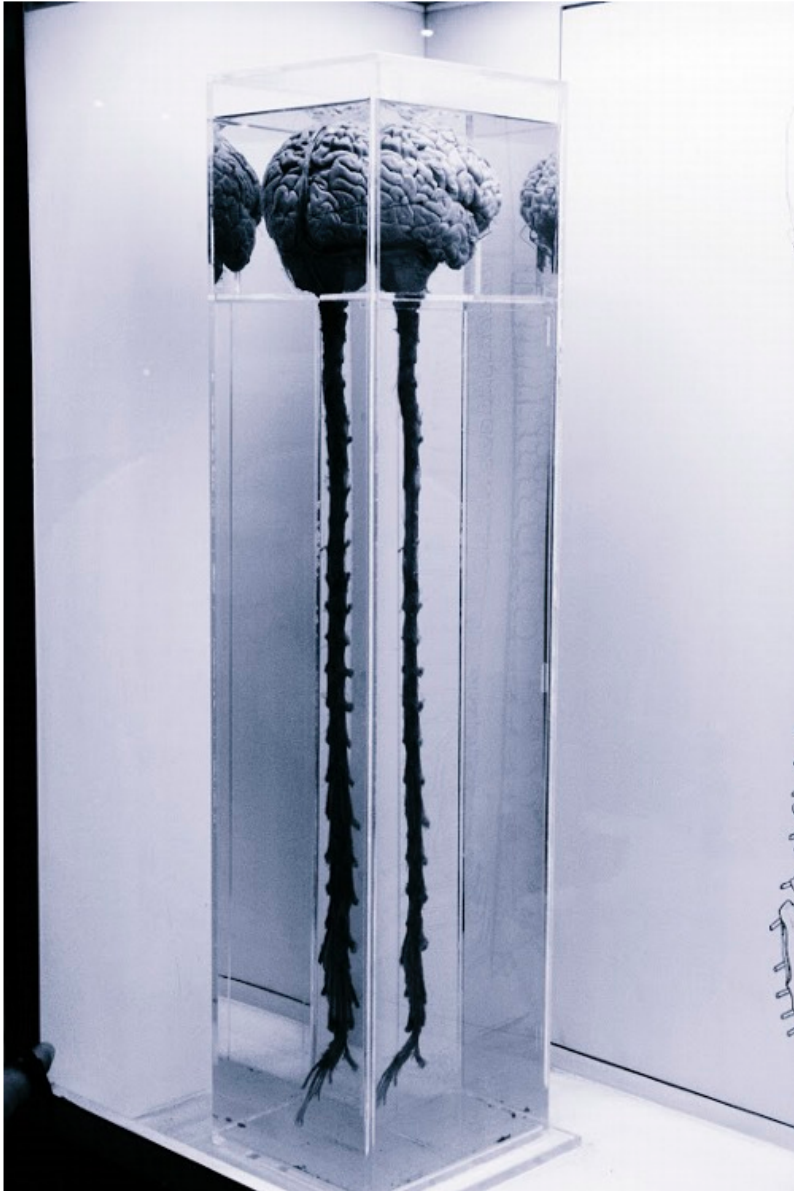


GROSS NEUROANATOMY

CNS - Brain and spinal cord



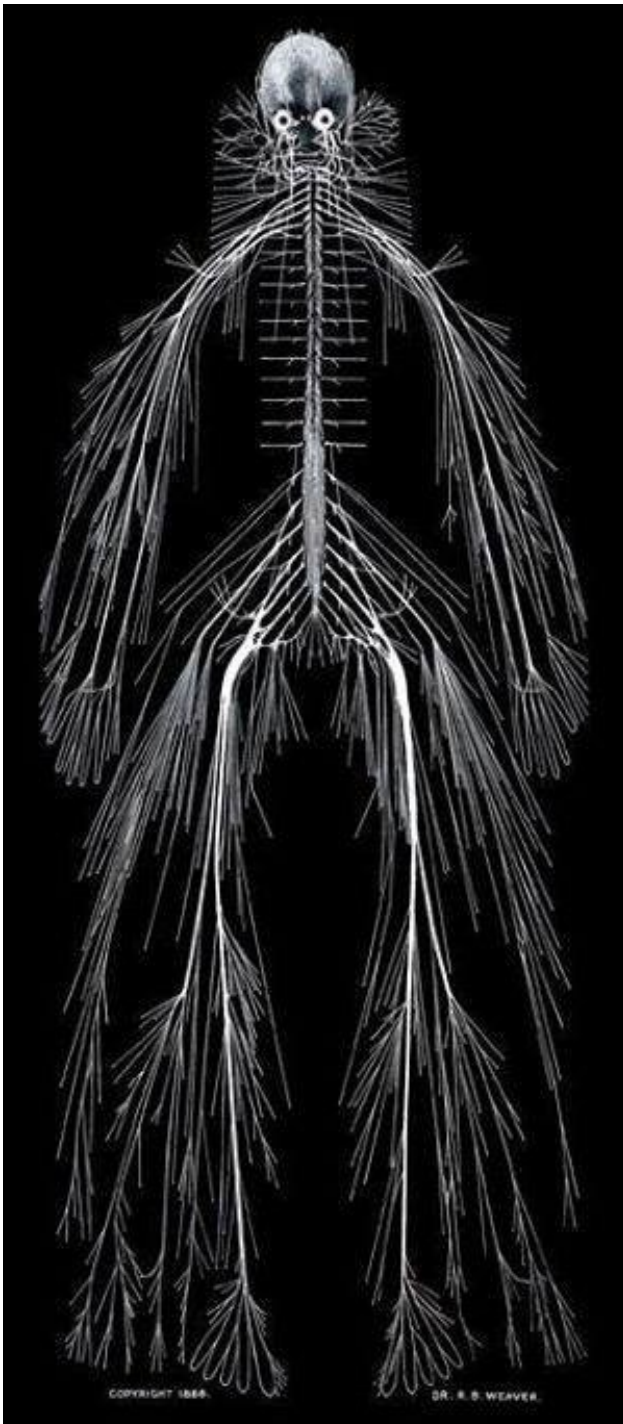
Human



Rat

GROSS NEUROANATOMY

Dissected central & peripheral nervous systems
(CNS & PNS)

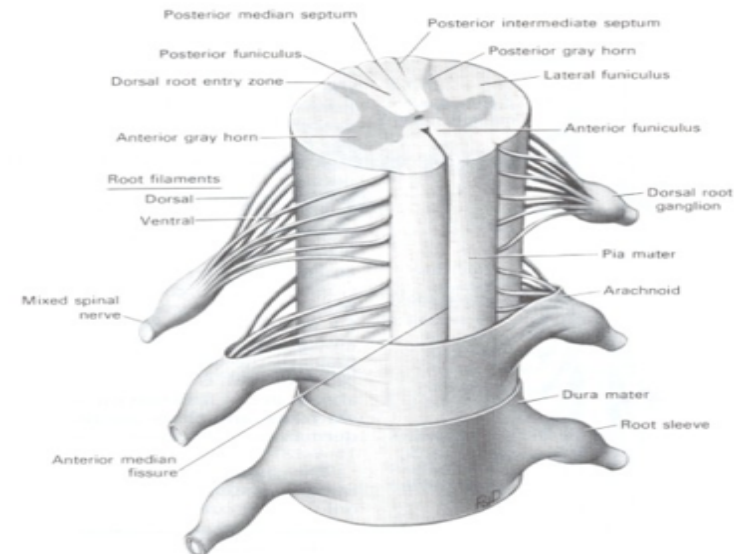
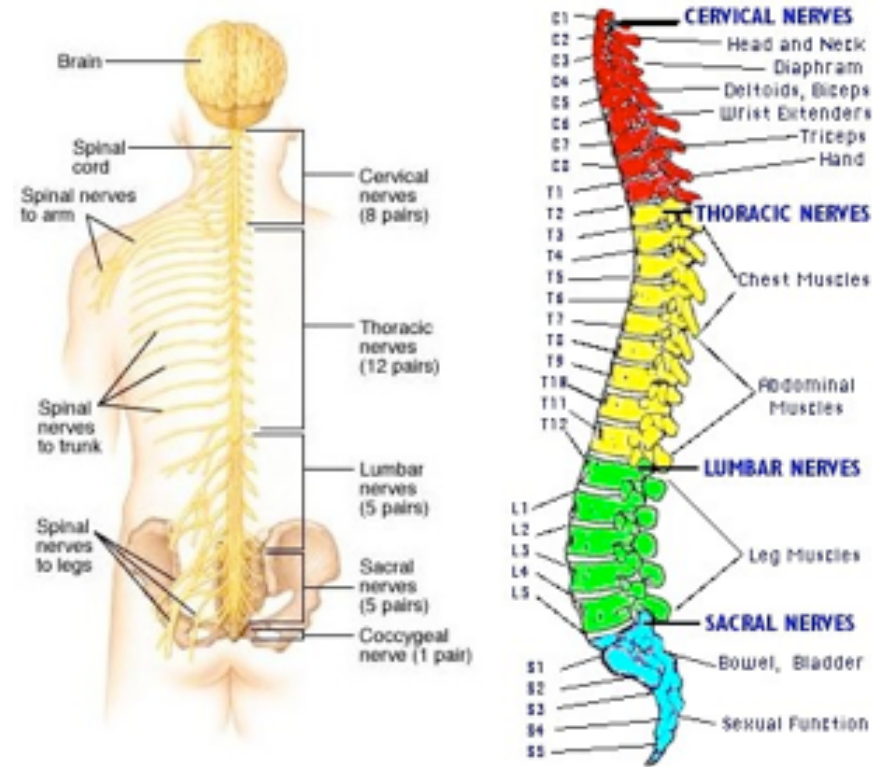


GROSS NEUROANATOMY

Central vs. Peripheral nervous systems

CNS =

- Brain
- Brainstem
- Spinal cord
 - cervical *
 - thoracic
 - lumbar *
 - sacral



GROSS NEUROANATOMY

Central vs. Peripheral nervous systems

PNS = *nerves* outside of CNS

31 pairs of spinal nerves

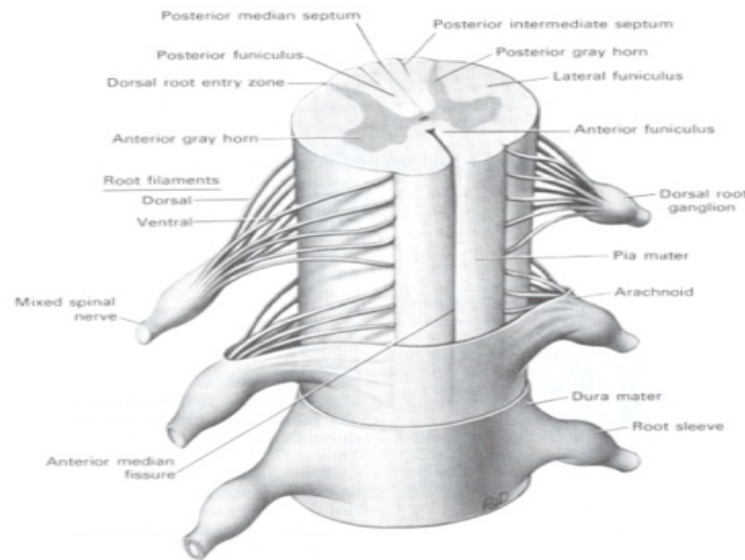
8 cervical

12 thoracic

5 lumbar

5 sacral

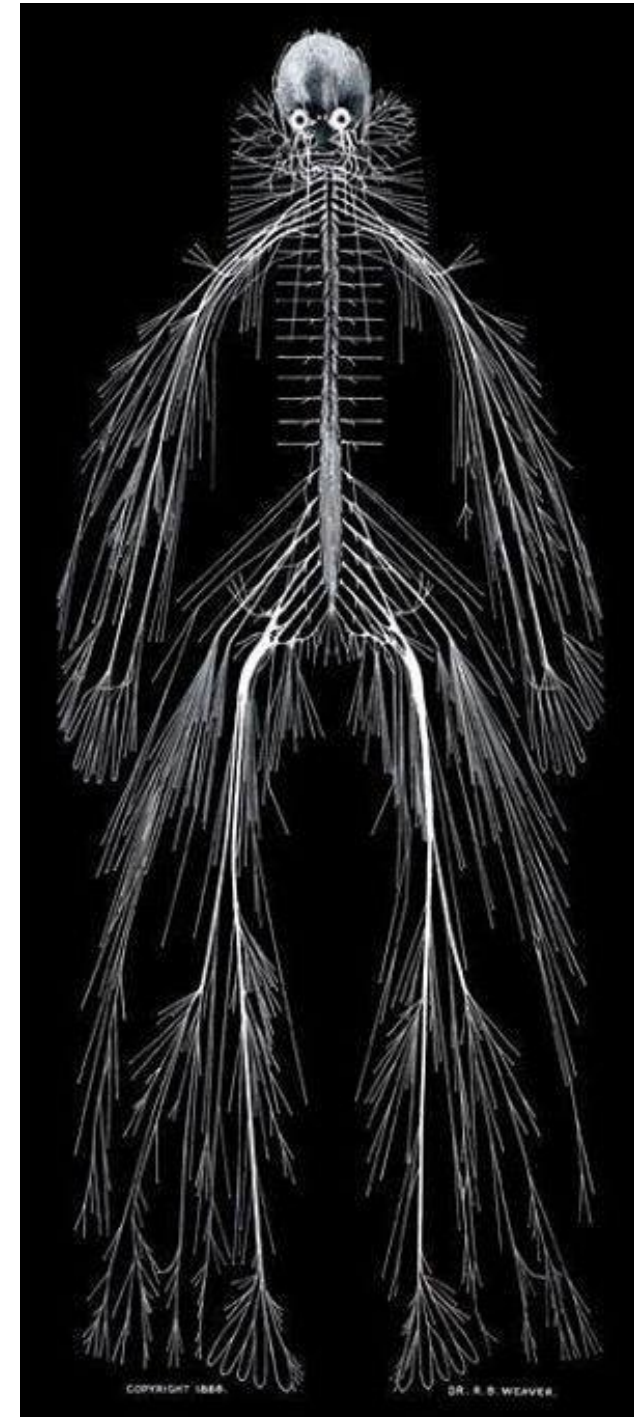
1 coccygeal



Each spinal nerve has 2 “roots”

- dorsal (w/ ganglia) - sensory pathways (in)

- ventral - motor pathways (out)



GROSS NEUROANATOMY

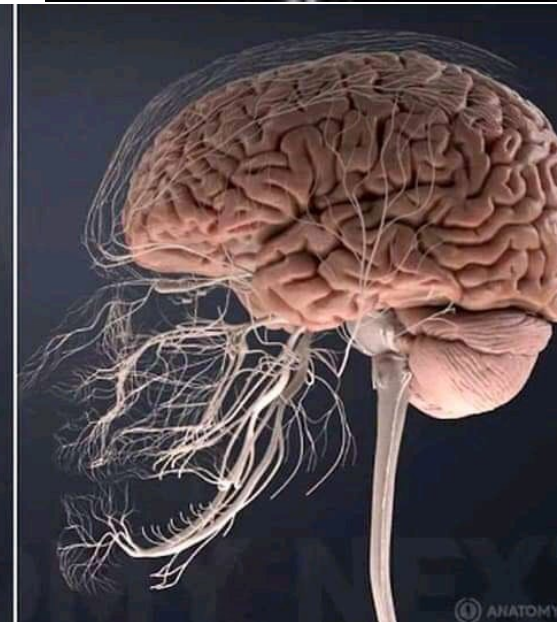
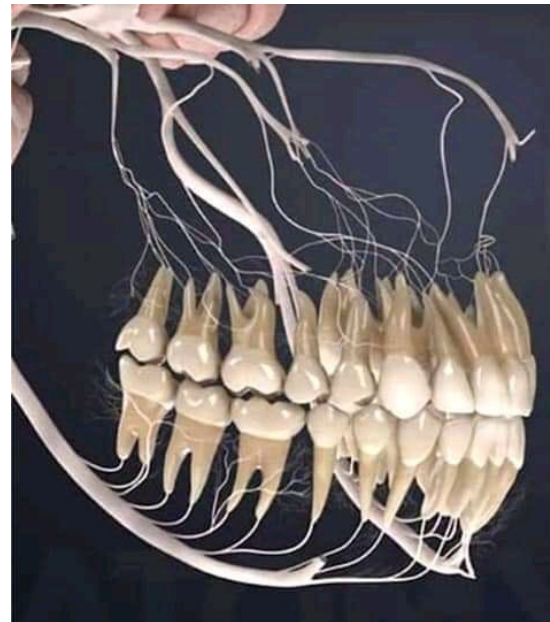
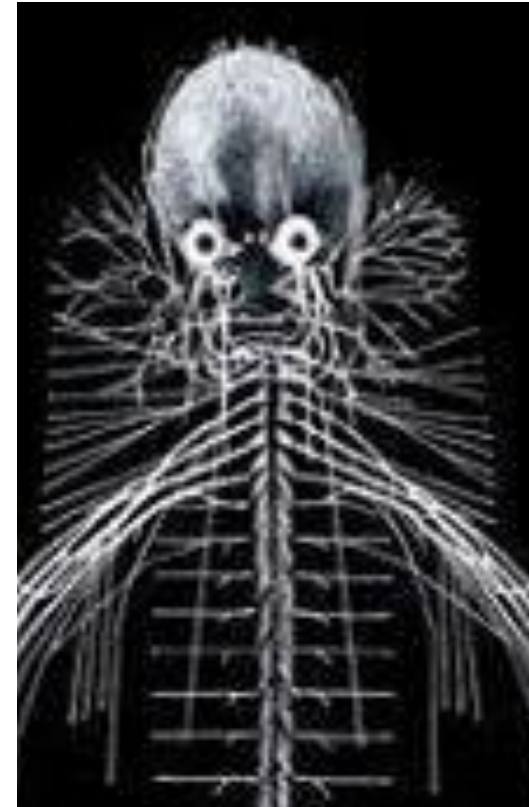
Central vs. Peripheral nervous systems

