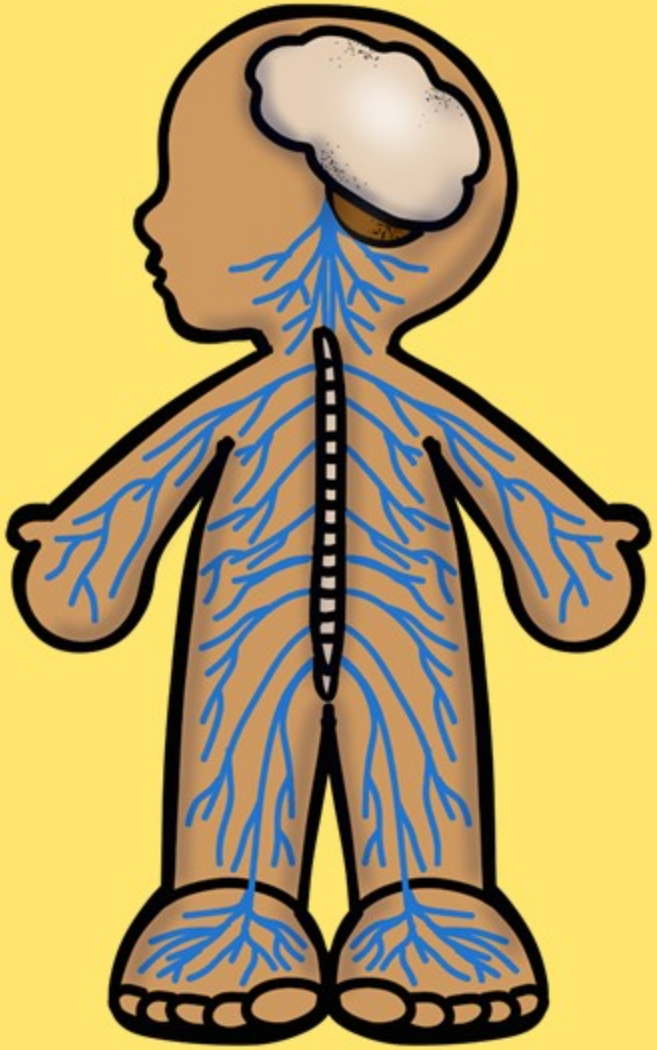
Nervous system

For Notes

Nervous System



Function:

Detects impulses from the senses; control center.

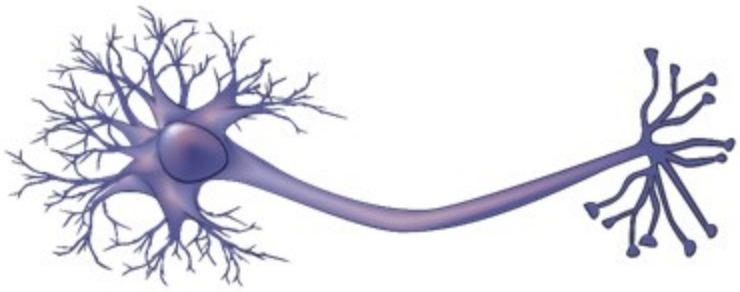
Major Organs:

-Brain
-Spinal cord
-Senses
-Nerves

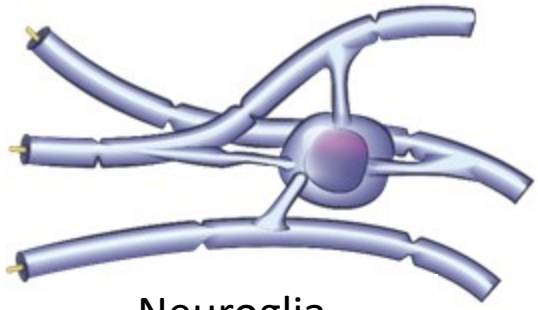
Nerves

Nerve Cells

- Nerve cells pass impulses throughout the body.
- There are 2 major types of nerve cells:
  - Neurons (make up 10% of the nervous system)
  - Neuroglia (“nerve-glue”, make up 90% of the nervous system)



Neuron

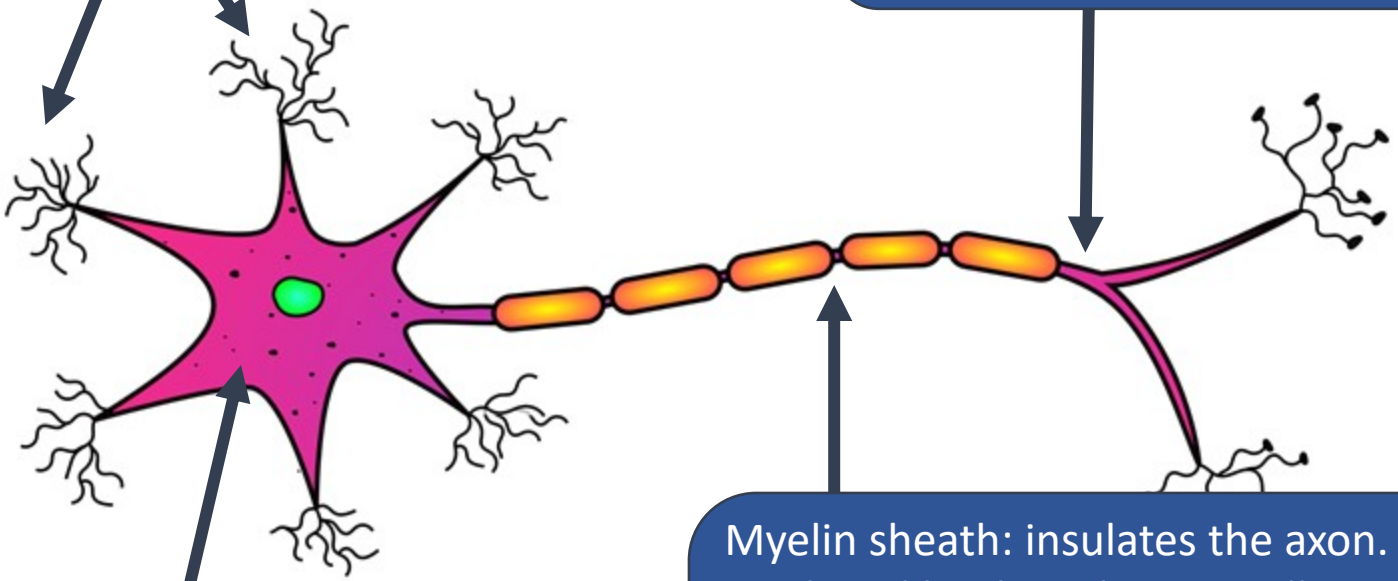


Neuroglia

Structure of a neuron

Dendrites: receive the nerve impulse from the senses or another neuron

Axon: passageway for nerve impulse after cell body; end in axon terminals

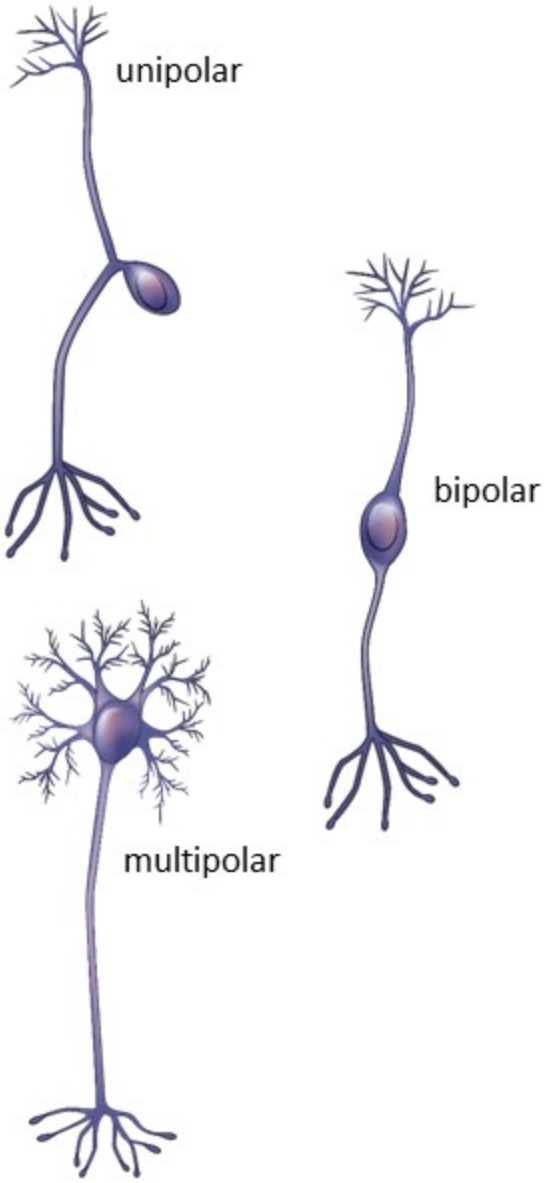


Cell Body: contains the nucleus; transmits impulse to the axon

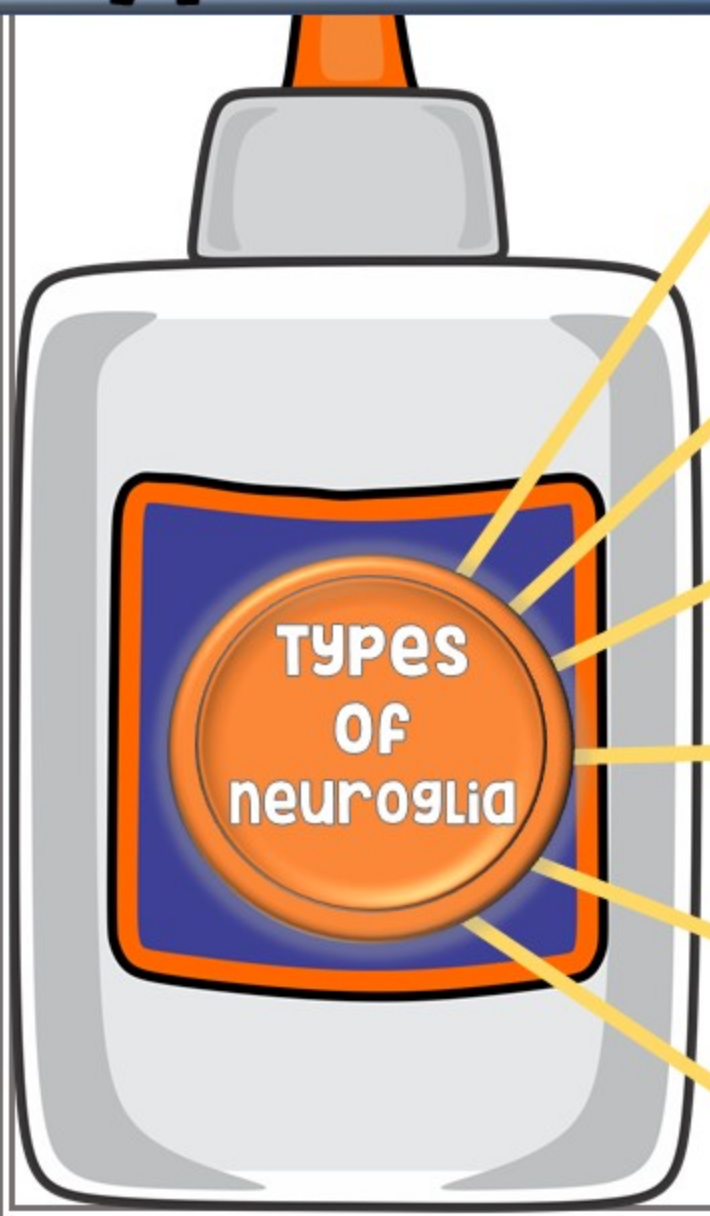
Myelin sheath: insulates the axon. Produced by the Schwann cells. Between the myelin sheath is the Nodes of Ranvier. Nerve impulses jump from node to node, which increases the speed of the impulse.

Types of Neurons

- Neurons are classified by the number of processes (extensions) from the cell body.
  - **Unipolar neurons** have one process
  - **Bipolar neurons** have two processes
  - **Multipolar neurons** have many processes (usually several dendrites and one axon)

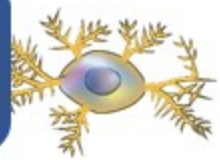


Types of Neuroglia



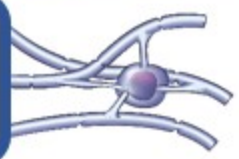
Astrocytes: Support and anchor neurons to surrounding capillaries

Microglia: Provides immune response to Central Nervous System



Ependymal cells: Secrete and circulate cerebrospinal fluid

Oligodendrocytes: Provide myelin insulation to neurons in the CNS

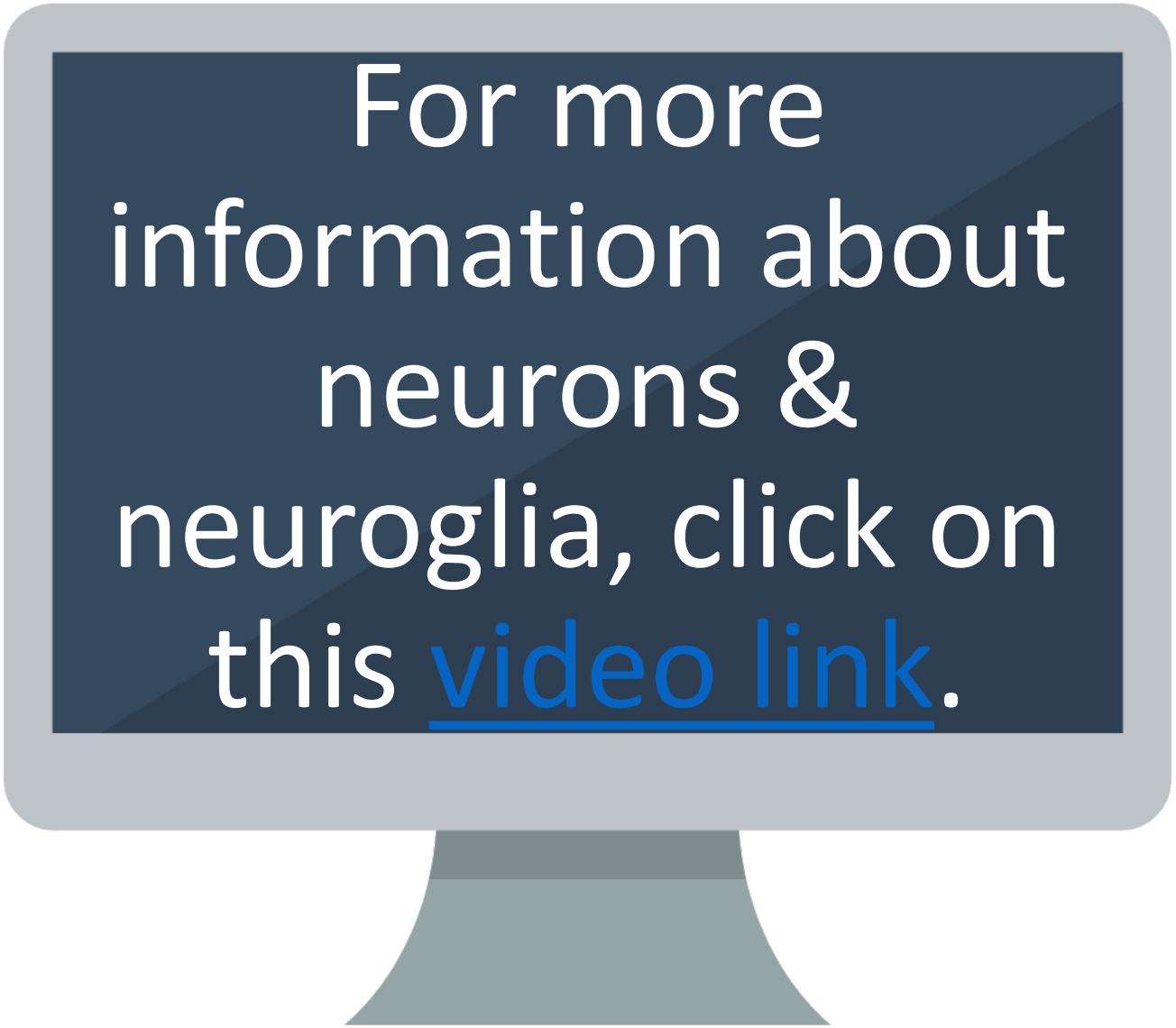


Found in Central Nervous System

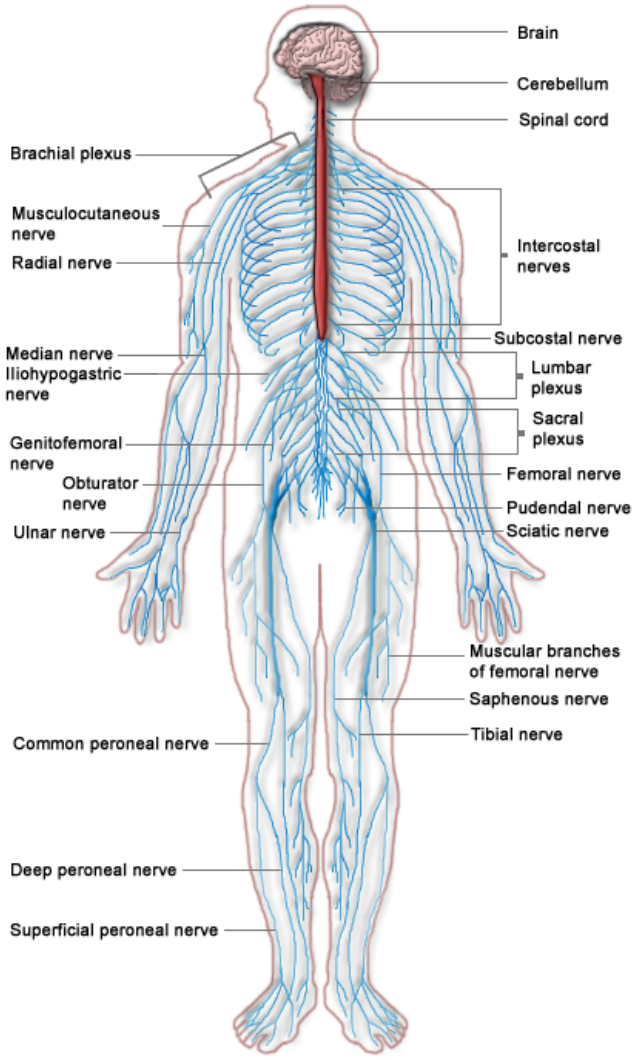
Satellite cells: Support and anchor neurons in the Peripheral Nervous System

