

# Chapter 35

## Nervous System



# Objectives

- You will be able to describe the function of the nervous system, relate the structure of a neuron to its function and explain the changes that occur across a neuron during the transmission of a nerve impulse.



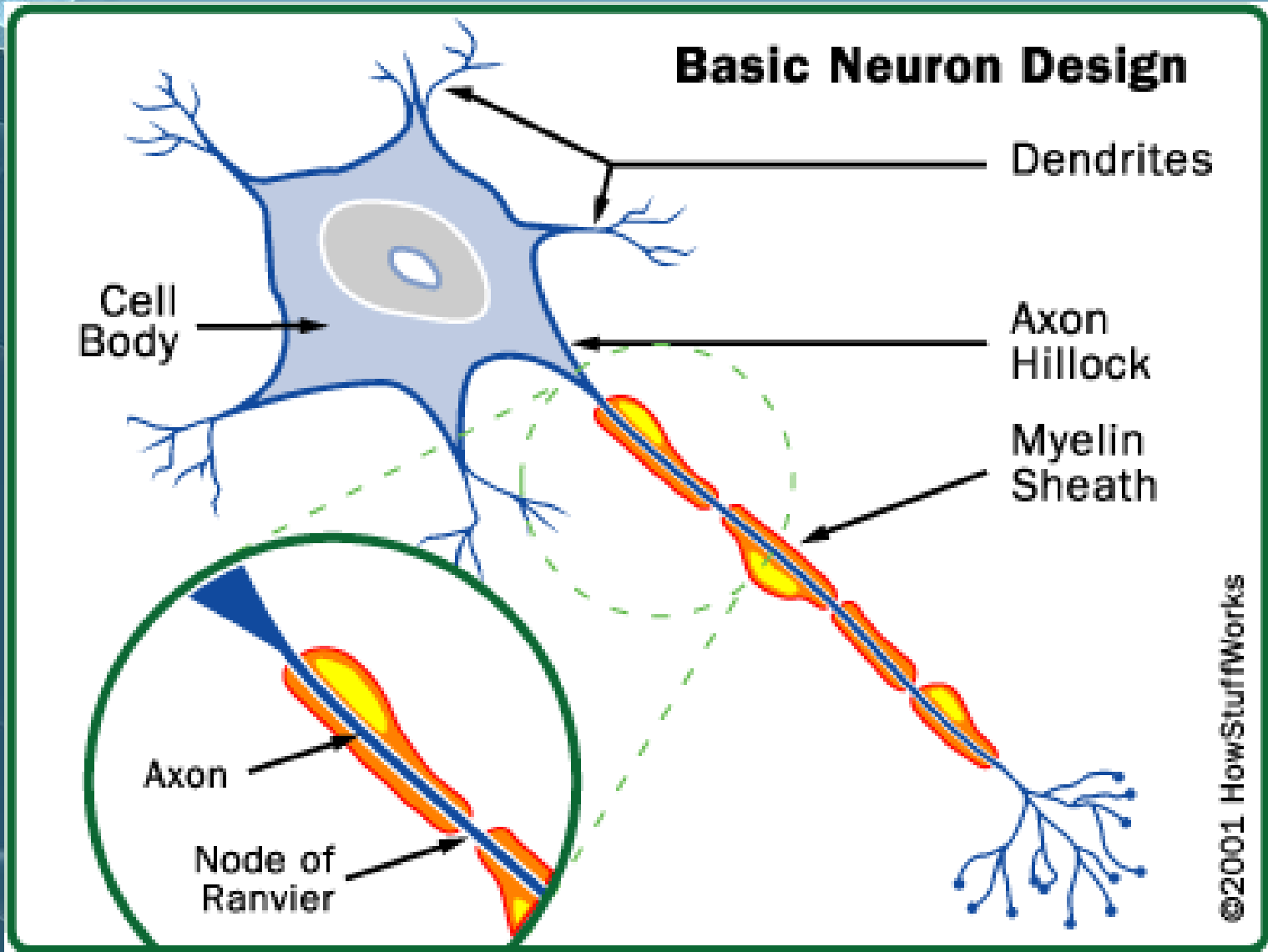
**Nervous System – controls and coordinates all the essential functions of the human body.**



# I. The Neuron

1. Neuron – cell that carries messages throughout the nervous system.
2. Impulses – these messages take the form of electrical signals called impulses.
  - A. Three types of Neurons
    1. Sensory neurons – carry impulses from the sense organs to the brain and spinal cord.
    2. Motor neurons – carry impulses from the brain and spinal cord to muscles or glands.
    3. Interneurons – connect sensory and motor neurons & carry impulses between them.

# Structure of a Typical Neuron





**Cell Body:** largest part, contains the nucleus & most of the cytoplasm.  
**Function:** generation of ATP & synthesis of proteins.

**Dendrites:** carry impulses from environment or from other neurons toward the cell body; neurons can have hundreds of these.



**Axon:** long fiber that carries impulses away from the cell body; nerves generally only have one axon.

**Axon Terminals:** found at the end of the axon. They allow for the release of neuro-transmitters.



## II. The Nerve Impulse

### I. Luigi Galvani

1. Found that the nervous tissue displays electrical activity.
2. This activity is in the form of a nerve impulse which is a flow of electrical charges along the cell membrane of a neuron.
3. Flow is due to the movement of ions.





## II. Resting Potential

1. Nerve cells have approx. 70 millivolts (mv) of electrical potential. 0.00070 volts. 2142 nerve cells would equal 1 AAA battery.
2. The source of this potential is proteins in the neuron known as sodium-potassium pumps. They move  $\text{Na}^+$  out of the cell and pump  $\text{K}^+$  into the cell.



3. This pump results in the cytoplasm of the neuron having more  $K^+$  ions and fewer  $Na^+$  ions along with negative ions already there.
4.  $K^+$  ions leak back across the membrane more easily than  $Na^+$  & the neg. charged ions do not leak in or out.



5. Result: Neg. charged on the inside of the neuron and Pos. charged on the outside. This is called resting potential: the neuron is polarized.
6. Neuron is not actually resting because it must produce ATP to fuel Na-K pump.
7. Neuron will maintain this polarized action until it is stimulated.



# III. The Moving Impulse

1. An impulse causes a movement of ions across the cell membrane of a neuron.
2. An impulse begins when a neuron is stimulated by another neuron or by the environment.
3. At an impulse, Na gates open to allow  $\text{Na}^+$  ions to flow inside causing the inside of the membrane to be more positively charged. Membrane is now depolarized.



4. After the impulse has passed: K gates open and membrane is repolarized, which means the membrane is negatively charged on the inside and positively charged on the outside.
5. Action potential: produced by the depolarization & repolarization of the membrane. Impulses = action potential.