PNS = *nerves* outside of CNS

12 pairs of cranial nerves
(ganglia in brainstem)

1. Olfactory
2. Optic
3. Oculomotor
4. Trochlear
5. Trigeminal
6. Abducens
7. Facial
8. Vestibulocochlear
9. Glossopharyngeal
10. Vagus
11. Accessory
12. Hypoglossal

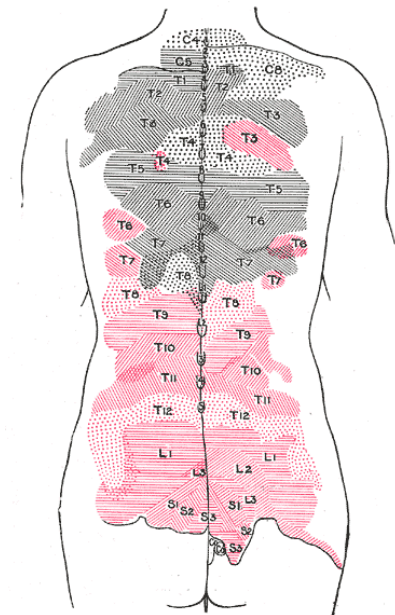
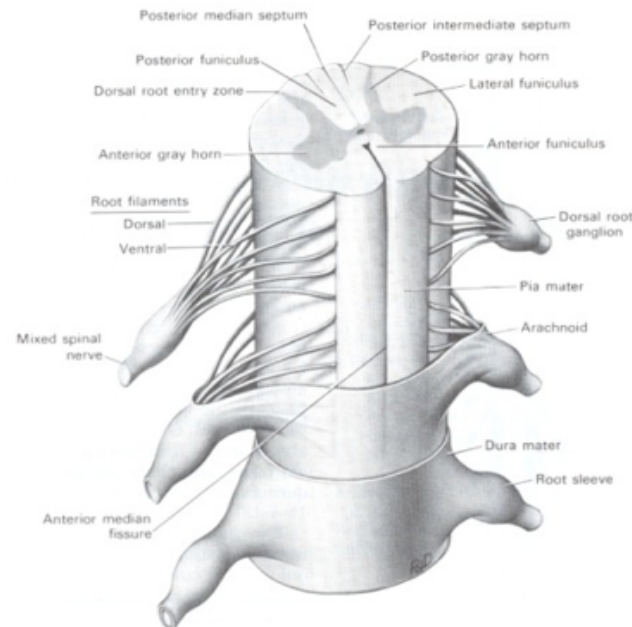
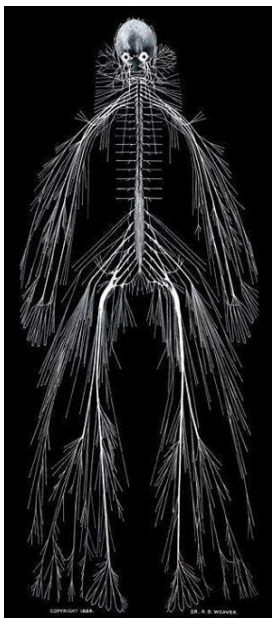
(Sensory / motor / mixed)



GROSS NEUROANATOMY

PNS provides inputs/outputs from “periphery” to CNS

- 2 divisions:
 - somatic - sensory neurons
 - *motor neuron cell bodies are in the CNS*
 - autonomic - sympathetic / parasympathetic (+ enteric)

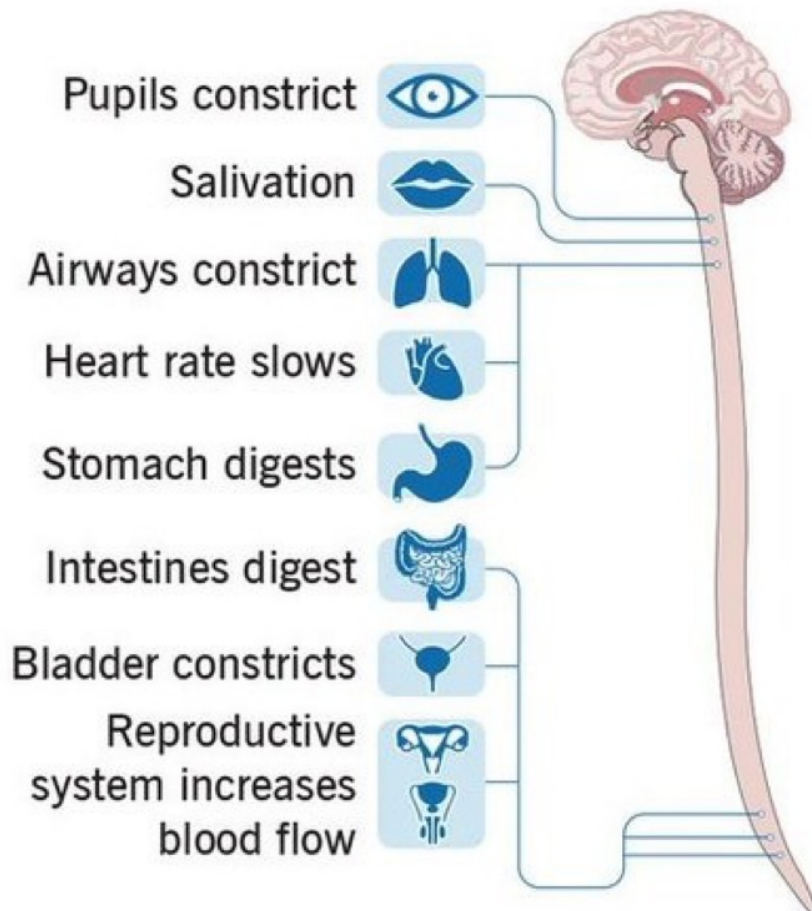


GROSS NEUROANATOMY

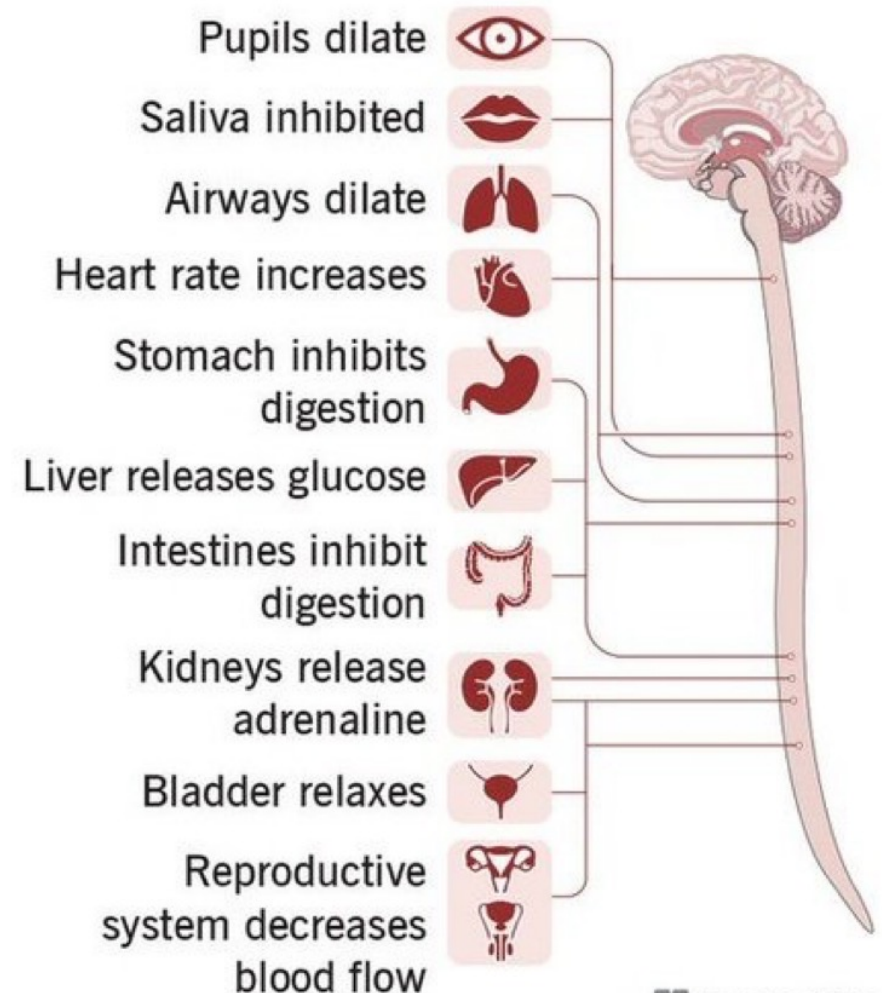
PNS provides inputs/outputs from “periphery” to CNS

Autonomic Nervous System

Parasympathetic Division



Sympathetic Division



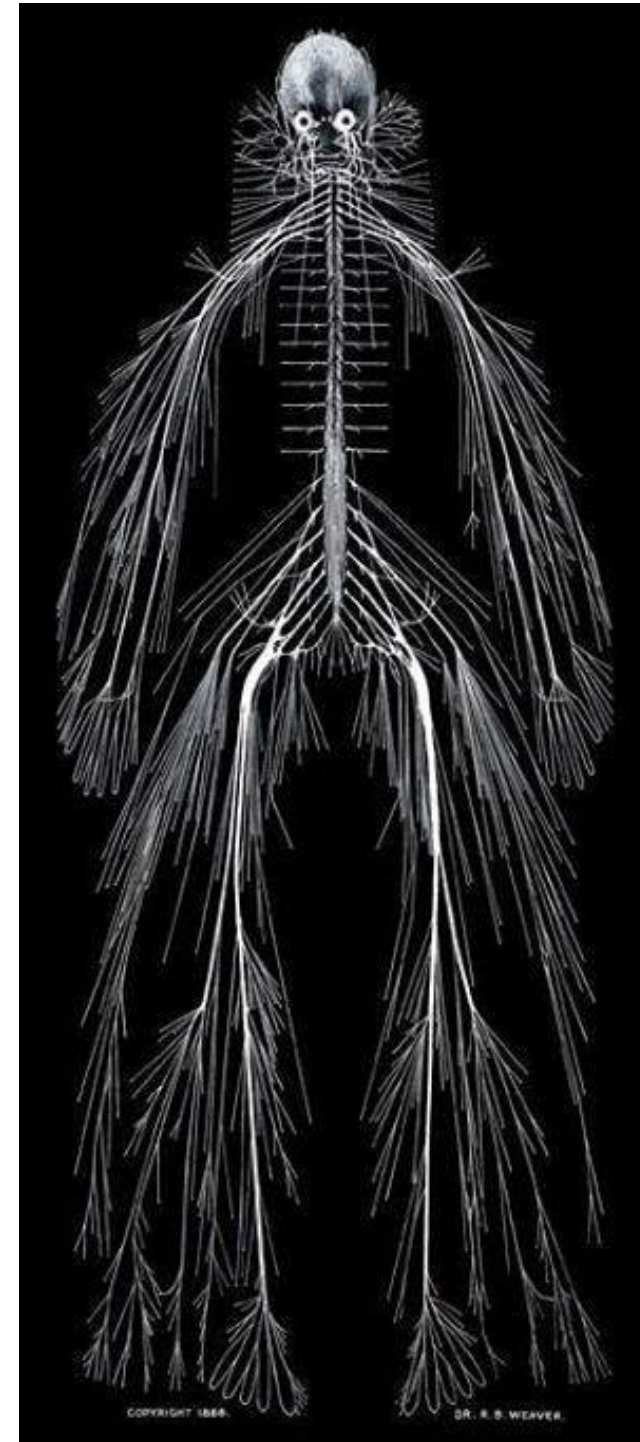
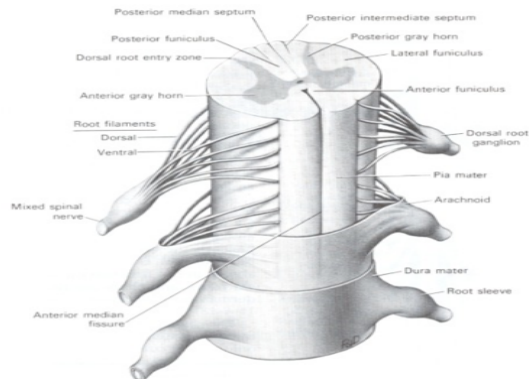
GROSS NEUROANATOMY

- Nervous system is a hierarchy of progressively more complex functions:

Complex brain functions are simply built from multiple smaller functions happening in parallel and in sequence

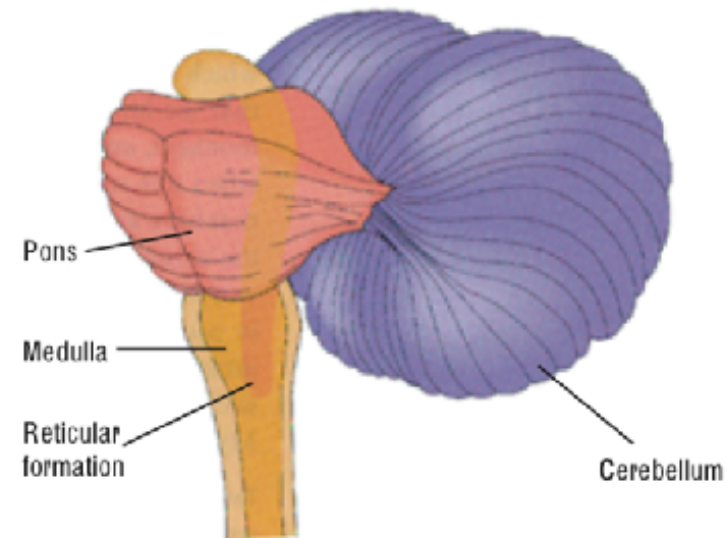
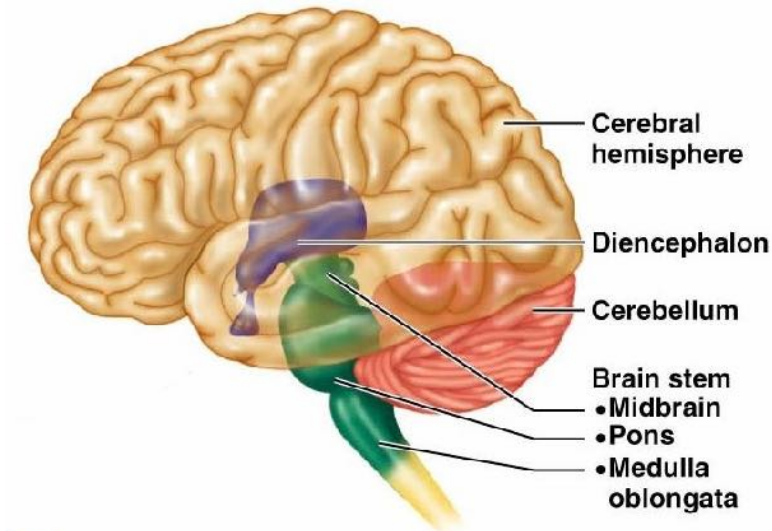
- ***Spinal cord***

- info transfer \leftrightarrow brain & muscles / sensory organs
 - reflexes, touch sensations, pain
- By itself (disconnected from brainstem / brain):
 - can generate monosynaptic reflexes (e.g., patellar) and upkeep very basic rhythmic behaviors (e.g., taking steps with external initiation)
 - cannot support basic life functions or initiate voluntary movements



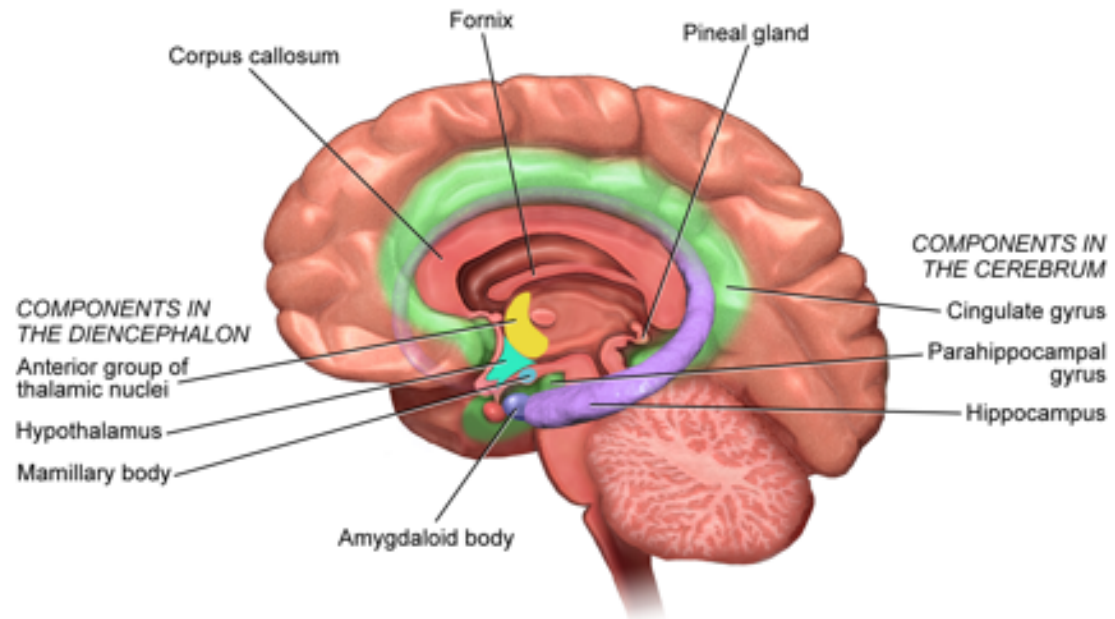
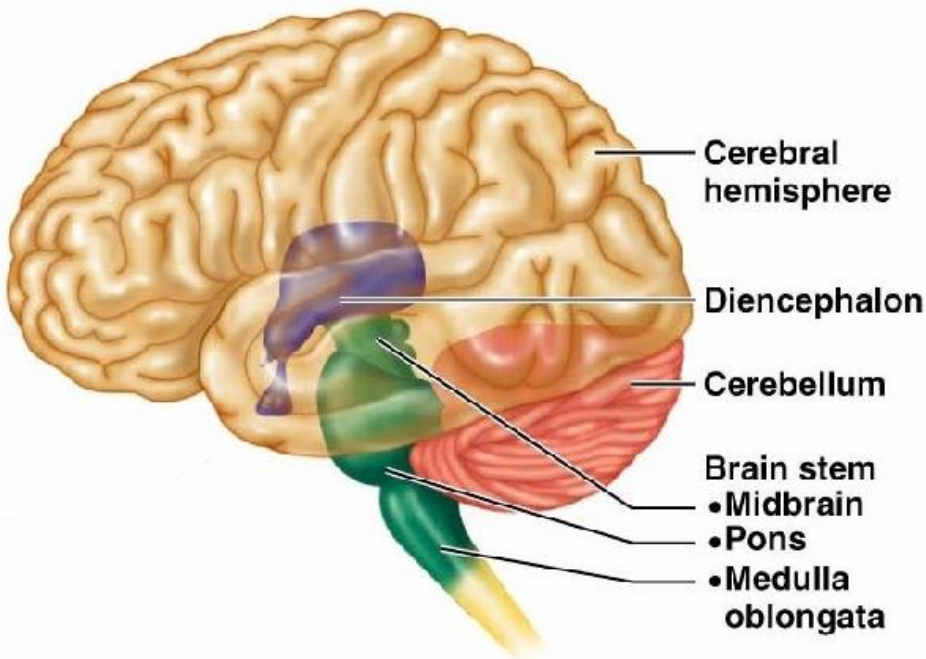
GROSS NEUROANATOMY

