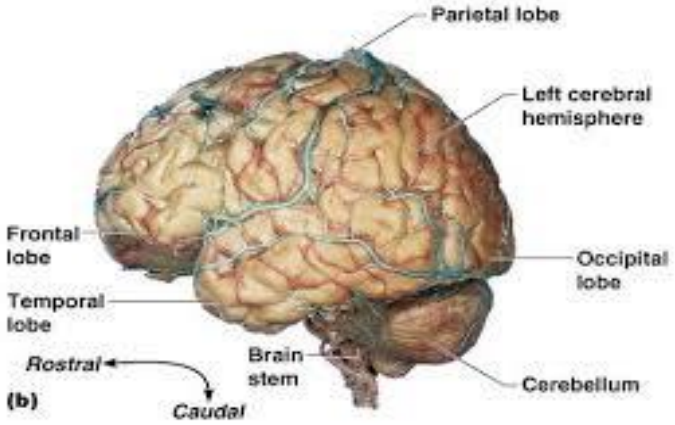

The Nervous System

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Asso. Prof.
MKSSSBTINE

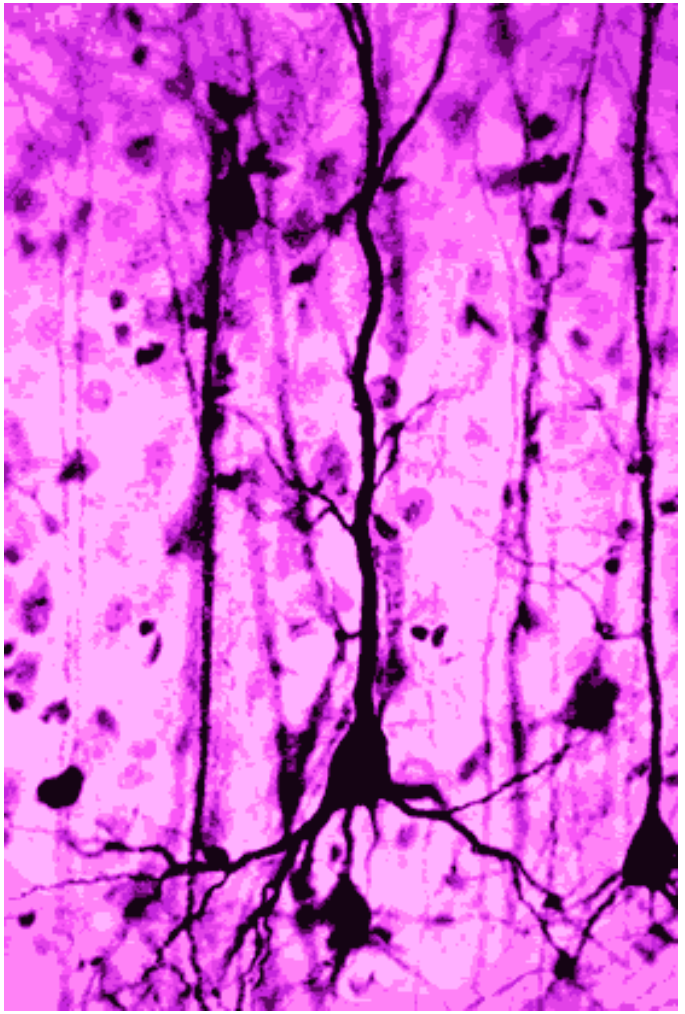
Functions of the Nervous System

1. Control center for all body activities
2. Responds and adapts to changes that occur both inside and outside the body
   (Ex: pain, temperature, pregnancy)

Cellular structure of Nervous System

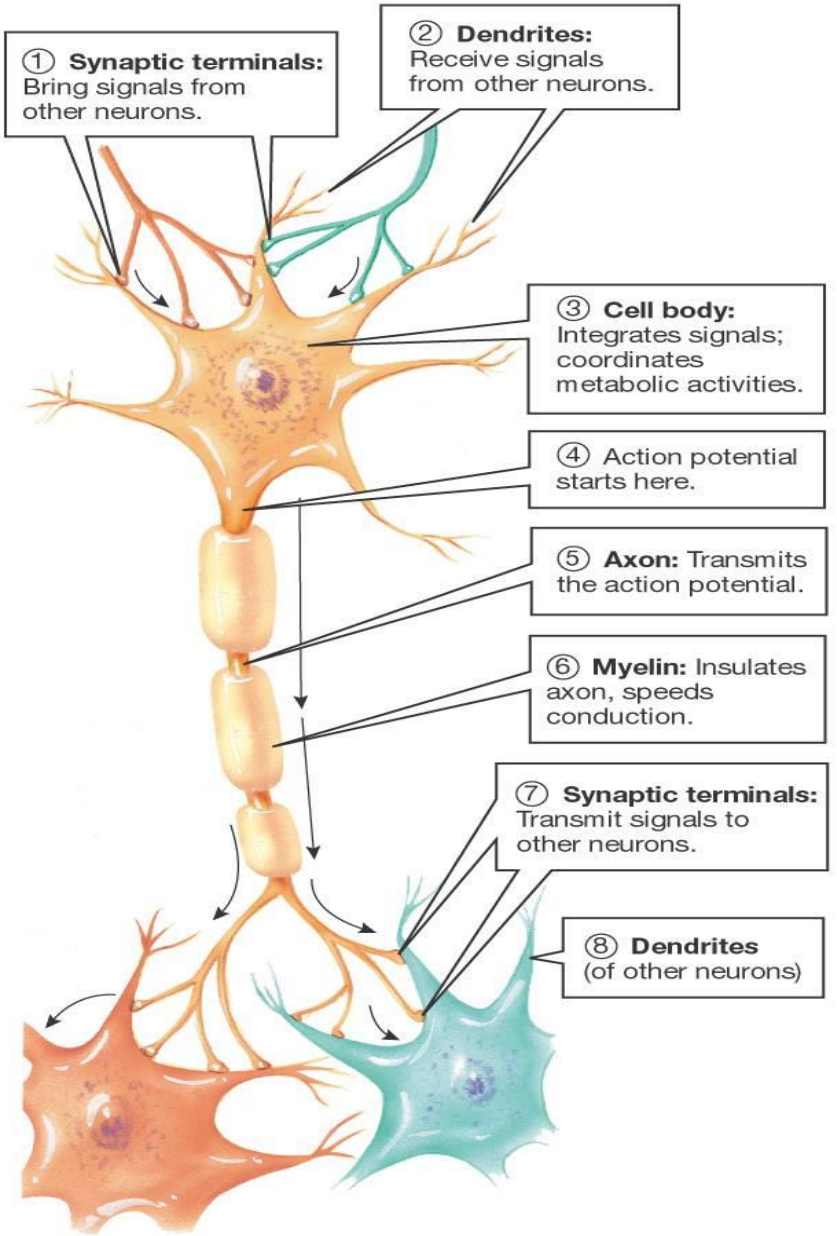
Neurons :
microscopic nerve cells that make up the brain, spinal cord, and nerves

- 30,000 neurons can fit on a pinhead



The Neuron

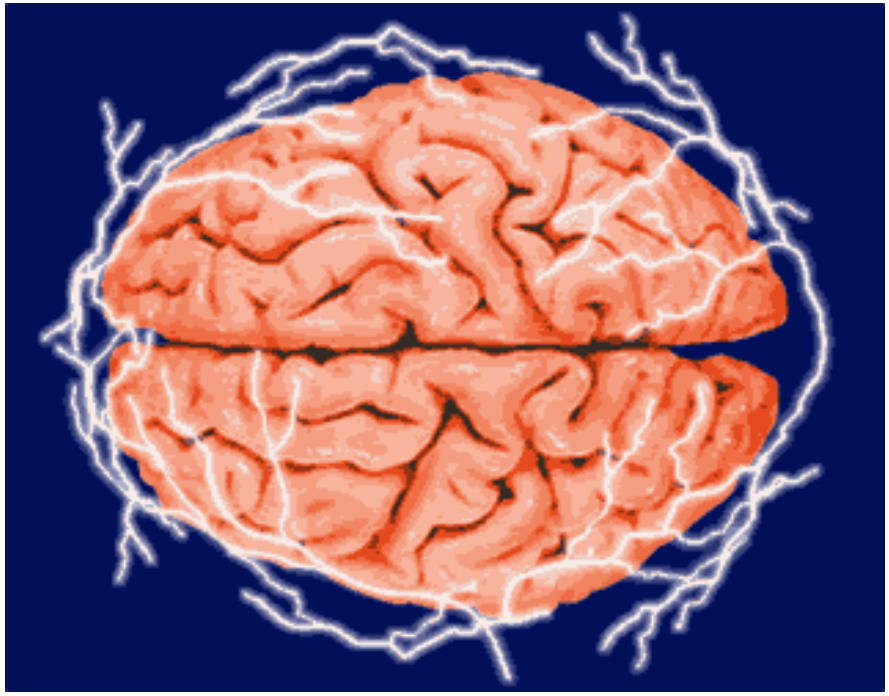
- Dendrites receive signals.
- The cell body integrates signals.
- The axon transmits action potential. The myelin sheath makes the signal travel faster.
- Synaptic terminals transmit signals.



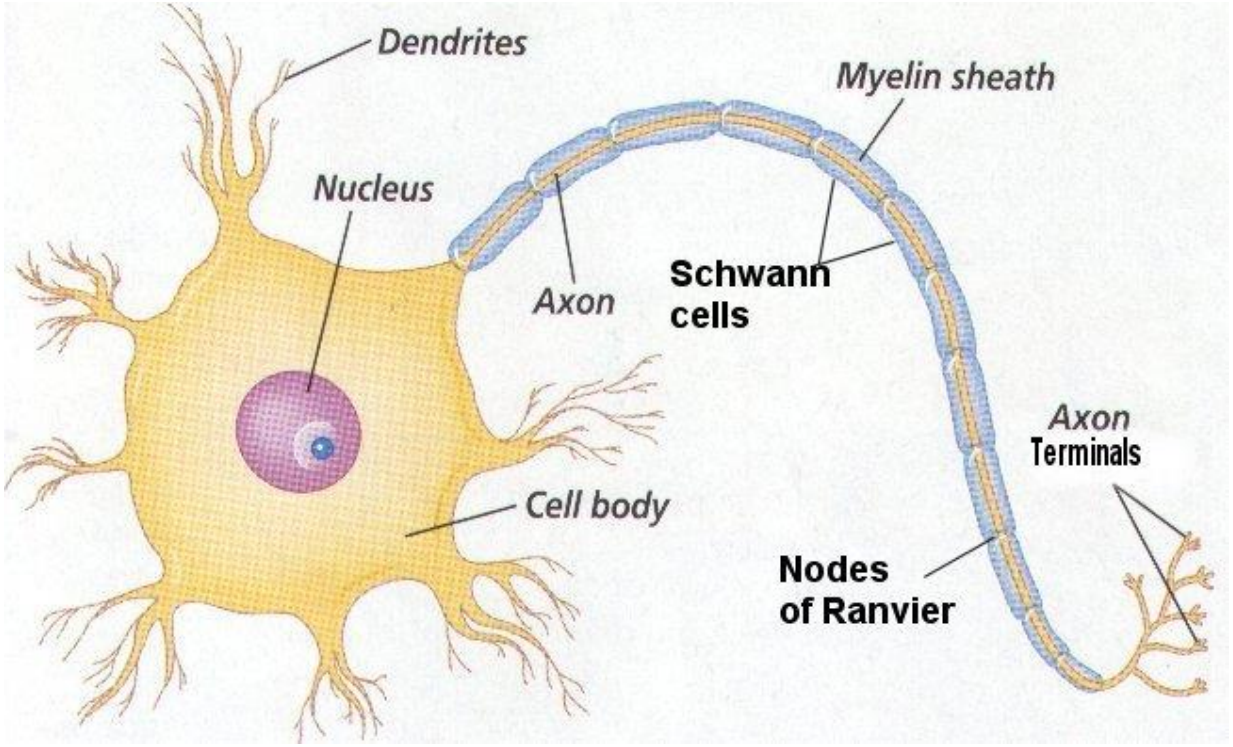
Communication Between Neurons

- The use of neurotransmitters causes an electrical current

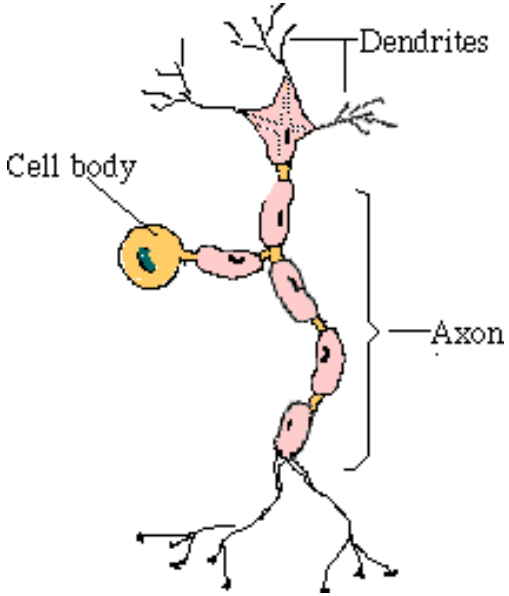
There is enough electrical current in the brain to power a flashlight



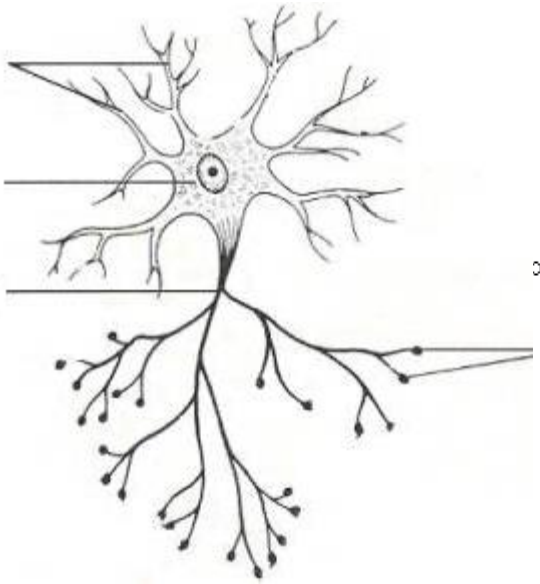
Basic nerve cell structure



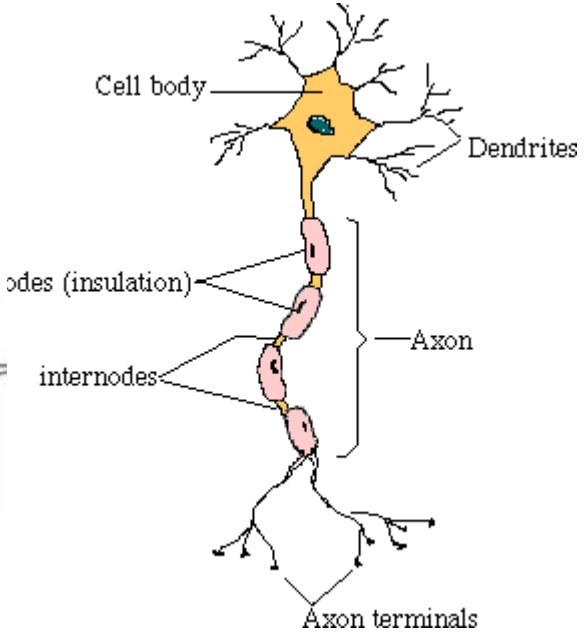
3 main types of nerve cells



sensory neurone

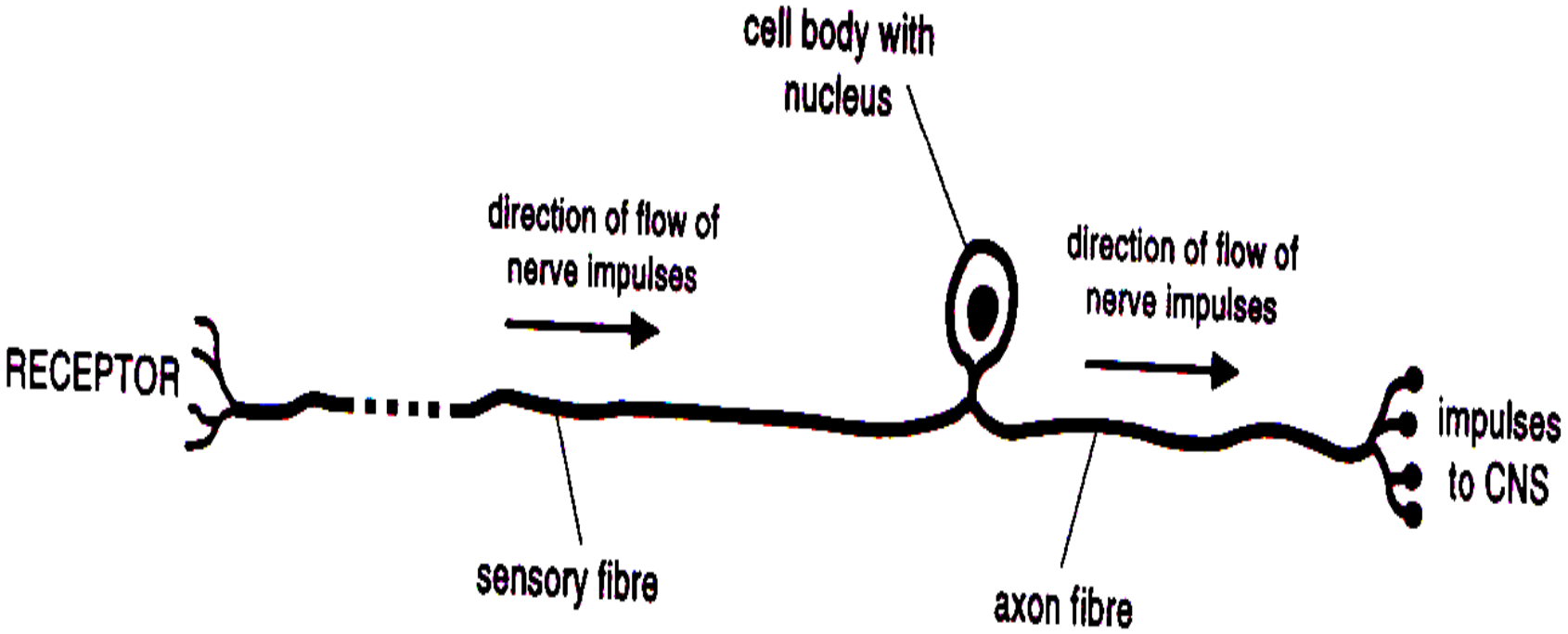


relay neurone



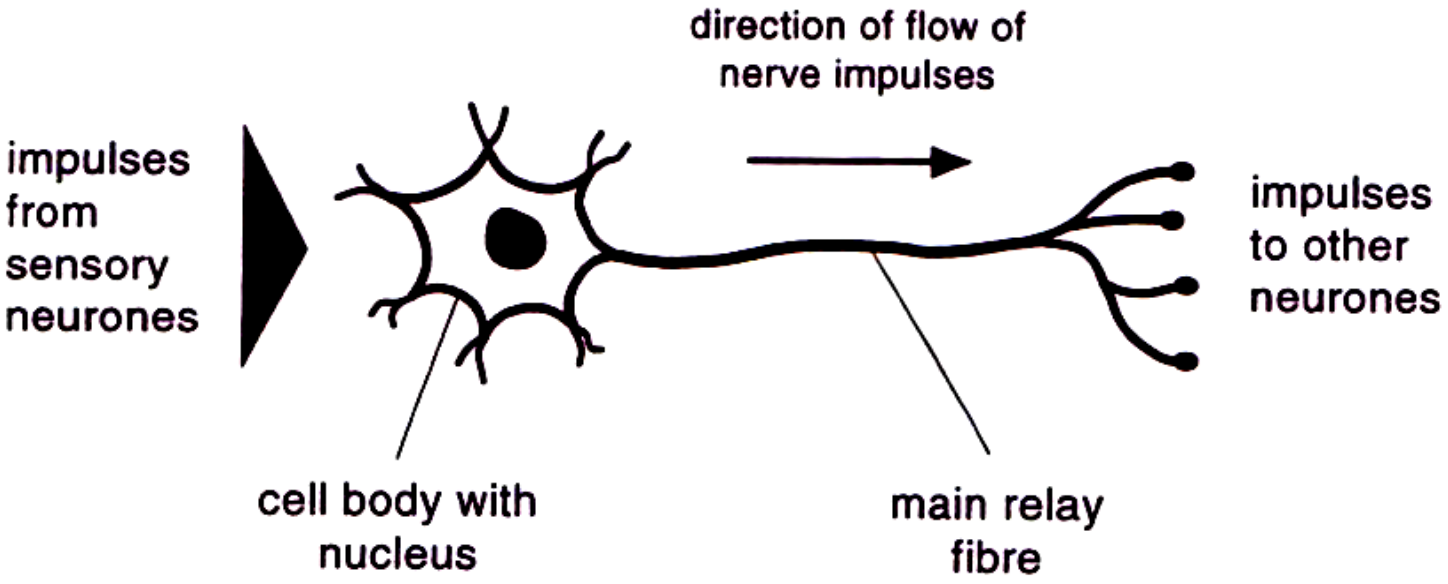
motor neurone

Sensory neurons



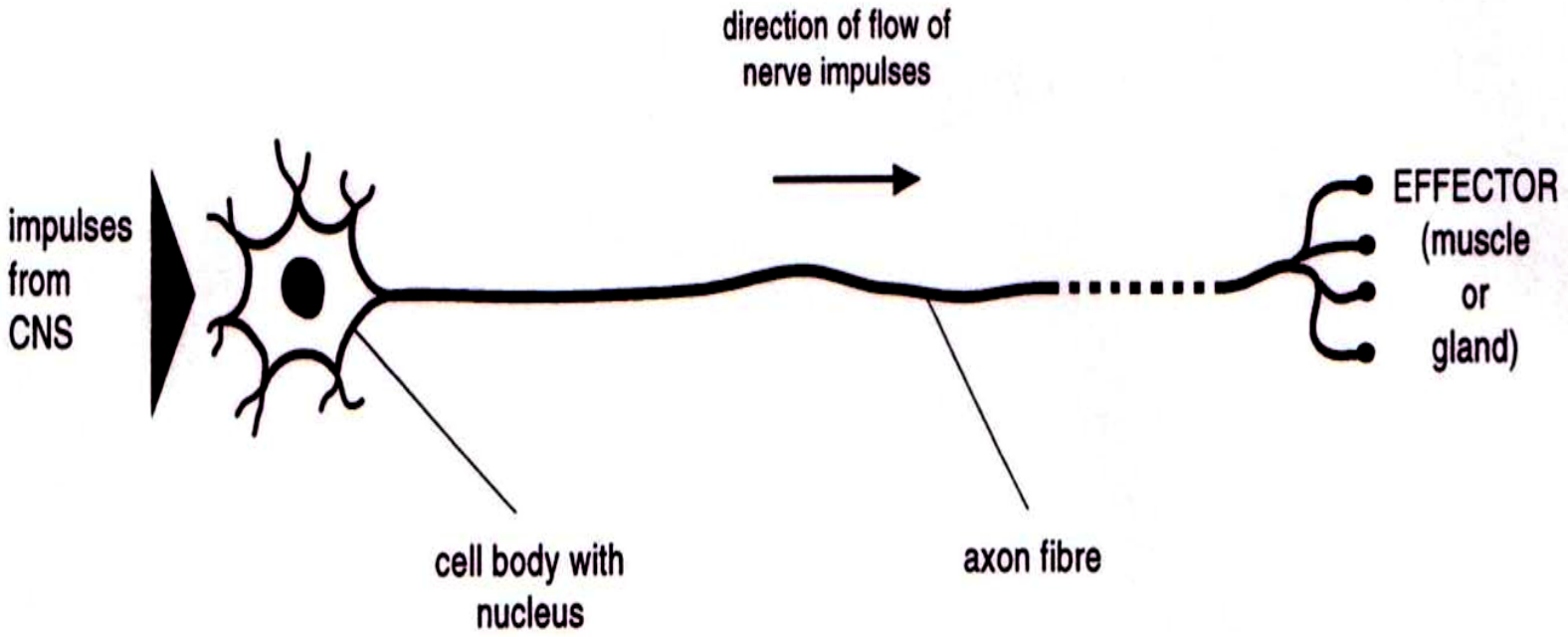
Carries impulses from receptors e.g pain receptors in skin to the CNS(brain or spinal cord)

Relay neuron



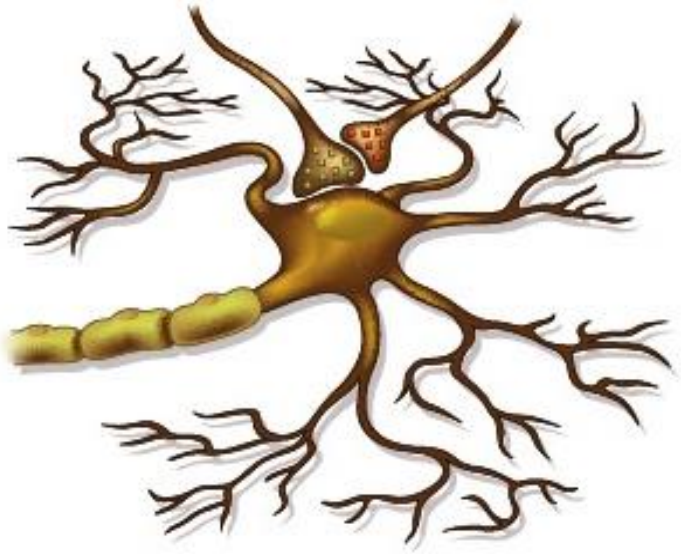
Carries impulses from sensory nerves to motor nerves.

