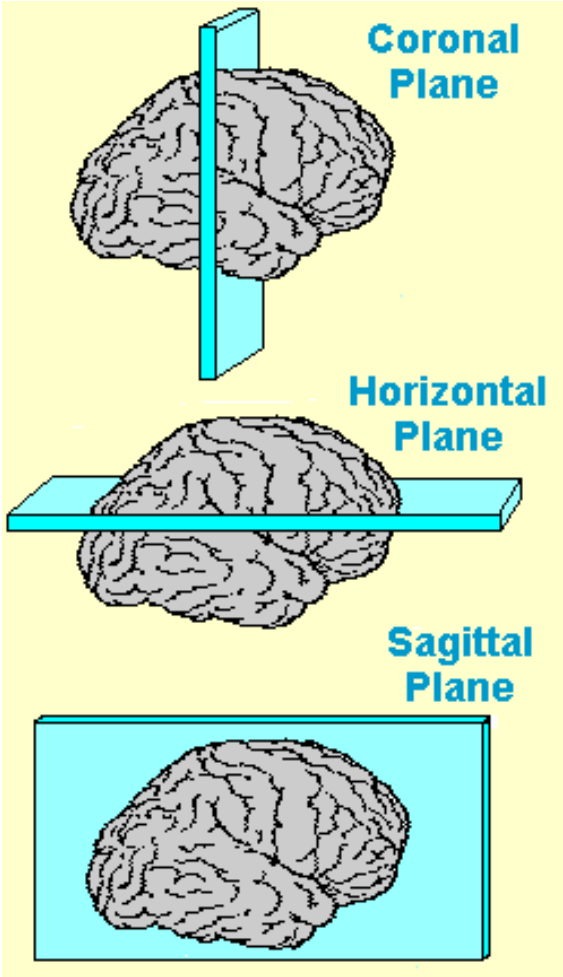


see also: http://en.wikipedia.org/wiki/File:Hippocampus.gif

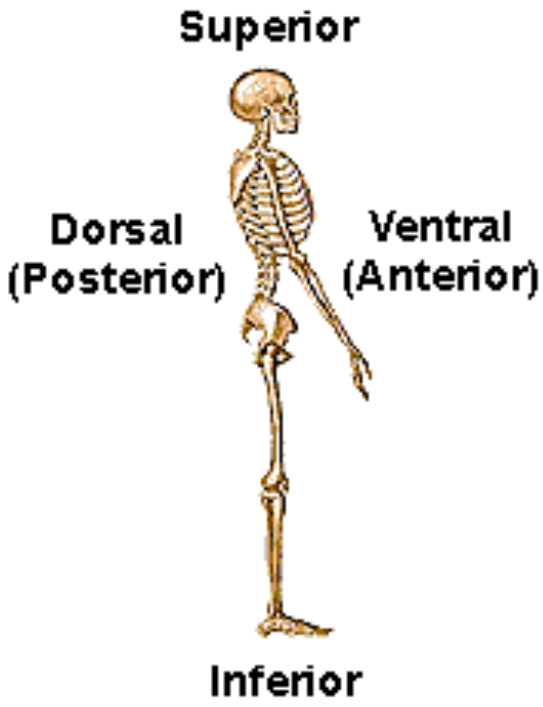
Brain lingua

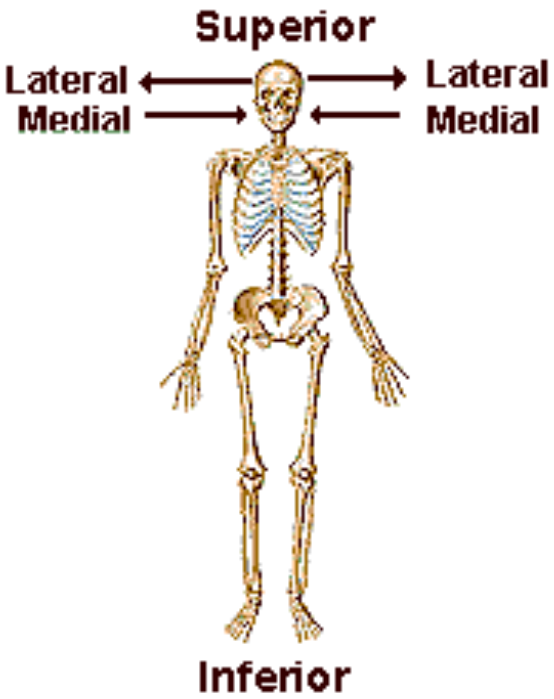


Brain lingua



Brain lingua





Bilateral - On both sides
Ipsilateral - On the same side
Contralateral - On the opposite side

Hot off the presses: a new parcellation of the brain

- Brodmann's parcellation of the brain, published in 1909, has had amazing longevity, as his system is still widely used.
- In July 2016, a new parcellation, including 180 areas in total, was proposed based on many different types of data.