- **Brain stem:**
 - medulla / pons / midbrain
 - breathing / blood pressure / heart rate / GI fx / sleeping / arousal
 - + cerebellum
 - movement / posture / coordination
- Adds basic life support functions and very simple (generally “subconscious”) movements to abilities of spinal cord



GROSS NEUROANATOMY

- **Diencephalon (“interbrain”):**
 - thalamus - *sensory relay*
 - hypothalamus - *autonomic control*
 - *plays a major role in the regulation of basic biological drives related to survival, including the so-called “four Fs”: fighting, fleeing, feeding, and mating*
 - pituitary - *hormones*
 - *Hypothalamus-Pituitary-Adrenal (HPA) axis - hypothalamus “tells” pituitary to produce a hormone that induces the release of adrenaline from the adrenal glands (on the kidneys) during stress*
- Adds body temperature maintenance / hormonal regulation (homeostasis)



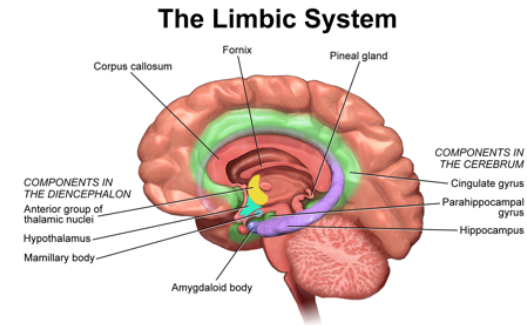
GROSS NEUROANATOMY

- Subcortical structures:
 - Limbic system - memory / emotions / arousal
 - amygdala - *emotional learning*
 - hippocampus - *learning / memory*
 - nucleus accumbens - *reward*
 - Basal ganglia - *movement initiation, intention*

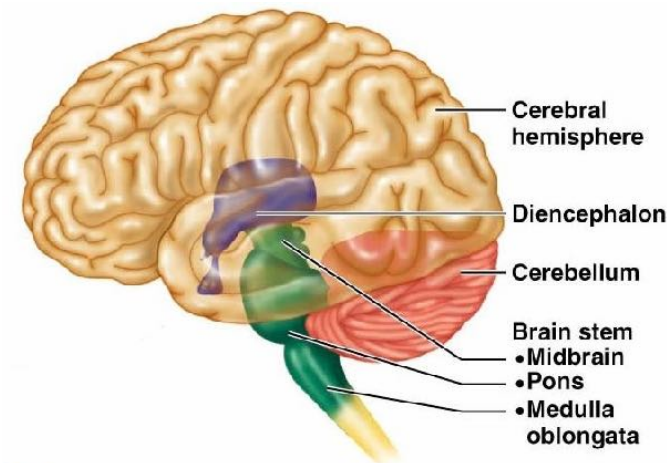
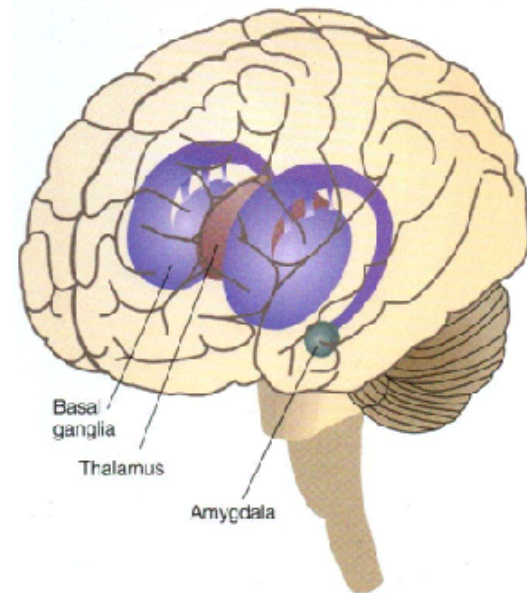
“Higher” hierarchical levels build more complex behaviors.

Subcortical structures add to the functions of the spinal cord / brainstem by mediating the complex behaviors of cortex.

- very basic survival behaviors (approach / withdraw)
 - Limbic system is “primitive”



The Location of the Basal Ganglia in the Human Brain



GROSS NEUROANATOMY

- cortex / forebrain / cerebrum - largest part of human brain

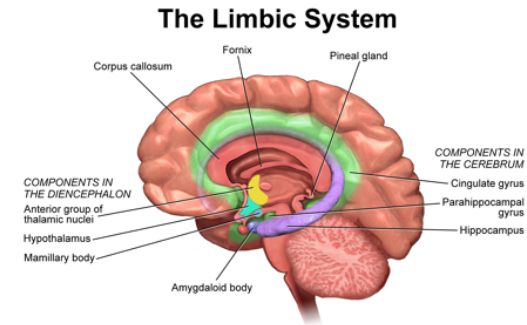
- Top of hierarchy = most complex

- *thinking / cognition / complex behaviors*

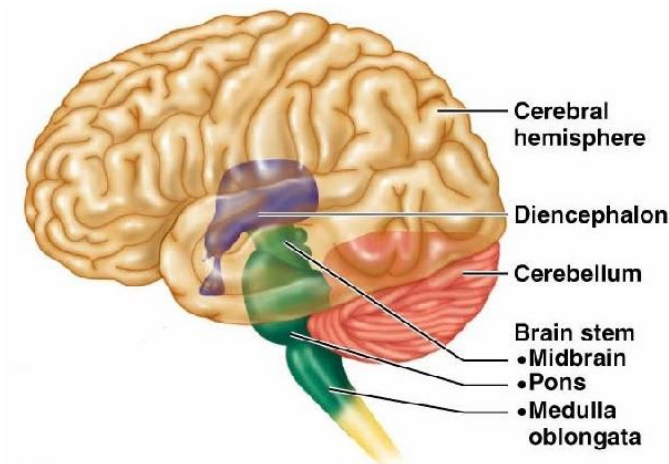
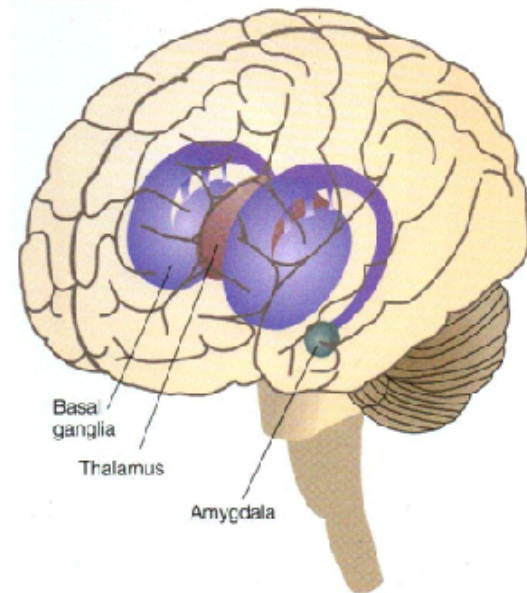
- *Perception*

- *Voluntary / goal directed movements*

- *Learning / adaptation*

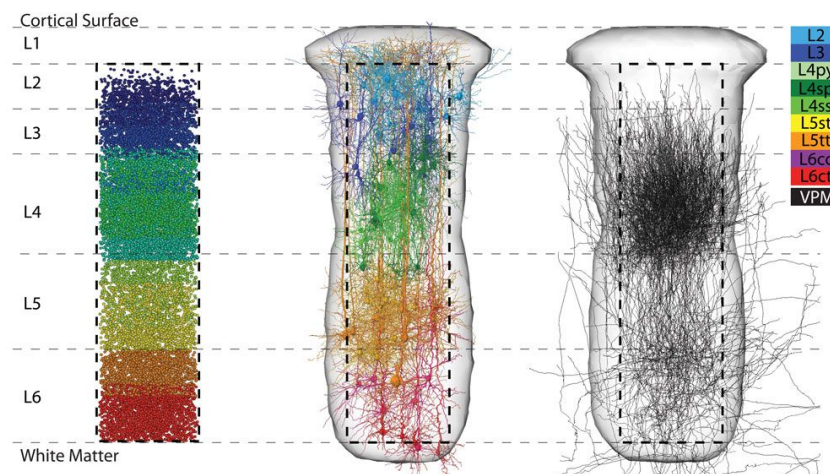


The Location of the Basal Ganglia in the Human Brain



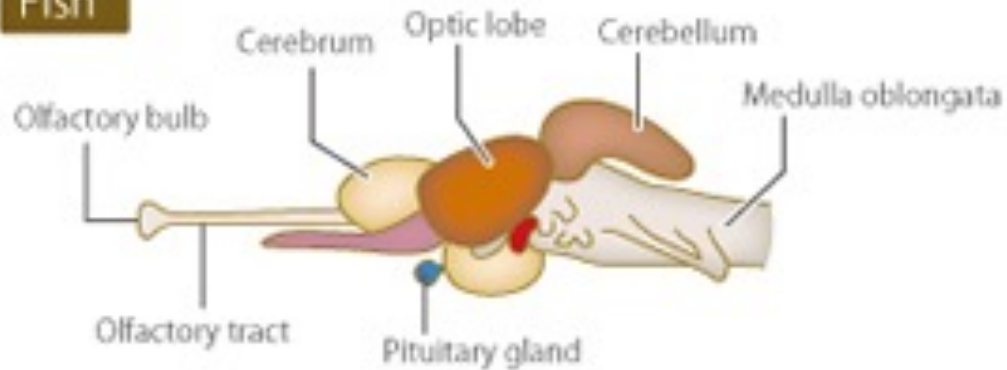
FOUNDATIONS OF BEHAVIORAL NEUROSCIENCE

- Cortex is ~ pizza sized: 1.3 sq ft, .12 sq m
 - ~40–75% of human brain’s volume
- Neocortex arranged in interconnected functional units called “columns”
 - 1 mm sq & ~3 mm deep
 - ~4000-8000 neurons arranged in mini-columns and up to 6 layers
 - hypercolumns
- All columns basically compute a “common cortical algorithm” (Vernon Mountcastle)
 - each column gets 1 “vote” (probabilistic statistics)
 - generic - no specific fx
 - “visual cortex” is just “visual” because it’s connected to eyes
- increase computing power simply by increasing number of columns
 - ~100,000-150,000 columns or computational units in human neocortex

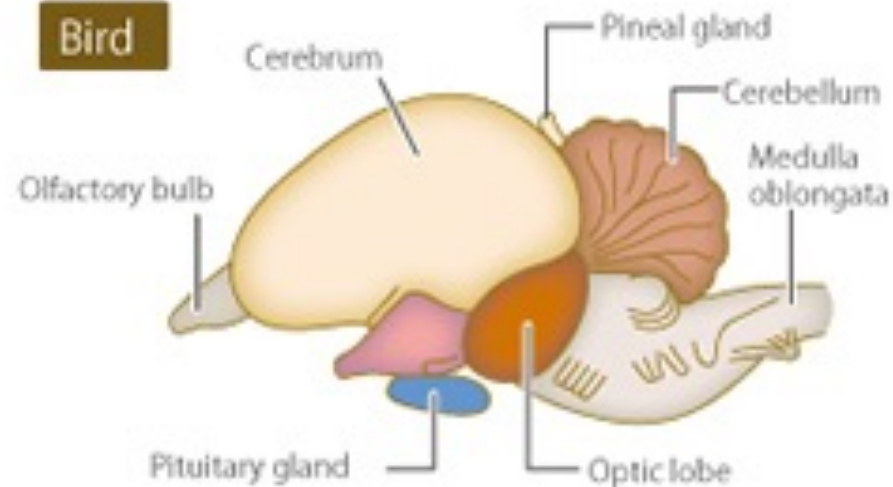


GROSS NEUROANATOMY

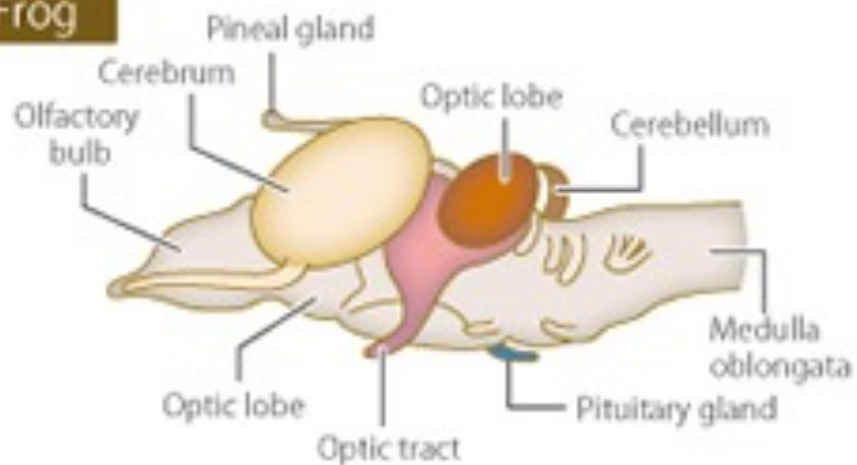
Fish



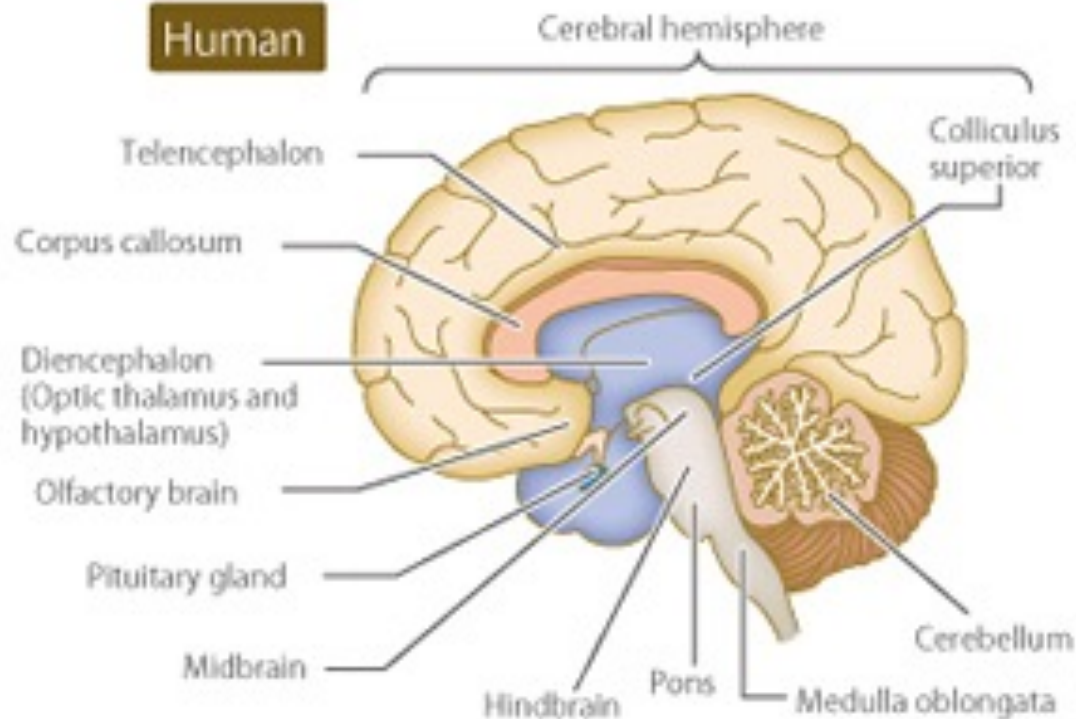
Bird



Frog



Human





Layered organization of cortex:

