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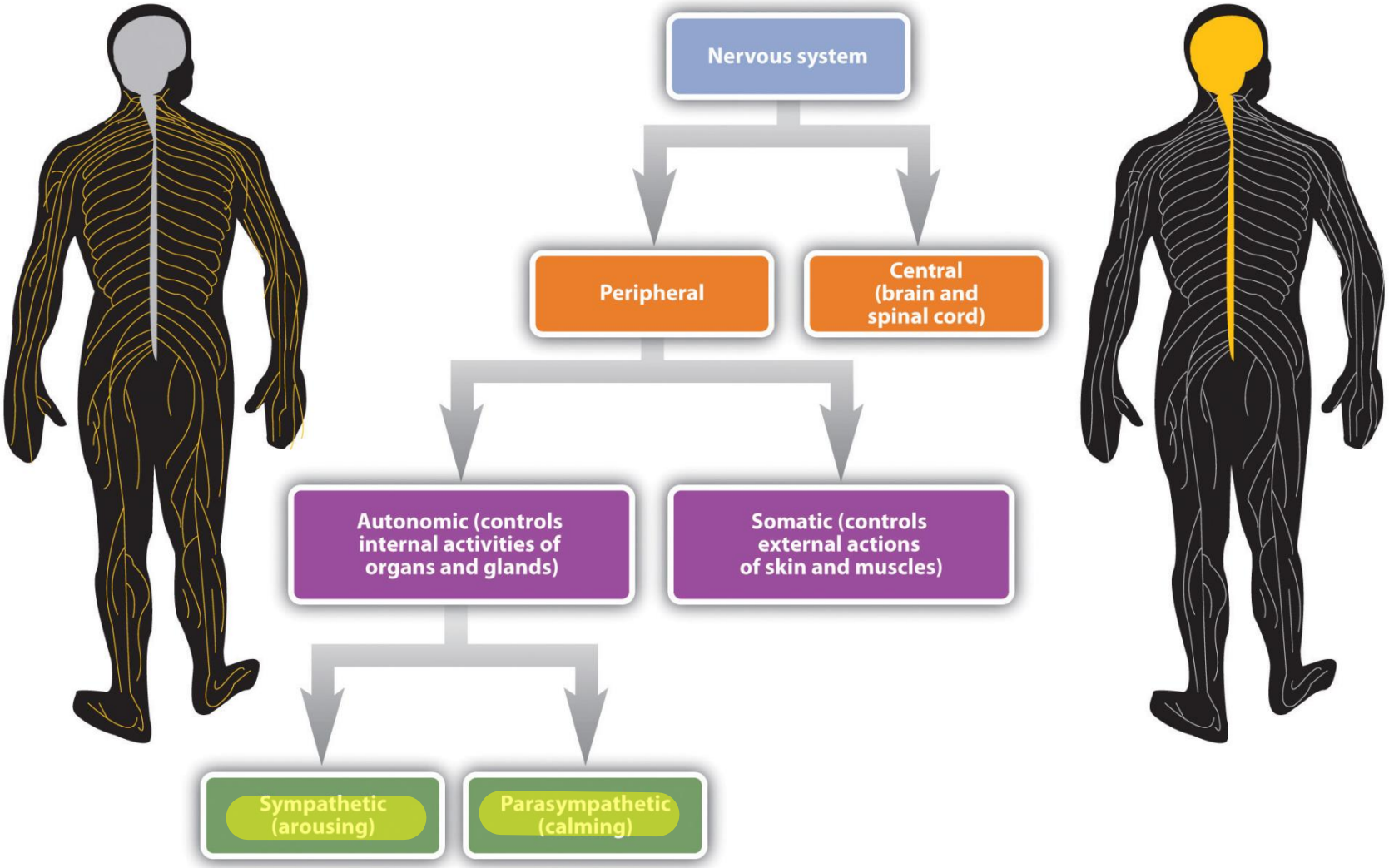
PSYC 10009: BIOLOGICAL PSYCHOLOGY

Lecture 4: Anatomy of the Nervous System

Overview

- Divisions of the human's nervous system – CNS & PNS
  - Peripheral nervous system: sympathetic & parasymphathetic subsystems
- How to talk about the brain – the coordinate system, main landmarks
- Cortical organisation of the cerebral hemispheres: four brain lobes and their main functions

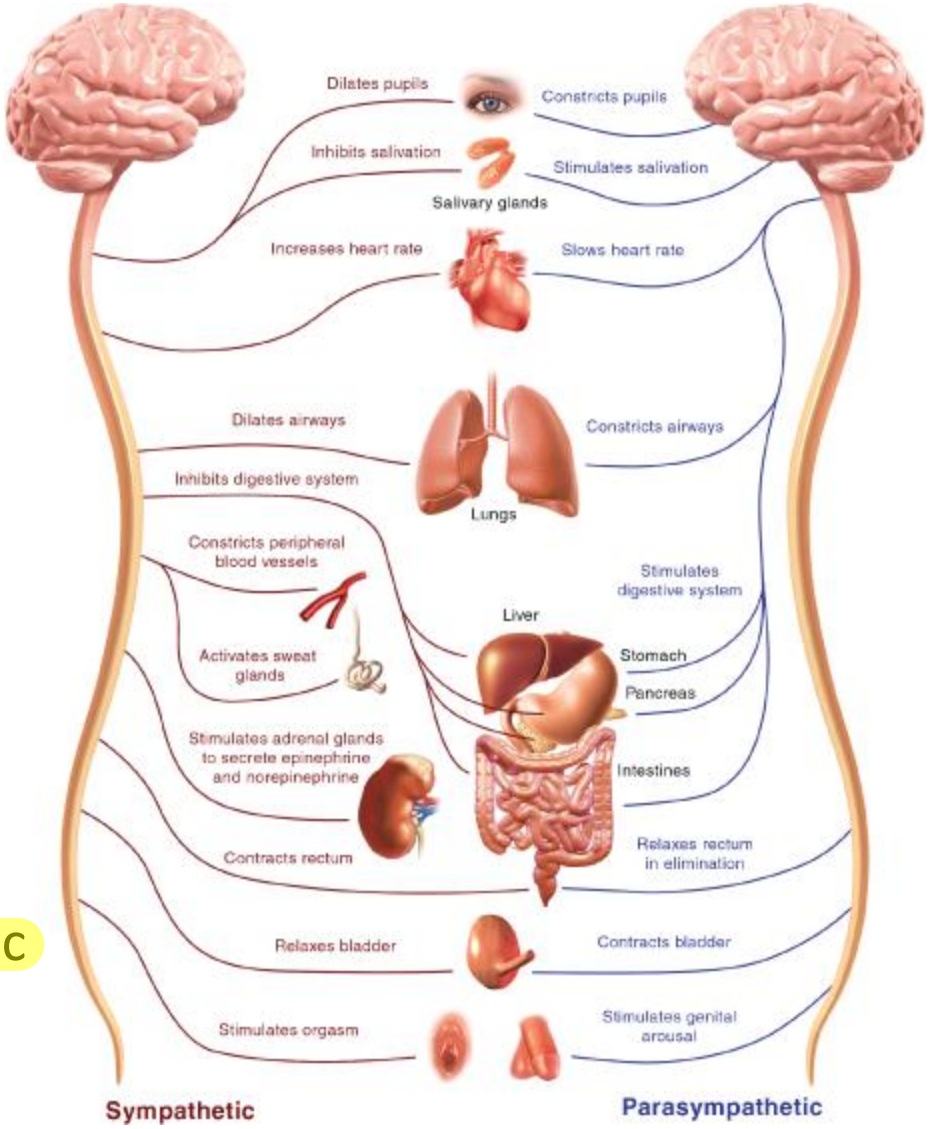
The Human Nervous System

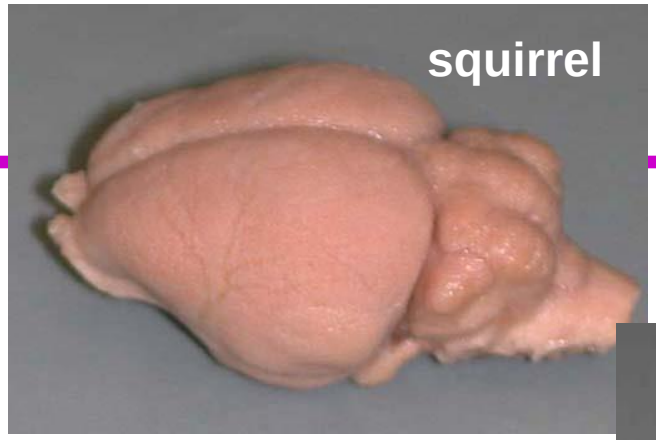


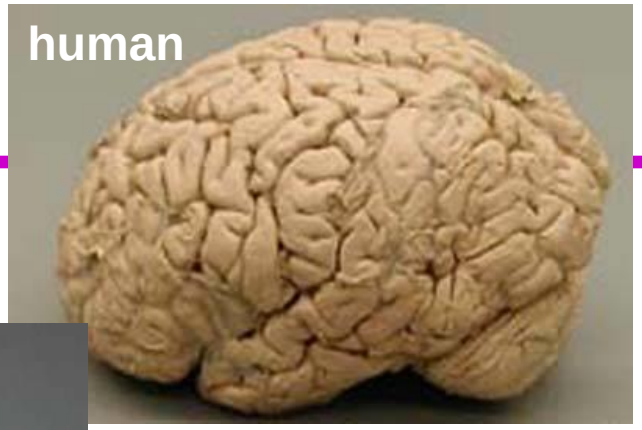
The Autonomic Nervous System

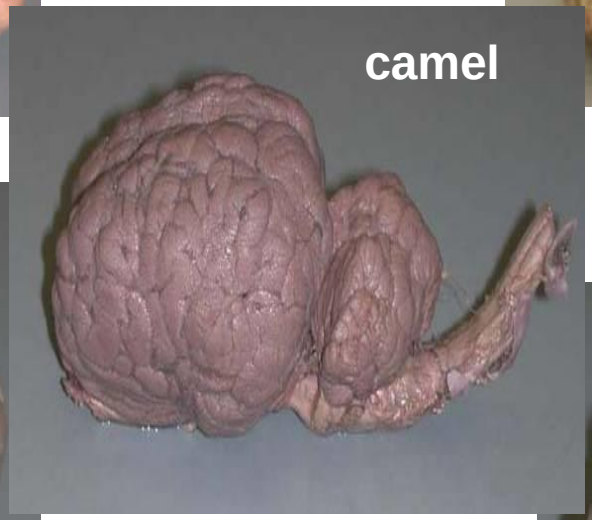
- The **sympathetic** division of the autonomic nervous system prepares the body for action during times of threat and prepares the body for muscular exertion or stressful activities ("fight or flight")

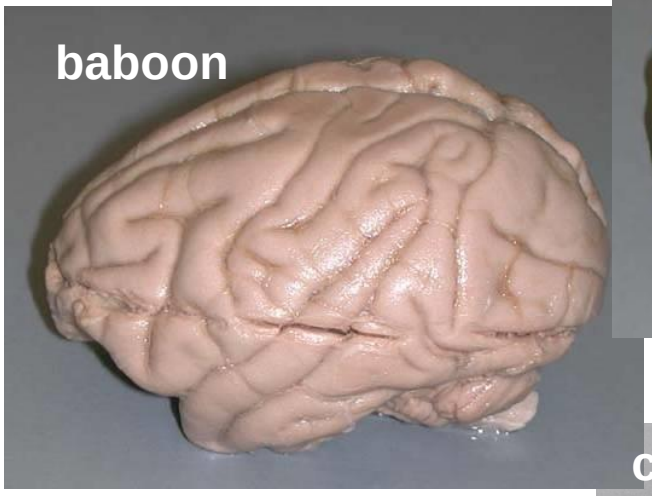
- The **parasympathetic** division is active during times of relaxation and rest and dominates in controlling the body for metabolic "business as usual"

