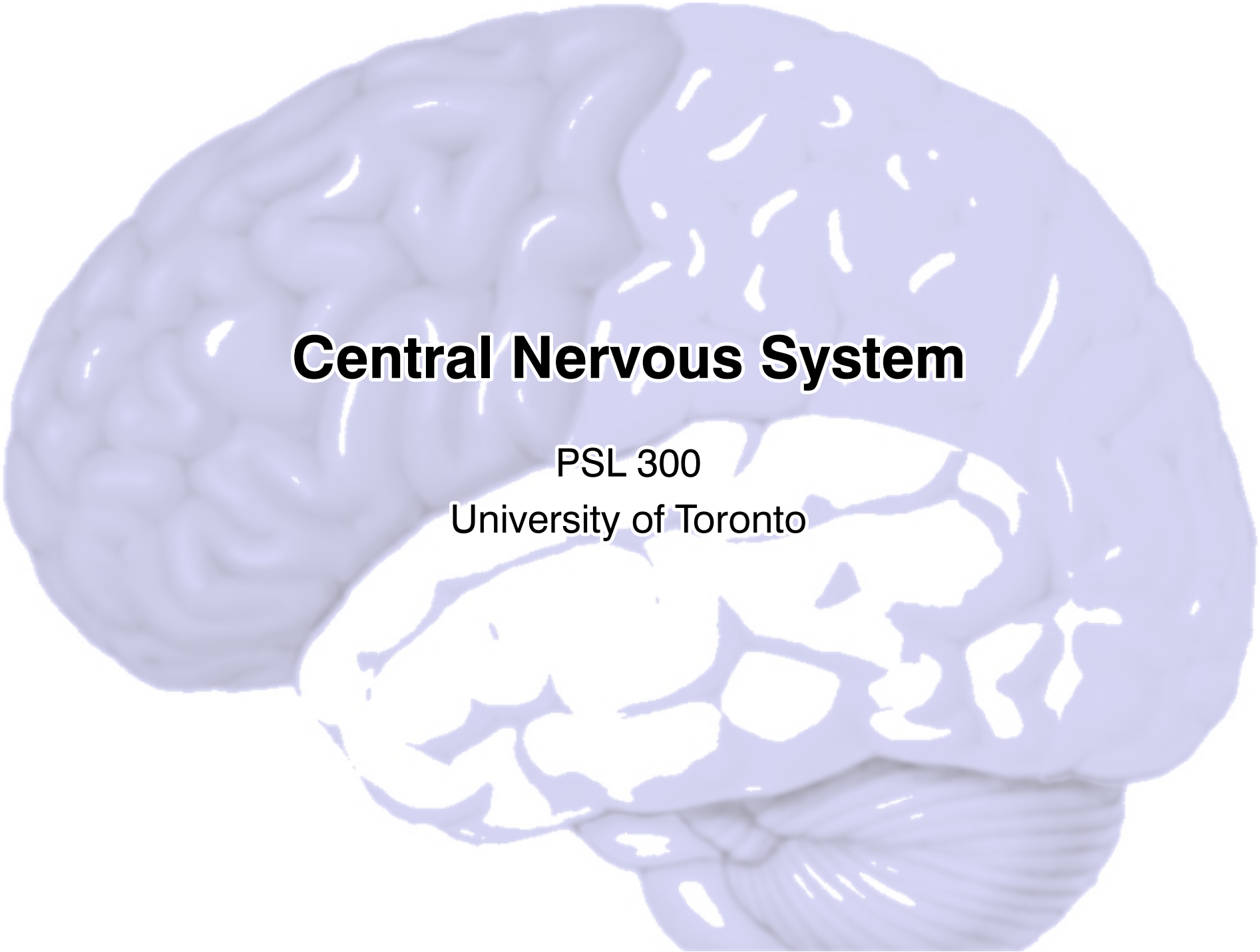
Welcome to PSL300 Section 4
CNS and Senses

- Instructor **Douglas Tweed**
- Office **MSB 3221**
- Office hours **Mondays 12:30–13:30**
- For the test and exam, you are responsible for everything in the slides except for text printed gray.
- Come to the lectures, where I will explain concepts in the slides.
- Read Silverthorn's *Human Physiology* for further explanation.

Schedule of lectures

- Oct 28 **Central Nervous System**
- Oct 31 **Introduction to the Senses**
- Nov 2 **Optics of the Eye**
- Nov 4 **Visual Processing**
- Nov 9 **Color Vision**
- Nov 14 **Hearing and Equilibrium**
- Nov 16 **Somatic Senses**
- Nov 18 **Smell and Taste**



Central Nervous System

PSL 300

University of Toronto

Question of the day

Why are only 4% of the neurons
in your brain firing right now?

Outline

- **Overview of the CNS**

  Anatomy
  Energy supply

- **Spinal cord**

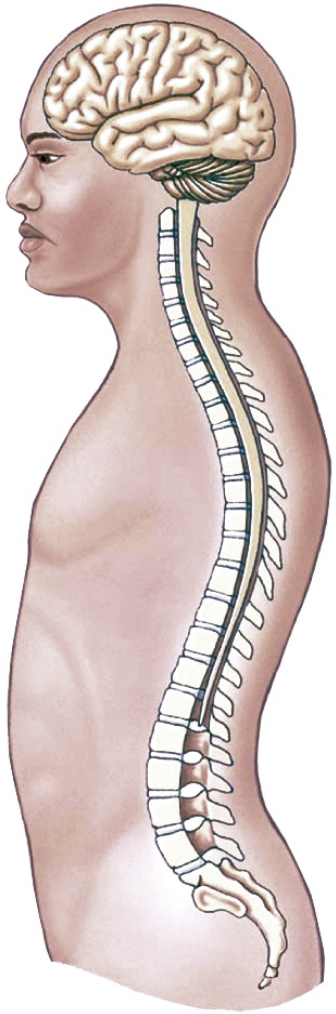
  Segmental structure
  Nuclei and tracts
  Spinal reflexes