Paleocortex – 3 layers

hippocampal formation / ventral & medial cortex
closest to brainstem

Archicortex – 3-4 layers

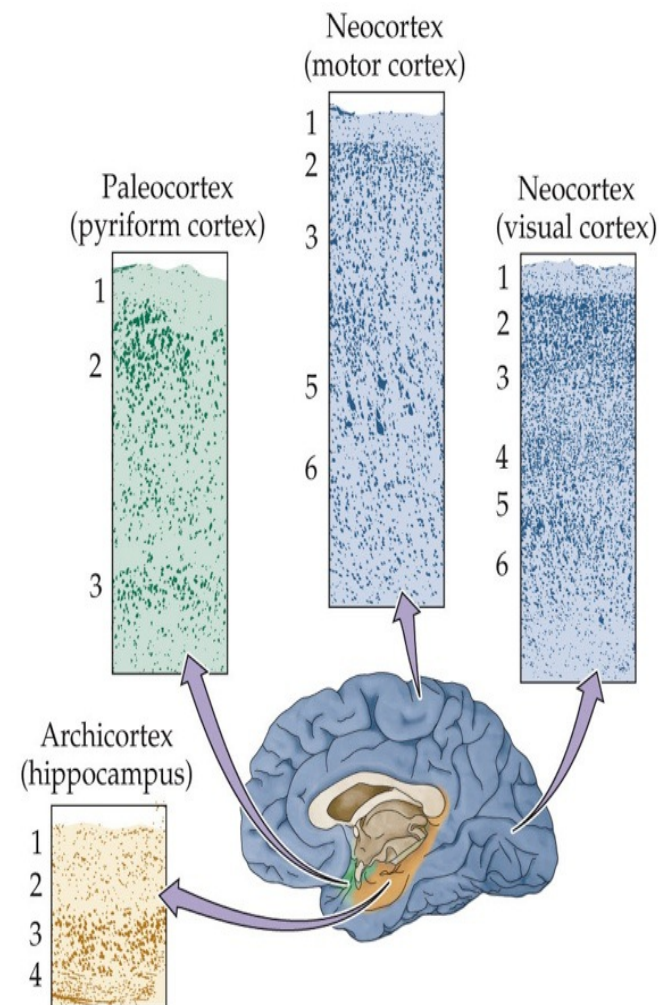
hippocampal formation / amygdala

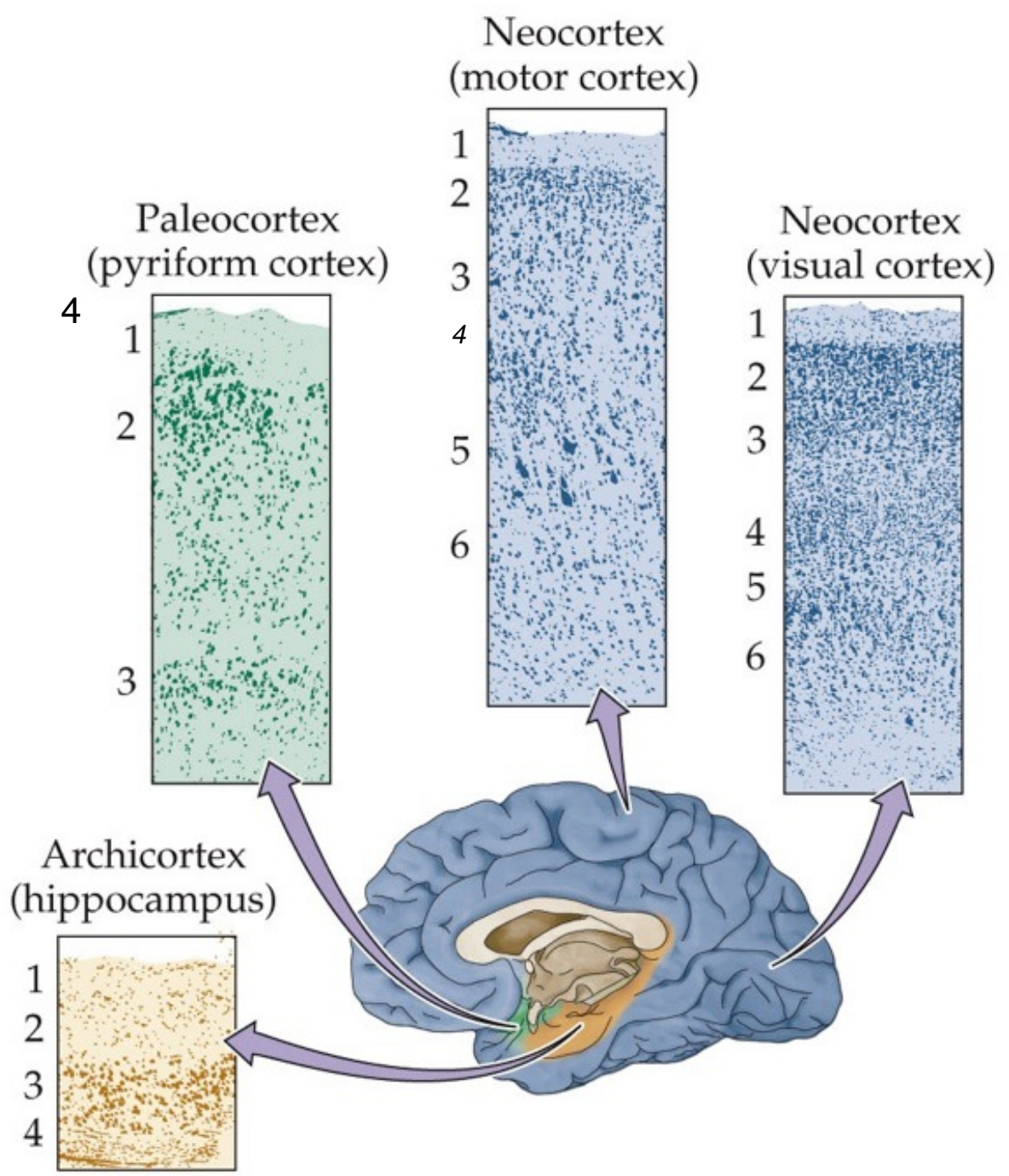
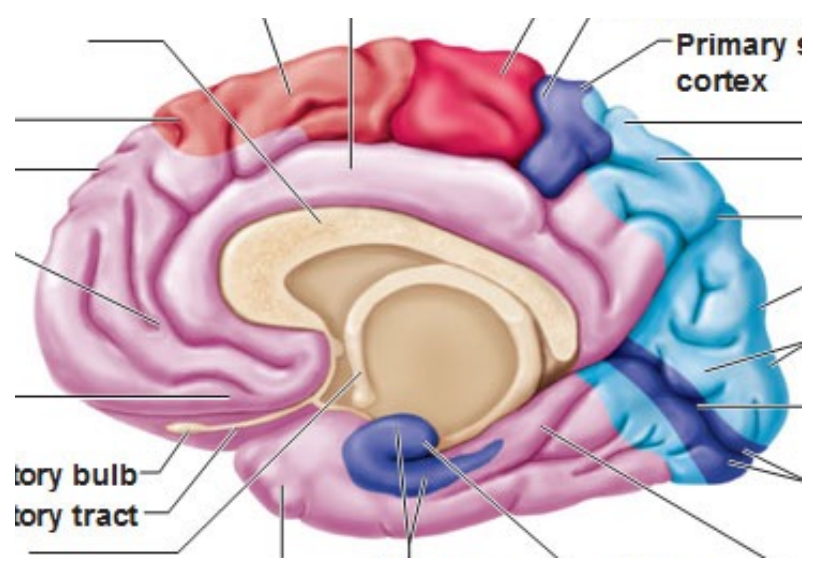
Neocortex – 6 layers

more layers > more complex processing
cytoarchitecturally distinct regions
functionally distinct

Across all neocortical areas:

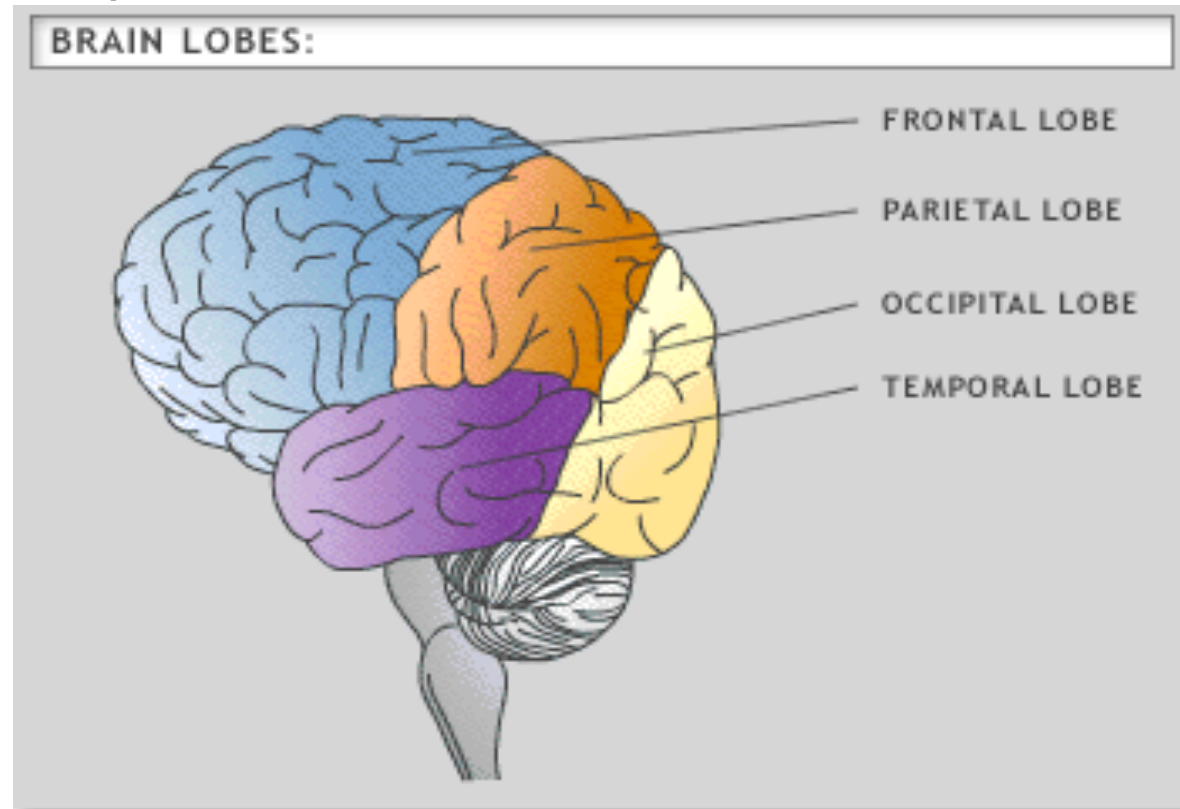
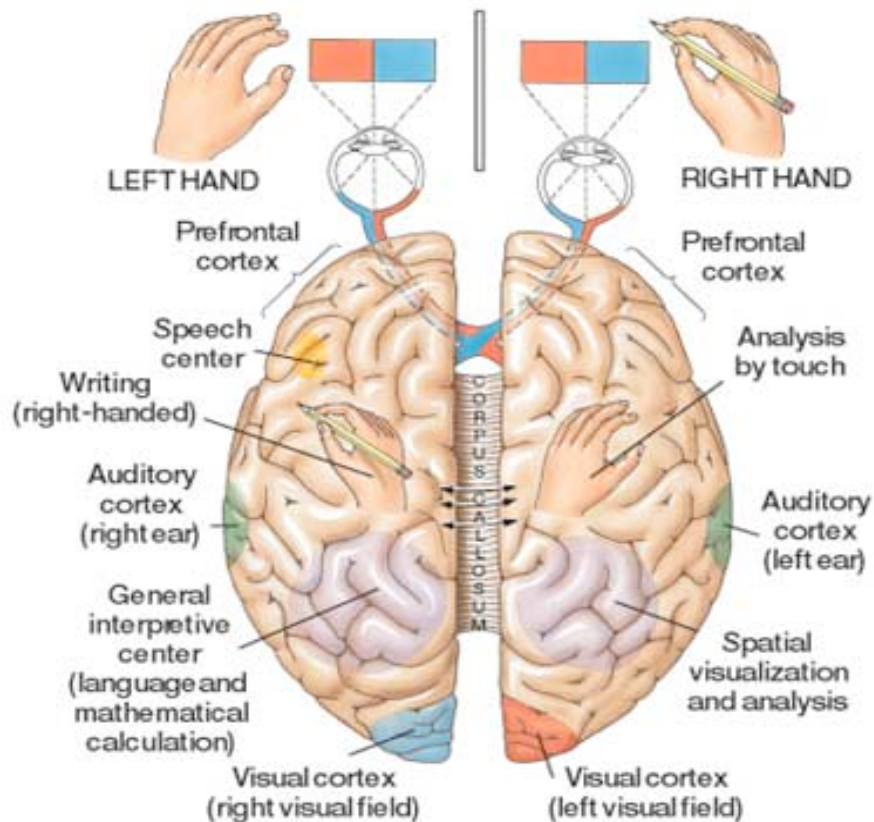
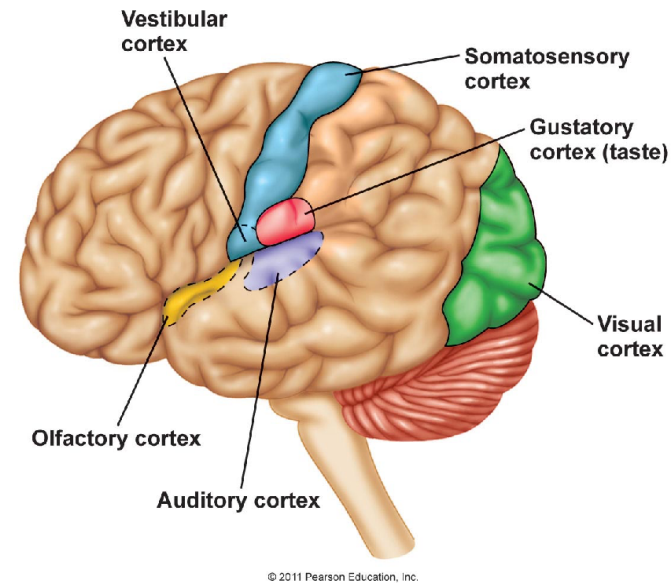
- each layer has a primary source of inputs & primary output targets
- columnar organization (connections)
- lateral connections
 - between local columns and other cortical areas





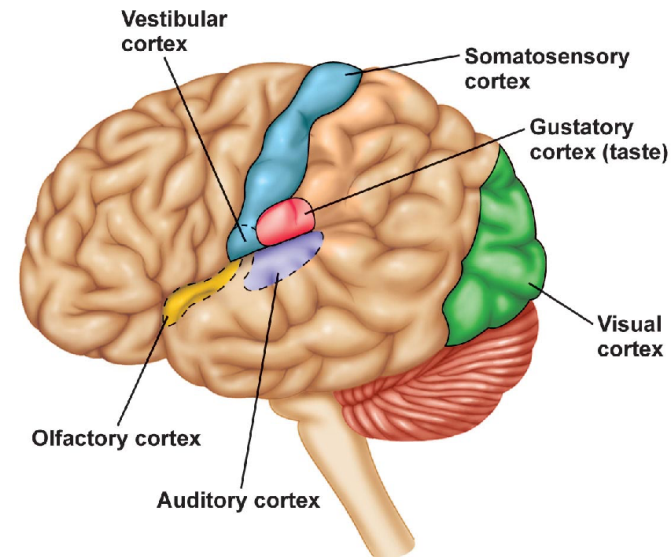
GROSS NEUROANATOMY

- Cerebrum - 2 cerebral hemispheres (left / right) connected by *corpus callosum* (fiber pathway of ~200-300 million neuronal axons)

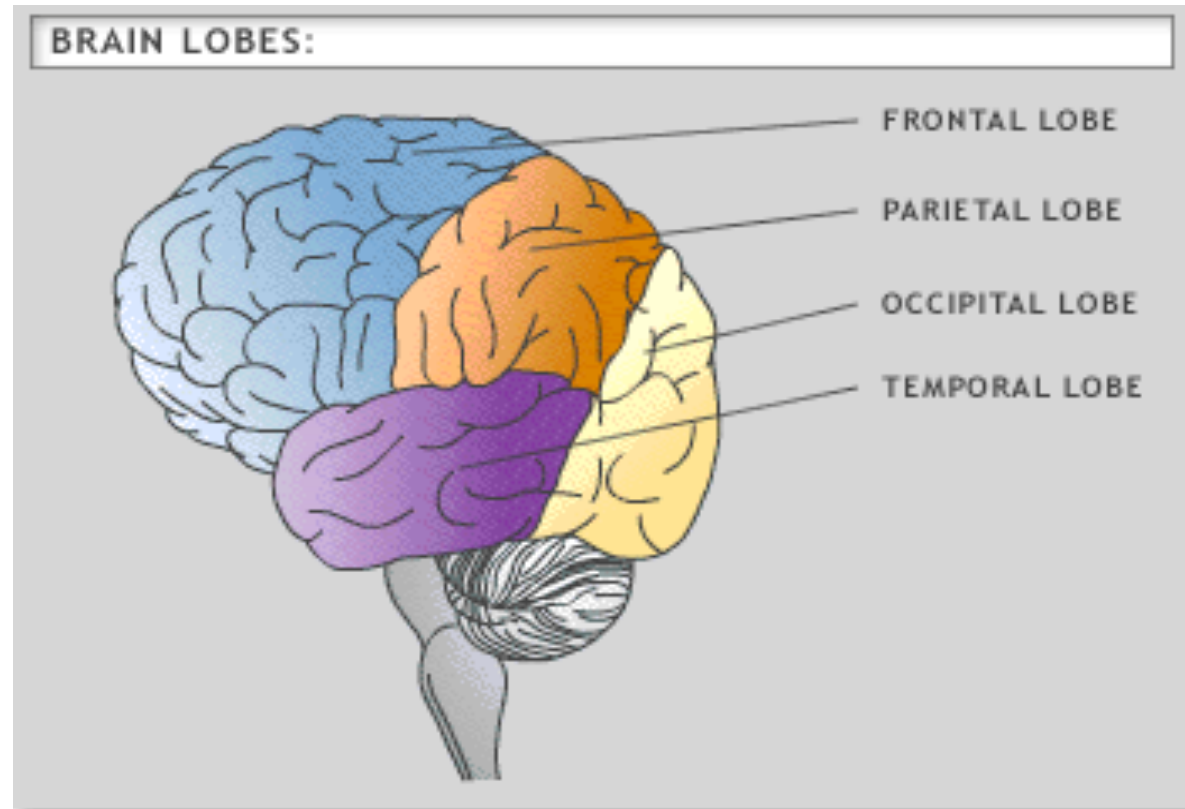
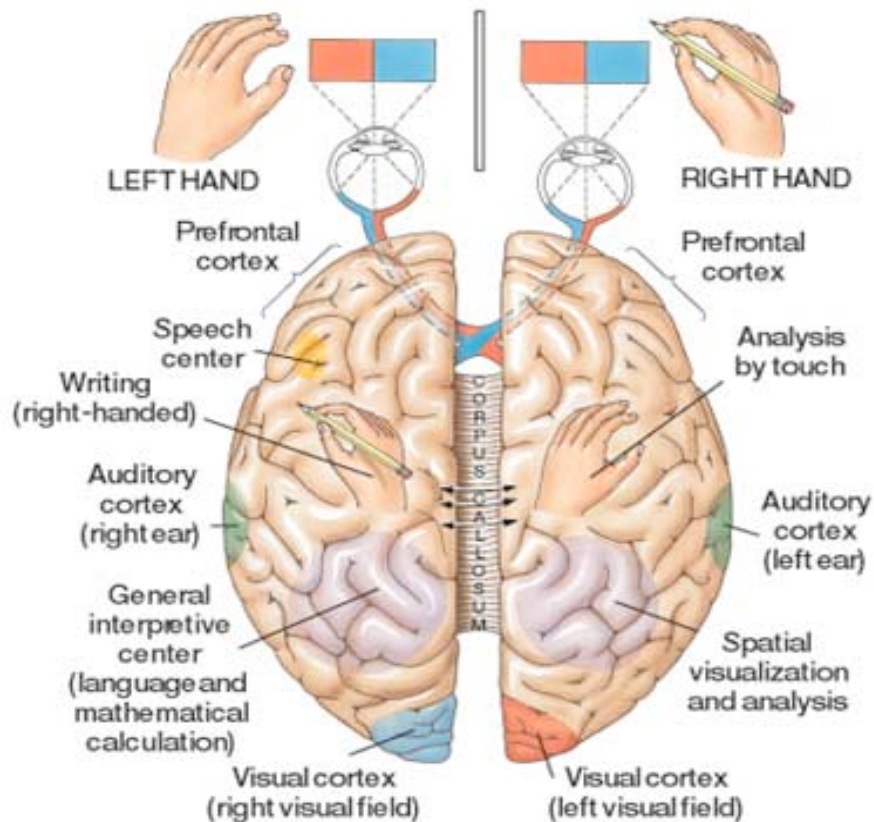