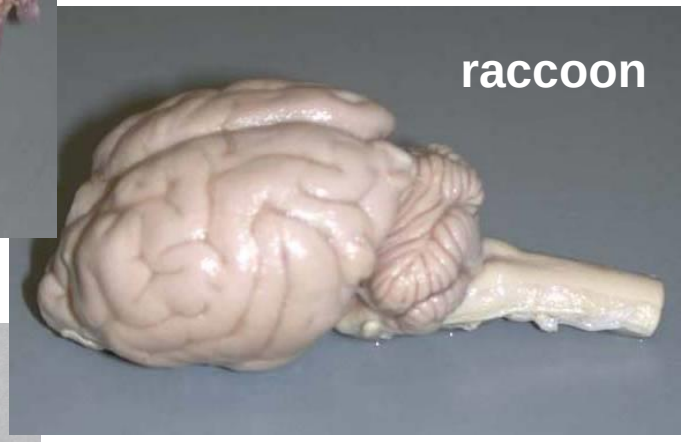


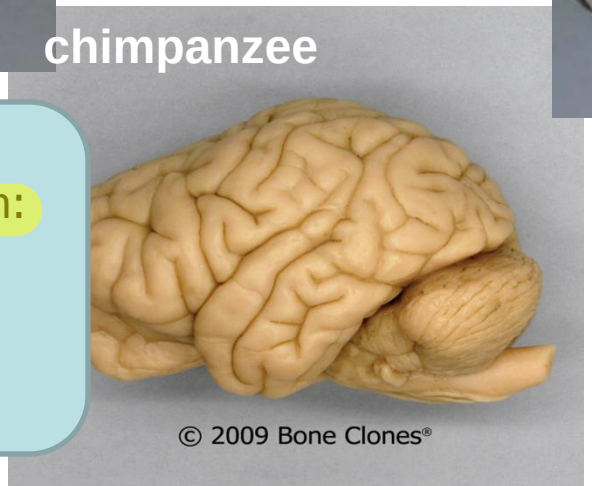






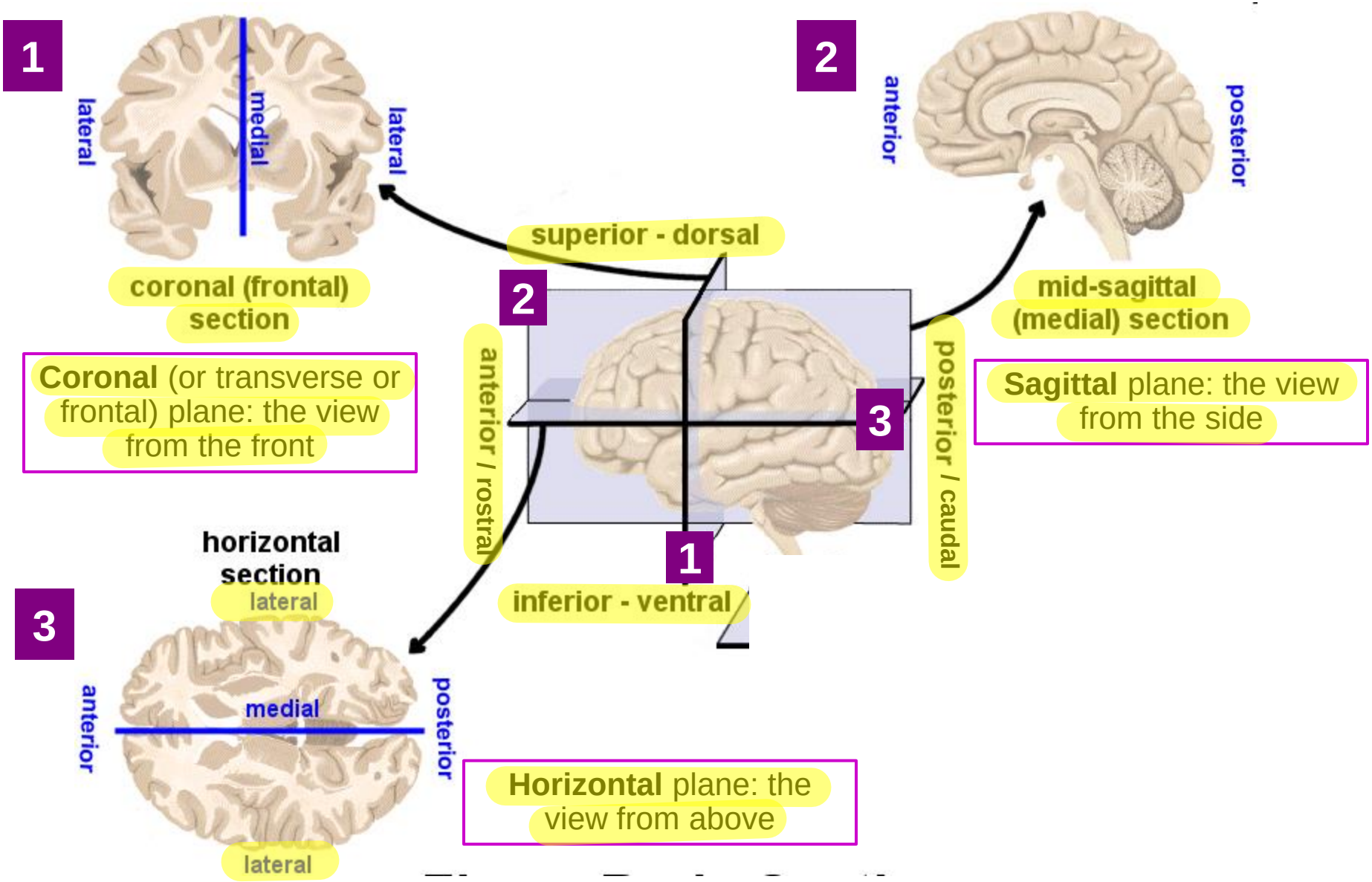






More intelligence correlates with:
- more convolutions
- cerebral hemispheres are proportionally larger

Dissecting planes



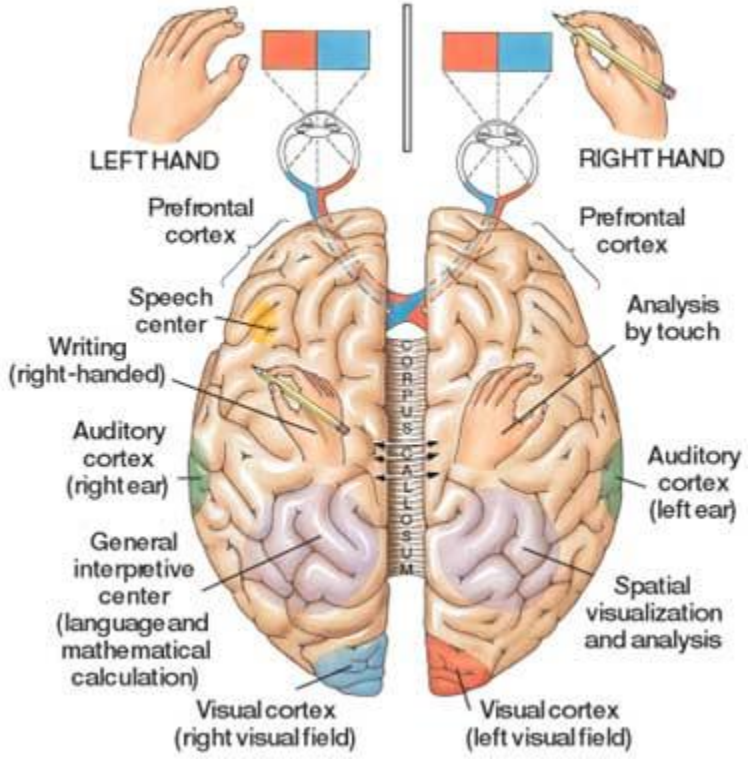
Coronal (or transverse or frontal) plane: the view from the front

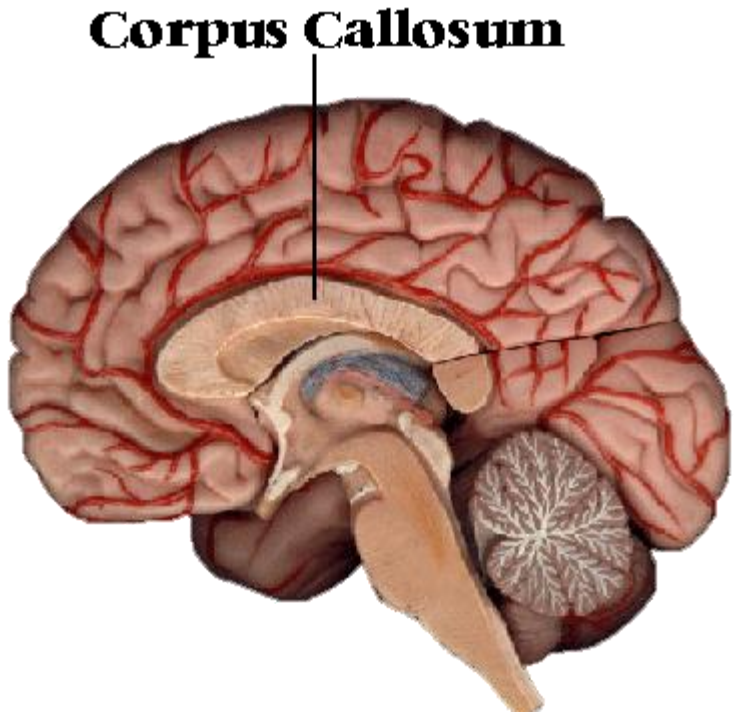
Sagittal plane: the view from the side

Horizontal plane: the view from above

Cerebral hemispheres (more later)

- The brain comprises two roughly symmetrical halves
- The left and right cerebral cortices are joined by the **corpus callosum**, a dense band of fibers at the bottom of the **longitudinal fissure**, shares information between the hemispheres
  - Incoming information is often directed to one hemisphere (e.g. visual info in the left visual field is processed by the RH)





Corpus callosotomy

- **Corpus callosotomy** - a surgical procedure that disconnects the cerebral hemispheres, resulting in a condition called 'split-brain'