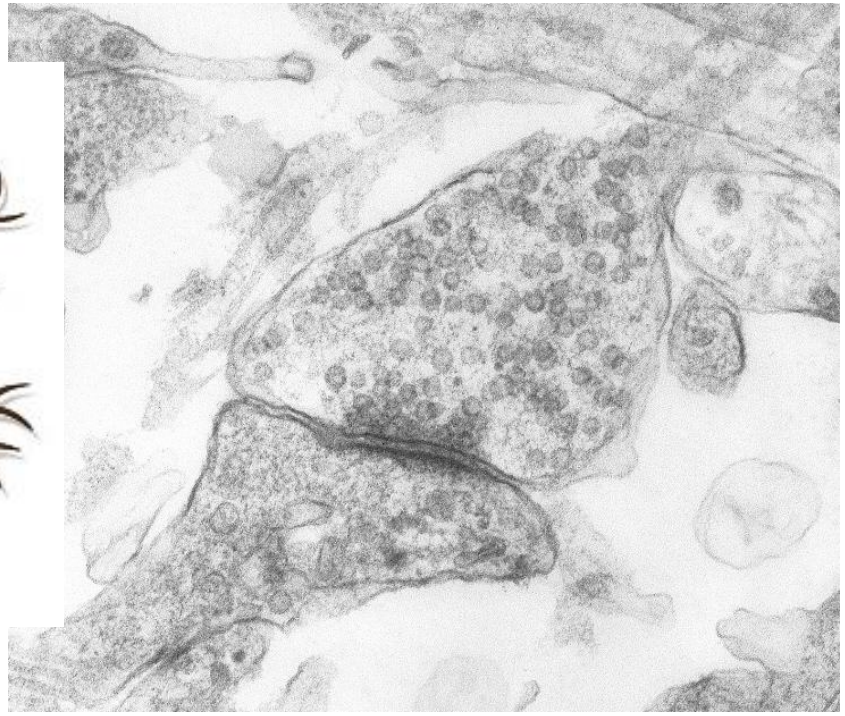
Motor neuron



Carries impulses from CNS to effector e.g. muscle to bring about movement or gland to bring about secretion of hormone e.g ADH

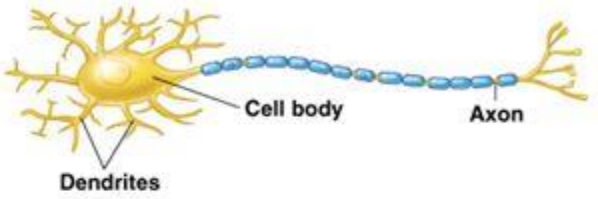
Transmission of signals





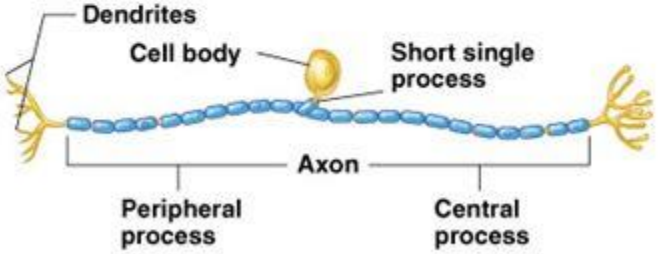
Structural Classification of Neurons

- Multipolar neurons
  - Three or more processes
  - One axon and the rest dendrites
  - Most common neuron type (motor and interneurons)
  - Major neuron type in CNS
- Bipolar neurons
  - Two processes
  - An axon and a dendrite from opposite sides of the cell body
  - Rare, found in special sensory organs
- Unipolar neurons
  - Have a short single process leaving the cell body
  - Mainly found in ganglia of PNS (sensory neurons)

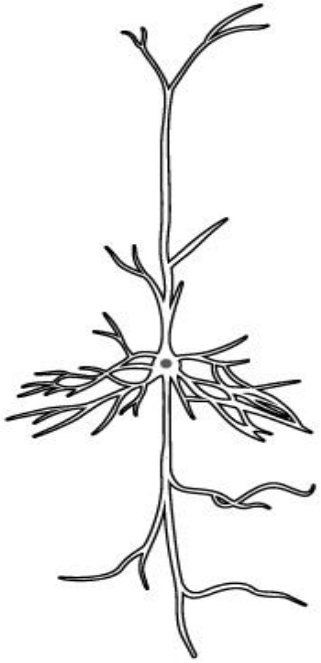


(a) Multipolar neuron

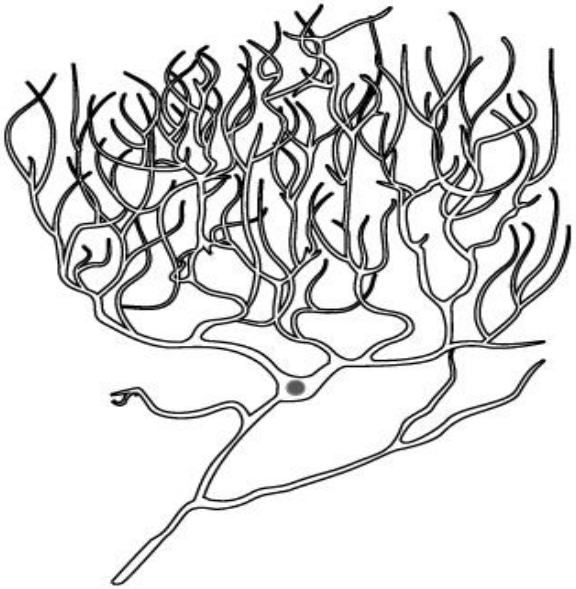
(b) Bipolar neuron



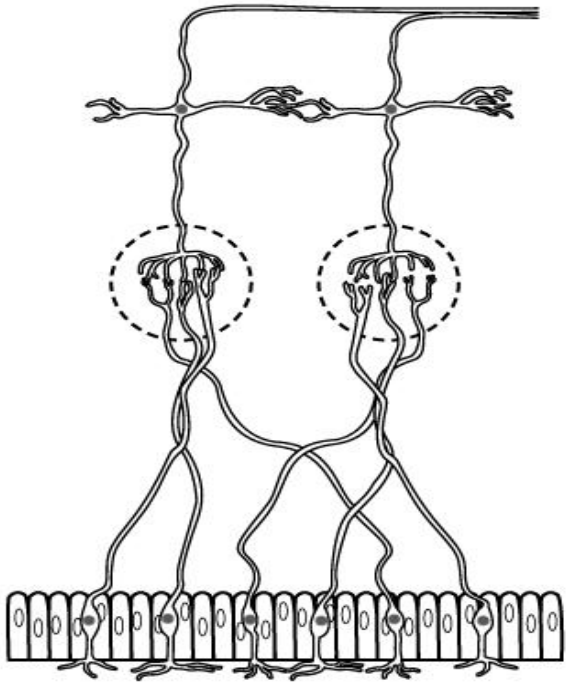
(c) Unipolar neuron



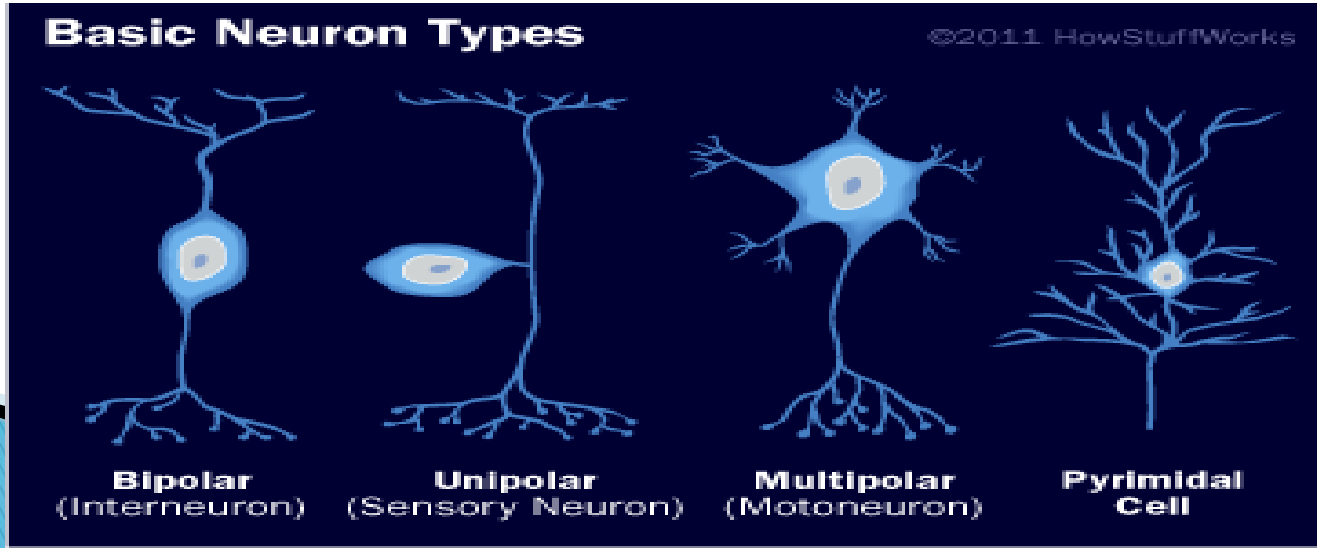
(a) Pyramidal cell of the cerebral cortex



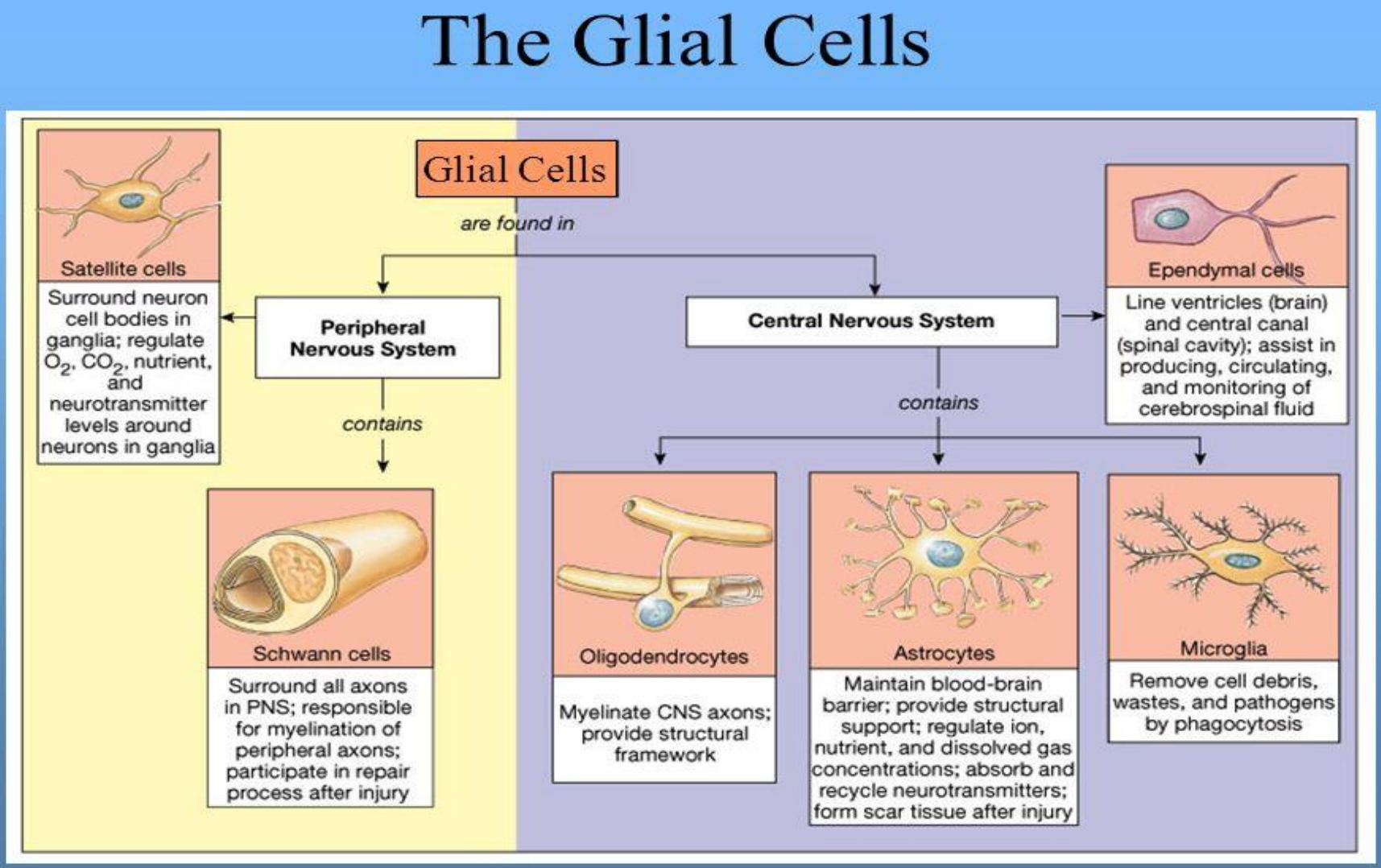
(b) Purkinje cell of the cerebellar cortex