Schwann cells: Provide myelin insulation to neurons in the PNS

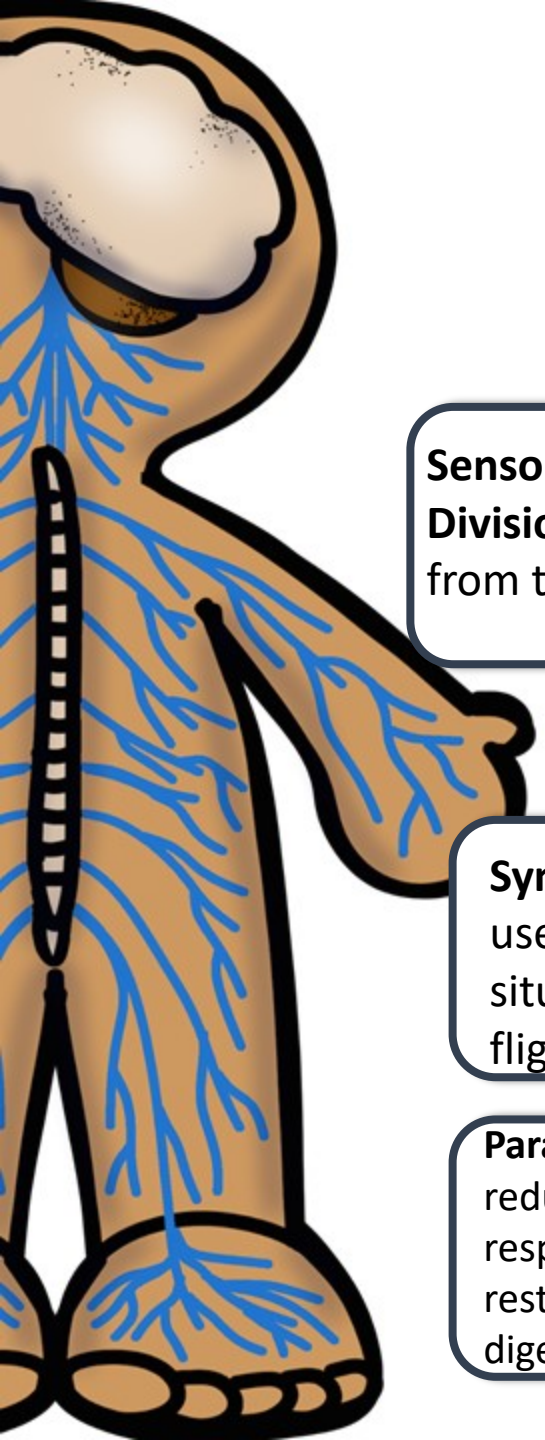
Found in Peripheral Nervous System


For more information about neurons & neuroglia, click on this video link.

Organization of the Nervous System



- The nervous system is divided into
  - **Central nervous system** (CNS), which consists of the brain and spinal cord
  - **Peripheral nervous system** (PNS), which consists of the other nerves
    - Cranial nerves- originate in the brain
    - Spinal nerves- originate in the spinal cord
- The peripheral nervous system is then further divided.



Peripheral Nervous System (PNS), comprised of all nerves not in brain or spinal cord

Sensory (Afferent) Division- sends impulses from the senses to the CNS

Motor (Efferent) Division- sends impulses from the CNS to the muscles and glands

Autonomic Nervous System- involuntary muscle control

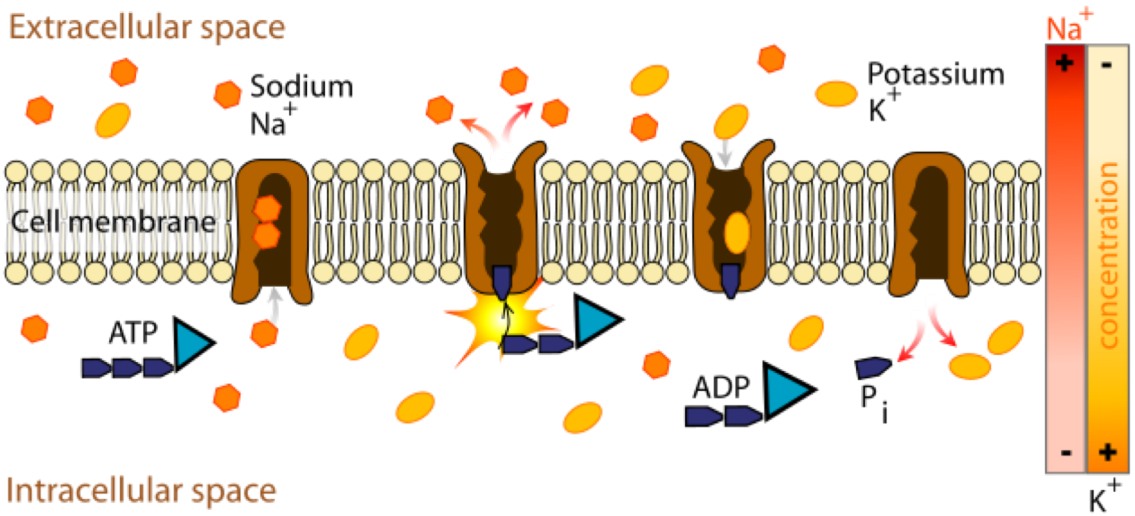
Somatic Nervous System- voluntary muscle control

Sympathetic Division- used in emergency situations ("fight or flight")

Parasympathetic Division- reduces sympathetic response and provides resting functions such as digestion and urination

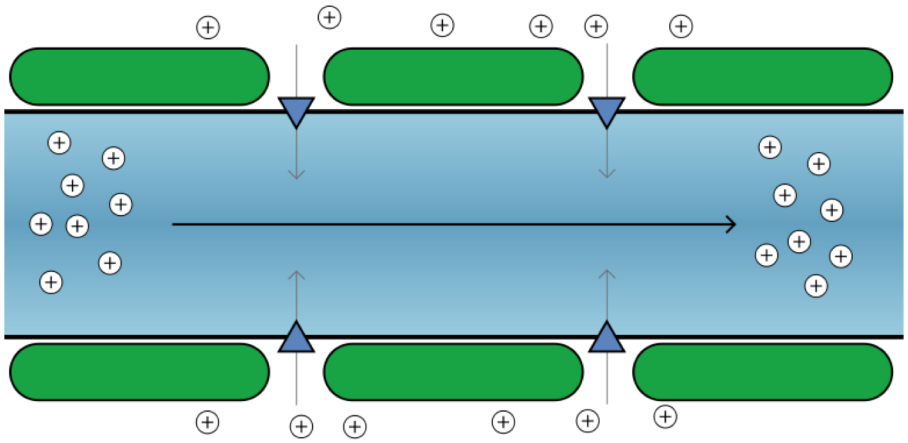
Nerve Impulses

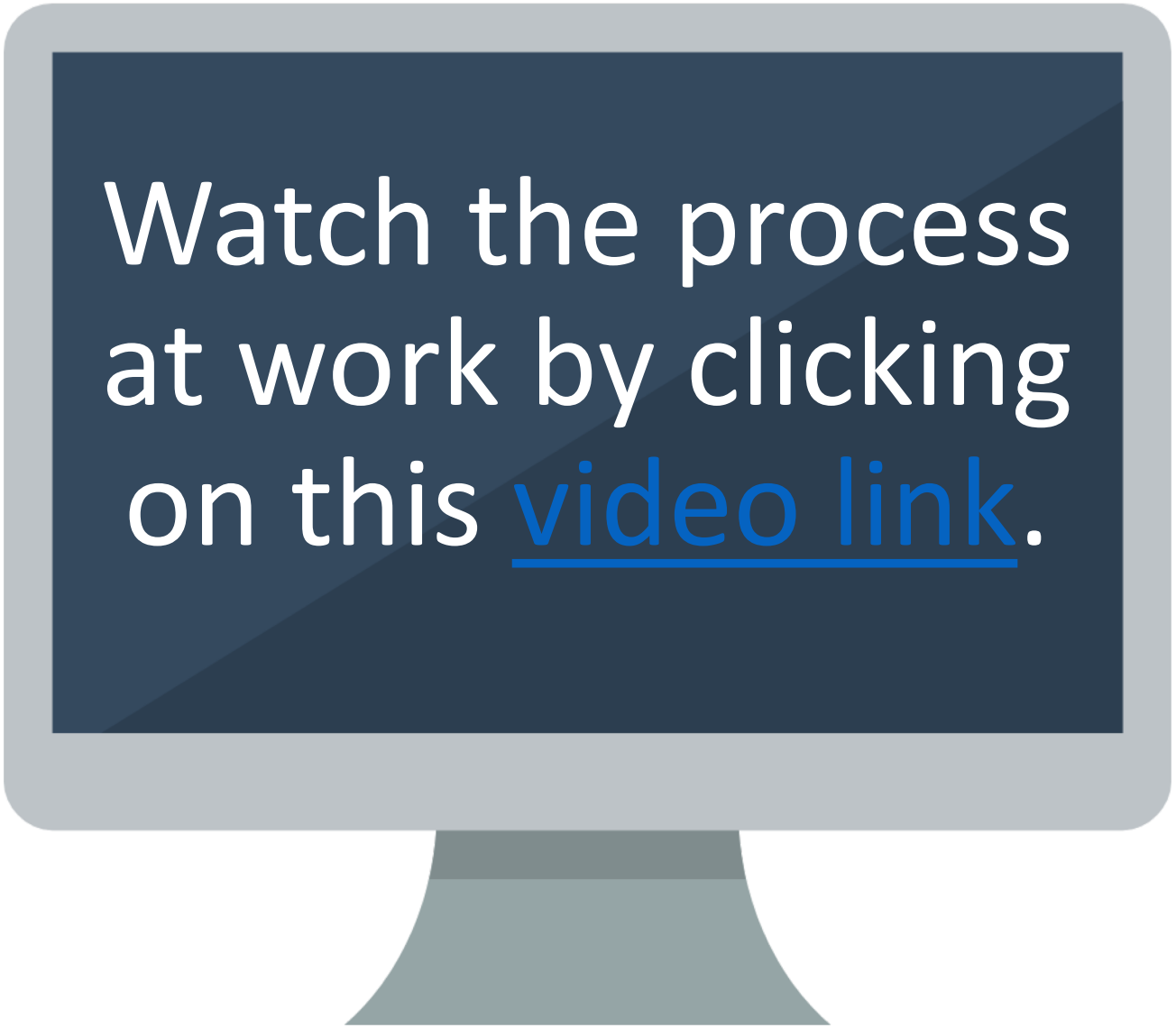
- A **nerve impulse** is an electrical signal that travels along the neuron.
- A **sodium-potassium pump** (transport of ions that requires energy) creates an electrical potential along the neuron in which the cell is negatively charged and the environment is positively charged. This is called the **resting potential.**



Nerve Impulses

- When the neuron is stimulated, either by the environment or another neuron, sodium rushes into the neuron and quickly reverses the charges. This is called the **action potential**.
- This process quickly moves down the length of the neuron.
- As the impulse passes, sodium again is pumped out and the resting potential returns.




Watch the process at work by clicking on this video link.

Action Potential

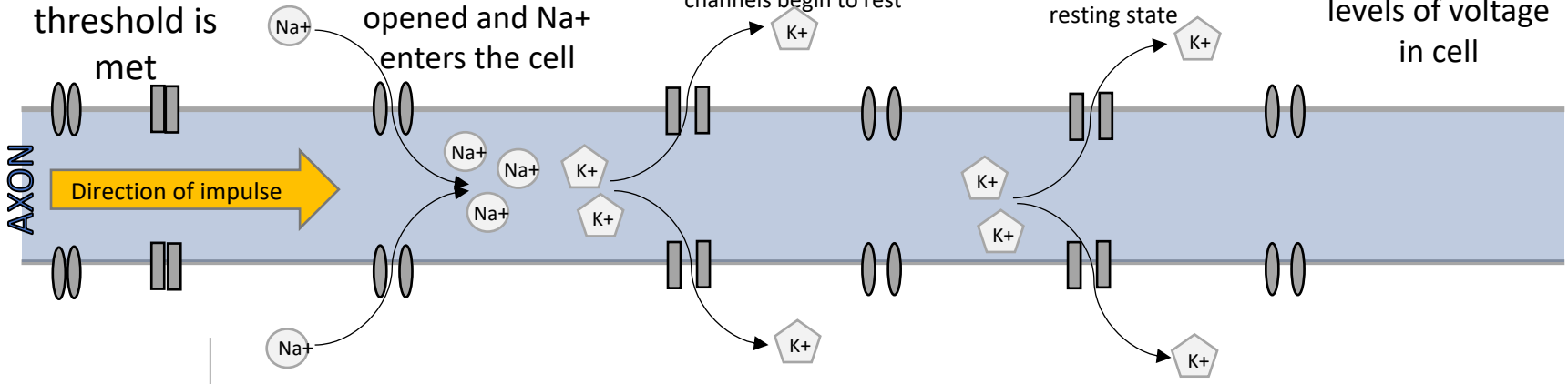
1- Impulse arrives and threshold is met

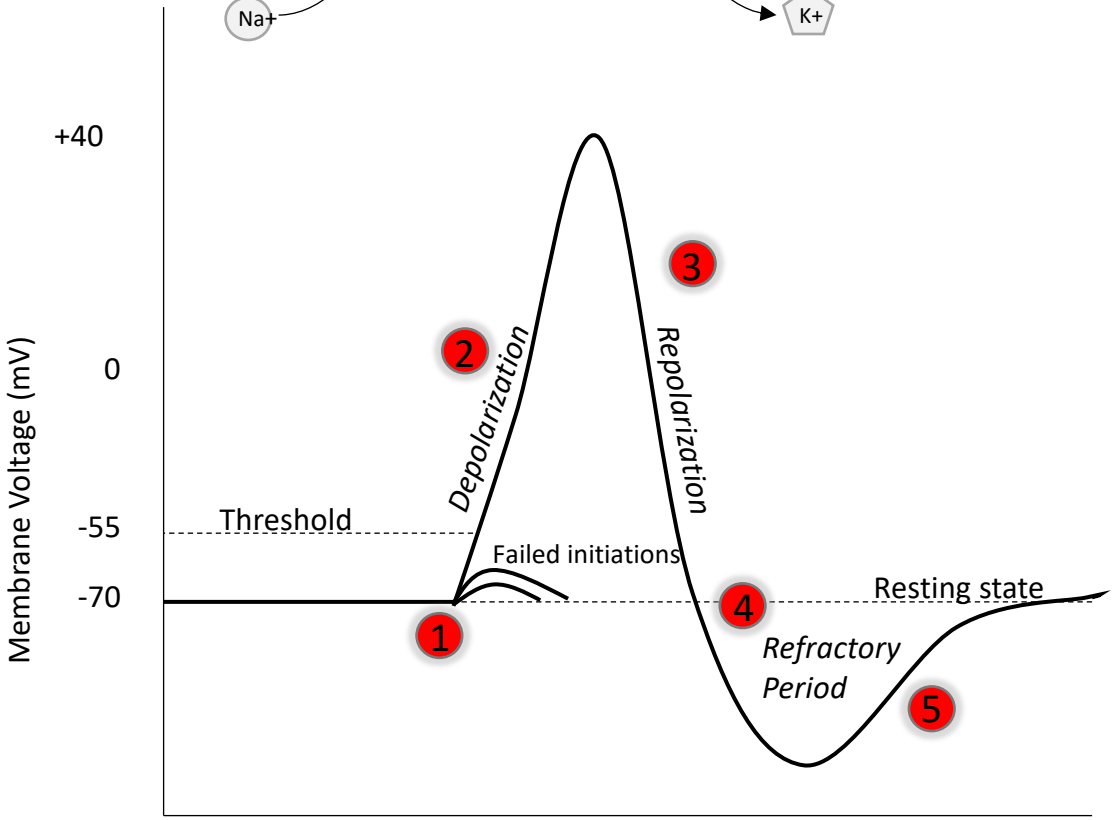
2- Voltage-gated Na+ channels are opened and Na+ enters the cell

3- Voltage-gated K+ channels are opened and K+ leaves the cell; Na+ channels begin to rest

4- Voltage-gated K+ channels are still open; Na+ channels are in the resting state