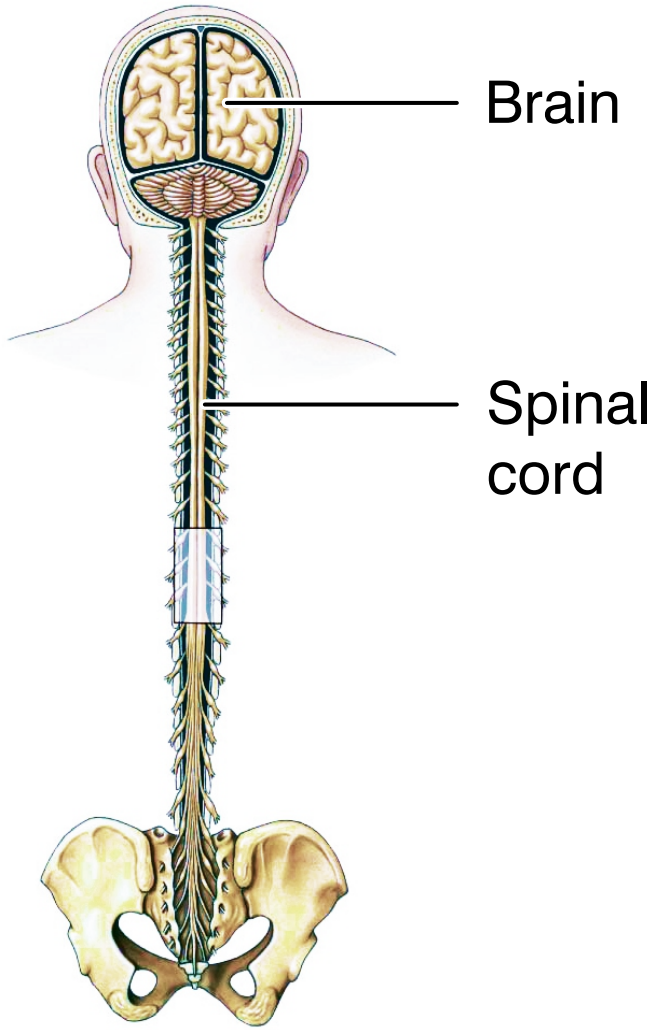
- **Brain**

  6 divisions
  Brain stem
  Cerebrum

Overview of the CNS

The *central nervous system* (*CNS*) is the *brain* and *spinal cord*





Neurons *outside* the CNS make up the *peripheral nervous system*

- The peripheral nervous system, or *PNS*, includes all neurons, and parts of neurons, outside the CNS.
- The PNS comprises the *somatic nervous system*, for controlling voluntary action via skeletal muscle, and the *autonomic nervous system*, for visceral functions such as heart rate and breathing.
- Part of the autonomic system is the *enteric nervous system*, which controls digestion and movements of the gut. It gets input from spinal cord, but can also work independently.

walking

blood pressure and the intestines

Enteric nervous system is the network of nerves that controls digestion and movement of the gut.

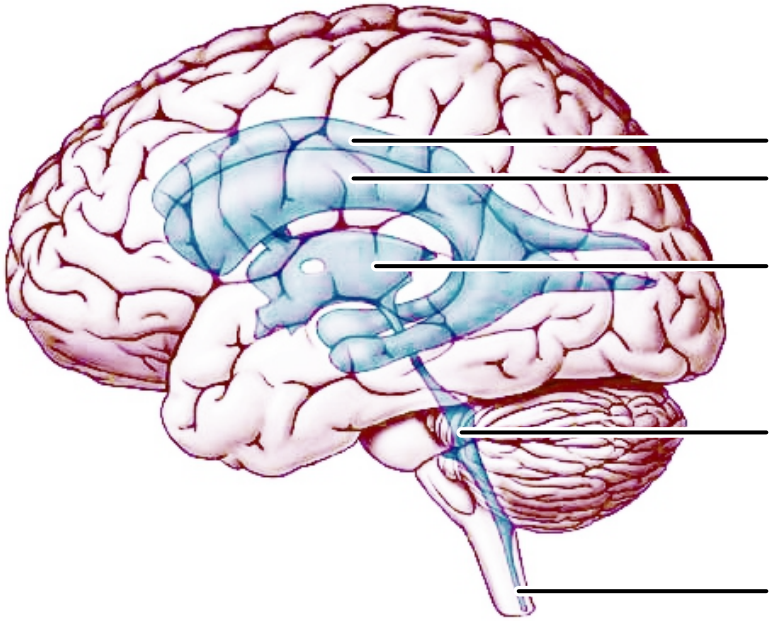
Most neurons are in the CNS

A scientist take 4 volunteers, and made what was called "brain soup", she calculate the # of neurons per person, and she got 86 Billion.

- The brain has ~86 billion neurons, and the spinal cord ~1 billion.
- Estimates for the enteric nervous system range from 100–600 million, and the total for the PNS is likely not much more.
- CNS and PNS also have cells called *glia*, which support and protect neurons, and are about as numerous.

Years ago was thought that there were 10x glia cells than neurons.

The CNS contains *ventricles* filled with *cerebrospinal fluid*



These are cavities in form of a C

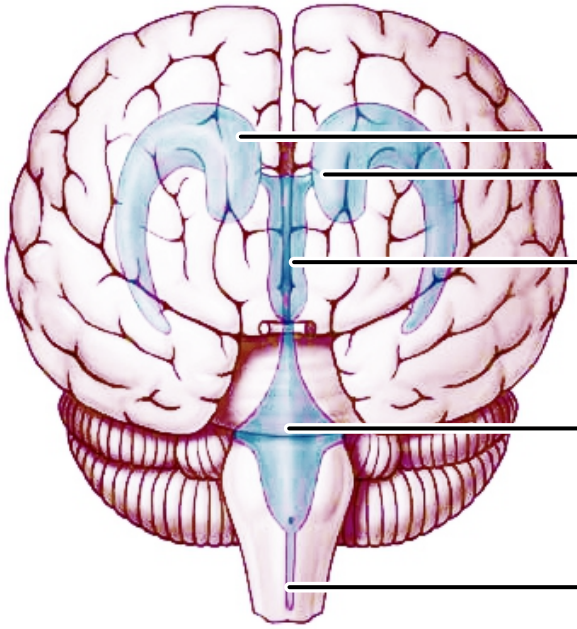
Lateral ventricles

Third ventricle

Fourth ventricle

Central canal of spinal cord

Front view of the ventricles



Lateral ventricles

Third ventricle

This V is btw and down the LV

Fourth ventricle

Central canal
of spinal cord

The entire group of ventricles look like coconuts

The CNS includes gray and white matter

- *Gray matter* consists of nerve cell bodies, unmyelinated axons, and dendrites. The cell bodies are arranged either in layers (in parts of the brain) or in clusters called *nuclei*.

singular: nucleus

- *White matter* consists of myelinated axons running in bundles called *tracts*.

- In the *peripheral* nervous system, clusters of neurons are called *ganglia*, and bundles of axons are *nerves*.

singular: ganglion

These are the same but with different names than in CNS

Compared to other organs, the CNS uses a lot of energy

- The brain has just ~2% of the body's mass, but gets 15% of the blood pumped by the heart.
- It consumes half the body's glucose.

Compared to computers, the CNS uses very little energy

Watson

The brain run on aprox 40 watts

- It runs on ~40 watts, like a lightbulb, whereas computers that try to mimic it, such as IBM's *Jeopardy*-playing computer Watson, need much more — ~200,000 watts.