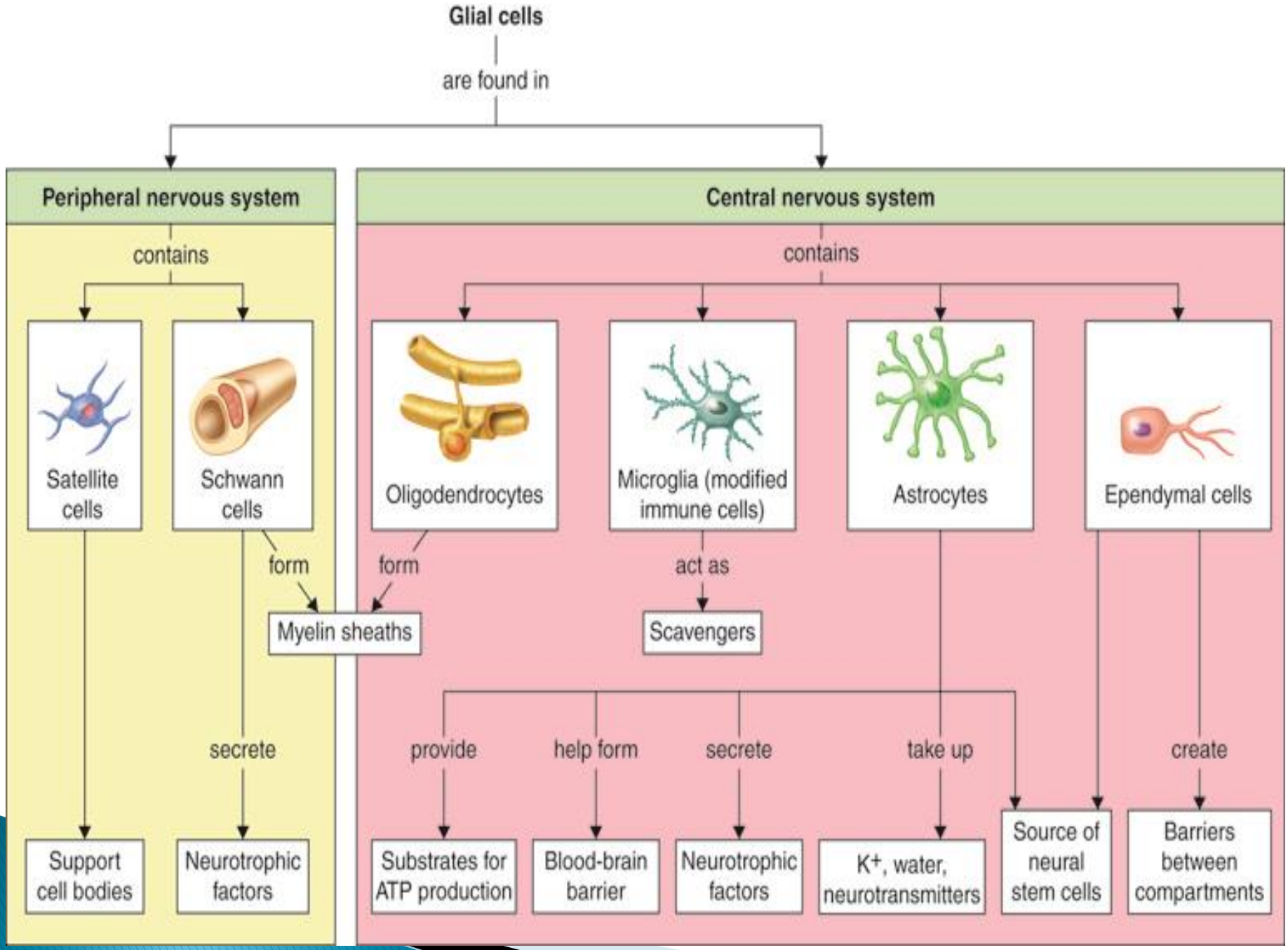


(c) Olfactory cells in the olfactory epithelium and olfactory bulbs

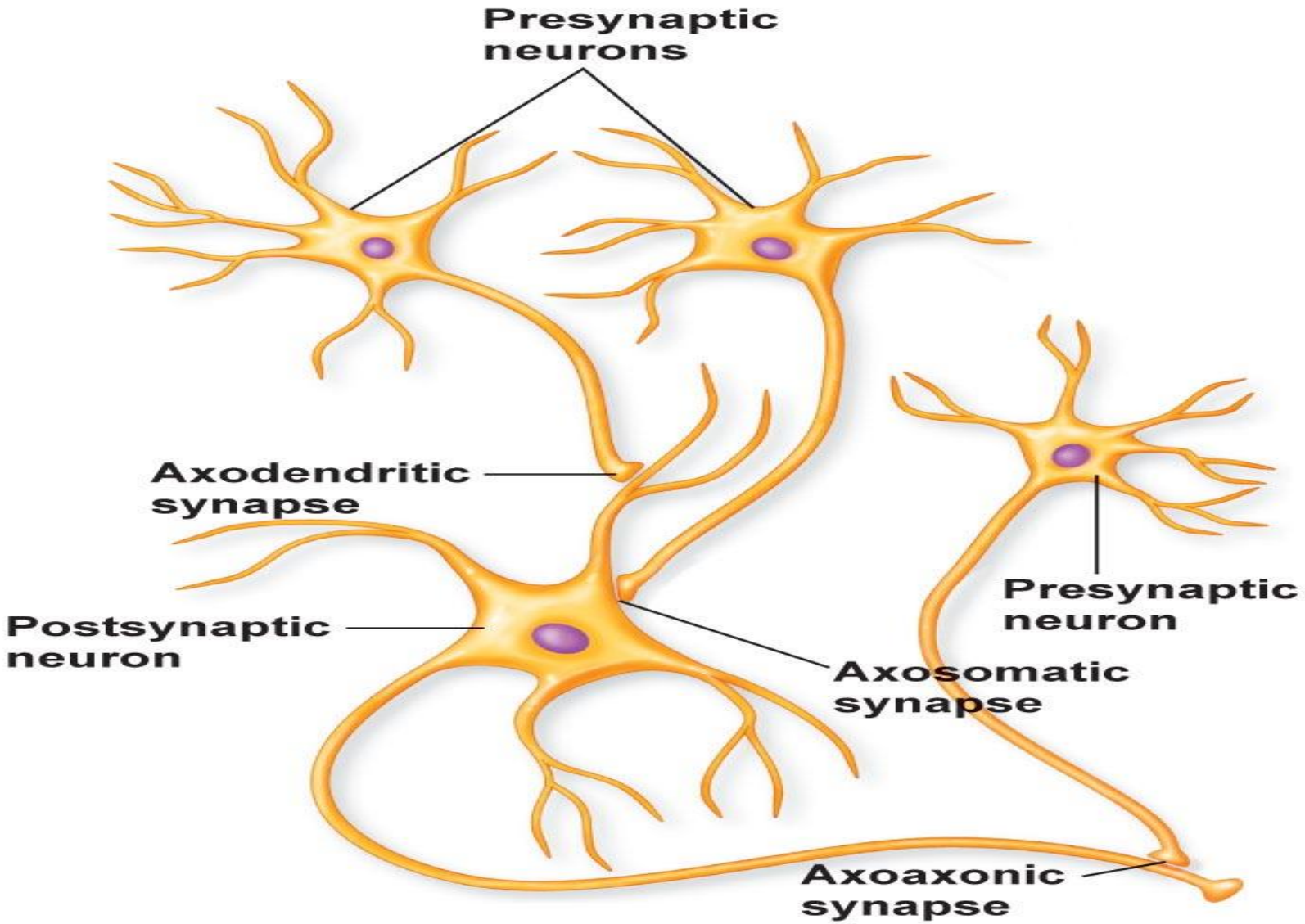


Neuroglial cell

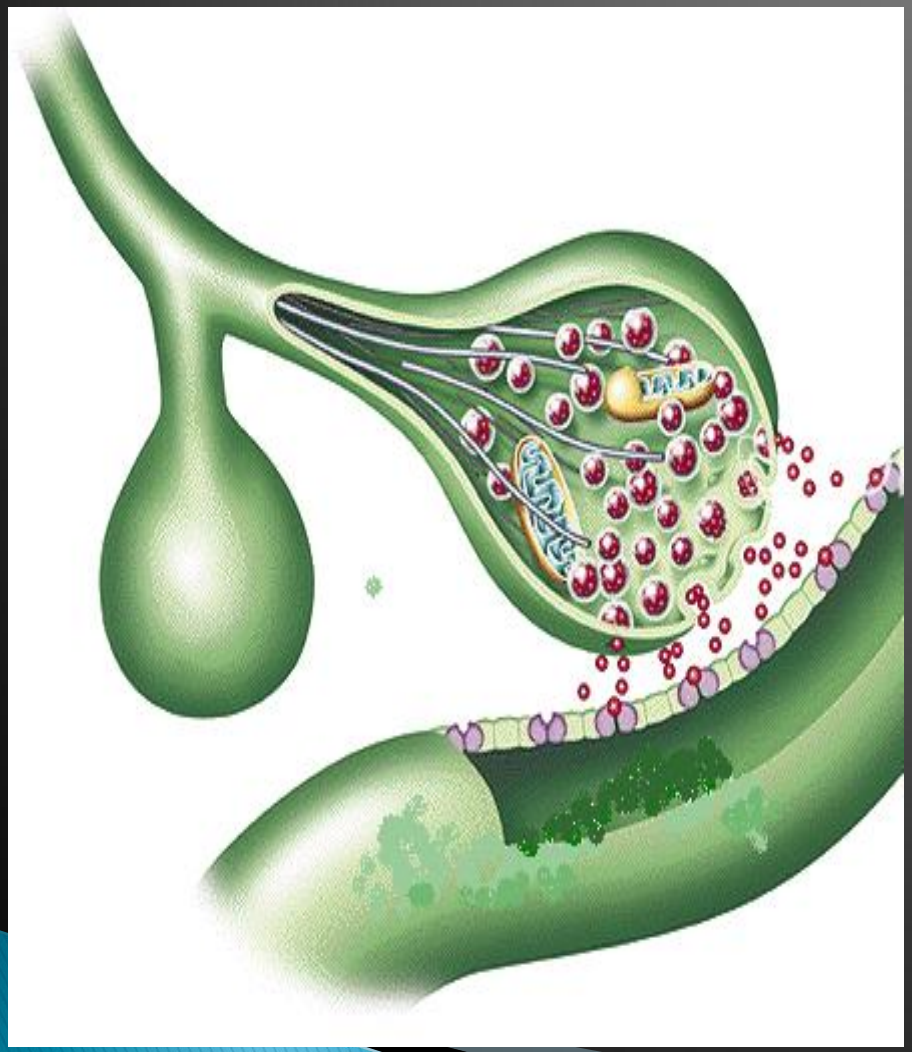


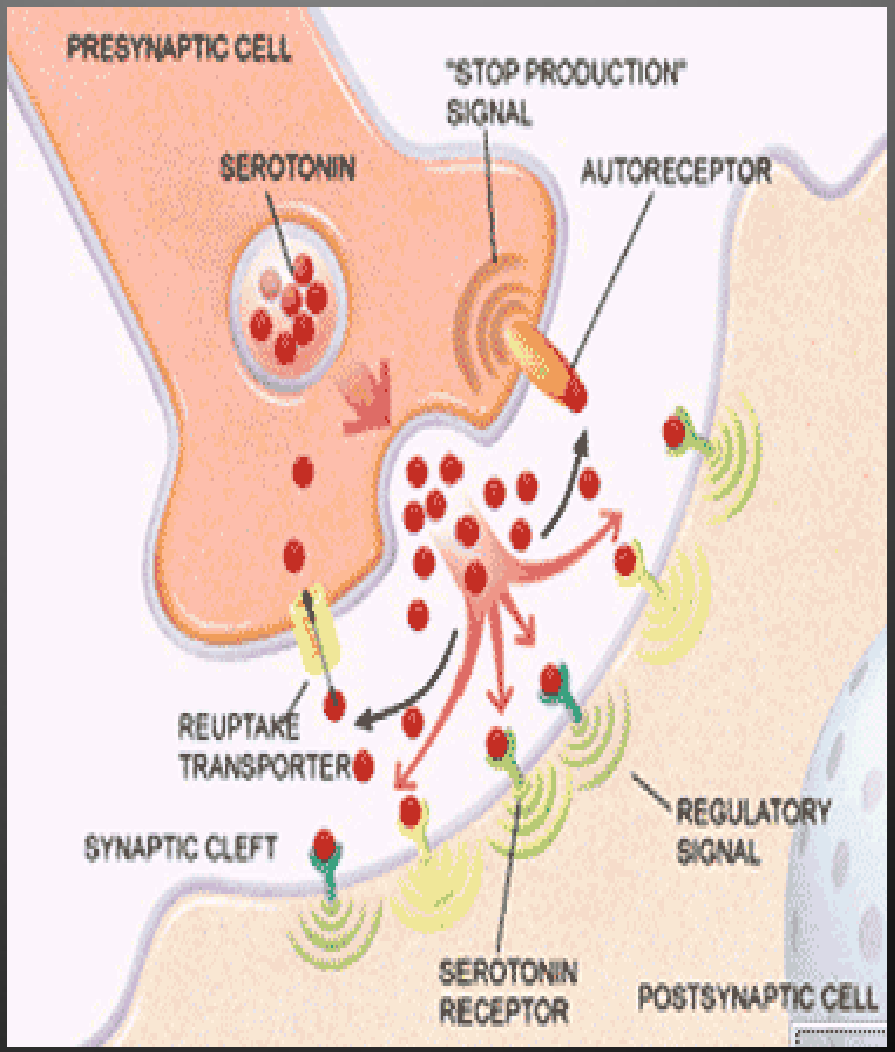

Glial cells
are found in
Peripheral nervous system
Central nervous system
contains
contains
Satellite cells
Schwann cells
Oligodendrocytes
Microglia (modified immune cells)
Astrocytes
Ependymal cells
form
form
act as
Myelin sheaths
Scavengers
secrete
provide
help form
secrete
take up
create
Support cell bodies
Neurotrophic factors
Substrates for ATP production
Blood-brain barrier
Neurotrophic factors
K+, water, neurotransmitters
Source of neural stem cells
Barriers between compartments

Type of synapse



The Synapse

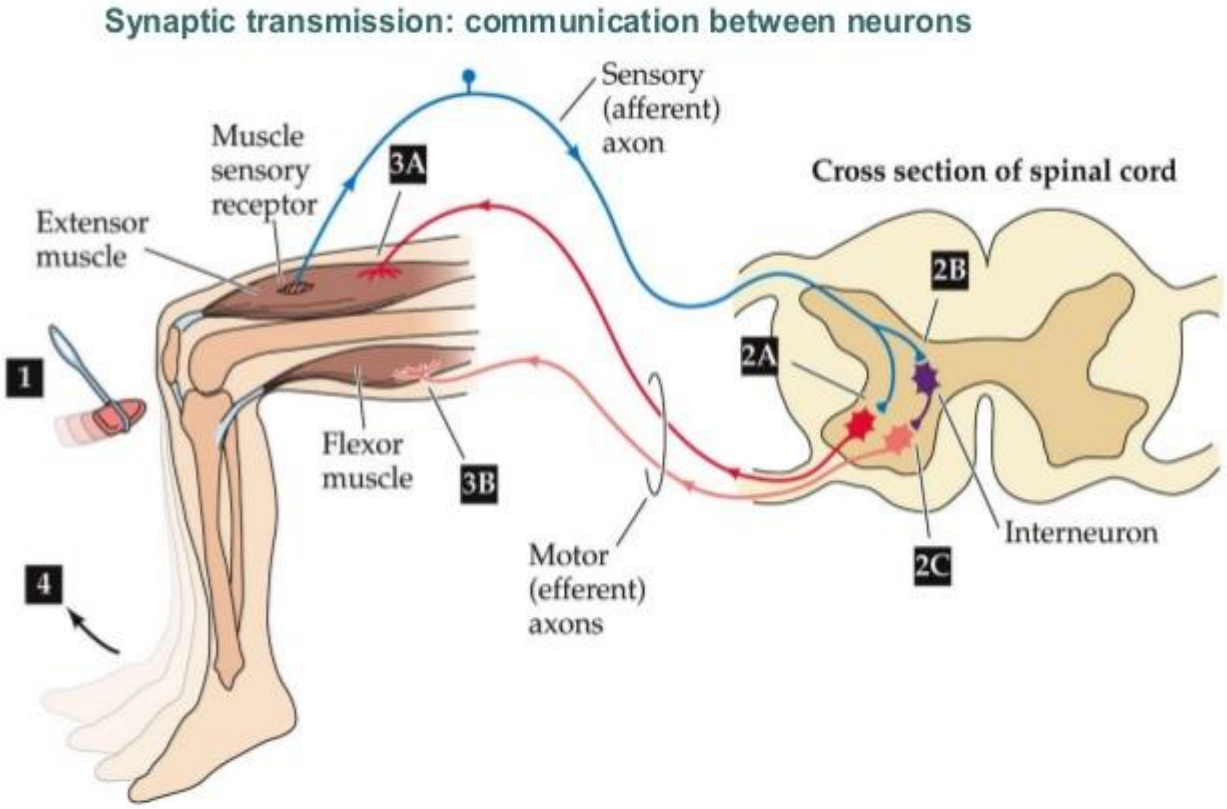



PRESYNAPTIC CELL
"STOP PRODUCTION" SIGNAL
SEROTONIN
AUTORECEPTOR
REUPTAKE TRANSPORTER
SYNAPTIC CLEFT
REGULATORY SIGNAL
SEROTONIN RECEPTOR
POSTSYNAPTIC CELL

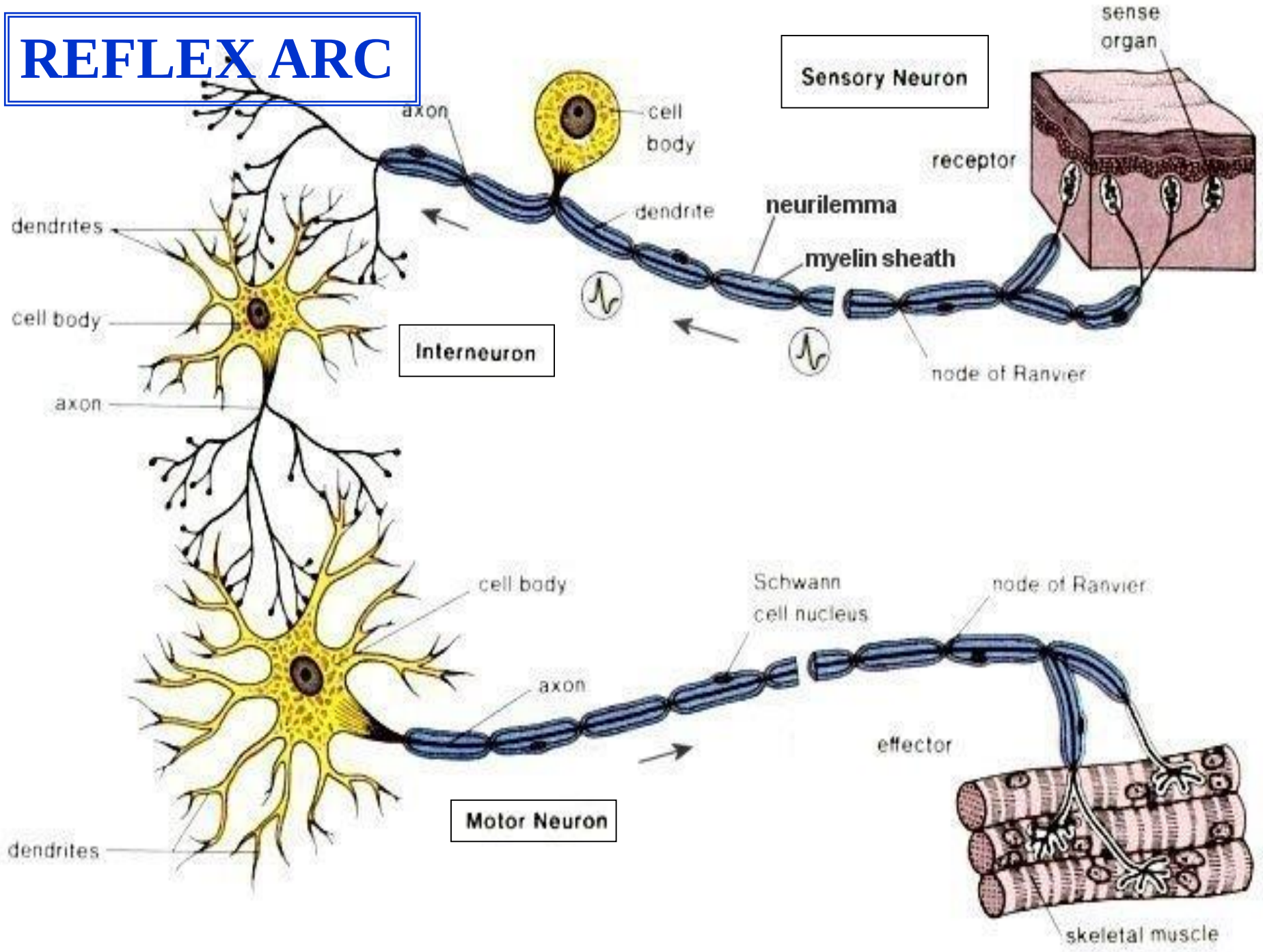
Reflex Arc

- A reflex arc is the functional unit of the nervous system. In its simplest form, it consists of:
- Five components
  - Receptor Eg. The skin or muscle
  - Sensory neuron
  - Interneuron in spinal cord
  - Motor neuron
  - Effector Eg: the muscle

Reflex arc pathway



REFLEX ARC


Sensory Neuron
sense organ
receptor
axon
cell body
dendrite
neurilemma
myelin sheath
node of Ranvier
dendrites
cell body
Interneuron
axon
cell body
Schwann cell nucleus
node of Ranvier
axon
effector
Motor Neuron
dendrites
skeletal muscle

Applied Anatomy:

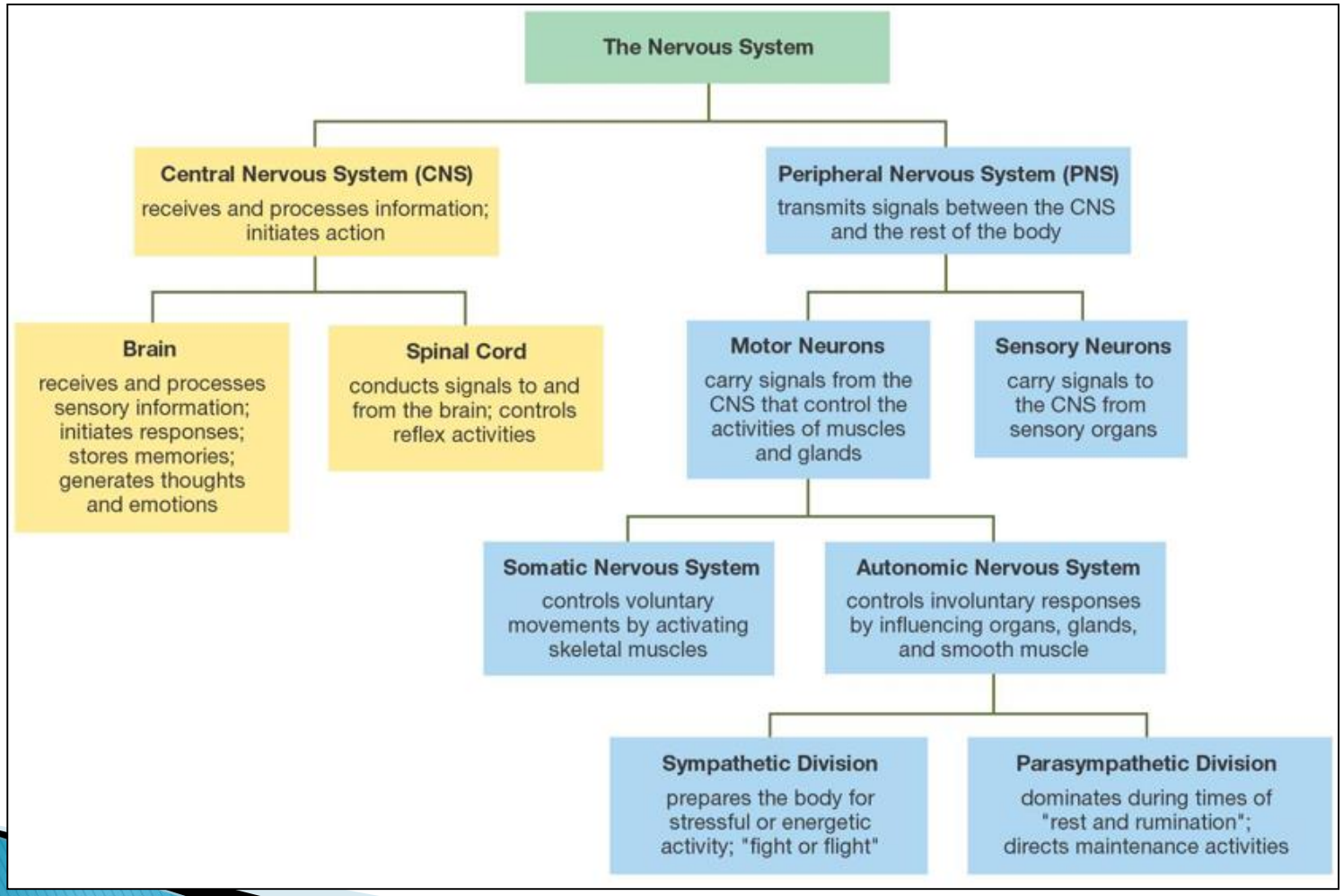
- Tumours of the nervous tissue arise mostly from the neuroglia, as developed neurons have lost the power of multiplication.
- Tumour from neuroglial cella are called gliomas. These are highly malignant and rapidly growing tumours.

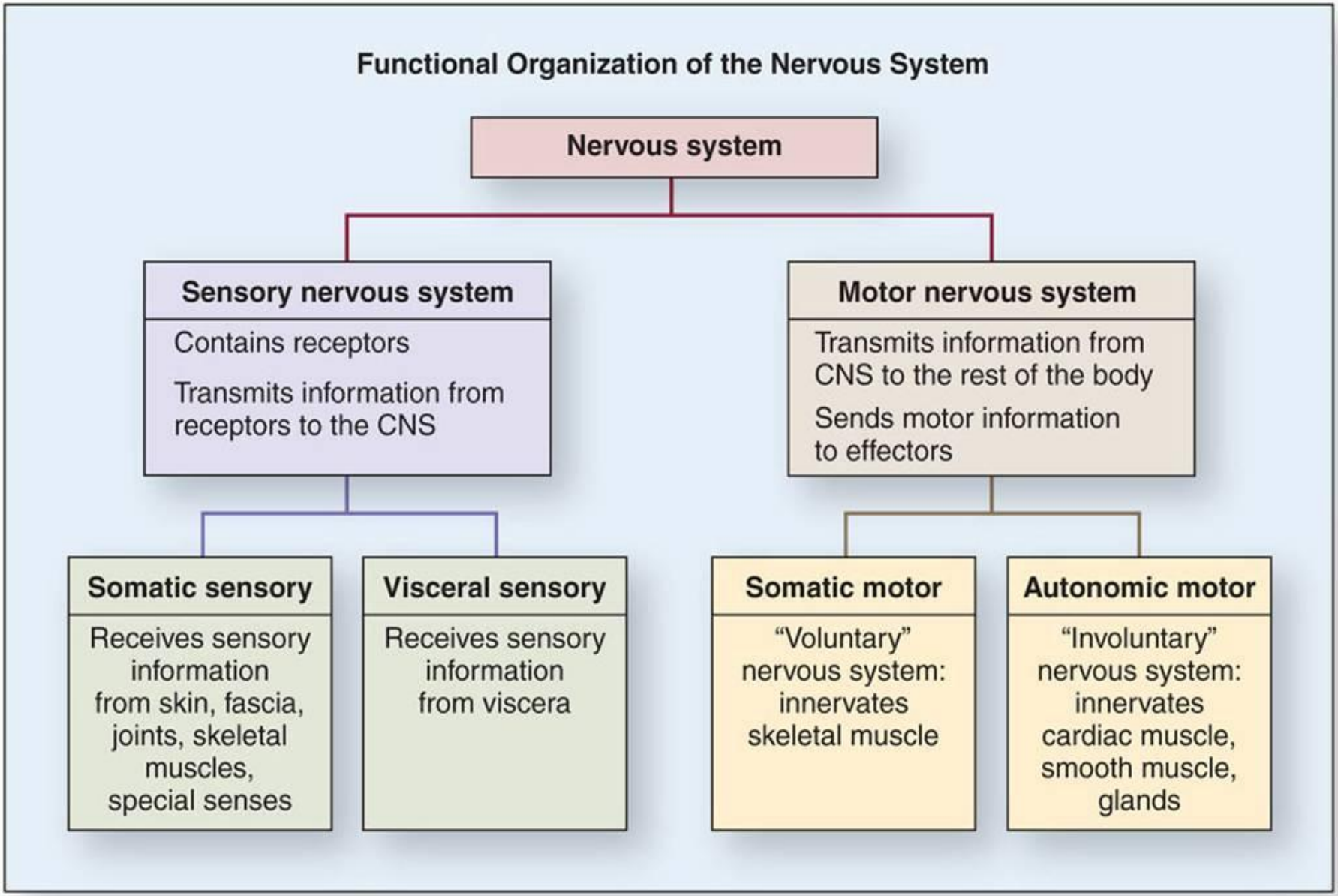
Brain Teaser

If you were running a race, and you passed the person in 2nd place, what place would you be in now?