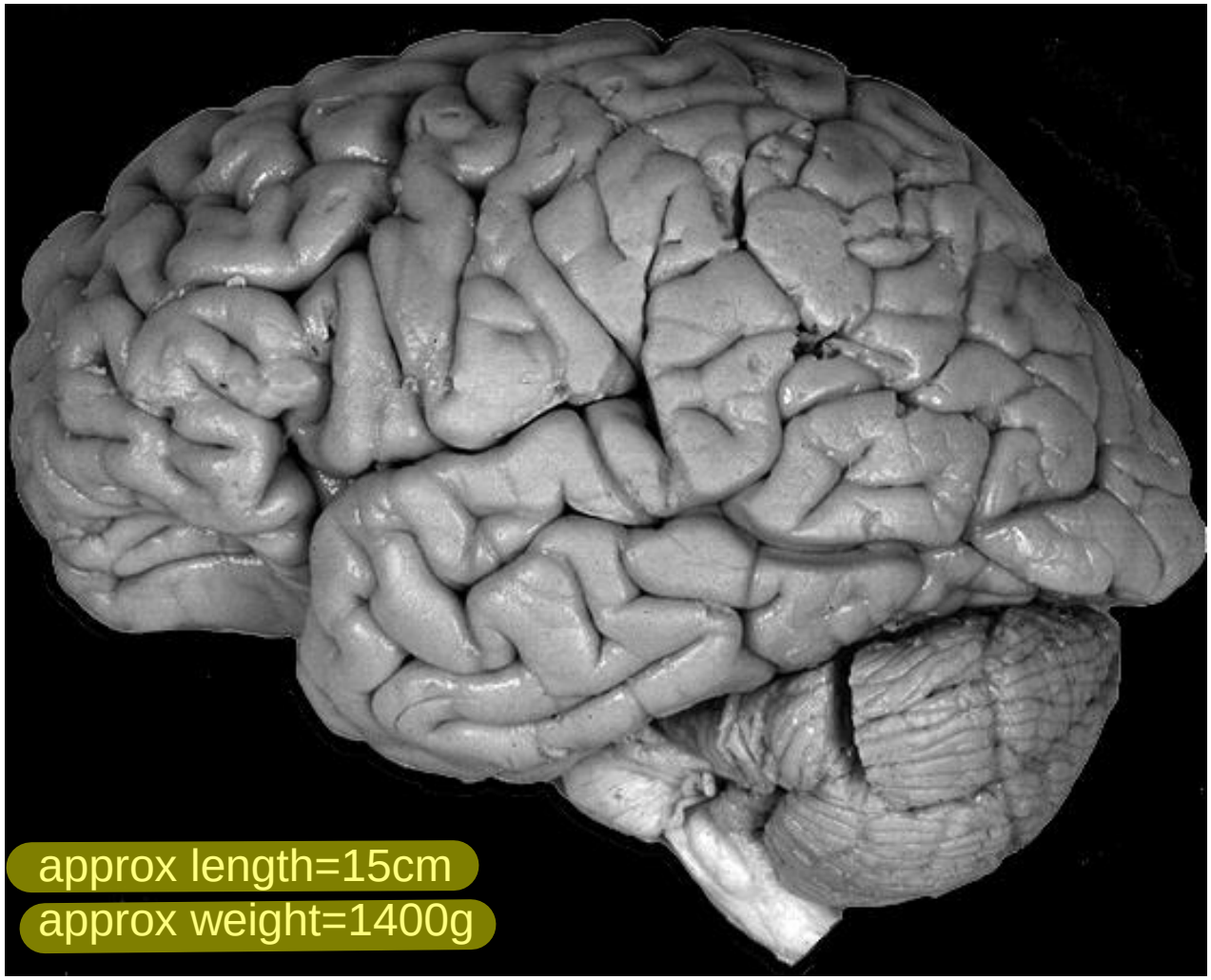
- Epilepsy patients whose corpus callosum has been severed in order to prevent the seizure in one hemisphere to engulf the other hemisphere ('split-brain' patients) have been helpful in studying the specializations of the two hemispheres
  - LH is more specialised for language, RH is more specialised for face recognition and spatial orientation

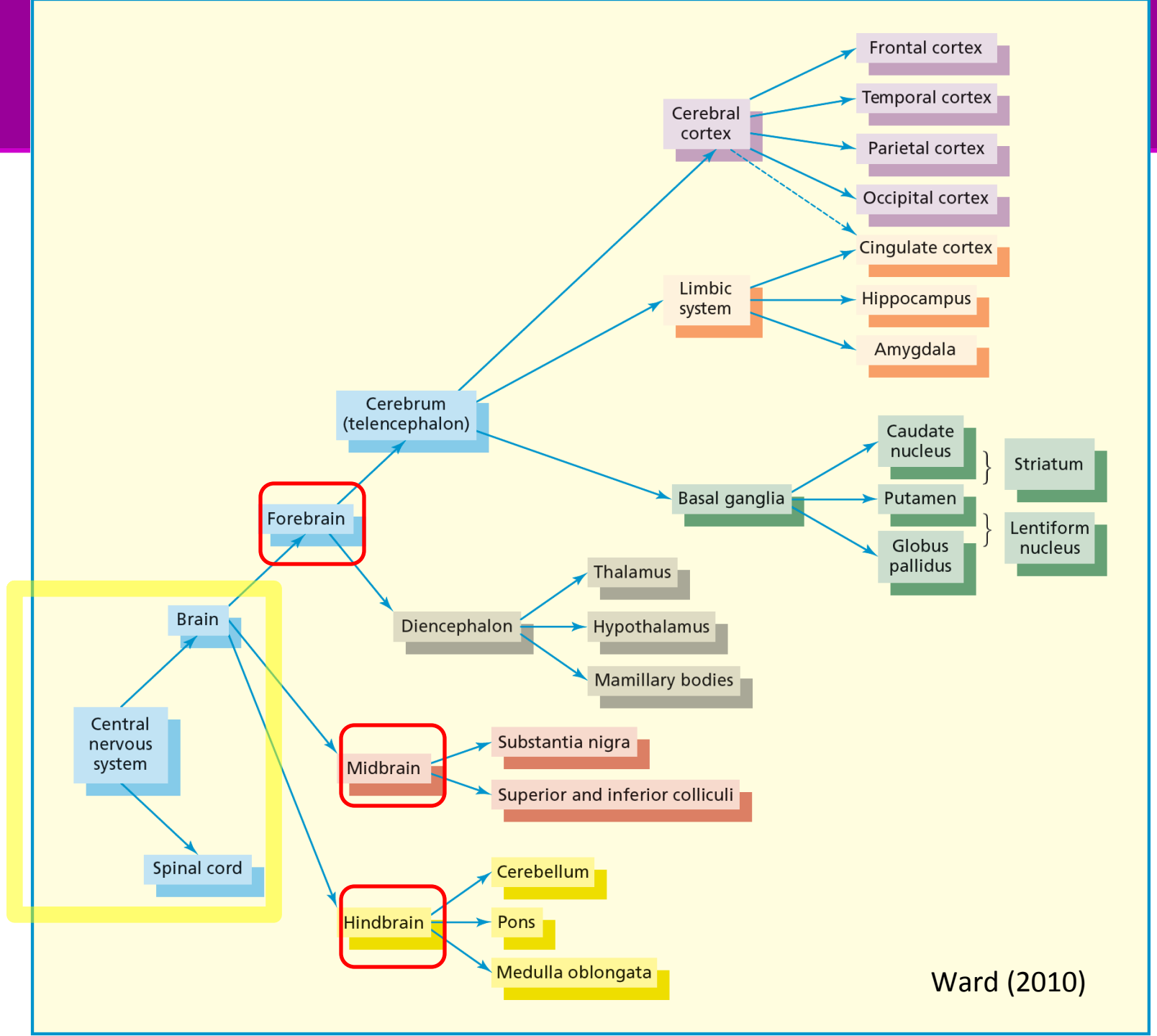
FIGURE 3.14 A Patient With Severed Corpus Callosum Identifying Objects by Touch.

He cannot say what the object is because the right hemisphere, which receives the information from the hand, has been disconnected from the more verbal left hemisphere. Results are similar for visually presented stimuli and sound information.

Garrett (2011)

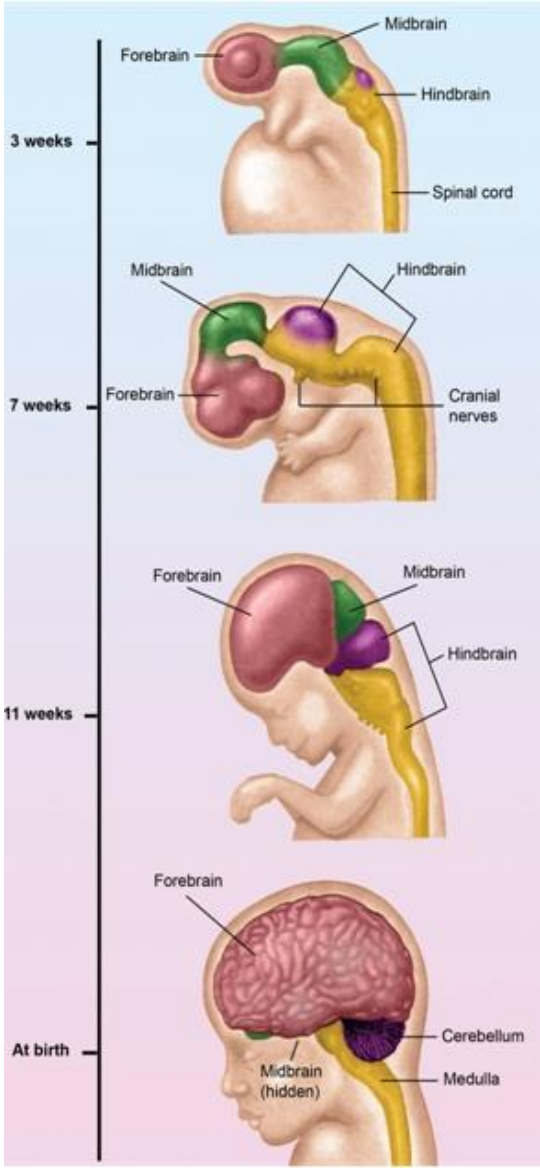
Human Brain



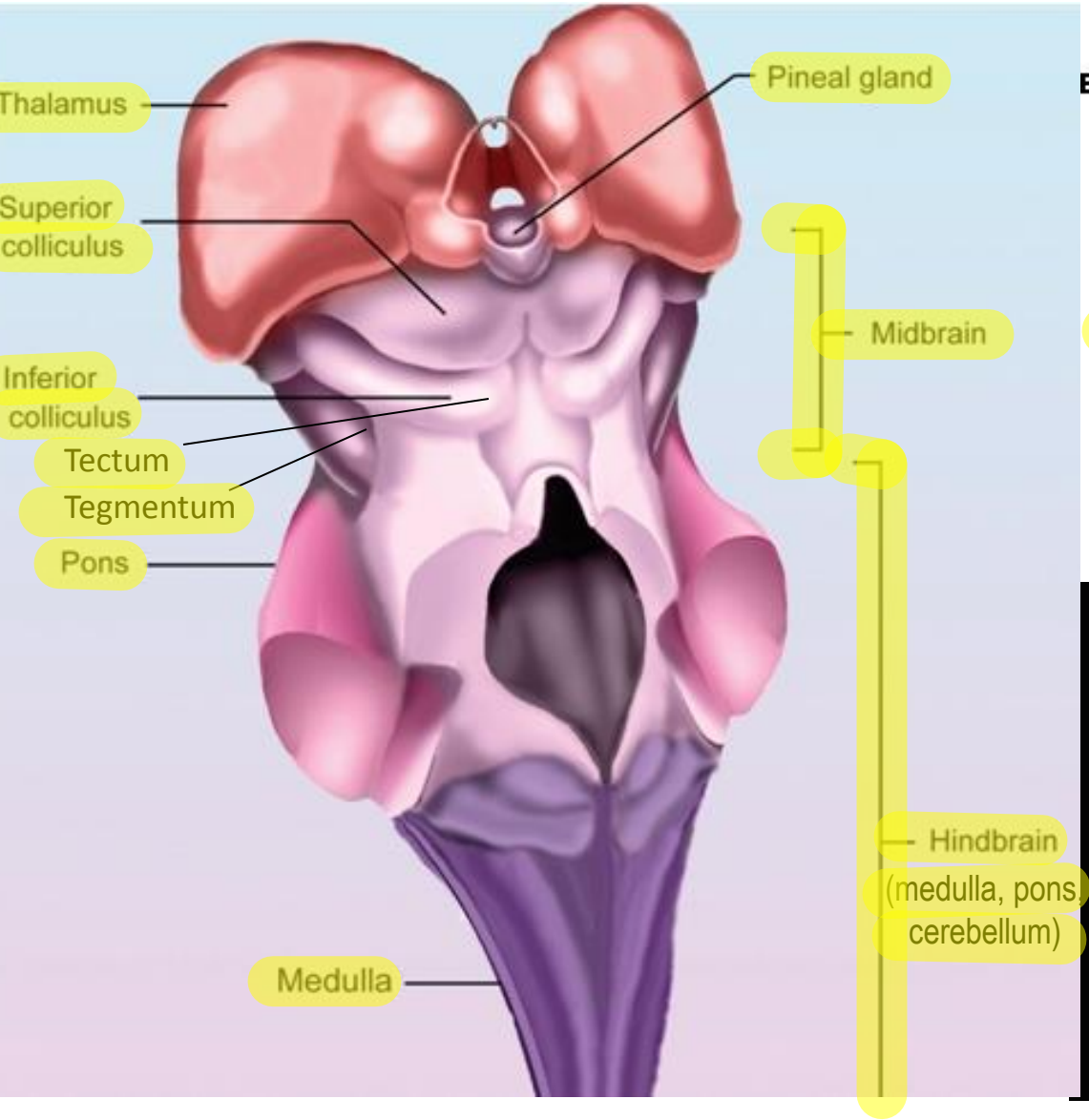

Central nervous system
Brain
Spinal cord
Forebrain
Midbrain
Hindbrain
Cerebrum (telencephalon)
Diencephalon
Thalamus
Hypothalamus
Mamillary bodies
Cerebral cortex
Frontal cortex
Temporal cortex
Parietal cortex
Occipital cortex
Limbic system
Cingulate cortex
Hippocampus
Amygdala
Basal ganglia
Caudate nucleus
Putamen
Globus pallidus
Striatum
Lentiform nucleus
Substantia nigra
Superior and inferior colliculi
Cerebellum
Pons
Medulla oblongata