Fig. 35-7 pg. 899




## IV. Propagation of the Impulse

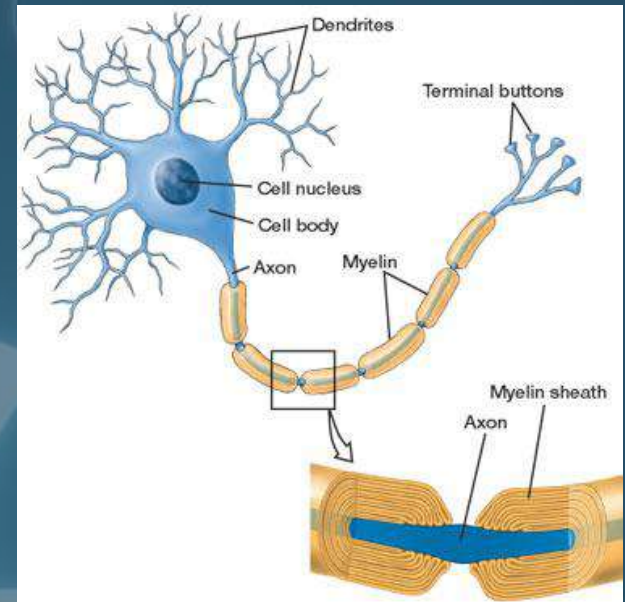
1. Impulses are self-propagating – meaning at any point on the membrane, an impulse can begin.
2. An impulse can only go in one direction (Na gates behind starting impulse point are closed for a brief second).



# V. The Role of Myelin

1. Note: Impulses can move along the membrane at rates as fast as 1 meter per second.
  - Fast Enough? What about large animals?
2. Myelin, made up of lipid & protein (cholesterol), forms an insulating sheath around the axon improving the rate of impulses.

- 
3. Myelinated axons have gaps called nodes in which impulses jump.
  4. This increases the speed to 200 meters per sec.







## VI. The Threshold

1. Definition: the minimal level of a stimulus required to activate a neuron.
2. The strength of an impulse is always the same no matter what the stimulus is.
3. Nerve impulses follow the all or none rule. If the stimulus is weaker than the threshold an impulse will not result.



## VII. The Synapse

1. At the terminals, some neurons will connect with other neuron's dendrites.
2. Receptors – special sensory neurons in sense organs that receive stimuli from the external environment.
3. Effectors – muscles or glands that bring about a coordinated response.



4. The points of contact at which the impulses are passed from one cell to another are called synapses.
5. The tiny sacs on the terminals contain chemicals called neurotransmitters – a substance that is used by one neuron to signal another. See figure 35-8 pg. 900



# Divisions of the Nervous System

The objectives of this section are for you to understand the two major divisions of the nervous system.

-> The human nervous system is divided into 2 major divisions:

1. CNS – Central Nervous System
2. PNS – Peripheral Nervous System



# I. Central Nervous System

1. Located in the center of the body and includes the brain and spinal cord.
2. Both are protected by bone.
3. Functions: relay messages, process information, compares and analyzes information.
4. CNS does not come in contact with the environment.



## II. Peripheral Nervous System

1. Lies outside the CNS.
2. Includes all nerves (and bundles of axons) that are not part of the CNS.



# The Central Nervous System

## 1. The Brain

1. Protected by bone and three layers of connective tissue called meninges.
2. Pia mater: inner-most layer which covers the brain.  
Function: Has many blood vessels to help carry food and O<sub>2</sub> to the spinal cord.
3. Dura mater: thick outermost layer.
4. Arachnoid layer – found in the middle; cobweb like.
5. Found between the pia mater and the arachnoid is a space filled w/ cerebrospinal fluid – protects the brain.
6. The brain must have food and oxygen at all times – only a few minutes without oxygen can cause enormous damage.

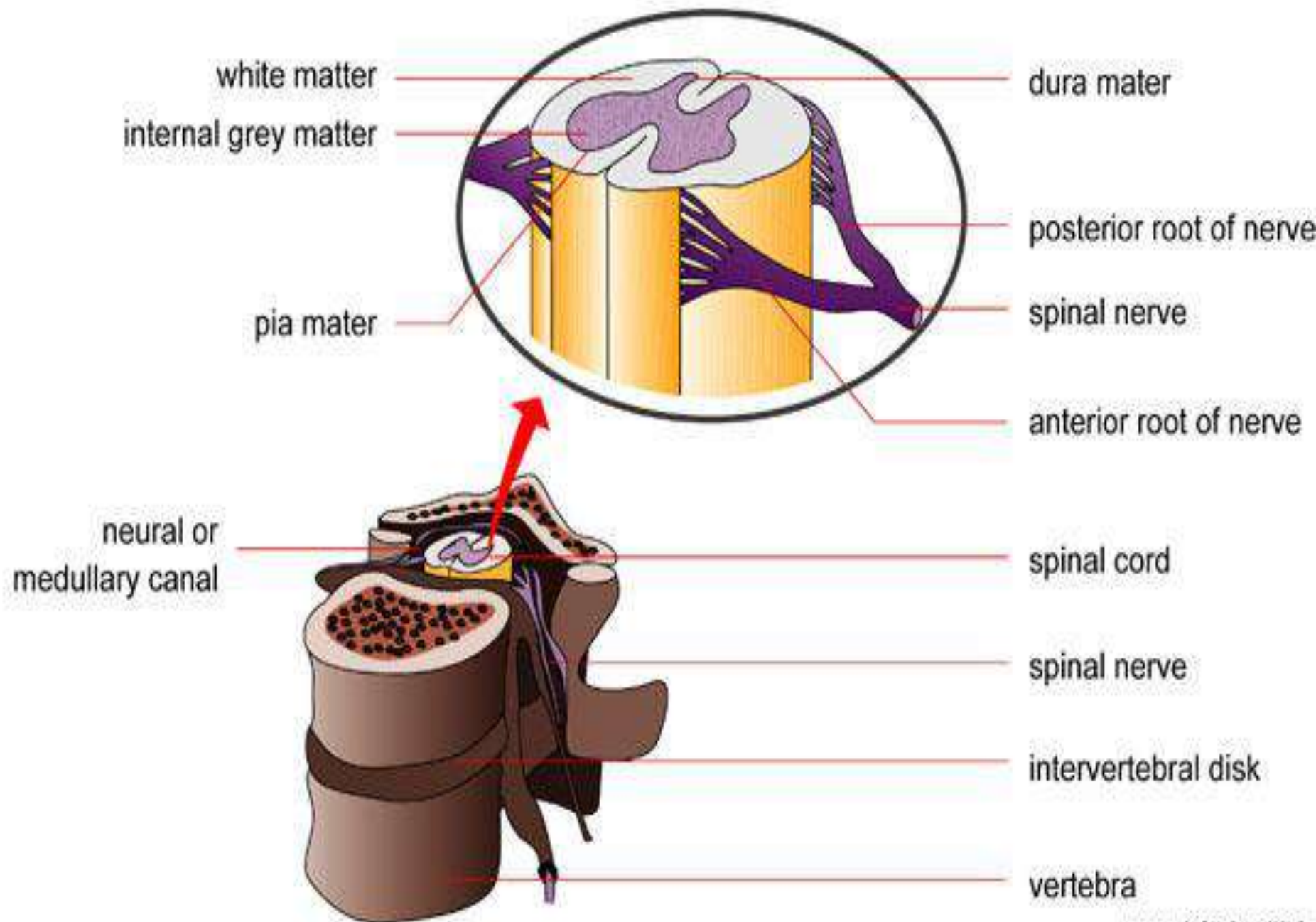


## II. Spinal Cord

1. A continuation of the brain.
2. Stretches approximately 42-45 cm.
3. Protected by bone, the meninges, and cerebrospinal fluid.