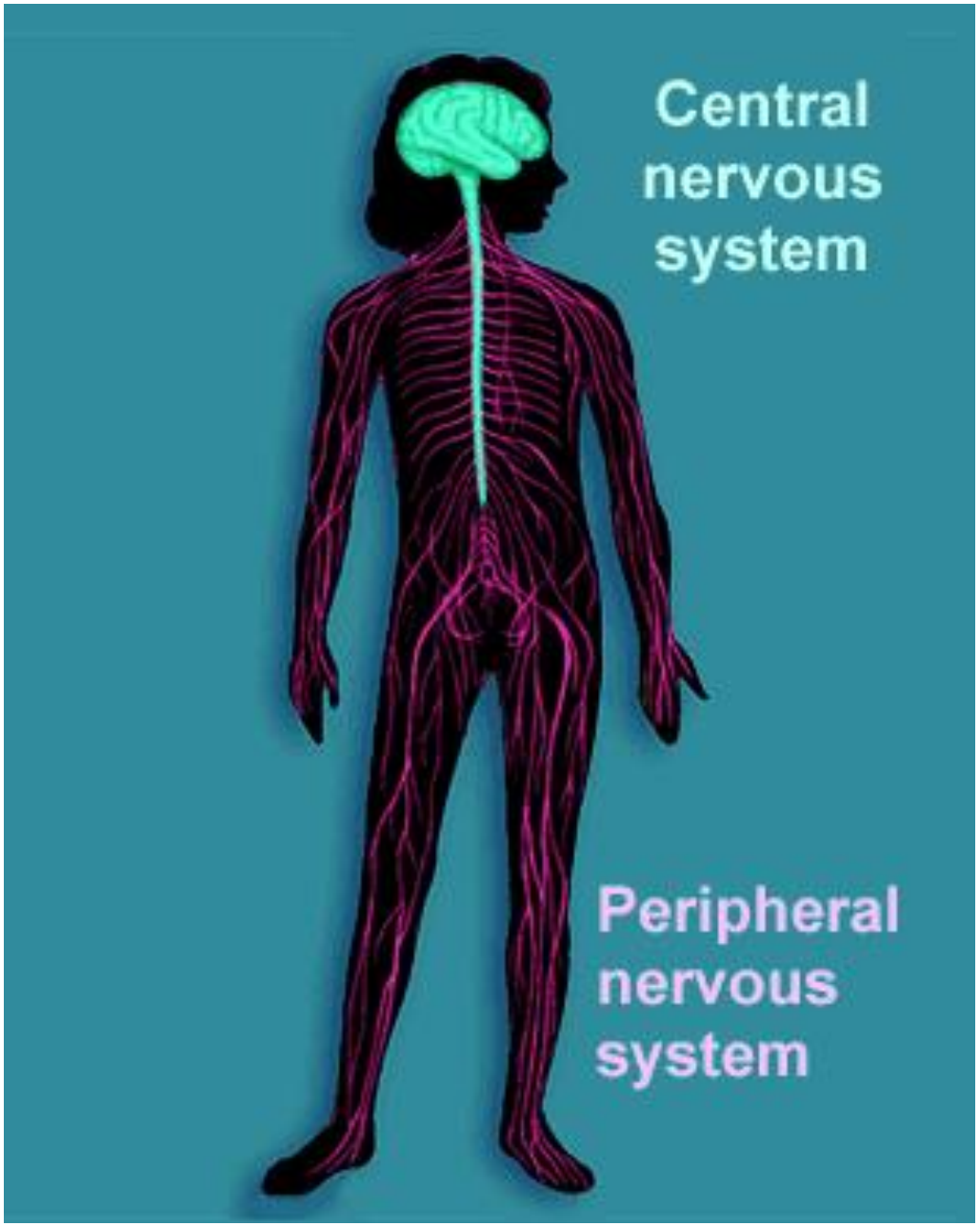
Second

Neural Organization of the nervous system





Two Major Divisions of the Nervous System



Components of Central Nervous

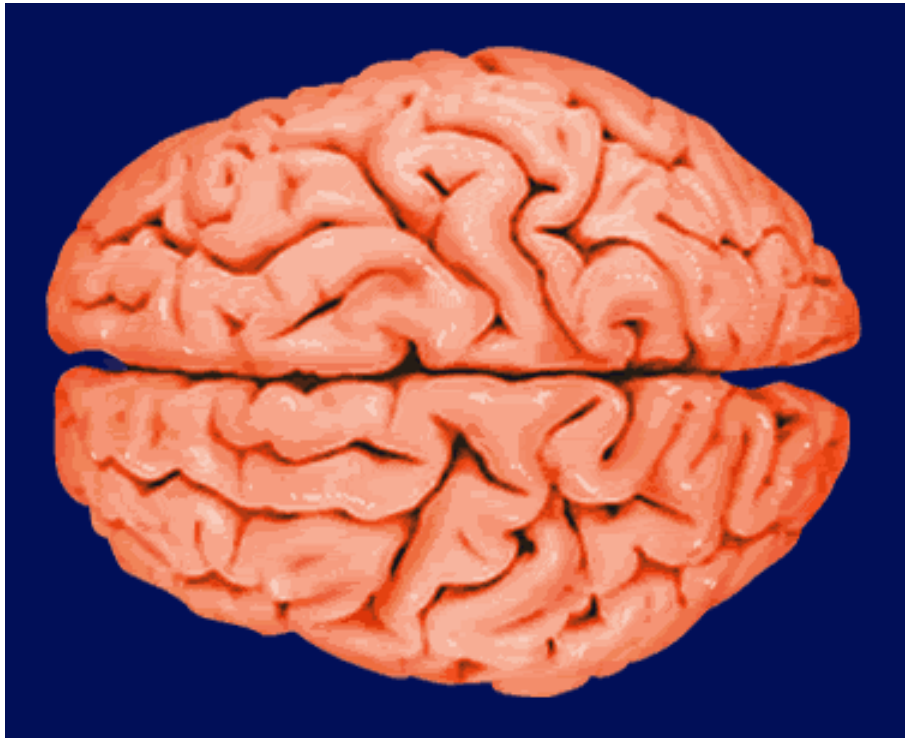
- The spinal Cord: it extends from the base of the skull to the lower border of the first lumbar vertebra in an adult. The spinal cord receives sensory information from the skin, joints and muscles of the trunk and limbs. It is responsible for reflex and voluntary movements.
- Brain stem: it include – the medulla, the pons, the midbrain.
- Cerebellum: the cerebellum lies dorsal to the pons and medula.

- The Diencephalon: It includes the thalamus and hypothalamus. It is present between the cerebral hemisphere and midbrain.
- The cerebral hemisphere: it consists of the cerebral cortex/ grey mater and the fibres which form white matter with deeply located nuclei i.e. the basal ganglia, the hippocampal formation and the amygdala.
- Ventricles of the brain: Ventricles are continuous cavities in various parts of brain.
- Protective coverings: Brain and spinal cord are covered by 3 meninges with intervening spaces. The outer most is the dura mater, middle layer is delicate cobweb like arachnoid space and inner one is the pia mater.

Central Nervous System

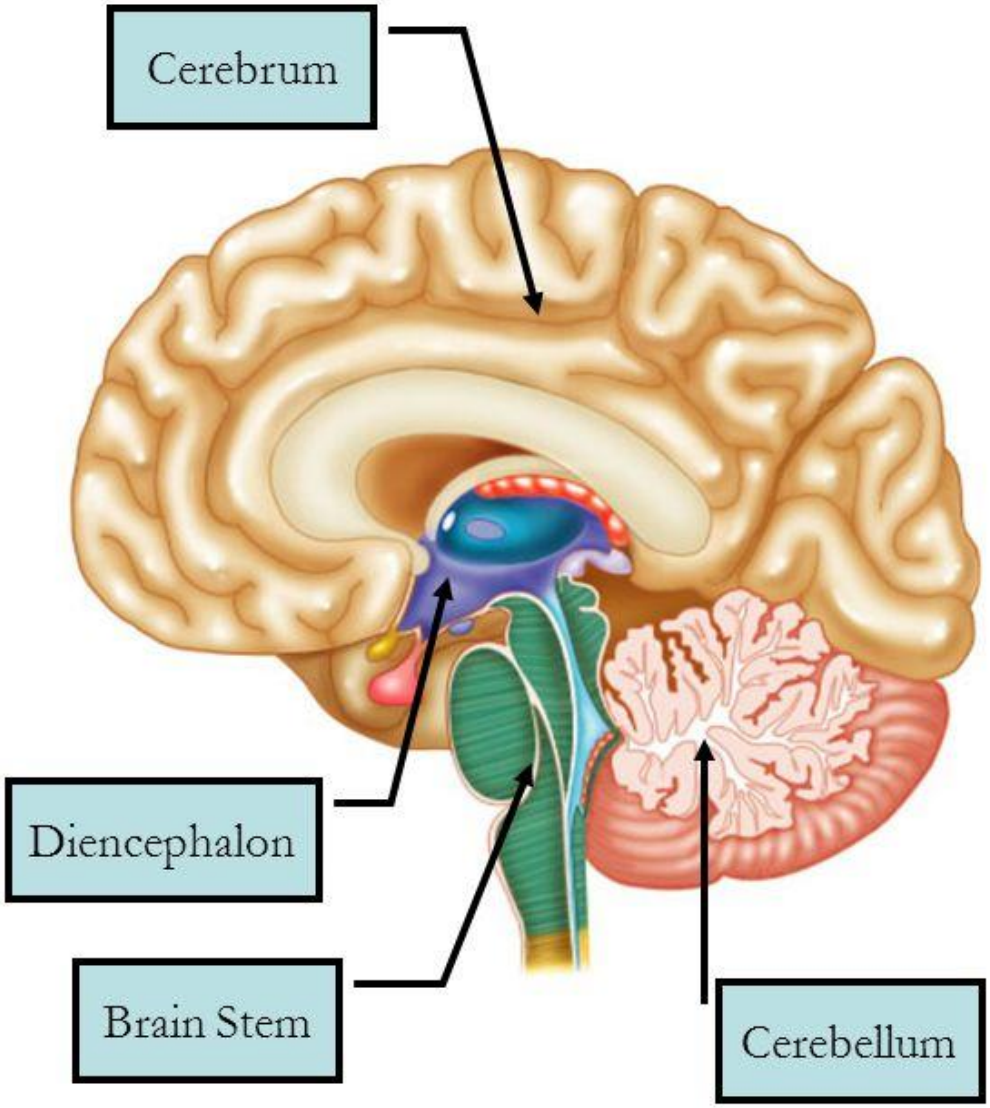
Brain : a mass of 100 billion neurons located inside the skull

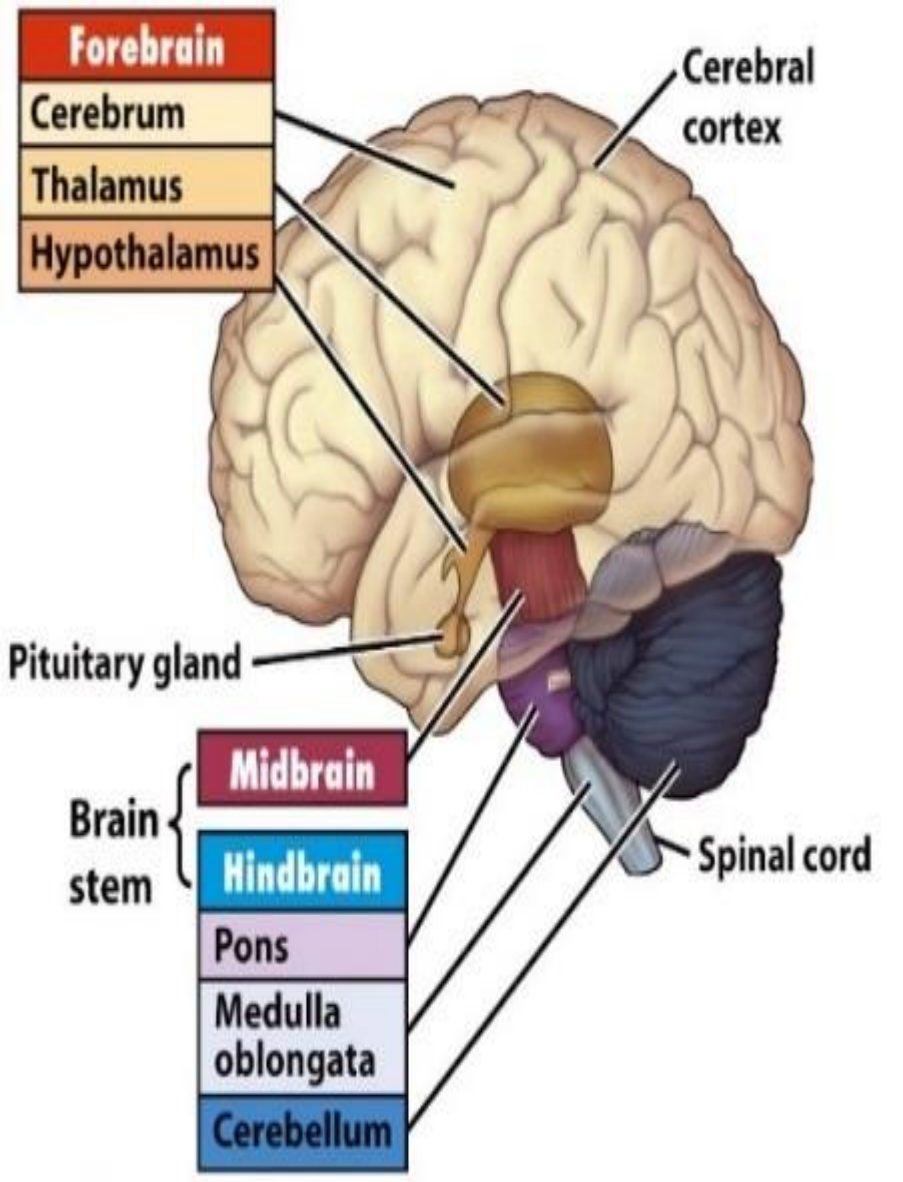
-Learning occurs as more and stronger connections are made between neurons

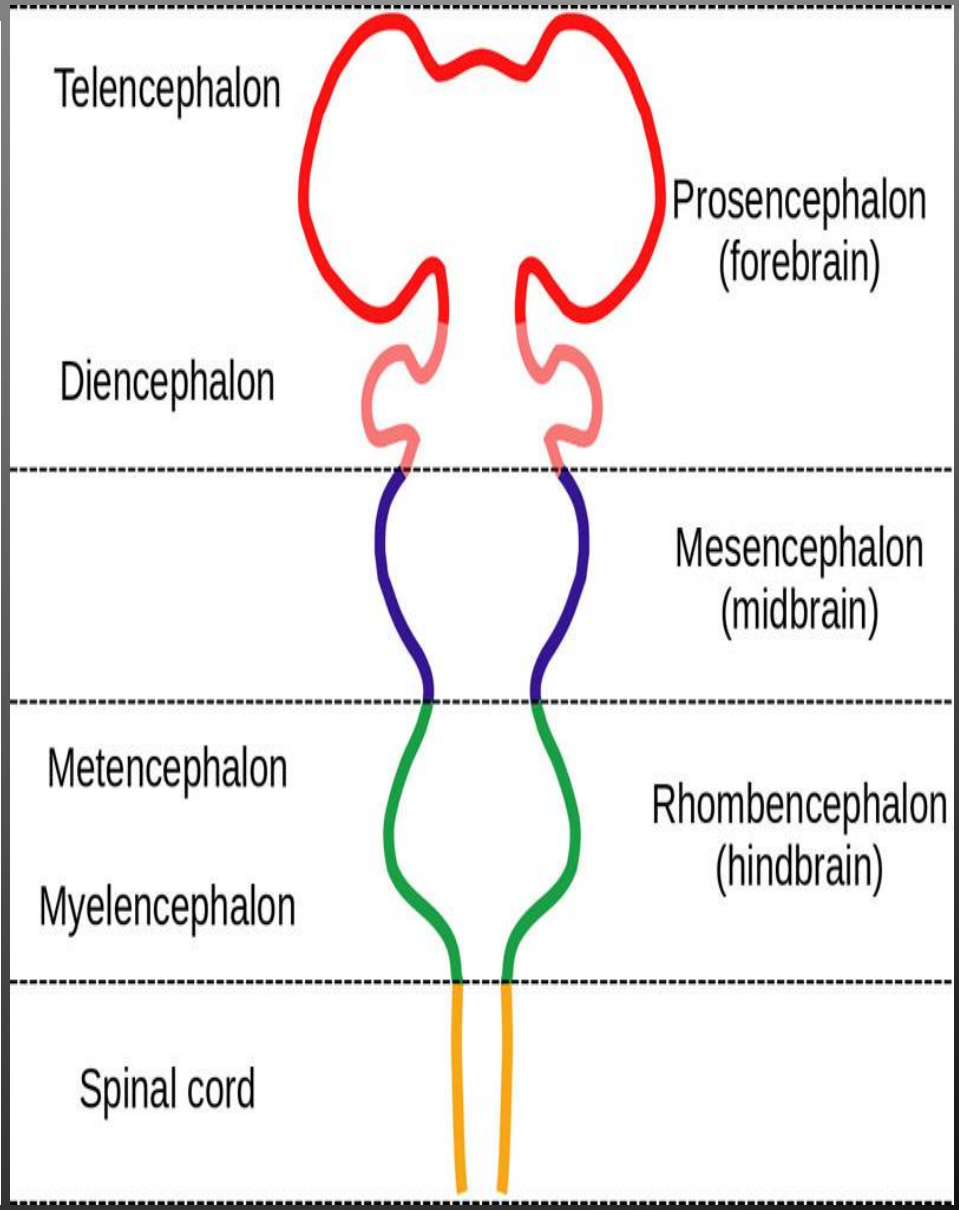


Principal Parts of the Brain

1. Cerebrum
2. Diencephalon
   a) Thalamus
   b) Hypothalamus
3. Cerebellum
4. Brainstem
   a) Medulla
   b) Pons
   c) Midbrain

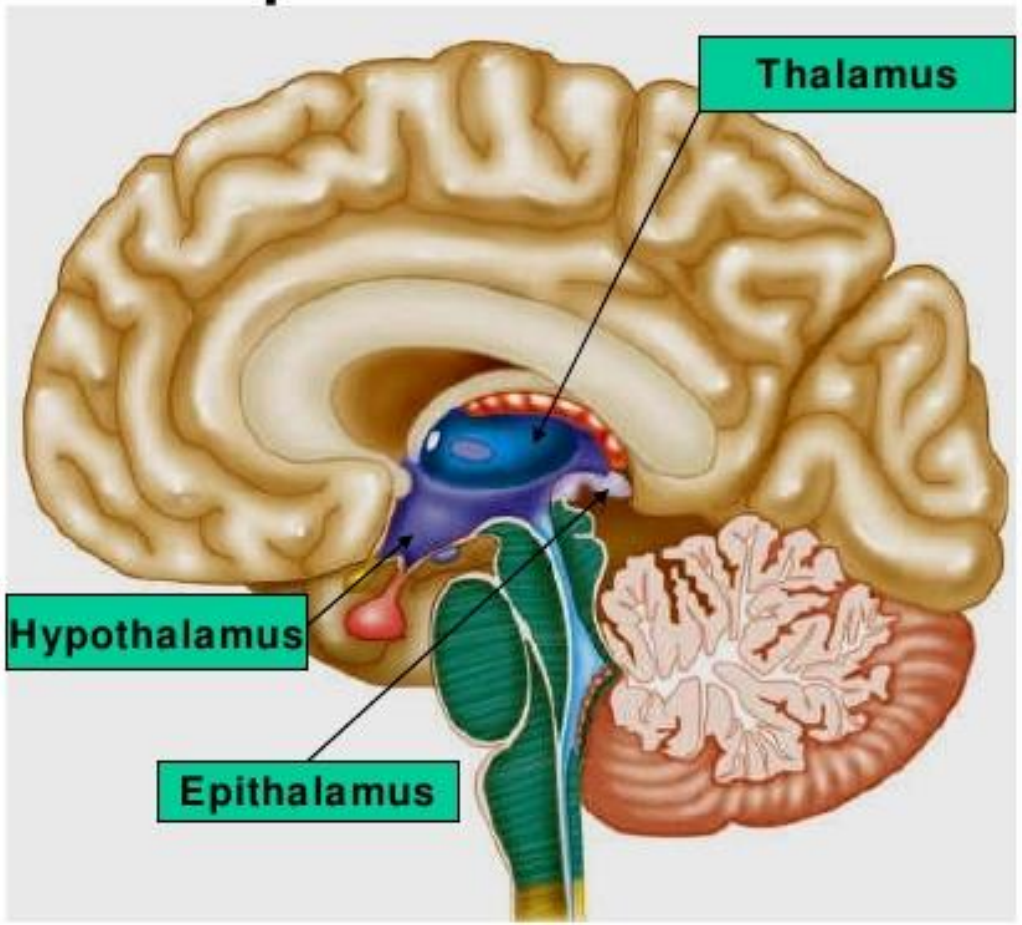



Forebrain
Cerebrum
Thalamus
Hypothalamus
Cerebral cortex
Pituitary gland
Midbrain
Brain stem
Hindbrain
Pons
Medulla oblongata
Cerebellum
Spinal cord


Telencephalon
Prosencephalon (forebrain)
Diencephalon
Mesencephalon (midbrain)
Metencephalon
Rhombencephalon (hindbrain)
Myelencephalon
Spinal cord