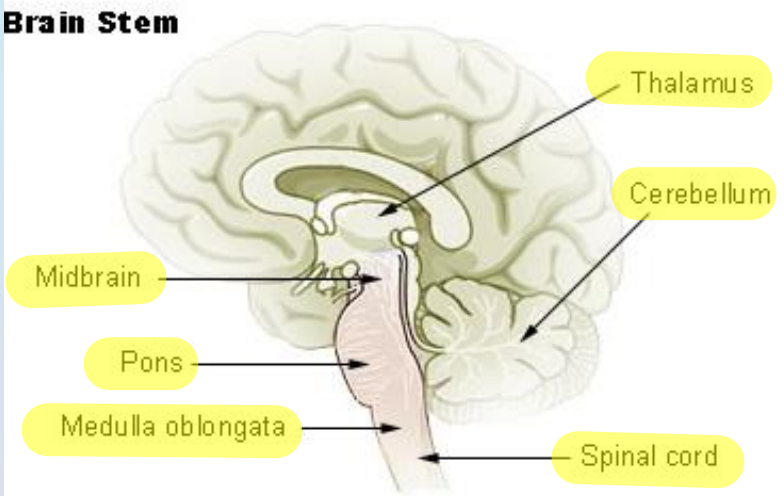
Ward (2010)

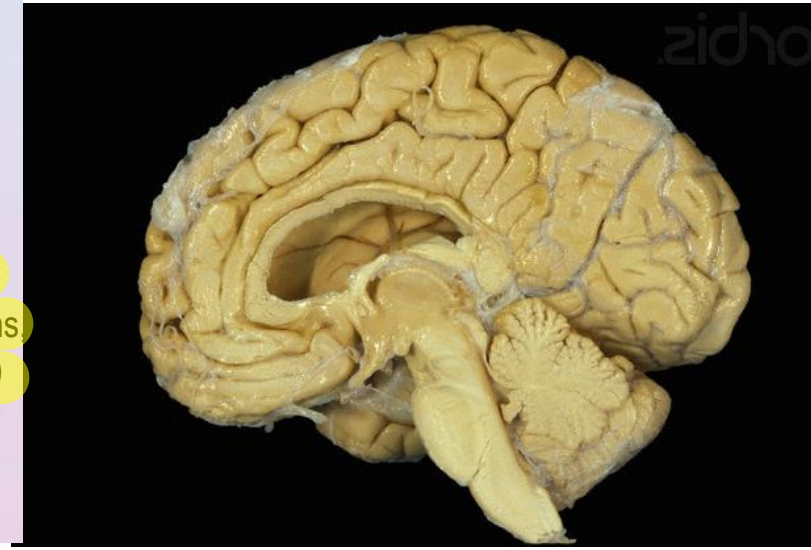
- During development, three major parts of the brain are formed
  - the hindbrain (medulla, pons, cerebellum)
  - the midbrain
  - the forebrain



The Brain Stem (hindbrain & midbrain)

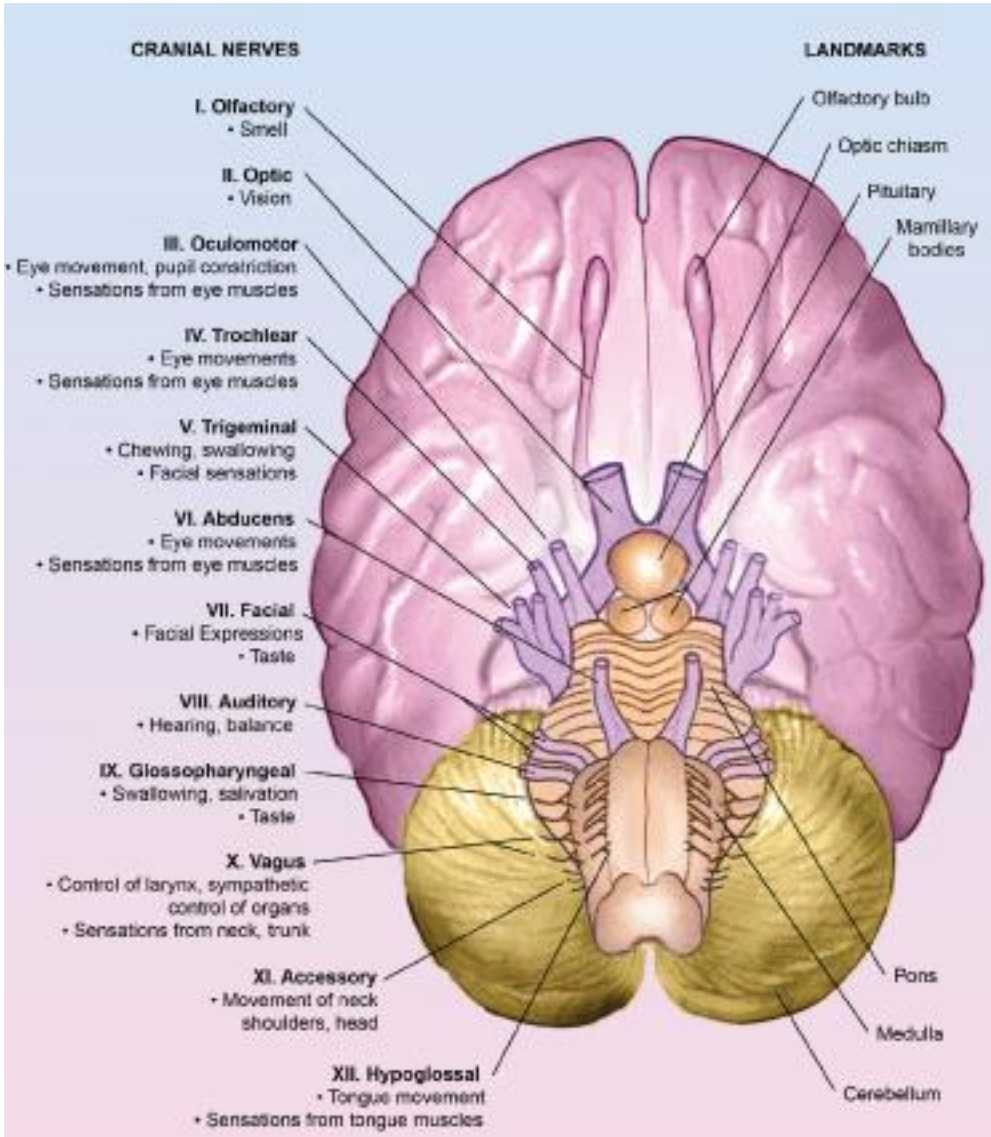






Hindbrain

- **Medulla** (an extension of spinal cord)
  - controls vital reflexes (heart rate, circulation, respiration, salivation, coughing, sneezing) via **cranial nerves (VI-XII)** which control sensations from the head, muscle movements in the head & parasympathetic output to organs
- **Pons** (Latin: bridge) – a major relay at which axonal projections cross sides, i.e., become contralateral
  - contains centres related to sleep & arousal
- **Cerebellum** – controls fine motor skills, coordination & balance
  - Plays a role in motor learning
  - Cognitive functions of attention and language

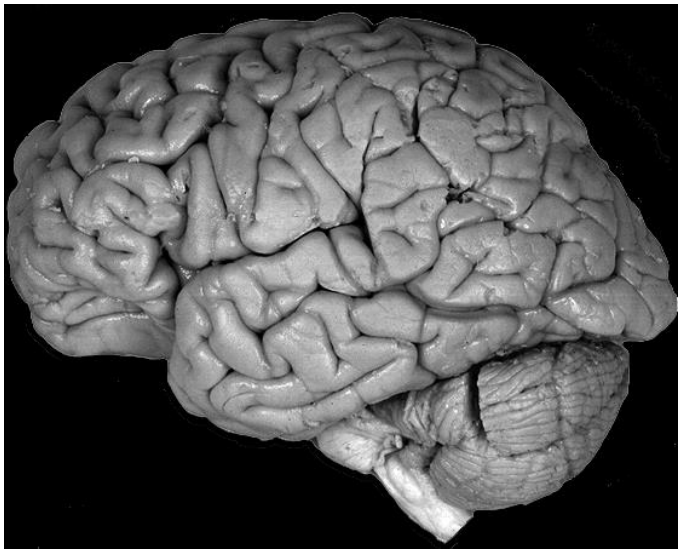


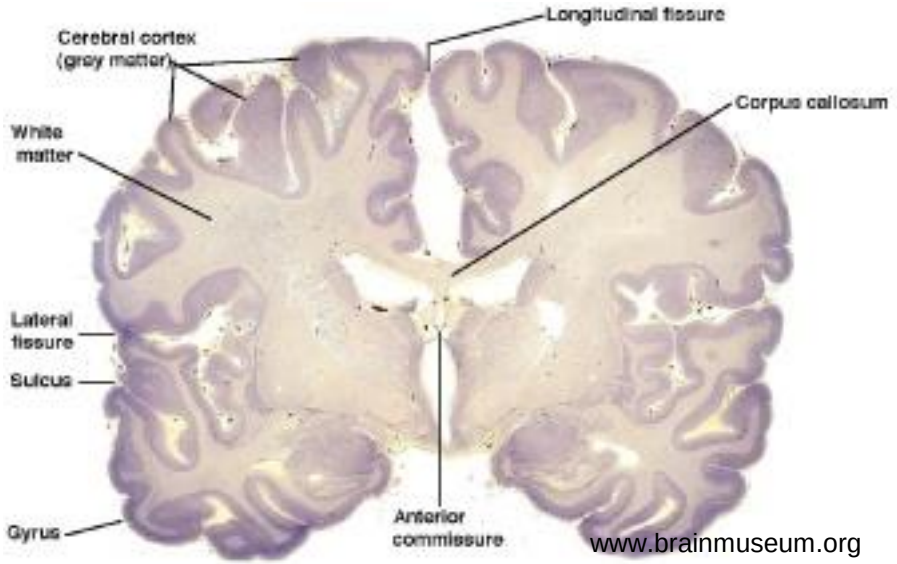
Midbrain

- The midbrain is located at the top of the brain stem and contains structures that have secondary roles in vision, audition and movement
  - The superior colliculi help guide eye movements and fixation of gaze
  - The inferior colliculi help sound localisation
  - The substantia nigra plays a role in reward, addiction, projects to the basal ganglia to integrate movements (a dopamine-containing pathway implicated in Parkinson's disease)