# SPINAL CORD

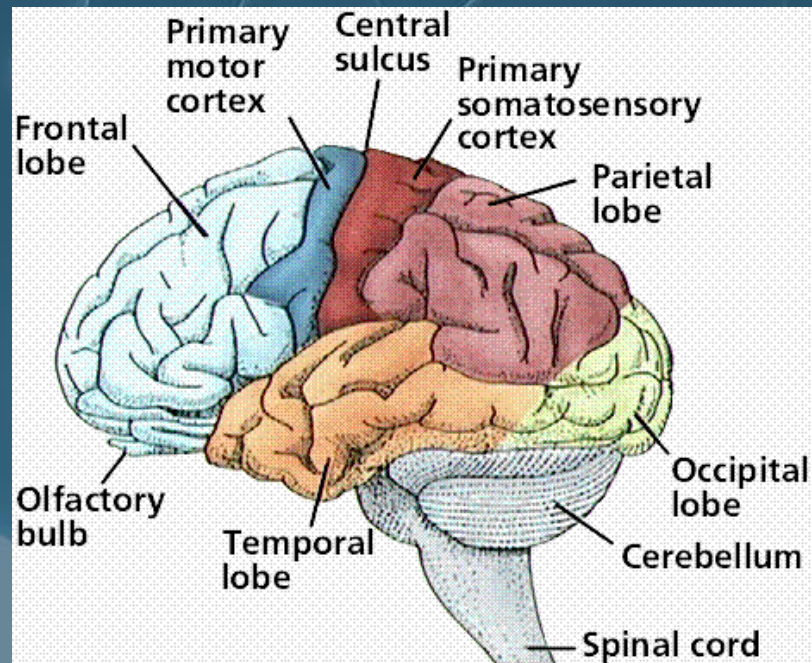




## III. The Cerebrum

1. The largest, most prominent part of the brain.
2. Responsible for all voluntary activities.
3. Also the site of intelligence, learning, and judgement.
4. Divided into left and right hemispheres which are connected by the corpus collosum.
  1. Allows Na or K ions to pass through.

5. Found on the surface are a number of folds which increase surface area.
6. Each hemisphere is then divided into lobes.
7. Left hemisphere controls the right side of the body and vice versa.





## IV. The Cerebrum Consists of Two Surfaces

### A. Cerebral Cortex.

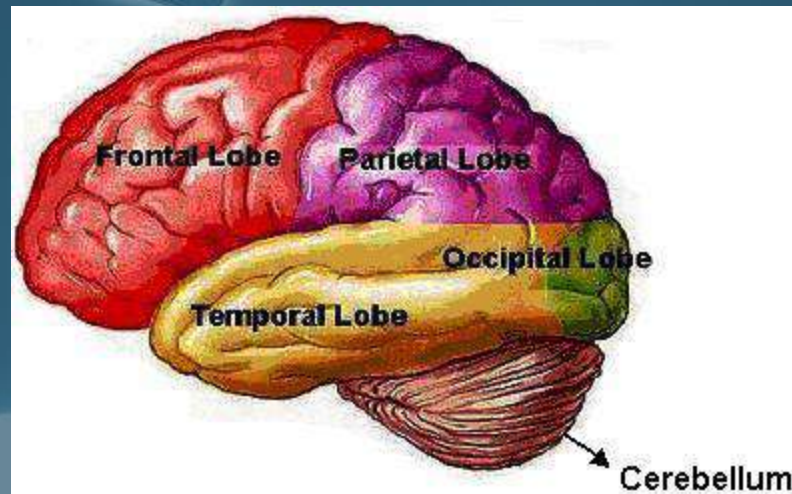
1. Outer surface of the cerebrum.
2. Consists of gray matter which is composed of packed nerve cell bodies.

### B. Cerebral Medulla

1. Inner surface of cerebrum.
2. Consists of white matter which is composed of myelinated axons.

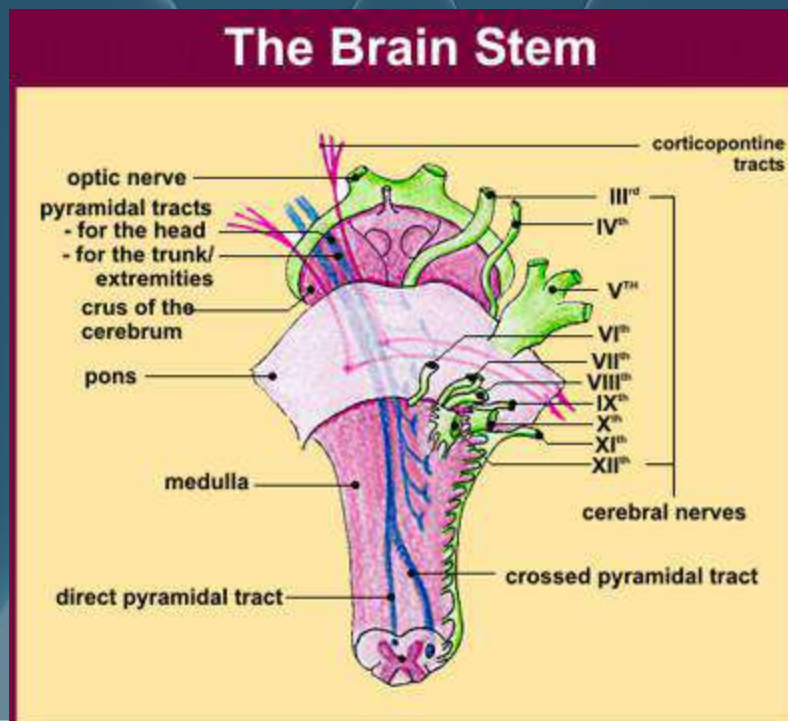
# V. Cerebellum

1. 2<sup>nd</sup> largest part of the brain. Located in the back of the skull.
2. Coordinates and balances the actions of muscles.



