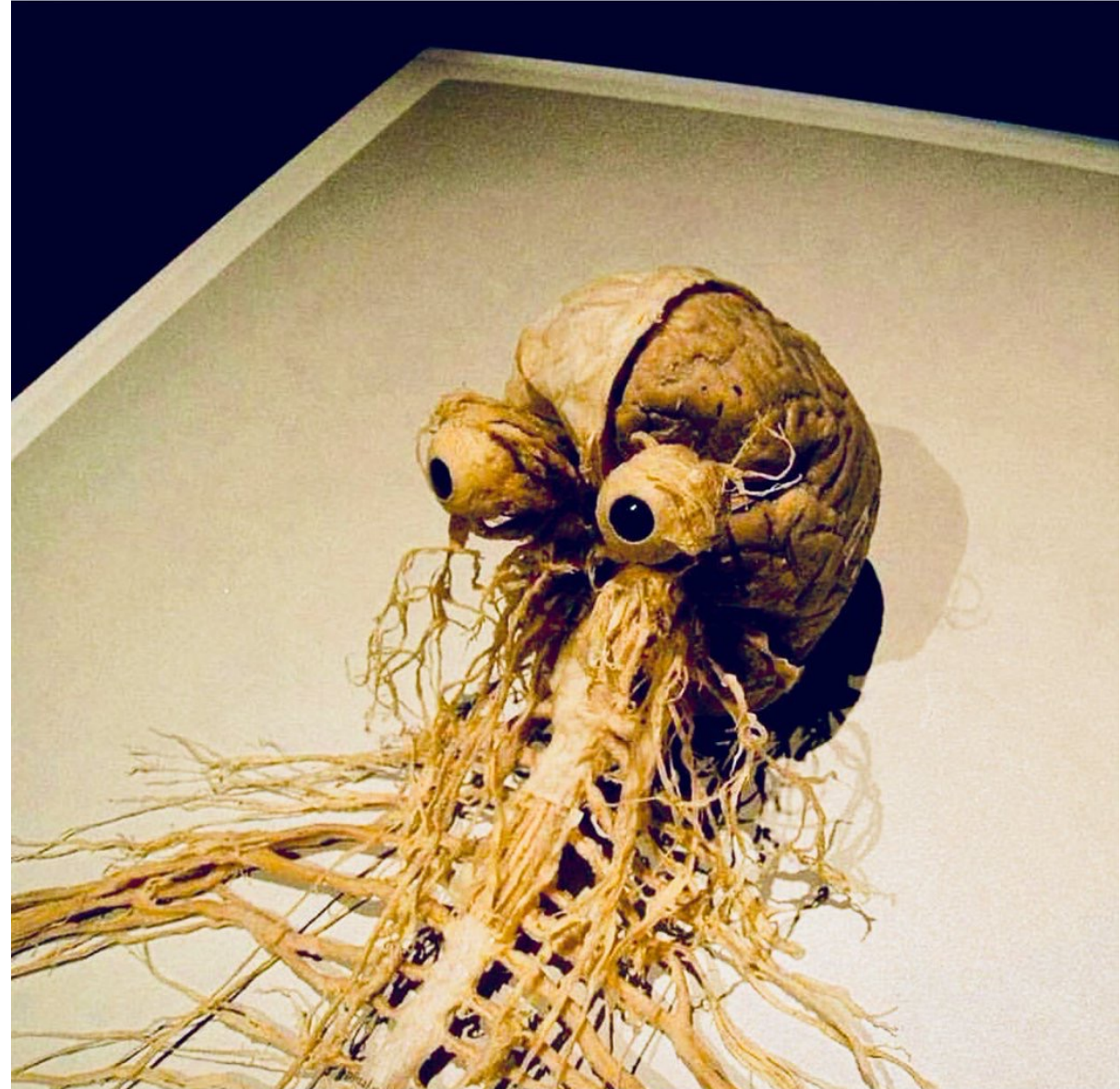


The nervous system. That is us...the rest of the body is an organic spacesuit worn by this creature to live on this particular rock revolving around a star.

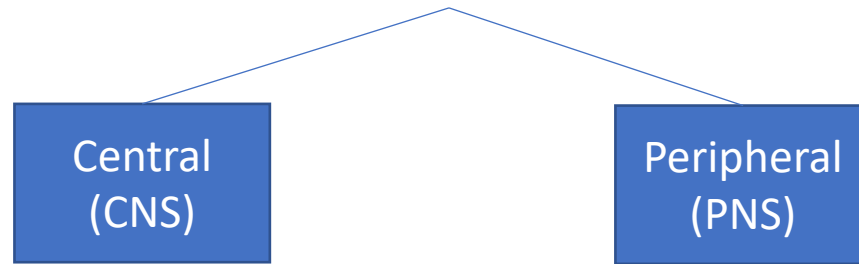
PSYC304: Neuroanatomy & Basic Neurobiology

Tristan Hynes, PhD



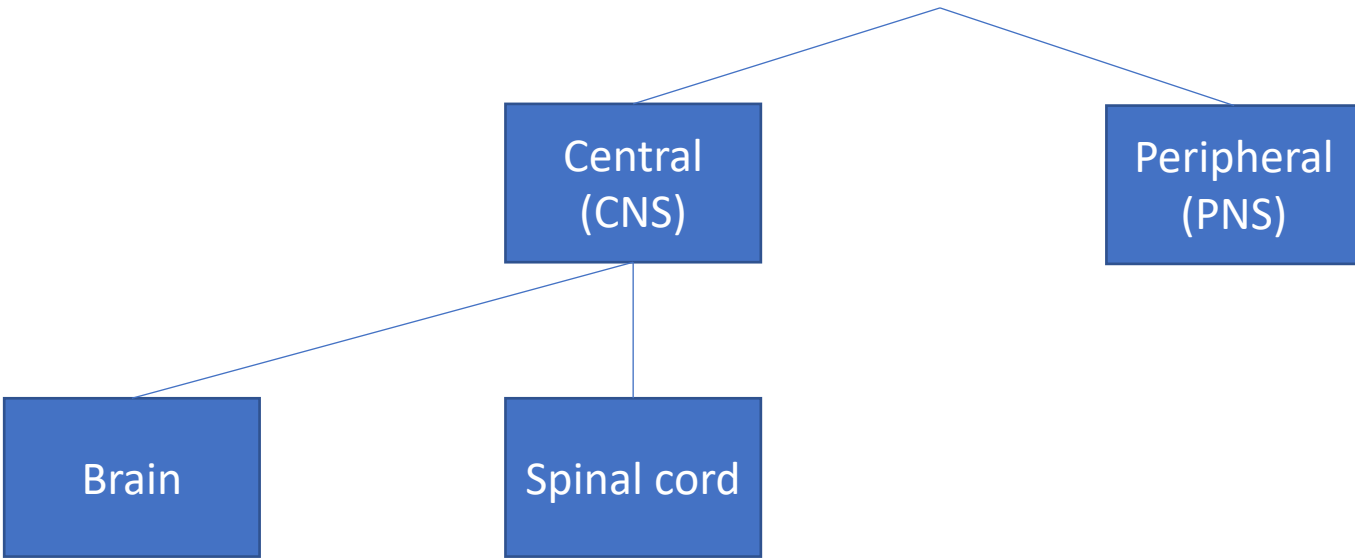
The nervous system

(Well, the vertebrate nervous system)



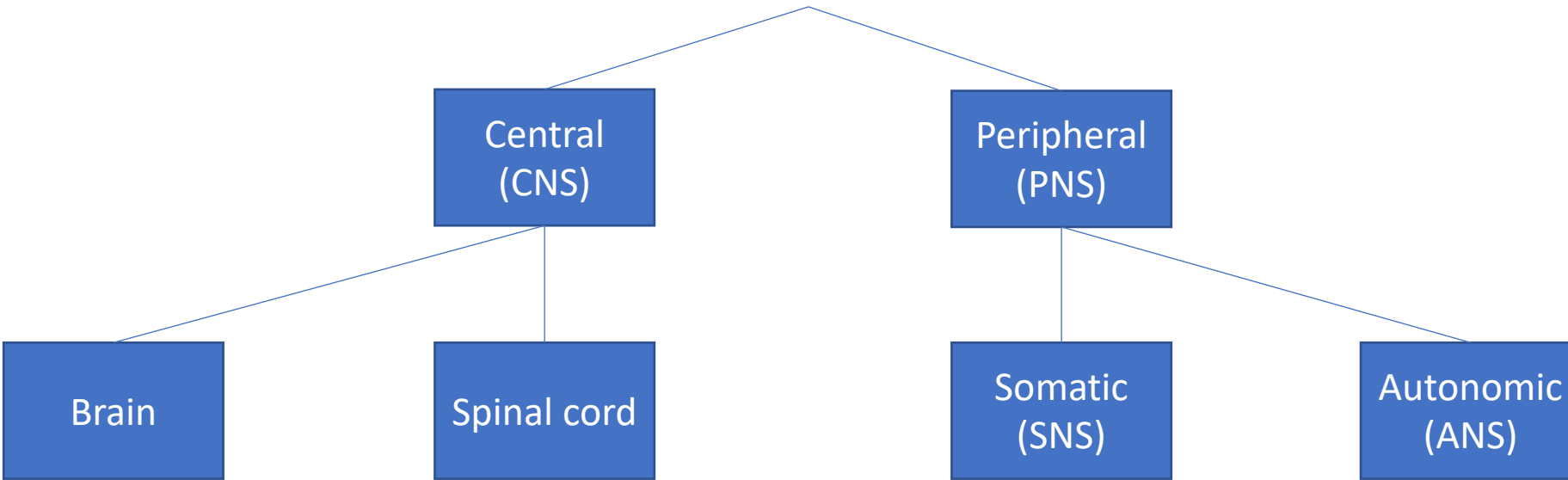
The nervous system

(Well, the vertebrate nervous system)



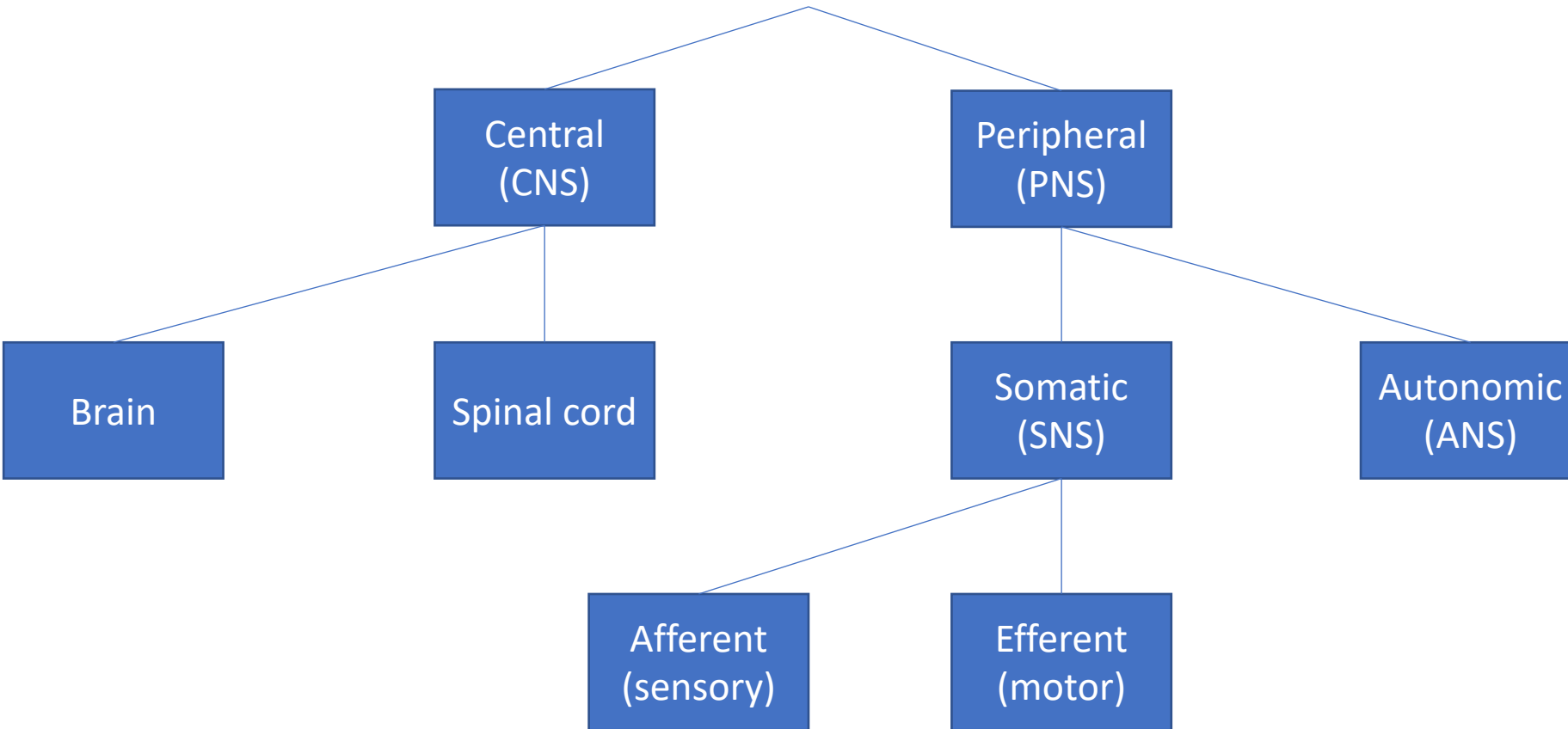
The nervous system

(Well, the vertebrate nervous system)



The nervous system

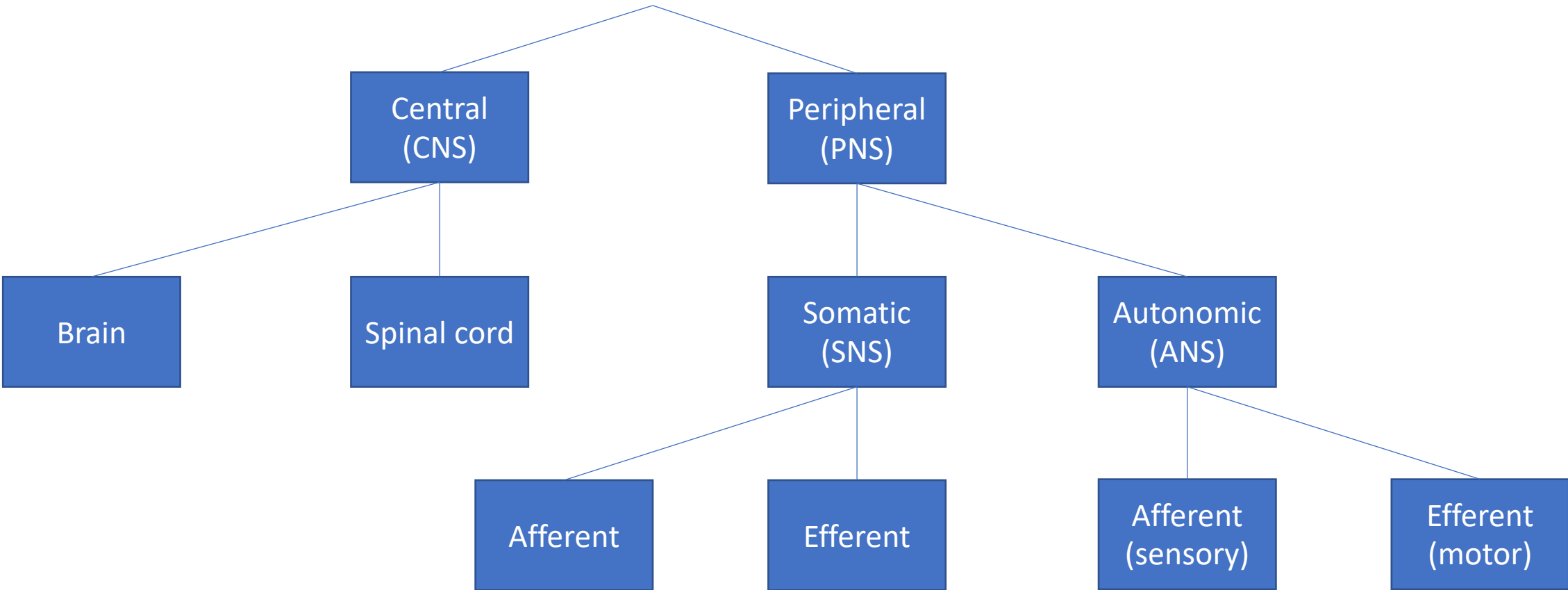
(Well, the vertebrate nervous system)



SNS: external environment, (mostly) conscious

The nervous system

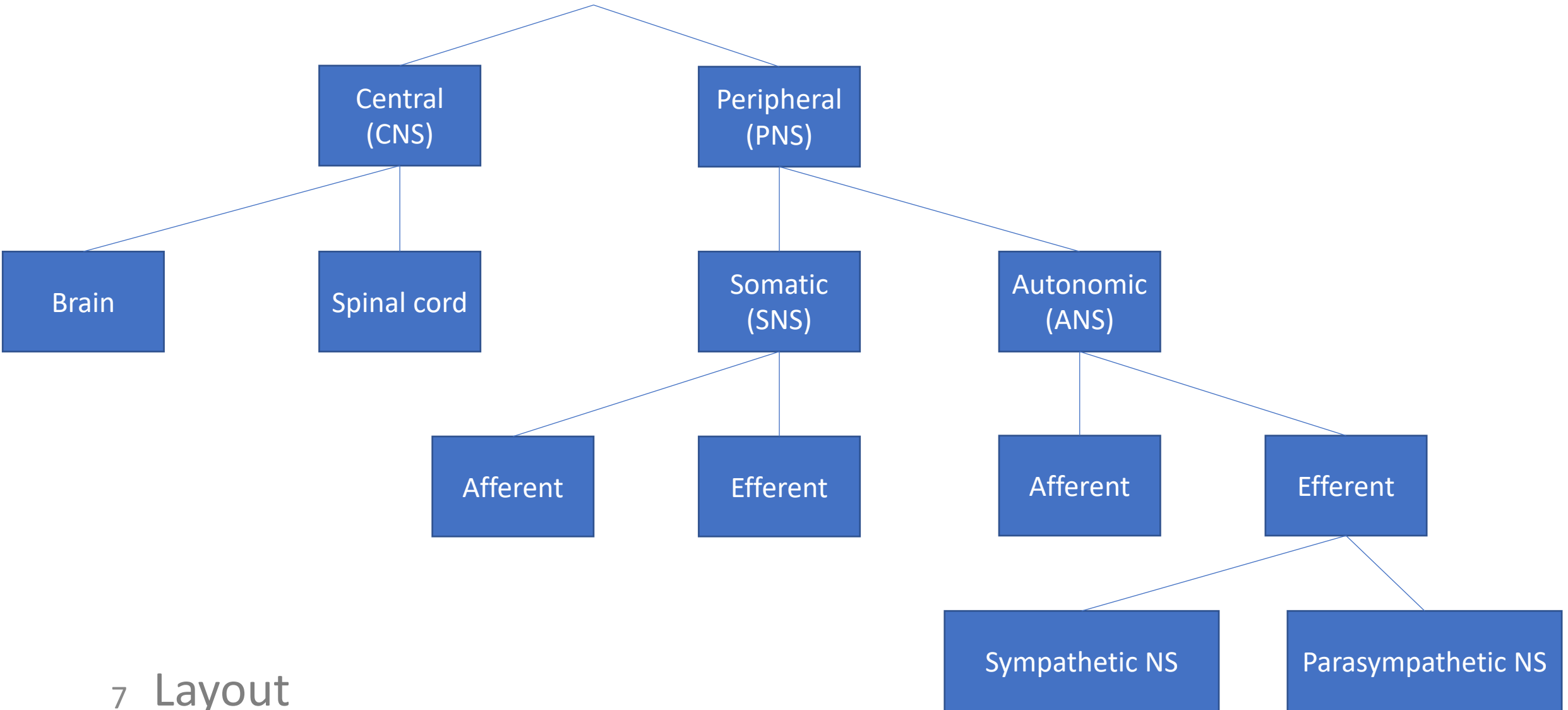
(Well, the vertebrate nervous system)



ANS: internal environment, (mostly) non-conscious

The nervous system

(Well, the vertebrate nervous system)

