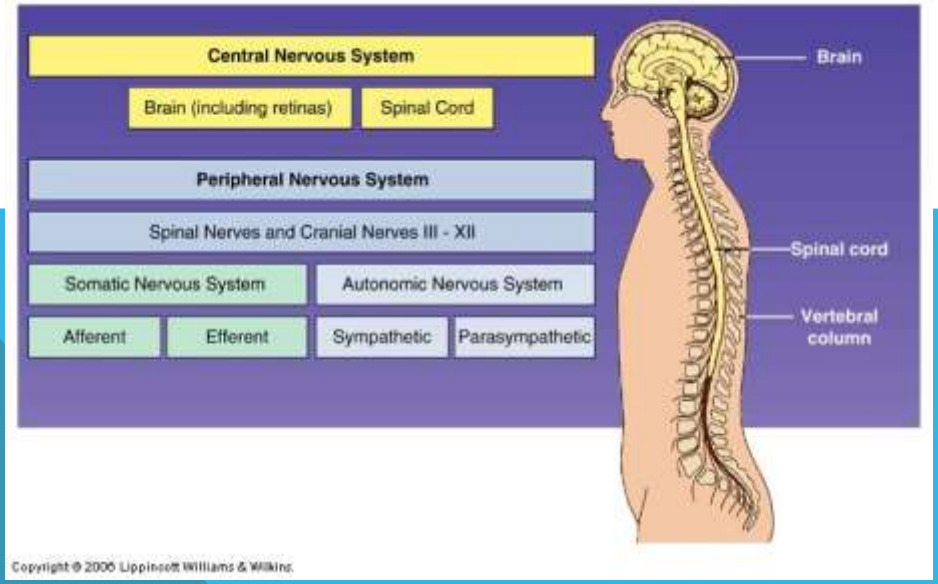
LEC-5-

NERVOUS SYSTEM

THE NERVOUS SYSTEM

Millions of interconnected neurons form the nervous system

Human nervous system two major parts: central nervous system and peripheral nervous system