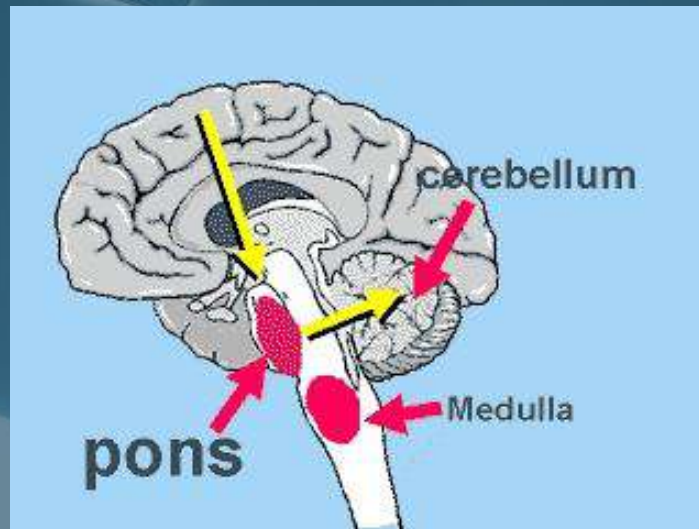
# VI. The Brainstem

1. Connects brain to spinal cord.
2. Serves as a place of entry and exit for 10 of the 12 cranial nerves.



# A. Medulla Oblongata

1. The lowest part of the brainstem.
2. Controls involuntary functions such as breathing, blood pressure, heart rate, swallowing, and coughing.





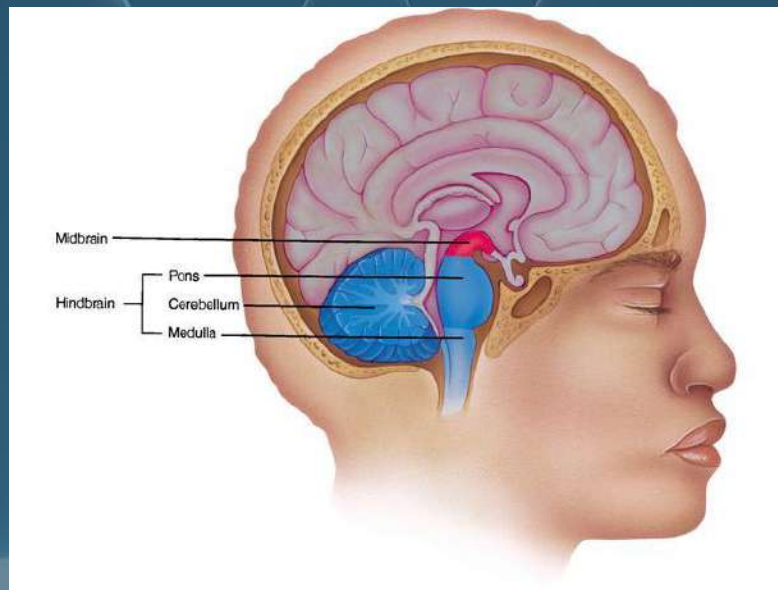
## B. Pons

1. Found above the medulla oblongata.
2. Provides a line between cerebral cortex and cerebellum



# C. Midbrain

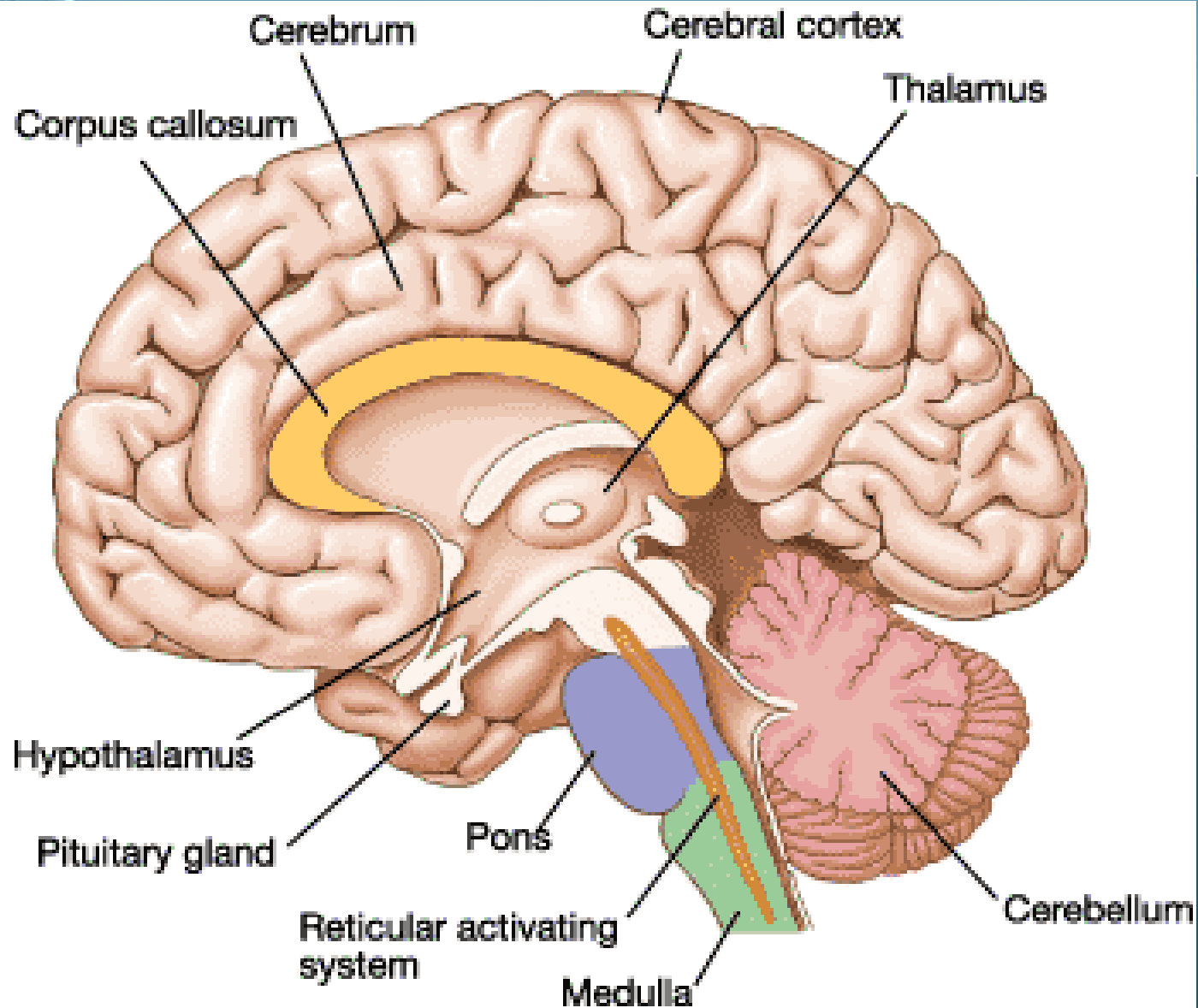
1. Found above the pons.
2. Functions in hearing and vision.