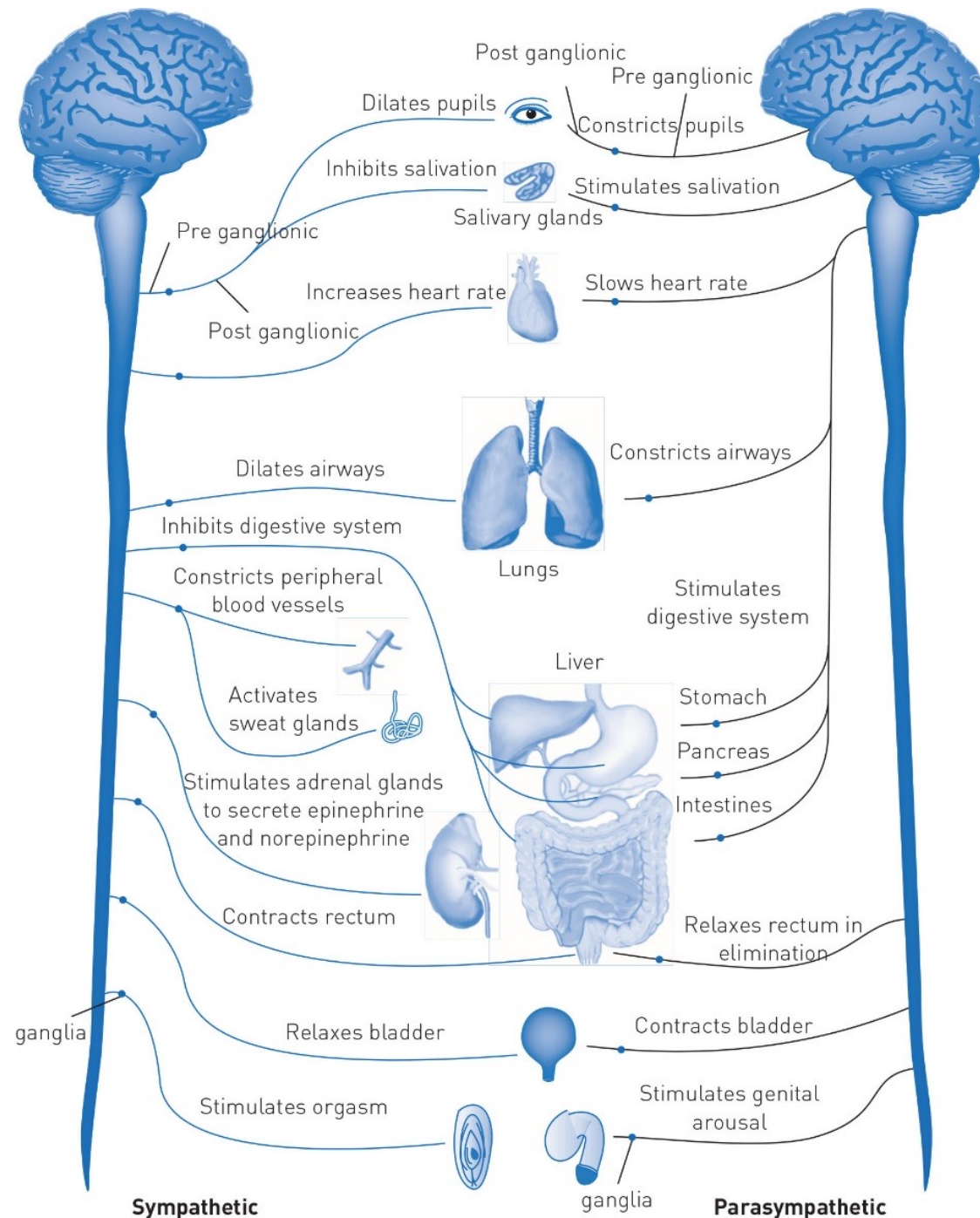


ANS efferents

Sympathetic: mobilize energy

Parasympathetic: conserve energy

Not always mutually exclusive /
in opposition to one another



Clusters and bundles

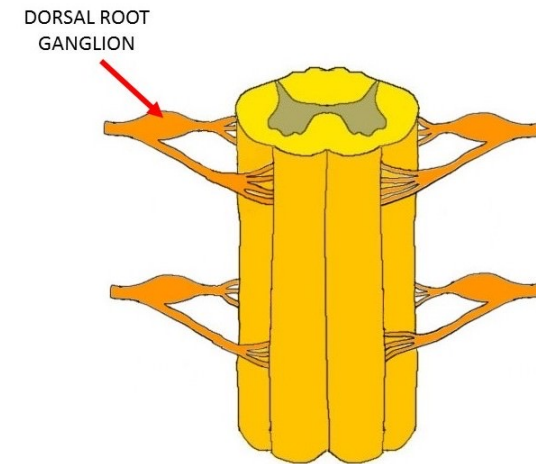
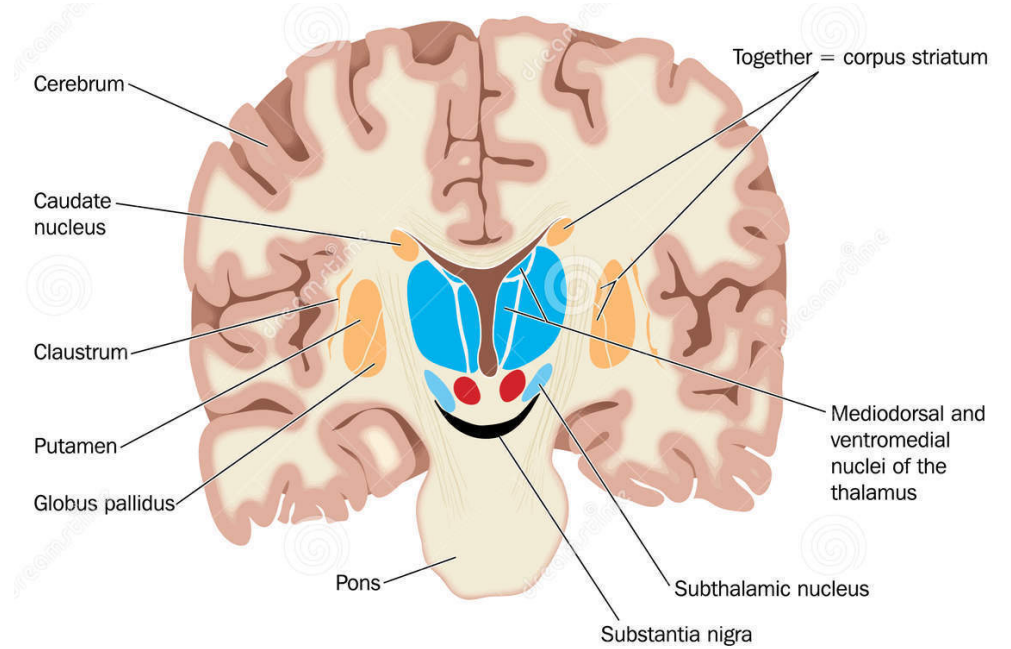
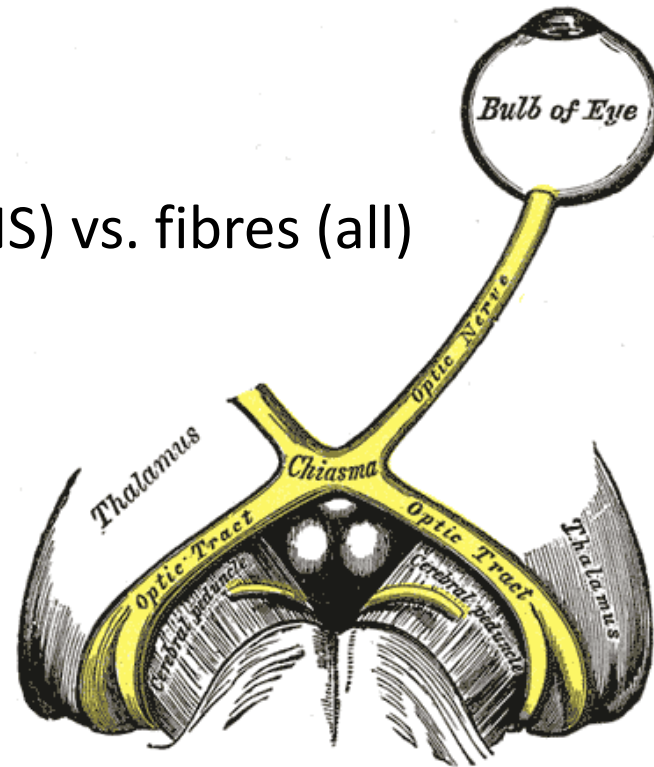
Cell clusters:

Nucleus/nuclei (CNS) vs. ganglion/ganglia (PNS)
(except when the old anatomists screw it up)

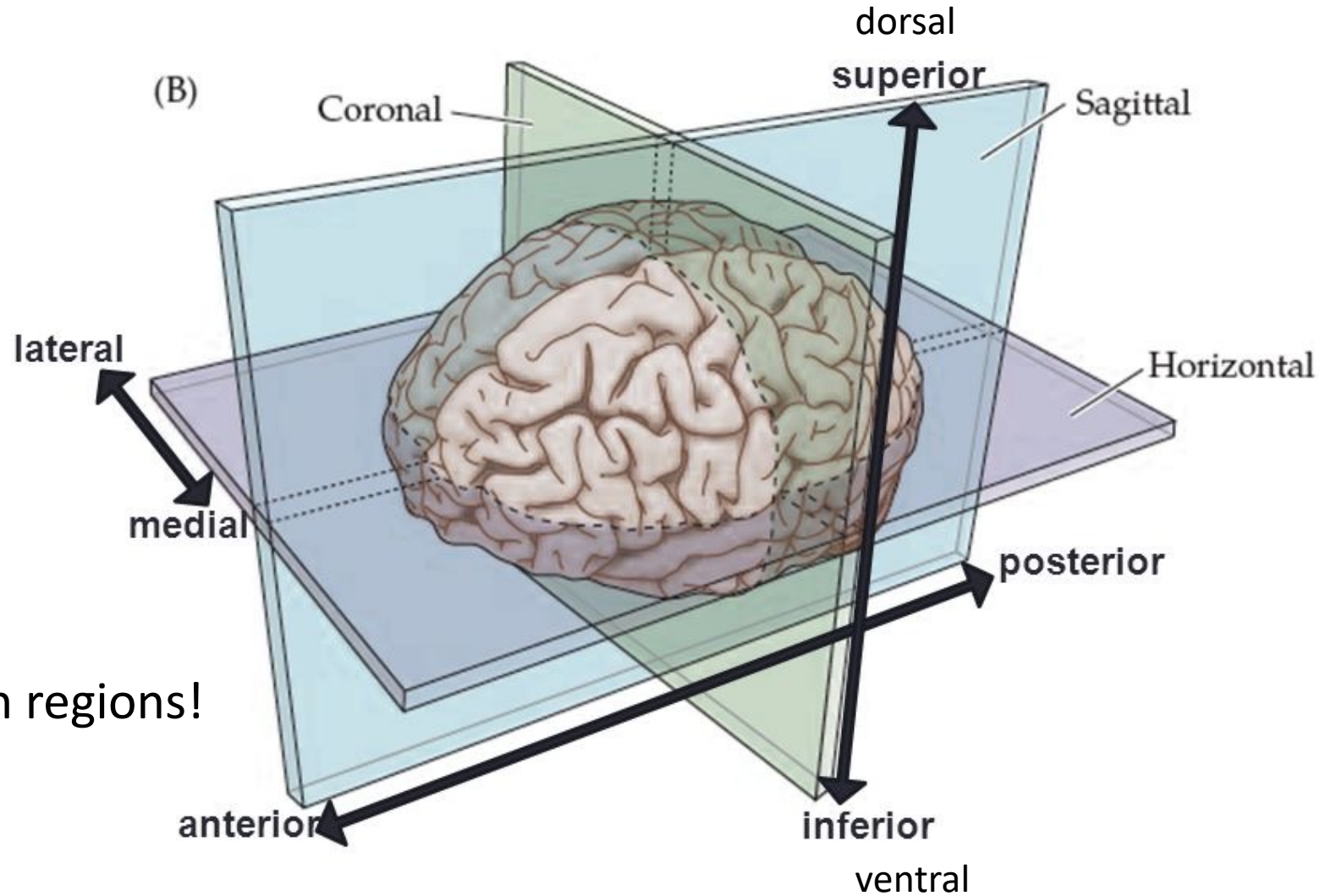
Bundle of axons:

Tract (CNS) vs. nerve (PNS) vs. fibres (all)

Gray vs. White Matter

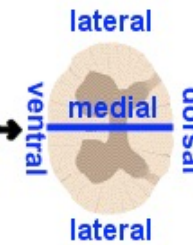
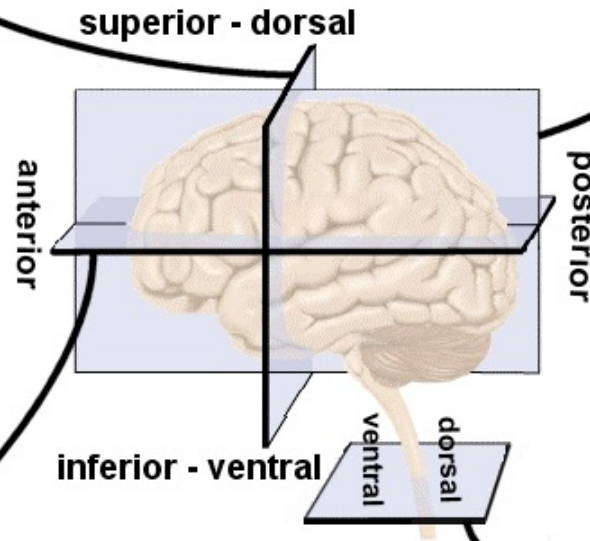
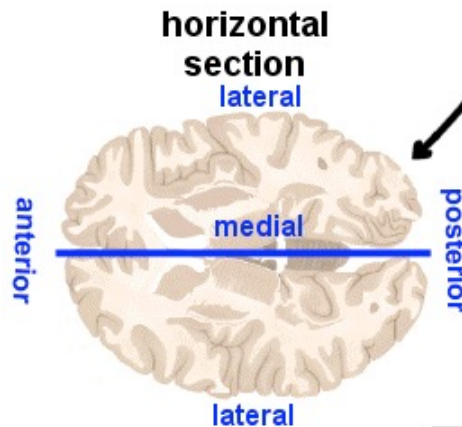
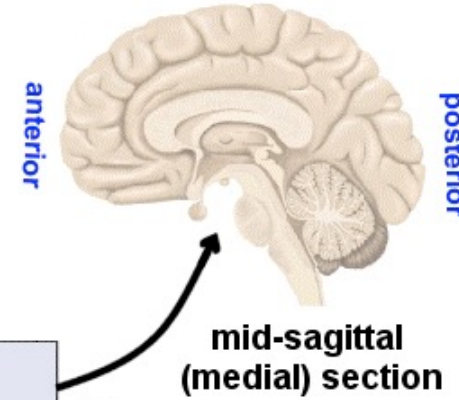
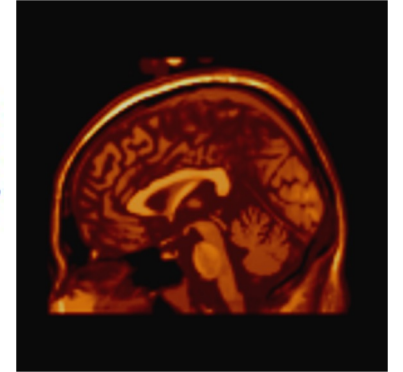
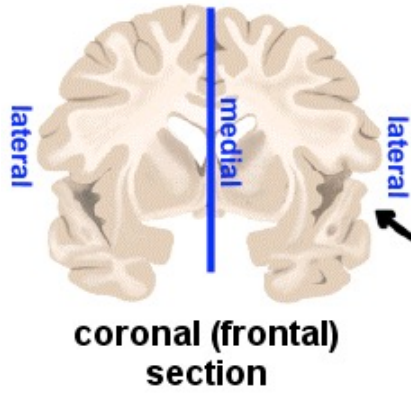
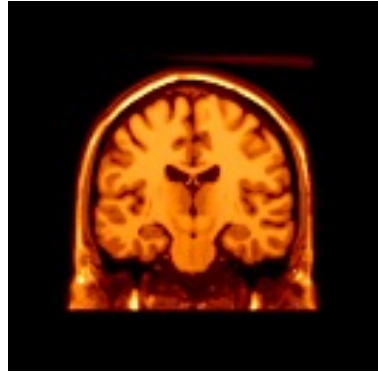


Anatomical dimensions



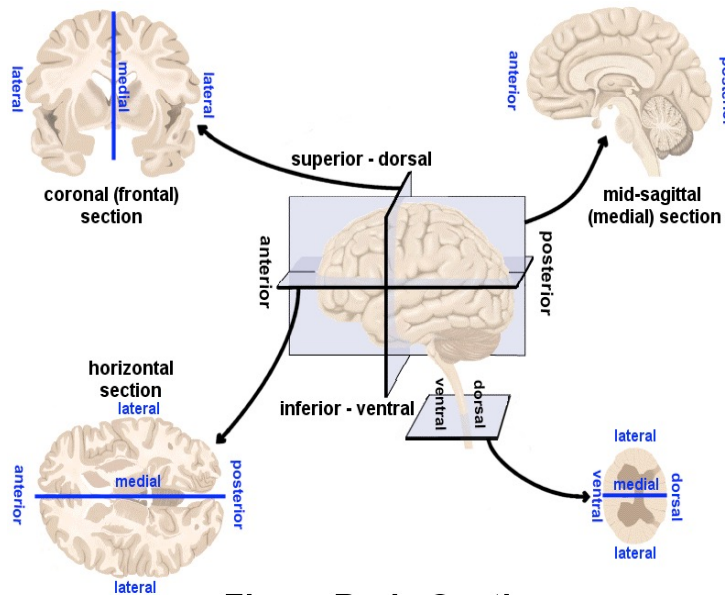
Critical for
describing brain regions!

Anatomical dimensions

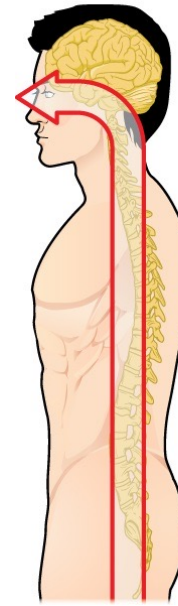


Sections/cuts

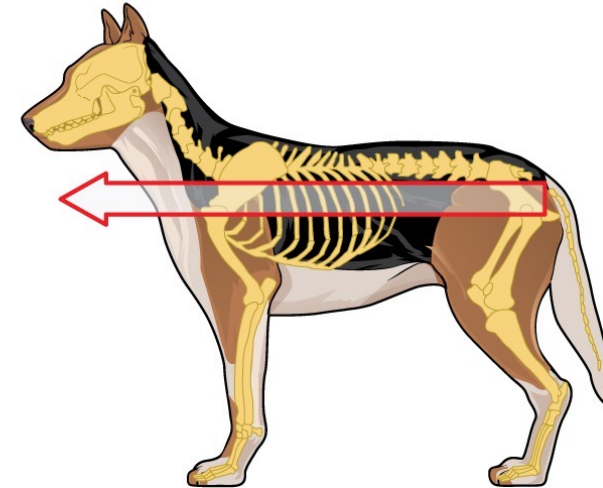
Anatomical dimensions, revisited



Human (bipedal)

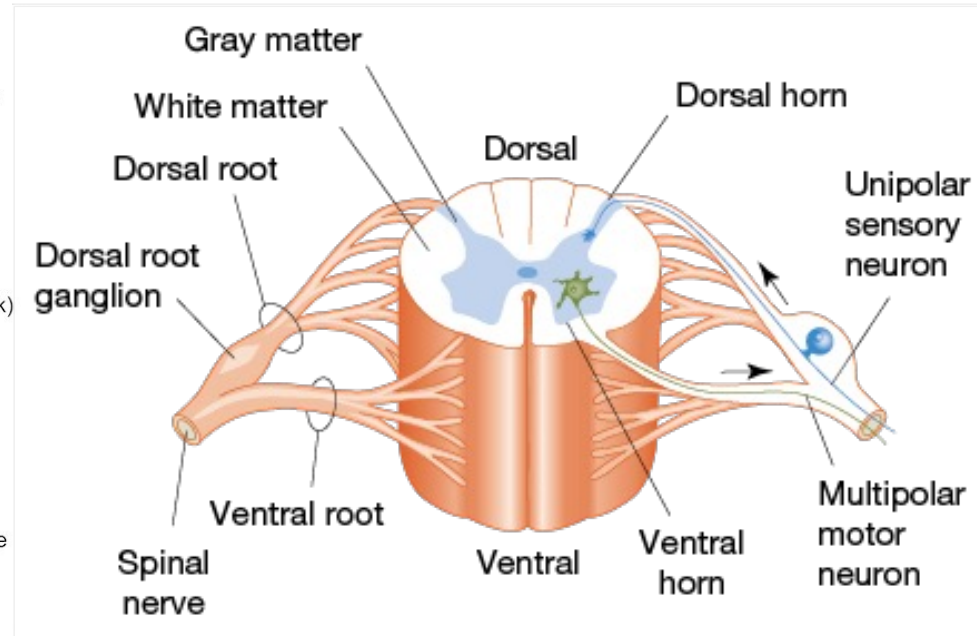
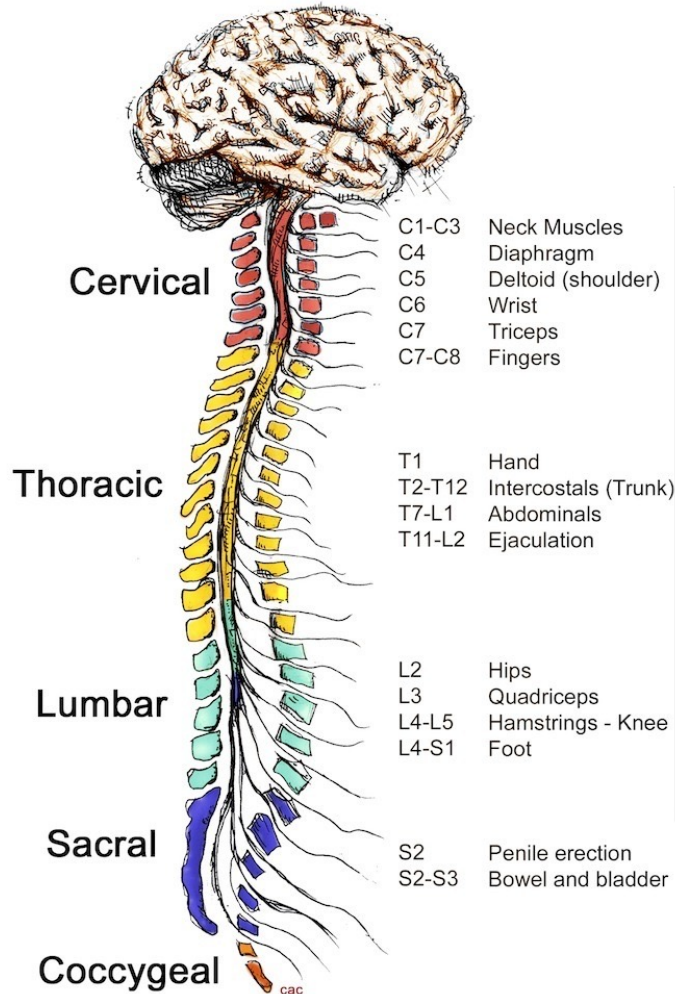


Dog (quadrupedal)



One important point that caused substantial confusion in one of my other classes was in regards to the **neuraxis**, and how we bipedal humans have a change of direction in our anatomical dimensions. Because of this change, we neuroscientists mostly **don't** use superior/inferior to describe the spinal cord, hindbrain, or midbrain. In a quadrupedal animal's brain (like the dog above), superior/inferior and dorsal/ventral are synonymous all throughout the nervous system; so when talking about brain areas across species, it's often unclear whether superior/inferior would refer to anterior/posterior (from our bum to our head) or dorsal/ventral (from our back to our belly). So feel free to use superior/inferior in the forebrain (it's the same as dorsal/ventral), but don't use it for the rest of the nervous system.

Spinal cord



Intermittent projections from spinal cord – why?

Narrows/tapers when from cervical to coccygeal – why?

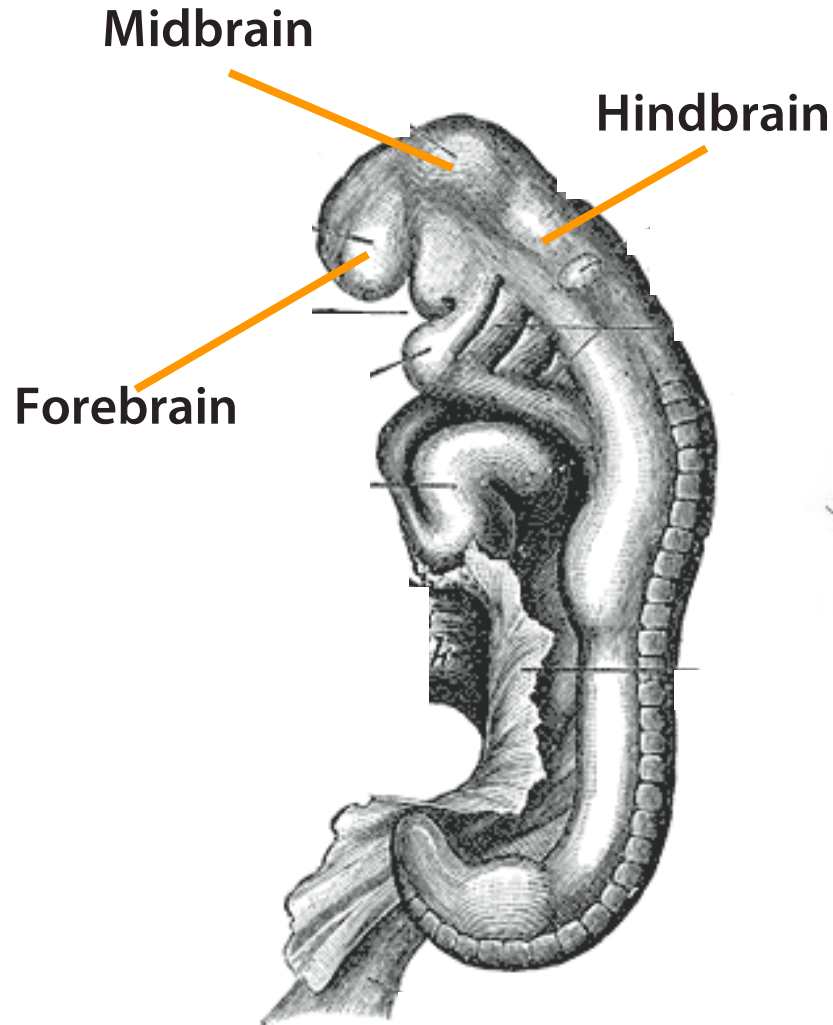
Ends in *cauda equina*

Grey/white matter divisions (Grey is inner “H”)

Dorsal/ventral organization

Spinal cord damage: loss of function related to segment of damage!