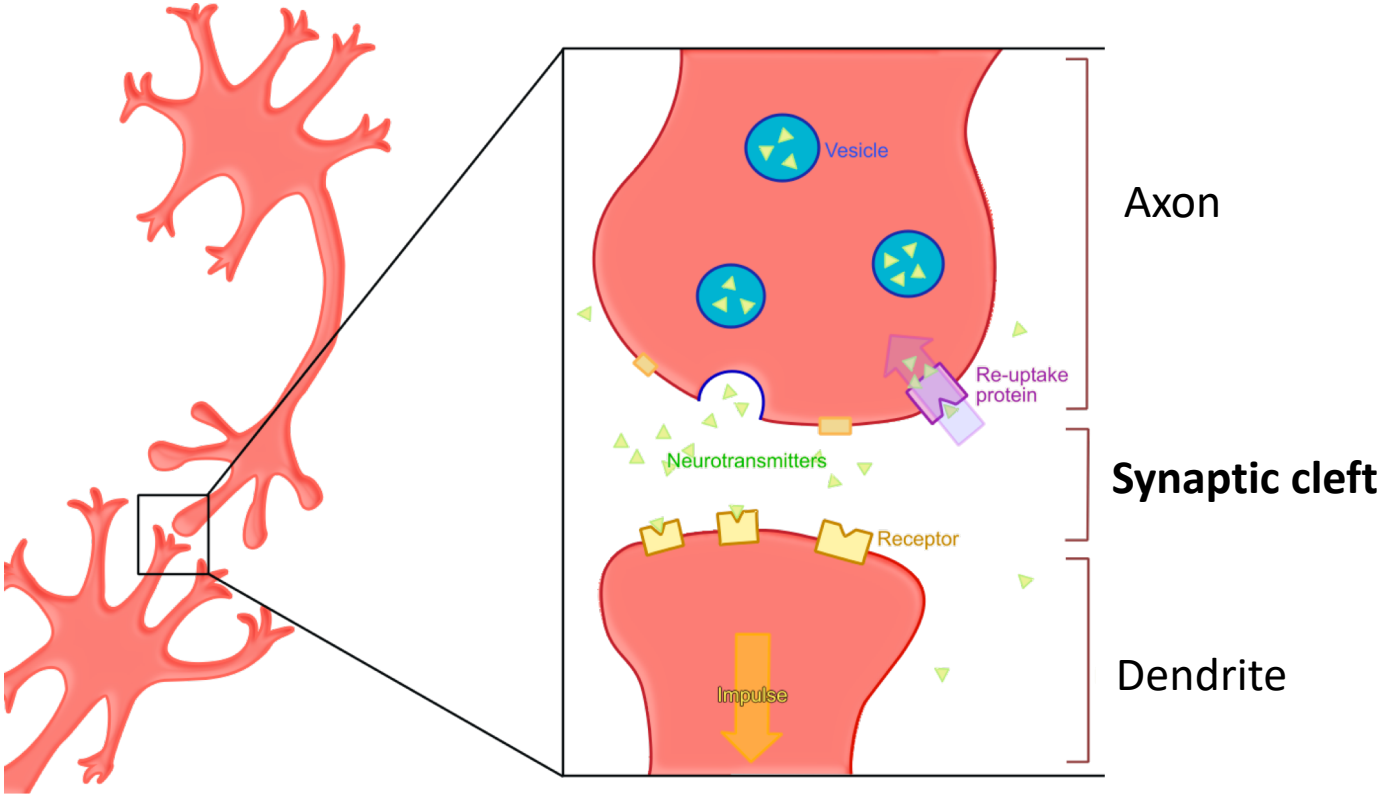
5- Na+/K+ pump restores original levels of voltage in cell





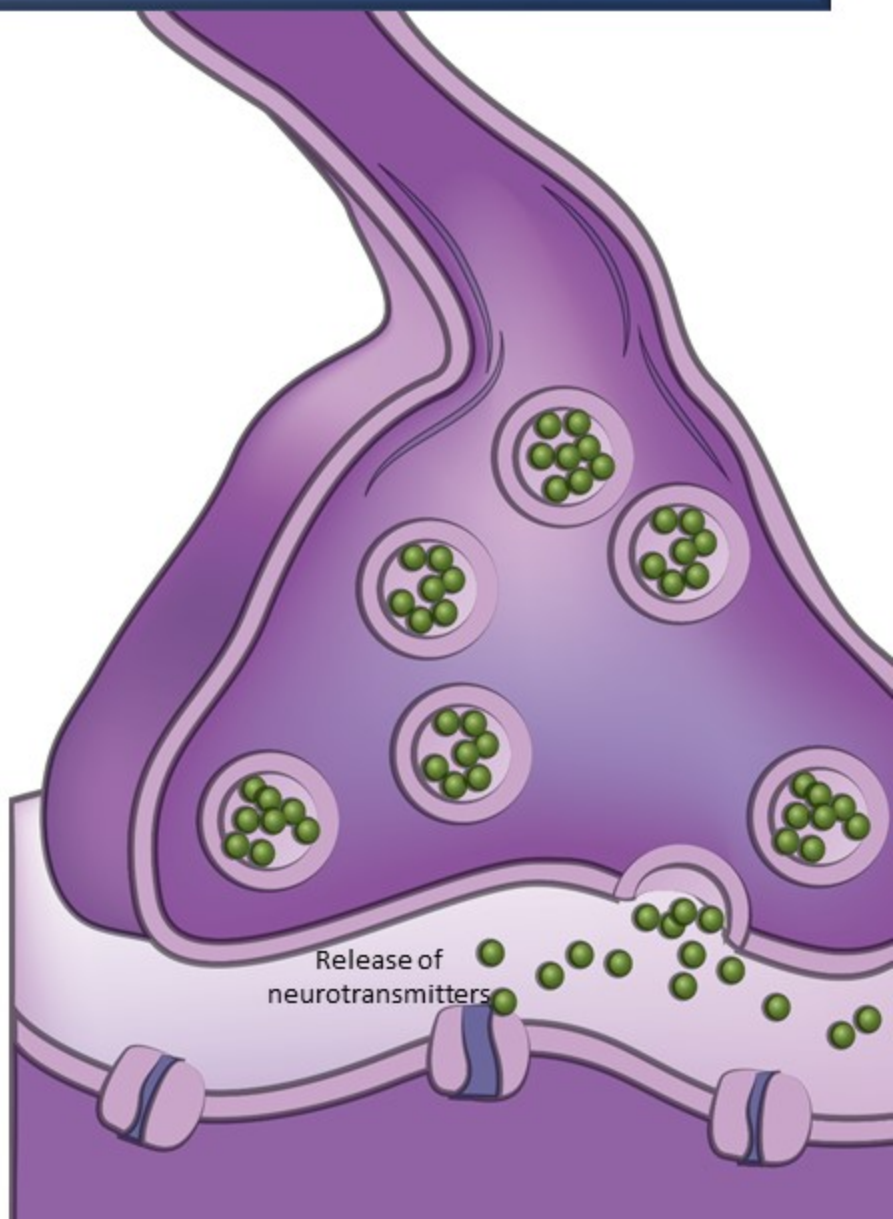
Nerve Synapse: Continuing the Impulse

- Where 2 neurons meet is a **synapse**.
- The 2 neurons do not touch. The space between them is called the **synaptic cleft**.



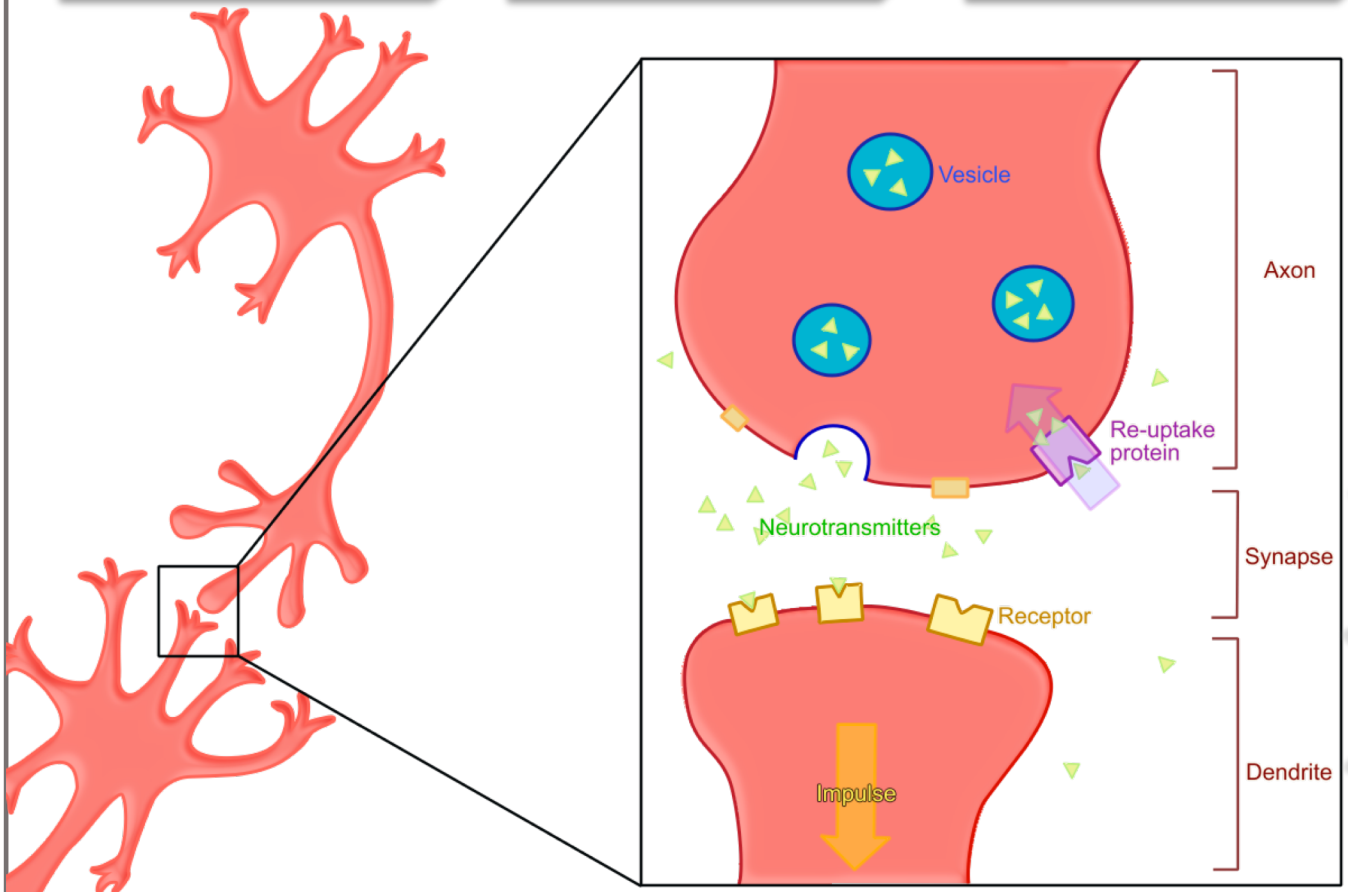
Nerve Synapse: Continuing the Impulse

- As the impulse reaches the axon terminal, it can not cross the gap.
- The impulse stimulates **neurotransmitters** to be released across the synaptic cleft.
- These neurotransmitters cause the channels to open in the next neuron, continuing the action potential from one neuron to the next.



Overview of Synaptic Transmission

1. Action potential arrives at presynaptic terminal
2. Ca^{2+} channels open on presynaptic terminal
3. Synaptic vesicles release neurotransmitters
4. Neurotransmitters bind to receptors on the postsynaptic neuron
5. Na^{+} channels open on the postsynaptic neuron

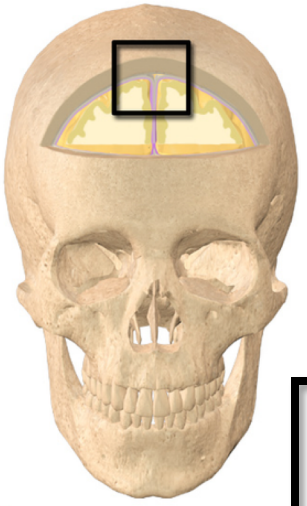


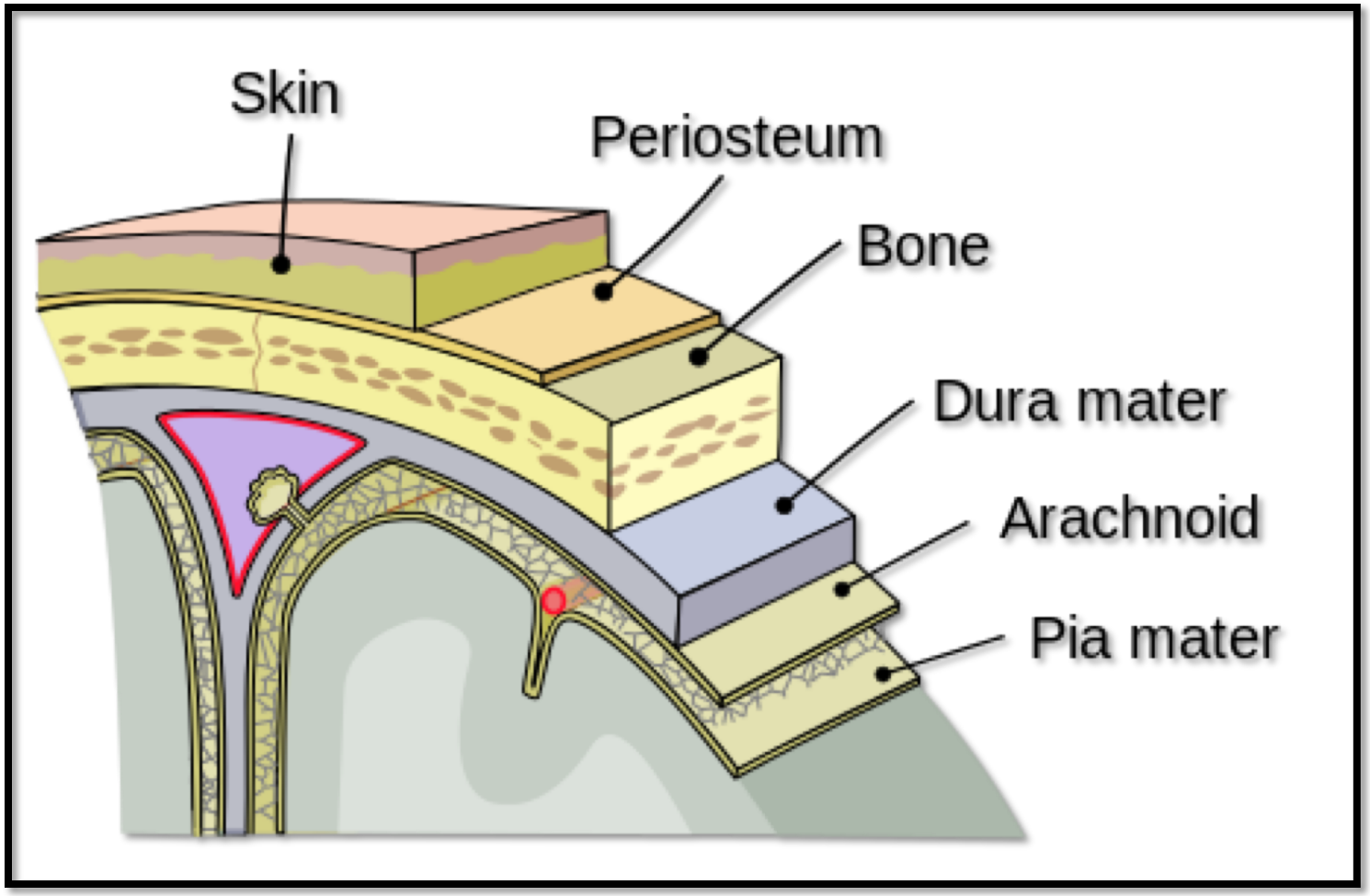
Impulse continues

The Brain

Central Nervous System

- The brain and spinal cord make up the Central Nervous System (CNS).
- These structures are protected by three layers of connective tissue called the **meninges**.
  - **Dura mater-** thick, tough layer
  - **Arachnoid membrane-** thin, cobweb-like layer
  - **Pia mater-** thin layer containing lots of blood vessels