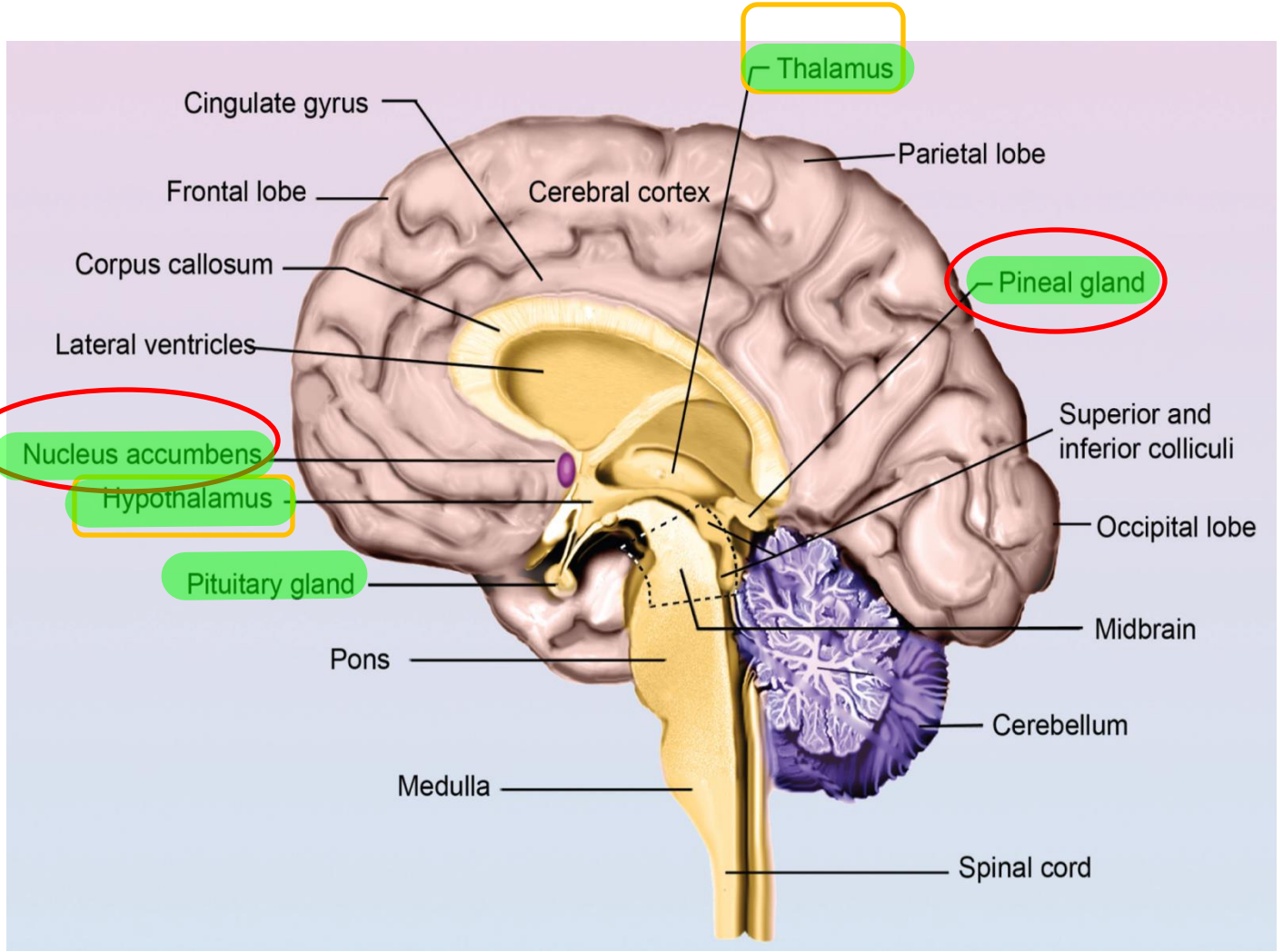
Forebrain

- The forebrain is the largest part of the brain
  - It is made up of two **cerebral hemispheres** separated by the **longitudinal fissure**
  - The **cortex** (1.5-4 mm thick, gray matter – cell bodies) covers the cerebral hemispheres and is wrinkled or convoluted, increasing the amount of cortex
    - A ridge is called a **gyrus**
    - A groove is called a **sulcus** or, if large, a **fissure**

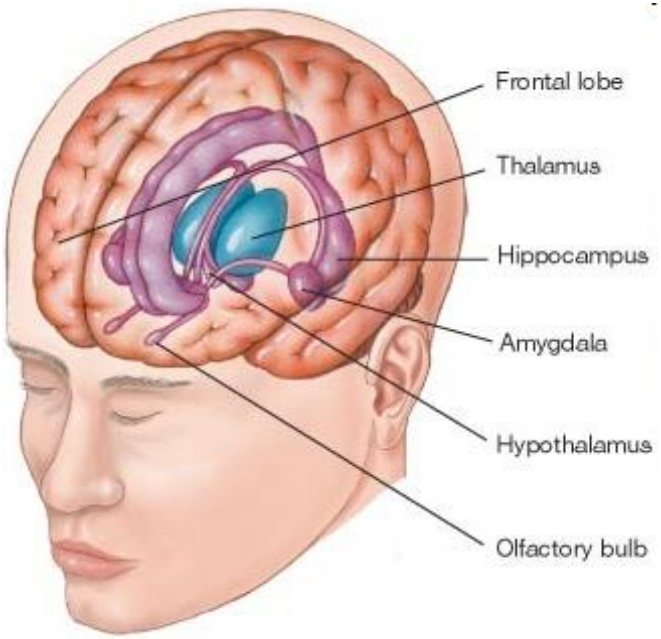


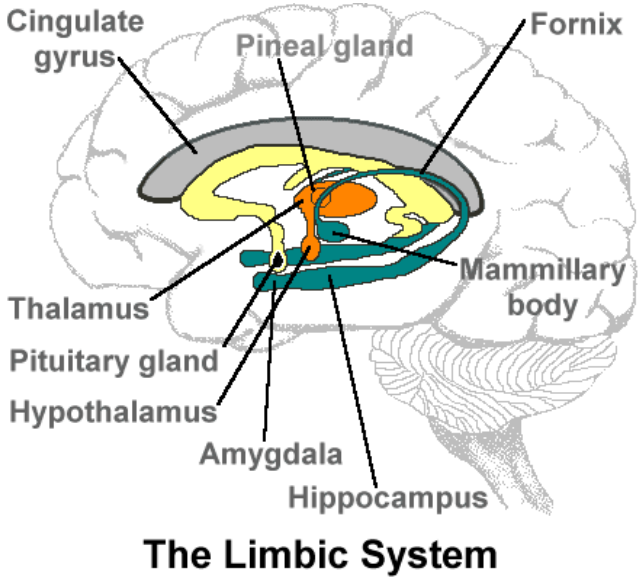


Subcortical areas



Forebrain: subcortical areas

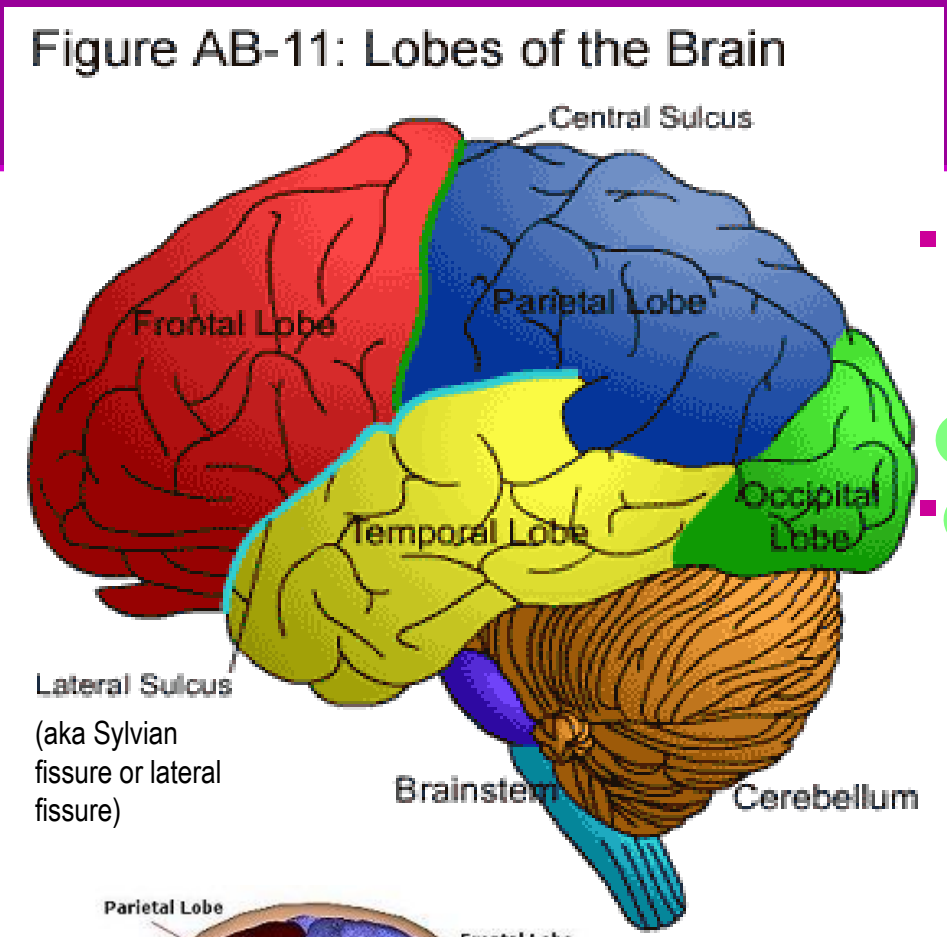


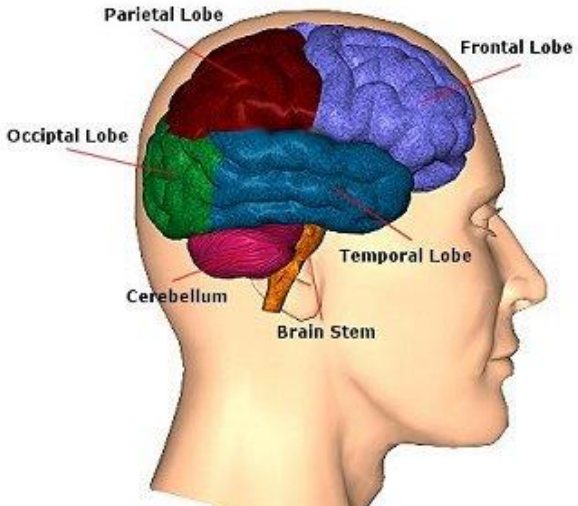


The Limbic System

- **Thalamus** – relays and filters information from sensory organs (except olfaction) and transmits it to the cortex
- **Hypothalamus** – regulates body temperature, hunger, thirst and sexual behaviour
- **Pituitary gland** – releases hormones regulating many other glands in the bogy, "master-gland"
- **Hippocampus** – creation of new memories & integration of new memories into stable knowledge
- **Amygdala** – emotional behaviour & formation of emotional memories
- **Basal ganglia** (the caudate nucleus, putamen & globus pallidus) – participates in planning behaviour and emotional expression, abundant connections with prefrontal cortex