GROSS NEUROANATOMY

- each hemisphere has 4 lobes:
 - frontal (motor / cognition)
 - parietal (sensory / attention)
 - occipital (vision)
 - temporal (auditory / memory / emotion)

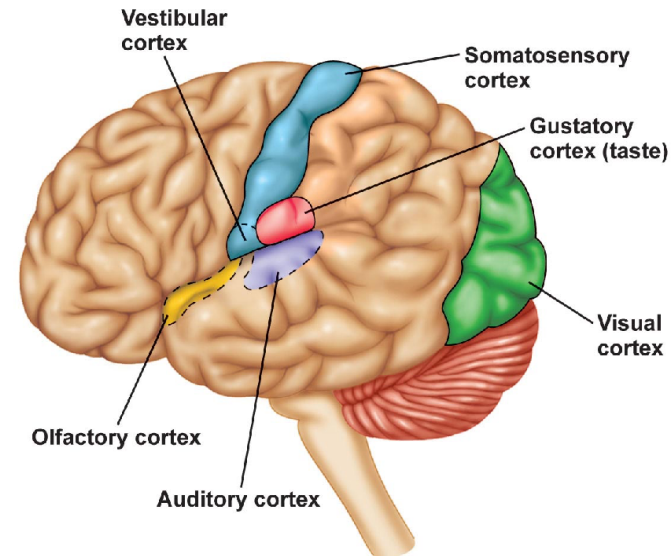


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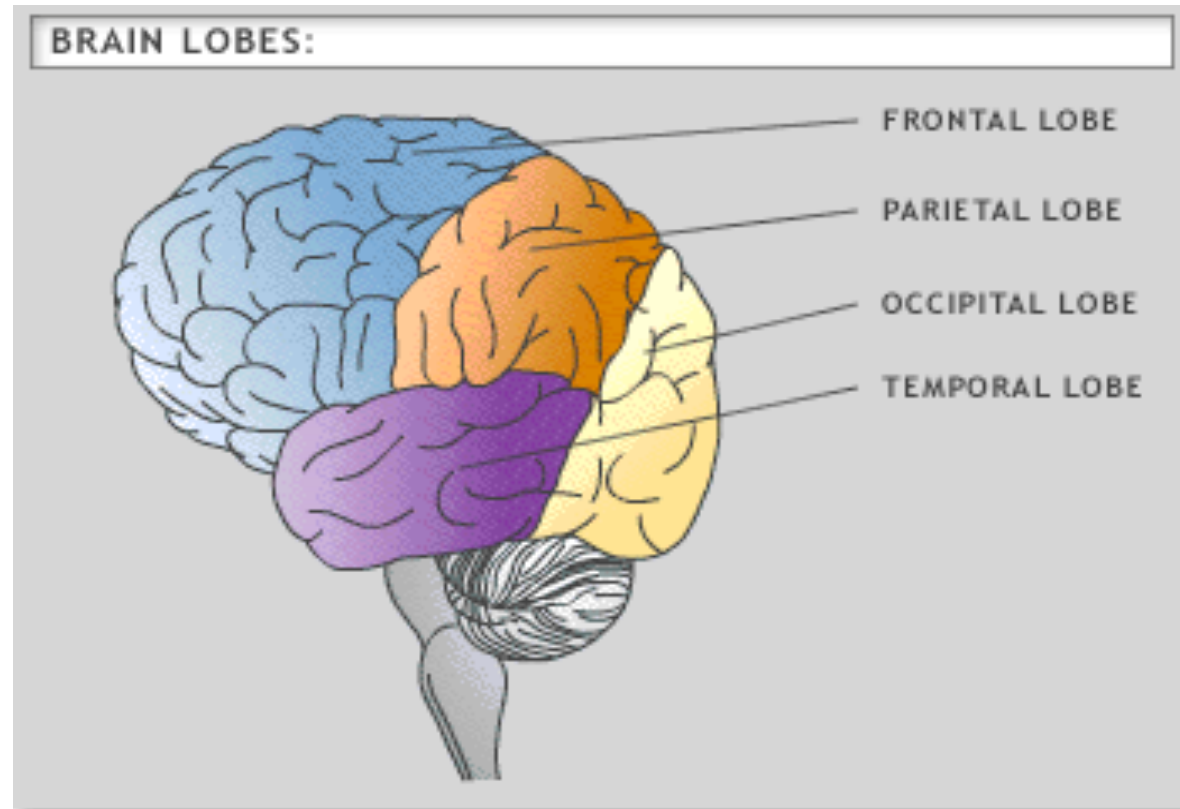
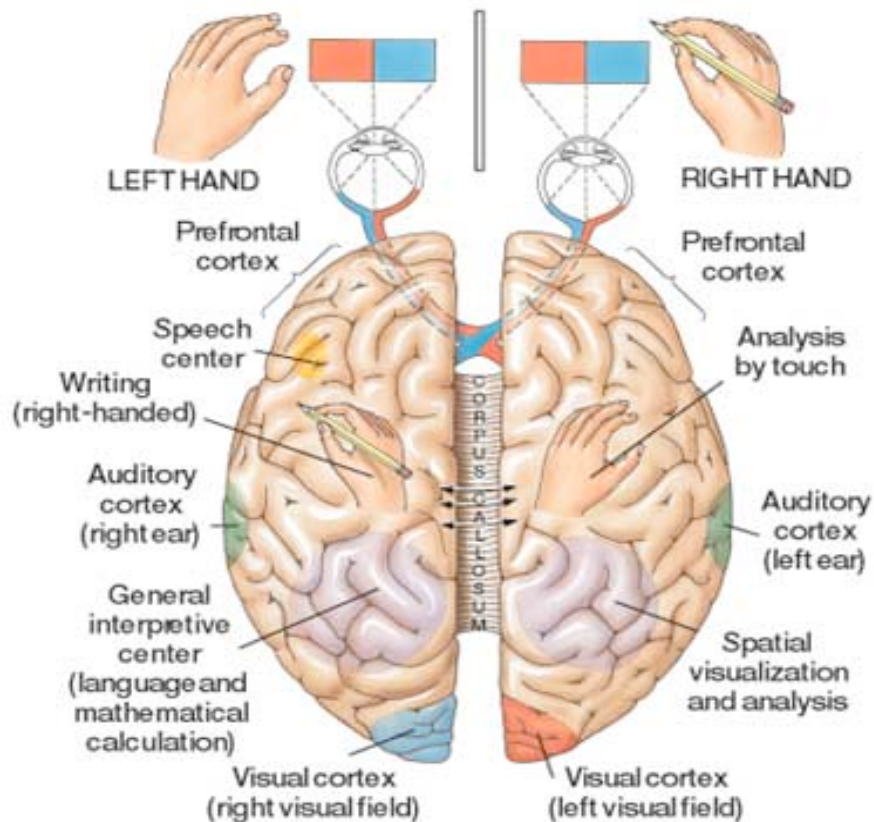


GROSS NEUROANATOMY

- about 20% is directly dedicated to the overt sensorimotor functions (“primary cortex”)
- rest is “association” cortex (~80%)



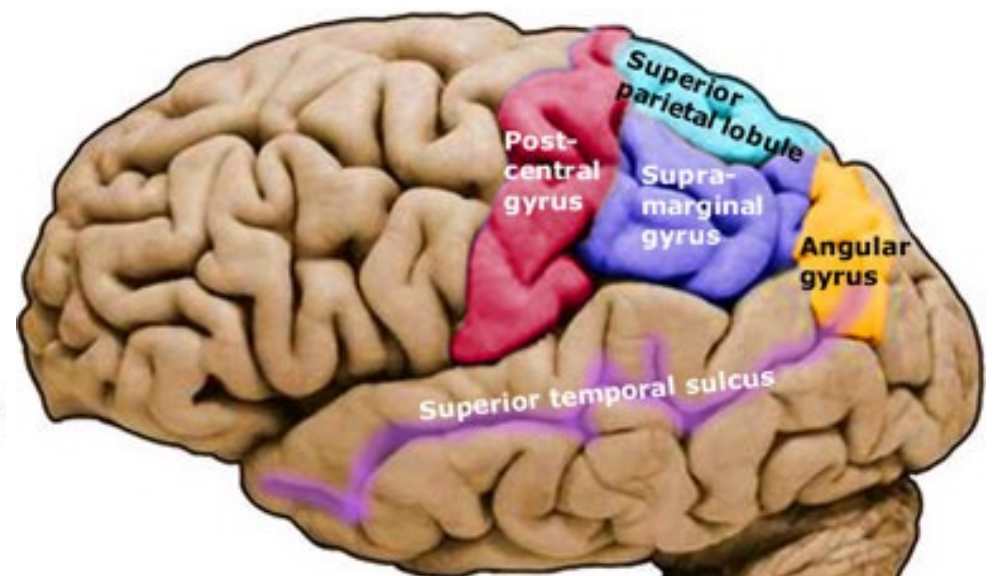
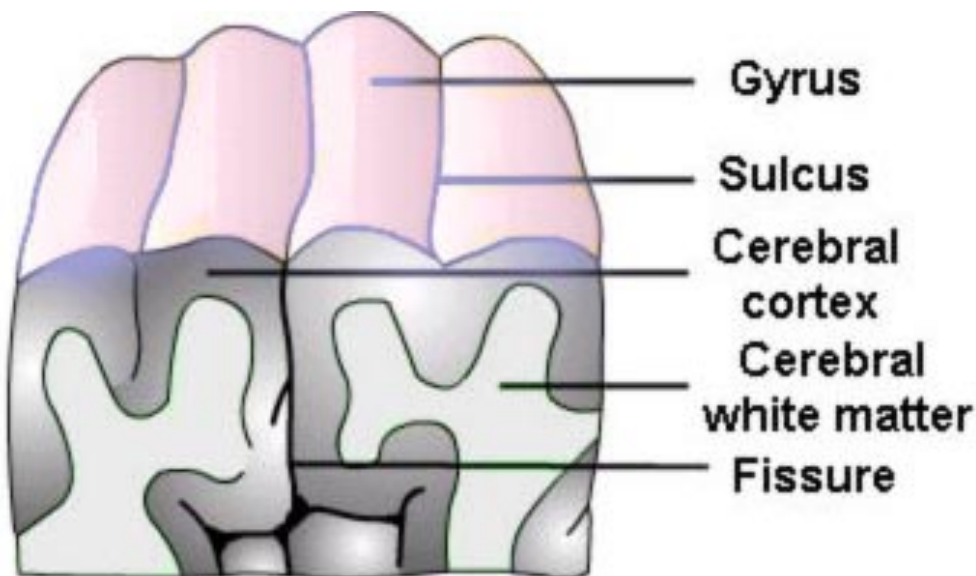
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GROSS NEUROANATOMY

Basic Neuroscience Terminology

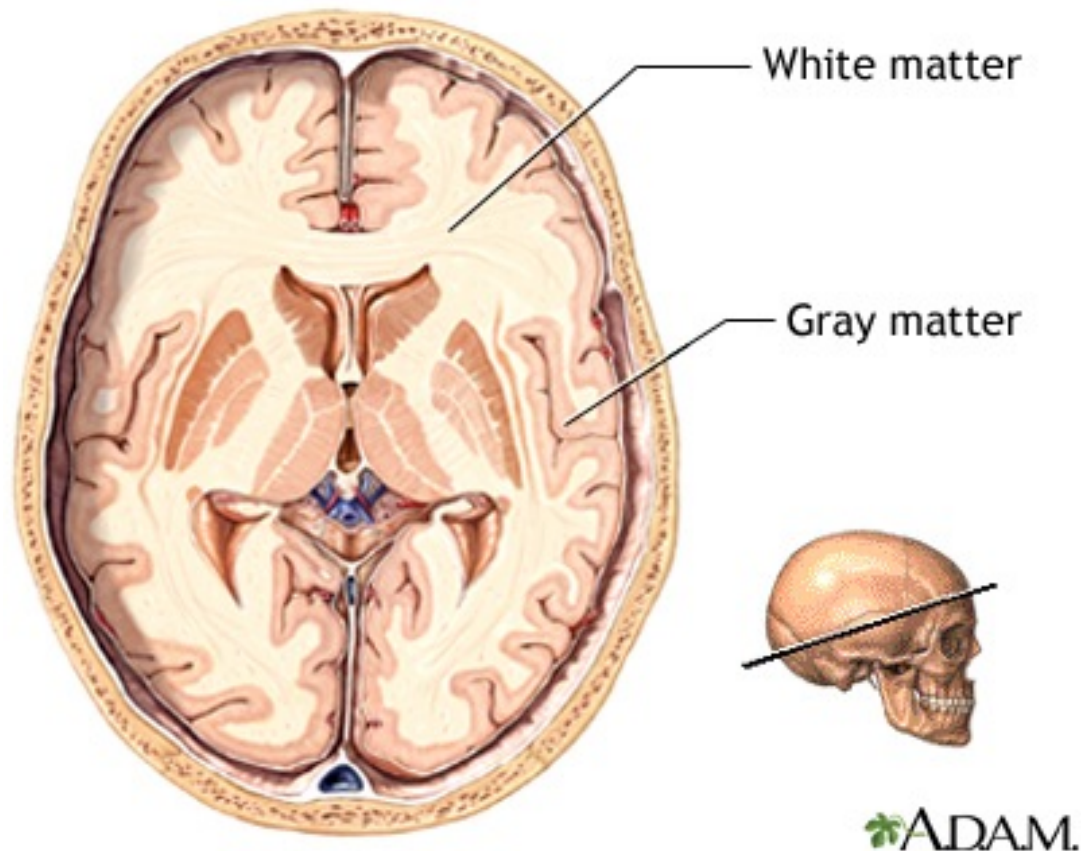
- gyrus (gyri) - ridge or convolution of cortex
- sulcus (sulci) - “valley” formed by gyri



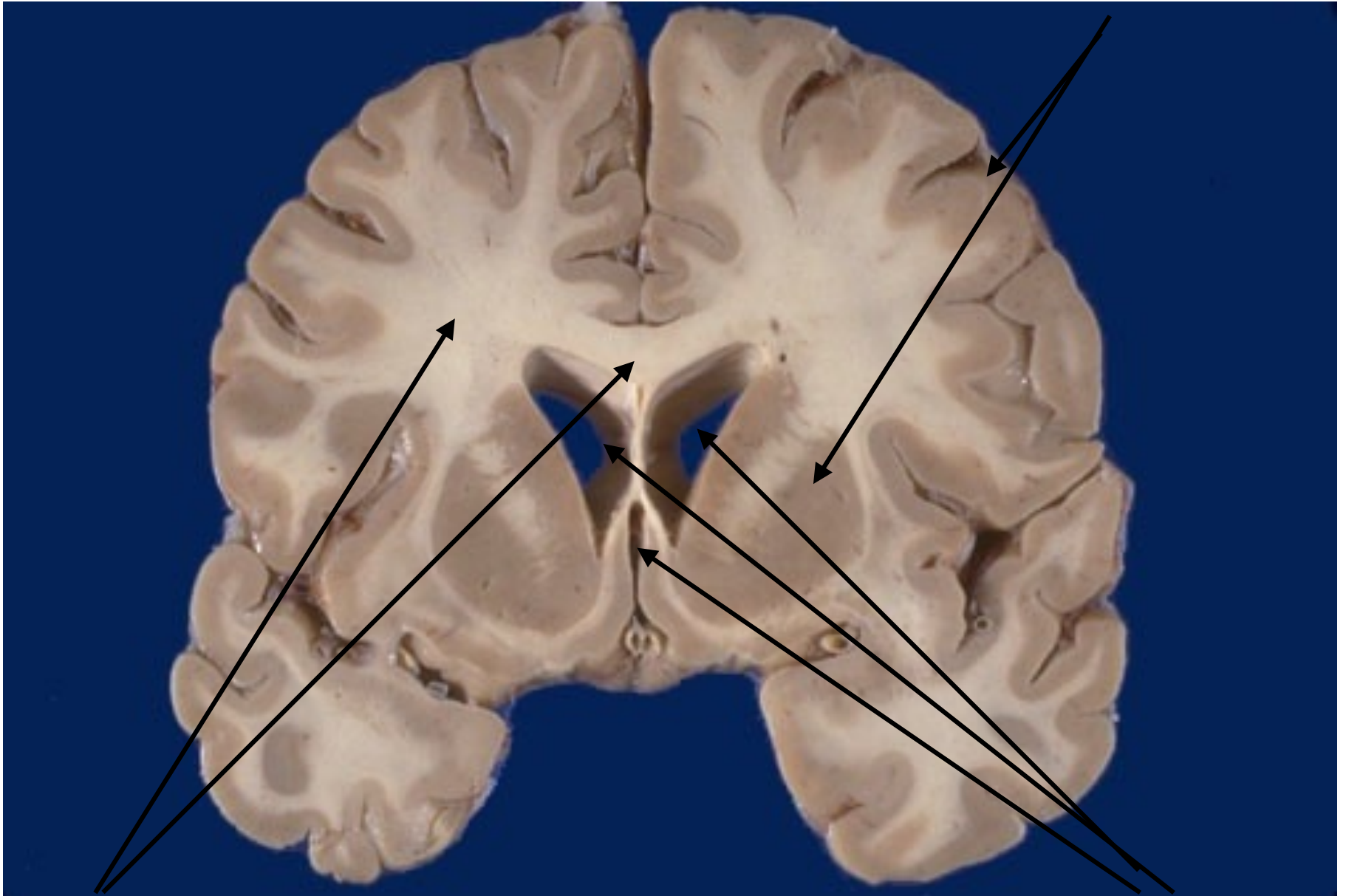
GROSS NEUROANATOMY

Basic Neuroscience Terminology

- gray matter - cell bodies of neurons / glia (aka *neuropil*)
- white matter - fibers (neuronal axons covered in “myelin”)
that connect brain regions