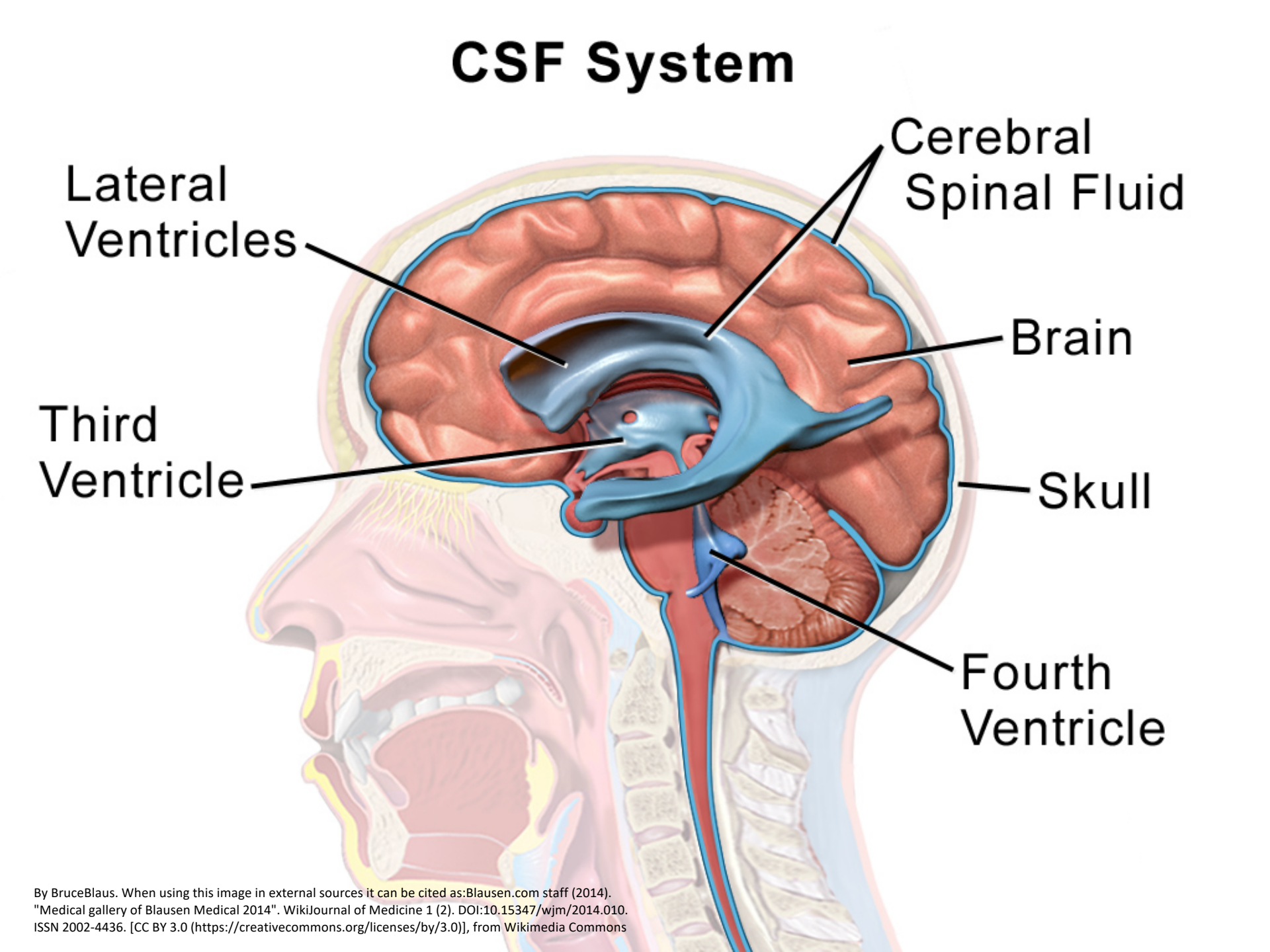



Skin
Periosteum
Bone
Dura mater
Arachnoid
Pia mater

Central Nervous System

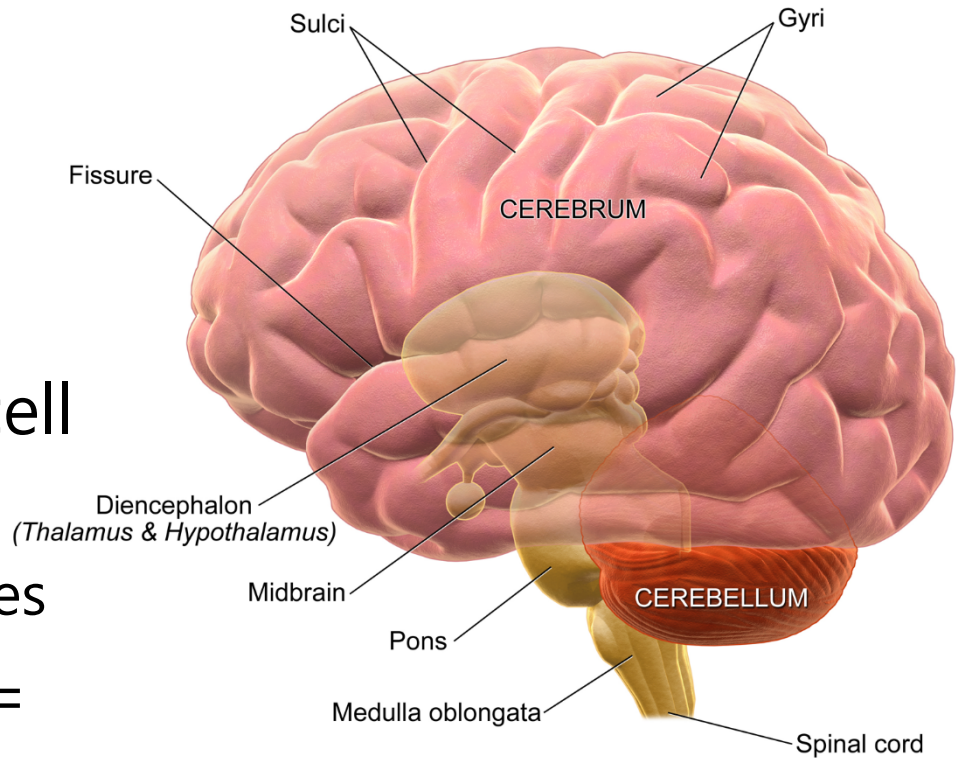
- Between the arachnoid layer and the pia mater is the **cerebrospinal fluid (CSF).**
  - The cerebrospinal fluid protects the brain by preventing the it from contacting the skull.
  - It also maintains the blood-brain barrier, which controls homeostasis for the brain and prevents infection.
- The CSF is produced in spaces within the brain called **ventricles**.
  - CSF is constantly being produced, circulated and reabsorbed within these ventricles.

CSF System



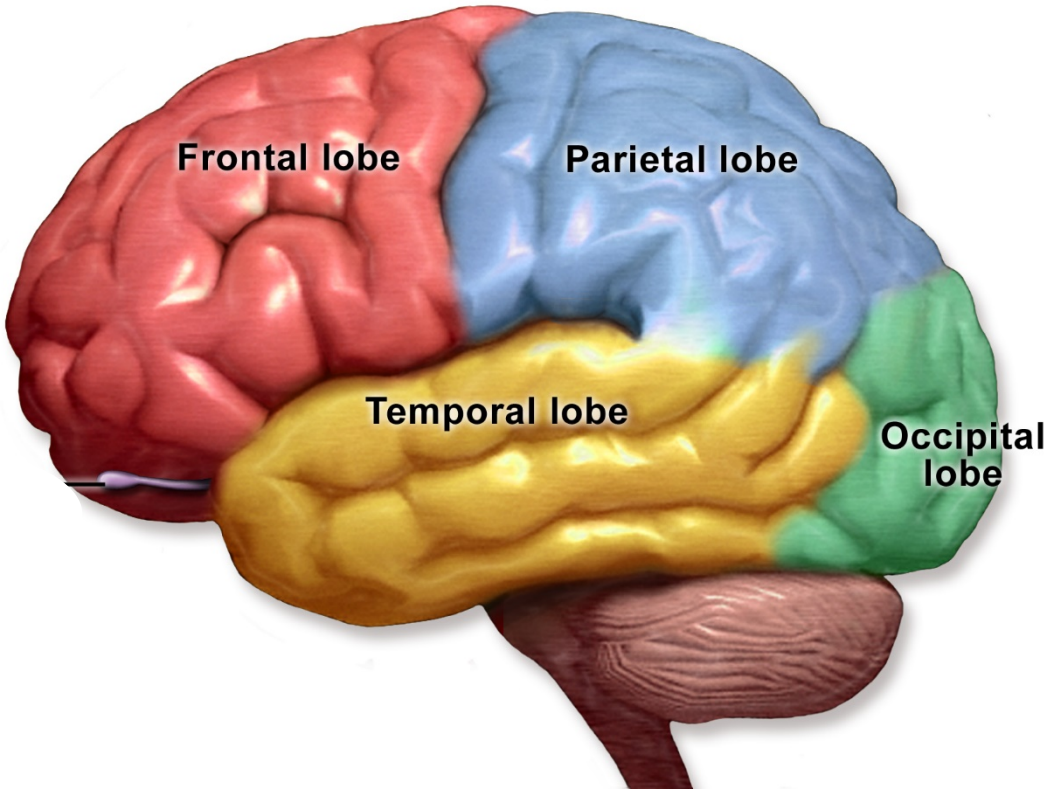
Structure of the Brain: The Cerebrum

- Largest part of brain
- Divided into 2 hemispheres
- Outer **cerebral cortex**= "gray matter," made of cell bodies & dendrites
  - Controls conscious activities
- Inner **cerebral medulla**= "white matter," made of myelinated axons



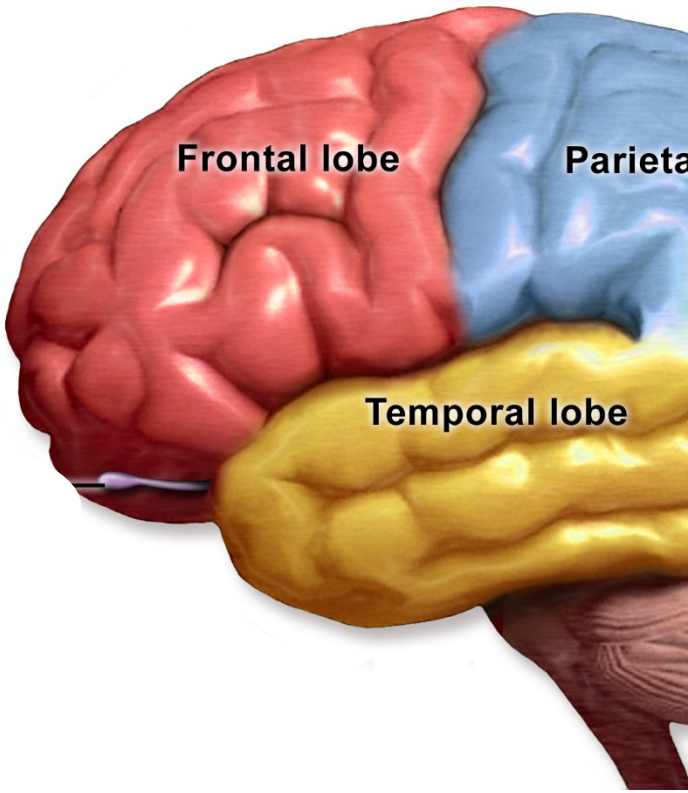
Structure of the Brain: The Cerebrum

- The cerebrum is divided into 4 lobes, based on their functions. They are named for the parts of the skull protecting them.



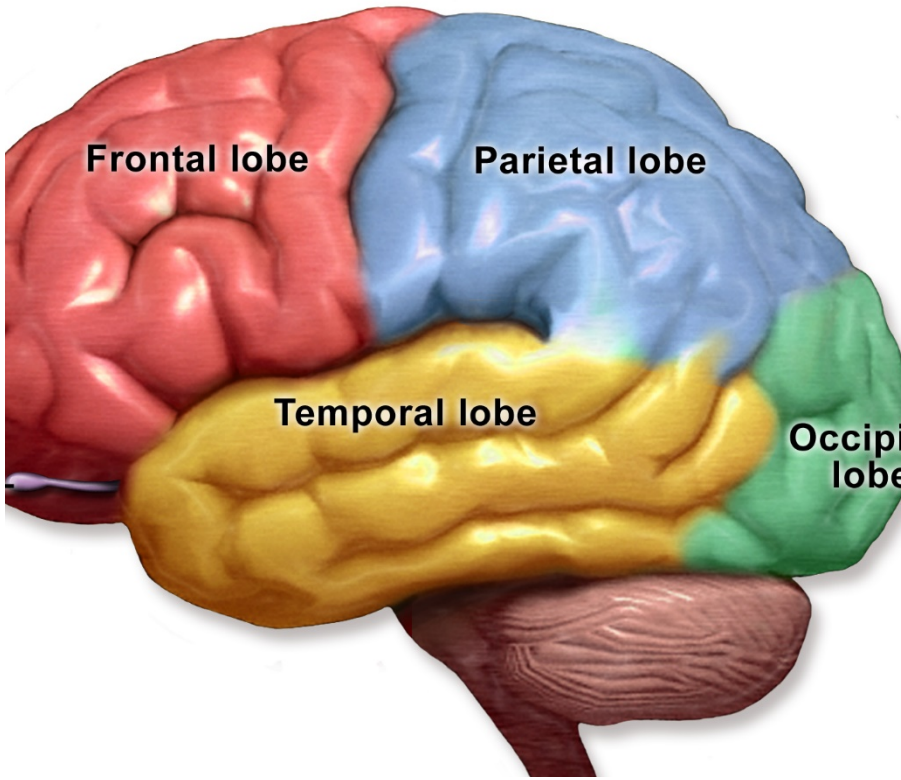
Cerebrum: Frontal Lobe

- The **frontal lobe** controls:
  - Voluntary movements (walking)
  - Reasoning & decision-making
  - Memory
  - Ability to predict consequences of actions
  - Planning
  - Verbal communication



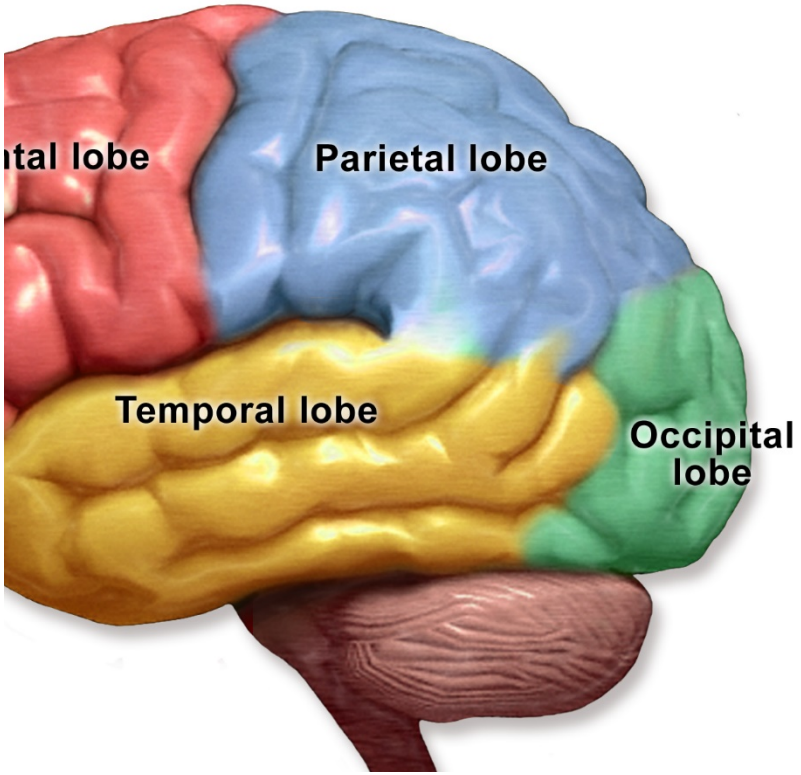
Cerebrum: Parietal Lobe

- The **parietal lobe** controls:
  - Sensations
  - Visual-spatial processing
  - Body position



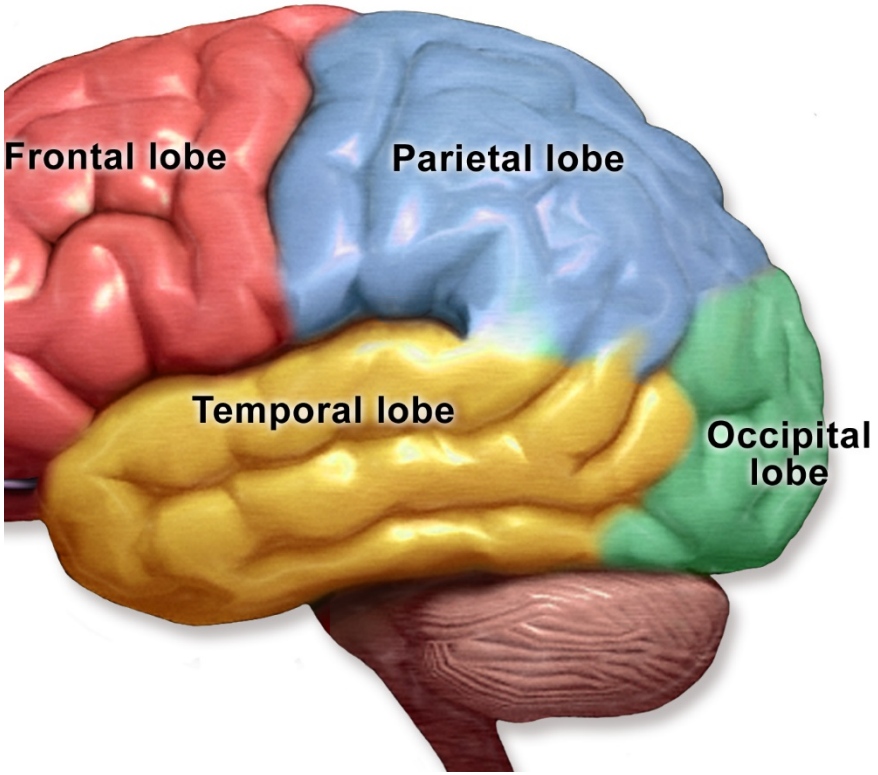
Cerebrum: Occipital Lobe

- The **occipital lobe** controls:
  - Visual processing- vision & memory of objects



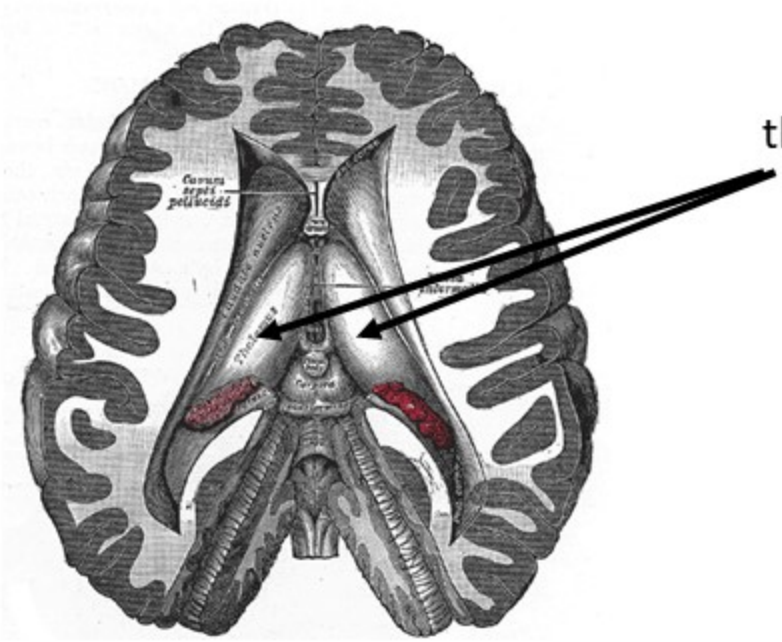
Cerebrum: Temporal Lobe

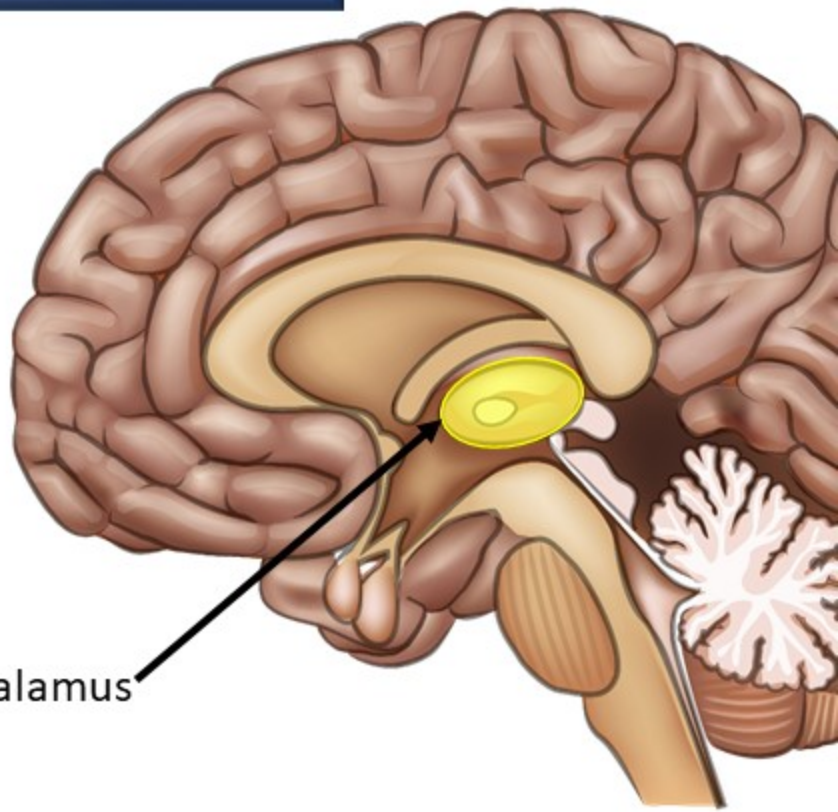
- The **temporal lobe** controls:
  - Memory
  - Comprehension & pronunciation of words
  - Sensations of smell and sound
  - Emotional association of memories