Forebrain: cerebral cortex

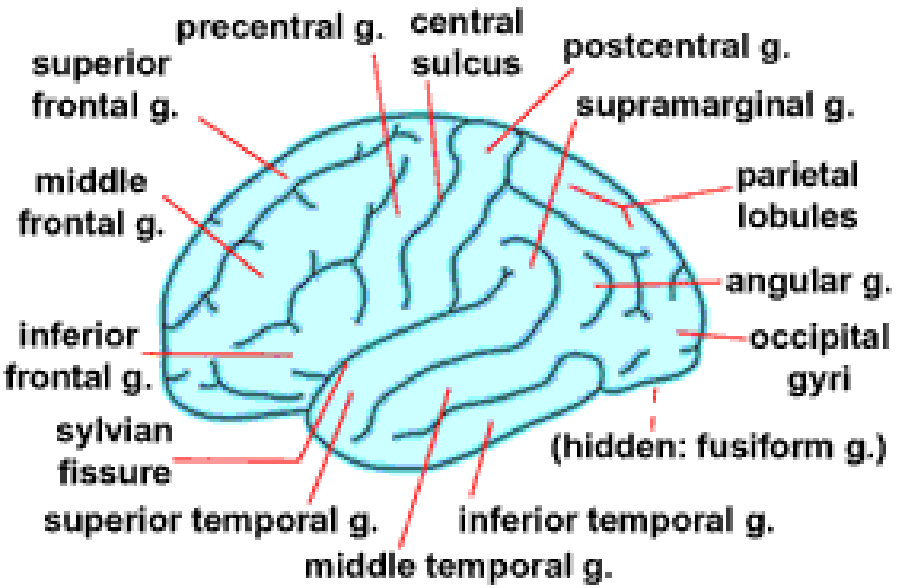


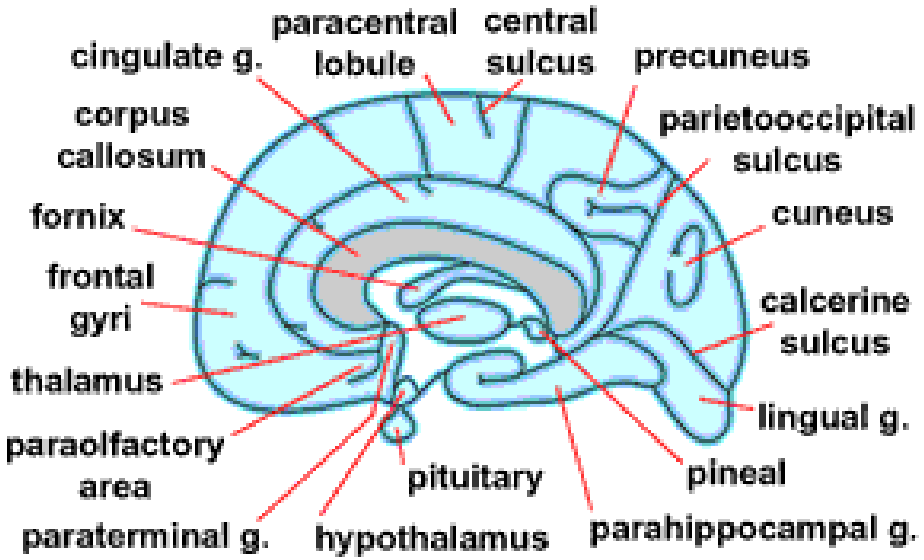


- The **cortex** covers the cerebral hemispheres and is wrinkled or convoluted, increasing the amount of cortex
- Four **lobes** in each hemisphere
  - **Frontal lobe**
    in front of (anterior to) the central sulcus & above (superior to) the lateral fissure
  - **Parietal lobe**
    behind (posterior to) the central sulcus
  - **Occipital lobe**
    at the back (posterior) of the brain
  - **Temporal lobe**
    located on the sides (laterally) of the brain

Cerebral cortex: main gyri & sulci

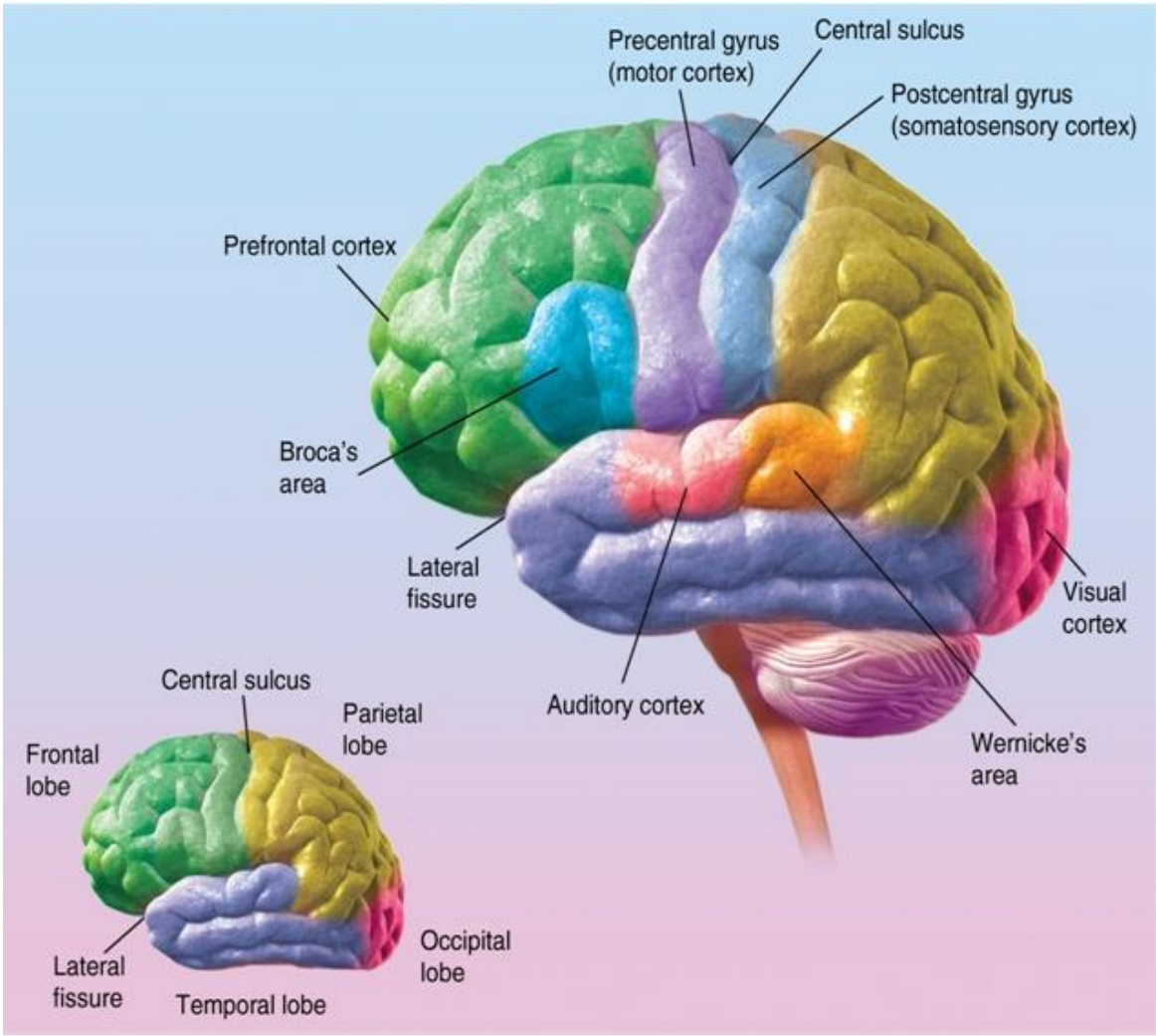
- Gyrus (pl: gyri) – a ridge on the cortex
- Sulcus (pl: sulci) – a groove in the brain surface
  - Deep sylci are called 'fissures'



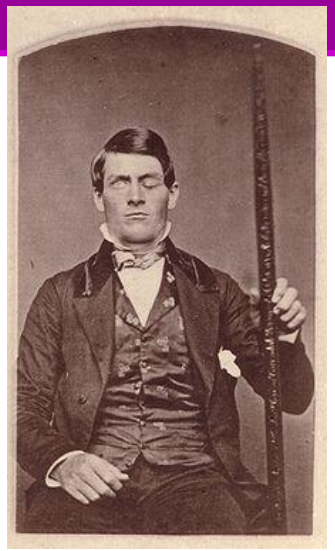


Frontal lobe

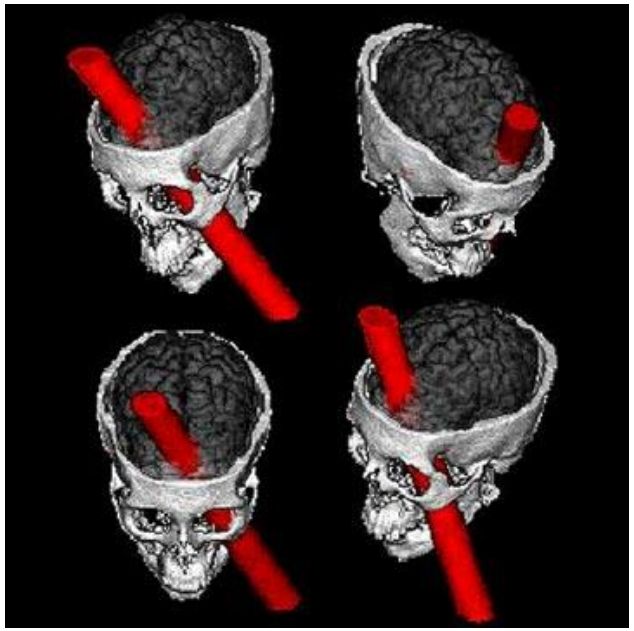
- The frontal lobes are important for movement and complex human capabilities.
  - **Broca's area** is important for speech production.
  - **The primary motor cortex**
- **Prefrontal cortex**
  - plays a role in organizing and planning, decision making, impulse control
  - adjusts behavior in response to rewards and punishments
- Prefrontal lobe dysfunction:
  - impairs the ability to learn from consequences & decreases the ability to control impulses
  - often found in depression and schizophrenia



Prefrontal cortex damage: Phineas Gage

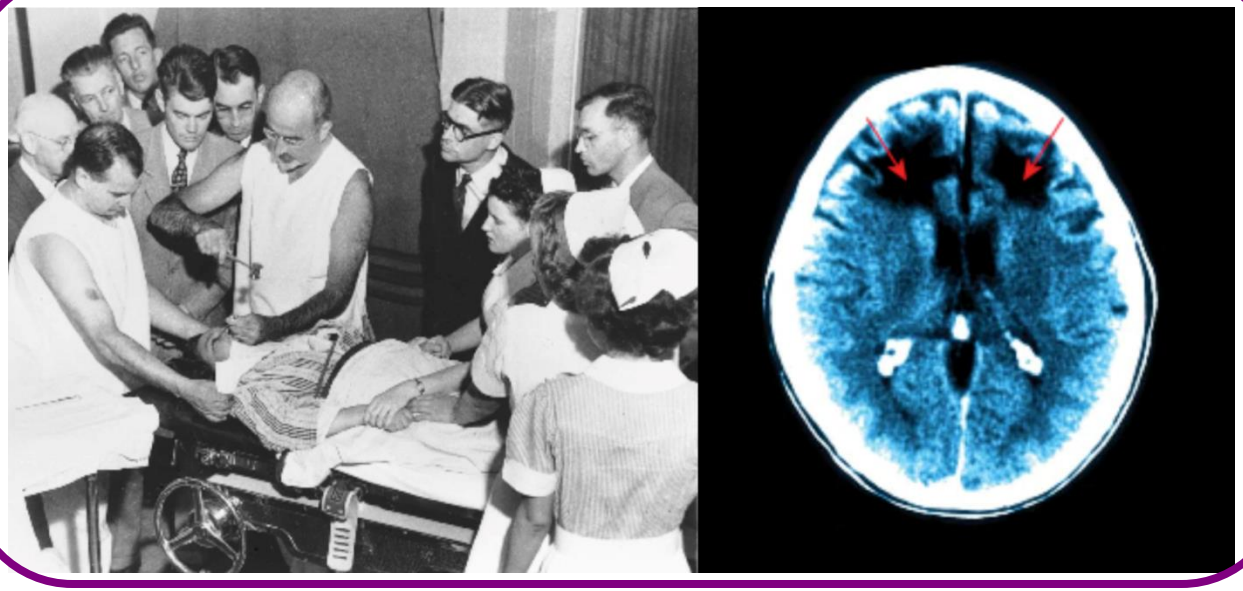


- In 1848 Phineas Gage, a 25-year-old American railroad construction worker , survided an accident in which a large iron rod was driven completely through his left cheek and out of his skull
  - Gage was left with no speech, movement, intelligence or learning impairment
  - The injury changed his personality and behaviour – friends said he was "no longer Gage”
  - Lived under the care of his family, died in 1860