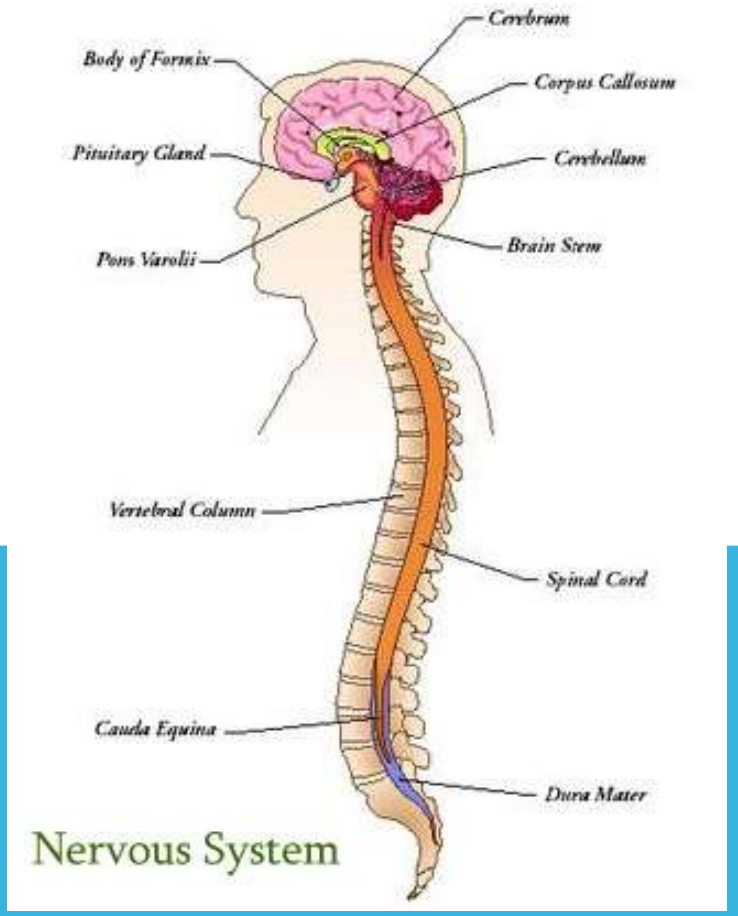


NERVOUS SYSTEM ORGANIZATION

CENTRAL NERVOUS SYSTEM

Brain

Spinal cord

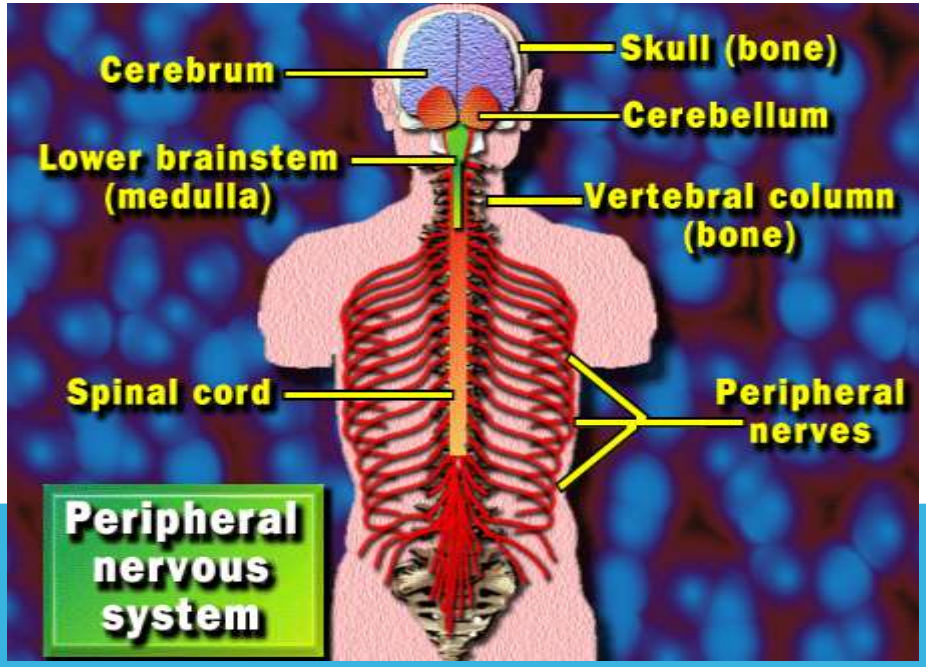


NERVOUS SYSTEM ORGANIZATION

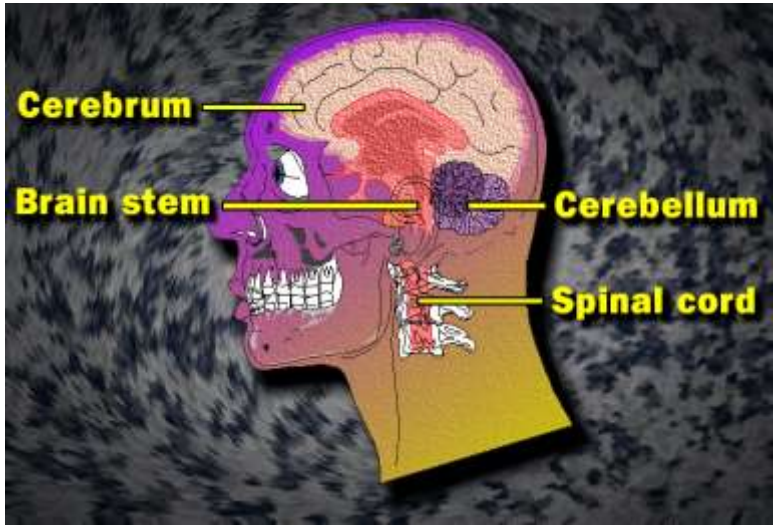
All neurons outside the CNS

- 31 pairs spinal nerves
- 12 pairs of cranial nerves

Peripheral Nervous System



THE BRAIN - 3 MAJOR AREAS



Cerebrum (telencephalon, diencephalon,)