Brain: Thalamus

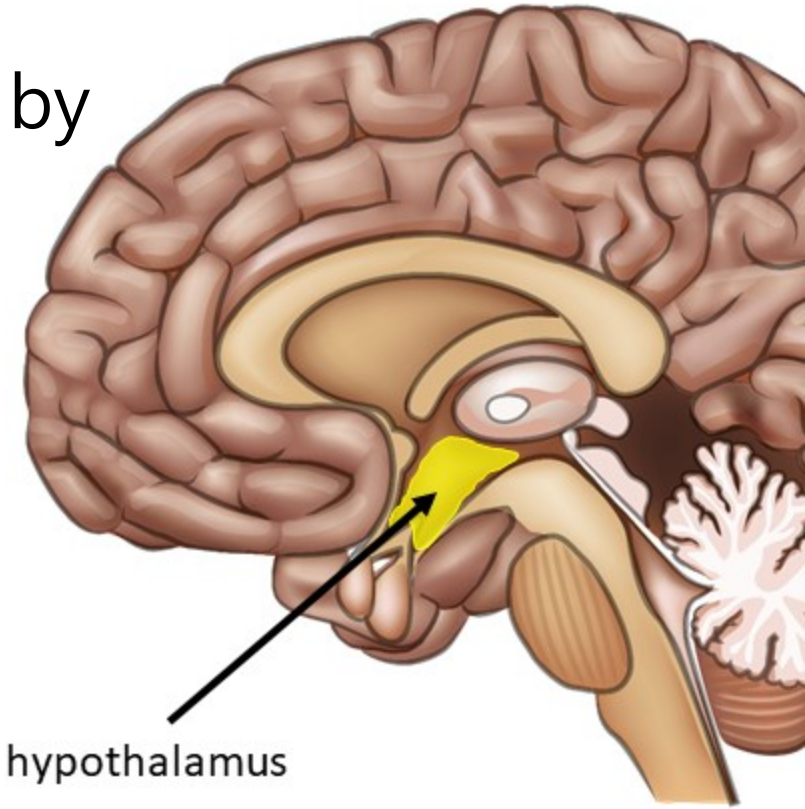
- 2 bulb-shaped halves in the center of the brain
- Relays sensory impulses to the cerebral cortex for processing and sorting





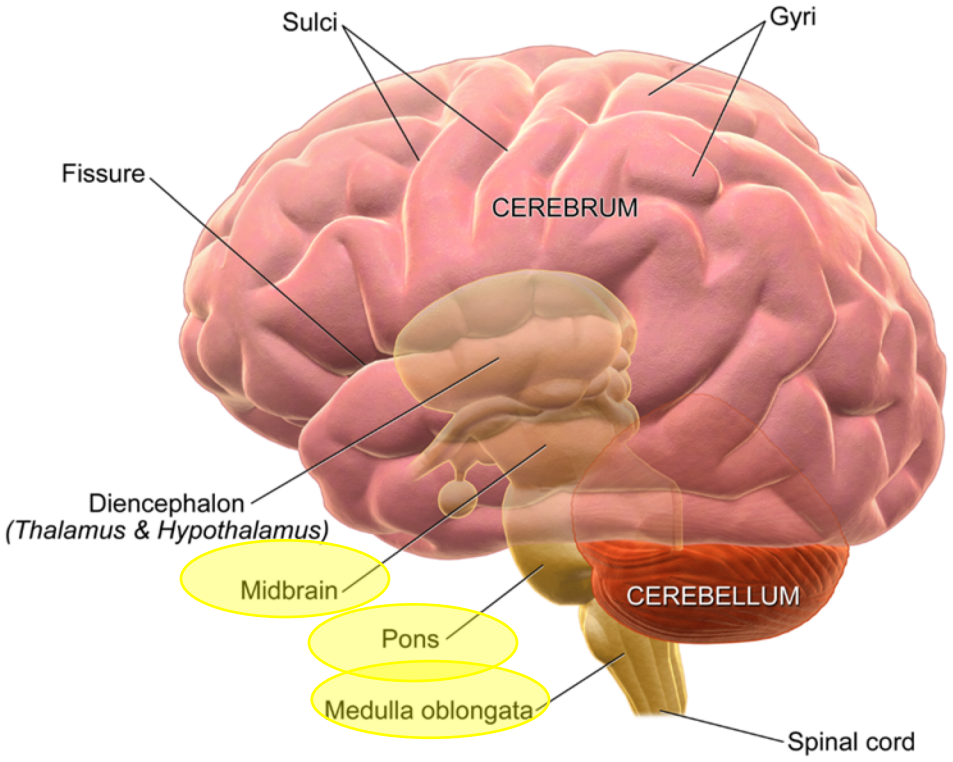
Brain: Hypothalamus

- Tiny portion of the brain near the thalamus (**hypothalamus**= "below thalamus")
- Controls hormones released by pituitary gland
  - Often called the "master endocrine gland"
- Responsible for autonomic processes such as body temperature, hunger, thirst, sleep, and blood volume



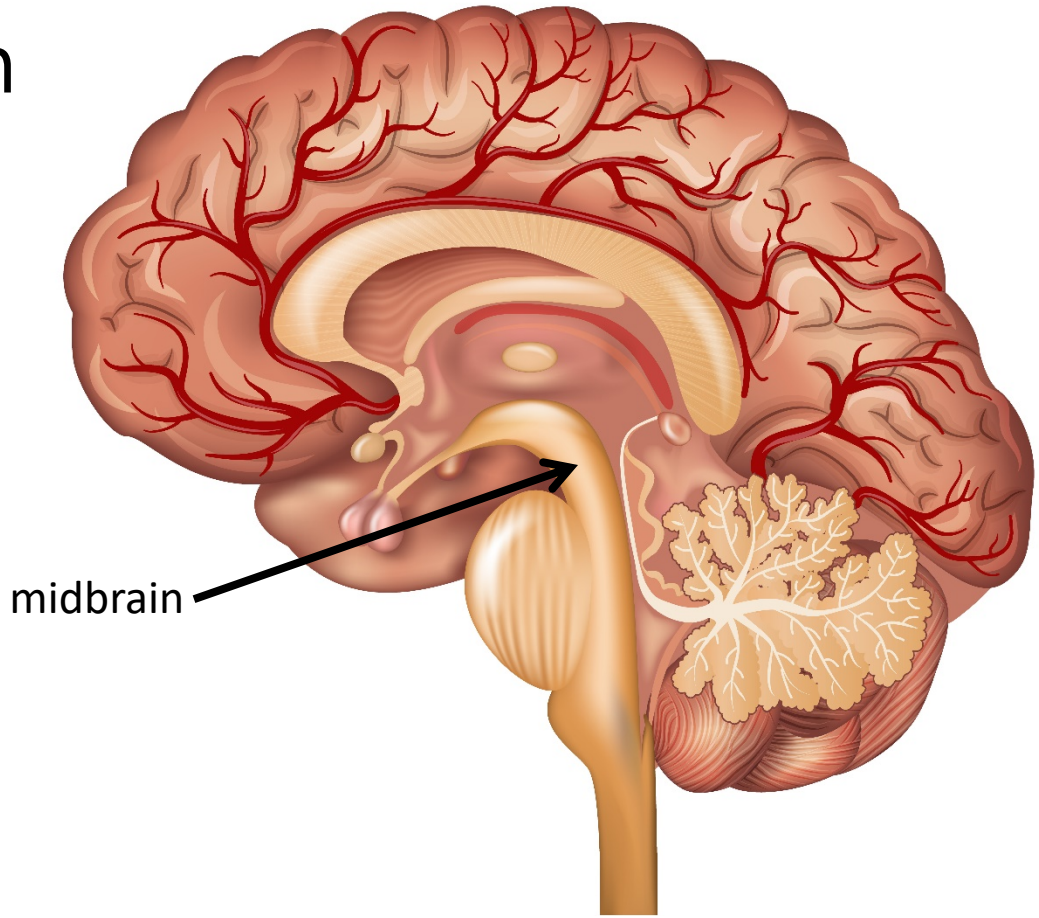
Brain: Brainstem

- The **brainstem** is located between the cerebrum and the spinal cord.
- It is broken into three regions:
  - Midbrain
  - Pons
  - Medulla Oblongata



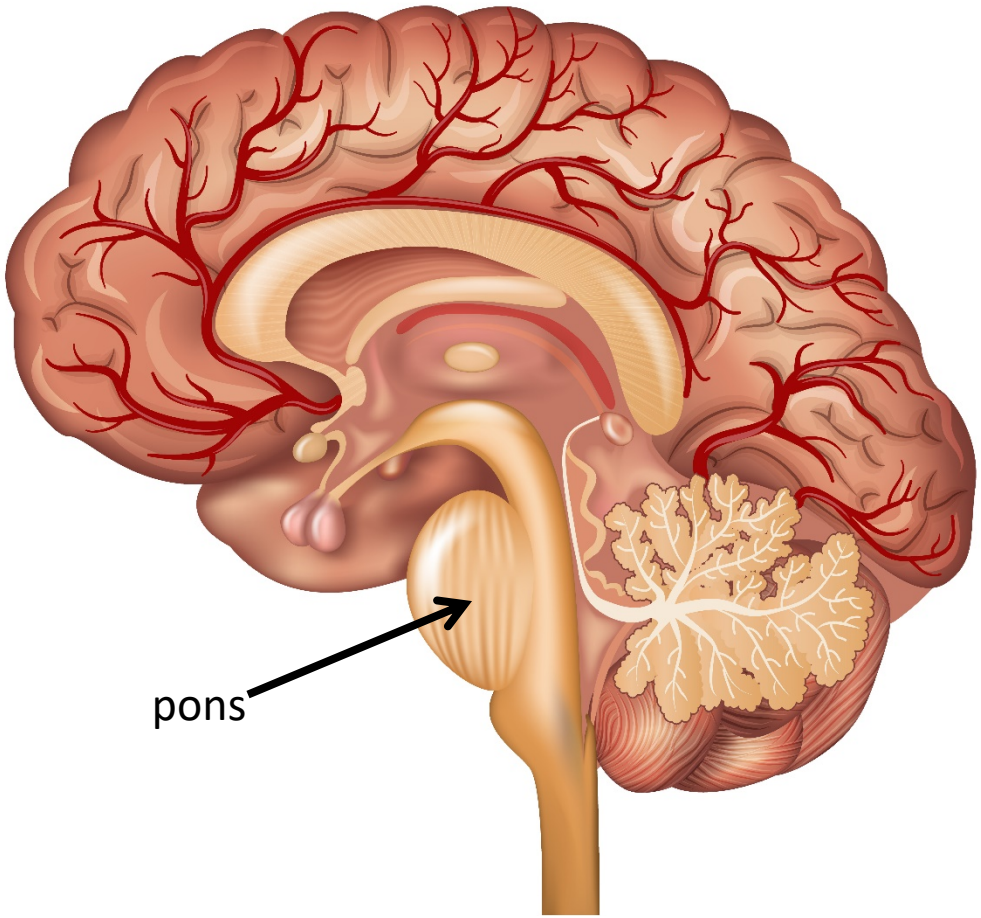
Brainstem: Midbrain

- Also known as mesencephalon
- Relays information to cerebrum
- Controls body movements and posture



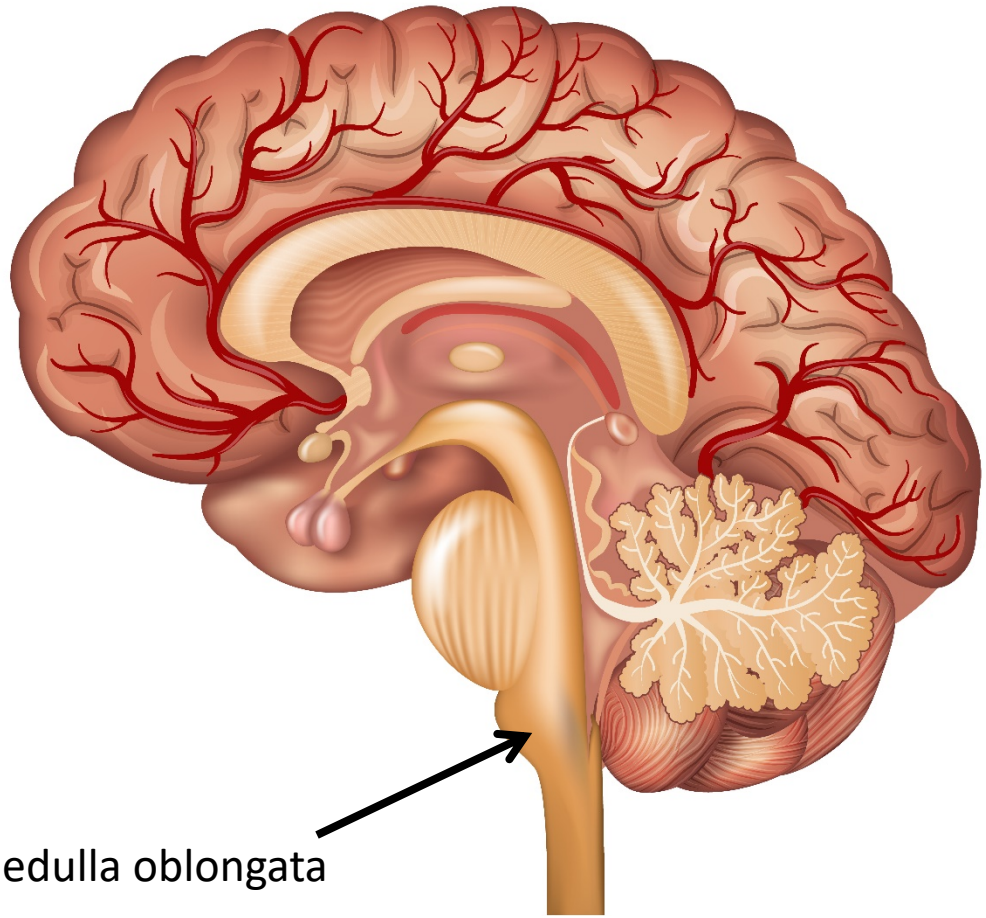
Brainstem: Pons

- "Pons" = "bridge"
- Almost completely made of white matter that links the cerebral cortex and the cerebellum
- Carries information from one side of the brain to the other
- Central control of breathing



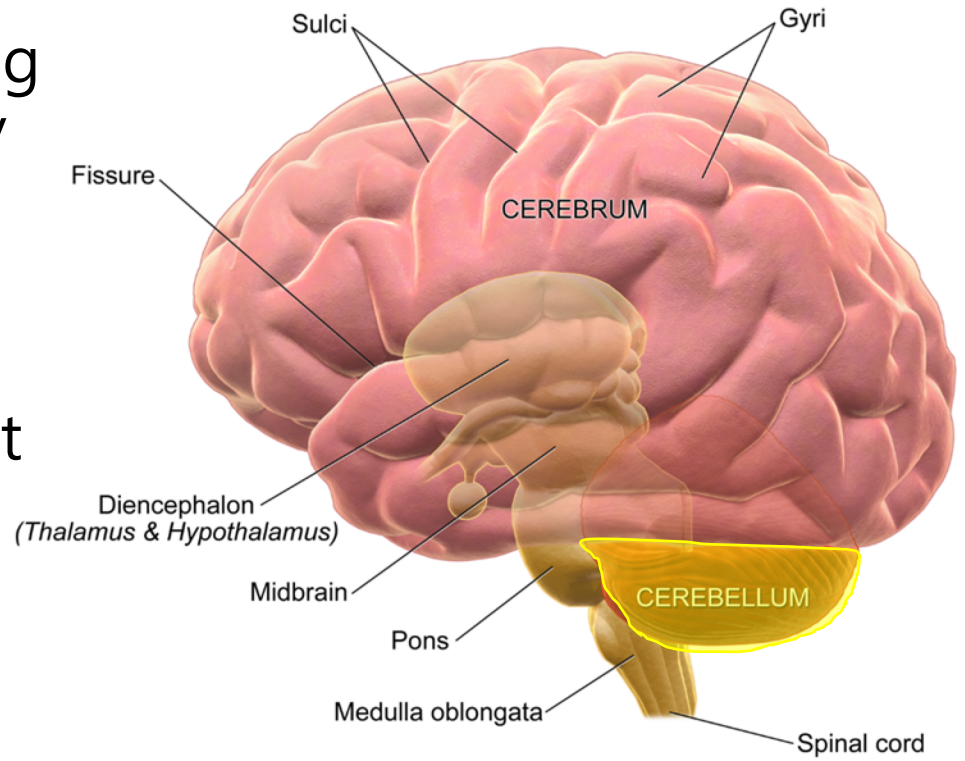
Brainstem: Medulla Oblongata

- Located just above the spinal cord.
- Transmits impulses between the spinal cord and the brain.
- Controls blood pressure, heart rate, swallowing, and coughing.