The CNS saves energy by limiting communication between neurons

- Neurons communicate with each other by sending action potentials down their axons, but those action potentials take a lot of energy.

spikes

Neurons use ATP to produce AP

- The energy supply to the CNS can support only a low rate of firing, e.g. in cortex it permits an average rate per cell of just one spike every 6 s. At any moment, only ~4% of your neurons are firing.

at a determinate moment

- That is, communication is expensive, and so the CNS has to use it sparingly.

to save energy

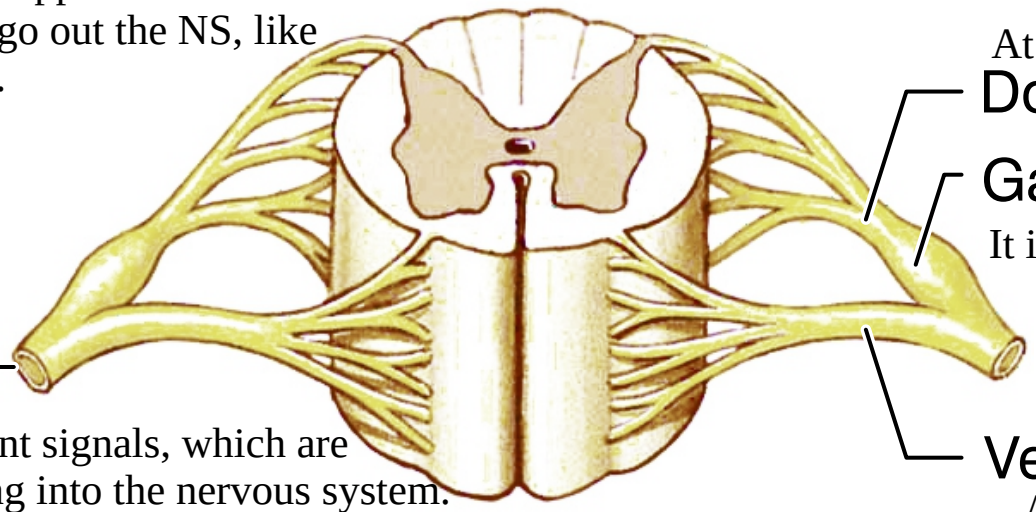
Your brain has worked down by natural selection to produce a coding for computation required for minimize the communication of AP btw neurons.

Spinal Cord

The spinal cord has 31 *segments*, each with a pair of *spinal nerves*

This are identical building blocks

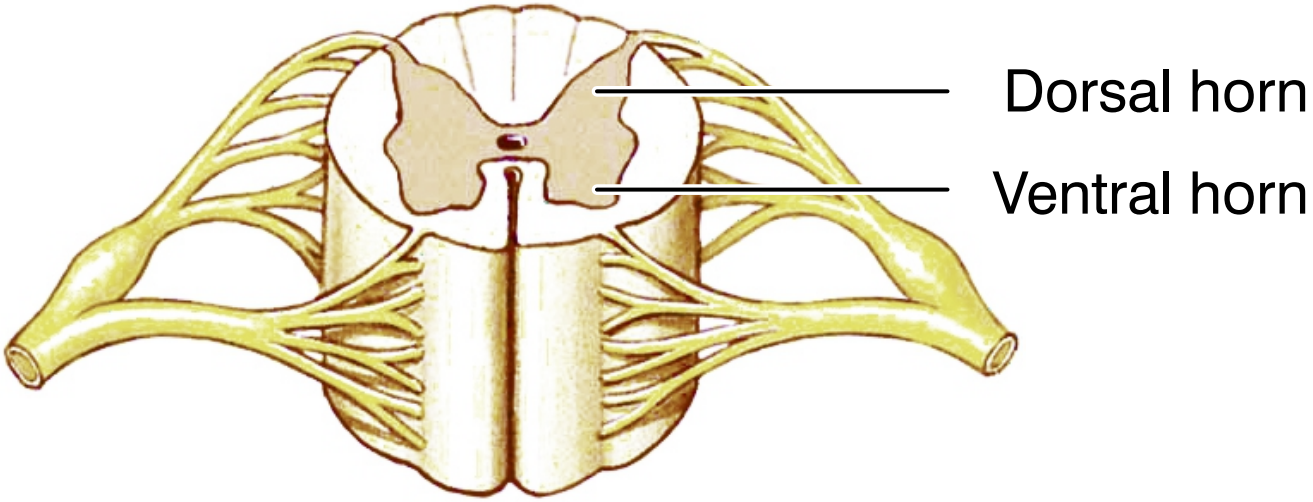
Afferent and efferent are opposite in definition.
Efferent are signals that go out the NS, like signals to move muscles.



Dorsal root carry afferent signals, which are incoming signals coming into the nervous system.
We also called them sensory signals bcs carry info from the senses.

- Each spinal nerve has a *dorsal root*, which carries *afferent* (i.e. incoming, sensory) signals. The *dorsal root ganglion* contains the cell bodies of the neurons carrying these signals.
- The *ventral root* carries *efferent* (i.e. outgoing) signals from the CNS to the body, including *motor* signals (i.e. to muscles).
- *Dorsal* means toward the back; *ventral* means toward the belly.

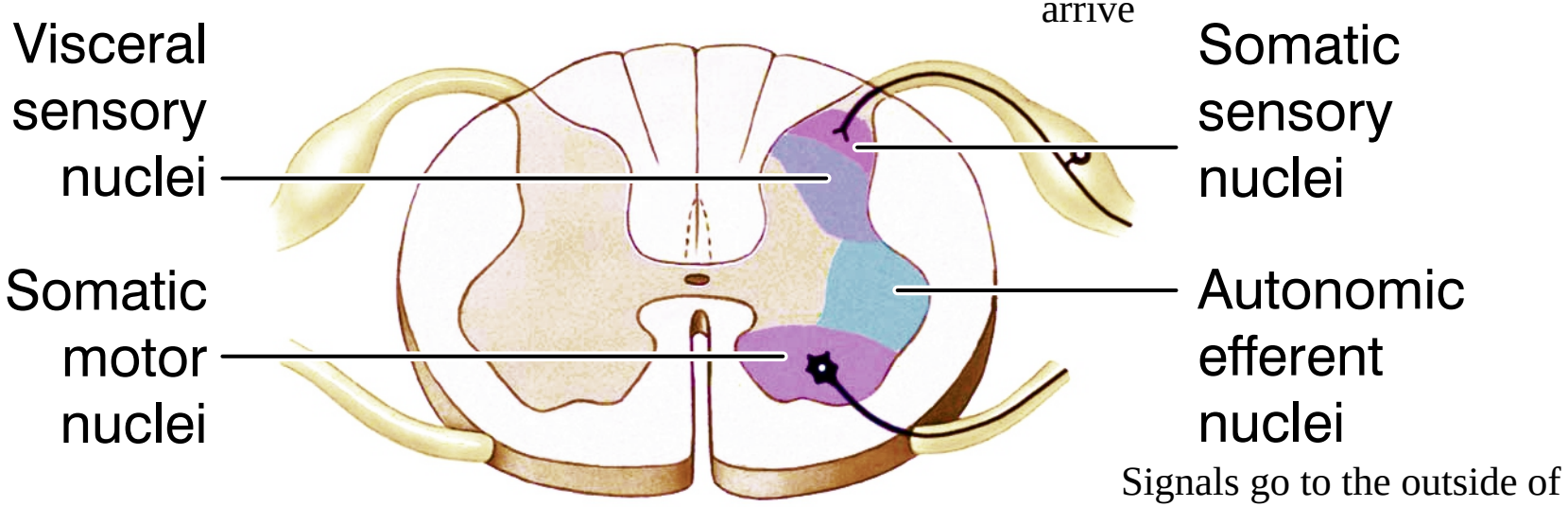
The gray matter is mainly in the middle of the cord



- It has a butterfly shape, with a dorsal and a ventral *horn* on each side.