Major divisions of the brain (3)



18-21-day-old embryo



Appear early in development

Termed the **forebrain**, **midbrain**, and **hindbrain**



Major divisions of the brain (3)



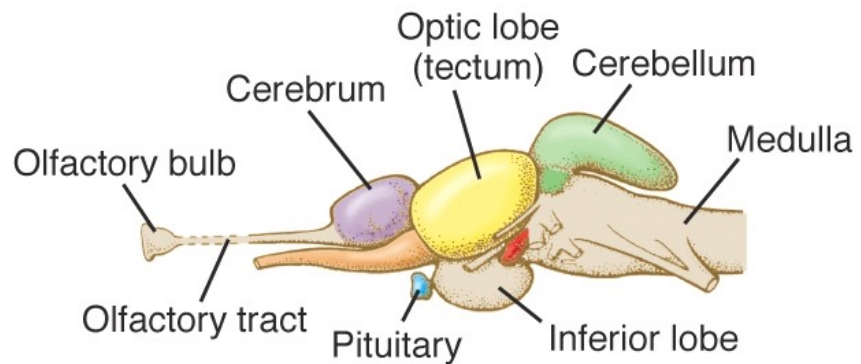
Forebrain



Midbrain

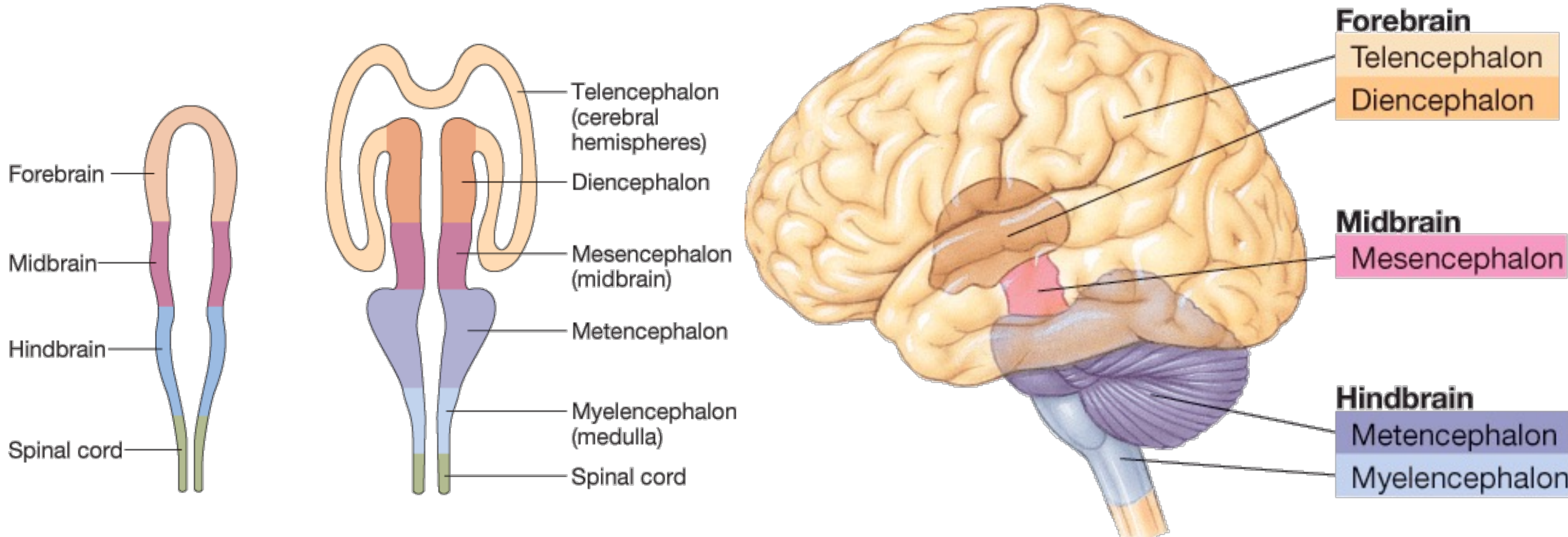


Hindbrain



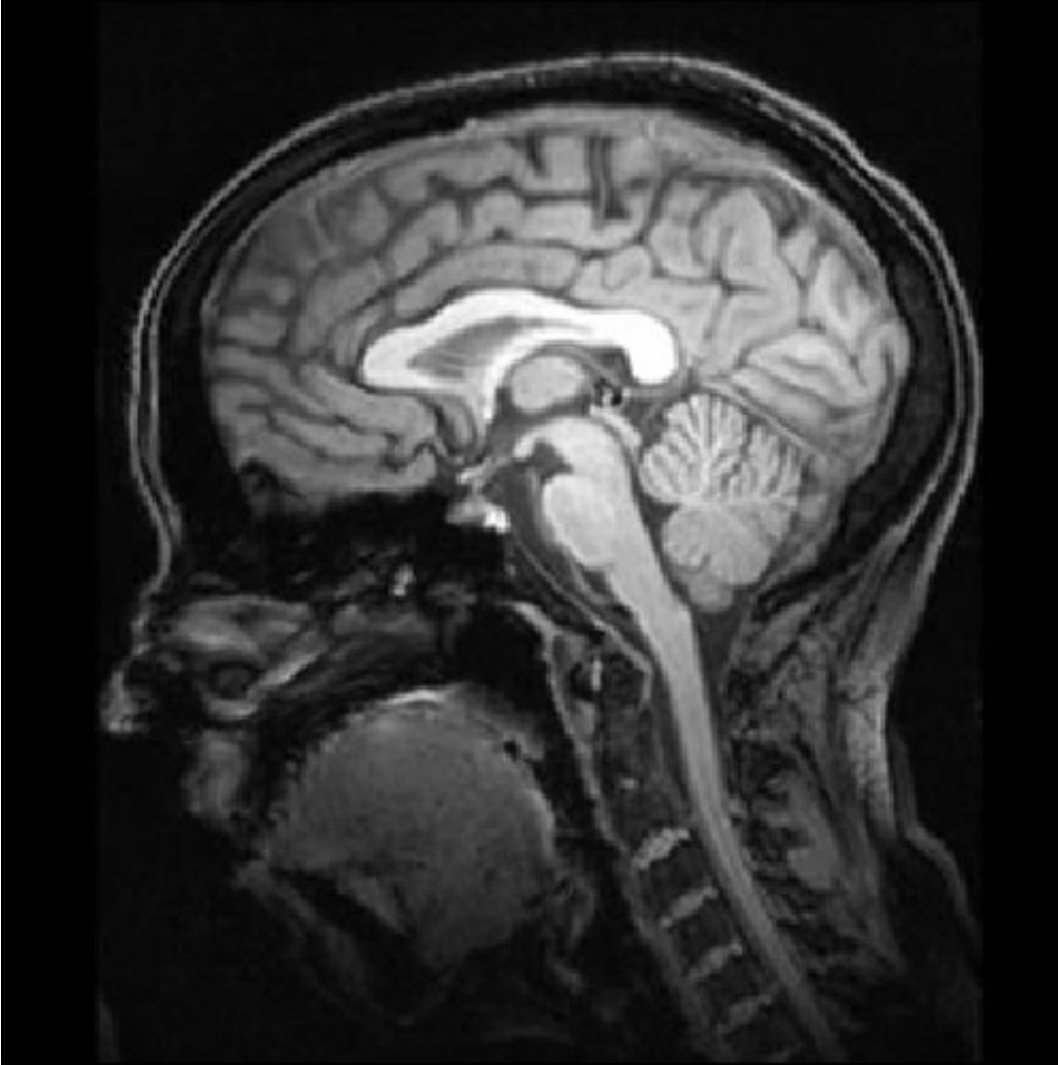
We have disproportionately large forebrains as compared to, say, fish

Major divisions of the brain (5)



Arguably more useful than three-division map

Our roadmap



A structural MRI
What kind of section?

Myelencephalon (aka the medulla)



Or *medulla oblongata*

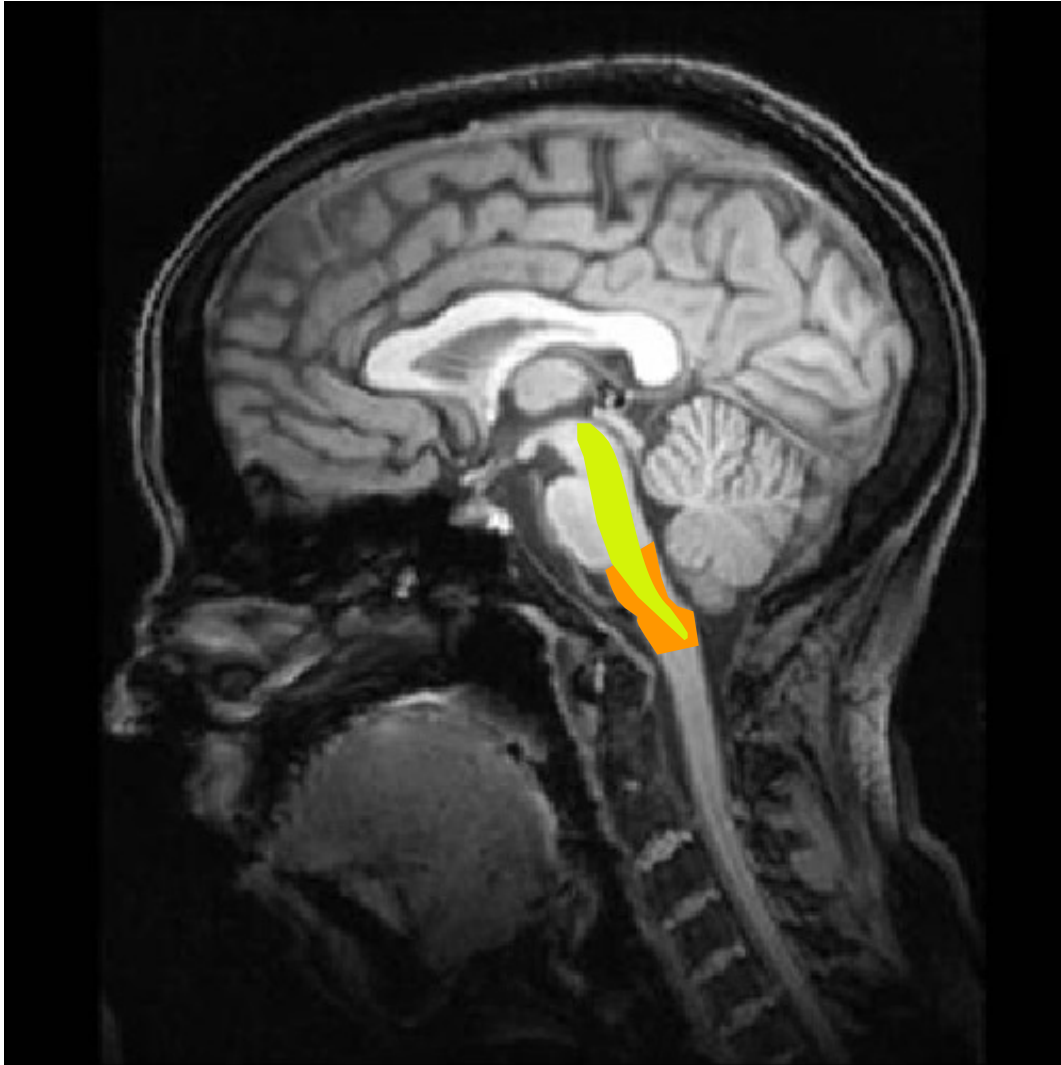
Lots of tracts

Involuntary control of
life-sustaining functions

Doctors reluctant to perform
surgery here

Insults here are often fatal

The reticular formation



aka The **reticular activating system**

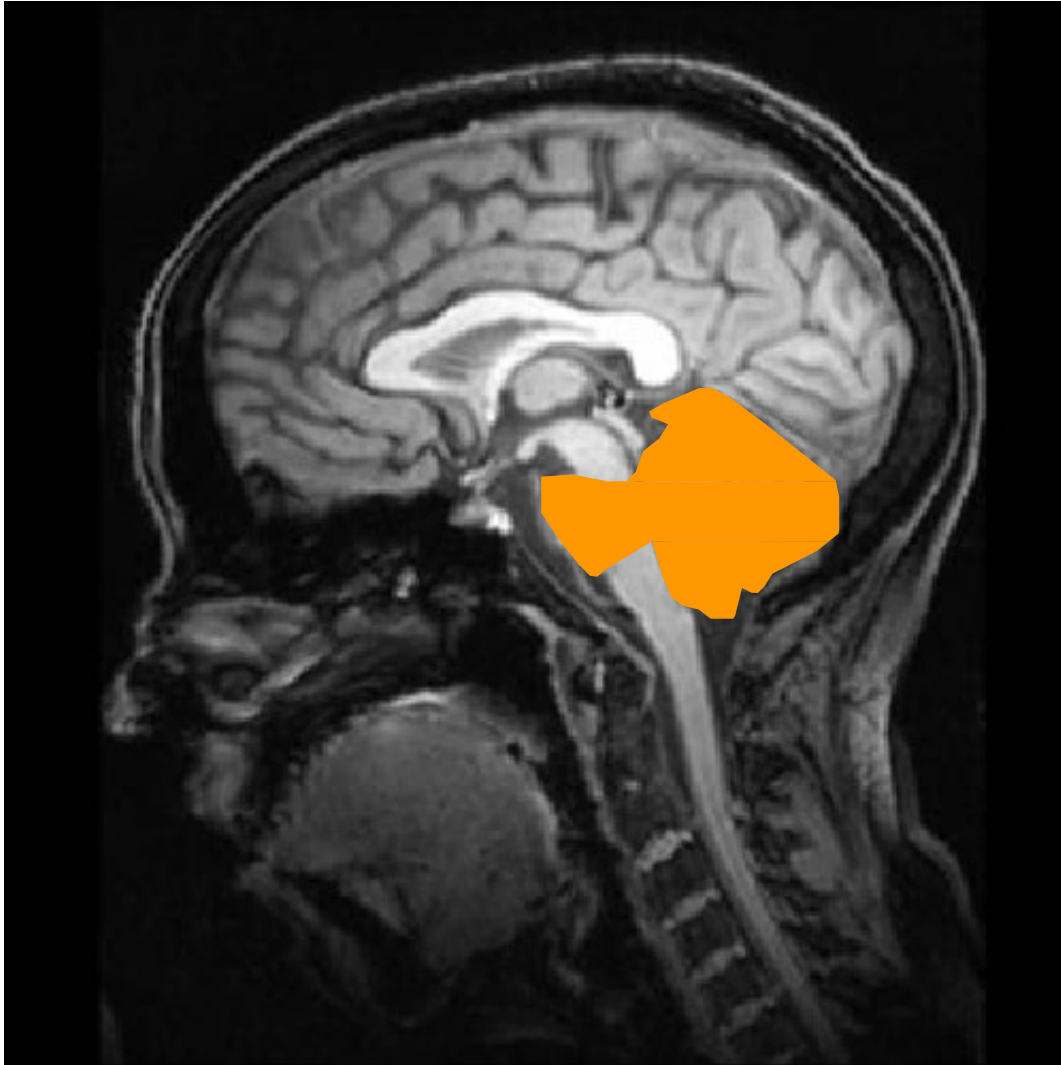
~100 nuclei

Runs from myelencephalon to
mesencephalon

Critical for arousal, wakefulness,
attention, sleep

Damage to this region causes major
disruptions to life, and/or can be fatal

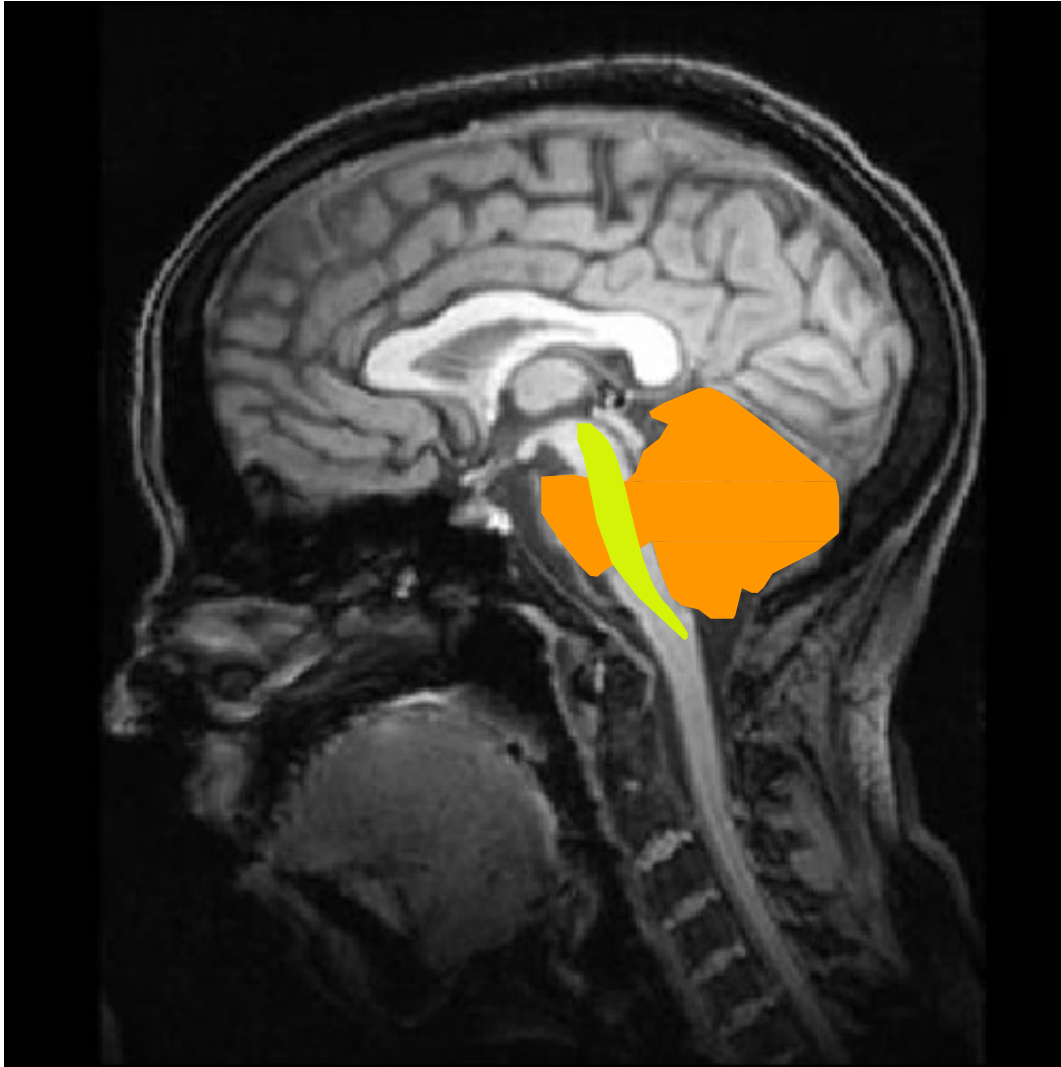
Metencephalon



Again, lots of tracts

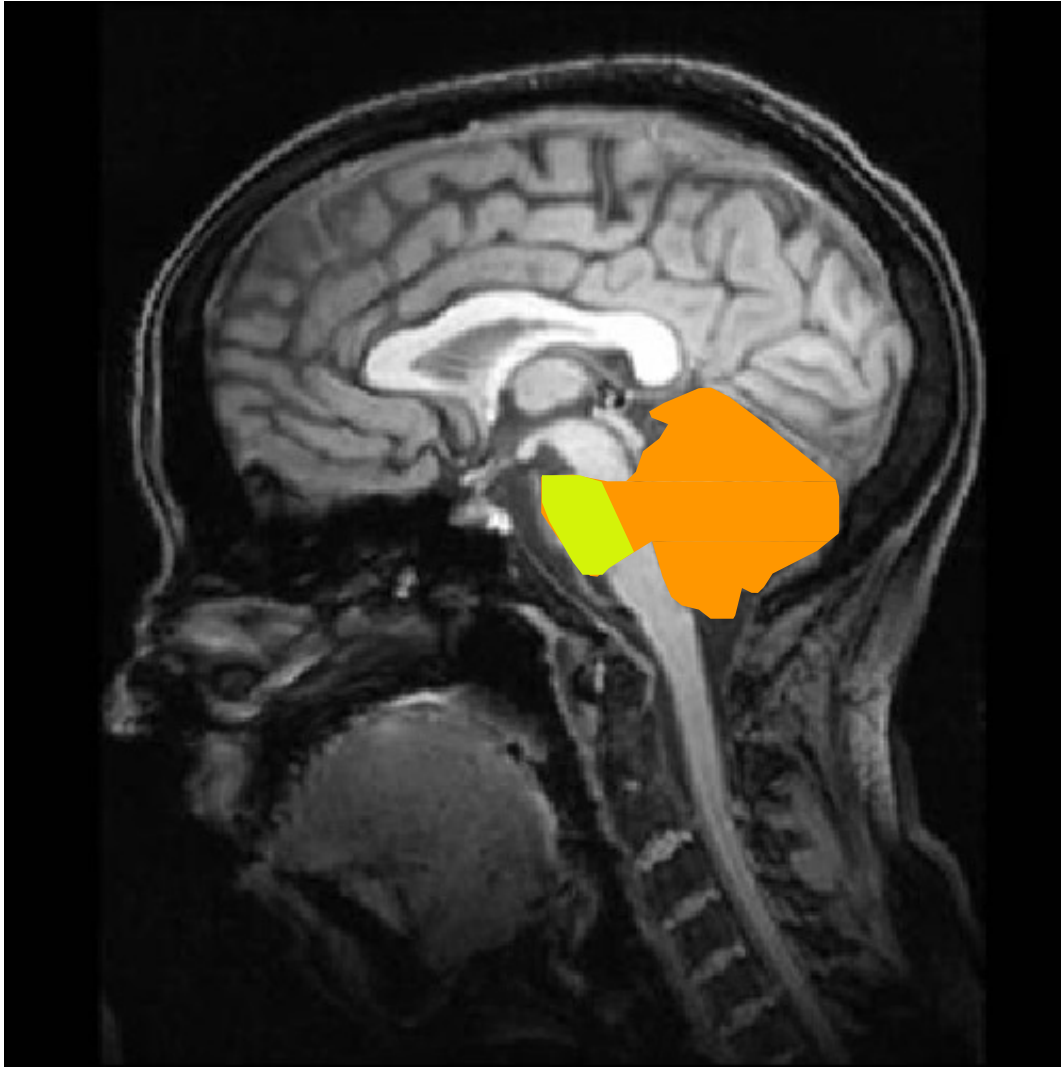
Comprised of multiple regions

Metencephalon



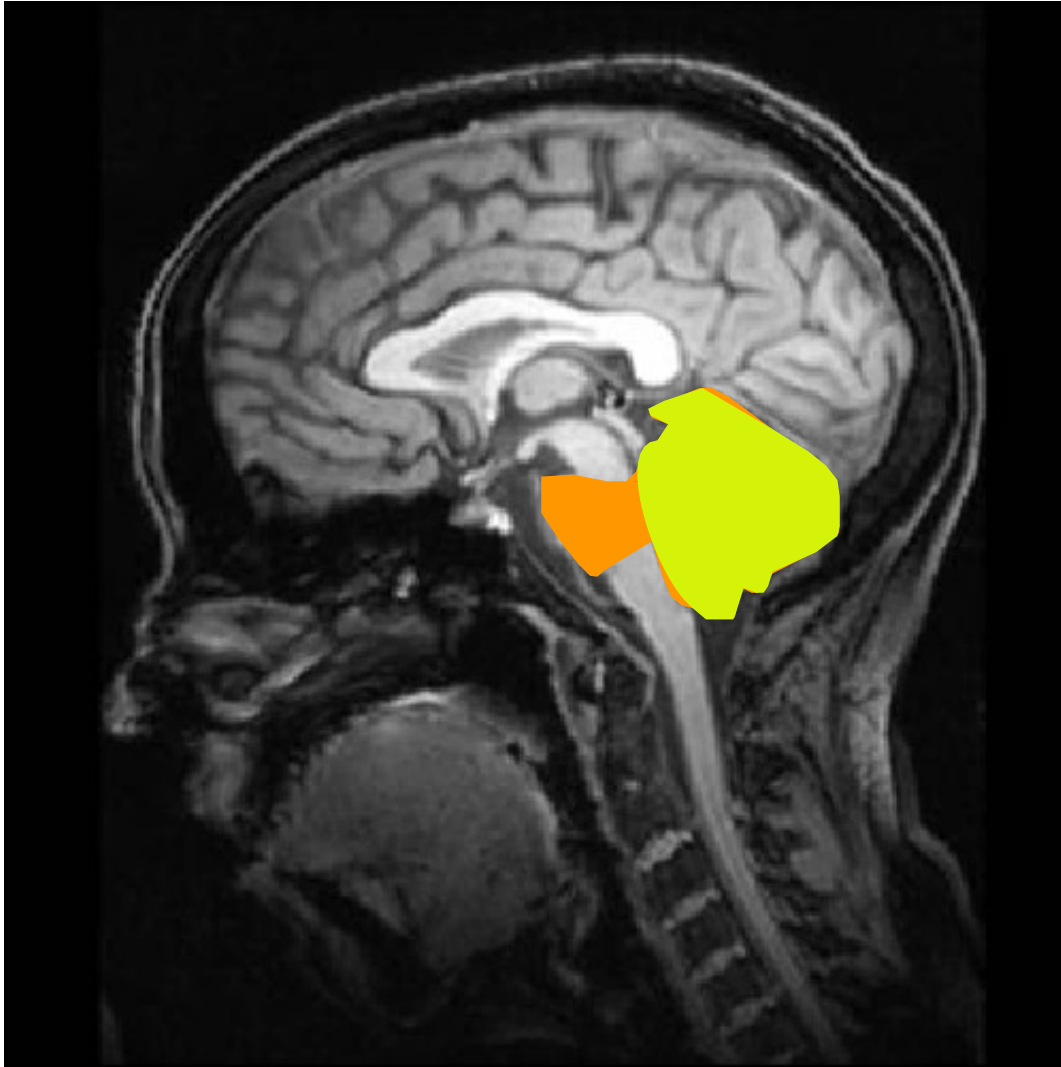
Also houses reticular formation

Metencephalon



The **pons**: large white-matter bulge,
continuing from spinal cord/medulla
Damage to this region?