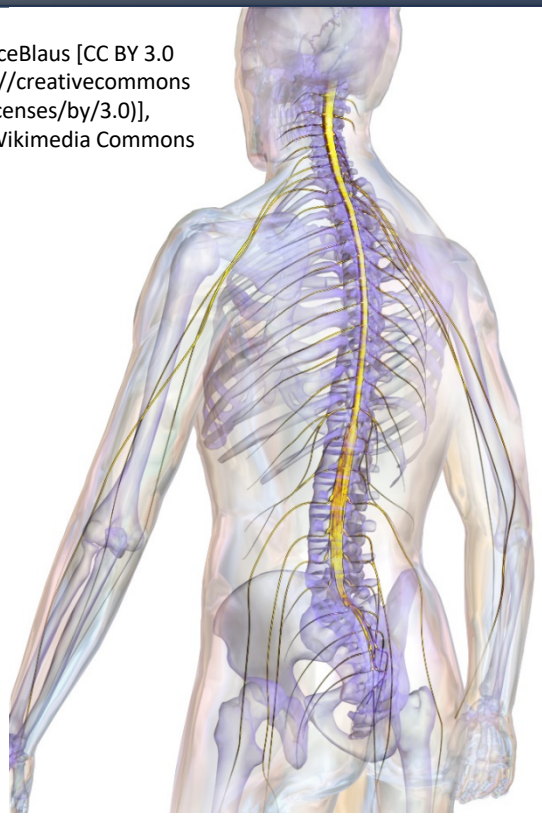


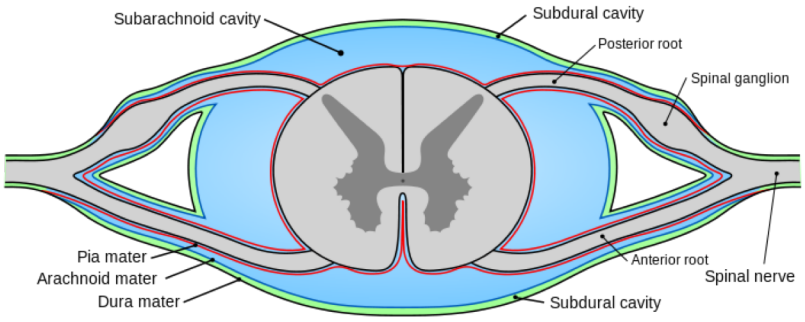
Brain: Cerebellum

- Second largest part of brain
- Near back of skull
- Responsible for coordinating the movements directed by the cerebrum so that they are graceful and efficient.
- All involuntary
- After practicing a new sport or movement, the cerebellum aids in "muscle memory".



Spinal Cord

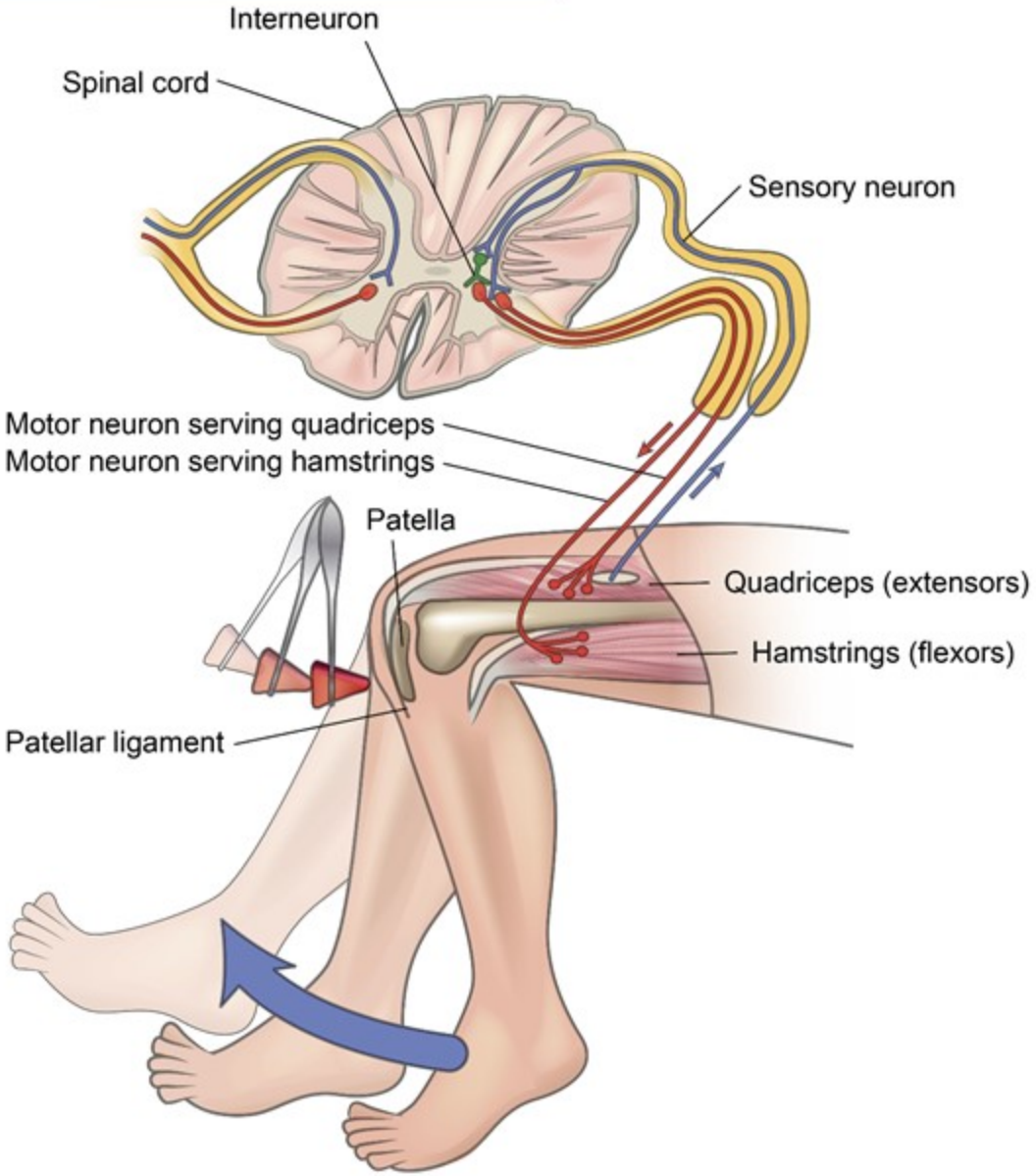




- Extends from the medulla oblongata
- 31 pairs of spinal nerve branch out from the spinal cord, connecting it to all parts of the body.
- Relays impulses from the peripheral nervous system to the brain.
- A cross-section of the spinal cord has a "butterfly" of gray matter surrounded by white matter.

Spinal Cord: Reflexes

- A **reflex arc** is caused by a stimulus, transmitted to the spinal cord by a sensory nerve, then back to the muscles through a motor nerve *without first being transmitted to the brain.*



Common Diseases of the Nervous System

- Cerebral palsy
- Coma
- Encephalitis
- Epilepsy
- Headache
- Hydrocephalus
- Mental illness
- Meningitis
- Multiple sclerosis
- Parkinson's disease
- Phobia
- Senility
- Shock

Senses

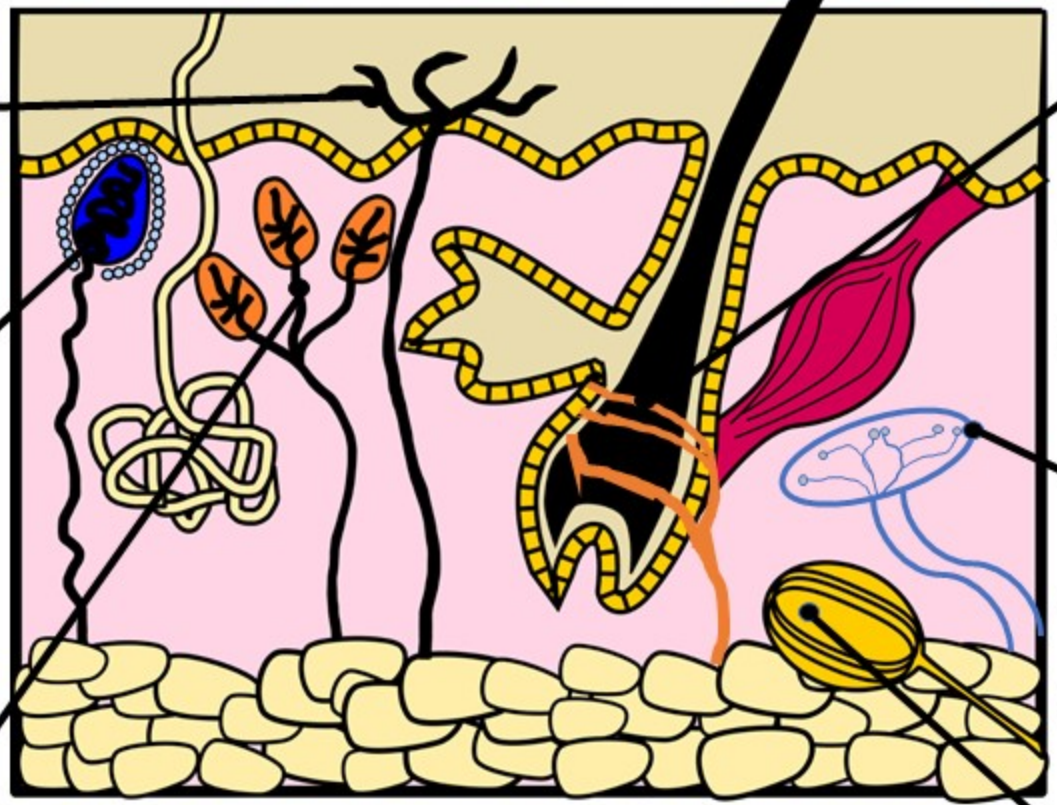
The Senses

- All sensory organs contain **sensory receptors**- dendrites that react to a certain external or internal stimulus.
- There are 5 major types of sensory receptors:
  - 1. **Mechanoreceptors** (touch)
  - 2. **Thermoreceptors** (temperature variations)
  - 3. **Pain receptors**
  - 4. **Chemoreceptors** (chemicals)
  - 5. **Photoreceptors** (light)
- Each sensory organ has one or more of these receptors.

Senses: Touch

- The impulses produced in the skin are called **cutaneous sensations**. These sensations include touch, heat, cold, pressure, & pain.
- These receptors are not equally distributed throughout the body. Some body parts are more sensitive than others.

Touch Receptors



Free nerve endings
Sense pain, temperature, touch, and pressure

Meissner's corpuscles
Encapsulated nerve endings found in hairless skin that detect light touch

Merkel's disk
Detect light touch and pressure within epidermis

Hair follicle receptors
Detect movement of hair

Ruffini's corpuscles
Detect deep pressure and stretching of skin

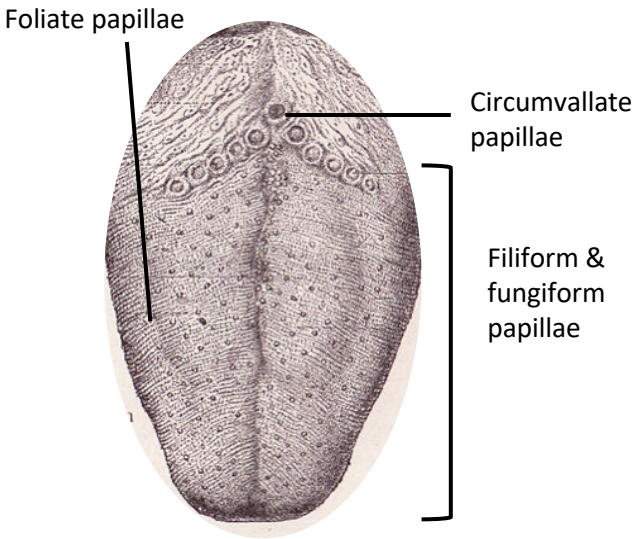
Pacinian corpuscle
Encapsulated nerve endings that detect deep pressure and vibrations

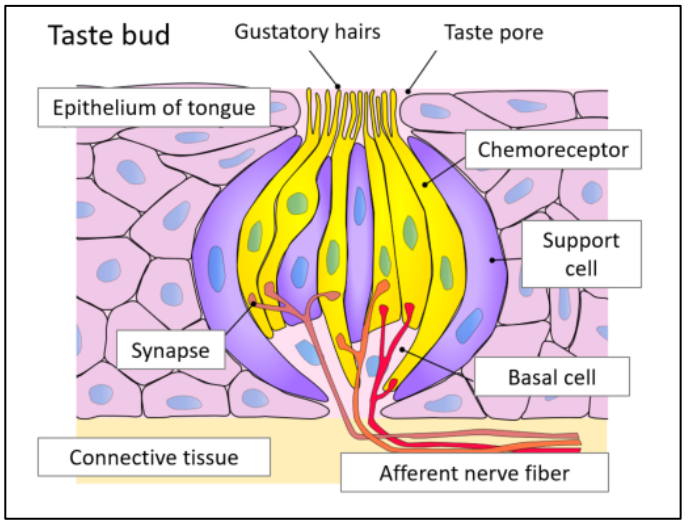
The 4 "Special Senses"

Special senses are those that have a specific organ associated with them.

Senses: Taste

- The tongue is filled with bumps called **papillae**. Many of these papillae contain **taste buds**, which contain **chemoreceptors**.
- These chemoreceptors bind to certain molecules and then initiate an impulse through the nerves.
- Children have more taste buds than adults, so they taste more strongly. Also, a child's taste buds are replaced more often than an adult's. This is why children become "less picky" as they grow.

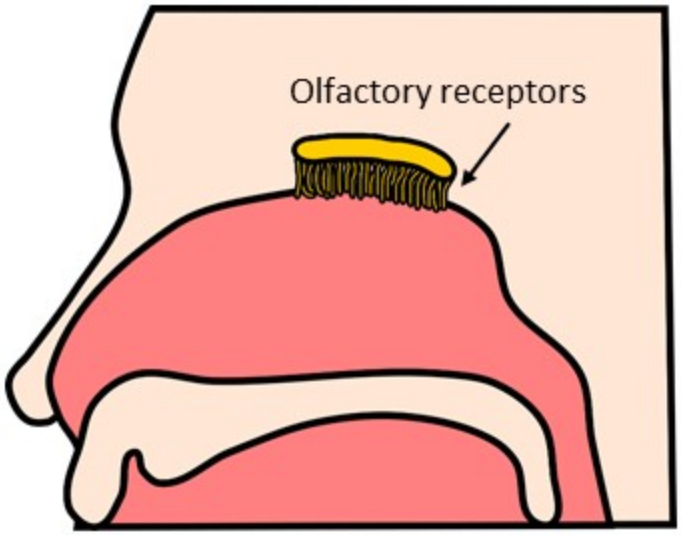




Cross section of a taste bud

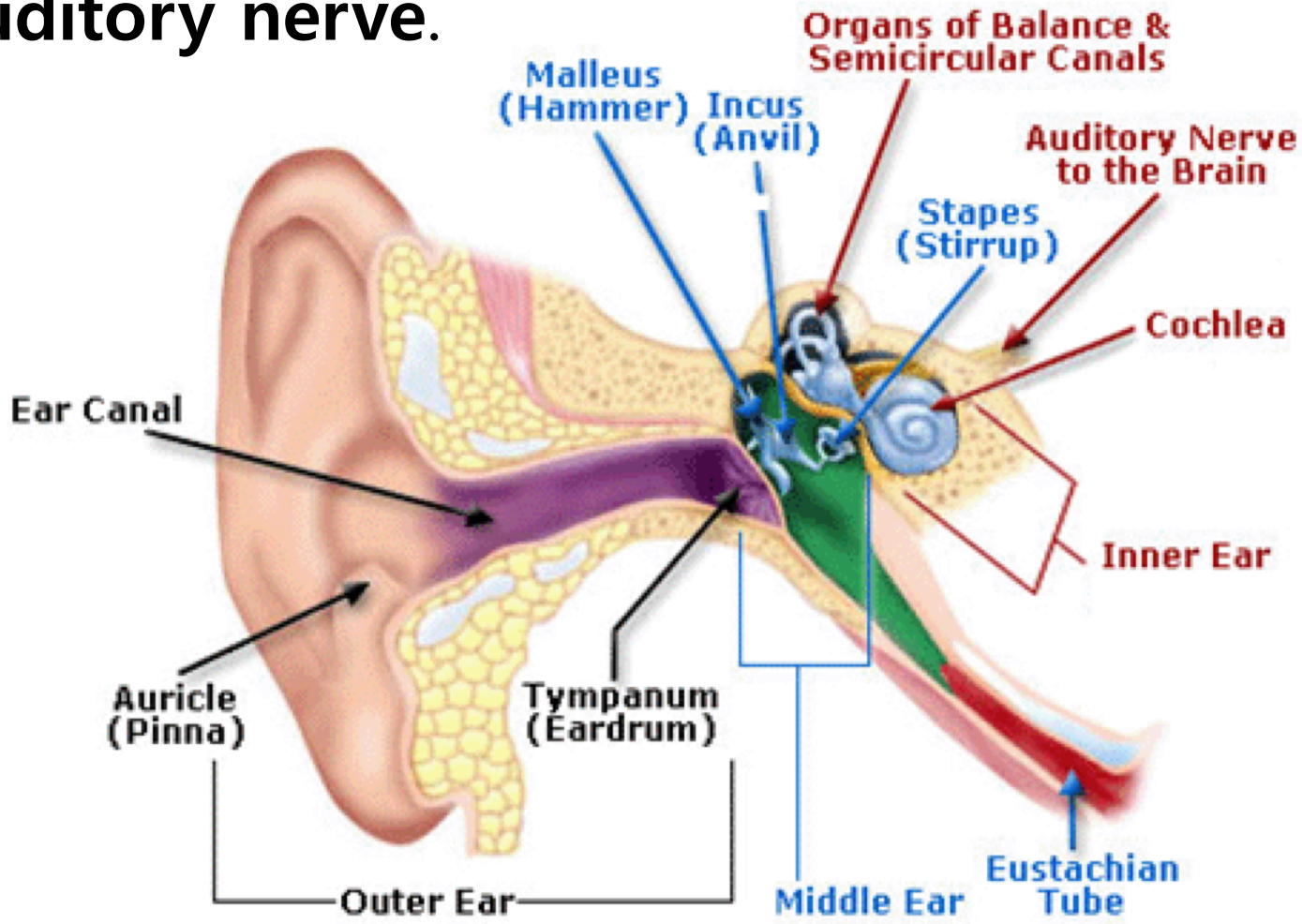
Senses: Smell

- The sense of smell is closely related to the sense of taste.
- **Olfactory receptors** in the upper nasal cavities help to distinguish thousands of different molecules.
- "Sniffing" helps to bring these molecules into contact with the olfactory receptors.
- When olfactory receptors contact a substance continually, they become insensitive to the smell. This is called **accommodation**.