The gray matter consists of sensory and motor nuclei

It has sense bcs it is near the dorsal root, where the sensory info arrive



Signals go to the outside of the nervous systemmye

- *Sensory* nuclei are in the dorsal horn because sensory signals arrive on the dorsal root. *Somatic* sensory nuclei get signals from skin; *visceral* sensory nuclei get signals from the viscera (internal organs).

From touch

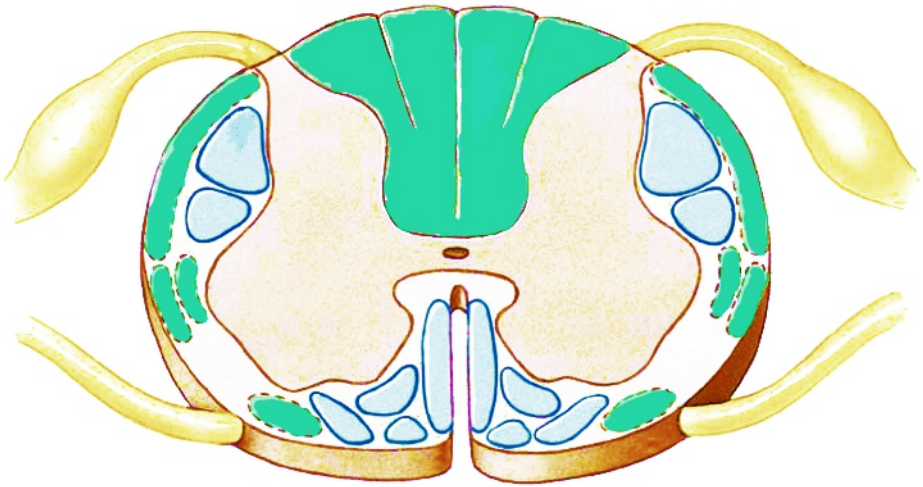
From the gut for example

- Efferent nuclei are ventral. *Autonomic* efferent nuclei send commands to glands and smooth muscle; *motor* nuclei send commands to skeletal muscle.

Somatic nuclei

White matter consists of axon tracts

myelinated axons carry signal for long distances



carry signals up to the brain

- *Ascending tracts* (green) carry sensory signals to the brain. They are mainly dorsal, because sensory signals arrive at the dorsal horn.

Carry info from the brain to the spinal core

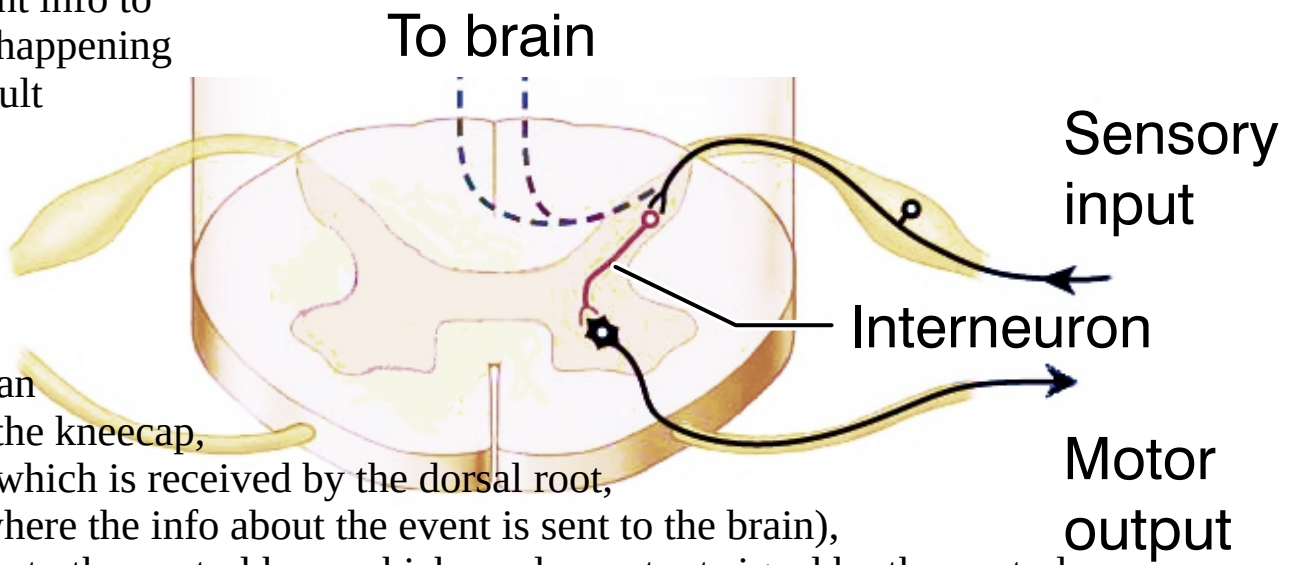
- *Descending tracts* (pale blue) carry signals *from* the brain. They are mainly ventral, where outgoing signals leave the CNS.

- *Propriospinal tracts* (not shown), stay in the spinal cord.

Some signals go up and other down through the spinal cord, these do not leave the spinal cord. Do not interact with the brain

In a *spinal reflex*, the cord responds to stimuli without consulting the brain

The spinal cord is really smart, it take care of every day jobs without have to consult to the brain. It sent info to the brain to inform what is happening but for reflexes do not consult the brain if do or not the job. It is bcs it is sufficient fast.



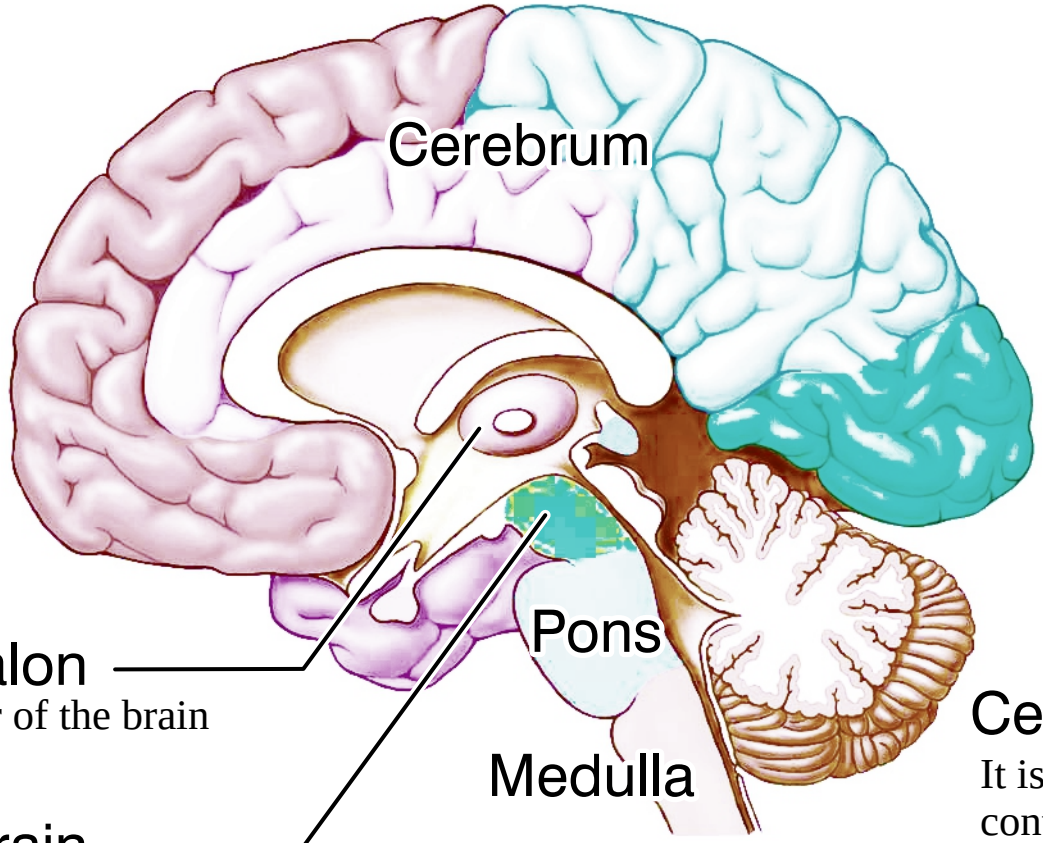
The example showed here is about reflexes. A physician stretch the ligament below the kneecap, it sense it, sends the signal which is received by the dorsal root, it pass to the dorsal horn (where the info about the event is sent to the brain), the interneuron pass the info to the ventral horn which sends a output signal by the ventral root to the kneecap which eventually contract. This process is a reflex and happen quickly.