The Diencephalon

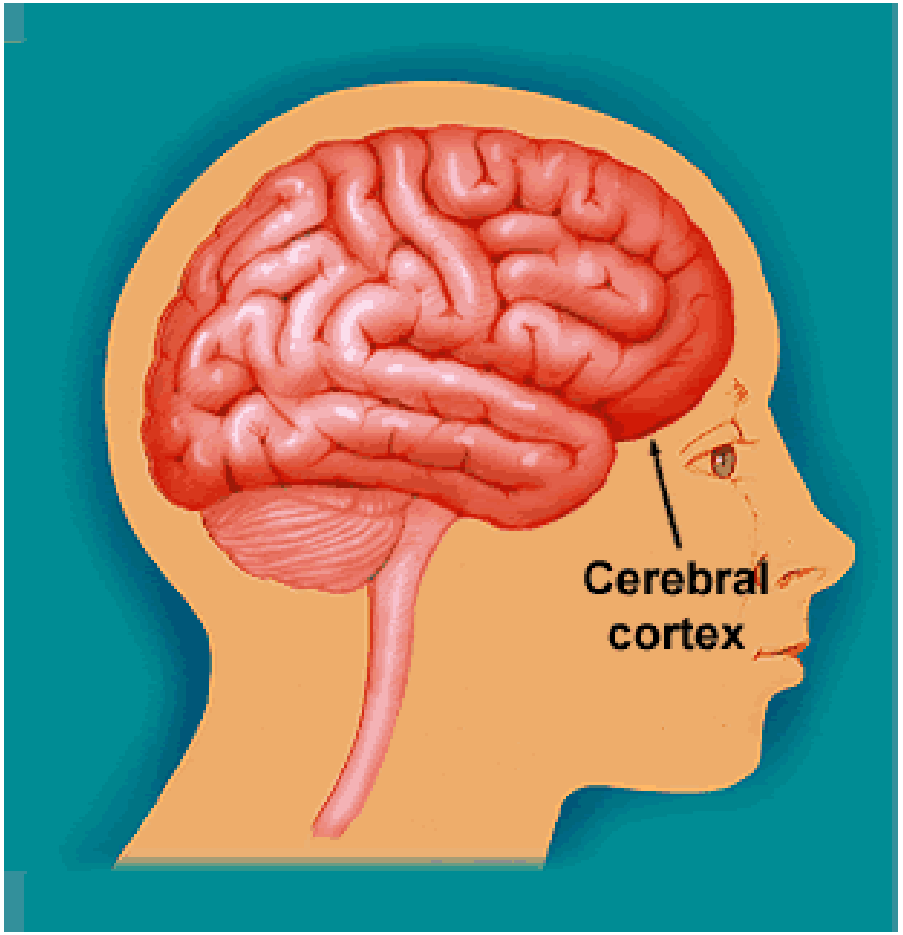
- The diencephalon consists of three structures
  - Thalamus
  - Hypothalamus
  - Epithalamus
- These structures effectively enclose the third ventricle

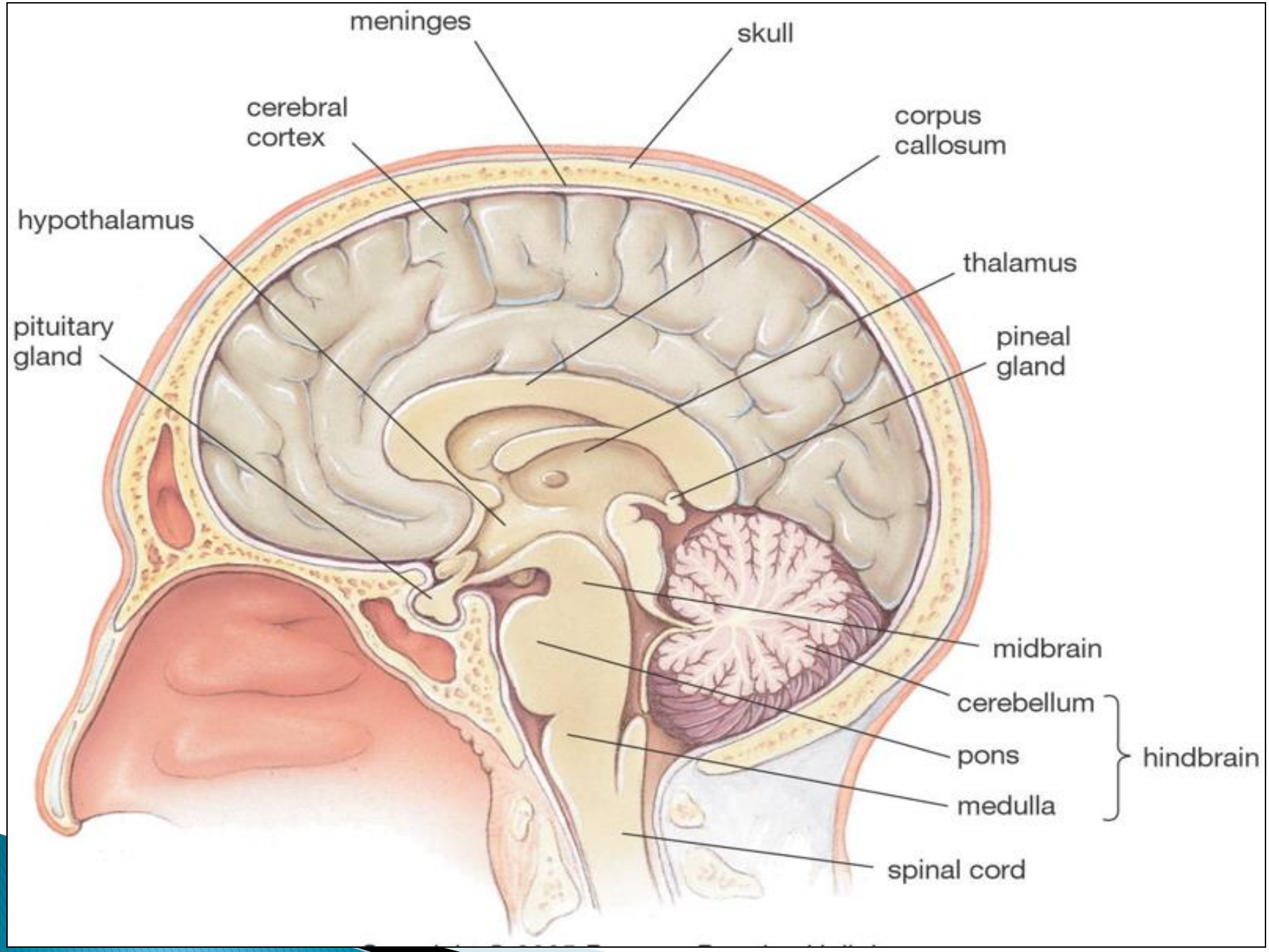


Anatomy of the Brain

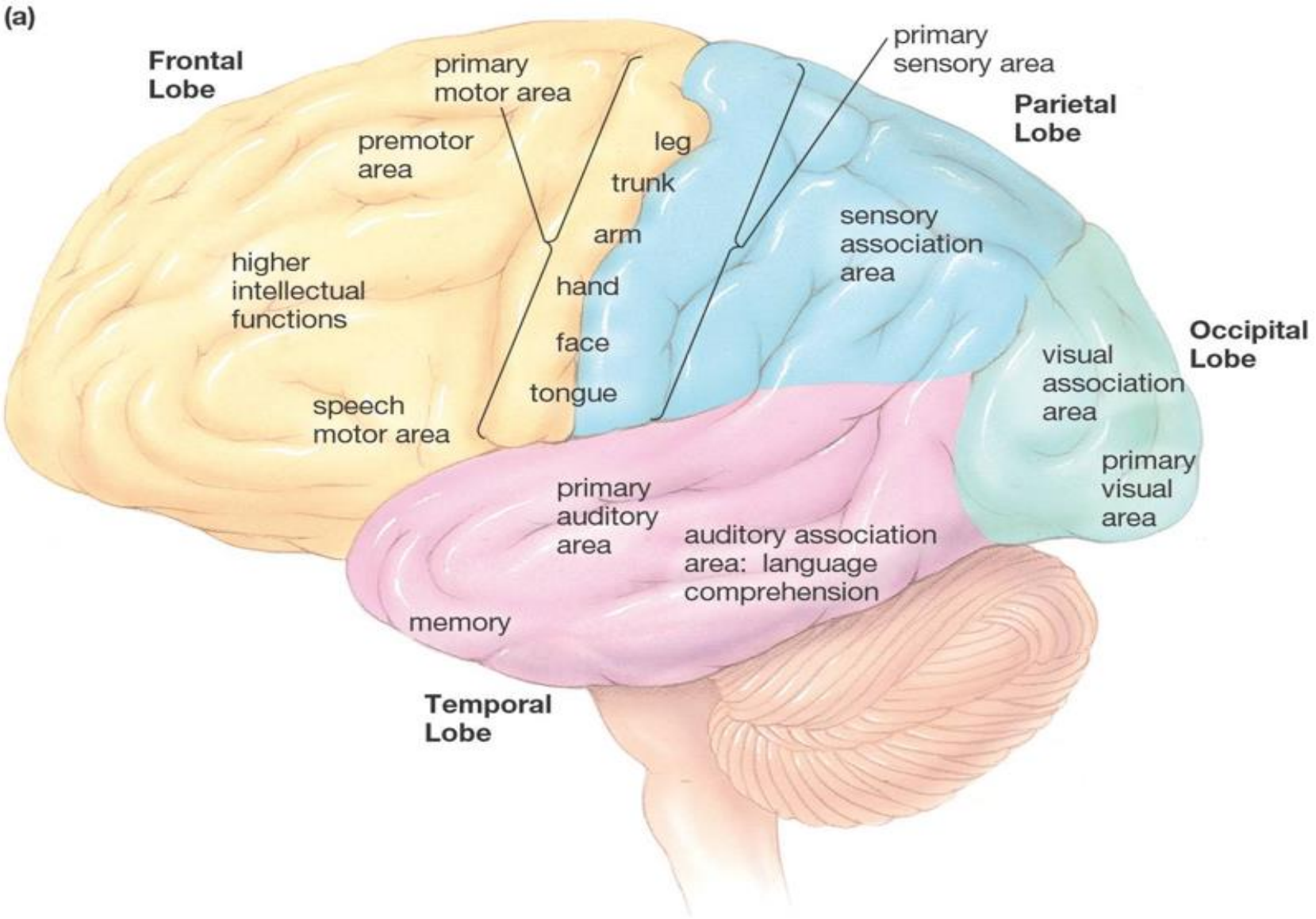
Cerebrum : largest part of human brain

- Responsible for:
  - Thought
  - Language
  - Senses
  - Memory
  - Voluntary movement




meninges
skull
cerebral cortex
corpus callosum
hypothalamus
thalamus
pituitary gland
pineal gland
midbrain
cerebellum
pons
medulla
hindbrain
spinal cord

CORTEX

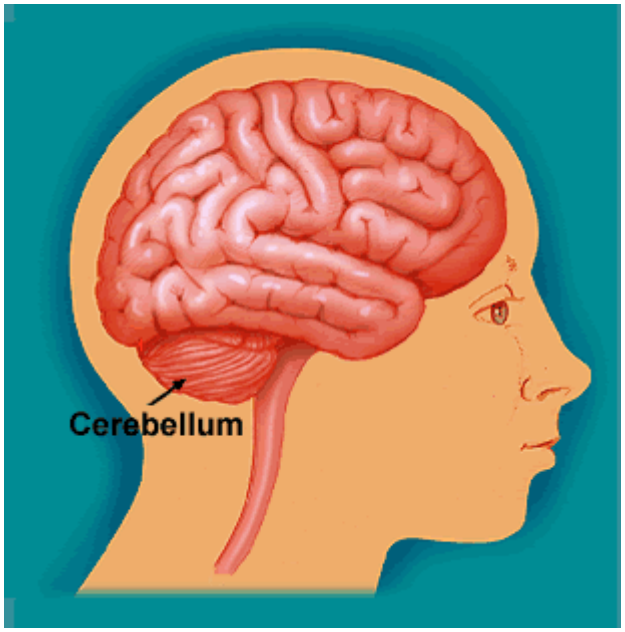


Anatomy of the Brain

Cerebellum : at base of brain

-Responsible for:

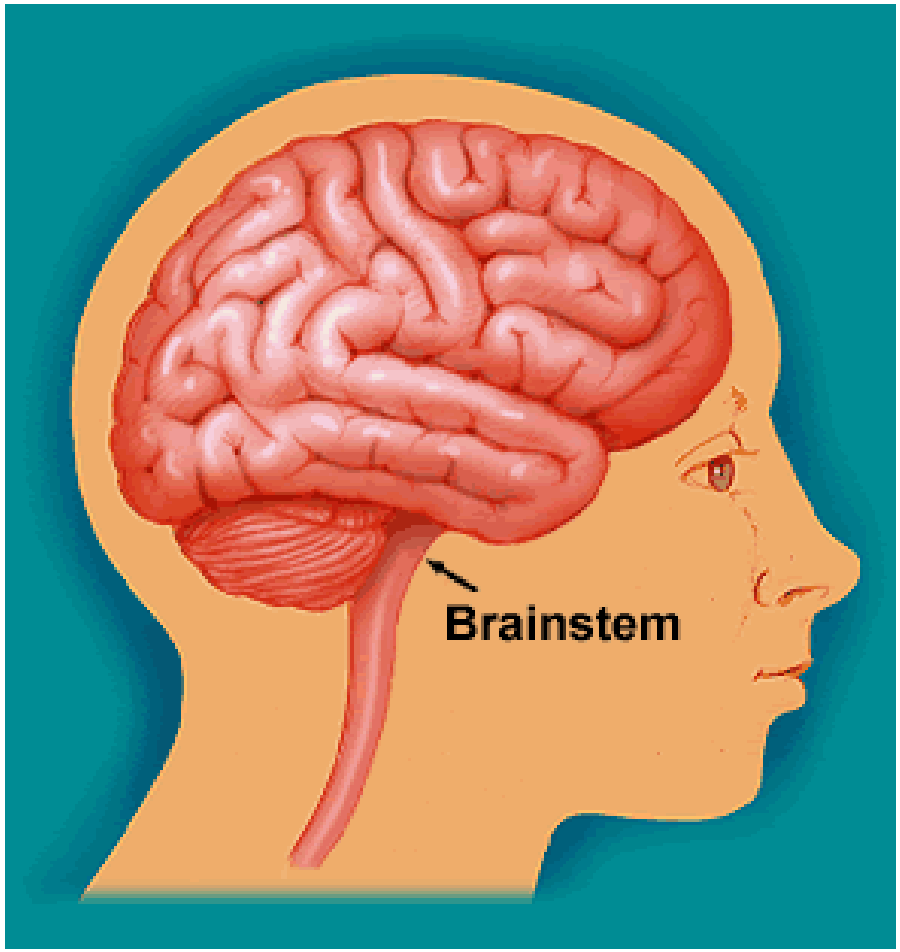
- Muscle coordination
- Balance
- Posture

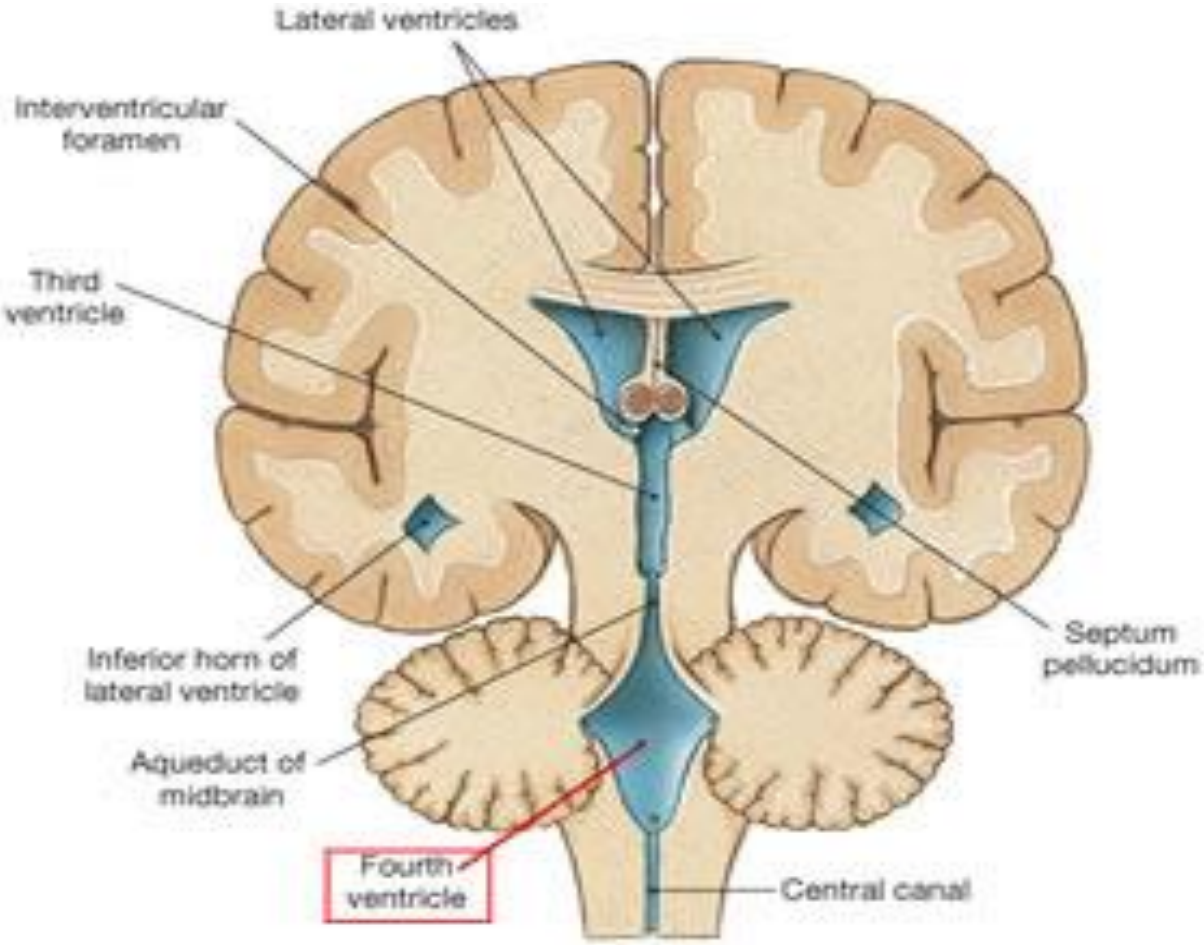


Anatomy of the Brain

Brain Stem :
connects brain to spinal cord

–Responsible for:
- Breathing
- Swallowing
- Heartbeat
- Blood pressure

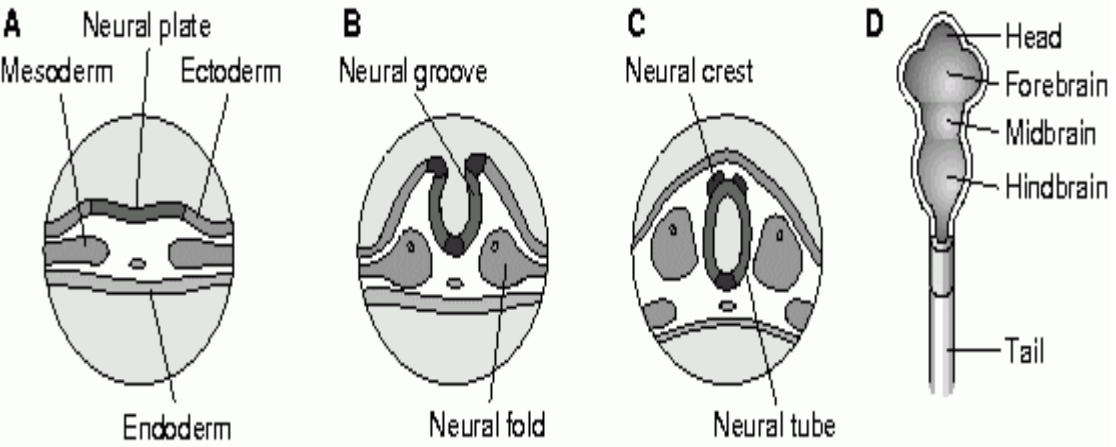


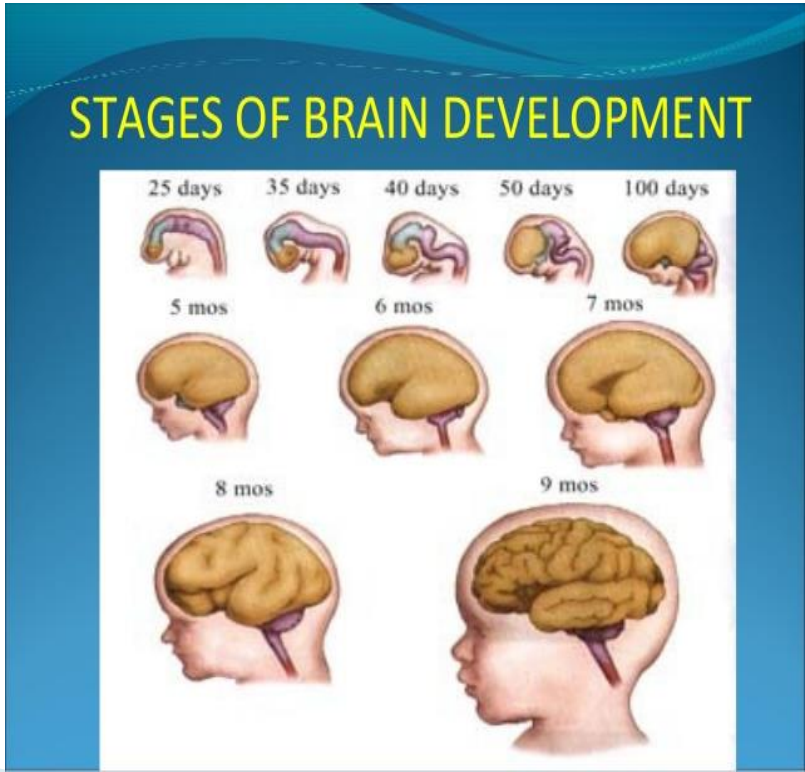


FOURTH VENTRICLE

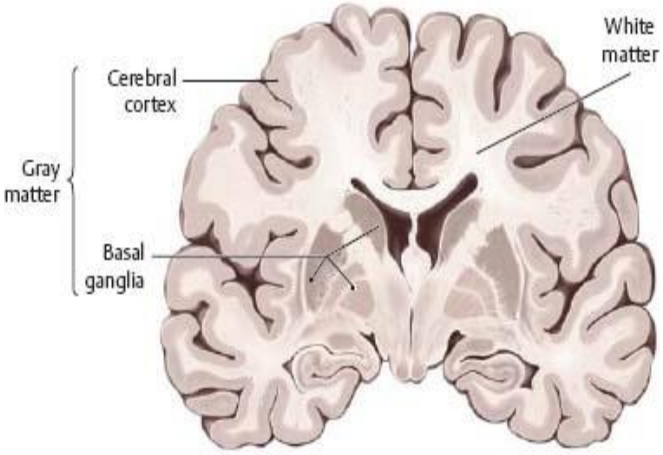
Development of brain

- Neural tube- the whole of nervous system develops from ectoderm. Formation of neuroplate lead to neural fold , then neural groove between the two fold, fusing lead to foramtion of neural tube.