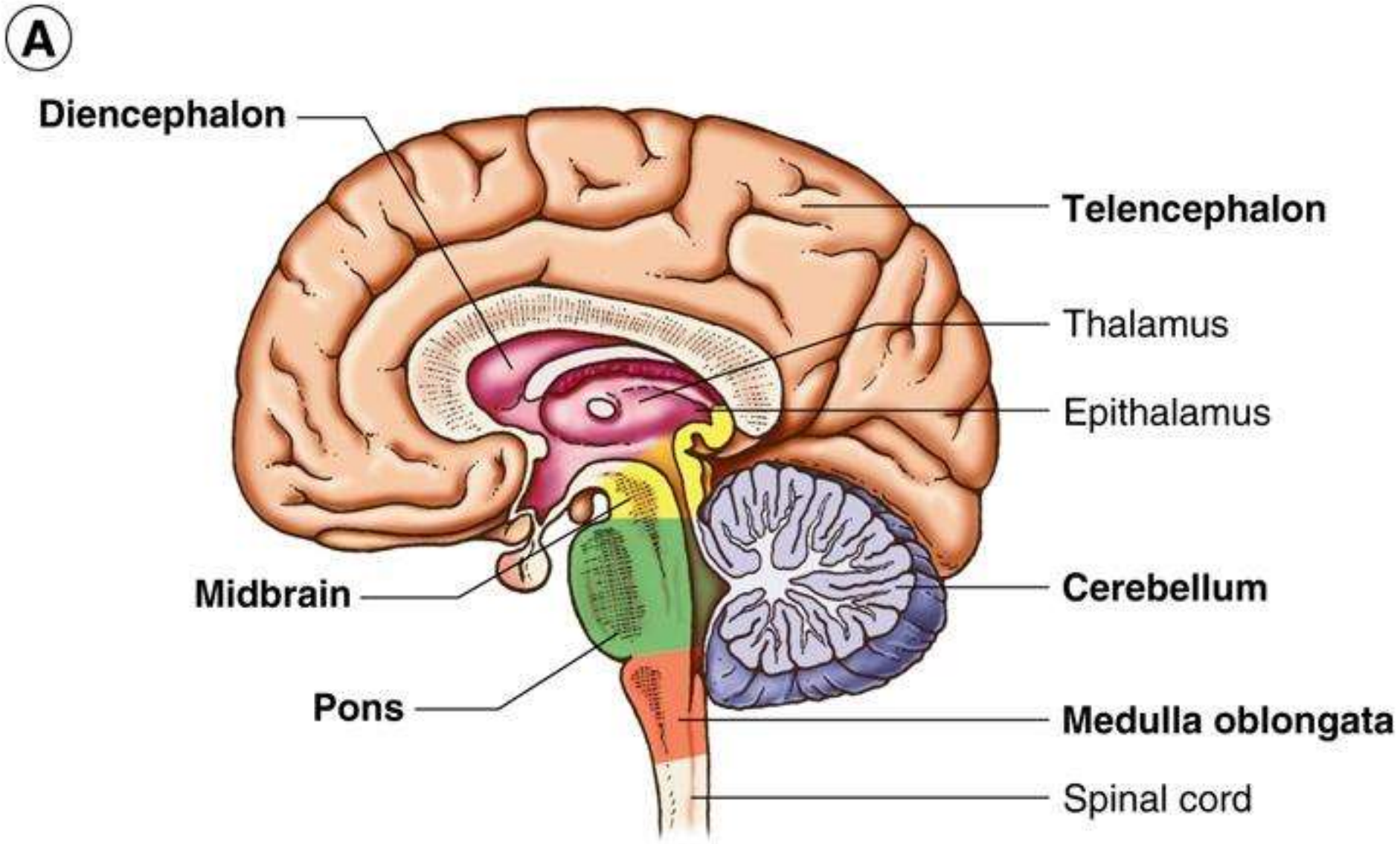
Cerebellum

Brainstem (midbrain, pons, medulla oblongata)