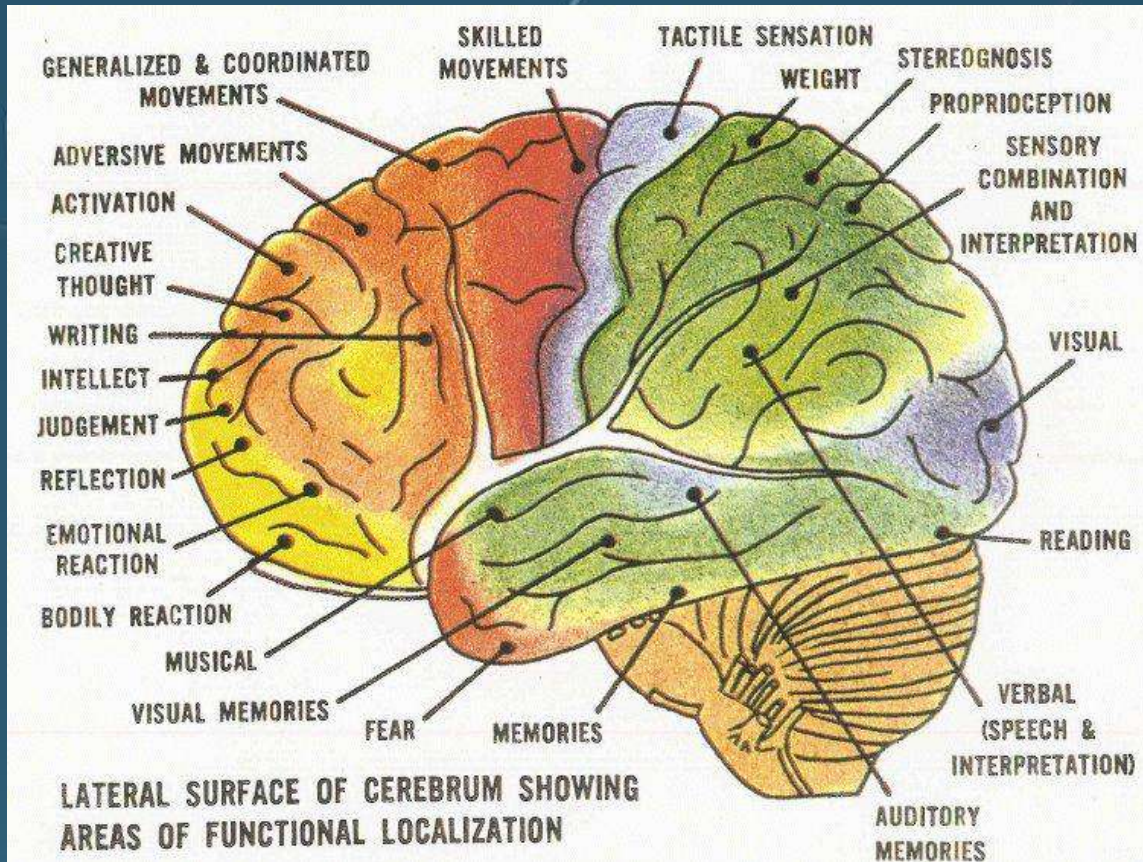
## VII. The Thalamus and Hypothalamus

1. Found between the brainstem and cerebrum.
2. Thalamus – functions in sensory input except for smell.
3. Hypothalamus – control center for hunger, thirst, fatigue, anger, and body temperature.



# VIII. Functions of the Brain

- Discuss Picture on handout also.





## IV. The Spinal Cord

1. Acts as a communication link between the brain and the PNS.
2. Also regulates reflexes -> the simplest response to a stimulus. (sneezing, blinking)
3. There are 31 pairs of neurons that originate in the spinal cord.
4. It too is made of gray and white matter.



# The Peripheral Nervous System

- PNS consists of the cranial & spinal nerves ganglion.
- Two divisions of the PNS.
  - A. Sensory Division
    1. Transmits impulses from sense organs to CNS.
  - B. Motor Division
    1. Transmits impulses from CNS to muscles or glands.
    2. Also divided up into the somatic nervous system and the autonomic nervous system



# I. The Somatic Nervous System

1. Regulates activities under conscious control like movement of skeletal muscles.
2. This system also contains reflexes which occur automatically (example: stepping on a tack).
3. Reflex arc – receptor, sensory neuron, motor neuron, and effector that are involved in a quick response to a stimulus.



# Example : Stepping On A Tack

- Receptor – Found in Skin - Once the threshold is reached, impulse is started.
- Sensory Neuron – nerve fiber of sensory neuron carries impulse to spinal cord.
- Motor neurons are activated before the impulse even reaches the brain.
- Effector – Leg muscles pull foot away from the tack.