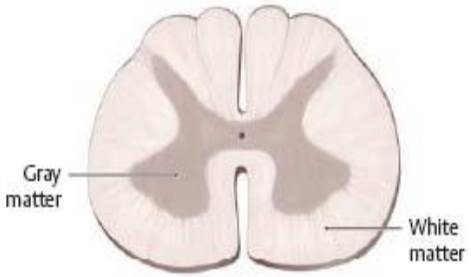




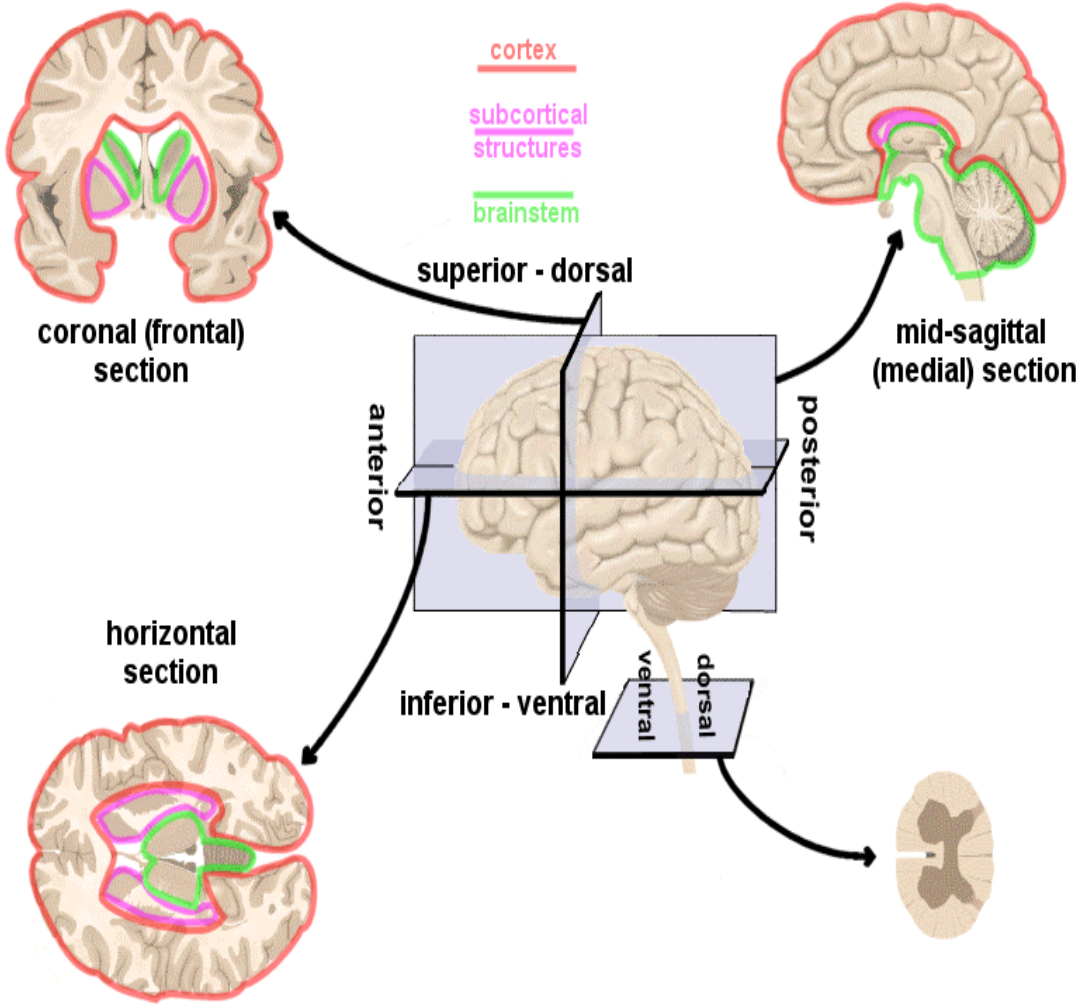
Gross study of brain



A Coronal section through the brain.

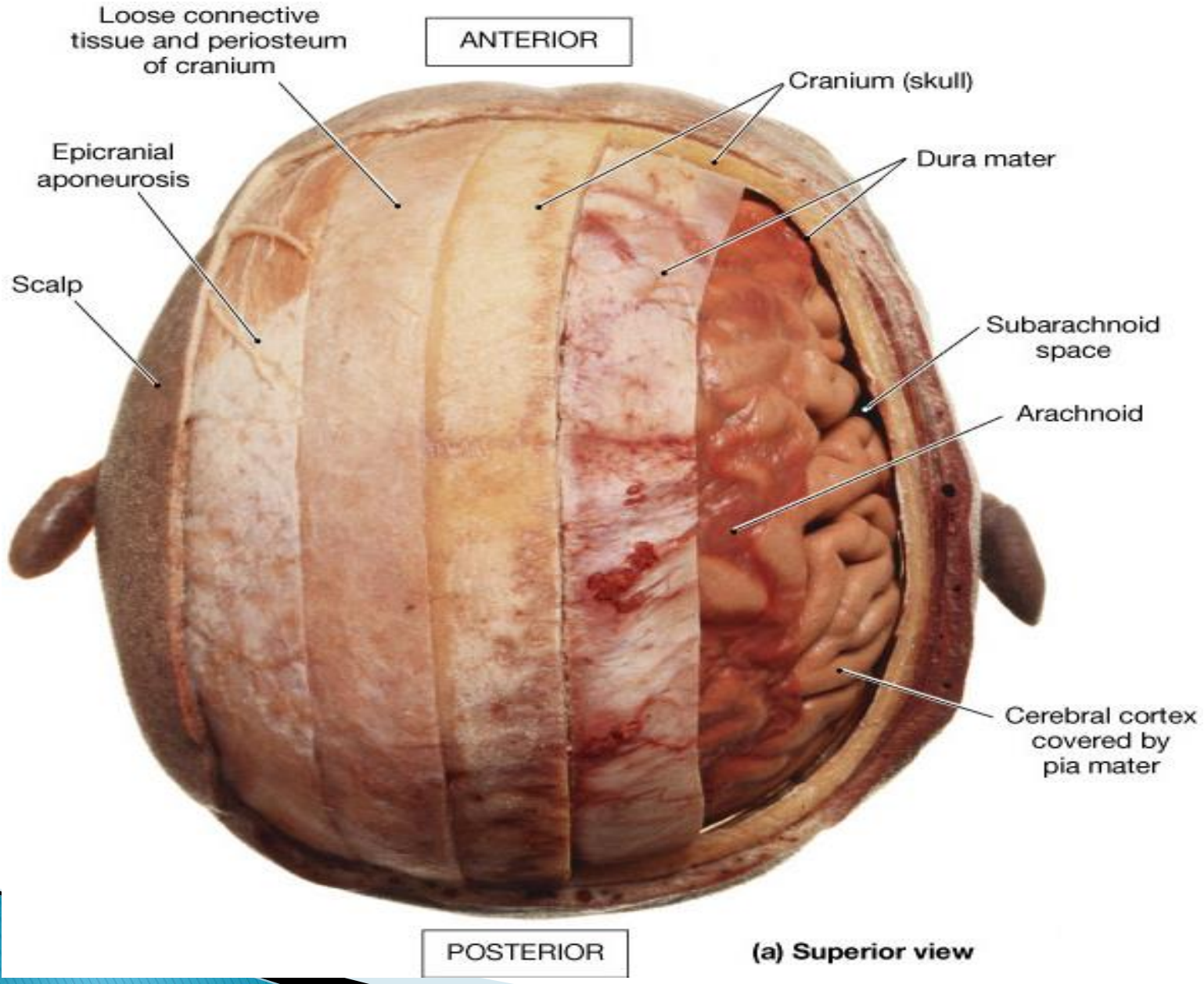


B Transverse section through the spinal cord.

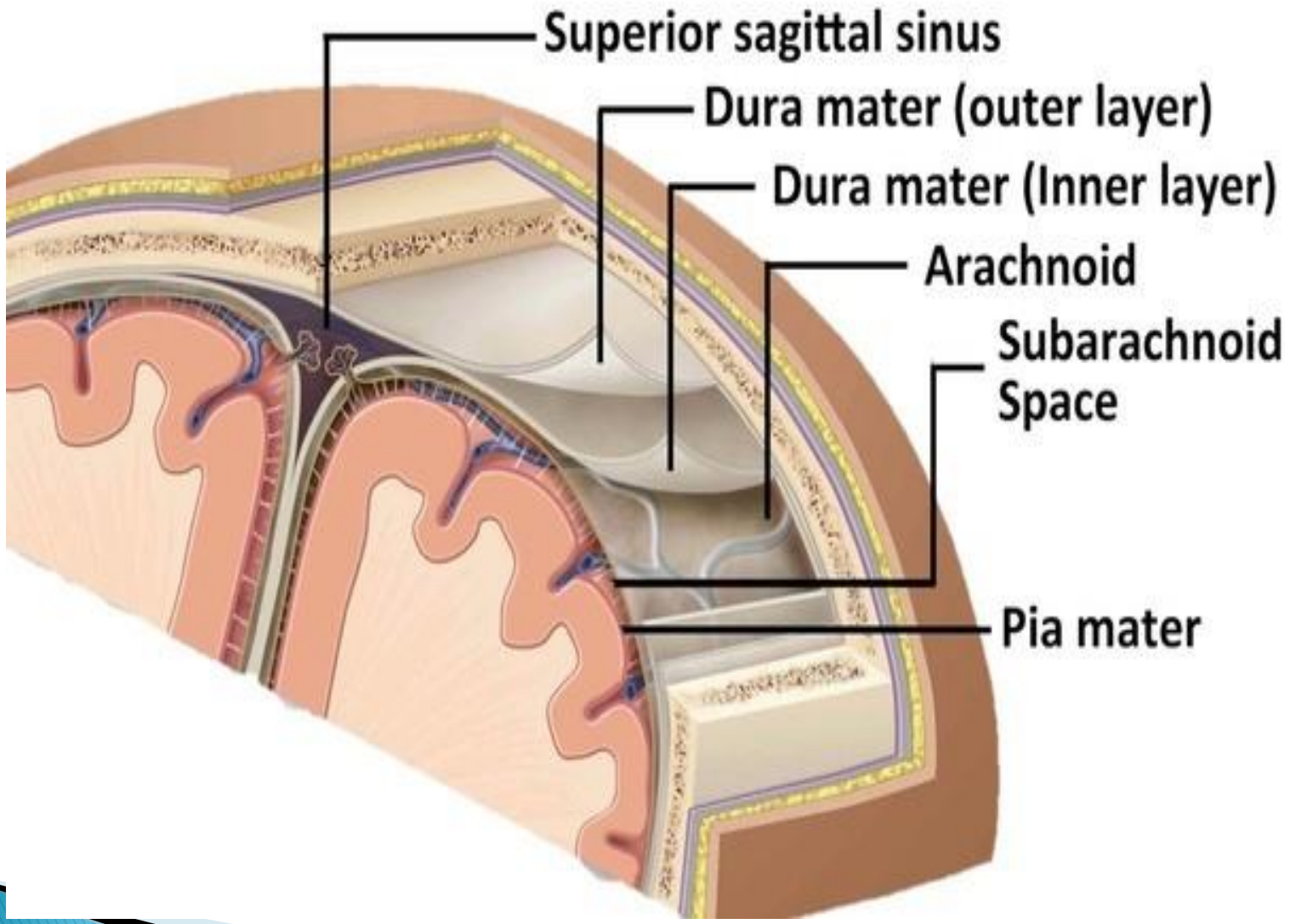


Meninges of the brain

- The brain is most protected part of the body. It is protected by:
- Bony covering of the cranium
- Three membranous covering (meninges)
  - The outer dura mater (pachymeninx)
  - The middle arachnoid mater
  - The inner pia mater. The arachnoid and pia are together known as the leptomeninges.
- The cerebrospinal fluid fills the space between the arachnoid and pia maters (subarachnoid space) and acts as a water cushion.

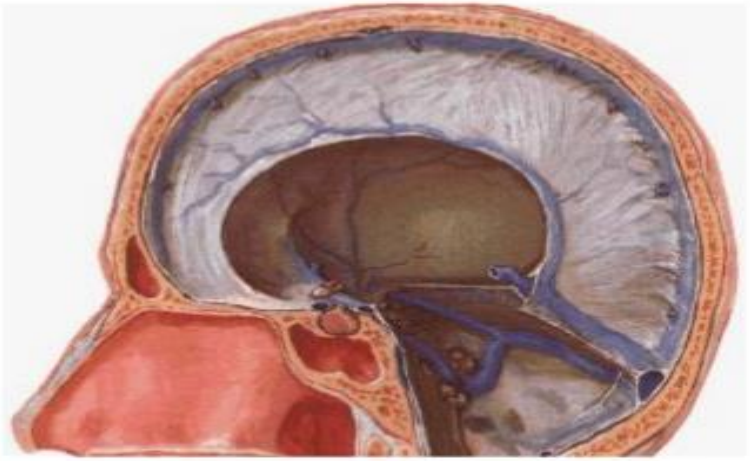


(a) Superior view


Superior sagittal sinus
Dura mater (outer layer)
Dura mater (Inner layer)
Arachnoid
Subarachnoid Space
Pia mater

DURA MATER

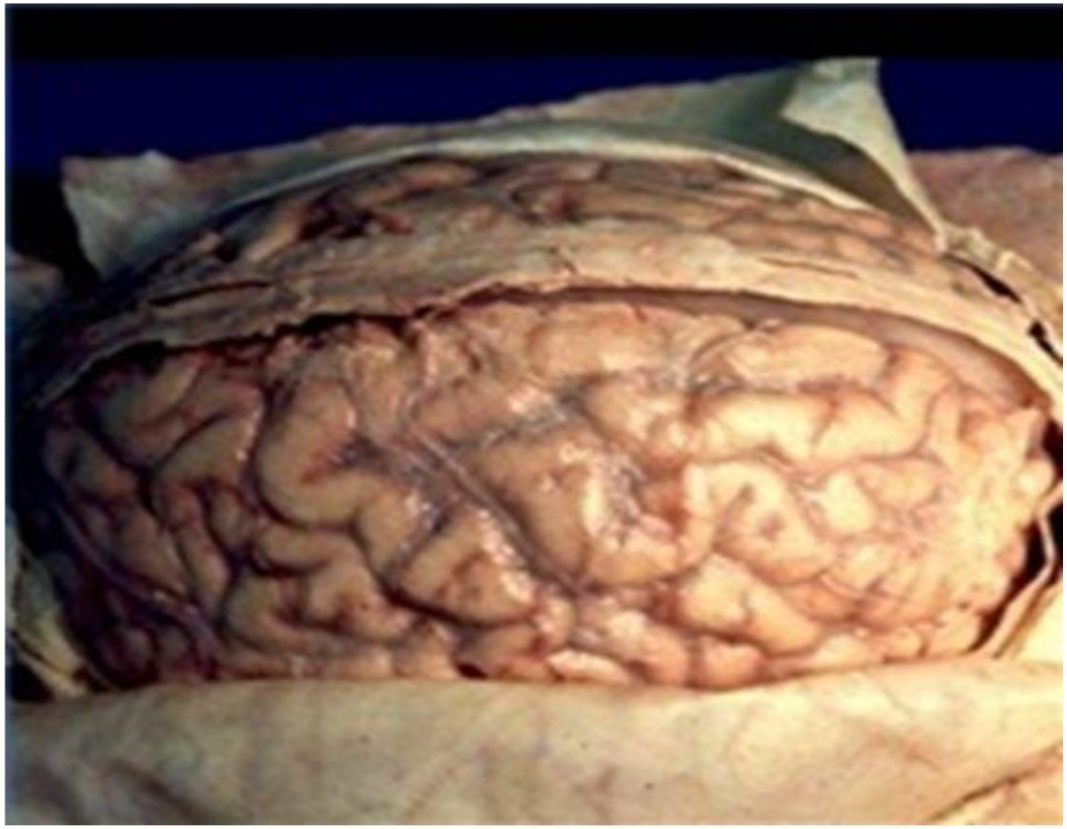
- Endosteal layer ;
  - Periosteum - inner surface of the skull bones
  - Not continuous with dura mater of spinal cord
- Meningeal layer ;
  - Dura mater proper
  - Covering the brain
  - Continuous with dura mater of spinal cord
  - Folded inwards as 4 septa between part of the brain
  - The function of these septa is to restrict the rotatory displacement of the brain.



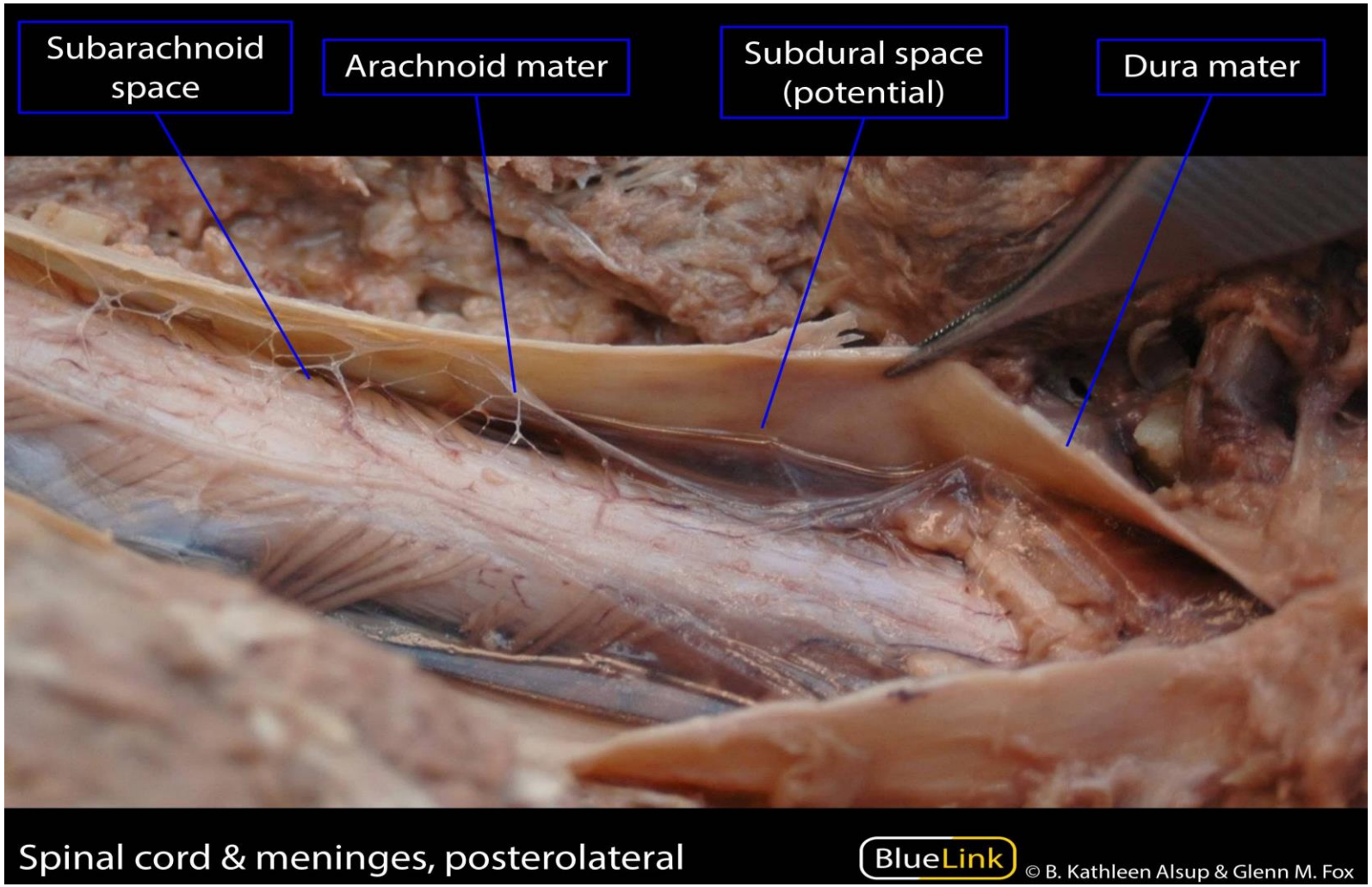
Dura (Latin- hard mother) mater has two layers, an outer endosteal layer and inner meningeal layer enclosing the cranial venous sinuses between the two

Arachnoid mater

- The arachnoid mater is a thin, avascular membrane, against, but not adherent to, the inner surface of the dura mater .