Metencephalon



The **cerebellum**:

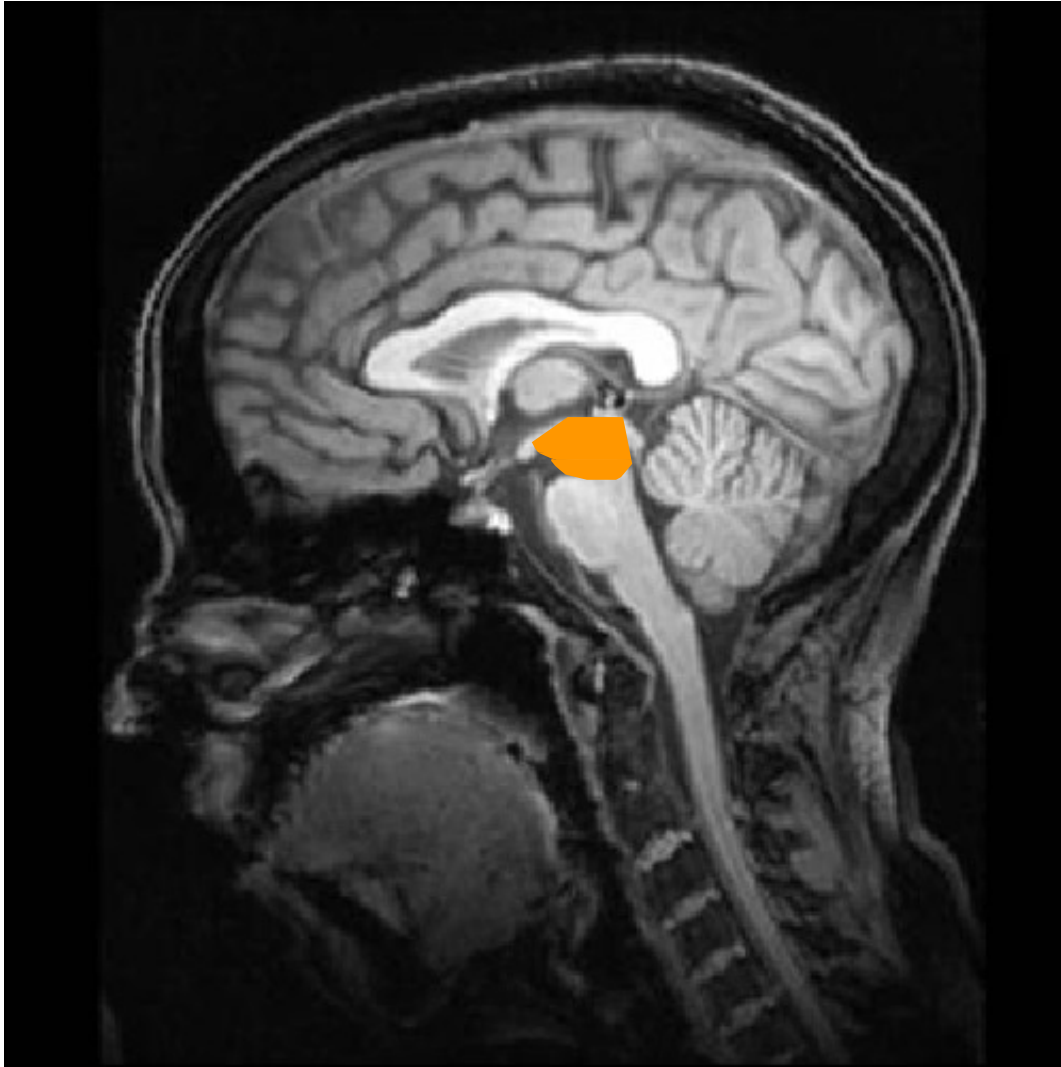
10% of brain volume,

>50% of neurons

Critical for motor coordination, more

Damage to this region?

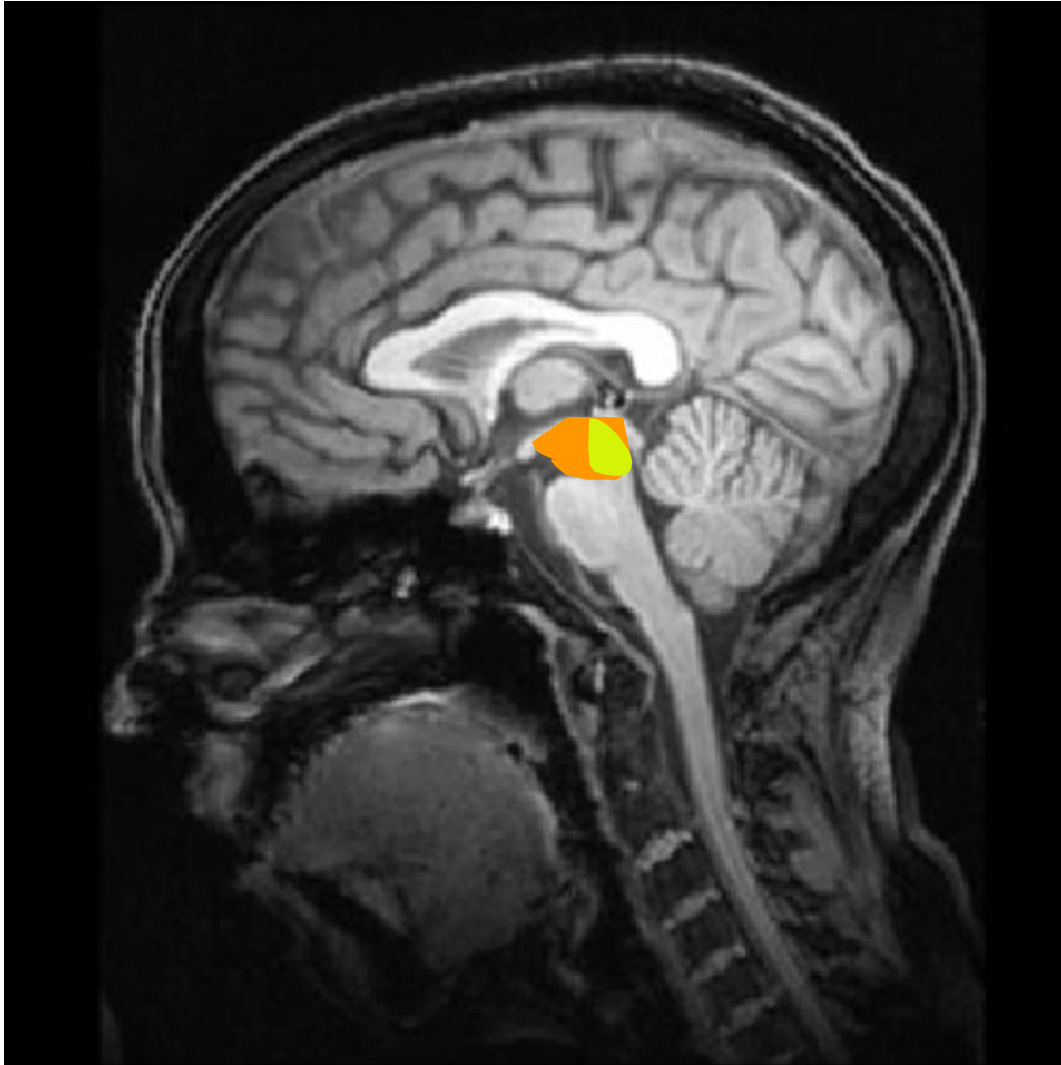
Mesencephalon



aka The midbrain

Comprised of a roof (**tectum**)
and a floor (**tegmentum**)

Mesencephalon



Tectum:

Comprised of two pairs of bumps
(*colliculi*)

Superior colliculi: vision with respect
to eye movement

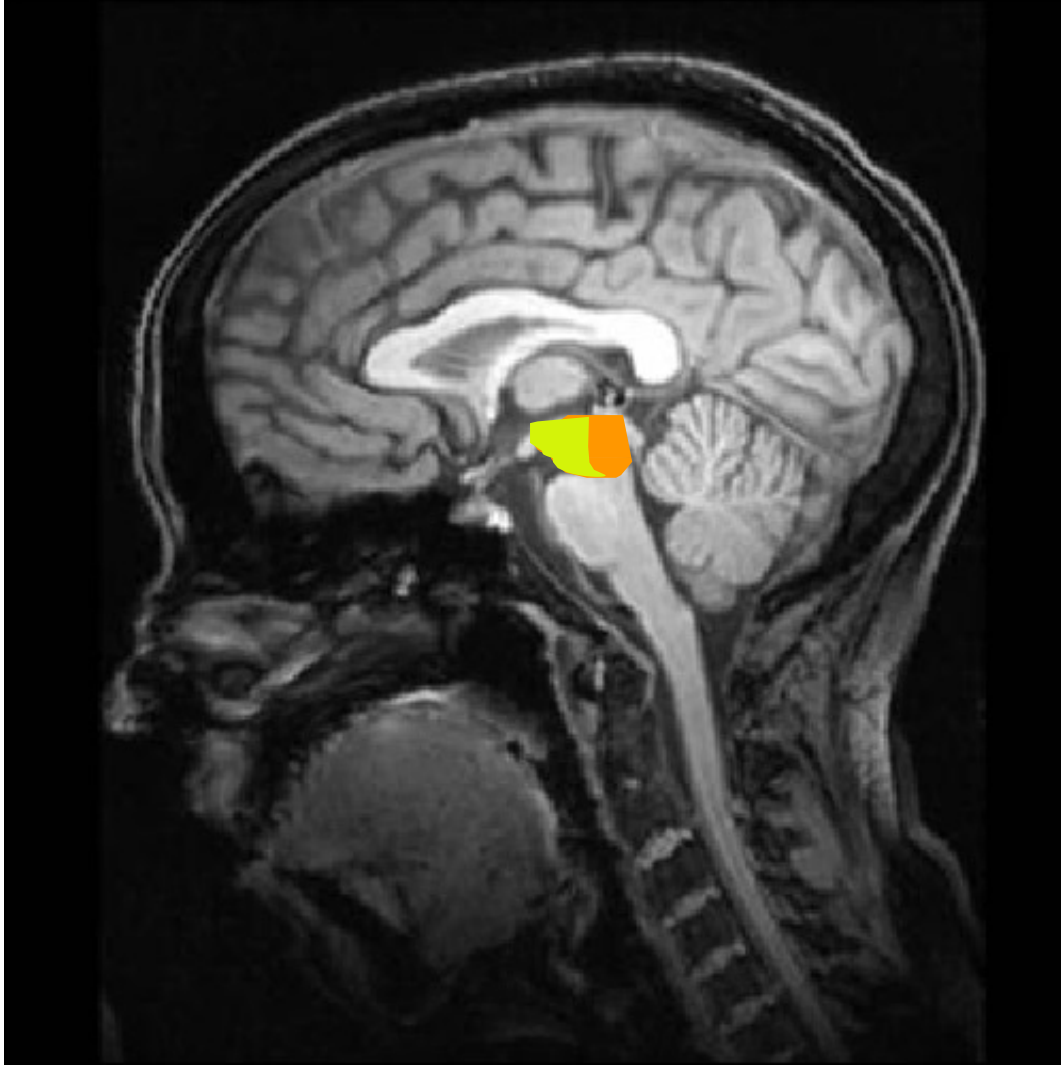
Inferior colliculi: audition with respect
to head/body orientation

Outside of conscious access

Damage to these regions?

(e.g. Parinaud's syndrome)

Mesencephalon



Tegmentum:

Contains top of reticular formation

More fibres

Periaqueductal grey

Dopamine-producing regions

Substantia nigra

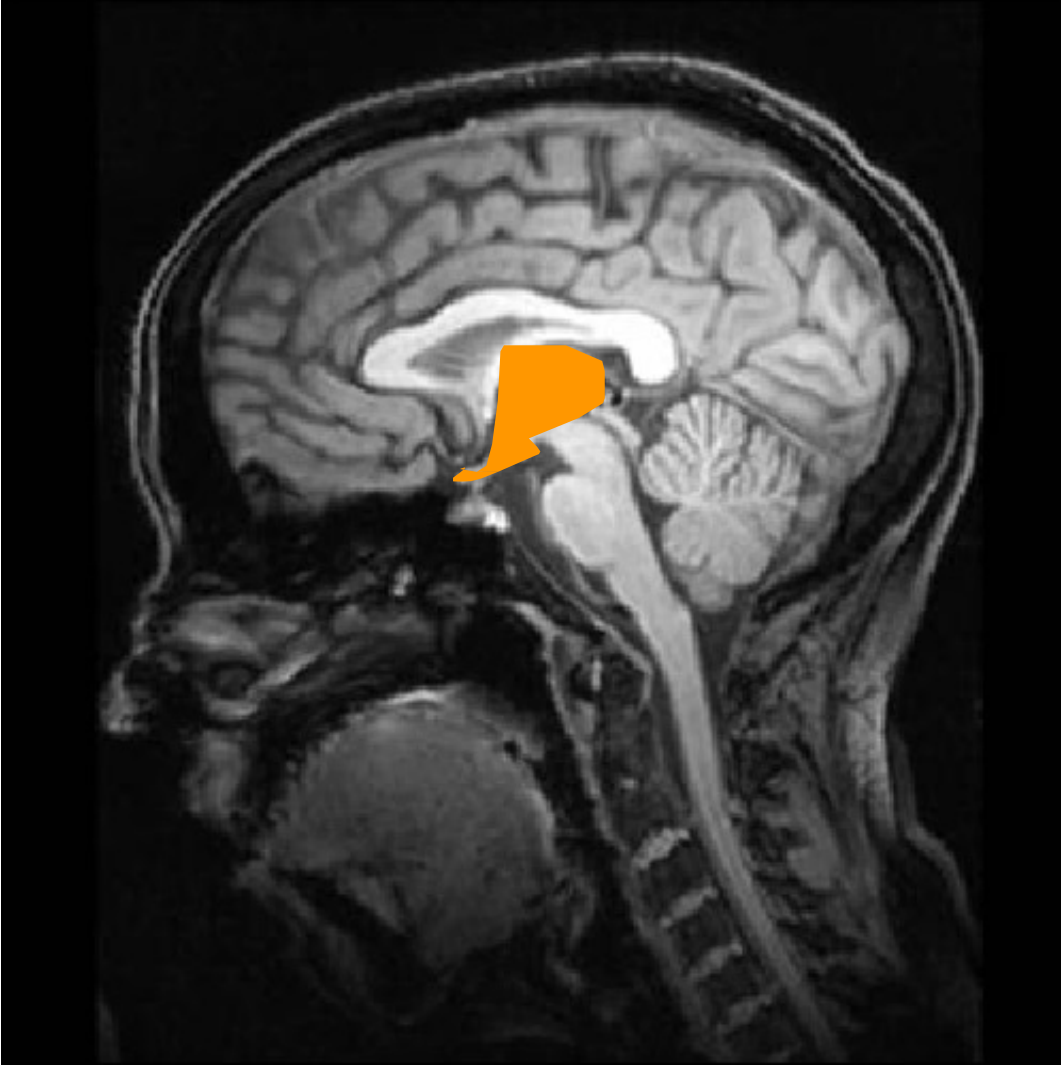
Ventral tegmental area (VTA)

Red nucleus

Pattern of function for these?

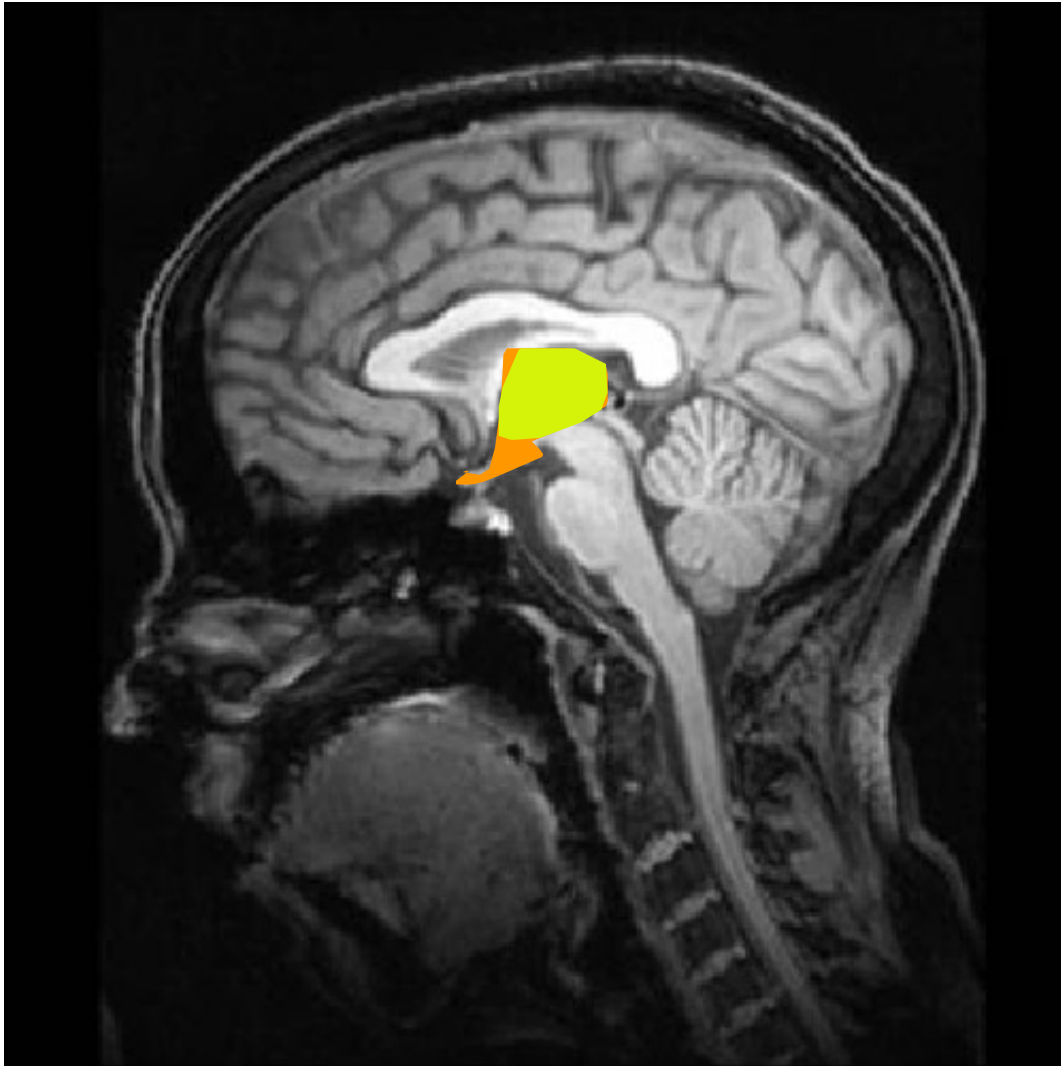
Damage to these?

Diencephalon



Comprised of two structures:
The **thalamus** and **hypothalamus**

Diencephalon



Thalamus:

Many nuclei: inputs from sensory systems, cerebellum, basal ganglia

Often called a “relay centre” for sensory information

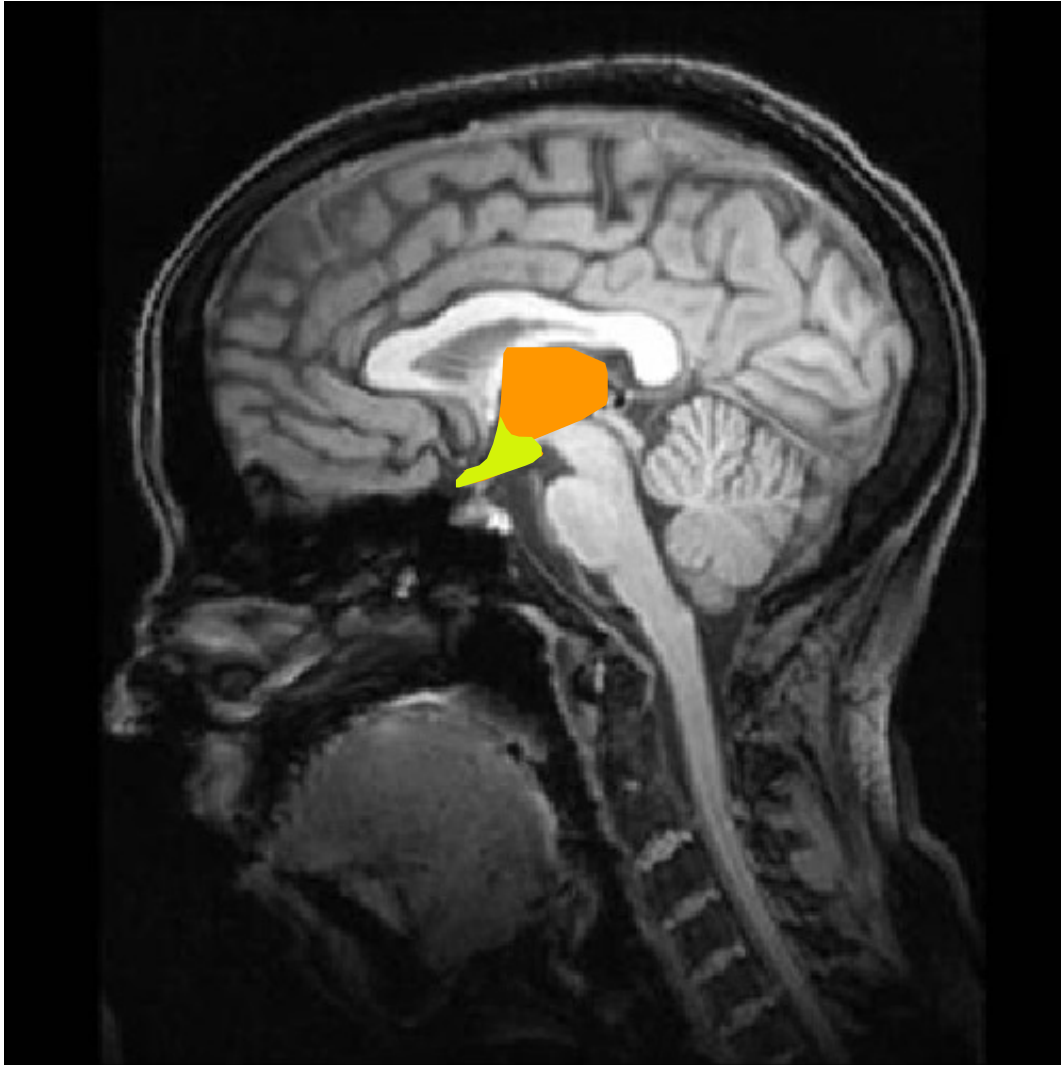
True, but: receives almost as much *from* cortex as it sends *to* cortex

And so many other inputs

Corticothalamic loops?

Damage to this region?