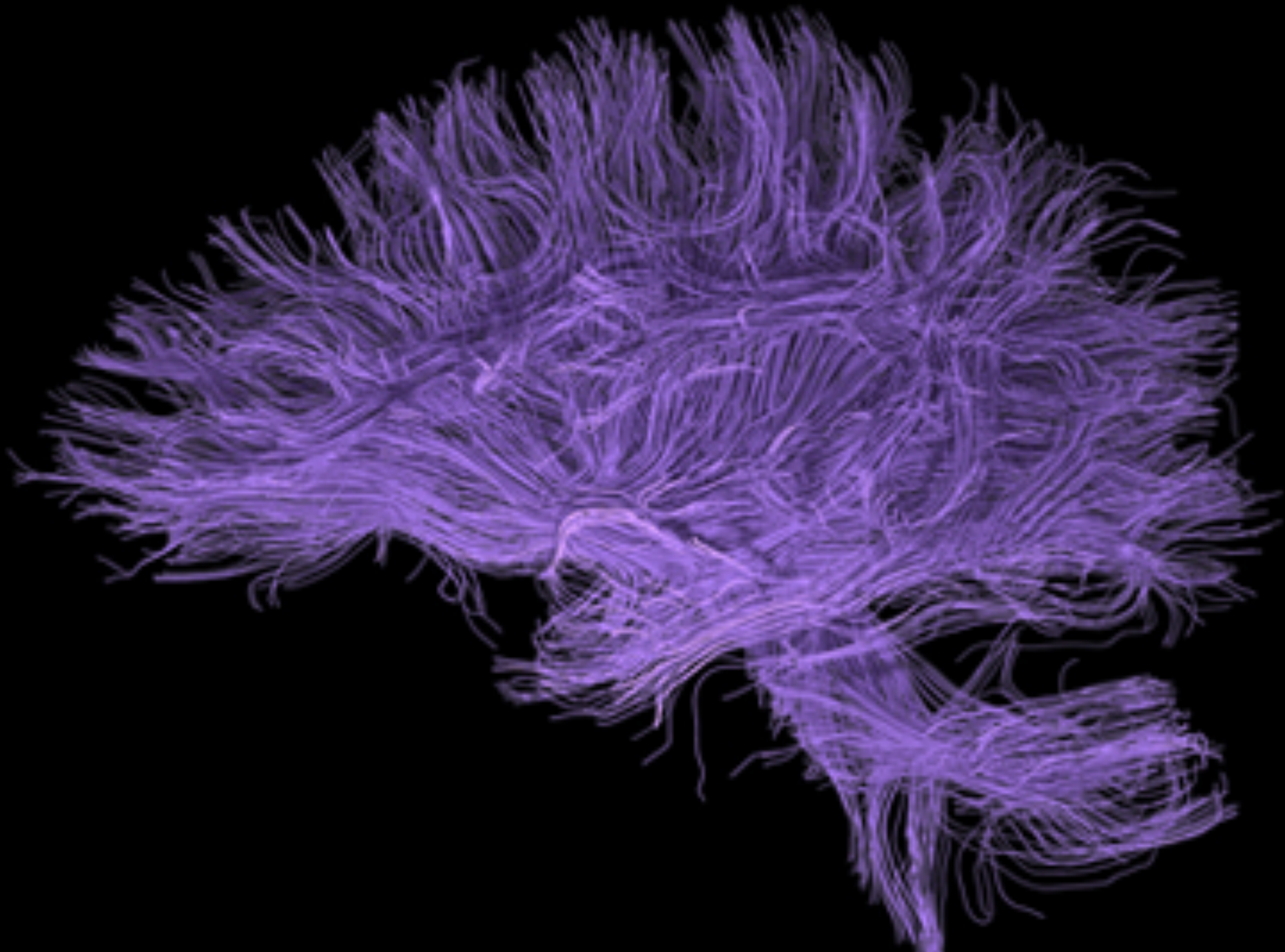


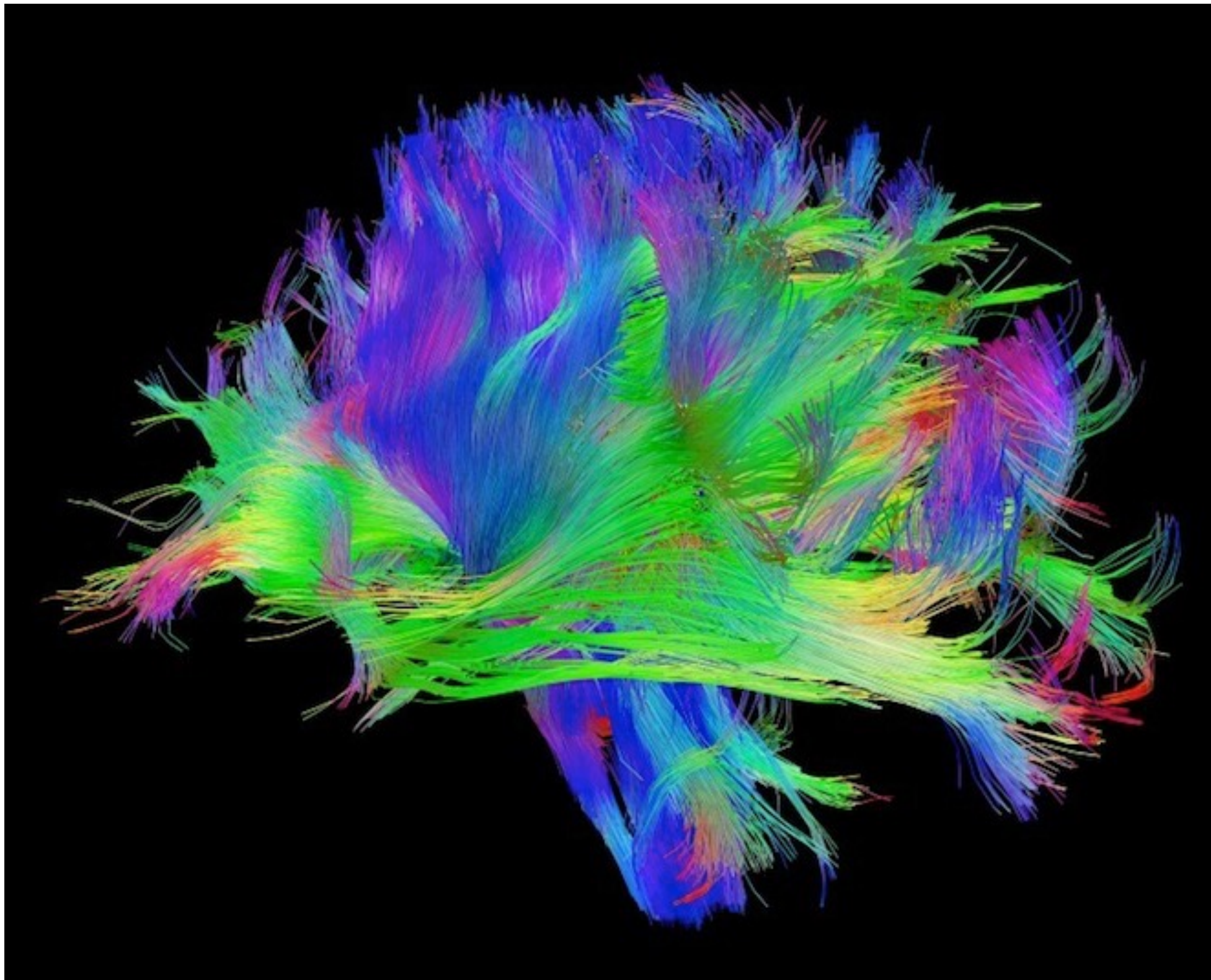
Cortex (“bark”) - gray matter (cell bodies)



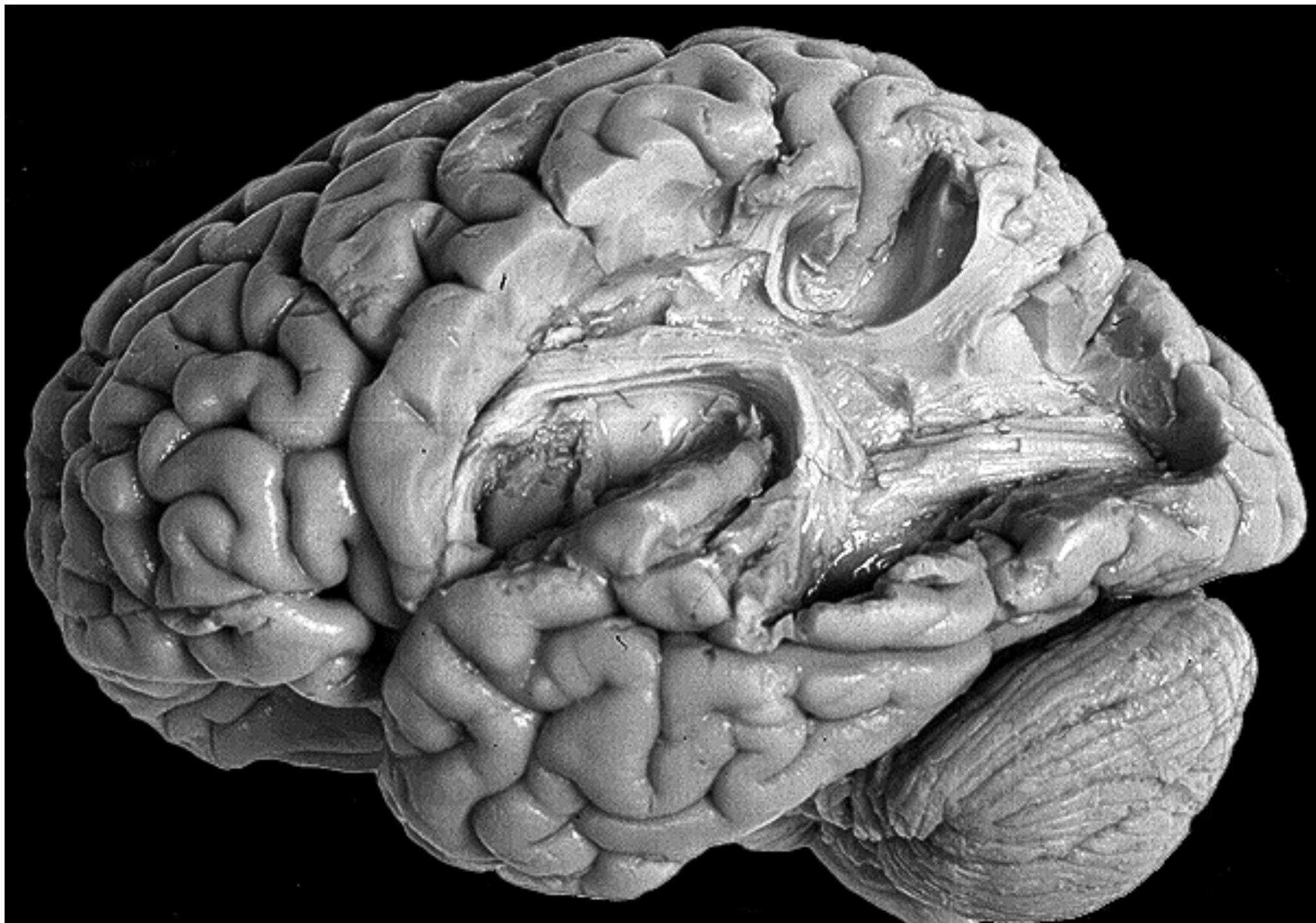
white matter (cell fibers)

ventricles (holes)