Arachnoid (latin cobweb like) mater is a thin transparent membrane surround the brain loosely without dipping into its sulci



It is separated from dura by the subdural space, from the pia by the subarachnoid space containing CSF and blood vessels

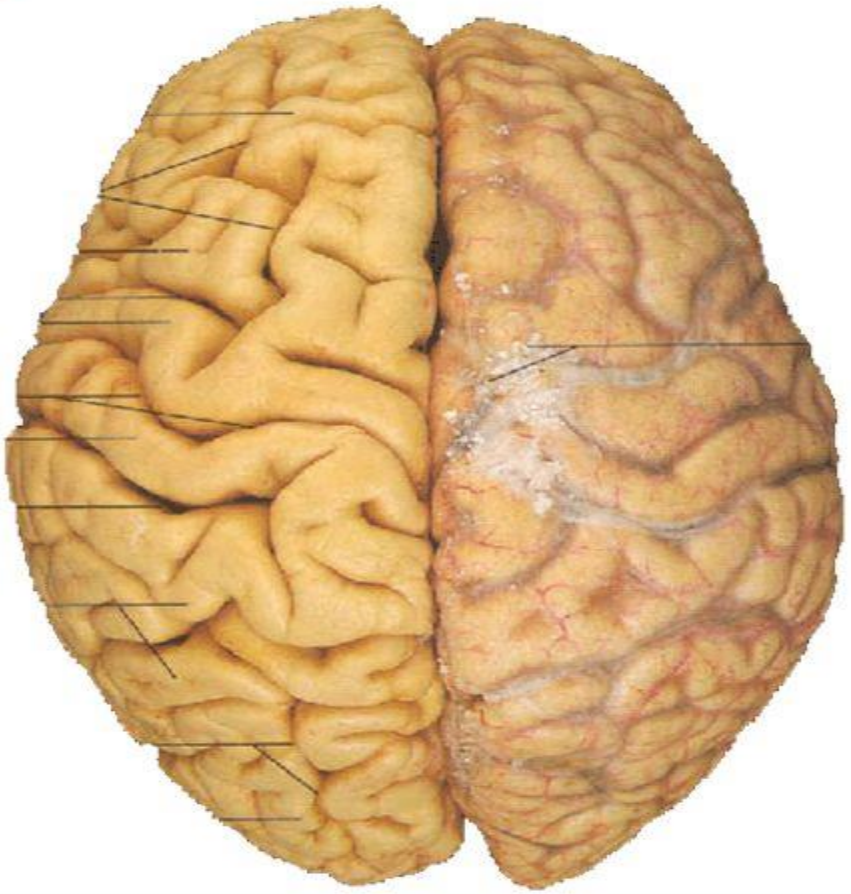
Arachnoid mater

- Prolongation:
  - It provides sheaths for the cranial nerves as far as their exit.
  - Arachnoid villi are small finger like processes of arachnoid tissue and absord CSF.

Pia mater

Cerebral pia mater

- Closely invests brain surface, in some areas the pia invaginates into ventricles to take part in the formation of choroids plexus



- The pia (Latin loving mother) mater is a thin vascular membrane which closely invests the brain, dipping into various sulci and other irregularities of its surface. It comprises epi-pia and pia glia.
- Prolonggation:
  - It provides sheaths for the cranial nerves merging with the epineurium around them.
  - Folds of pia mater enclosing tufts of capilaries form the telachoroidea and its line by secretory form the telachoroidea and its line by secretory ependyma form the choroid plexus.

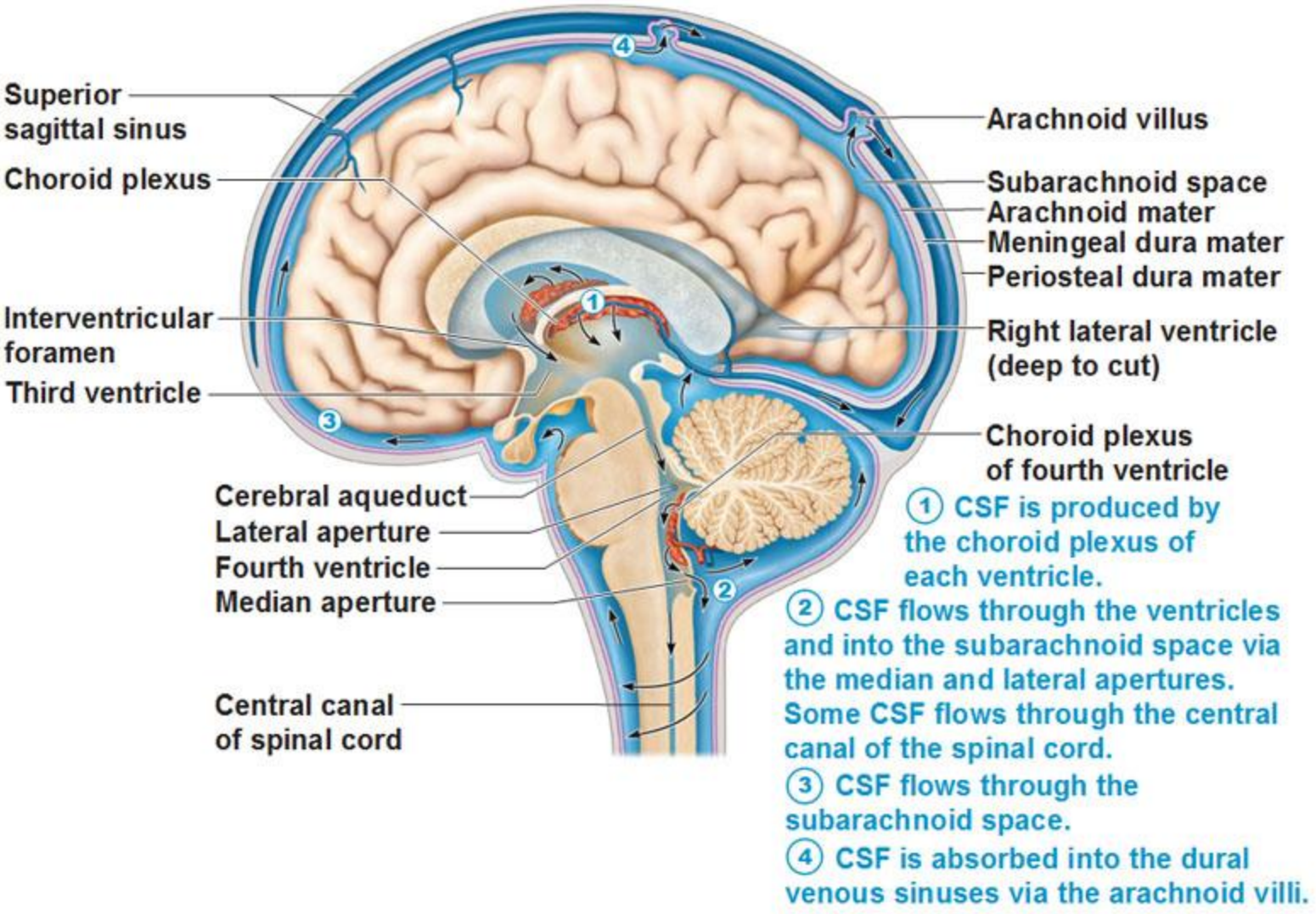
Cerebrospinal fluid (CSF)

- It is a modified tissue fluid.
- It contained in the ventricular system of the brain and in subarachnoid space around the brain and spinal cord.

Formation of CSF

- The bulk of the CSF is formed by choroid plexuses of the lateral ventricles and lesser amounts by the choroid plexuses of the third and fourth ventricles.
- Formed by the capillaries on the surface of brain and spinal cord.
- Total amount is 150 ml.
- Formation rate is 200ml per hour or 5000ml per day.

Circulation of Cerebrospinal Fluid (CSF)



(1) CSF is produced by the choroid plexus of each ventricle.

(2) CSF flows through the ventricles and into the subarachnoid space via the median and lateral apertures. Some CSF flows through the central canal of the spinal cord.

(3) CSF flows through the subarachnoid space.

(4) CSF is absorbed into the dural venous sinuses via the arachnoid villi.

Circulation of CFS

- CSF passes from lateral ventricles
- Through interventricular foramen of Monro
- To the third ventricles
- Through cerebral aqueduct
- To the fourth ventricles
- Through median and lateral apertures of 4^{th} ventricles
- To the subarachnoid space.

Absorption of CSF

- CSF is absorbed by villi and granulation of arachnoid space.
- Absorbed partly by the perineural lymphatics
- It is also absorbed by spinal nerves vein.
- And drain into the cranial venous sinuses.
- FUNCTION:
- Protective
- Nutritive
- A pathway for metabolites from CNS.

Applied Anatomy.

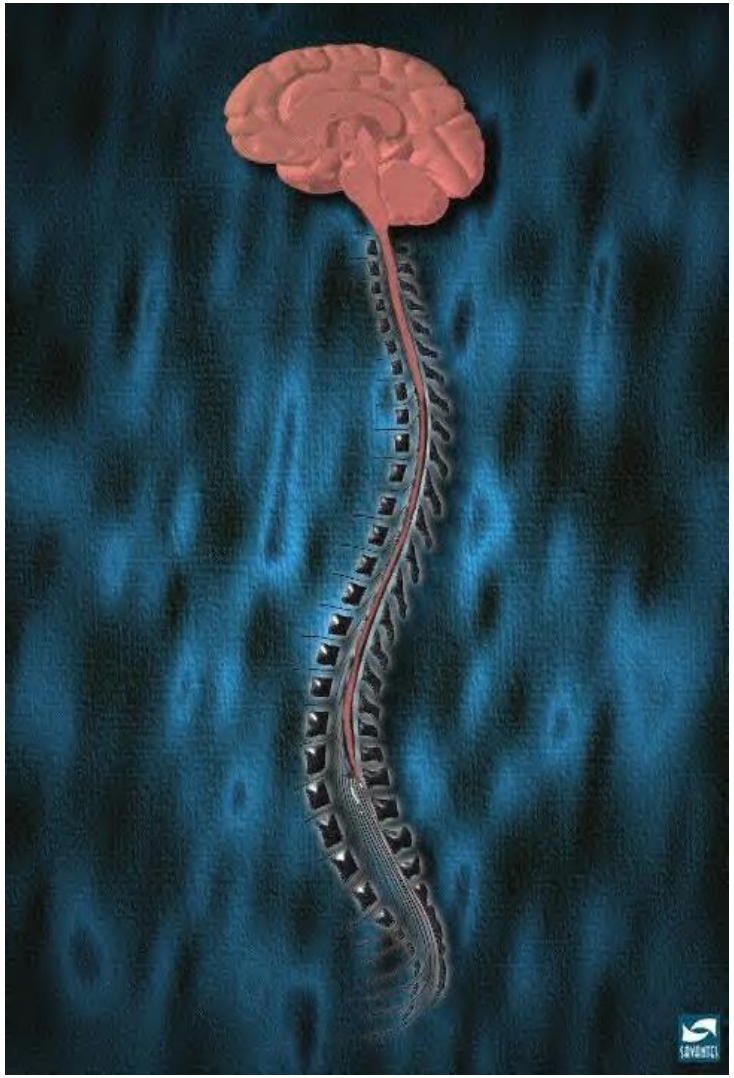
- CSF is obtained by Lumber puncture.
- Biochemical analysis of CSf is diagnostic in various diseases
- Obstruction of CSF flow lead to Hydrochephalus

Central Nervous System

Spinal Cord : Column of nerves from brain to tailbone – protected by vertebrae of spine

- Responsible for:
  - Conducting impulses between the brain and the rest of the body

*Impulses may travel as fast at 268 miles/hr



Brain Teaser

A H I M N O T U V W

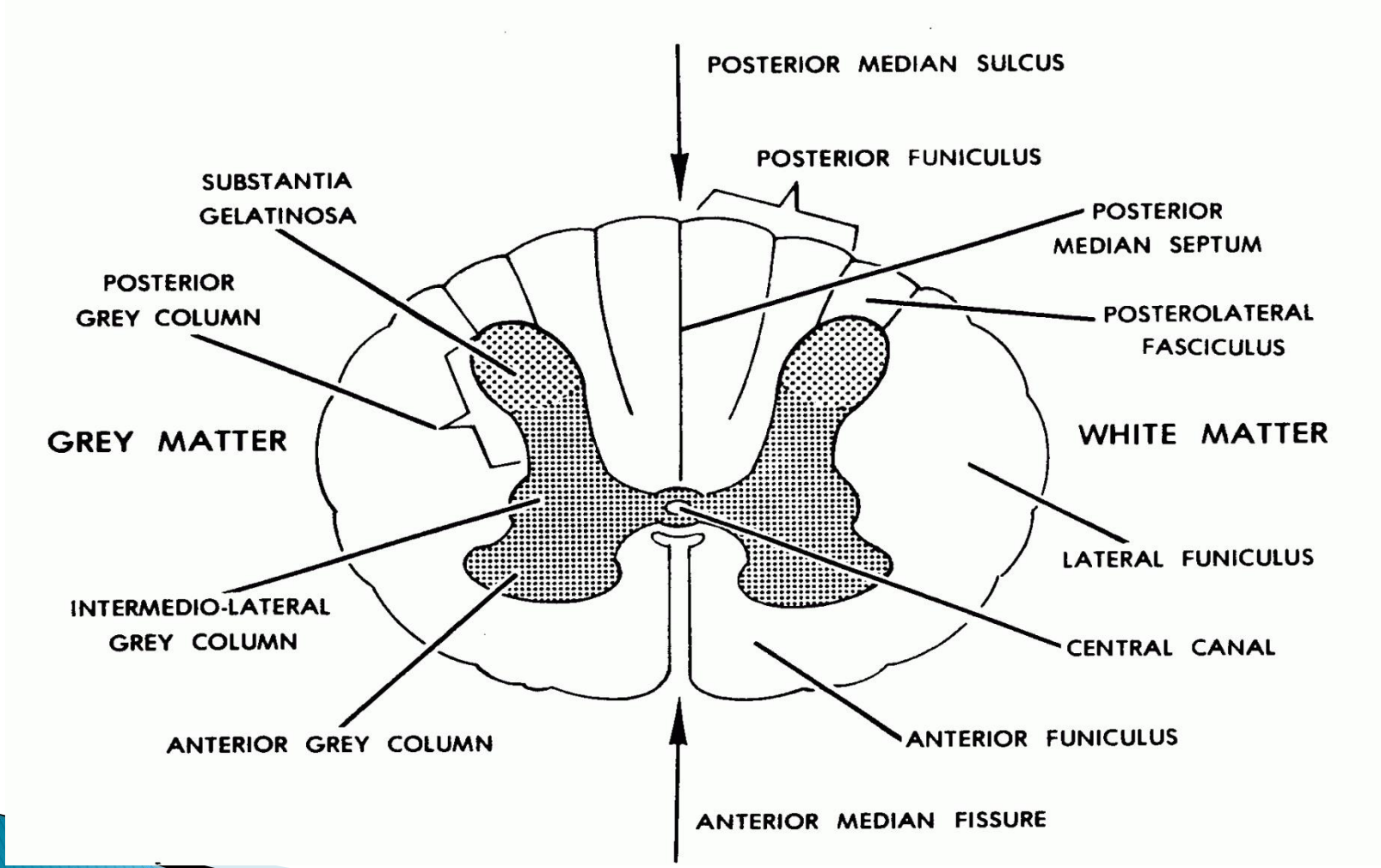
Which of the letters above does not belong with the rest?

N It is not a mirror-image of itself

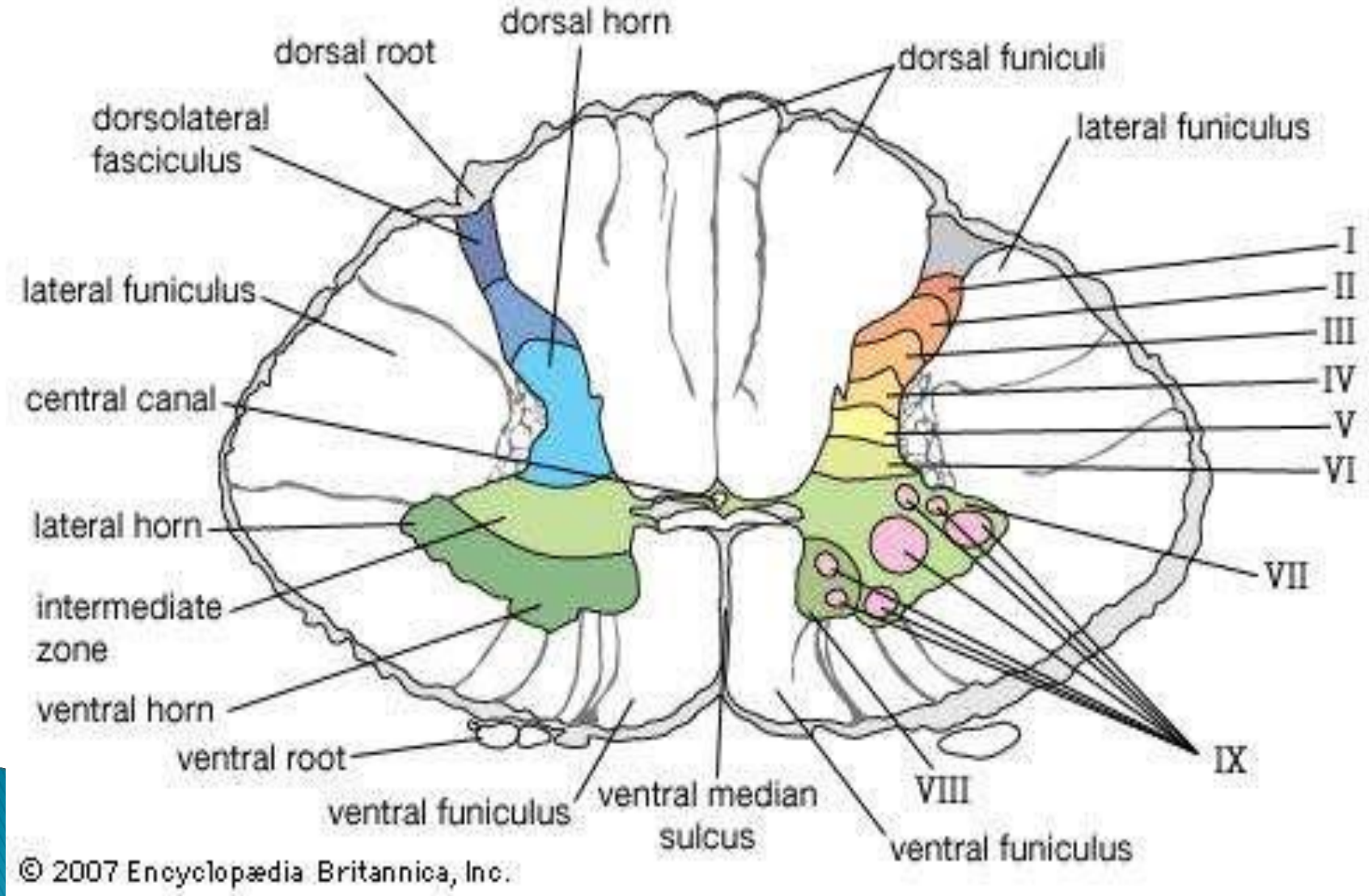
Spinal cord

- It is lower elongated, cylindrical part of the CNS. It occupies the upper two third of the vertebral canal
- Extend from level of upper border of atlas to the lower border of vertebra L1
- It is about 45 cm long.
- The lower end is conical and is called conus medullaris.
- The spinal cord gives off 31 pairs of spinal nerves.

Internal structure of spinal cord.



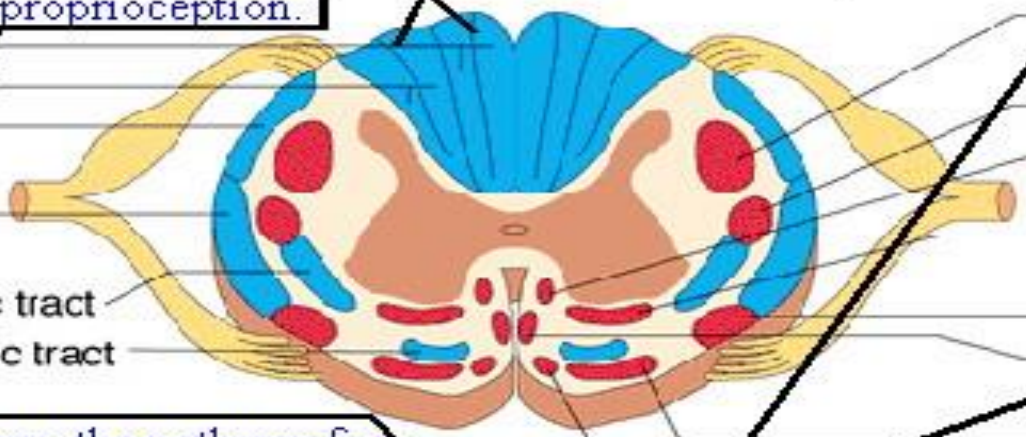
Laminar structure of spinal cord



The tract of spinal cord

- A collection of nerve fibres that connects two masses of grey matter within the CNS is called a tract.
- Tract may be ascending or descending.

The Spinal Tracts



sensory tracts
Ascending tracts

Often called the posterior white columns. Carry discriminative touch and conscious proprioception.

Fasciculus gracilis
Fasciculus cuneatus
Posterior spinocerebellar tract
Anterior spinocerebellar tract
Lateral spinothalamic tract
Anterior spinothalamic tract

Lead to the thalamus, the pathway for crude touch, pain, temperature, pressure.

From the spinal cord to the cerebellum. Carry subconscious proprioceptive stimuli. Proprioception is "body sense" and "muscle sense", the perception of body position and muscle position necessary for coordinating movements.

motor tracts
Descending tracts

Lateral corticospinal tract
Rubrospinal tract
Anterior reticulospinal tract
Lateral reticulospinal tract
Olivospinal tract
Anterior corticospinal tract
Vestibulospinal tract
Tectospinal tract

These tracts come from a variety of locations in the brain, as a group are termed the "extra-pyramidal tracts", and are generally associated with balance and muscle tone.

The corticospinal tracts carry voluntary motor stimuli from the cerebral cortex to motor neurons in the spinal cord. They are also called the "pyramidal tracts" because some of them cross in the pyramids of the medulla.

Cranial nerve

- There are 12 pairs of cranial nerve.
- It is supply to muscles of eyeball, face, palate, pharynx, tongue and two large muscles of neck, lungs, heart and most part of gastrointestinal tract.
- They are afferent to special senses like smell, sight, hearing, taste and touch.

Number	Name of cranial nerve	Mnemonic	Attached to
I	Olfactory	Oh	Forebrain
II	Optic	Oh	Forebrain
III	Oculomotor	Oh	Midbrain
IV	Trochlear	Try	Midbrain
V	Trigeminal	Try	Pons
VI	Abducent	Again	Pons
VII	Facial	failure	Pons
VIII	Vestibulocochlear	victory	Pons
IX	Glossopharyngeal	give	Medulla Oblongata
X	Vagus	value	Medulla Oblongata
XI	Accessory	and	Medulla Oblongata
XII	Hypoglossal	Happiness.	Medulla Oblongata

Functional components of cranial Nerves

- In spinal cord, grey matter forms and differentiated into two somatic and two visceral functional columns.
- Somatic columns are general somatic efferent (motor or anterior horn) and general somatic afferent (sensory or posterior horn).
- The visceral columns are general visceral efferent (motor) and general visceral afferent (sensory).