- An example is the *knee-jerk reflex*: the physician's rubber hammer stretches a ligament below the kneecap. Sensory fibers carry the news of this stretch into the dorsal horn.

- These fibers send branches up to the brain, but also excite neurons in the ventral horn that send signals out to leg muscles to contract and counter the stretch.

Brain

The brain has 6 major divisions



Diencephalon
It is the center of the brain

Midbrain

Pons

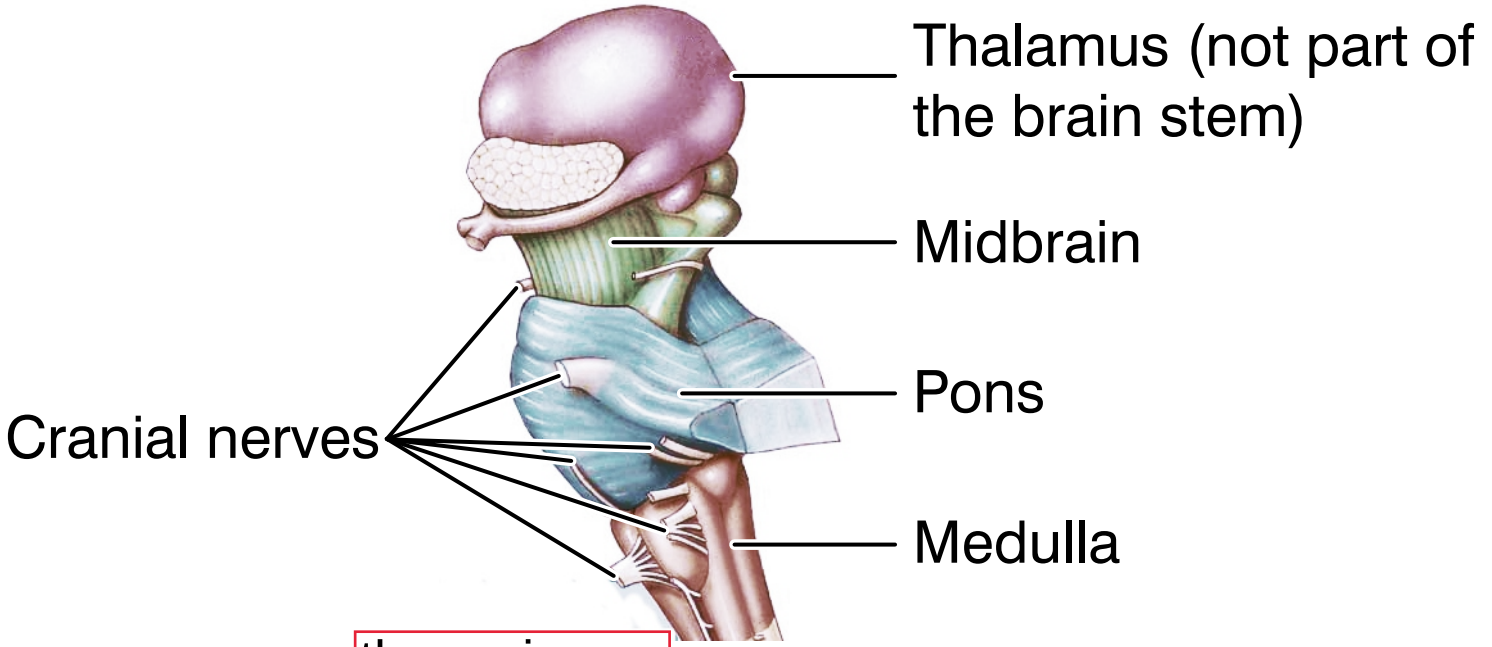
Medulla

It binds to the spinal cord.

Cerebellum

It is important for motor control.
It means small crebrum
Most of the neurons are in the cerebellum - 70 billion