Diencephalon



Hypothalamus:

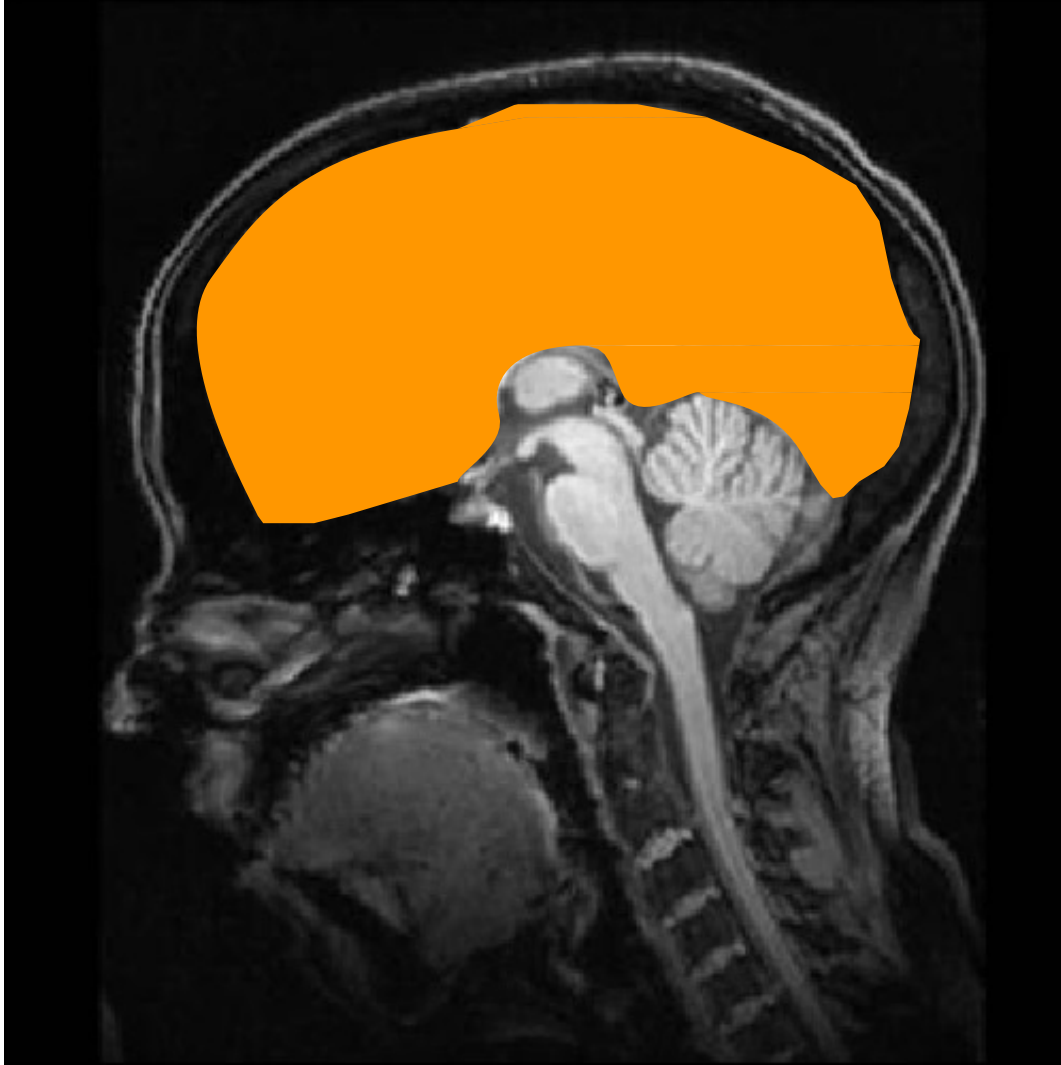
Many nuclei

Key intersection with endocrine system via the pituitary gland

Diverse functions: sex, aggression, feeding, sleep/wake, more

Damage to this region?

Telencephalon



The largest division of the human brain

Not just the cortex,
but also the underlying structures

Damage here is wide-ranging in its
symptoms, and is much of what we'll
be discussing in this course

Telencephalon

The **cerebral cortex**:

aka The cortex, neocortex

The largest and most prominent
feature of the human brain



Telencephalon

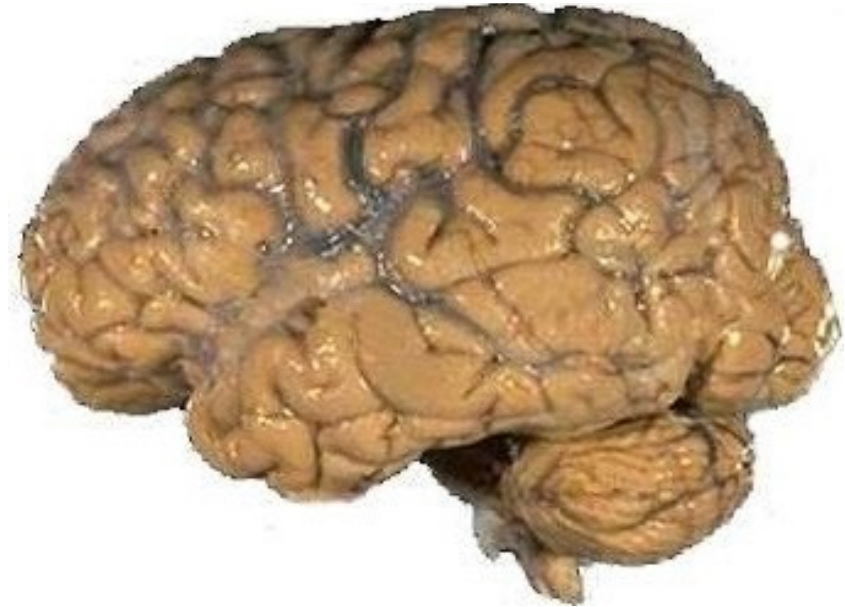
The **cerebral cortex**:

aka The cortex, neocortex

The largest and most prominent feature of the human brain

The cortex is highly convoluted — why?

cf. The *lissencephalic* (smooth) cortices of other mammals, birds, etc.



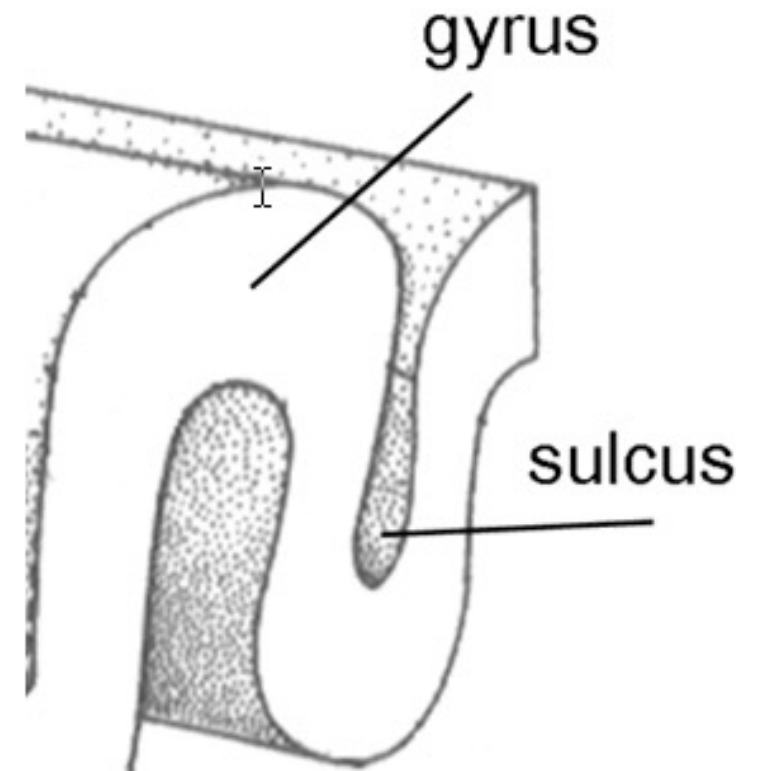
Convolutions

Gyrus/gyri and sulcus/sulci

Sulci sometimes called *fissures*

Not functionally meaningful, per se

But damage may show up in only one (?!?)

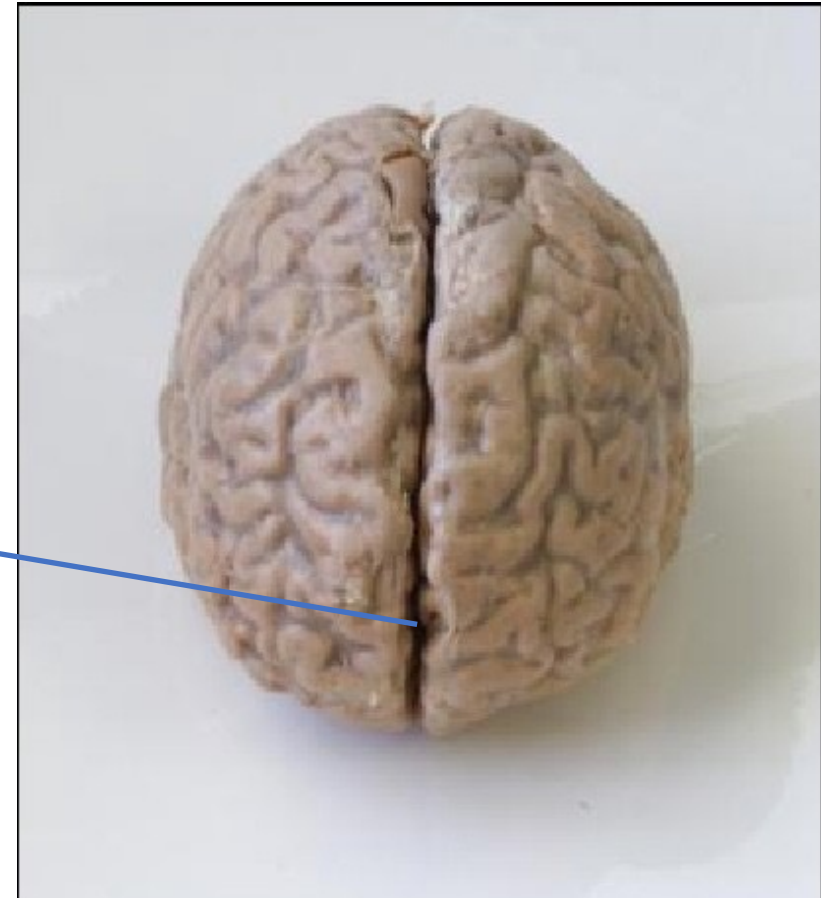


Hemispheres

The cerebrum is divided into two hemispheres

Separating the hemispheres:

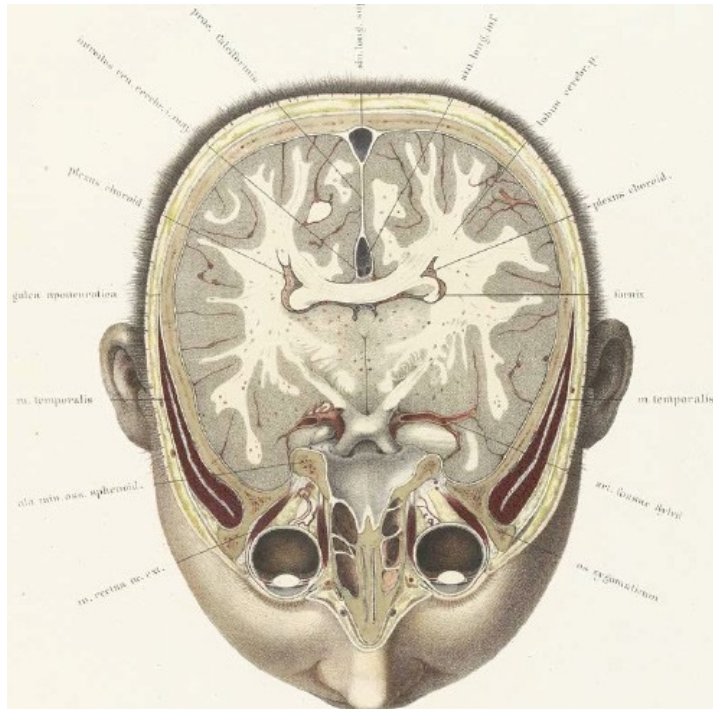
The longitudinal fissure



Connecting the hemispheres

Left and right hemispheres are only connected by a few tracts (commissures)

Largest: the **corpus callosum**



Disconnecting the hemispheres

i.e. Split-brain patients

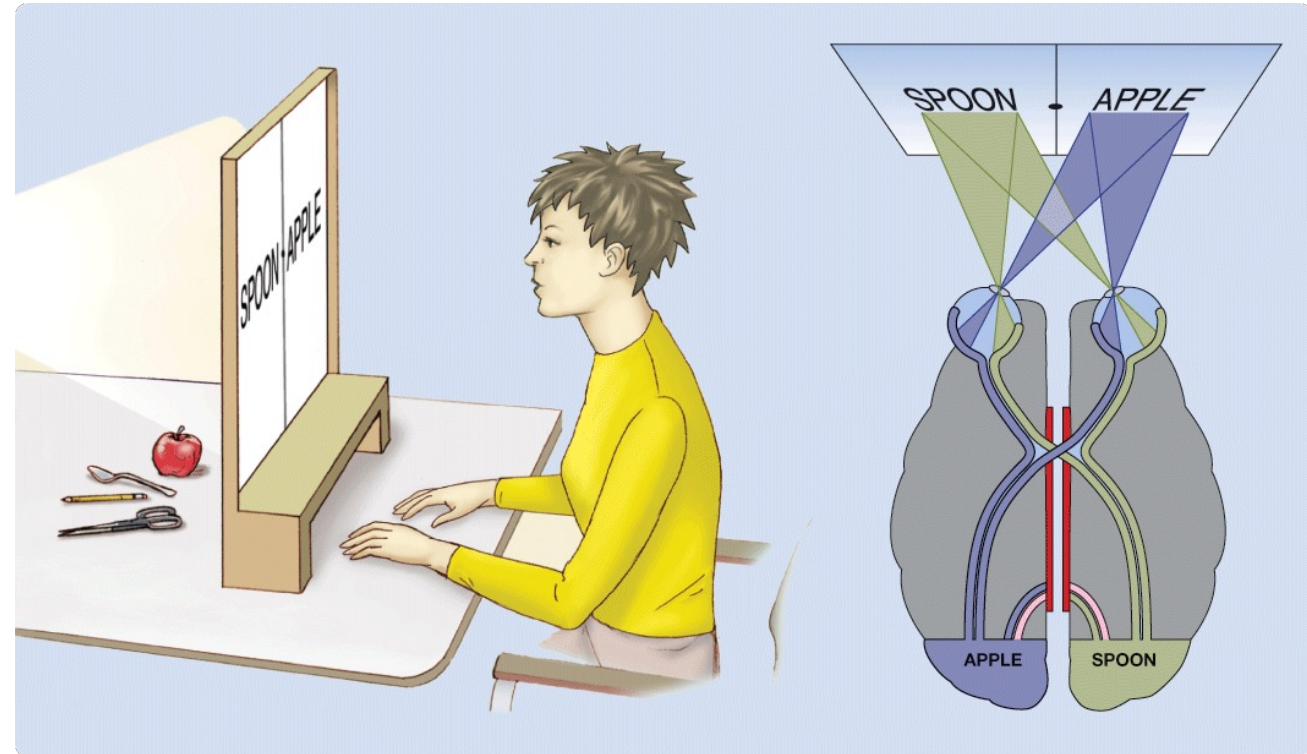
Callosotomy, a rare treatment for epilepsy

A person with two minds?

Learning point: **contralateral organization**

Learning point: **left hemisphere dominance for language**

Object presented to left vs. right hemisphere?



<https://www.youtube.com/watch?v=ZMLzP1VCANo>

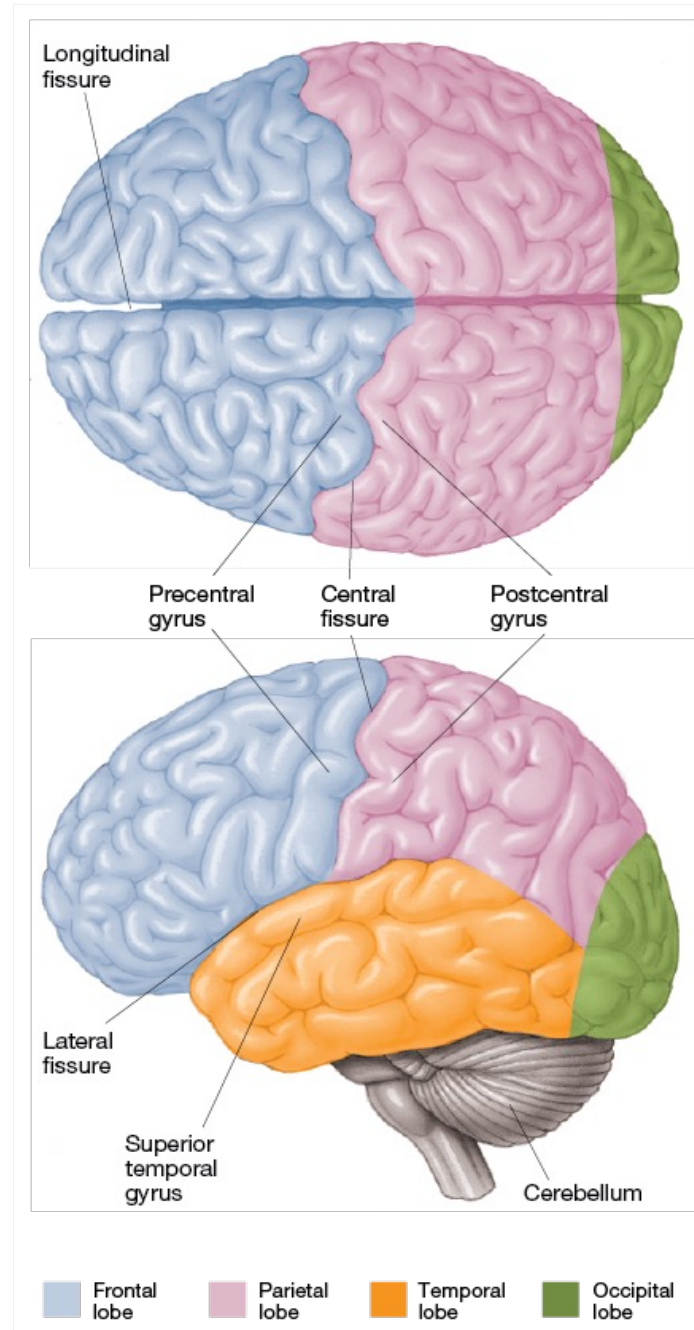
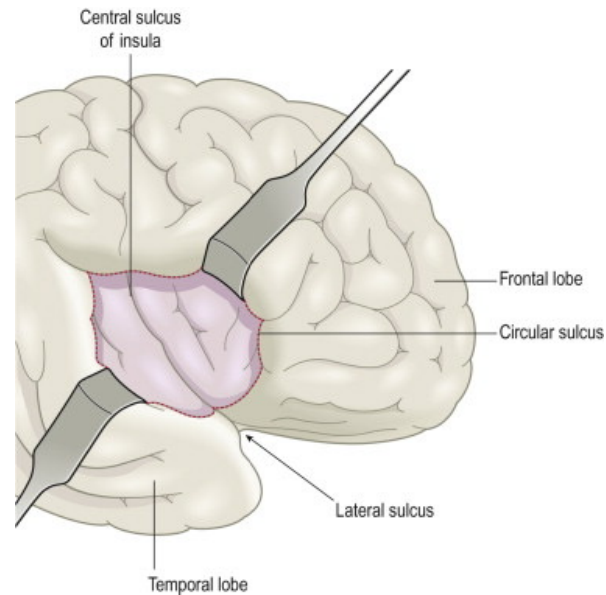
More fissures, and lobes

Four lobes of the brain — where do they get their names?

Central fissure separates frontal and parietal lobes

Lateral fissure separates temporal lobe from frontal/parietal

Deep in the lateral fissure: the insula

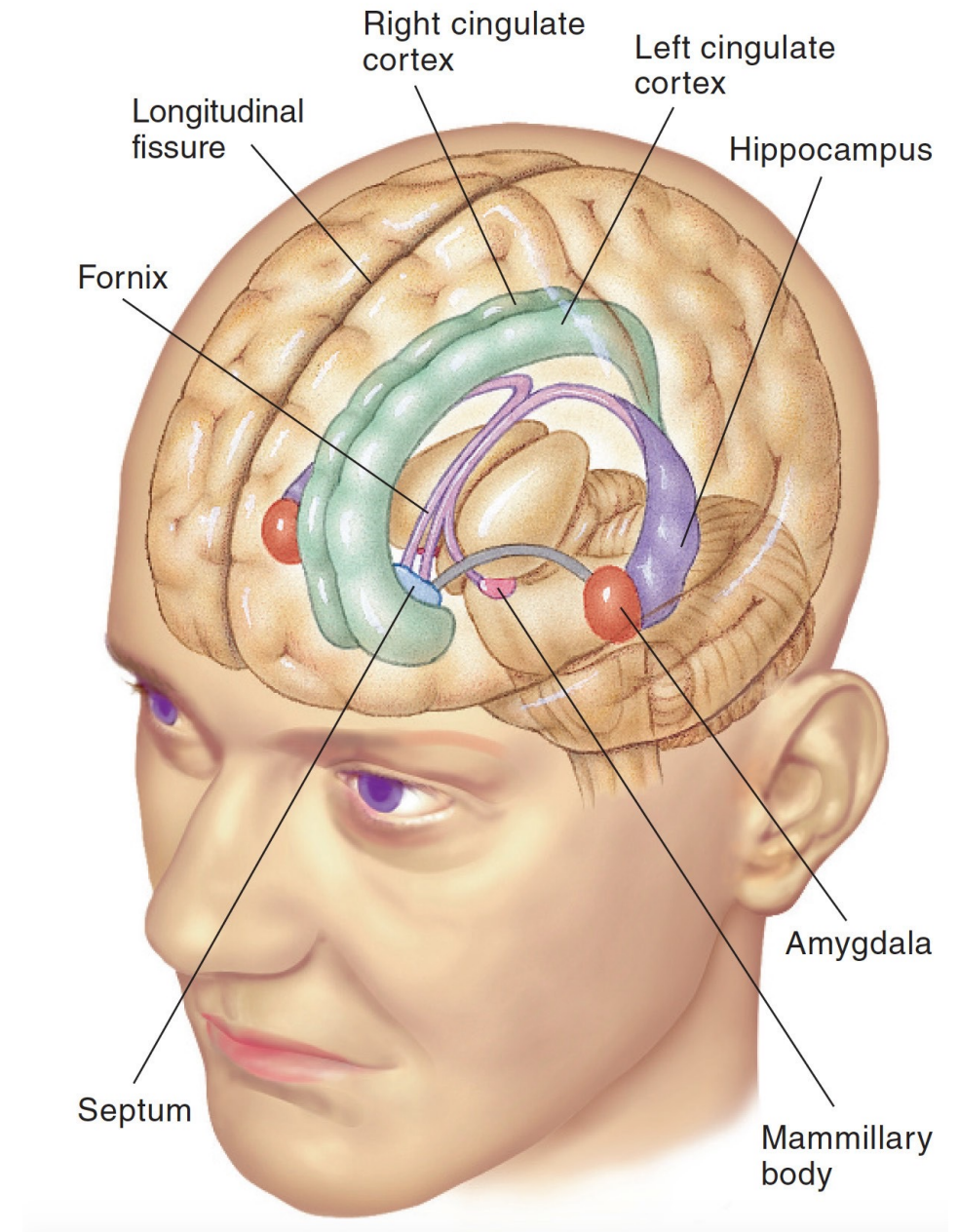


The limbic “system”: not a system

The Papez “Circuit”, aka the Limbic “System”

→ **Amygdala, HTh, mammillary body, hippocampus, fornix, cingulate cortex, septum, olfactory bulb**

Again, symptoms from damage can vary from region to region (we’ll come back to these)



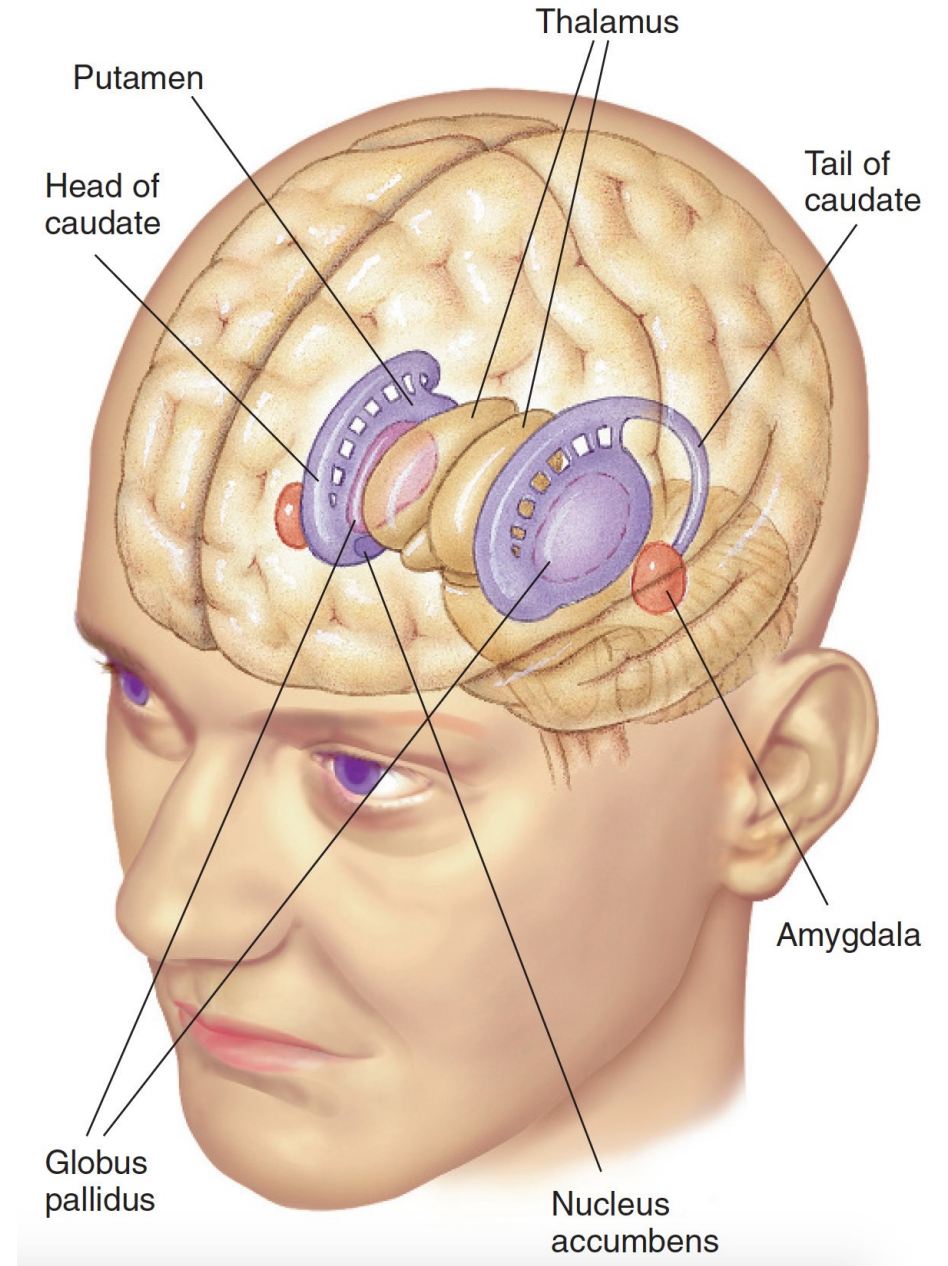
Basal ganglia

Includes **striatum (caudate + putamen)** and **globus pallidus**, sometimes others (e.g. **subthalamic nucleus**)