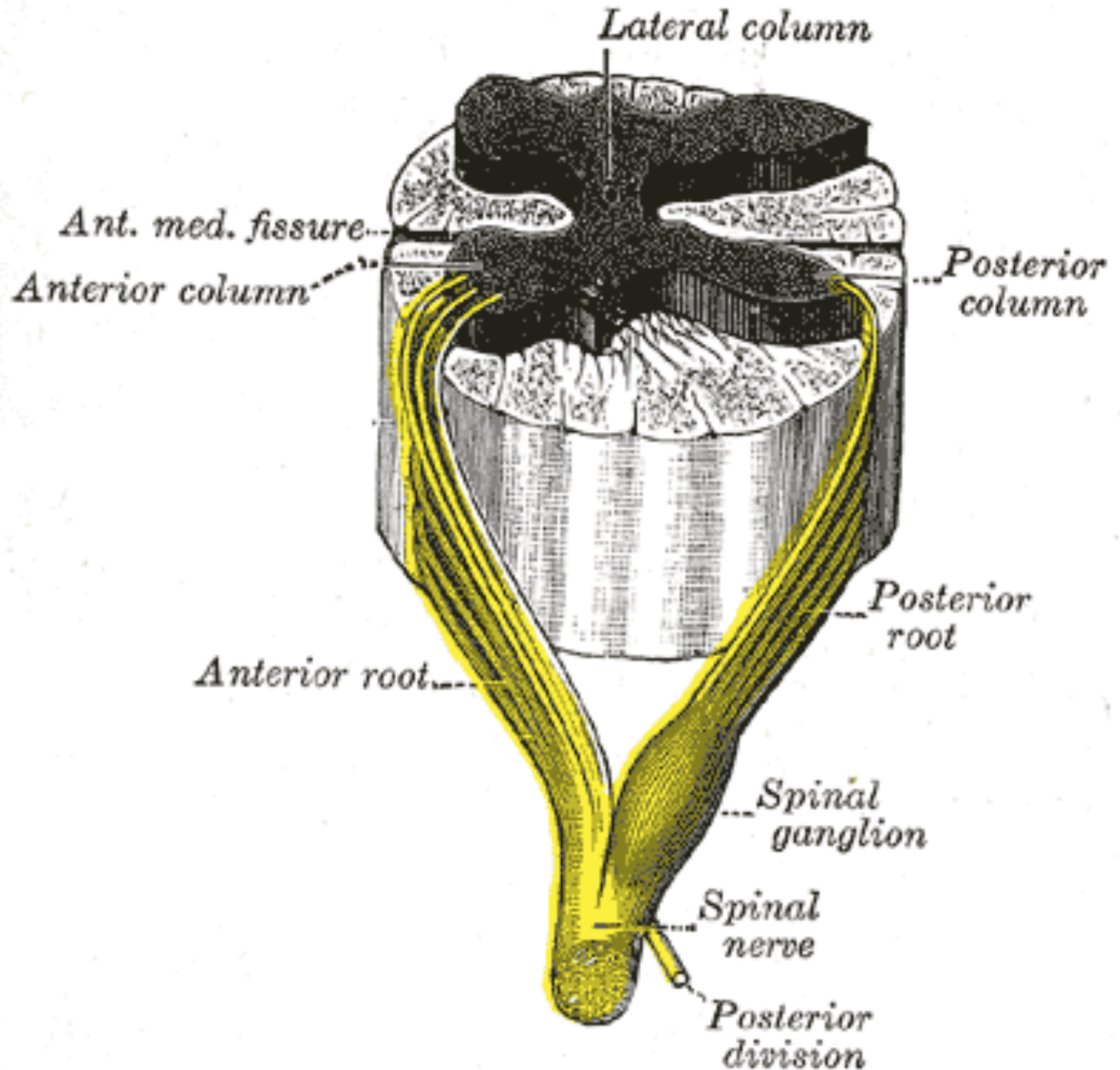




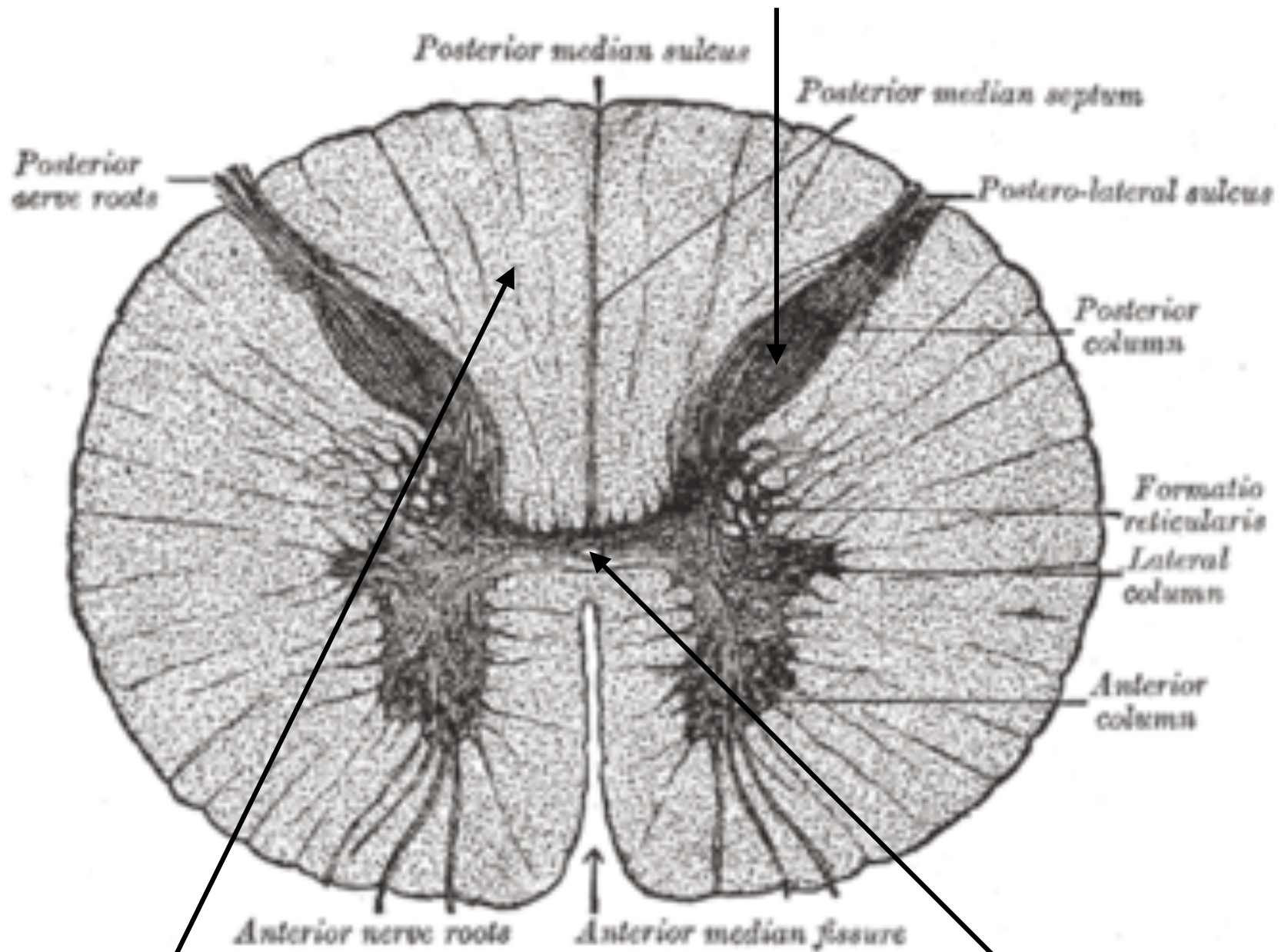
opposite arrangement in spinal cord

Posterior =
dorsal
(inputs)

Anterior =
ventral
(outputs)

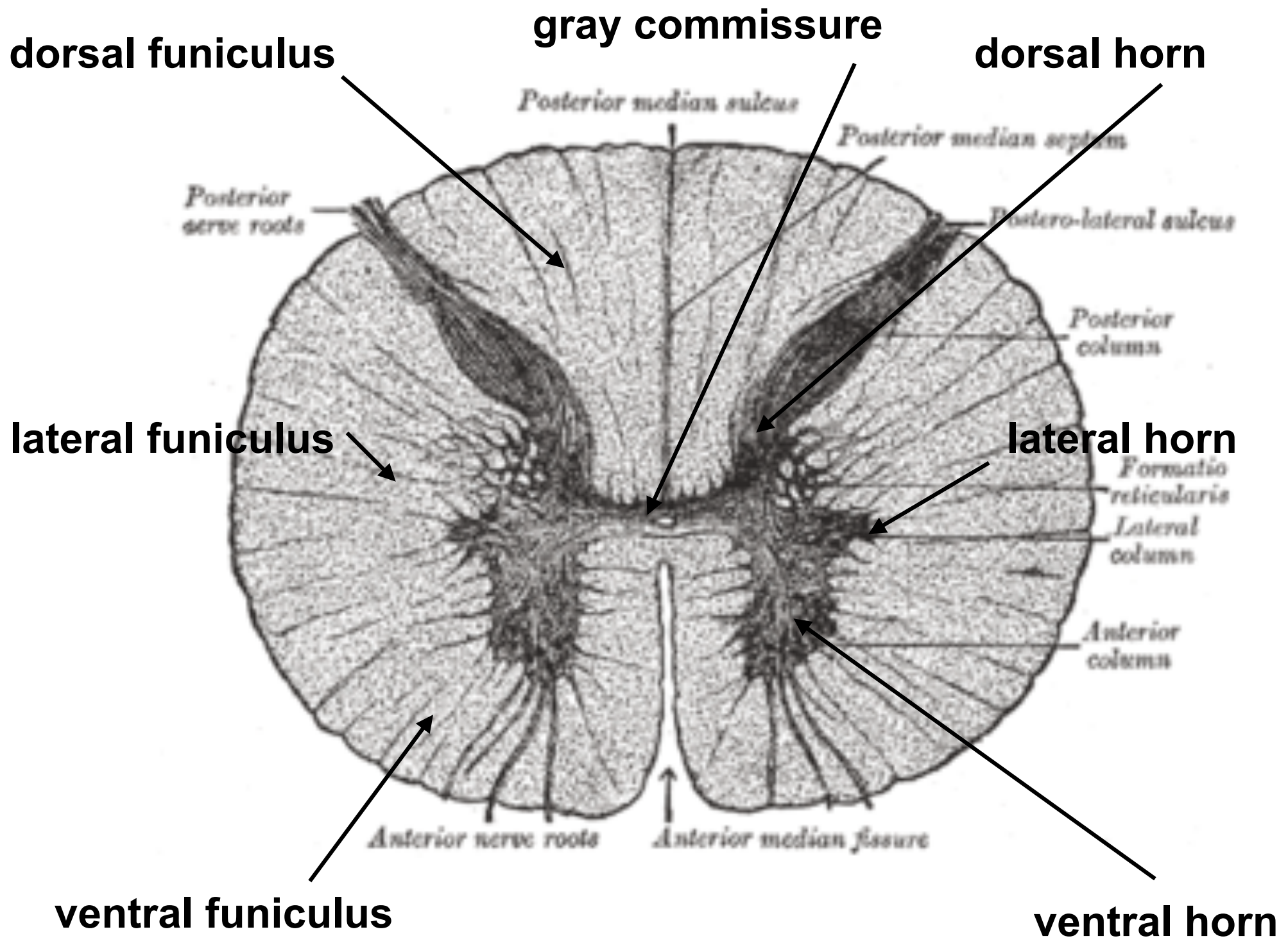


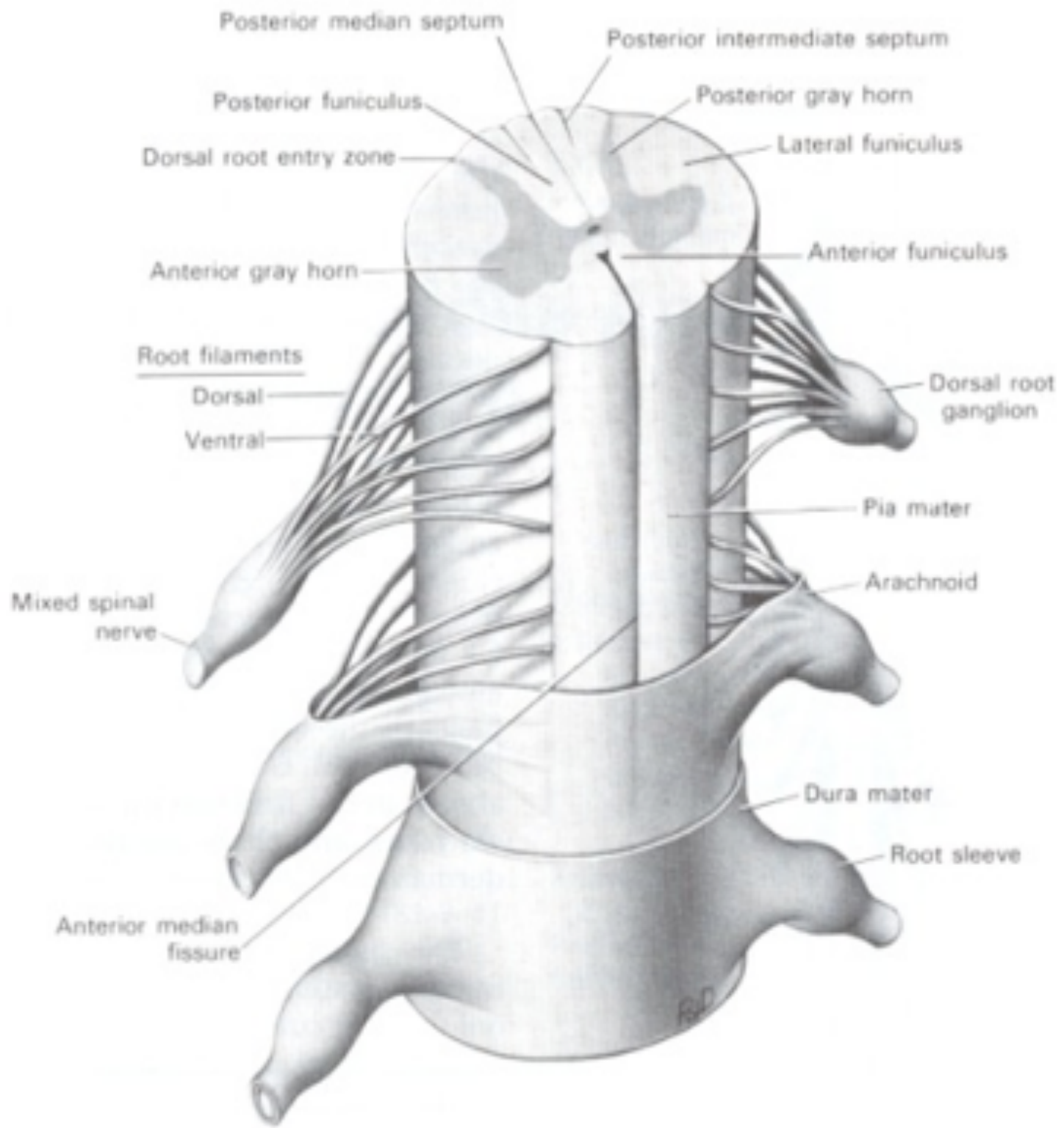
gray matter (cells)



white matter (fibers)

central canal (hole)

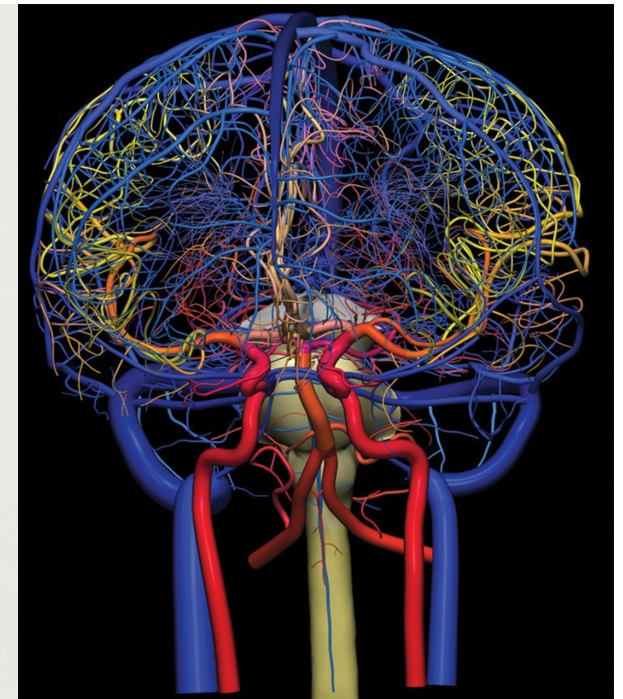
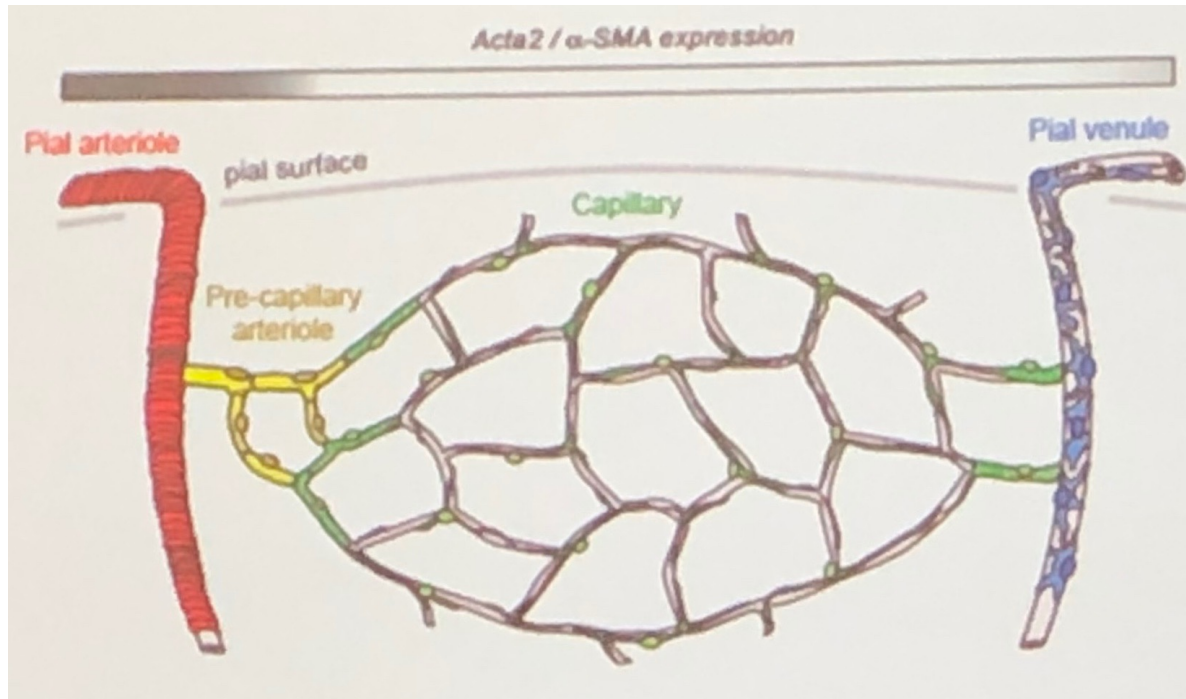




GROSS NEUROANATOMY

Basic Neuroscience Terminology

- *Blood Brain (and spinal cord) Barrier:*
 - ~400 miles of vasculature in brain (~90% is capillaries)
 - 2% of body mass, but 20% of total blood usage
 - Unlike capillaries in the rest of the body that have small pores, those in the brain:
 - have no pores
 - surrounded by fatty glial cells (sort of like myelin)