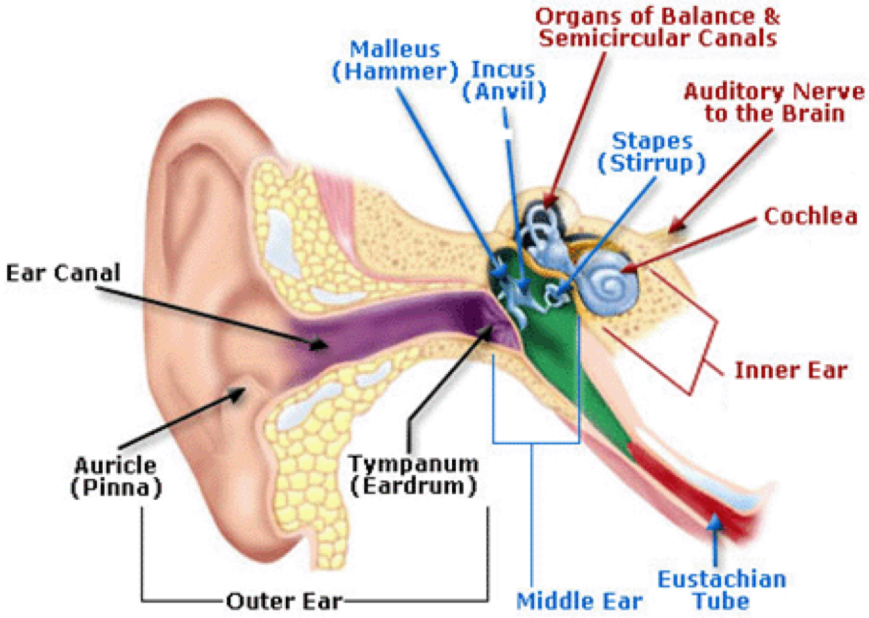
Senses: Hearing

- The structures of the ear all work together to collect and transfer sound vibrations to the **auditory nerve**.



Senses: Hearing

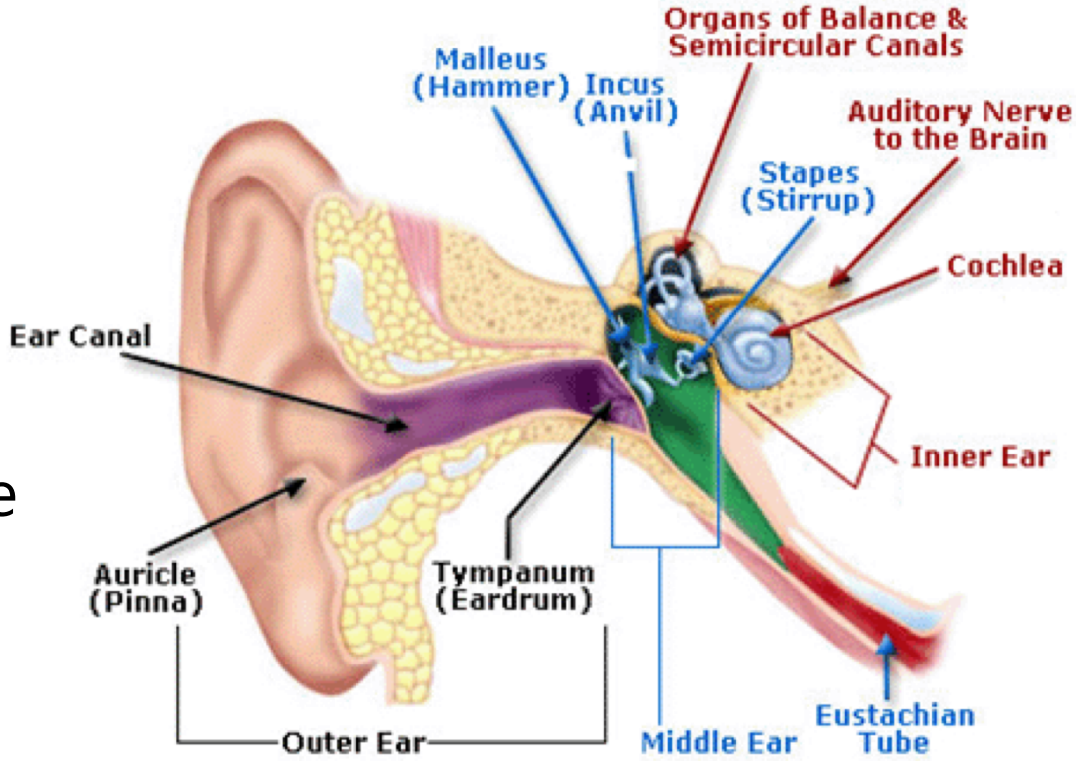
- Sound waves are collected by the **auricle** (outer ear) and are passed through the **external auditory canal.**
- The sound waves then vibrate the **tympanic membrane** (eardrum).
- Sound waves then travel through the middle ear, a set of 3 tiny, jointed bones: **malleus**, **incus**, and **stapes**
  - These are commonly known as the hammer, the anvil, and the stirrup.
  - They amplify the sound waves to the inner ear through a membrane called the **oval window.**



Watch a video of the ear working:
https://www.youtube.com/watch?v=dCyz8-eAs1I

Senses: Hearing

- The inner ear contains the **cochlea**, a bony snail-shaped structure containing membranes filled with fluid.
- As the tiny hair cells (stereocilia) inside the cochlea vibrate, they depolarize the ends of the nerve cells, which begins an action potential, transferring the impulse to the brain through the auditory nerve.
- The brain registers these impulses as sounds.

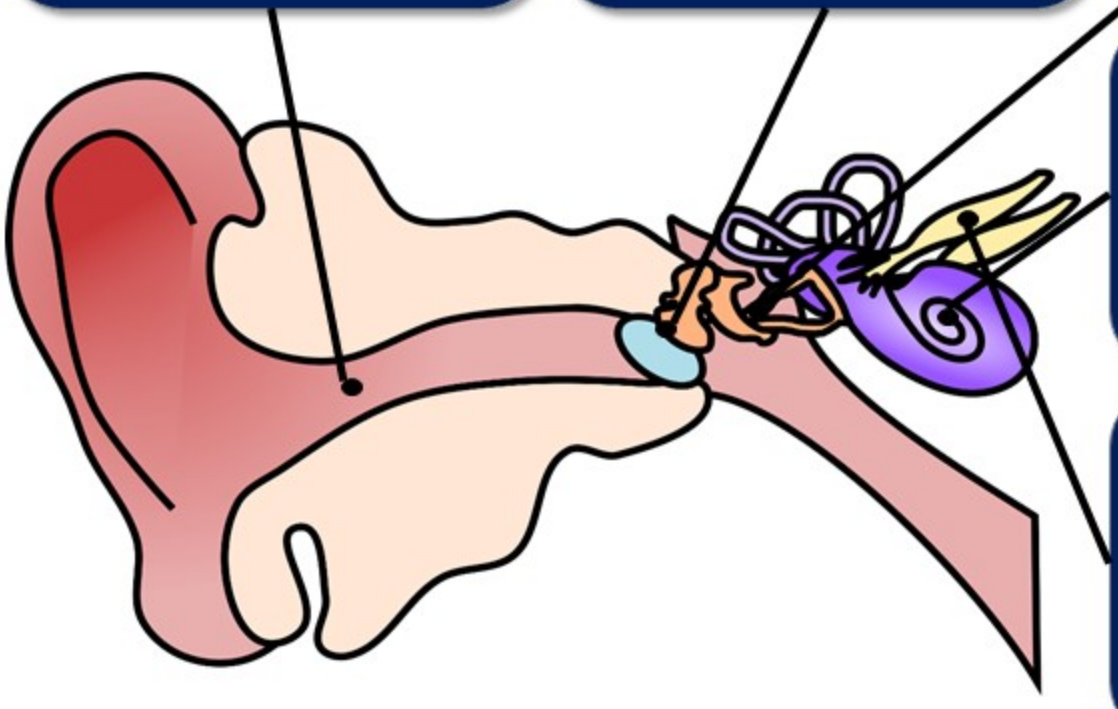


Hearing: An overview

1. Sound waves enter your outer ear and travel down the ear canal.

2. The tympanic membrane (eardrum) vibrates and sends the vibrations to the tiny bones in the middle ear (ossicles).

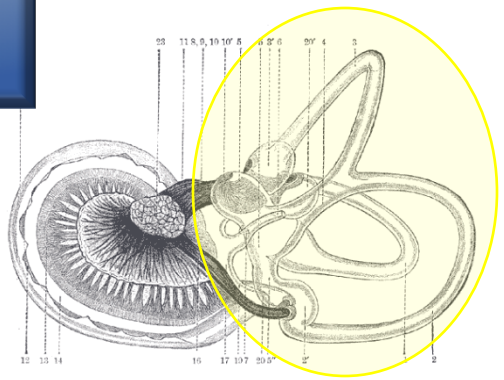
3. The malleus, incus, and stapes amplify the vibrations and send them to the inner ear.



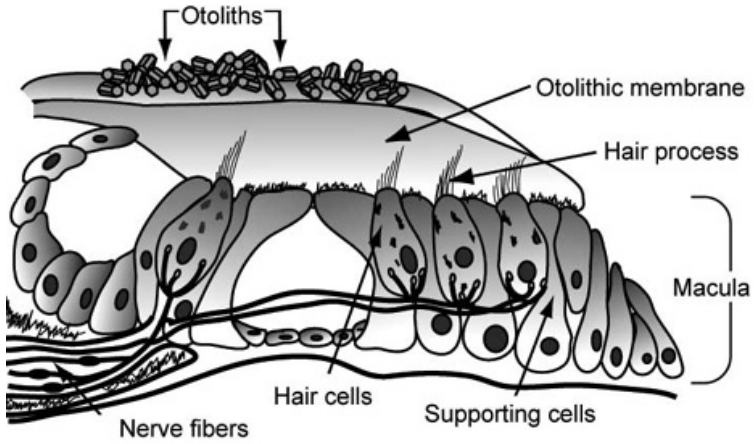
4. Within the cochlea, the organ of Corti is filled with stereocilia that transmit the mechanical energy of sound waves into electrical signals.

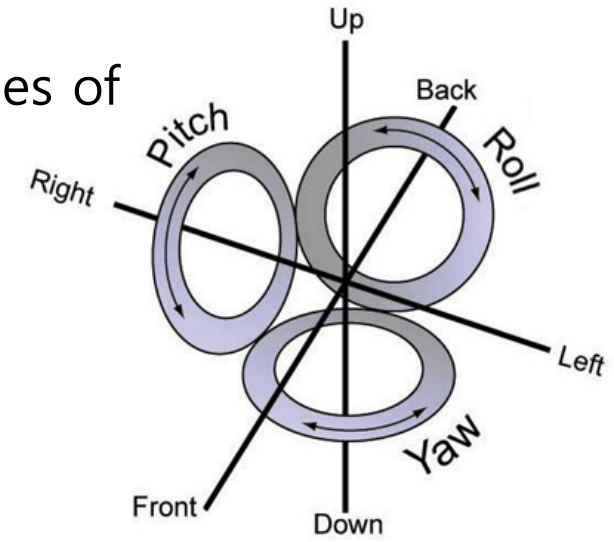
5. The electrical impulse travels through the auditory nerve towards the brain, which interprets the impulse as sounds.

Senses: Balance



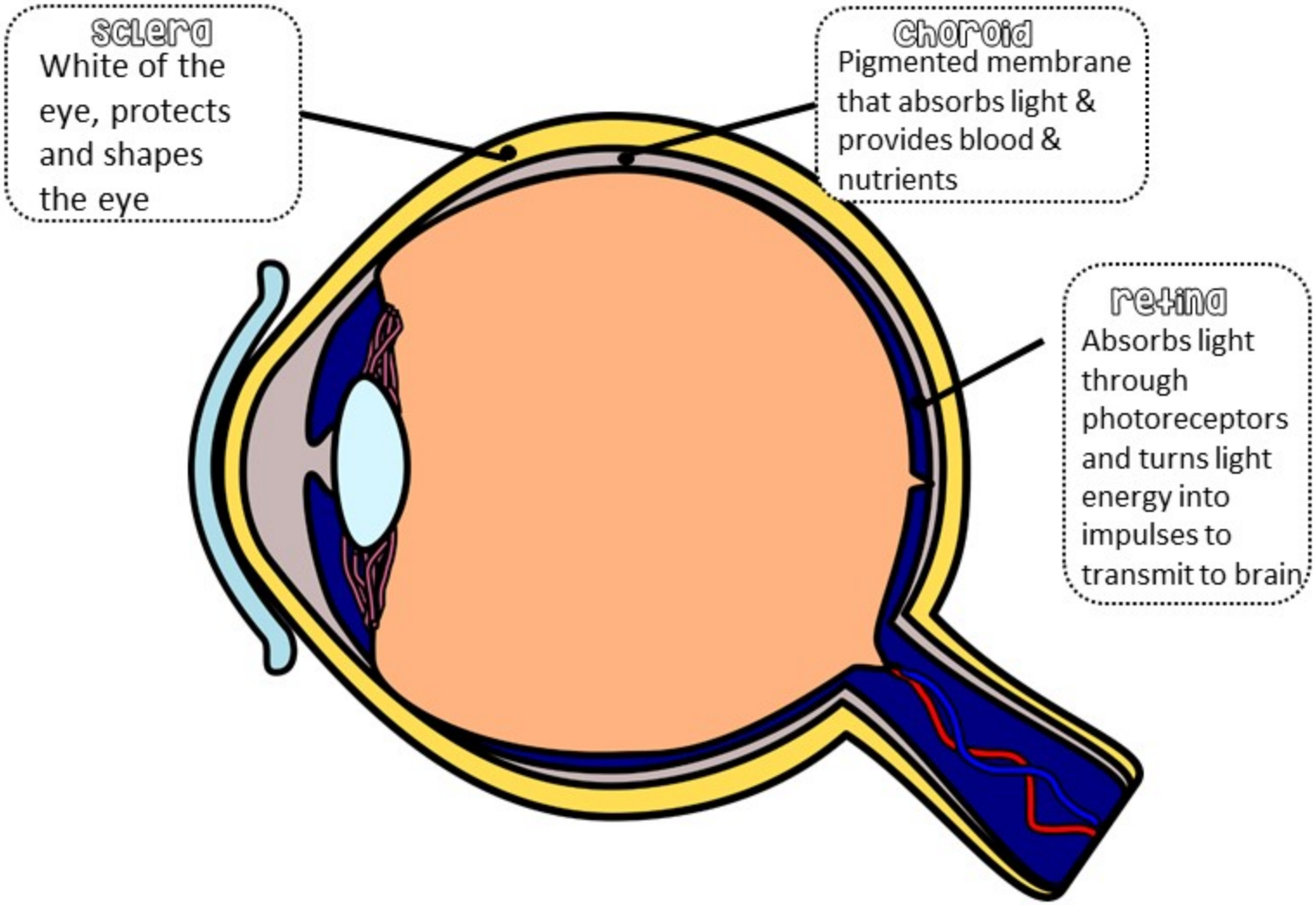
- In addition to hearing, the ear also helps us with balance.
- Three **semicircular canals** are located above the cochlea and are situated at right angles to each other.
- These canals are filled with fluid and lined with hair cells. Above the hair cells are tiny crystals called **otoliths**. When the head moves, these otoliths slide, stimulating the hair cells and sending an impulse to your brain.
- Because the 3 canals are at right angles, all types of motion can be recognized.