Nucleus accumbens is a subregion of striatum/caudate, sometimes called **ventral striatum**

Critical in movement, skills, habits, decision making

Again, more on this later

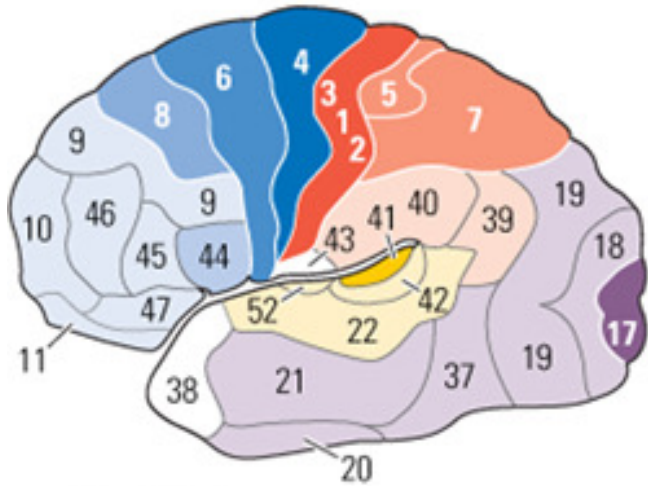


Anatomy of the cortical layers

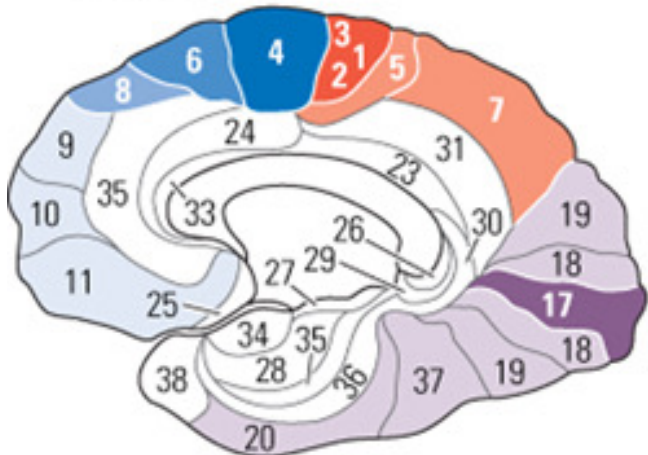
These differences between parts of the cortex can be used to make maps

e.g. **Brodmann areas**





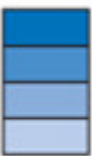

(A) Lateral view



Medial view

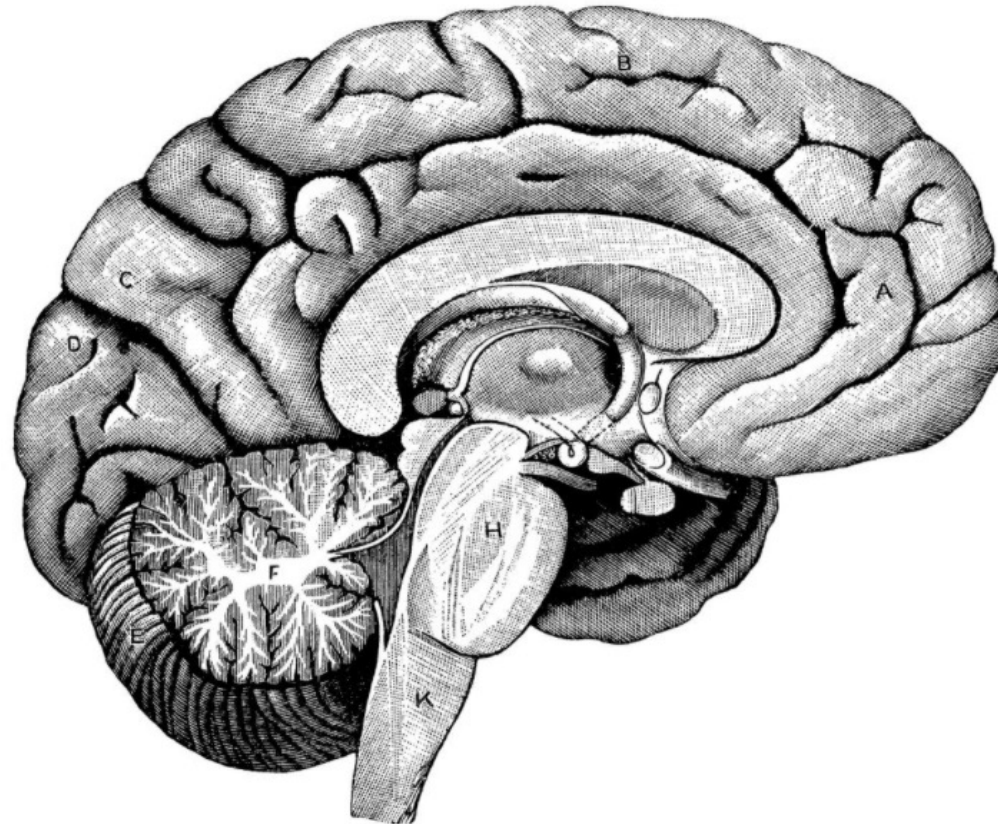


(B)

Function	Map code	Brodmann area
Vision		17
		18, 19, 20, 21, 37
Auditory		41
		22, 42
Body senses		1, 2, 3
		5, 7
Sensory, tertiary		7, 22, 37, 39, 40
Motor		4
		6
		8
		44
Motor, tertiary		9, 10, 11, 45, 46, 47

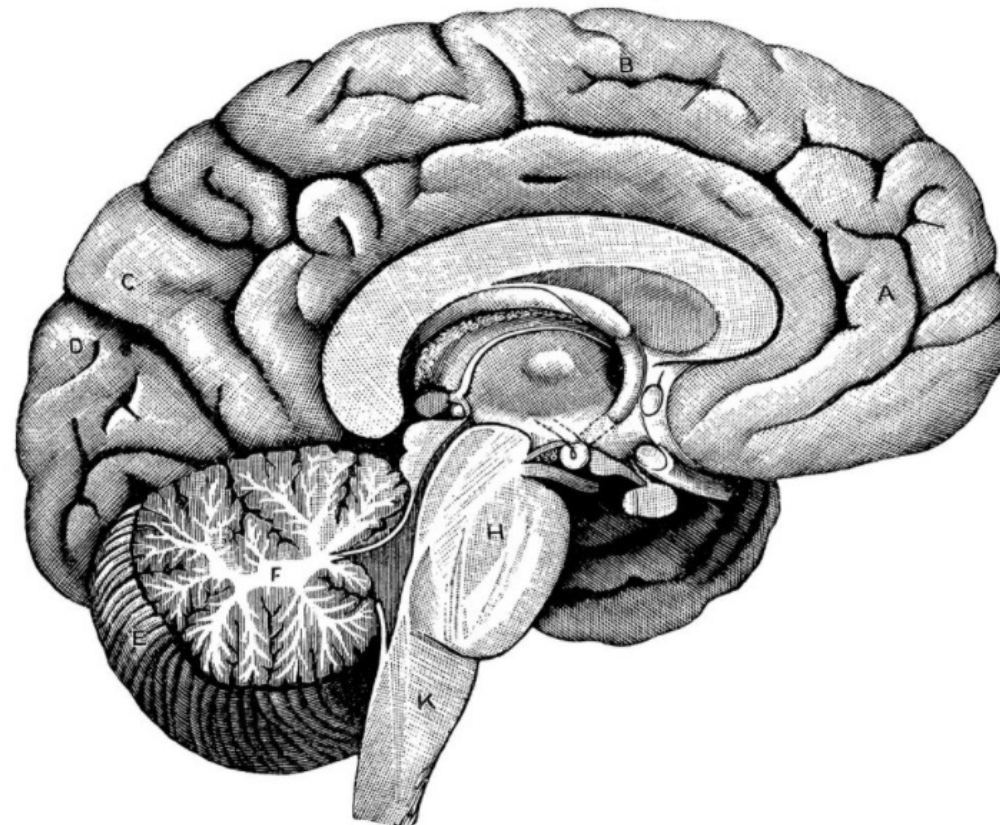
Do we only use 5%/10%/etc.
of our brains?

No.

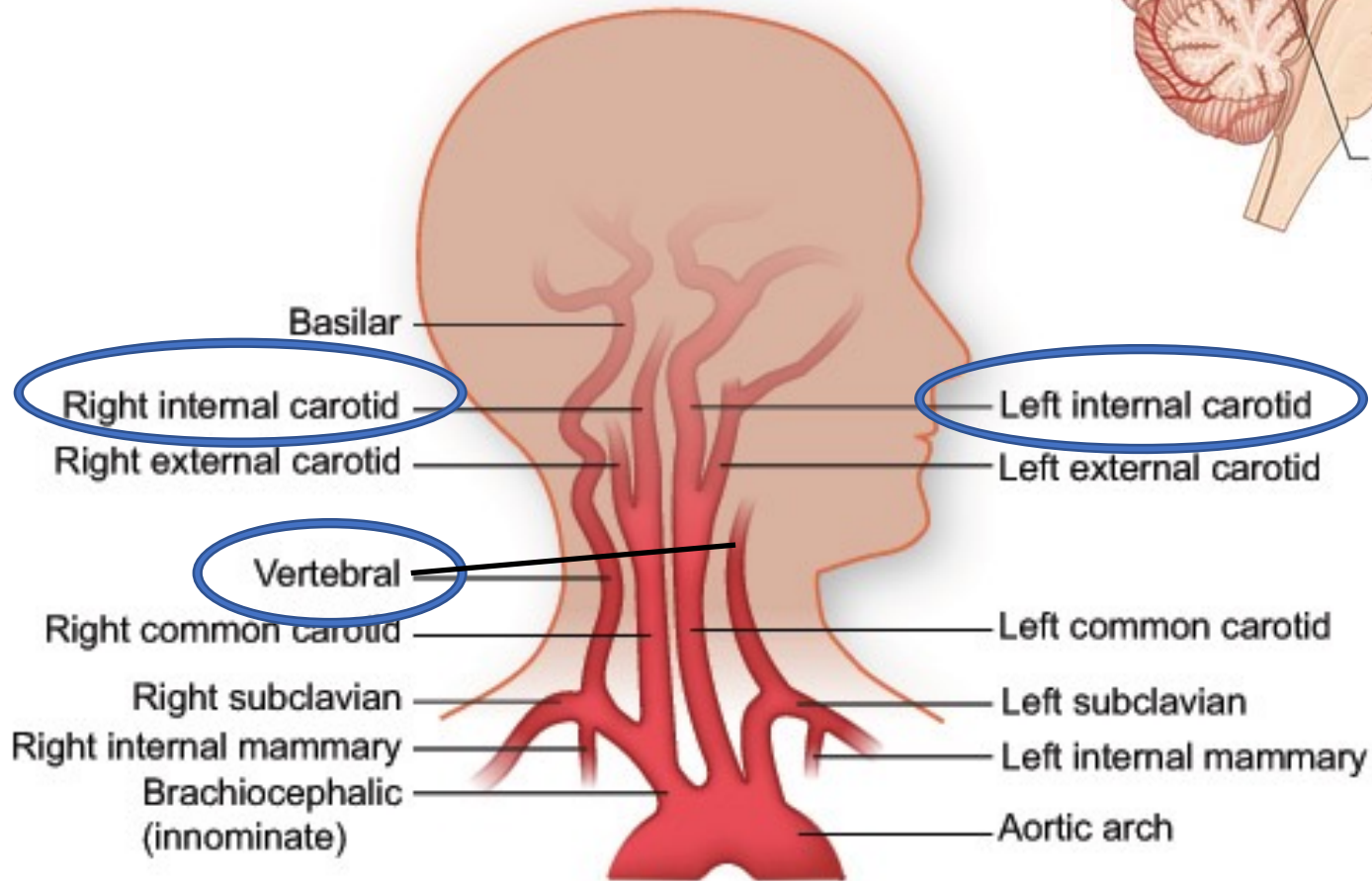
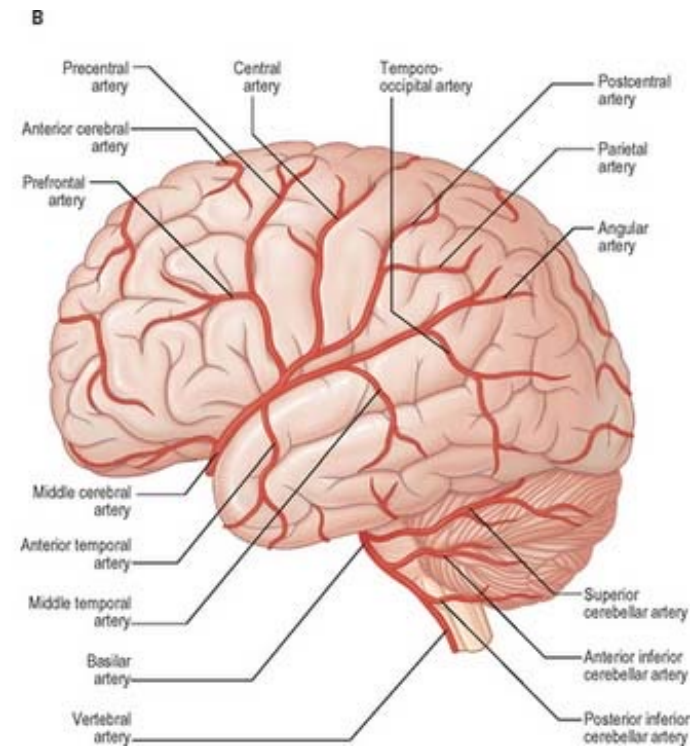
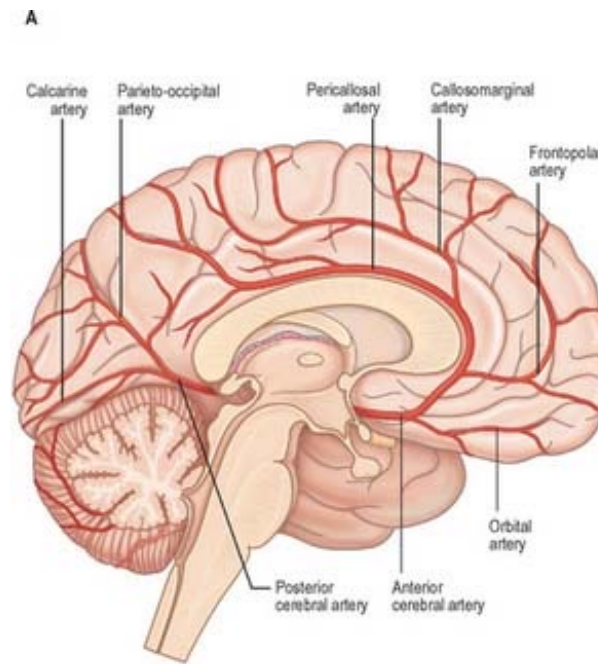


e.g. Controlling voluntary movement

Prefrontal cortex
Premotor areas
Motor cortex
Basal ganglia
Pons
Cerebellum
More



Cerebral blood flow



Limited supply

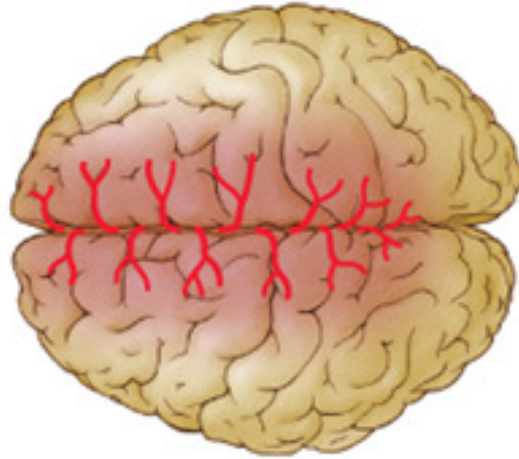
No reserves

No redundancy

Implications for brain dysfunction?

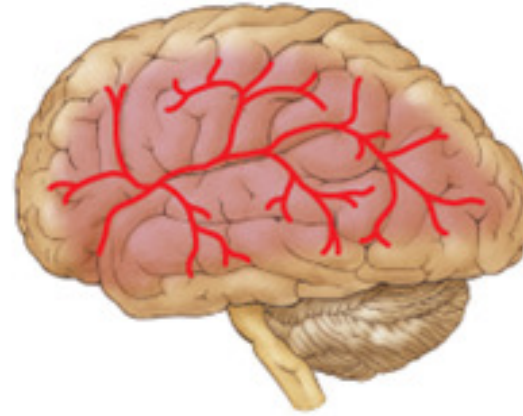
Cerebral blood flow

Anterior cerebral artery



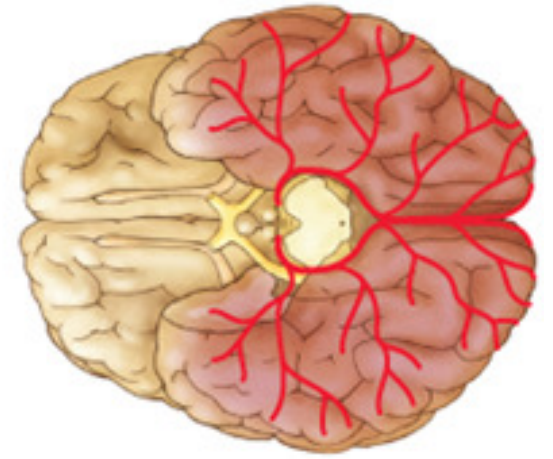
Dorsal view

Middle cerebral artery

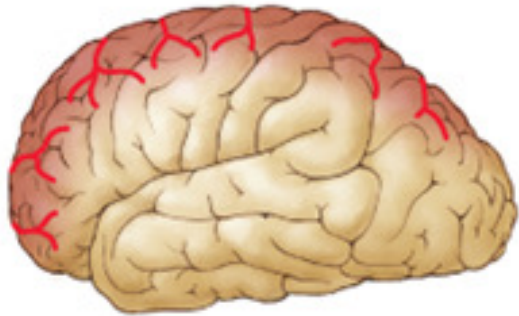


Lateral view

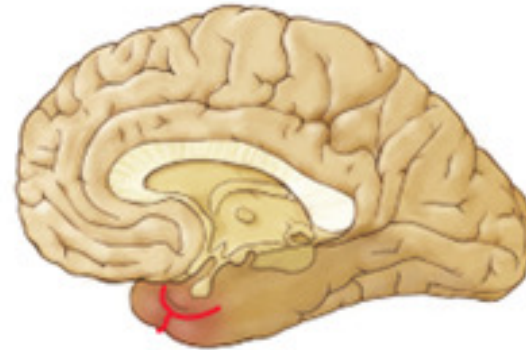
Posterior cerebral artery



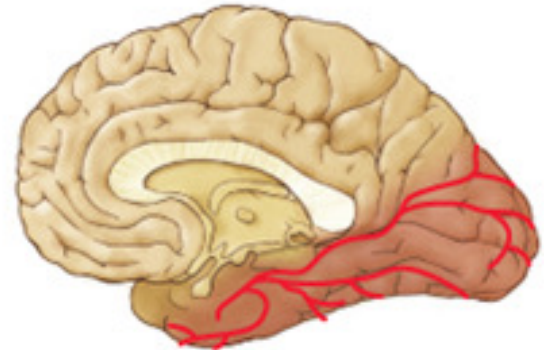
Ventral view



Lateral view



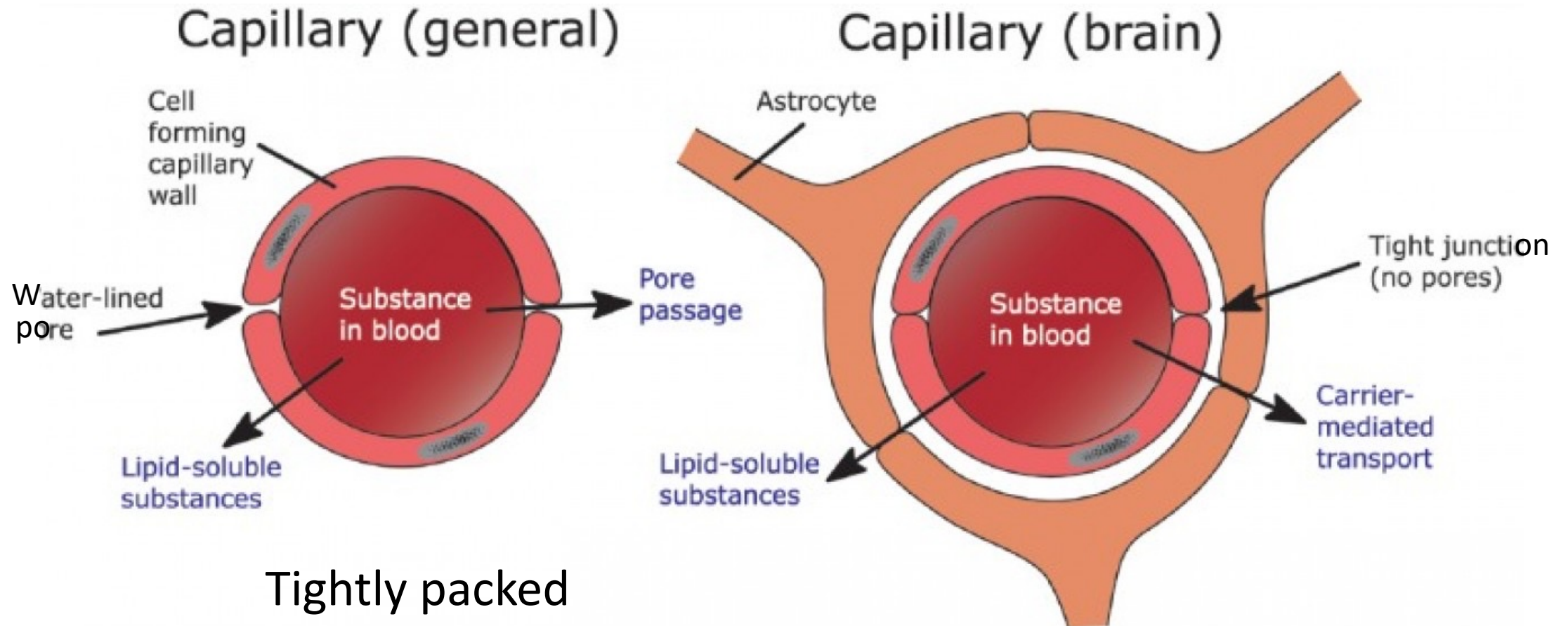
Medial view



Medial view

Limited supply
No redundancy
No reserves
Implications for brain dysfunction?