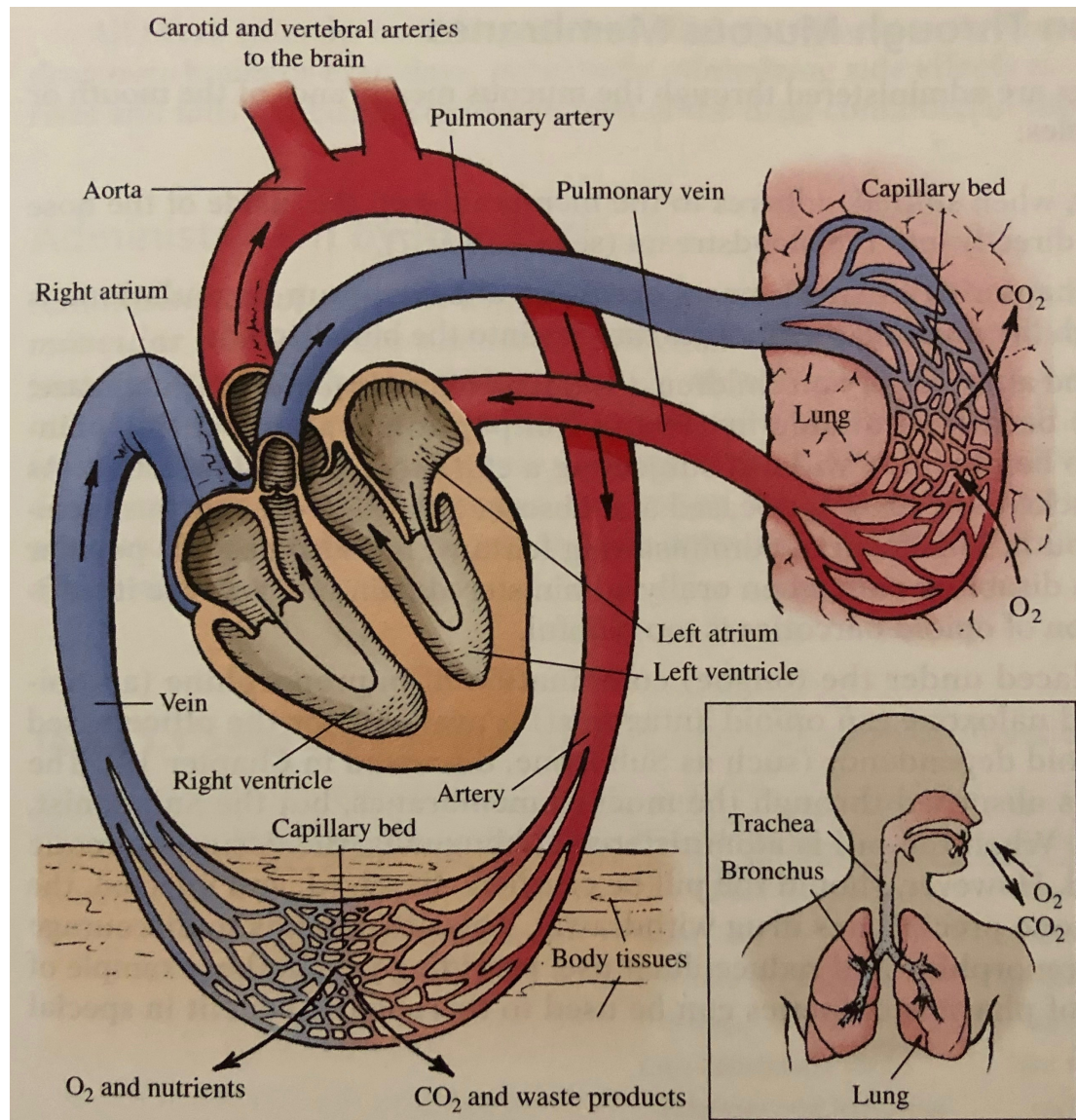
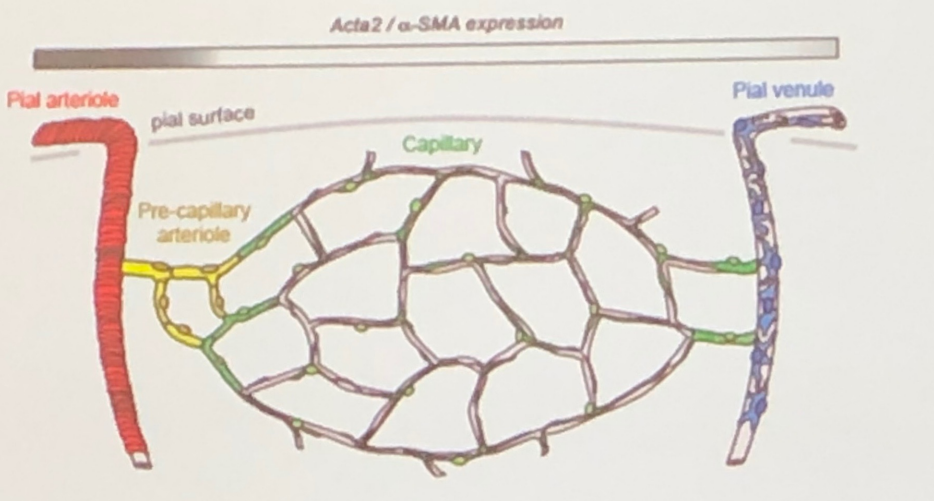
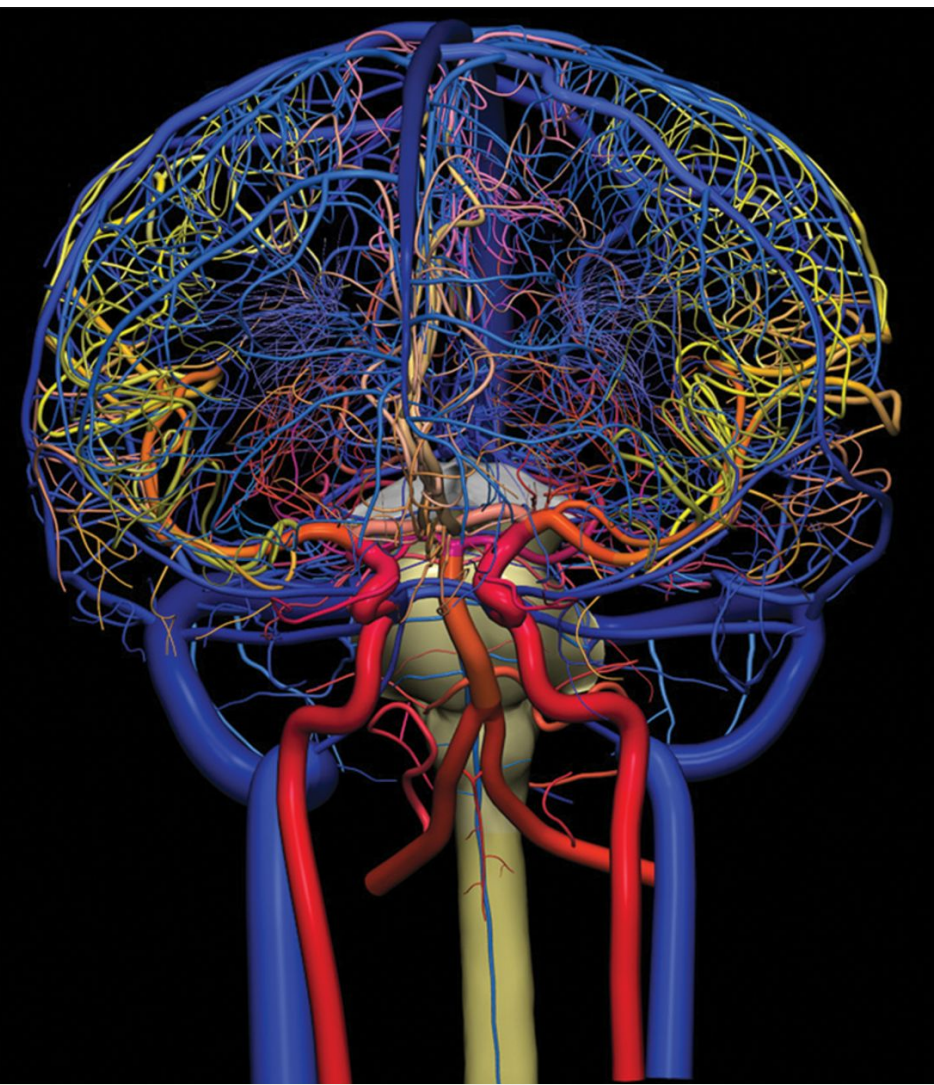
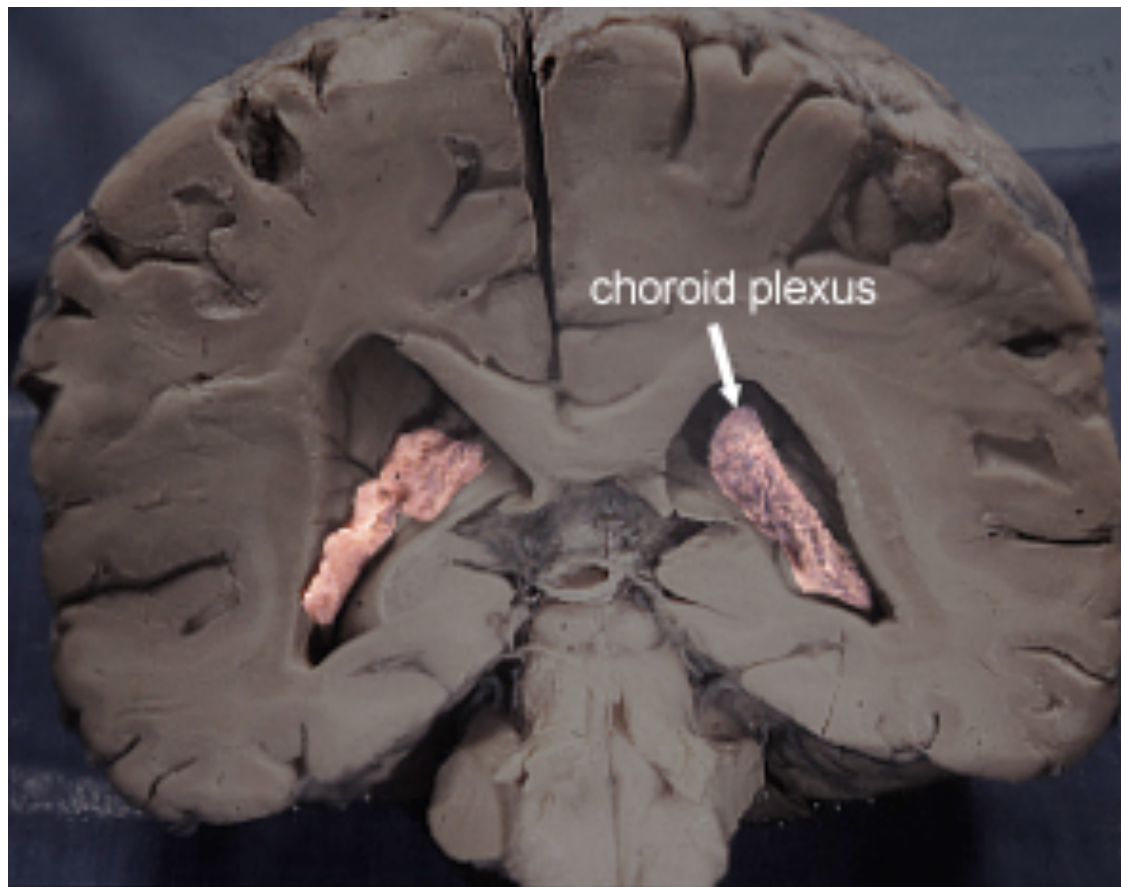


FIGURE 1.4 Heart and circulatory system. Blood returning from the systemic venous circulation to the heart enters the right atrium and flows into the right ventricle. With contraction of the heart, this blood is pumped into the pulmonary arteries leading to the lungs. Once in the pulmonary capillaries, carbon dioxide (CO_2) is lost and replaced by oxygen. The oxygenated blood returns to the heart in the pulmonary veins, which empty into the left atrium. With heart contraction, the oxygenated blood is pumped from the left ventricle into the aorta and is carried to the body tissues and brain, where oxygen and nutrients are exchanged in the systemic capillary beds. Oxygen and nutrients are supplied to the body tissues through the walls of the capillaries; CO_2 and other waste products are returned to the blood. The CO_2 is eliminated through the lungs and the other waste products are metabolized in the liver and excreted in the urine.

GROSS NEUROANATOMY

Basic Neuroscience Terminology

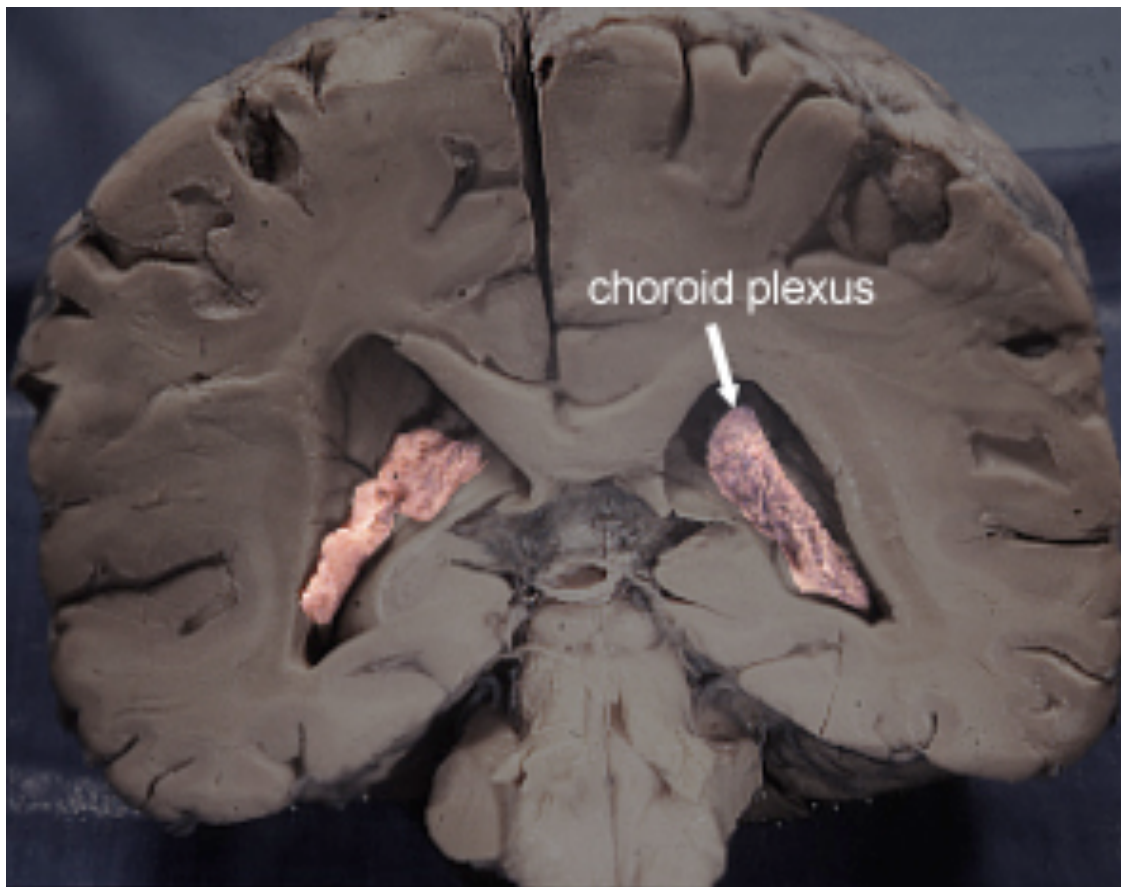
- Some blood vessels dump into the ventricles
- ventricles cavities are lined with *choroid plexus* cells
- filter proteins / cells etc from the blood before it enters the ventricular system.



GROSS NEUROANATOMY

Basic Neuroscience Terminology

- The resulting fluid is *cerebrospinal fluid (CSF)*
 - flows thru the ventricles on the inside of the brain (and spinal canal) and around the meninges on the outside
 - acts as a "fluid cushion" / shock absorber



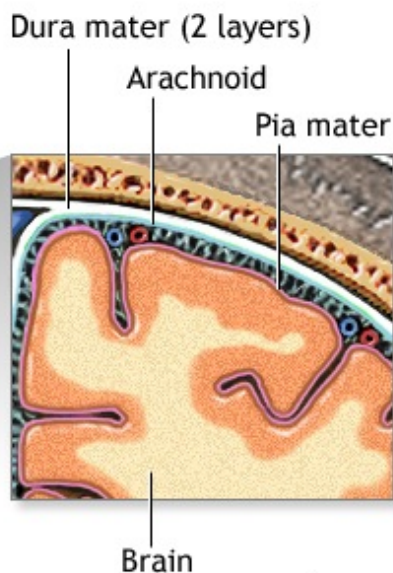
GROSS NEUROANATOMY

Basic Neuroscience Terminology

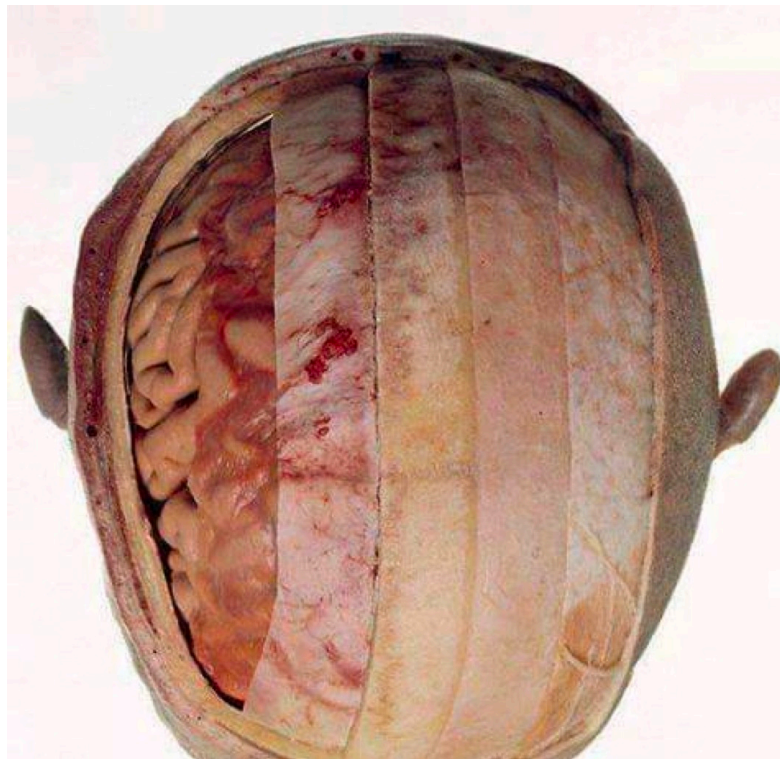
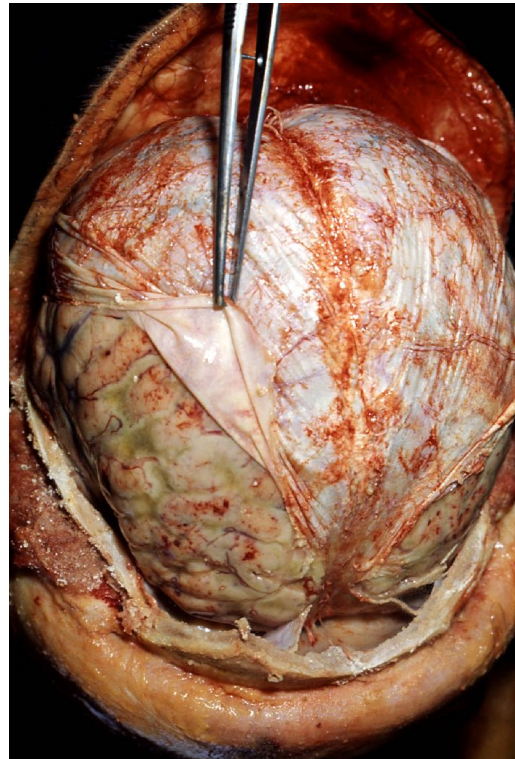
meninges - tough protective membrane covering the CNS

- *pia mater* (“soft mother”) - inner membrane
- *arachnoid* - vascularized middle section
 - contains *arachnoid villi* to re-absorb CSF back into bloodstream
- *dura mater* (“strong mother”) - outer membrane

The meninges are the membranes covering the brain and spinal cord



ADAM.



GROSS NEUROANATOMY

Basic Neuroscience Terminology

- Cells in the *meninges* called *arachnoid villi* absorb it back into the regular blood stream.
- So CSF is a "free-flowing" stream of filtered blood that leaves the regular bloodstream as it enters the ventricles and re-enters the regular bloodstream in the meninges.