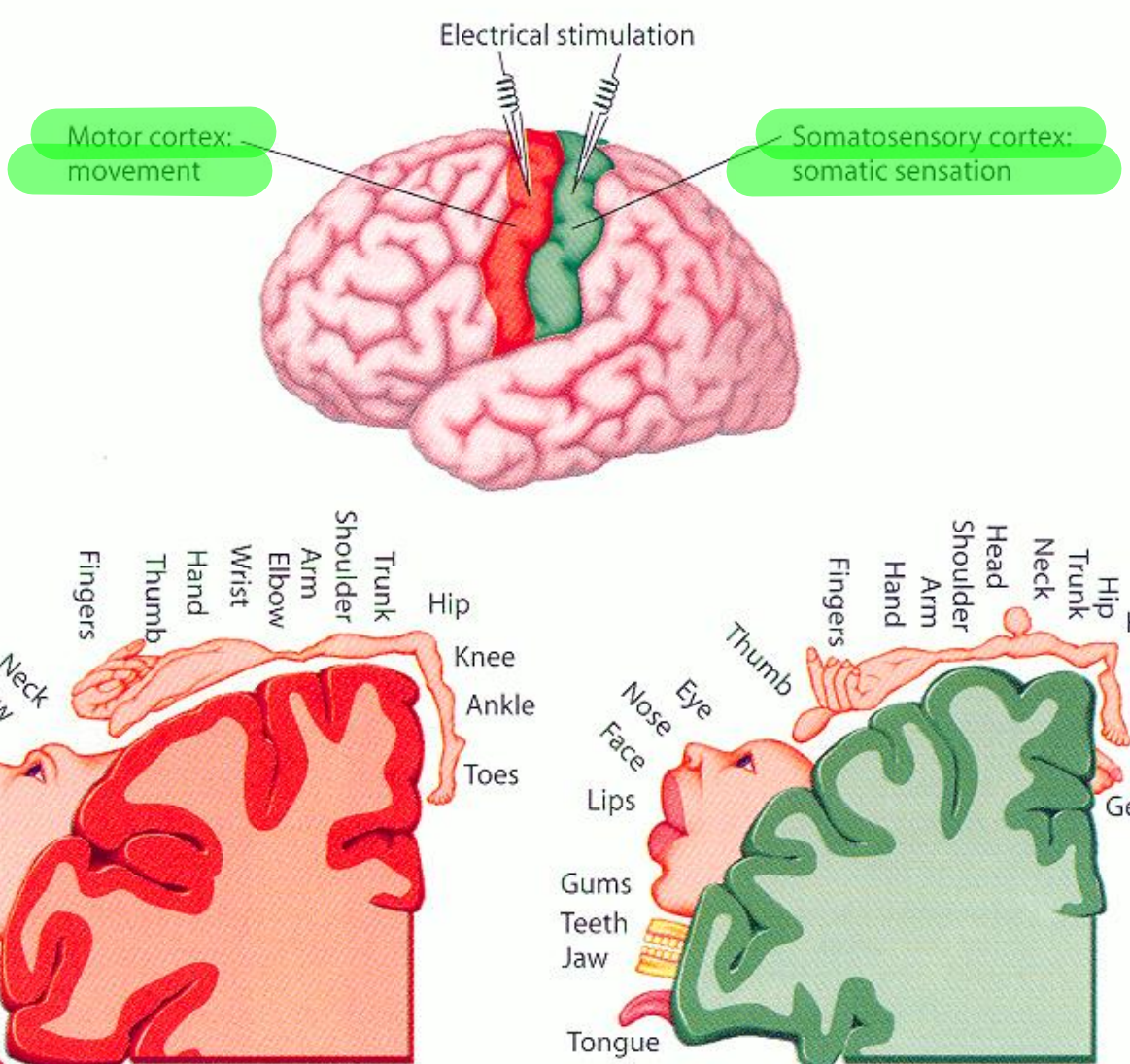
Frontal Lobotomy

- Frontal lobotomy: a surgical procedure that disconnects the prefrontal area from the rest of the brain
  - was performed on 40,000 patients in the U.S. during the 1940s and 1950s, mostly to calm agitated patients
  - provided little benefit at high cost to the patient and has largely been replaced by drug treatment



Walter Freeman inserts his instrument between the eyelid and the eyeball, drives it through the skull with a mallet and moves it back and forth to sever the connections between the prefrontal area and the rest of the brain (Garrett 2011, p.61)

Motor and somatosensory cortices



http://www.fizyka.umk.pl/~duch/ref/01/01-plastic/motorsomato.gif

Motor and Sensory Homonculi

- Motor homunculus

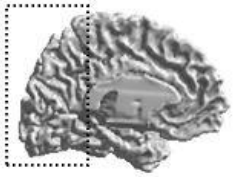
- Sensory homunculus

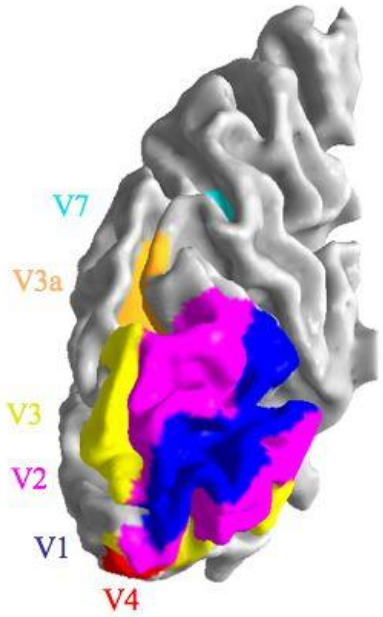
Parietal lobe

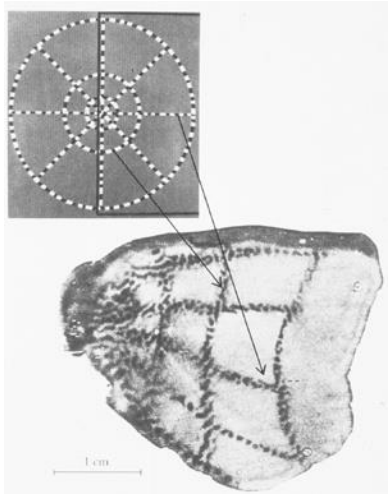
- The parietal lobes are important for body sensations and spatial localization
- The primary somatosensory cortex (the postcentral gyrus)
  - receives information about the skin senses, body position, and movement & maps these functions as a sensory homunculus (with size corresponding to sensitivity in that part of the body)
- Parietal association areas
  - combine information from body senses and vision;
  - identify objects by touch, determine the location of the limbs, and locate objects in space.
- Damage to the posterior parietal cortex (usually on the right) causes neglect of objects on the opposite side

Occipital lobe

- Is the location of the primary visual cortex (V1) (*aka* striate cortex due to its striped appearance in cross-section)
  - Contains a map of visual space because adjacent receptors in the eye send information to adjacent points in the visual cortex ('retinotopic map')
  - Destruction in the striate cortex causes **<u>cortical</u> blindness** in the related part of the visual field
- Has secondary visual areas that process individual components of a scene, including color, movement, and form