The blood-brain barrier (BBB)



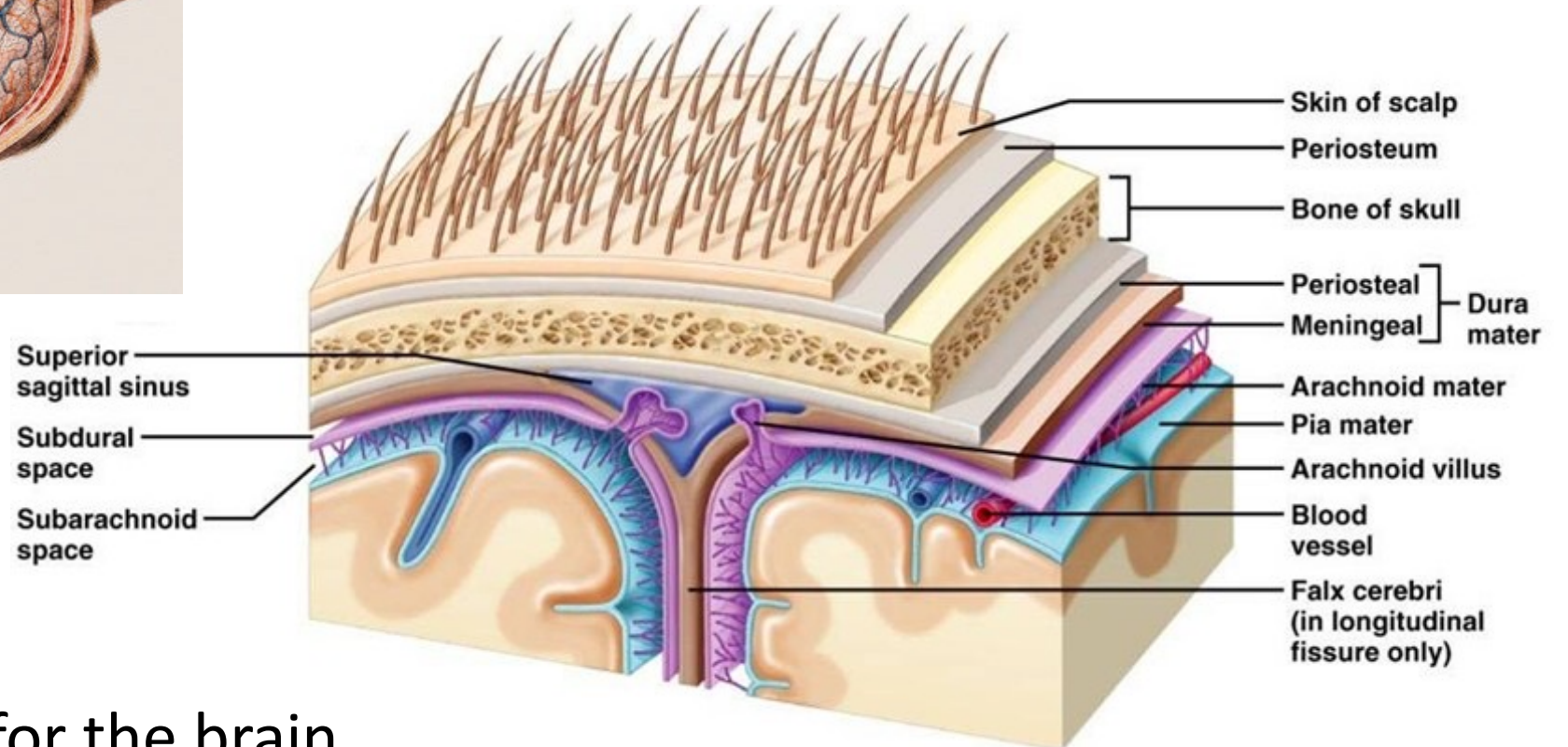
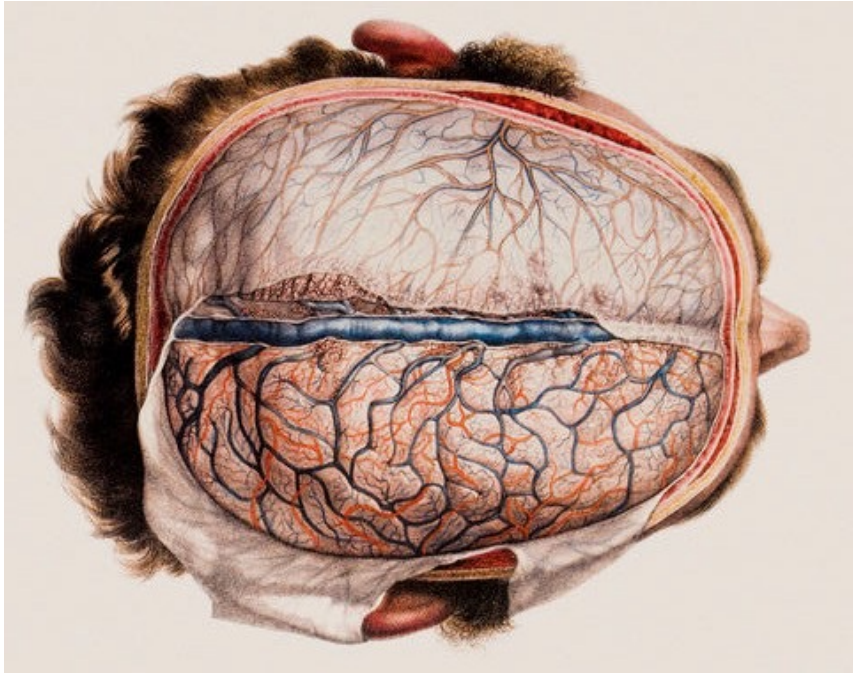
Tightly packed

Protects brain

Active transport for large molecules

Support

Skull and meninges



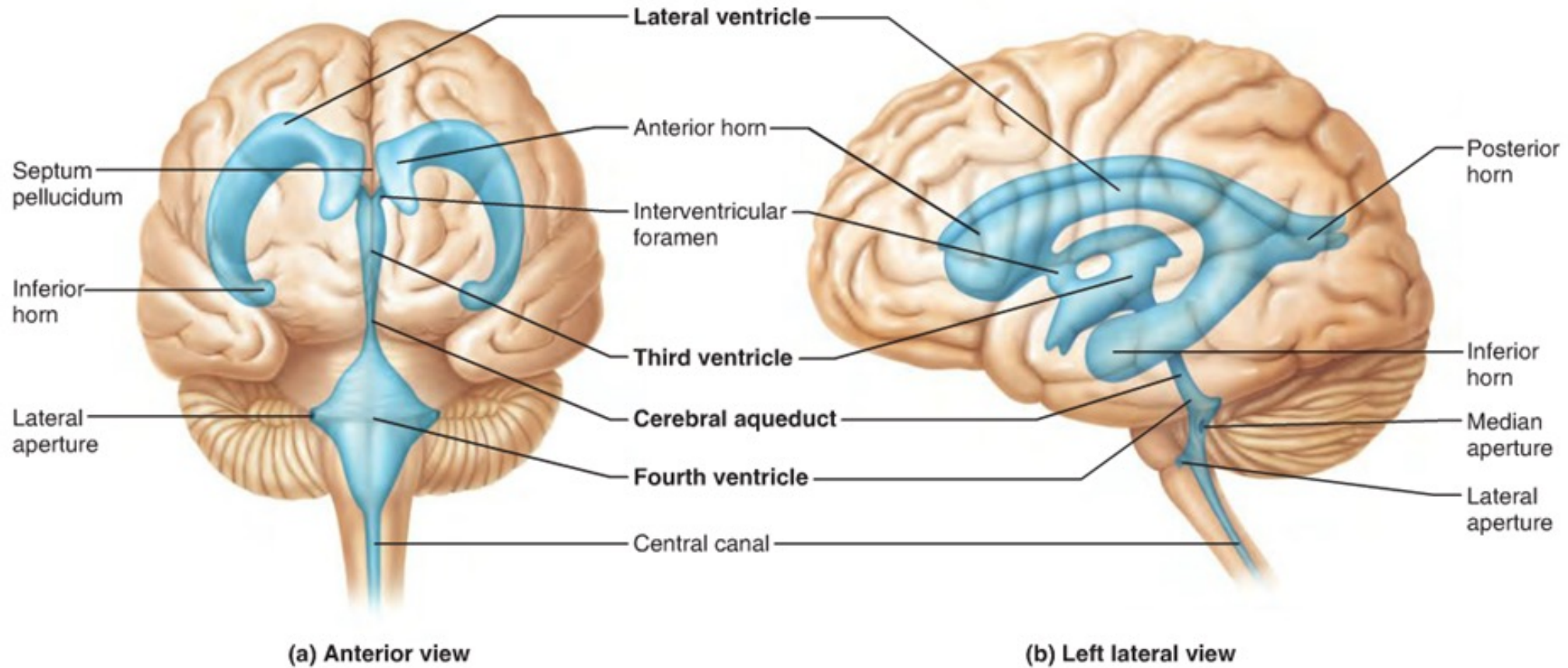
Primarily protection for the brain

Skull and meninges



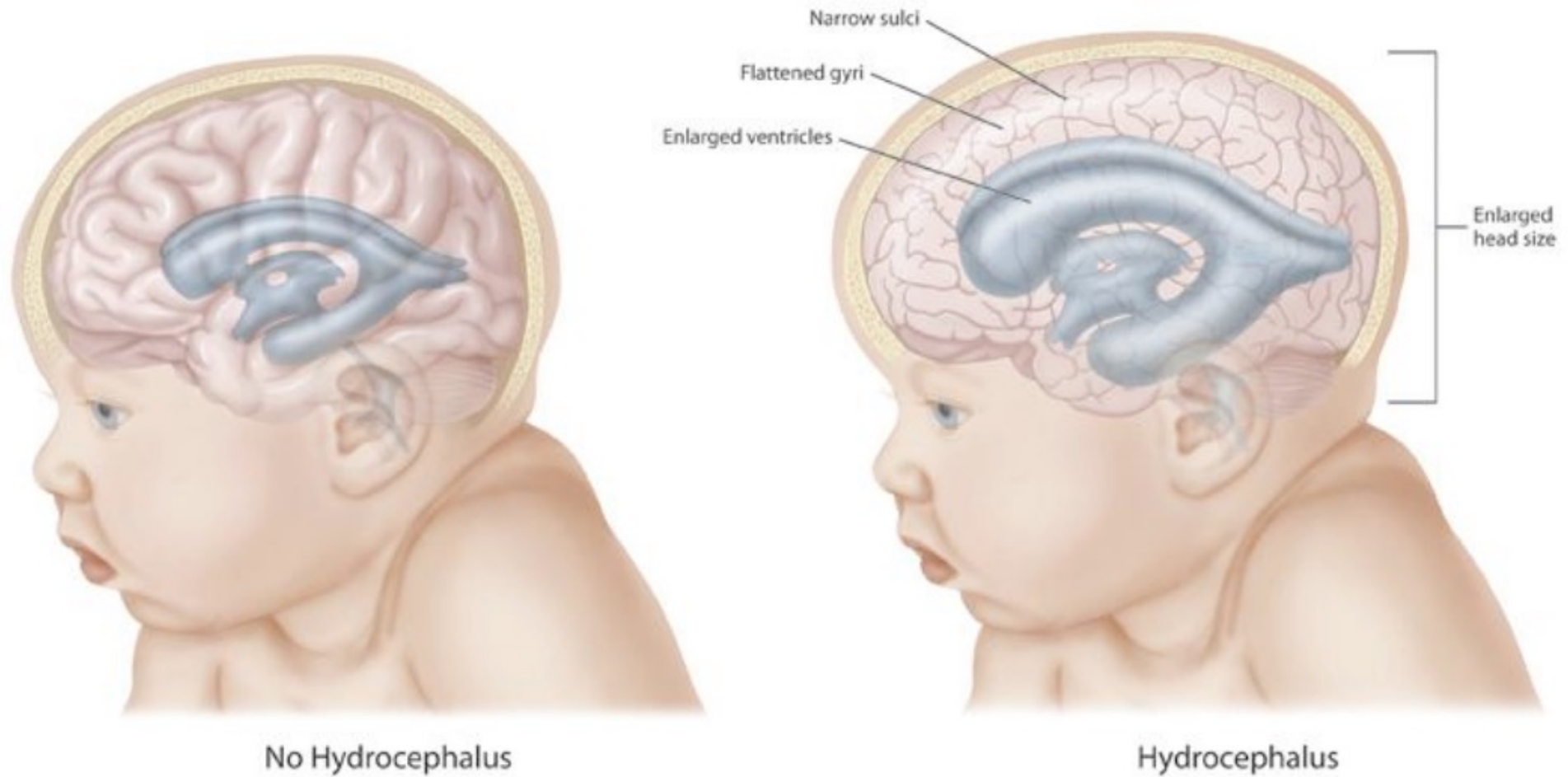
Primarily protection for the brain

Cerebrospinal fluid (CSF) and ventricles



Support, protection, nutrition

Hydrocephalus



Treated by a *shunt*

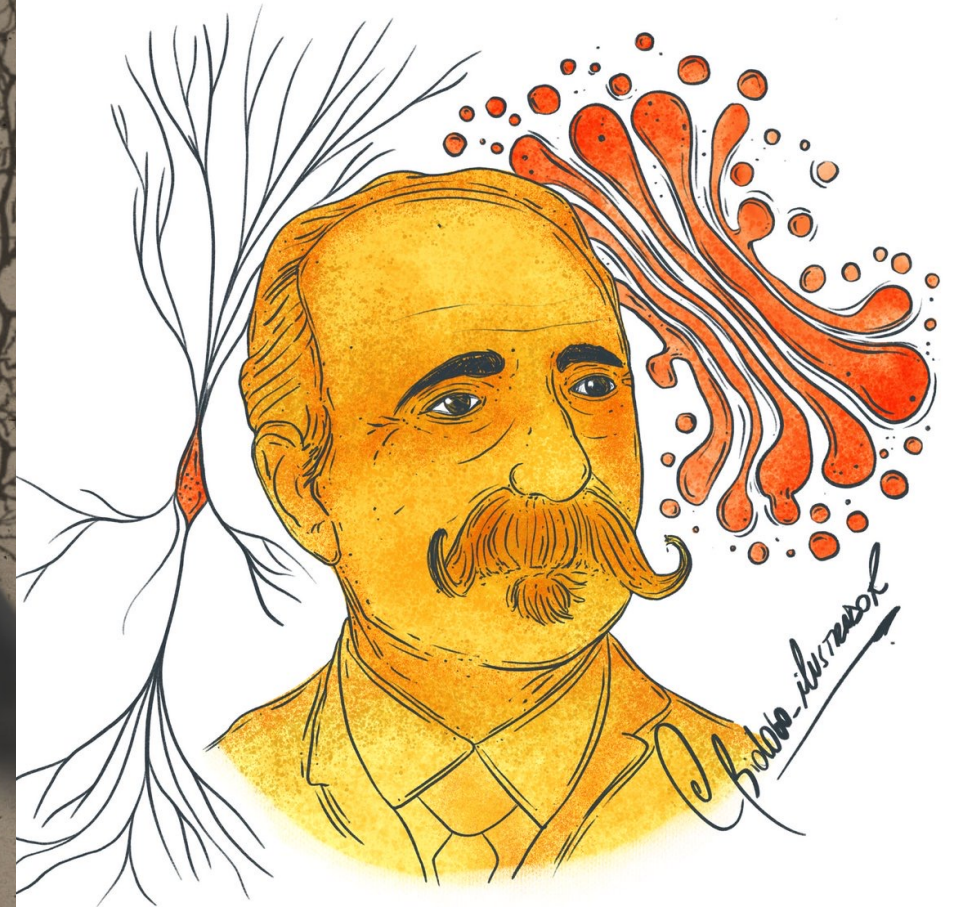
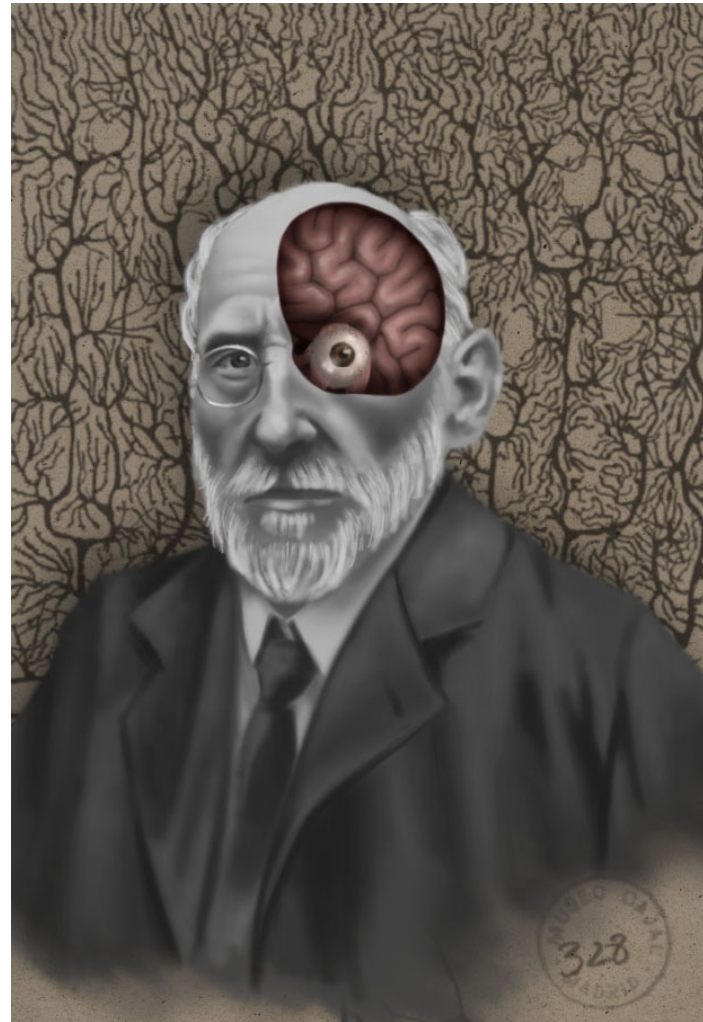
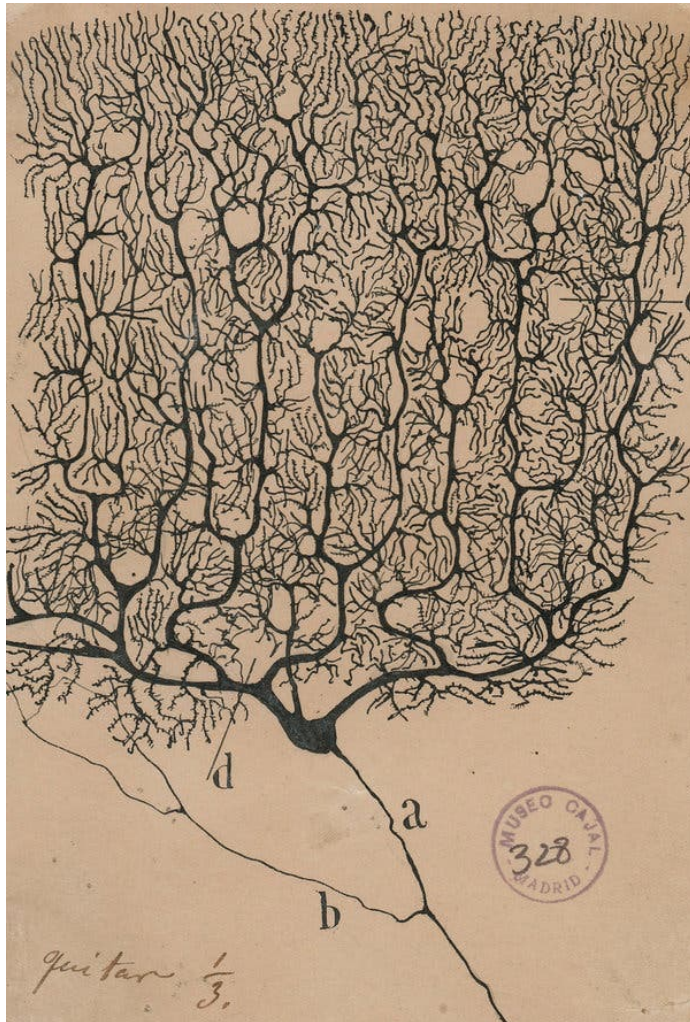
Summary of brain structures

Diencephalon	Thalamus	Massa intermedia Lateral geniculate nuclei Medial geniculate nuclei Ventral posterior nuclei
	Hypothalamus	Mammillary bodies
	Optic chiasm	
	Pituitary gland	
Mesencephalon	Tectum	Superior colliculi Inferior colliculi
	Tegmentum	Reticular formation Cerebral aqueduct Periaqueductal gray Substantia nigra Red nucleus
Metencephalon	Reticular formation Pons Cerebellum	
Myelencephalon or Medulla	Reticular formation	

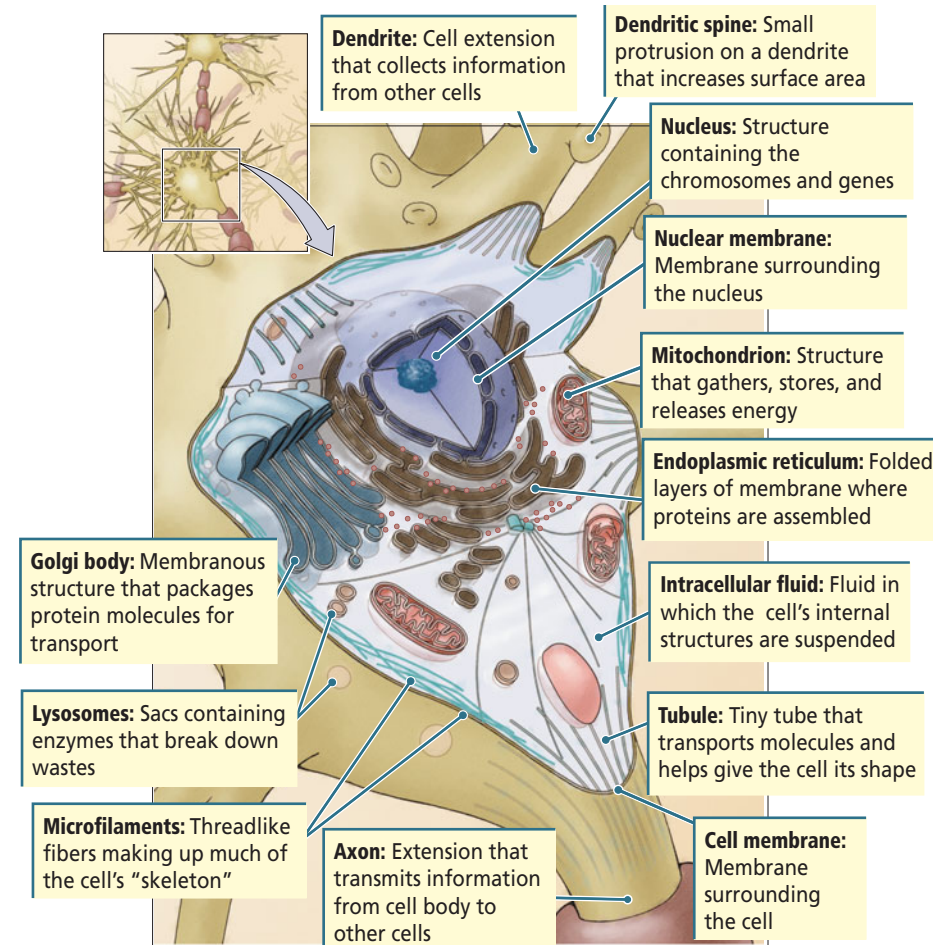
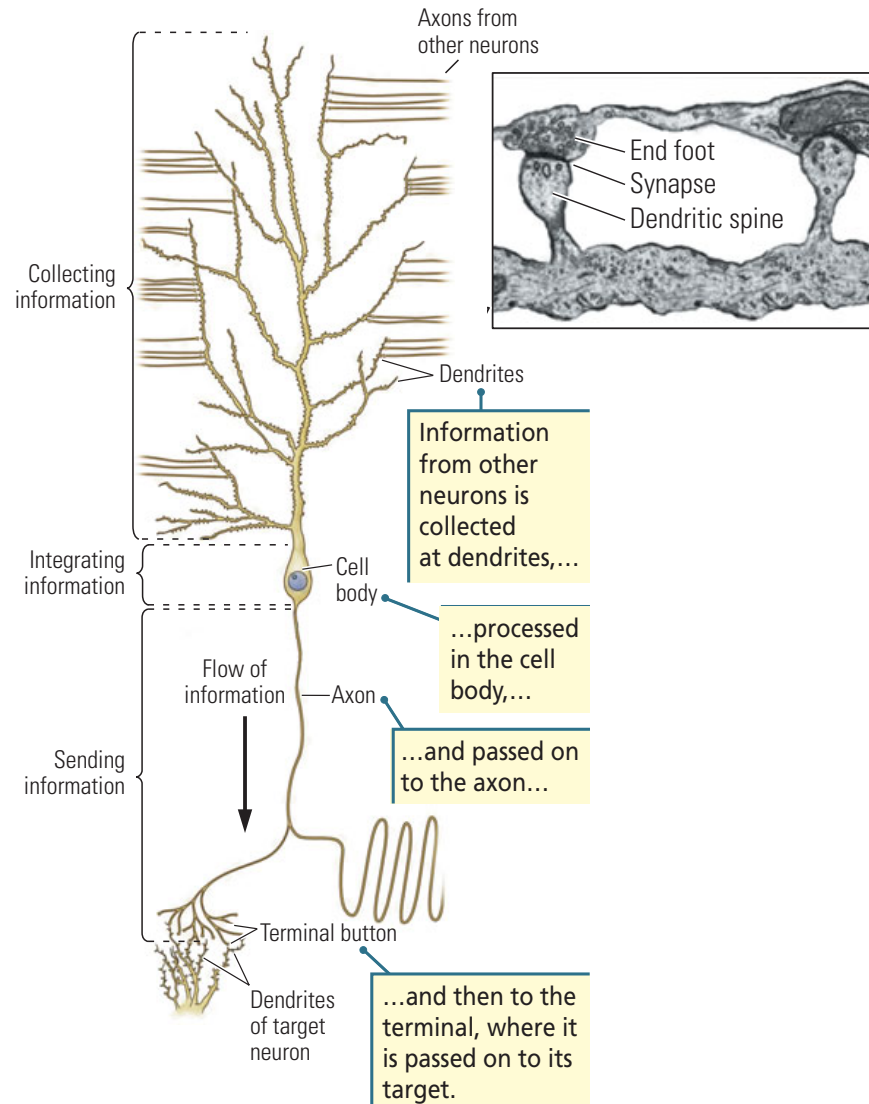
Telencephalon	Cerebral cortex	Neocortex Hippocampus
	Major fissures	Central fissure Lateral fissure Longitudinal fissure
	Major gyri	Precentral gyrus Postcentral gyrus Superior temporal gyrus Cingulate gyrus
	Four lobes	Frontal lobe Temporal lobe Parietal lobe Occipital lobe
	Limbic system	Amygdala Hippocampus Fornix Cingulate cortex Septum Mammillary bodies
	Basal ganglia	Amygdala Caudate } Striatum Putamen } Globus pallidus
	Cerebral commissures	Corpus callosum

It's a lot, but you can do it!