Medulla, pons, and midbrain make up the *brain stem*



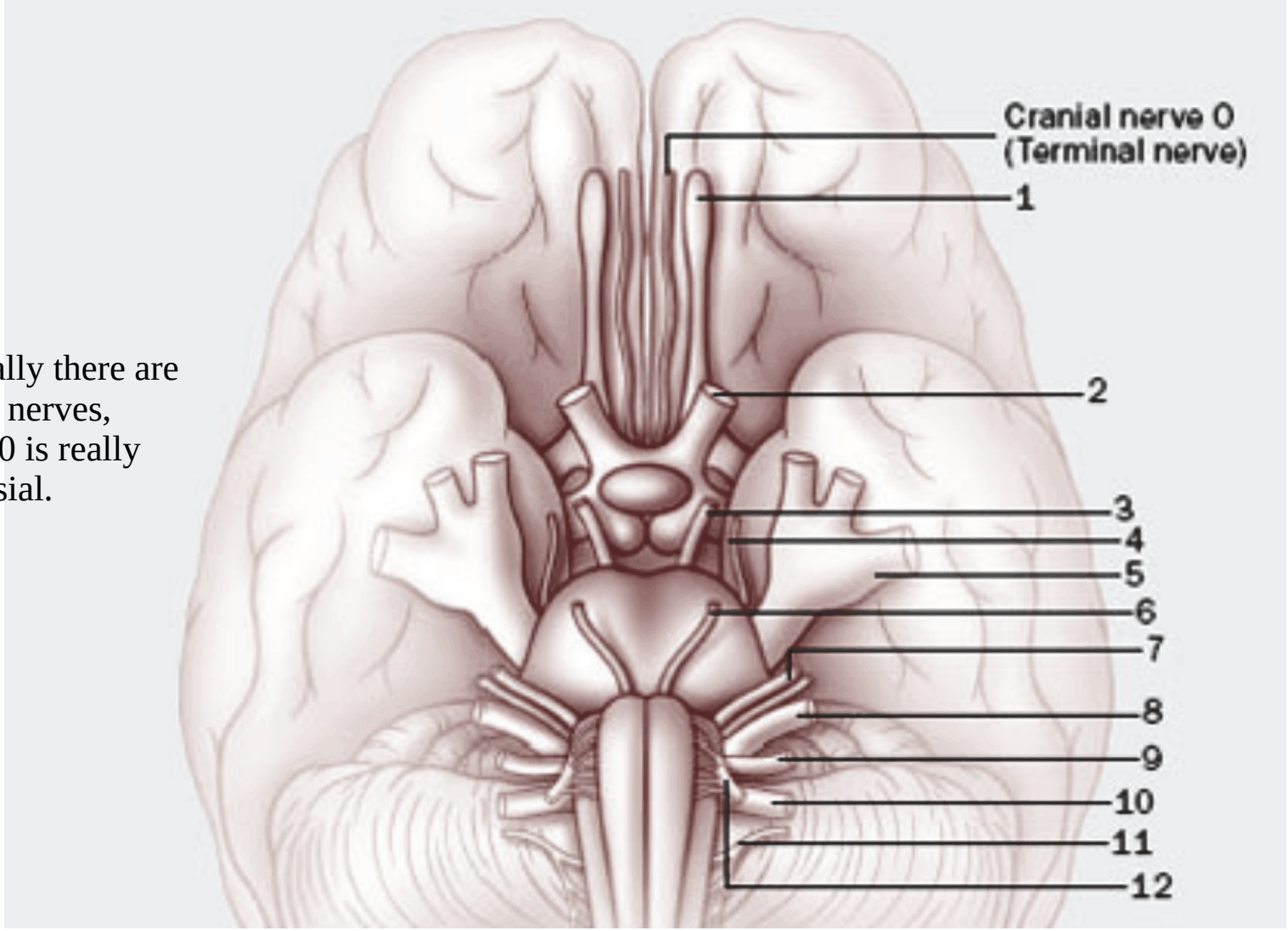
- The brain stem is the main control center for many autonomic functions and reflexes, such as breathing, swallowing, vomiting, and regulating blood pressure.

3 to 12

- Cranial nerves III–XII arise from the brain stem.

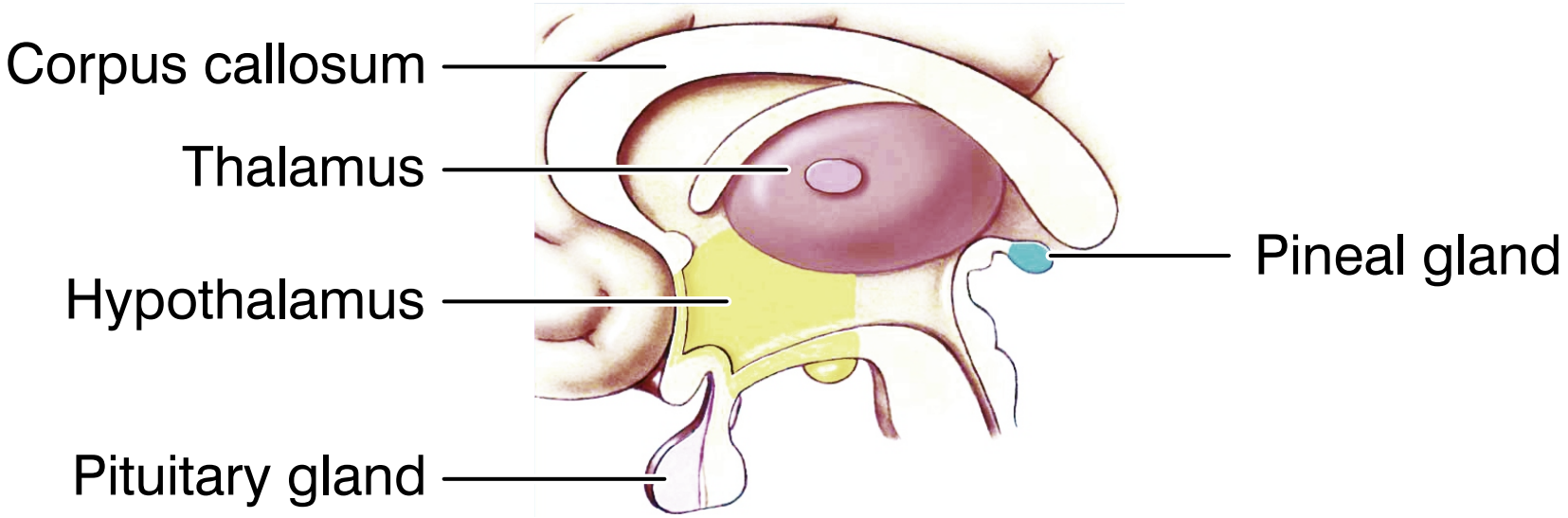
Cranial nerves are ones that enter or leave the brain rather than the spinal cord

Traditionally there are 12 cranial nerves, the nerve 0 is really controversial.



Fields (2007) *Sci Am Mind*

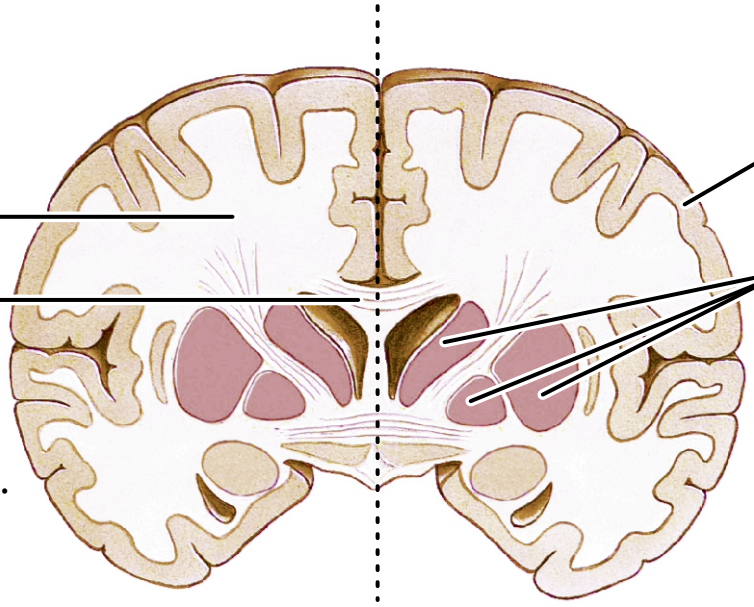
The *diencephalon* is the thalamus, hypothalamus, pituitary and pineal



- The thalamus processes information going to and from the cerebral cortex.
- The hypothalamus regulates behavioral drives, and endocrine and autonomic homeostasis Blood pressure, blood sugar, etc.
- Pituitary and pineal secrete hormones.

The *cerebrum* has 2 *hemispheres* connected by the *corpus callosum*

It is opposte to spinal cord which has the grey matter in the mid and the white in the otter membrane.