Nuclei of cranial nerve

- General Somatic Efferent (GSE) Nuclei supply skeletal muscle of somatic origin.
- Visceral efferent Nuclei supply striated muscle and smooth muscle or glands.
- General Visceral afferent Nucleus get sensation through Glossopharyngeal nerve from tonsil, pharynx, tongue, carotid body and sinus, through vagus nerve receive sensation from pharynx, larynx, trachea, oesophagus and thoracic and abdominal viscera.
- General somatic Afferent nuclei are all related to trigeminal nerve.

First cranial nerve

- OLFACTORY PATHWAYS-bipolar neurons
- Smell is perceived in olfactory areas.
- Applied Anatomy
- -anosmia is loss of olfactory fibres with aging.
- CSF can leak through nose in head injury.

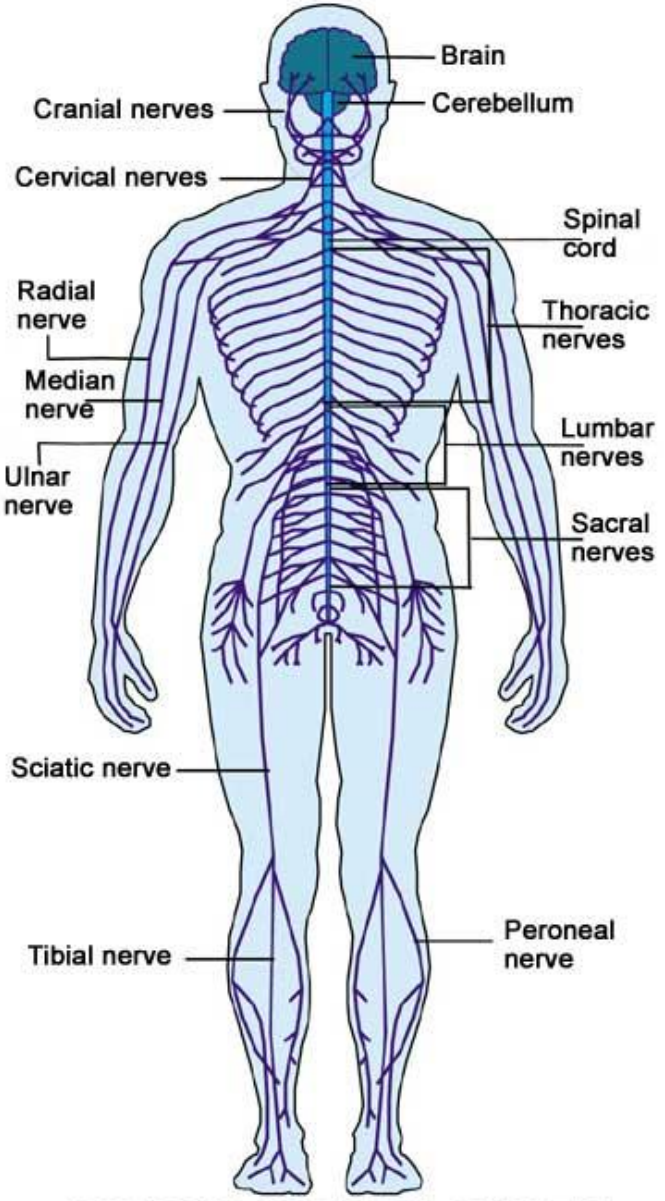
- Assignment:

Brain stem

- The brain stem consists of the medulla oblongata, the pons and midbrain.
- It connects the spinal cord to cerebrum.
- The various ascending and descending tracts pass through the three components of the brain stem.

Peripheral Nervous System

Nerves : visible bundles of axons and dendrites that entend from the brain and spinal cord to all other parts of the body

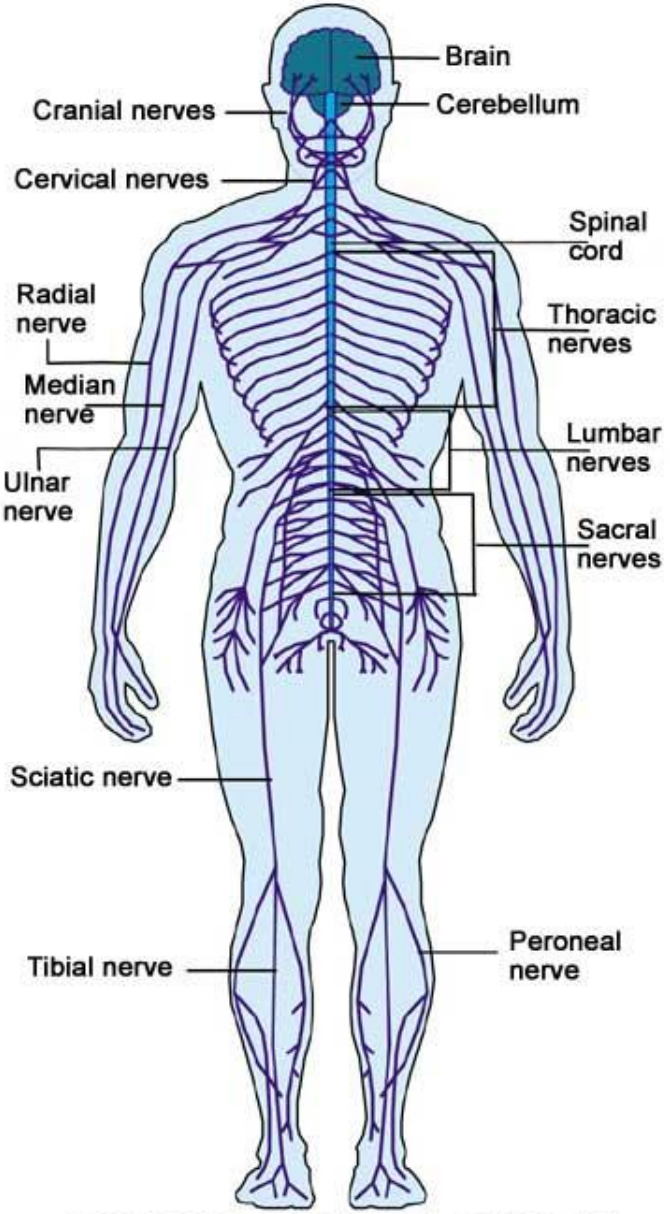


PERIPHAL NERVOUS SYSTEM

-Responsibilities:

- <u>Sensory nerves</u> - carry messages from body to brain (pain, pressure, temperature)

- <u>Motor nerves</u> - carry messages from brain to body to respond



PERIPHAL NERVOUS SYSTEM

Brain Teaser

There is a town where 5% of all the people living there have unlisted phone numbers. If you selected 100 names at random from the town's phone directory, on average, how many of these people would have unlisted phone numbers?

0 They would not be in the phone book if their number was unlisted

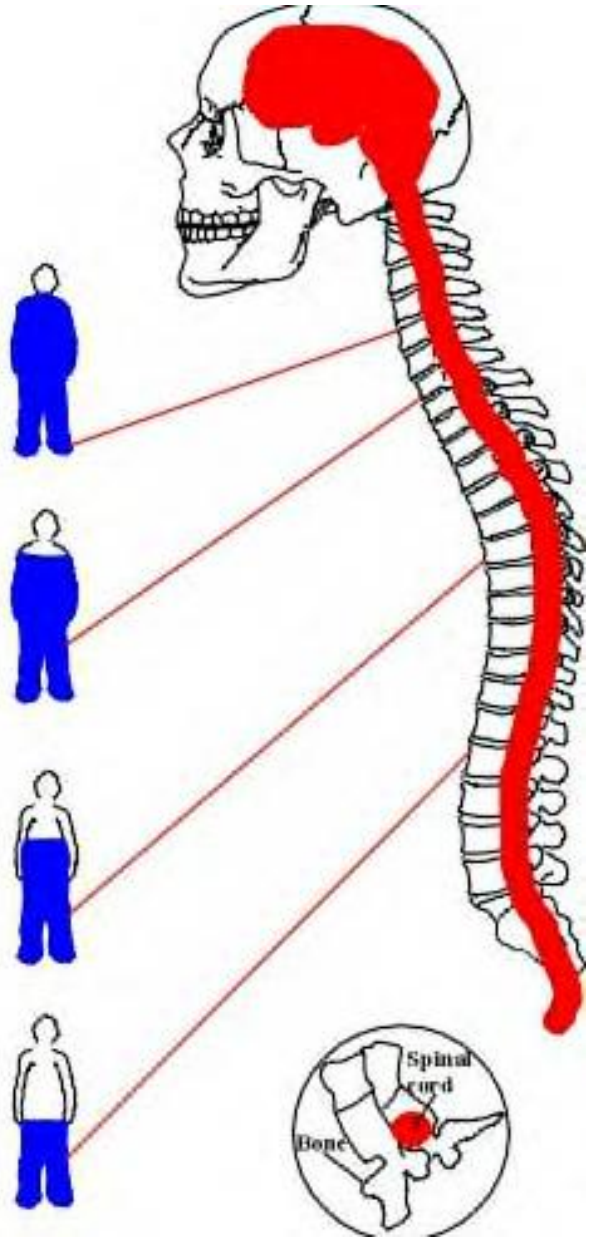
Problems of the Nervous System

Concussion

A temporary disturbance of the brain's ability to function due to a hard blow to the head

Paralysis

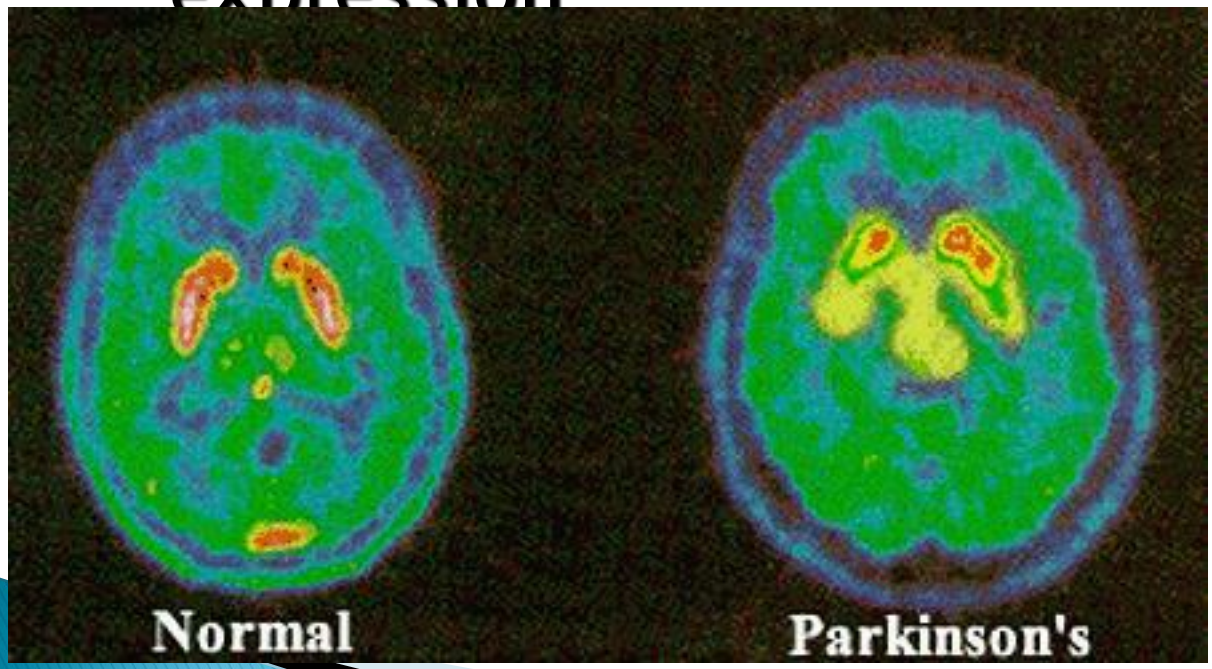
A loss of sensation and movement of part of the body due to an injury of the spinal cord or brain



Parkinson's Disease

The brain does not produce enough of the neurotransmitter that transmits messages from the brain to the muscles

Symptoms: tremors, rigid muscles, shuffling walk, and loss of facial expression

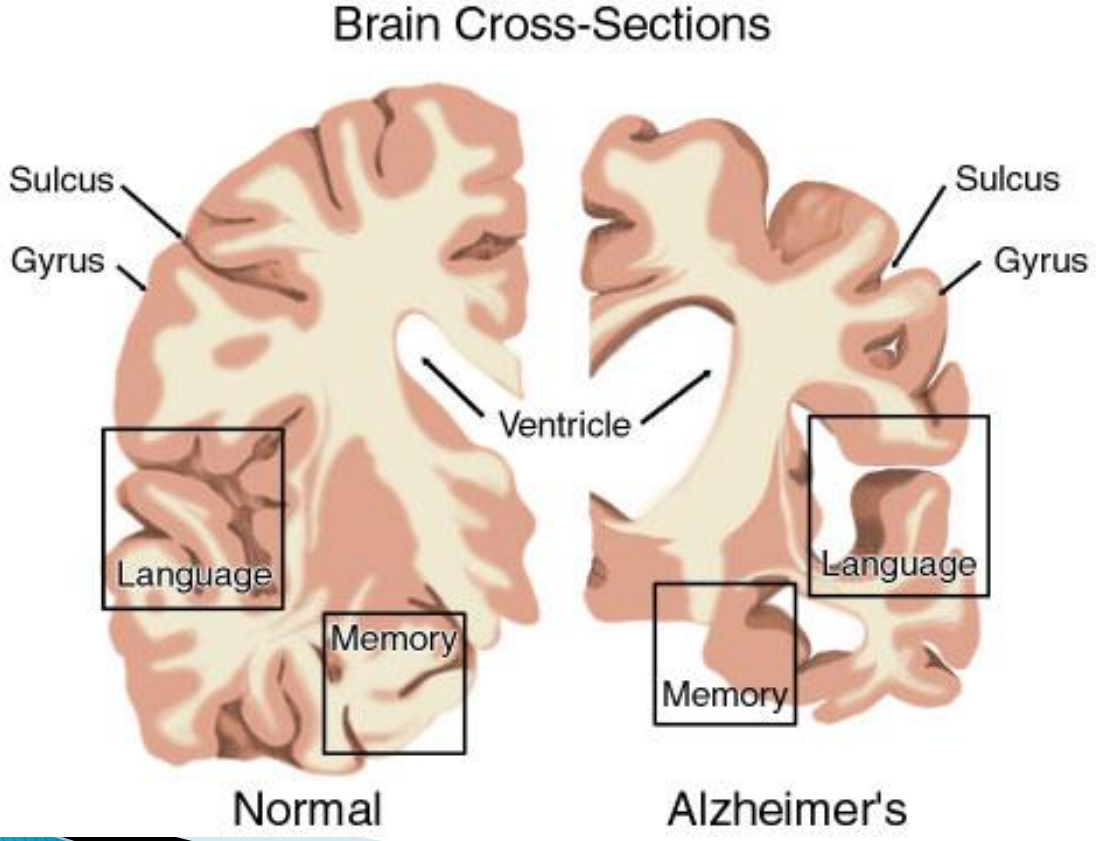


Red areas show where chemical is stored

Alzheimer's Disease

A gradual shrinking of the neurons in the cerebrum

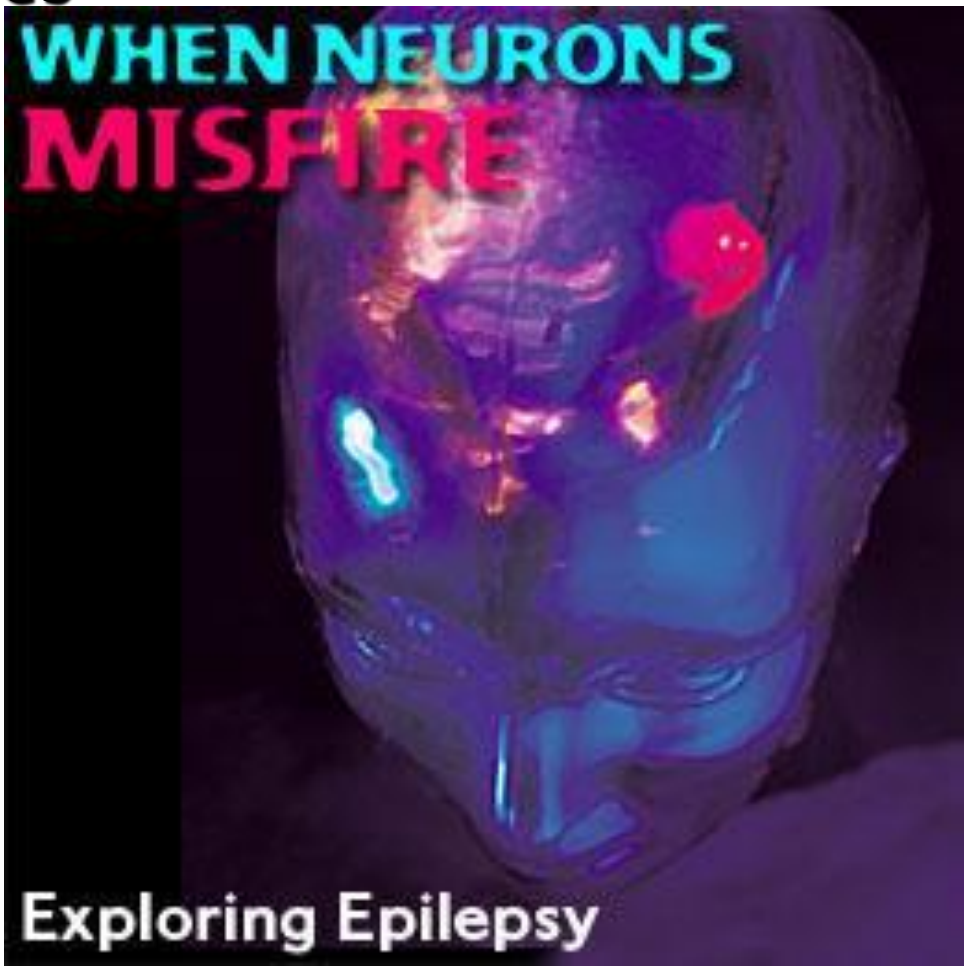
Symptoms: memory loss, emotional disturbances, inability to function on own, death



Epilepsy

Abnormal transmission of messages between the neurons in the brain

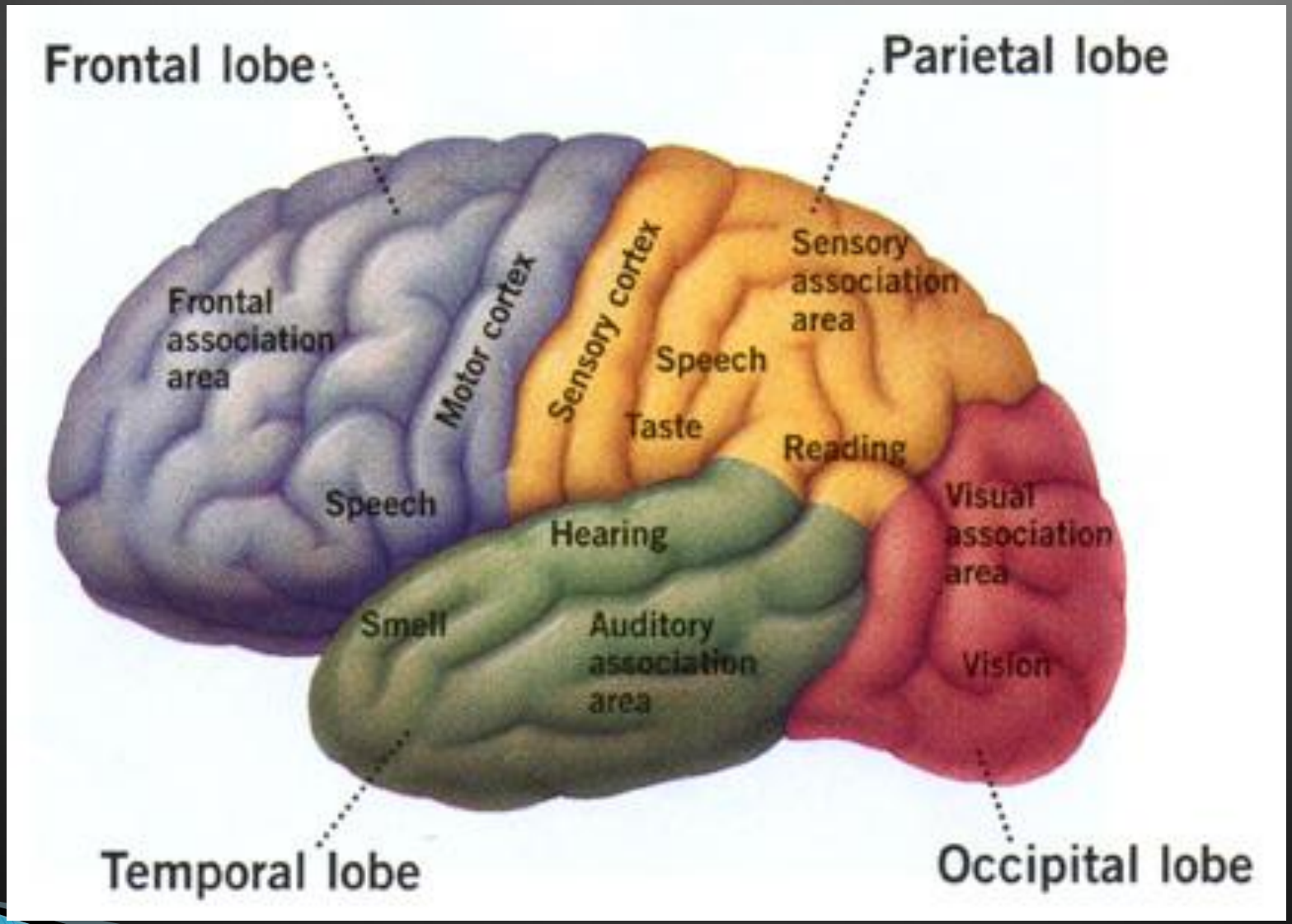
Symptoms: seizures



Brain Teaser

- 8 15 14 9 1 6 3

Which number comes next in the sequence?
4,7,10 or 12 ?


Frontal lobe
Parietal lobe
Frontal association area
Motor cortex
Sensory cortex
Sensory association area
Speech
Taste
Reading
Speech
Hearing
Visual association area
Smell
Auditory association area
Vision
Temporal lobe
Occipital lobe

Limbic system

- Hypothalamus: master controller of the endocrine system.
- Amygdala: sensations of pleasure or fear, recognition of fear in others.
- Hippocampus: formation of memories.