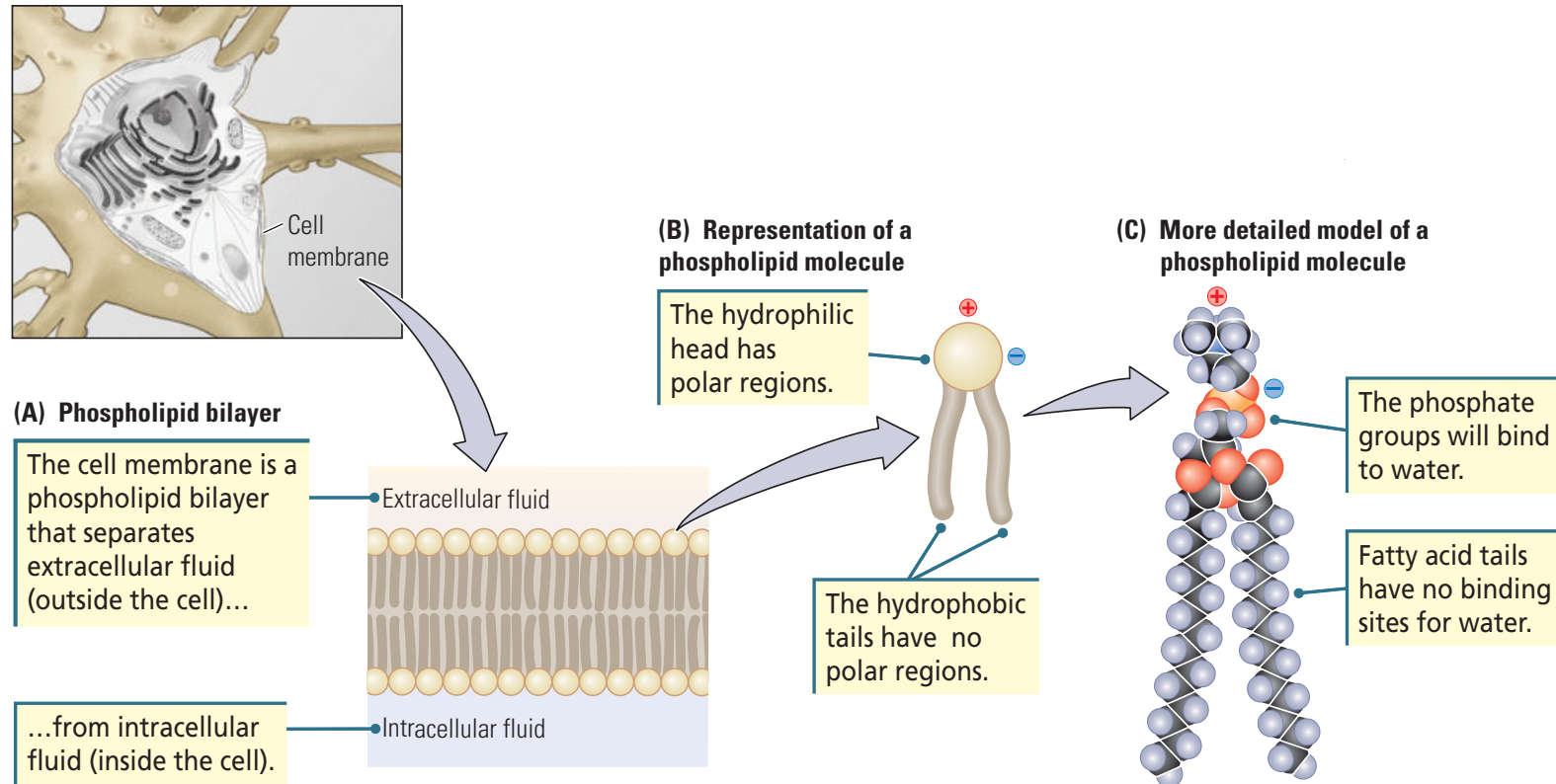
What is the nervous system made of?



Neurons are just (specialized) cells

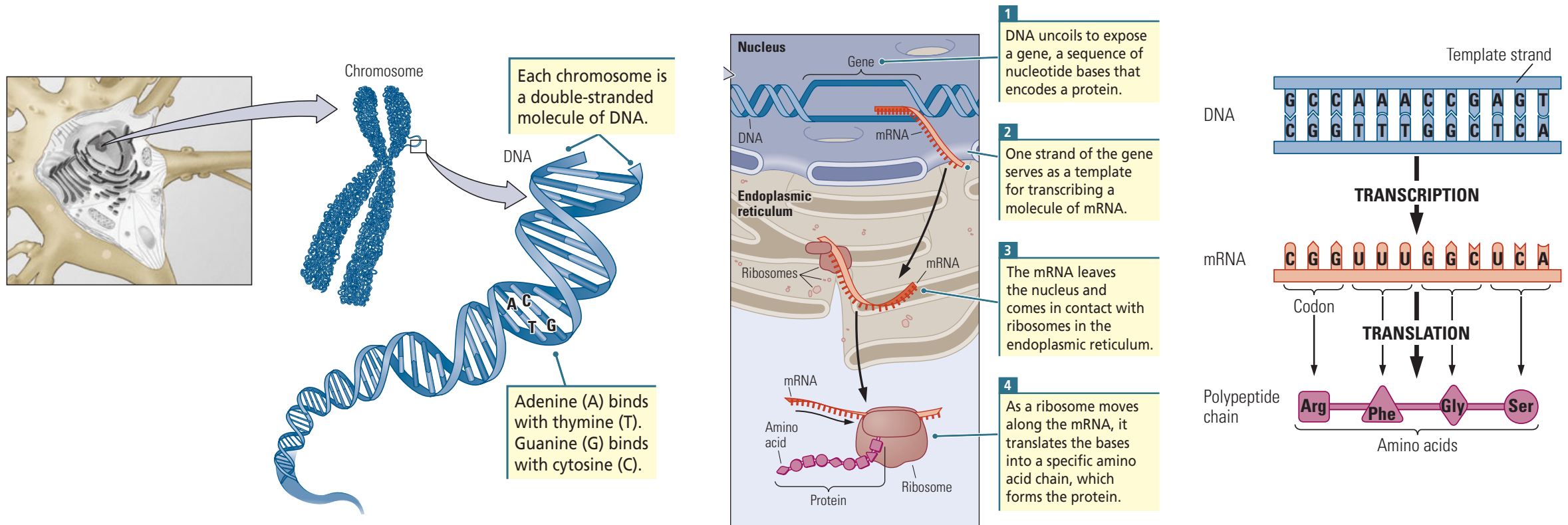


The cell membrane: barrier and gatekeeper

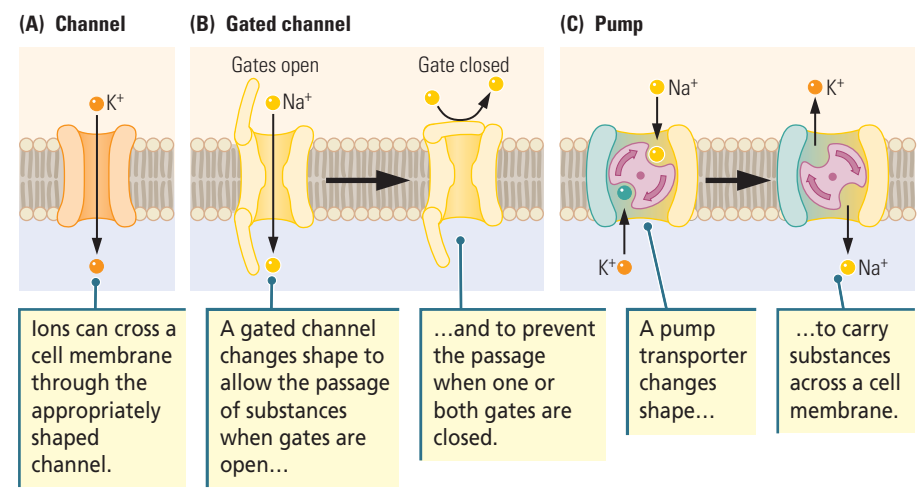
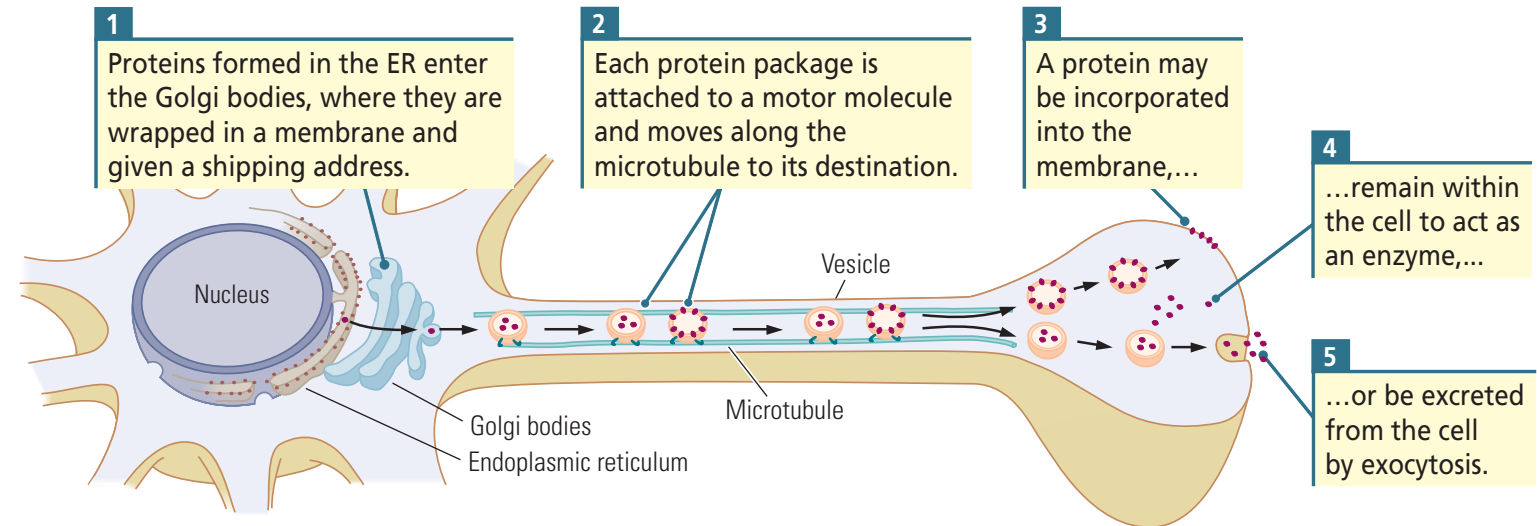
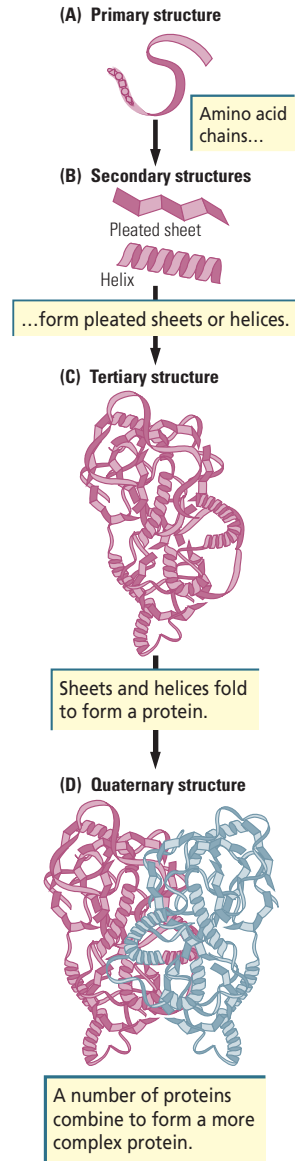


Neurons as “protein factories”

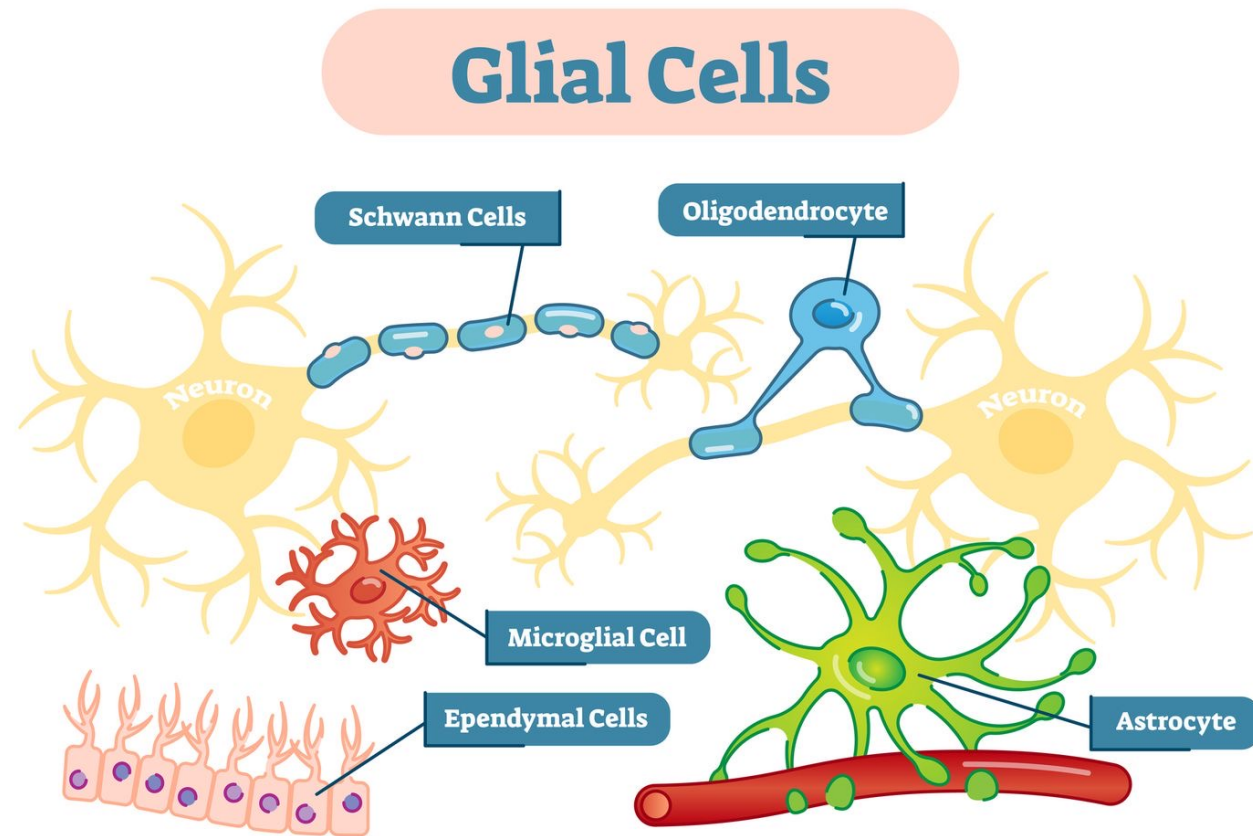
- Central dogma of molecular biology



Neurons as “protein factories”



Other cell types of the nervous system

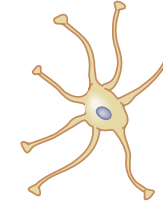


Ependymal cell



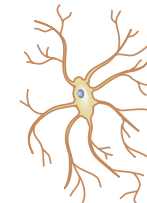
Small, ovoid; secretes cerebrospinal fluid (CSF)

Astrocyte



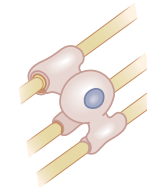
Star shaped, symmetrical; nutritive and support function

Microglial cell



Small, mesodermally derived; defensive function

Oligodendroglial cell



Asymmetrical; forms insulating myelin around axons in brain and spinal cord

Schwann cell



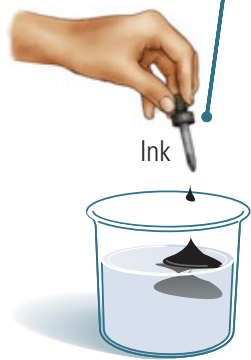
Asymmetrical; wraps around peripheral nerves to form insulating myelin

Equilibrium & Charged Particles (Ions)

(A) Concentration gradient

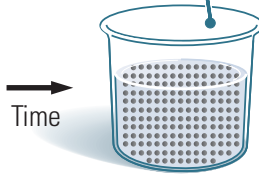
1

Ink dropped into water flows away from the initial point of contact...



2

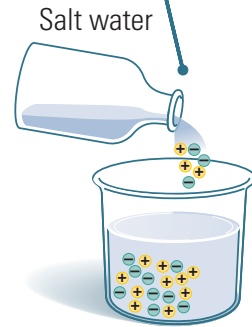
...until it is equally distributed throughout the water.



(B) Electrostatic gradient

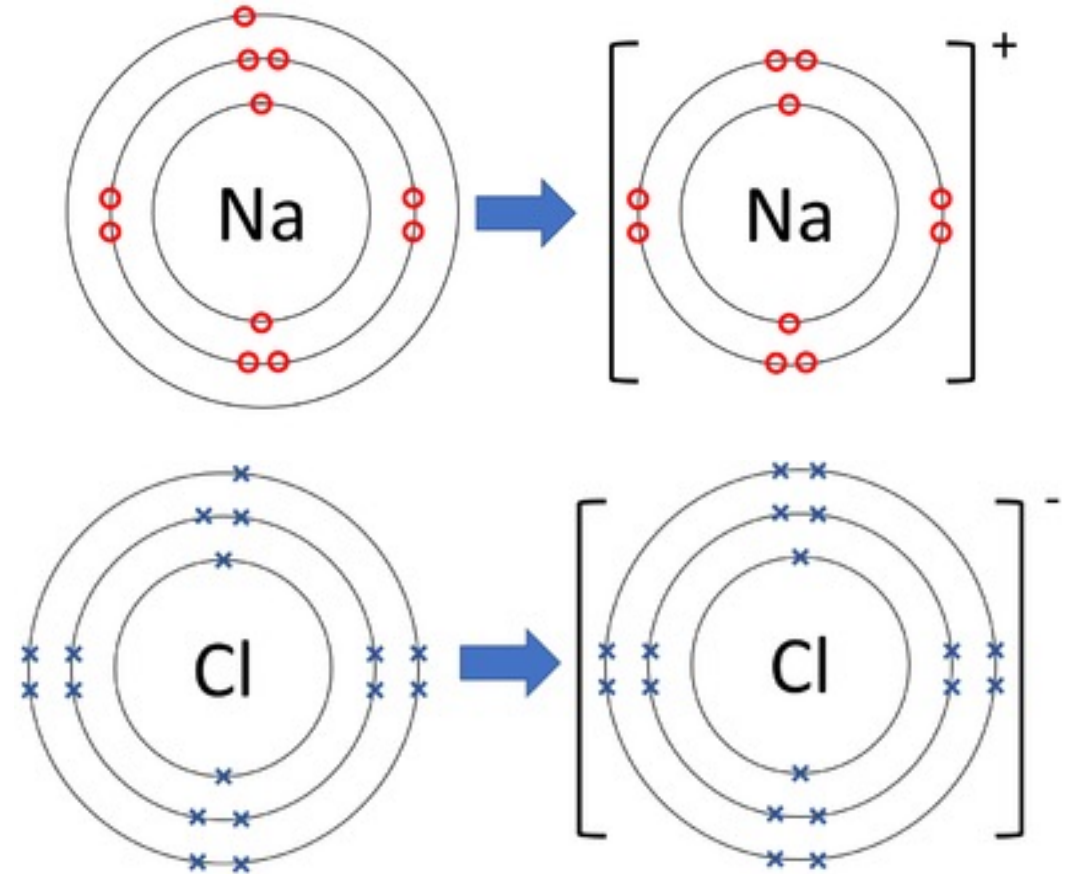
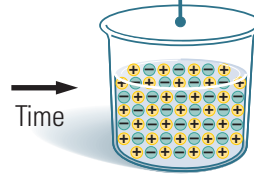
3

If a salty solution is poured into water,...



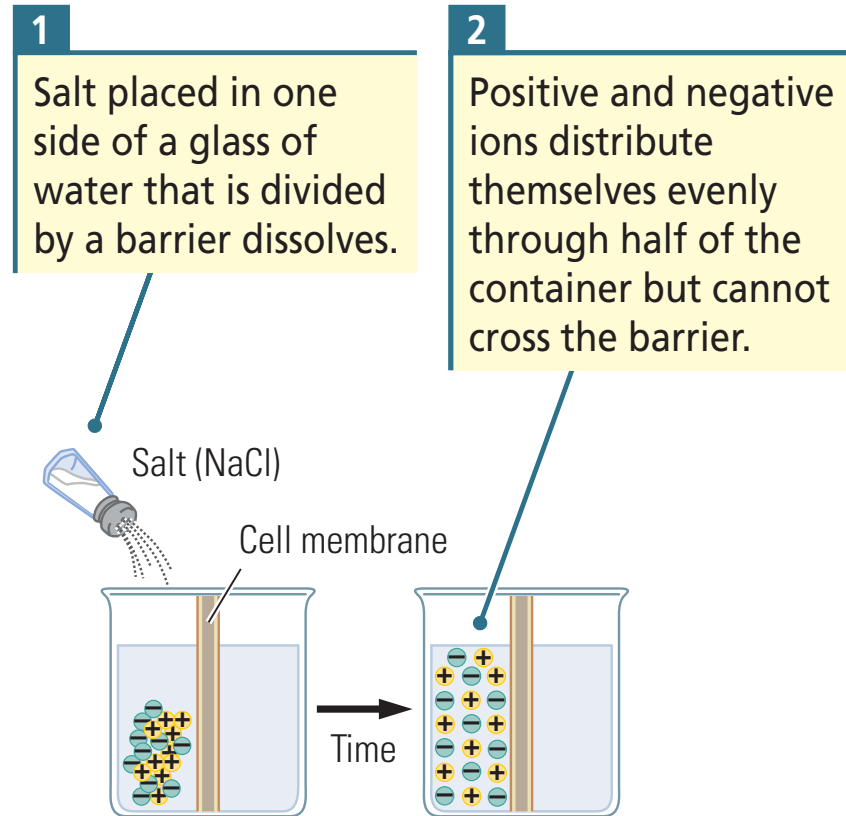
4

...the positive and negative ions will flow down their electrostatic gradients until positive and negative charges are everywhere equal.



Permeability

(A) Impermeable membrane



(B) Semipermeable membrane