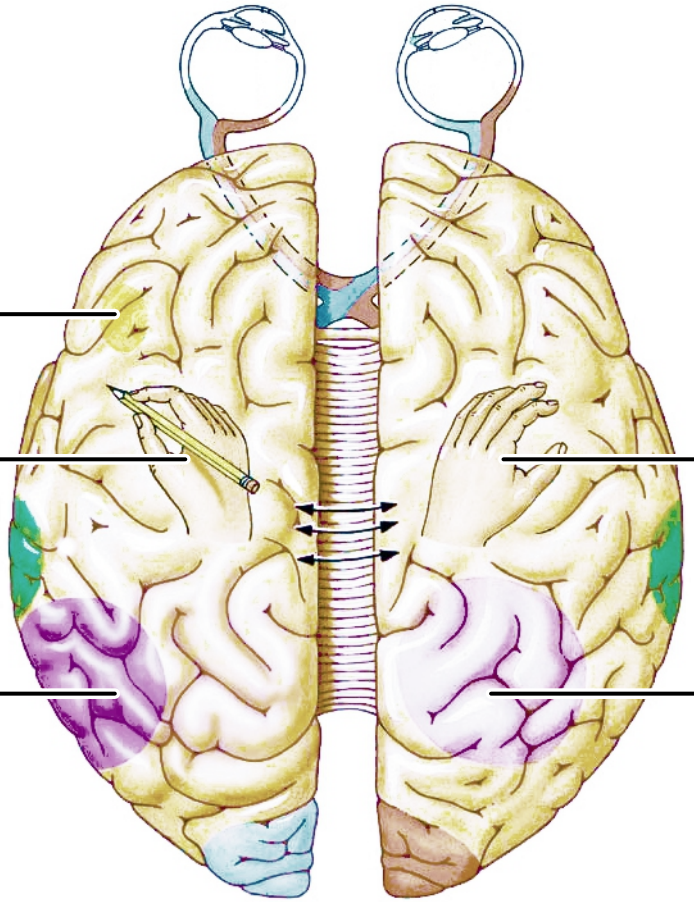
Connection btw the 2 hemispheres. Share information.

Control movement, attention, etc. It is an exception bcs it should call nuclei not ganglia, but is an exception. IT is bcs is part of the grey matter and bcs is composed of clusters of cell bodies.

- The cerebral gray matter includes the outer layer called the *cortex*, the limbic system (shown in a later slide), and the *basal ganglia* (which help control movement). It form most of the cerebrum.
- Corpus callosum is a large bundle of myelinated axons.