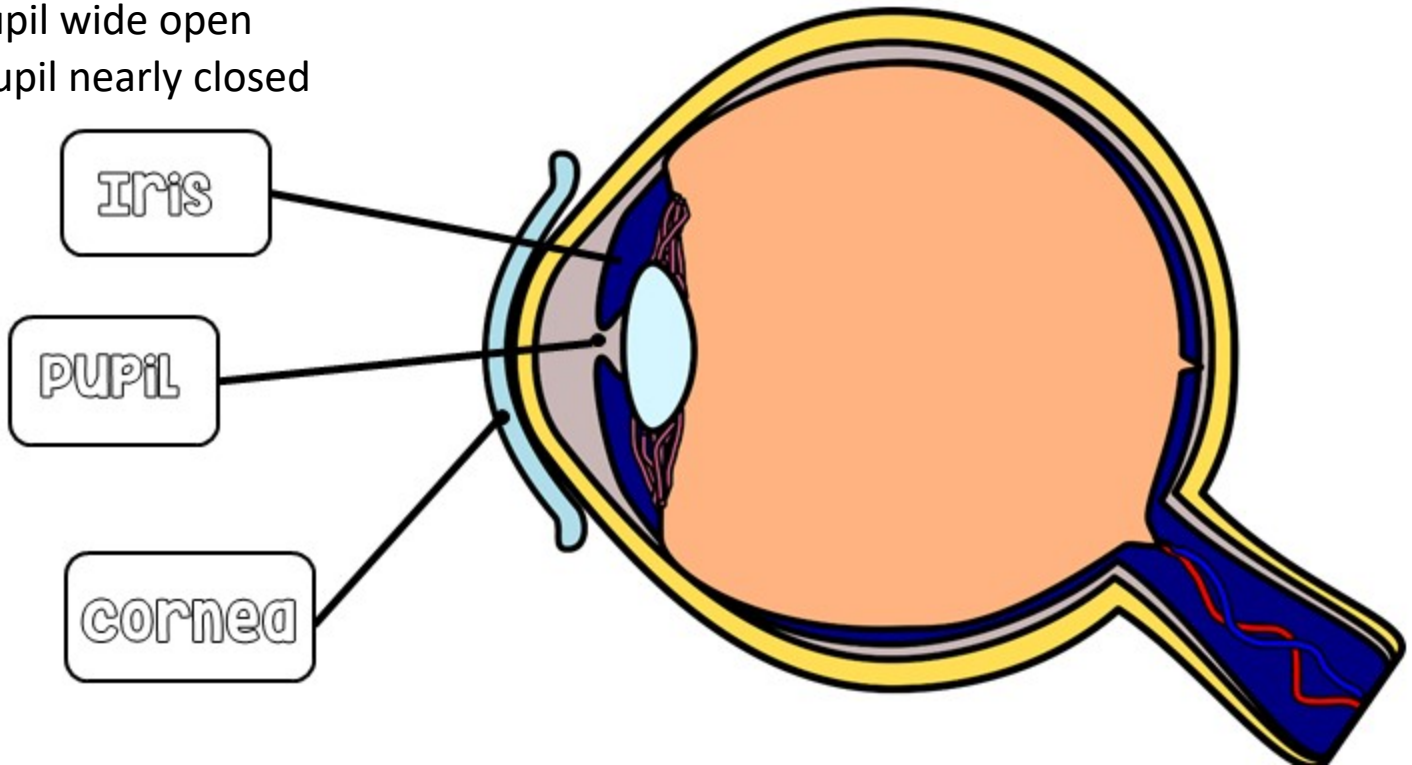
Senses: Vision

- The eye is comprised of 3 tissue layers:



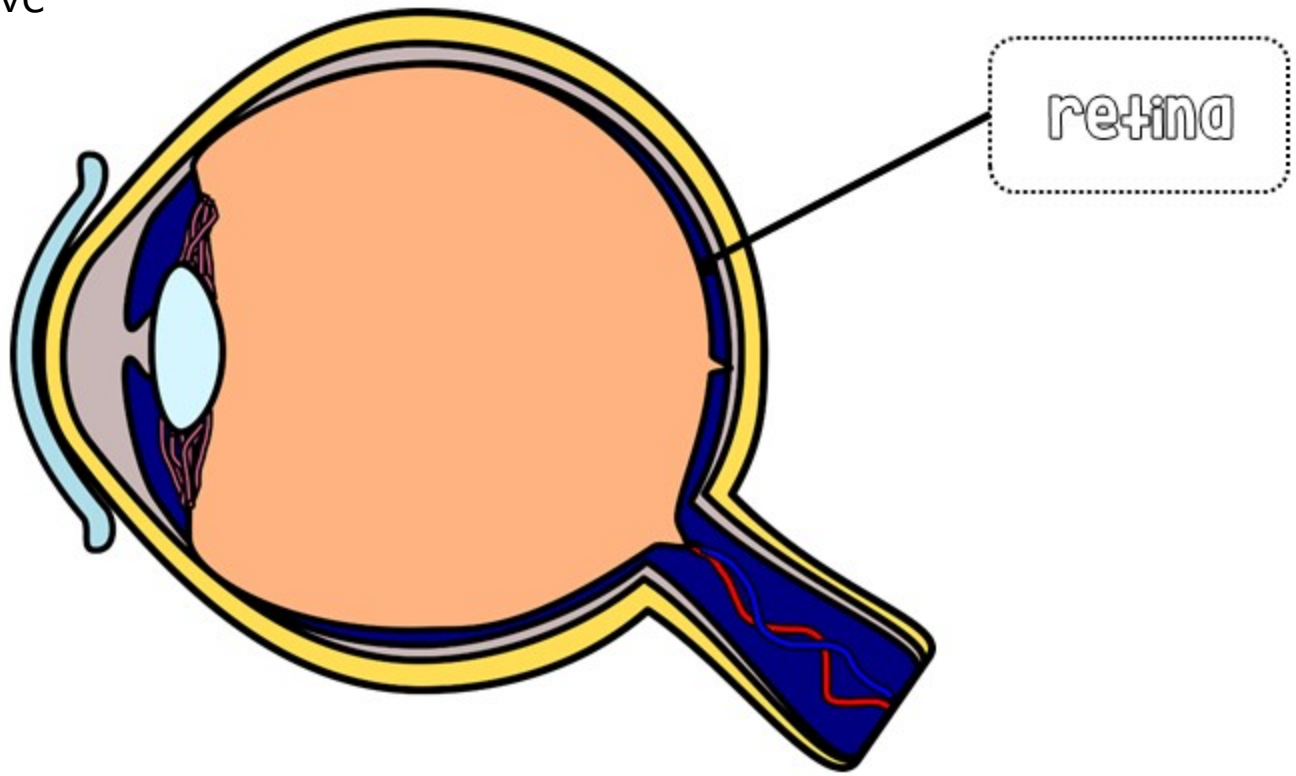
Senses: Vision

- Cornea is made of thick, transparent tissue
  - Function= allows light into the eye
- The iris is located behind the cornea. It is the colored part of the eye.
  - Function= works with pupil to regulate light entering the eye
- Pupil is the opening in the center of the iris
  - Function= muscles regulate the amount of light entering the eye
    - Low light- pupil wide open
    - High light- pupil nearly closed



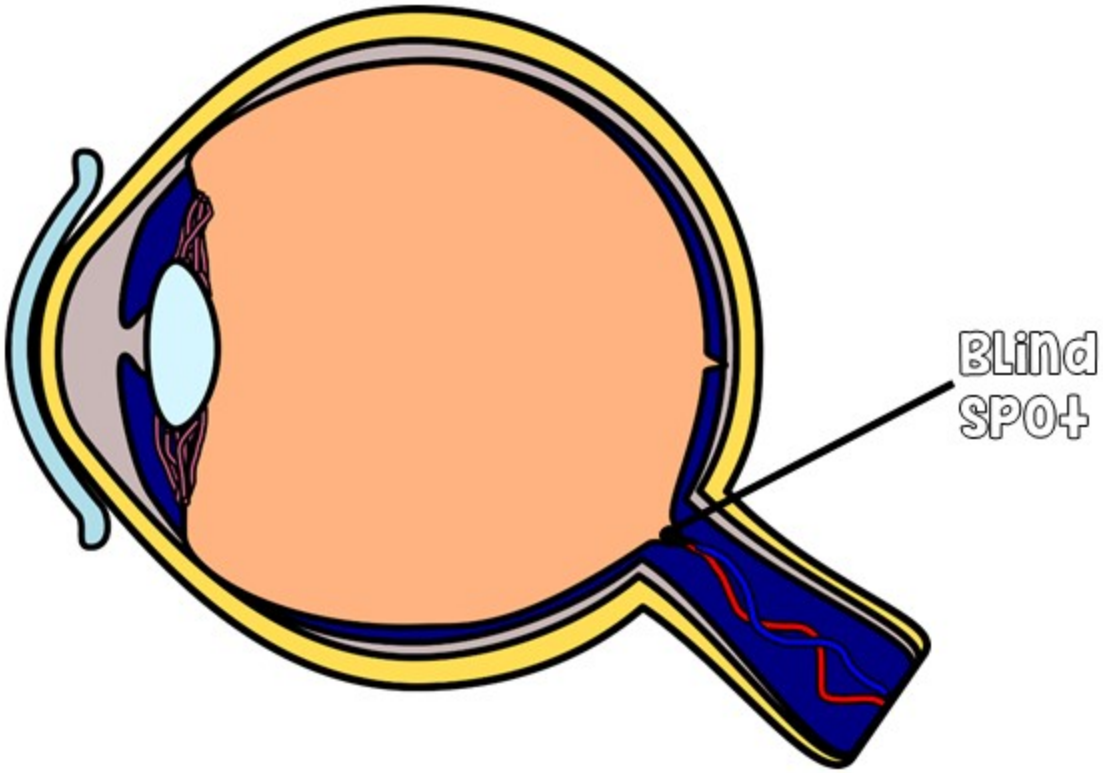
Senses: Vision

- The **retina**, located in the back of the eye, contains thousands of photoreceptors.
- There are two kinds of photoreceptors:
  - **Rods-** distributed all over the retina. Responsible for vision in low light, extremely sensitive
  - **Cones-** concentrated in center of retina. Responsible for detection of colors, less sensitive



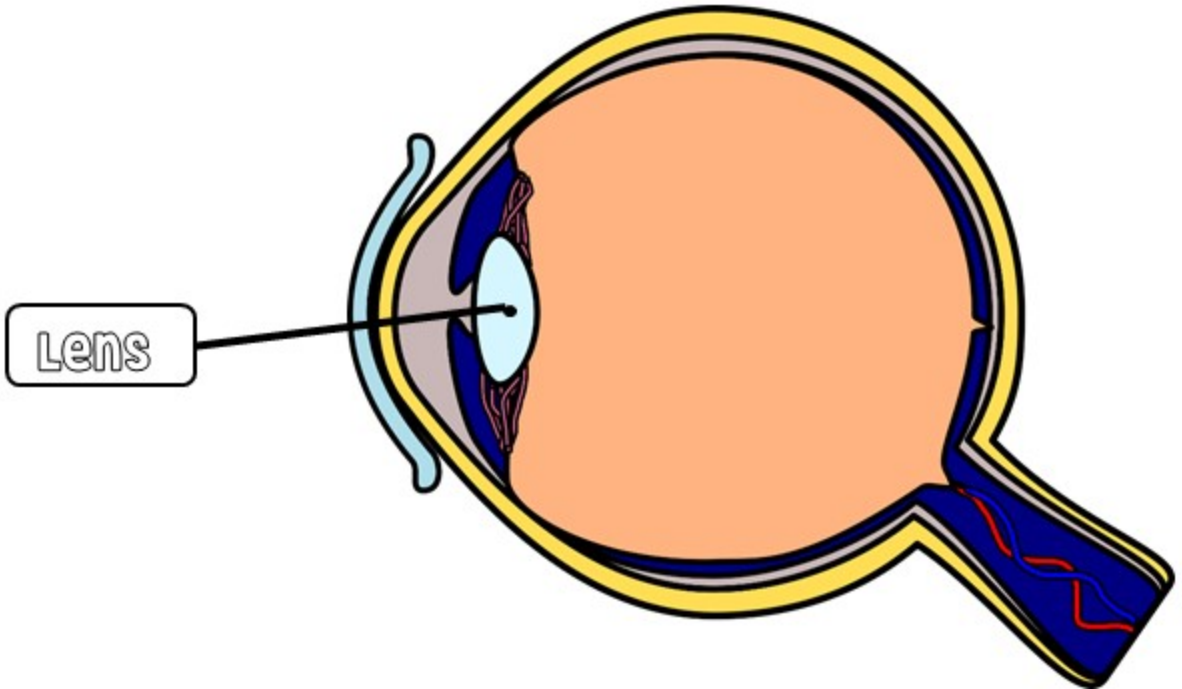
Senses: Vision

- There are no photoreceptors where the optic nerve meets the eye. This is called a **blind spot**.
- Because this blind spot affects different parts of each eye, it is not regularly noticed. The brain "fills in" the missing images.



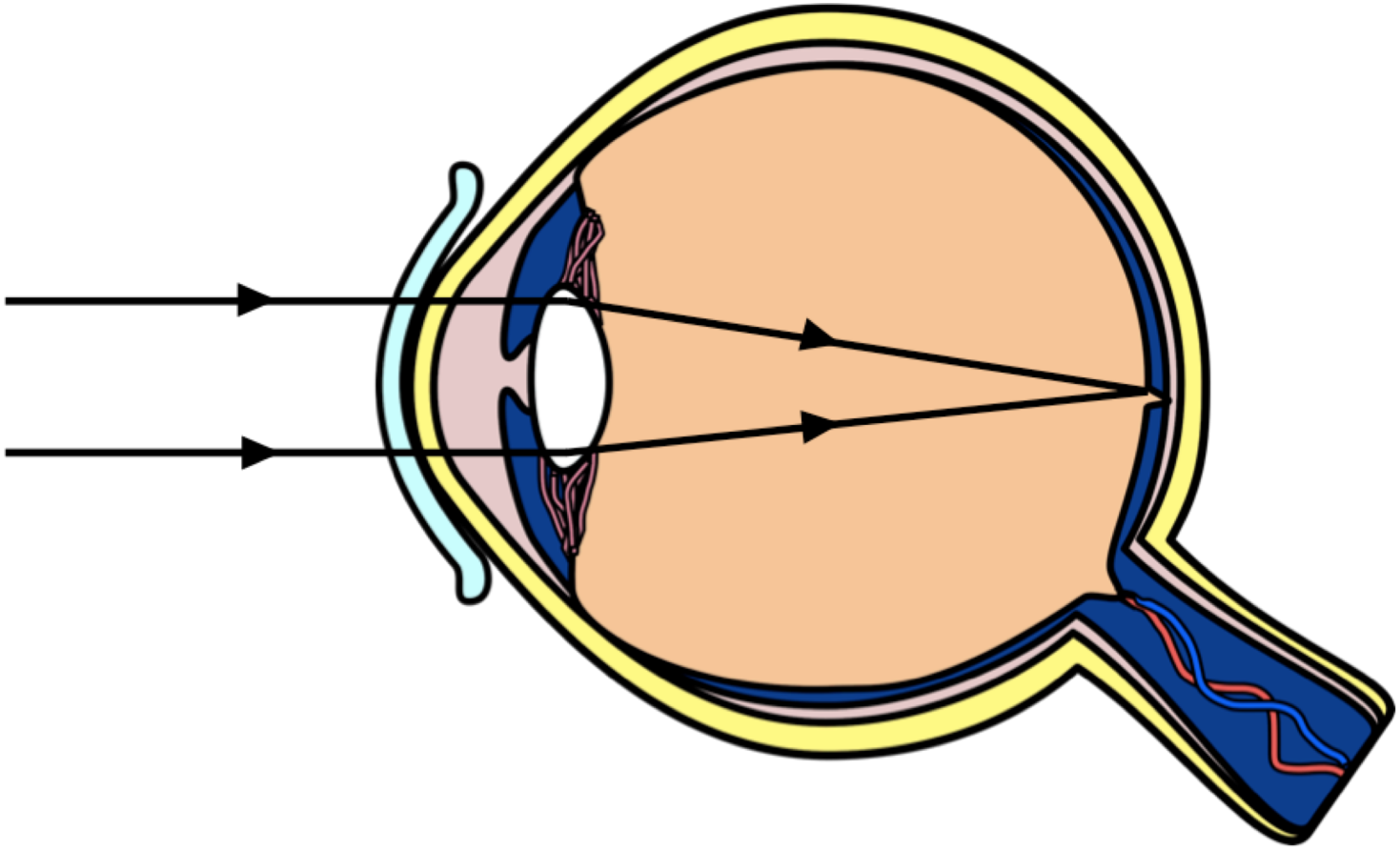
Senses: Vision

- The **lens** is a semi-solid disc that directs light waves towards the retina.
- It is controlled by **ciliary muscles** and **suspensory ligaments**.
- These muscles and ligaments help bend or flatten the lens based on the distance of the image being viewed.
  - The lens becomes less elastic with age, causing some adults to need corrective lenses to have difficulty focusing at certain distances.



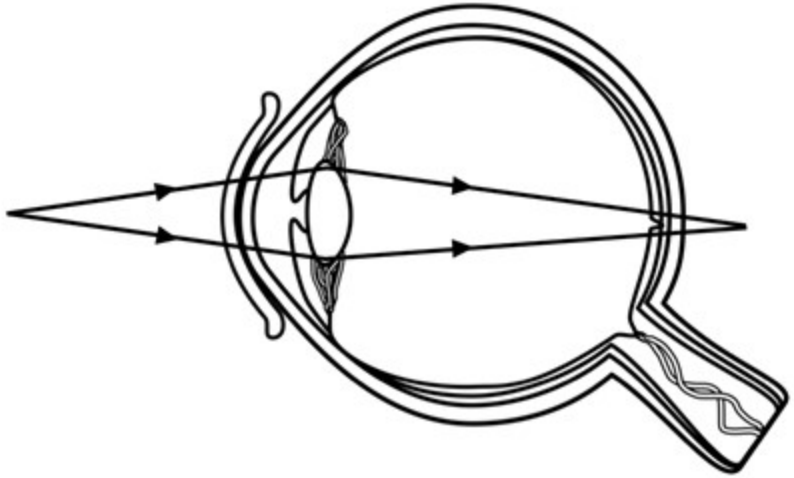
Senses: Vision

- The lens is responsible for focusing the light on the retina, to be interpreted by the photoreceptors and sent to the brain.

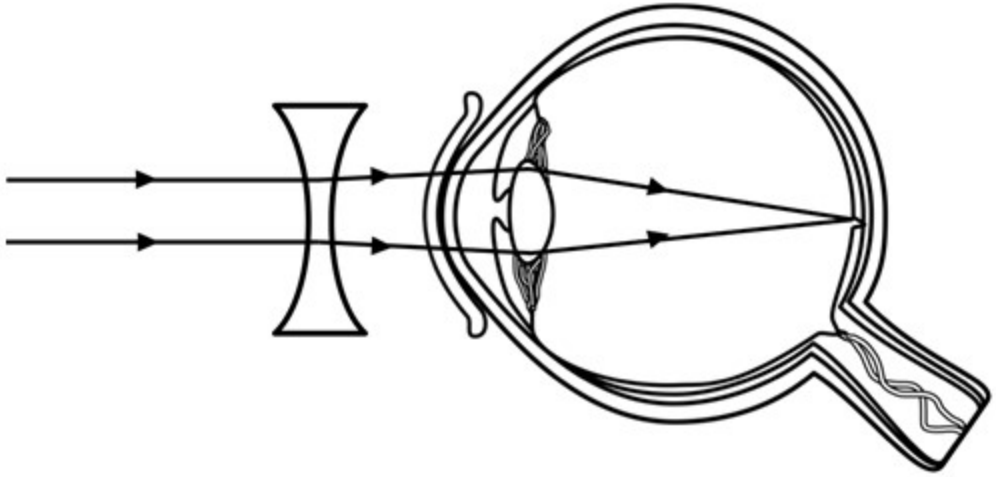


Senses: Vision

- In some individuals, the eye is too long or too short, causing near-sightedness or far-sightedness.
- Corrective lenses help to refract the light so they accurately converge on the retina.



Far-sightedness
(eyeball is too short)



Eyeball after corrected lenses are added

Senses: Vision

- In front of the lens is a fluid called **aqueous humor**, which nourishes the cornea and behind the lens is the **vitreous humor**, which is a thick, jelly-like fluid that refracts light and fills the space between the lens and retina.