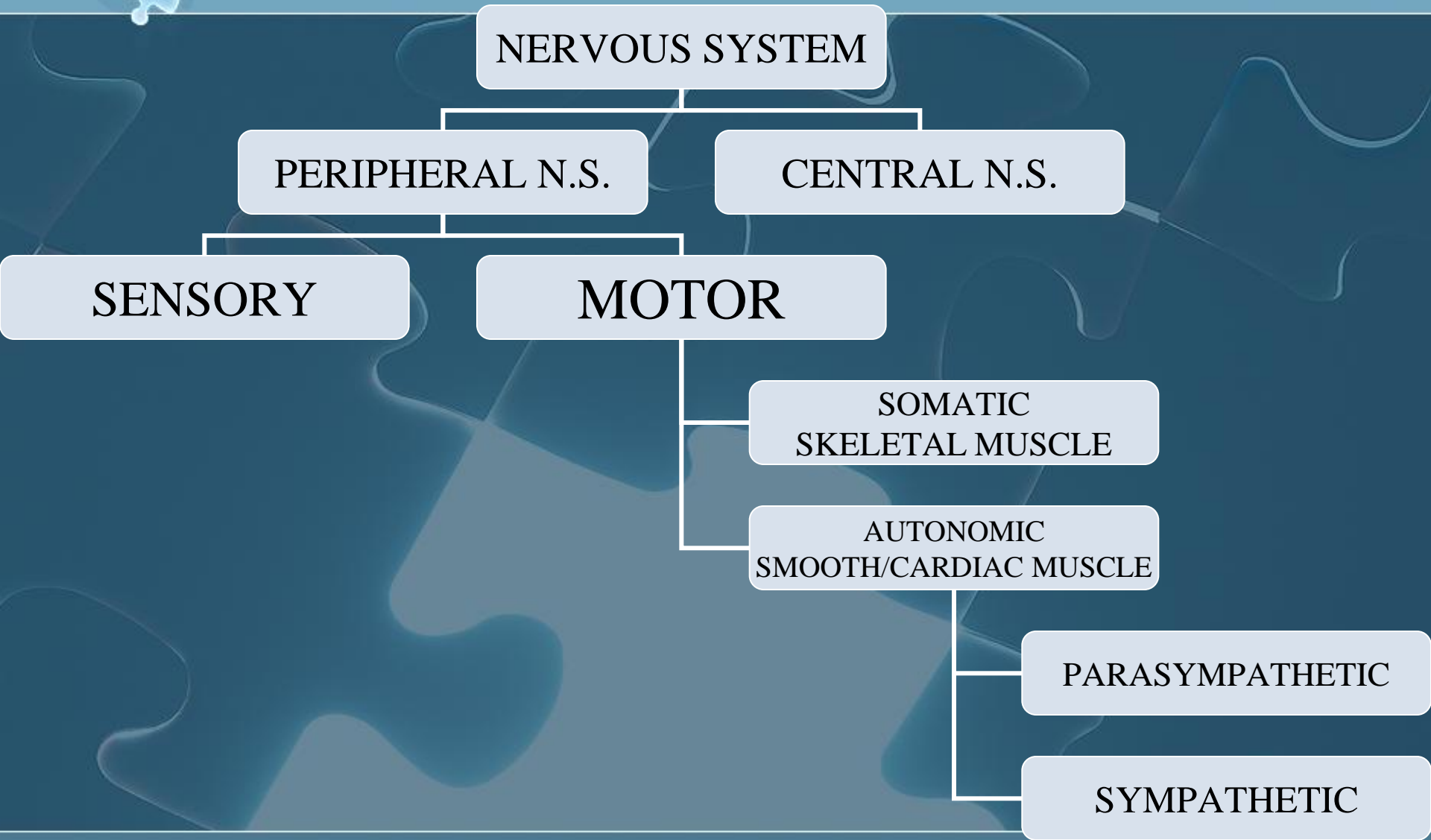


## II. The Autonomic Nervous System

1. Regular activities that are involuntary.  
Ex. Contraction in the heart or digestive system.
- A. Divided into 2 Parts
  1. Parasympathetic Nervous System.
  2. Sympathetic Nervous System.
- Most organs are controlled by both
  - Ex. Heart rate is increased by sympathetic and slowed down by parasympathetic.
  - Why? Like driving a car, w/o a brake the accelerator would decrease too slow in situations.



# Diagram of the Nervous System





# The Senses

- Sensory receptors do not receive impulses from other neurons but react directly to stimulation from the environment are contained in the sense organs.
- The five senses: sight, hearing, taste, touch, smell
  - All have a sense organ.



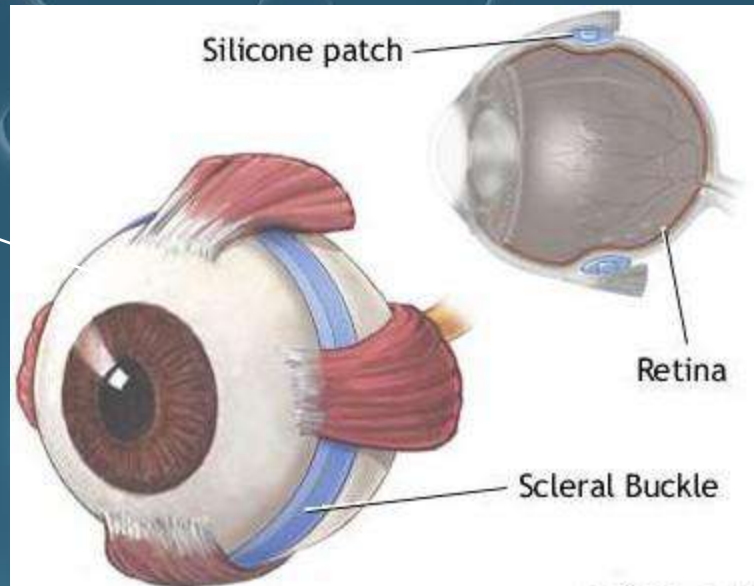
# I. Vision

- A. Eye is composed of Three Layers
  - 1. Sclera and Cornea make up the outer layer.
  - 2. Choroid, ciliary body & iris make up the middle.
  - 3. Retina is the inner layer.

## B. Sclera

1. White of the eye.
2. Helps maintain shape of the eye & provides a place of attachment for muscles that move the eye.

sclera





## c. Cornea

1. Clear layer in the front of the eye.
2. Part of the eye where light enters.
3. Aqueous humor – fluid just behind the cornea.



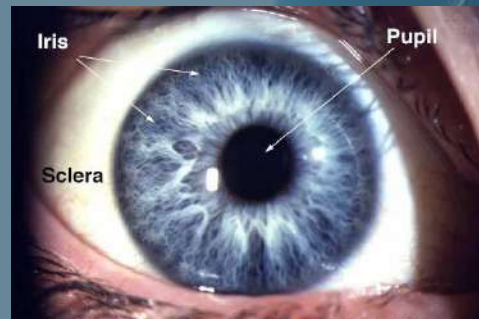
## D. Iris

1. Found @ the back of the aqueous humor.
2. Contains blood vessels of the eye gives your eye its color.



## E. Pupil

1. Found in the center of the iris where light enters.
2. Tiny muscles control the size of your pupil to regulate how much light enters your eye.





## F. Lens

1. Found behind the iris.
2. Formed by special cells with protein called crystallins. Almost transparent – allows light in.
3. Small muscles cause the lens to bend allowing us to see near and far objects.
4. Vitreal Chamber – found behind the lens; filled with a clear jelly like fluid called vitreous (VIH-tree-uhs) humor.