The 2 hemispheres' functions differ, i.e. we have *cerebral lateralization*

Both hemispheres are quiet similar, but lateralization give them diff functions



Speech

Writing

Language and math

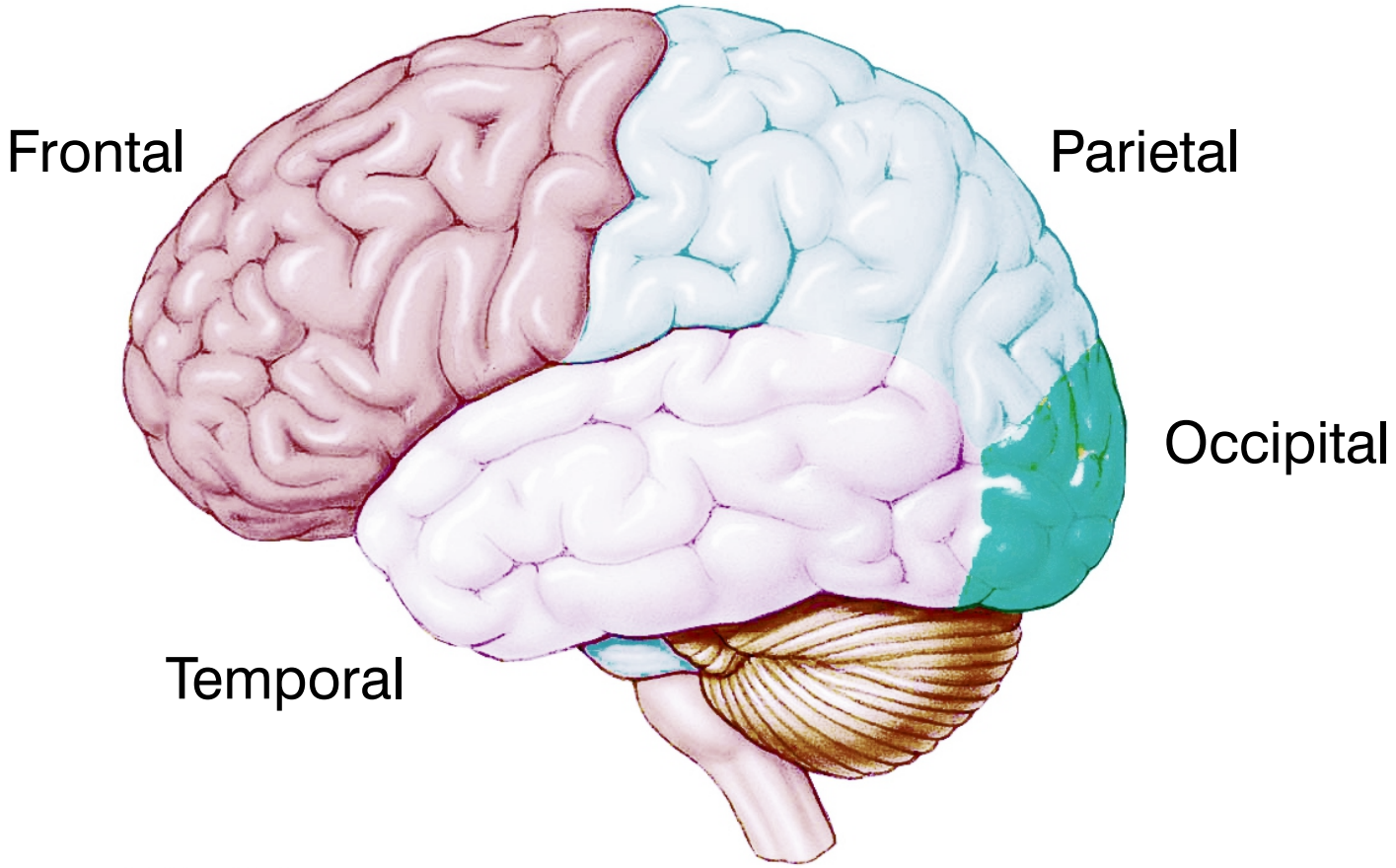
Analysis by touch

Spatial analysis

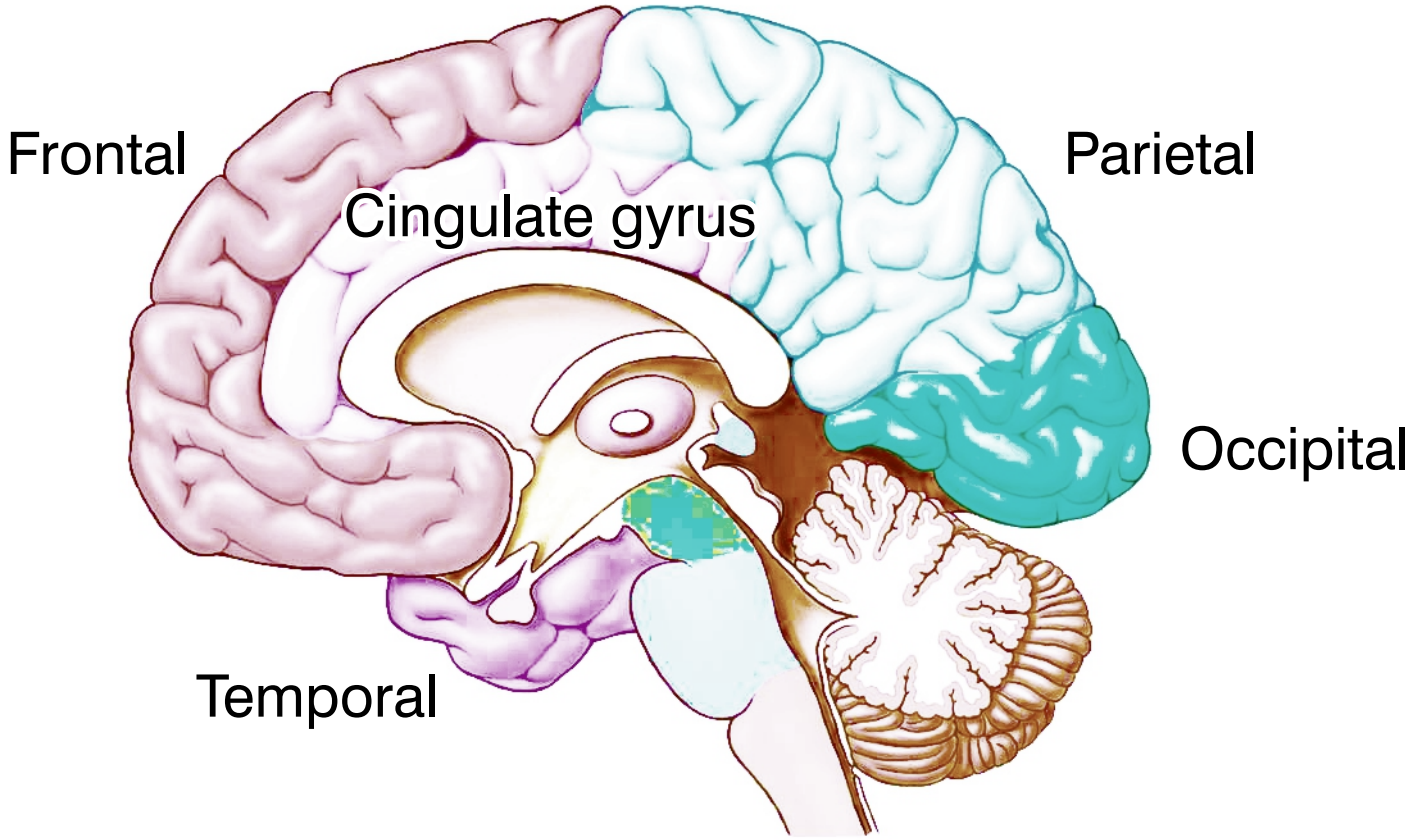
Geometry and shape of things

L hemisphere R hemisphere

Each hemisphere has 4 *lobes*

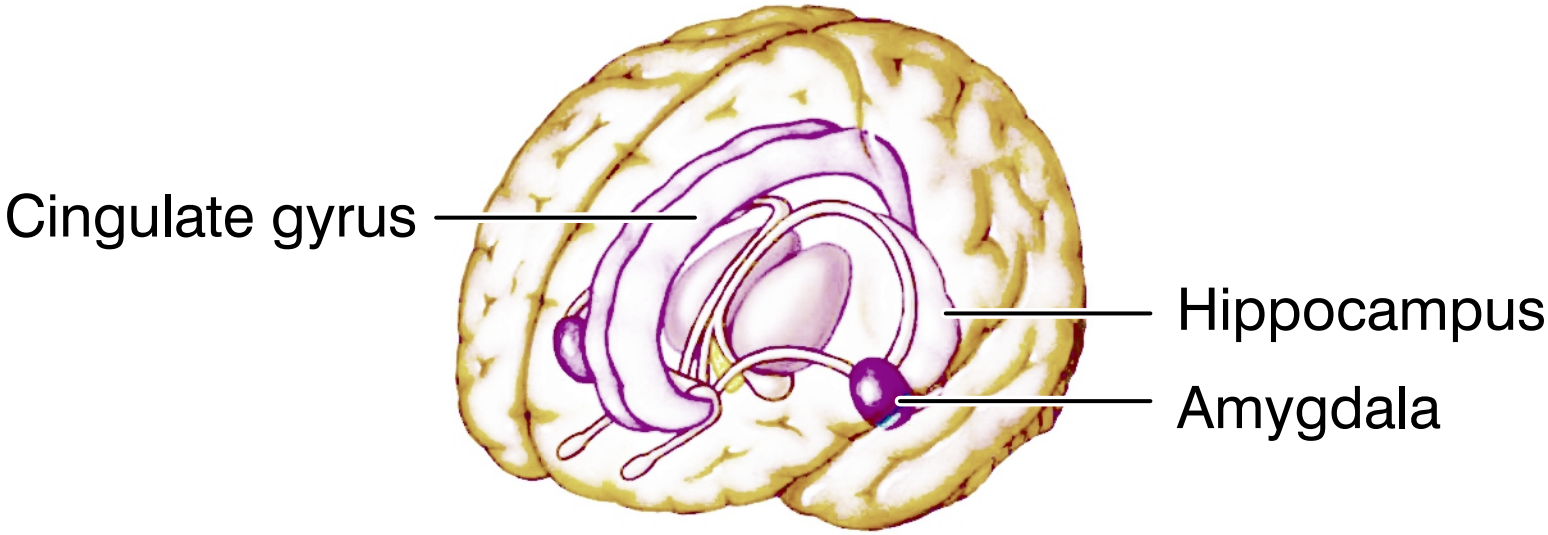


Each hemisphere also has a *cingulate gyrus*, which is part of the limbic system



The *limbic system* is an evolutionarily old group of brain regions

This means that the cerebrum and the cerebellum are not as old, are kind of new.



middle of the limbic system

- It includes the *cingulate gyrus*, *amygdala*, and *hippocampus*.
- It is concerned with motivation, emotion, and memory, e.g. monkeys with amygdala lesions, unlike normal monkeys, are not frightened of snakes. Not scared of snakes, prove lose of emotions in monkeys after lesion of amygdala.

Reading in Silverthorn's *Human Physiology*

- **7th edition**: Pages 277–280 ("The CNS Is Divided into Gray Matter and White Matter"), Figures 9.3(a) and 9.4(a), and pages 283–293, from the start of "Neural Tissue has Special Metabolic Requirements" to the end of "The Spinal Cord and Brain Integrate Sensory Information".

- **6th edition**: Page 293 ("The CNS Is Divided into Gray Matter and White Matter"), Figures 9.3(a) and 9.4(a), and pages 297–308, from the start of "Neural Tissue has Special Metabolic Requirements" to the end of "The Spinal Cord and Brain Integrate Sensory Information".