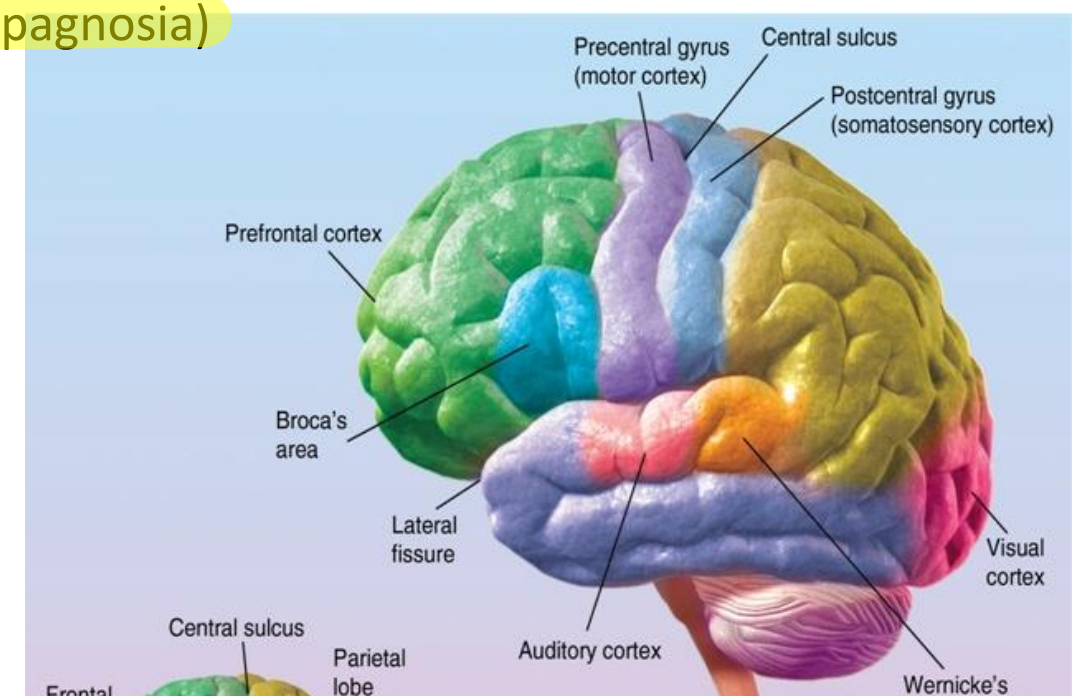






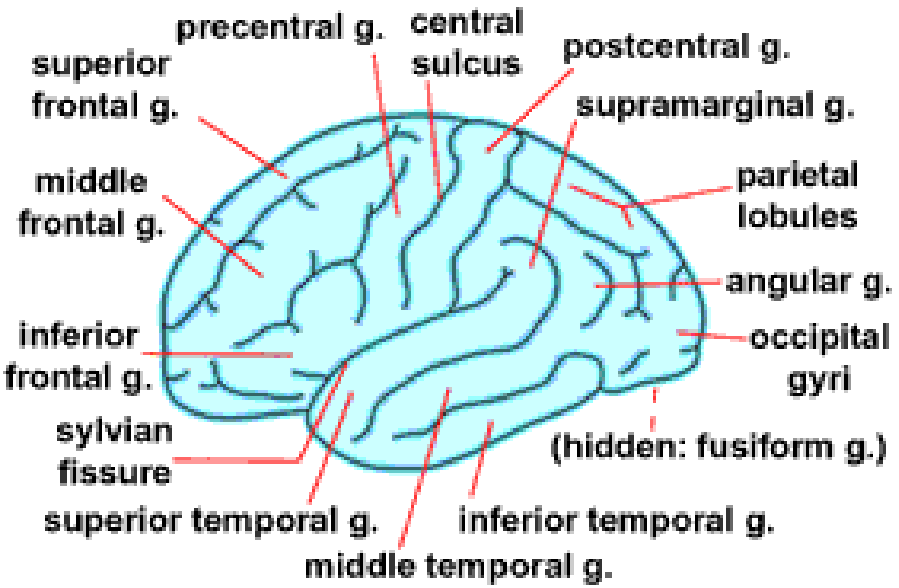
Temporal lobe

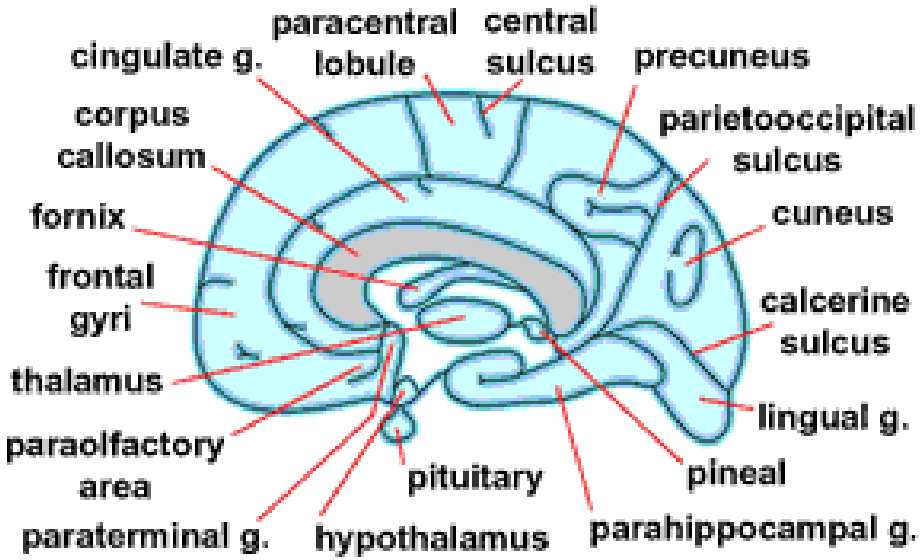
- Contains the primary auditory cortex
- Include language and auditory and visual association areas
  - Wernicke's area is involved in language comprehension and production; damage results in meaningless speech and poor comprehension of written and spoken communication.
  - Fusiform gyrus (in the ventral temporal cortex) is involved in visual word and face identification. Damage causes difficulty in recognizing objects and familiar faces (prosopagnosia)



Cerebral cortex: main gyri & sulci

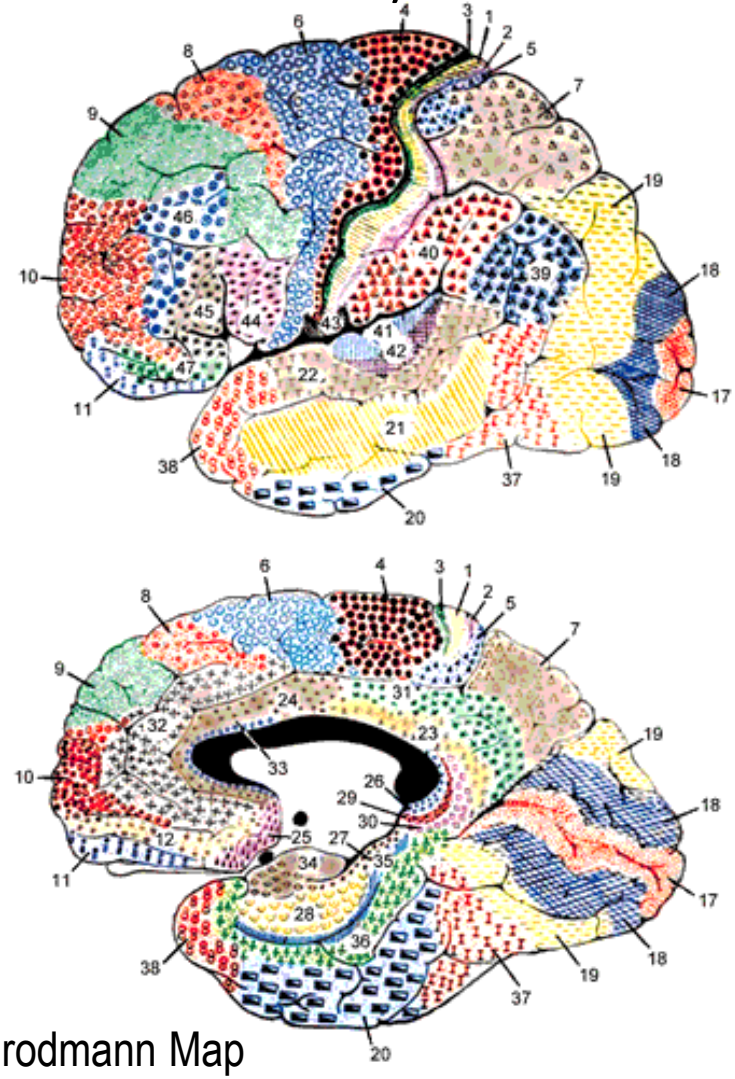
- Gyrus (pl: gyri) – a ridge on the cortex
- Sulcus (pl: sulci) – a groove in the brain surface
  - Deep sylci are called 'fissures'



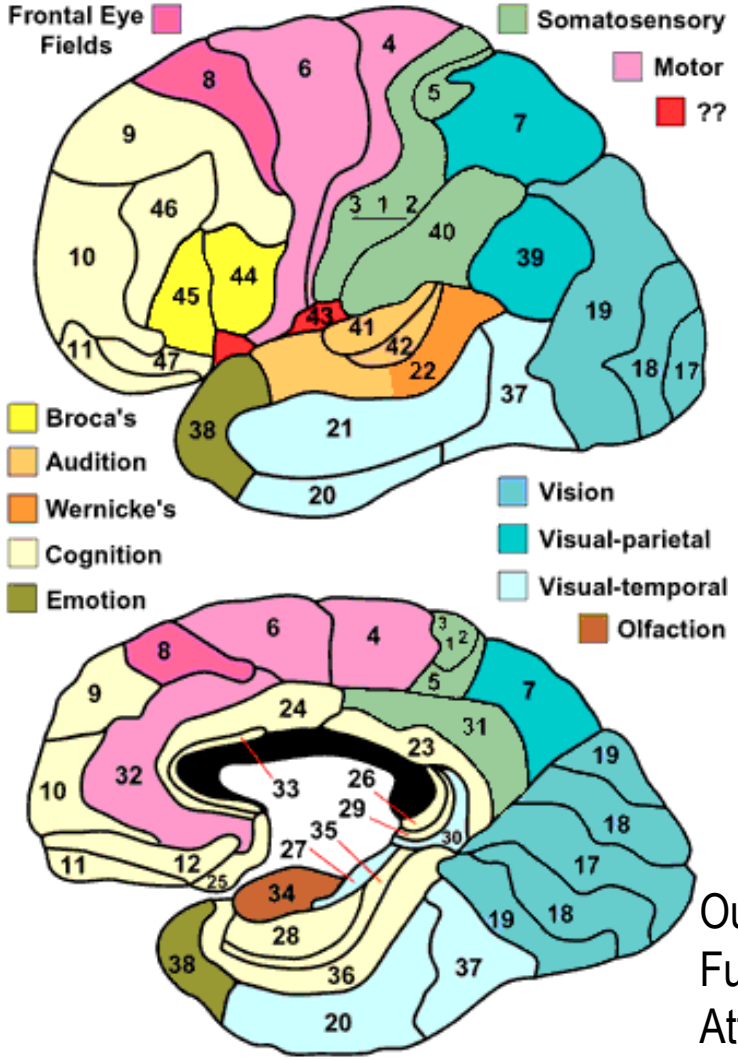


Broadmann's map of the cortex

- Korbinian Broadmann (1868-1918), a German neurologist, distinguished 52 cortical areas via a cytoarchitectural analysis



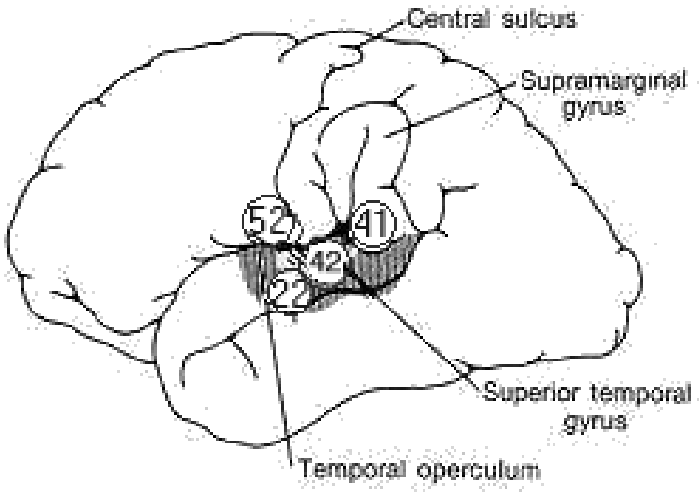
Original Brodmann Map

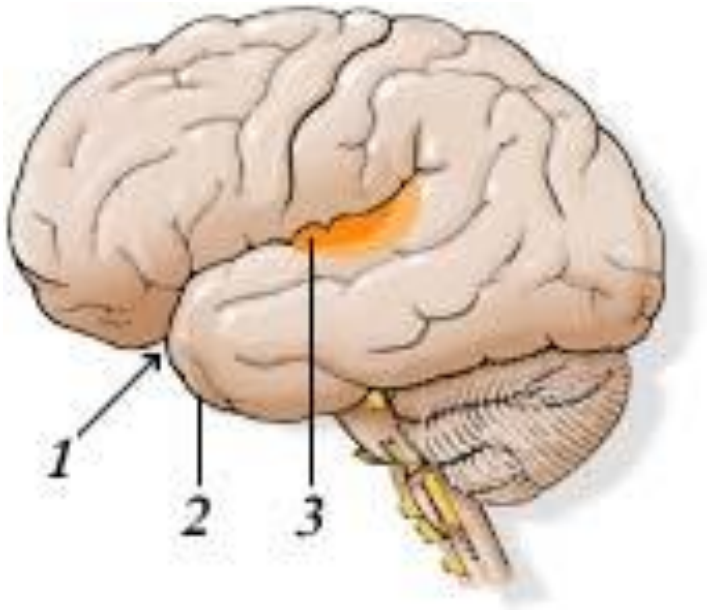


Outlines with Functional Attribution

One spot, many names

- The same brain area can be referred to in various ways:
  - Brodmann's area 41 & 42 =
  - Posterior half of the superior temporal gyrus diving into the lateral sulcus as the transverse temporal gyri (aka Heschl's gyri) [anatomical location] =
  - Primary auditory cortex [function]





Summary

- The nervous system – central (CNS) and peripheral (PNS) divisions
- Peripheral nervous system (PNS) – sympathetic & parasympathetic subsystems
- The brain consists of: the hindbrain, the midbrain, the forebrain
- Each hemisphere of the cerebral cortex contains four lobes (frontal, parietal, occipital, temporal)
- Functional specialisation of each lobe

Reading material

- SGW, chapter 3 – required

- Kalat, chapter 4, modules 4.1 and 4.2 only
- Garrett, chapter 3
- Jamie Ward's *The Student's Guide to Cognitive Neuroscience* – chapter 2
  - http://www.psypress.com/ward/contents/

For the curious

- **The Whole Brain atlas** (http://www.med.harvard.edu/AANLIB/home.html) contains many fMRI and PET scans of normal and abnormal brains
- Click on *NEW:* Normal Anatomy in 3-D with MRI/PET (Javascript) for an animated tool that makes it possible to explore different brain slices the way radiologists do.