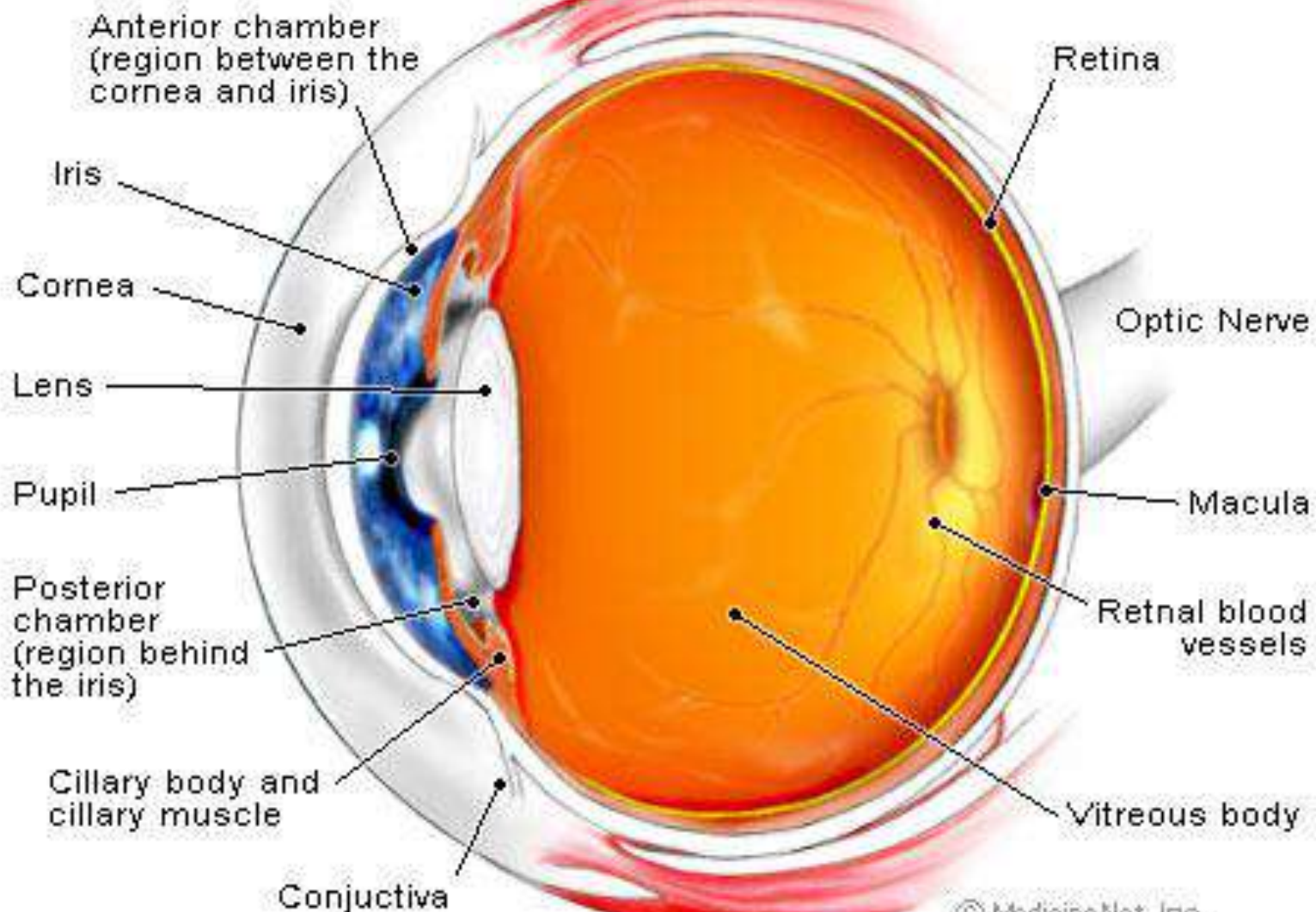




## G. Retina

1. Located in the back of the eye.
2. Photoreceptors: light-sensitive receptor cells found in the retina.
  - i. Convert light energy into impulses carried to the CNS.
  - ii. Found in the shape of rods and cones.
3. Rods: sensitive to all colors of light, but do not distinguish different colors.
4. Cones: less sensitive than rods but produce color vision.

# Anatomy of the Eye





## H. Optic Nerve

1. Carries impulses from the eye to the optic lobe in the brain.





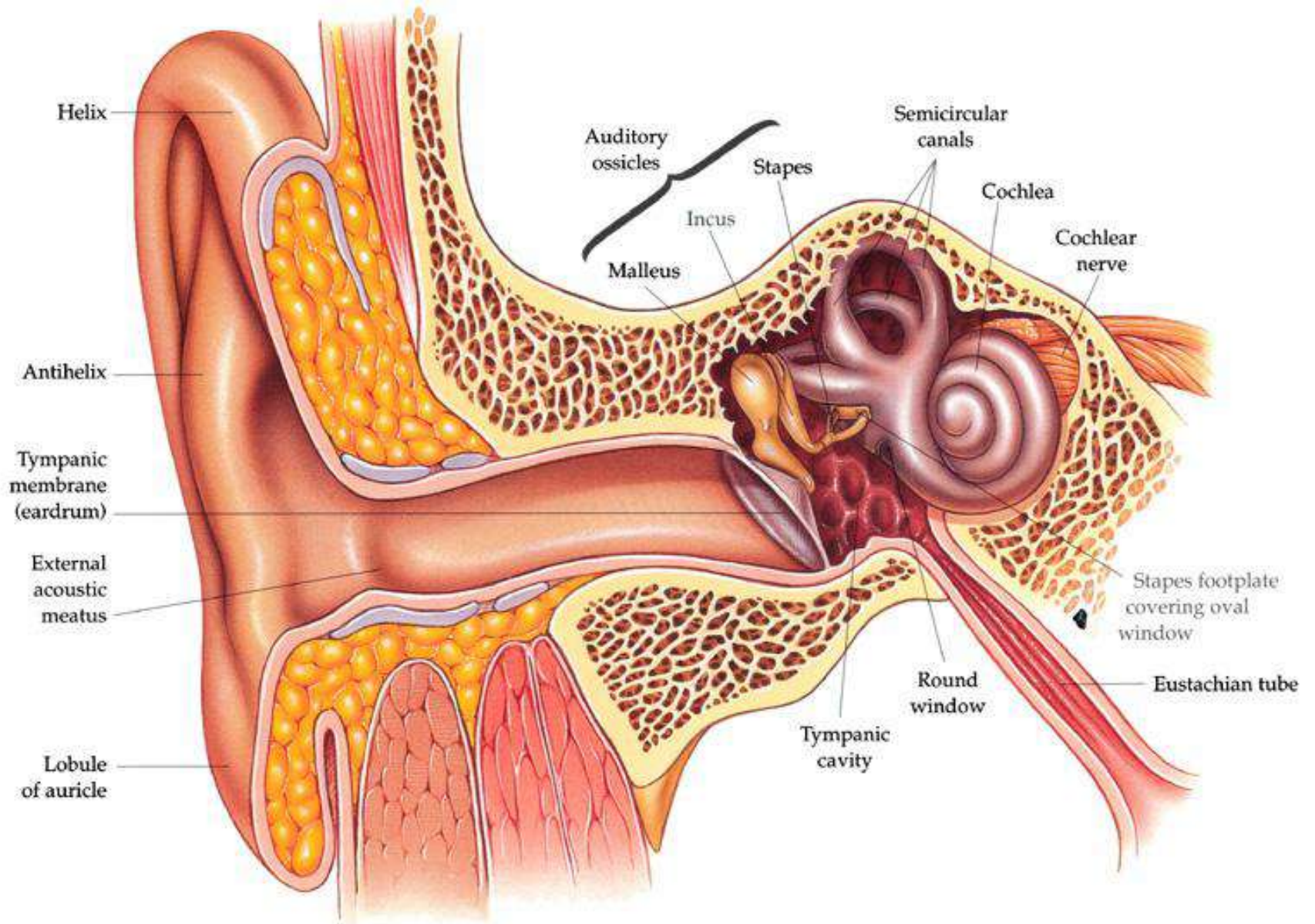
## II. Hearing and Balance

### A. Hearing

1. External Ear – collects sound & funnels it into the auditory canal.
2. Auditory Canal – contains tiny hairs & wax producing glands.
3. Eardrum or Tympanum: found in the middle ear; sound vibrations strike here and send them to tiny bones.
4. Three bones found in the ear: malleus (hammer), incus (anvil), and stapes (stirrup).