doi:10.1038/nature18933

A multi-modal parcellation of human cerebral cortex

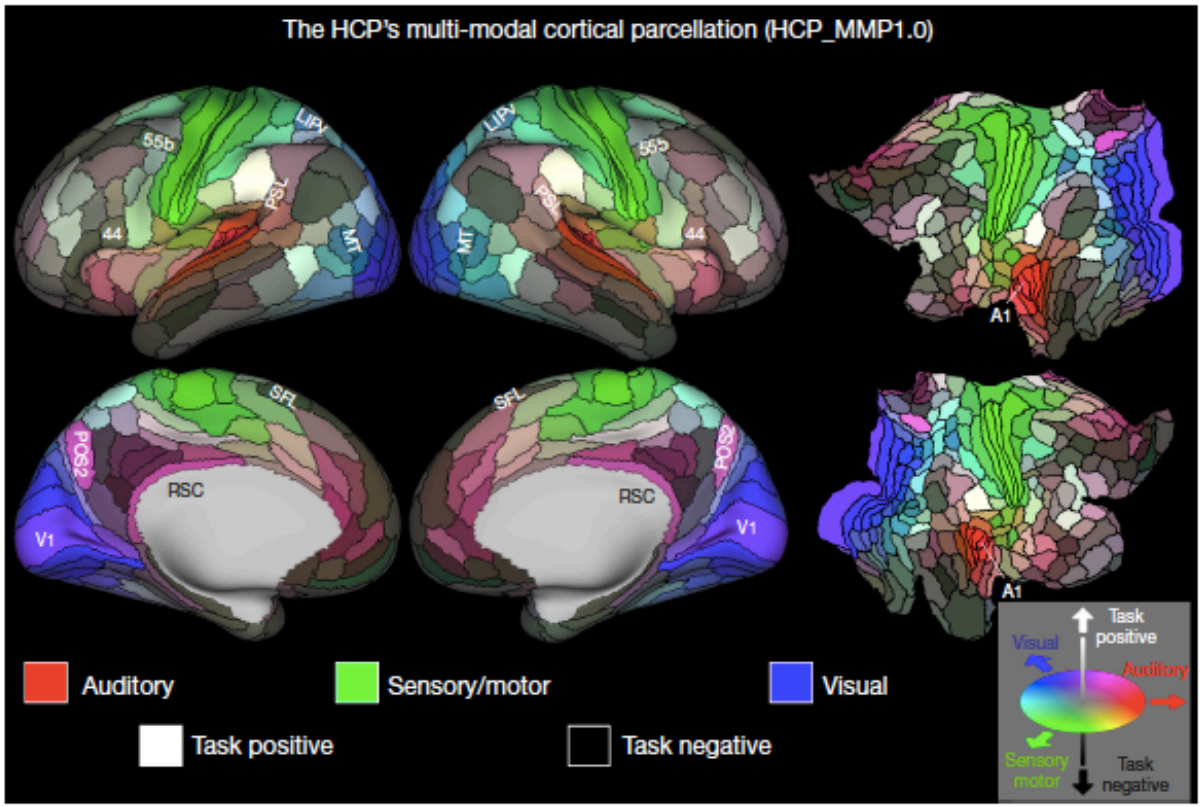


Figure 3 | The HCP's multi-modal parcellation, version 1.0 (HCP_MMP1.0). The 180 areas delineated and identified in both left and right hemispheres are displayed on inflated and flattened cortical surfaces. Black outlines indicate areal borders. Colours indicate the extent to which the areas are associated in the resting state with auditory (red), somatosensory (green), visual (blue), task positive (towards white), or task negative (towards black) groups of areas (see Supplementary Methods 5.4). The legend on the bottom right illustrates the 3D colour space used in the figure. Data at http://balsa.wustl.edu/WN56.

ARTICLE

doi:10.1038/nature18933

A multi-modal parcellation of human cerebral cortex

Matthew F. Glasser[1], Timothy S. Coalson[1*], Emma C. Robinson[2,3*], Carl D. Hacker[4*], John Harwell[1], Essa Yacoub[5], Kamil Ugurbil[5], Jesper Andersson[2], Christian F. Beckmann[6,7], Mark Jenkinson[2], Stephen M. Smith[2] & David C. Van Essen[1]

- Data from the Human Connectome project (210 parcellation data sets, 210 validation data sets).
- First parcellation based on multiple neurobiological properties: myelin, thickness, task, and resting state data.
- A combination of automatic and manual parcellation.
- A combination of cortical folding, myelin, and resting state fMRI was used to generate the 'typical subject's' parcellation from a highly detailed 210-subject group average data set.
- New "language area," are 55b, more activated for story vs. baseline.