5. **Oval Window:** vibrations from stapes comes to this thin membrane covering an opening.
  6. **Cochlea:** vibrations then come here; beginning of the inner ear; snail shaped; filled with fluid.
  7. When the fluid vibrates, tiny hair cells in the cochlea are pushed back and forth causing stimulations that turn into nerve impulses.
  8. **Acoustic Nerve (auditory nerve):** the nerve that carries impulses to the brain.
- **Label the Ear**



# Tubes





## B. Balance

1. Ears also allow us to maintain balance.
2. Above the cochlea are 3 tiny canals (semicircular canals) that help us to sense balance or equilibrium.



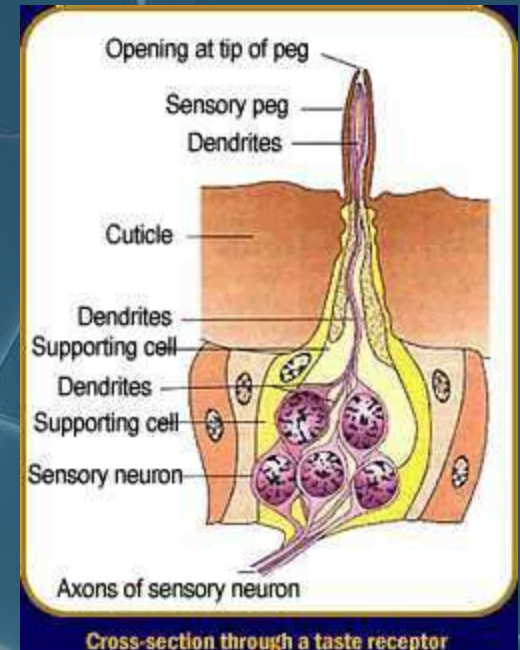


## III. Smell

1. Chemoreceptors located in the upper nasal cavity; responsible for smell.
2. The basics of scent discrimination are still being tested.
3. Very little is known about smell.

# IV. Taste

1. Also stimulated by chemoreceptors.
2. Taste is detected by taste buds.
3. 4 main tastes are detected: sweet, salty, sour, & bitter.





# V. Touch

1. Largest sense organ – skin
  - A. Several types of sensory receptors.
    1. Heat and Cold
      - i. There are 3-4 warm receptors for every 1 cold.
    2. Touch
      - i. Concentrated in some areas: fingers, toes, lips
    3. Pain
      - i. Scattered throughout the body.
      - ii. Pain sensation can be fast or slow like burning and aching.

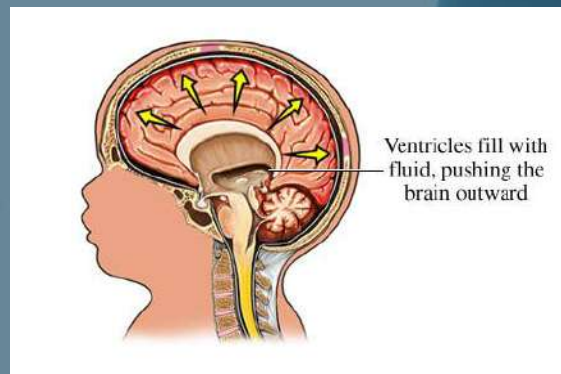
# NERVOUS SYSTEM DISORDERS

## I. Developmental

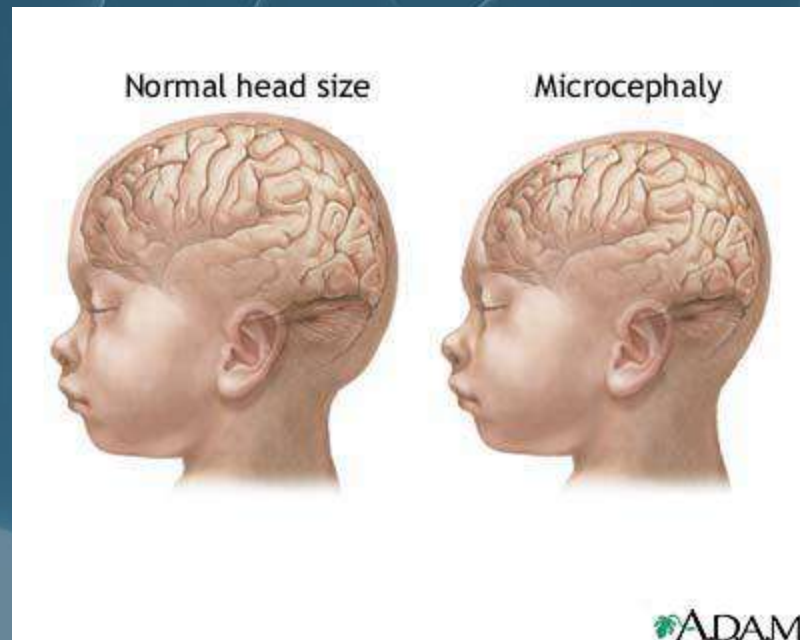
1. Spinal bifida – defective fusion of spinal cord – exposed spinal cord.



2. Hydrocephalus – increased accumulation of cerebrospinal fluid.



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- Microcephaly – brain development not completed (mental retardation).





## II. Injuries

1. Headaches – dilated blood vessels within the meninges.
2. Migraine Headaches – 5-10% of female population (stress, eye strain, fatigue)
3. Fainting – change in blood pressure. Rapid pooling of blood in lower extremities.
4. Concussion – bruised brain.
5. Amnesia – memory loss
6. Comatose – unconsciousness – cannot be waken.



7. Paralysis – loss of motor control
  - a. Paraplegic – legs
  - b. Hemiplegic – right or left half (stroke)
  - c. Quadraplegic – all limbs



### III. Degenerative Disease of Adult Life

1. Parkinson's – progressive shaking, tremor.
2. Alzheimer's – progressive memory loss.





# VI. Diseases & Infections

## 1. Mental Illness

- a. Neurosis – contact with reality – maladjusted to certain aspects. Ex: phobias
- b. Psychosis – withdrawal from reality Ex: paranoia, schizophrenia

## 2. Epilepsy – sudden burst of irregular electrical brain activity

- a. Petit mal – small seizures
- b. Grand mal – large seizures



3. Cerebral palsy – damage to motor areas of brain during fetal development - spastic shaking, loss of motor control.
4. Dyslexia – defect in language center – reverse order of letters – “The man saw a red dog” – “A red god was the man”
5. Meningitis – inflammation of the meninges.



6. Polio – virus destroys cell body of CNS motor neurons. Vaccine developed in the 1950's.
7. Stroke – blood clot or broken blood vessels in the brain.
8. Multiple sclerosis – myelin sheath is progressively destroyed – jerky movement of limbs b/c sheath is harder which interferes with impulses.