CEREBRUM

Composed of Telencephalon (Cerebral Cortex) and Diencephalon

Cerebral Cortex is gray matter because nerve fibers lack white myelin coating



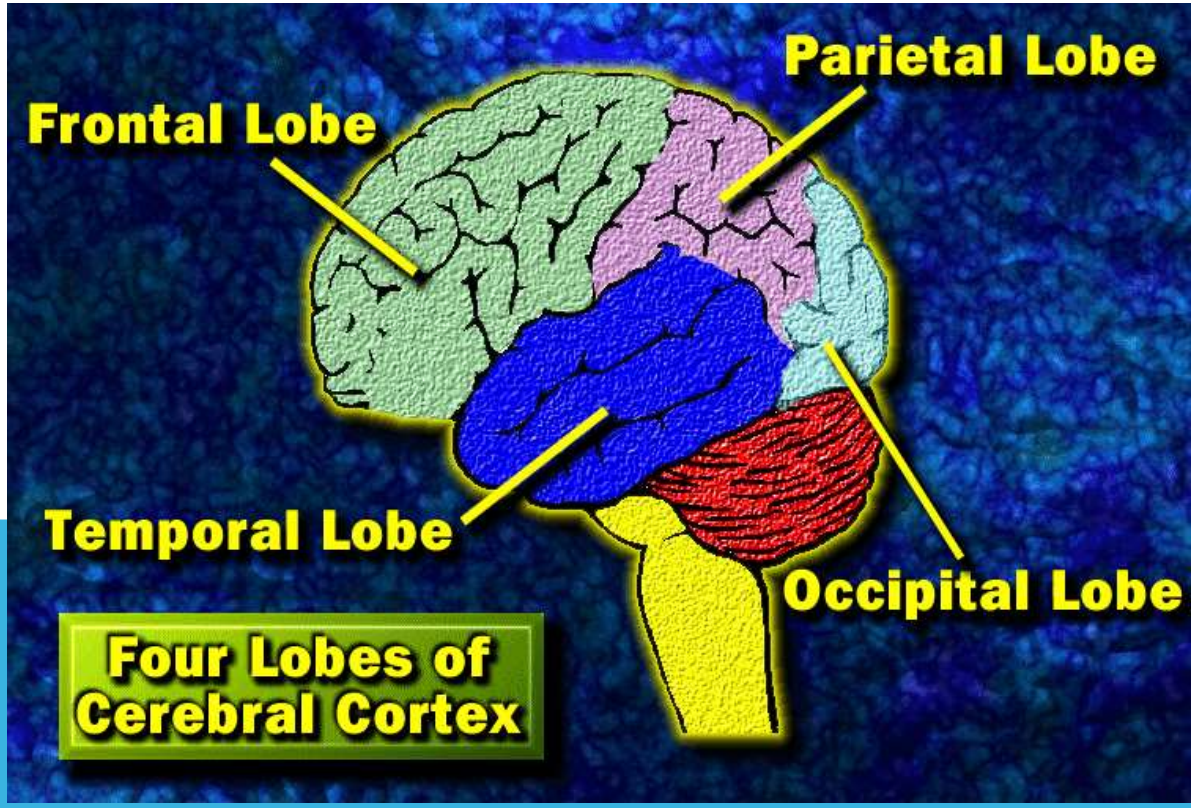
CEREBRAL CORTEX - 4 MAJOR LOBES

Parietal

Frontal

Temporal

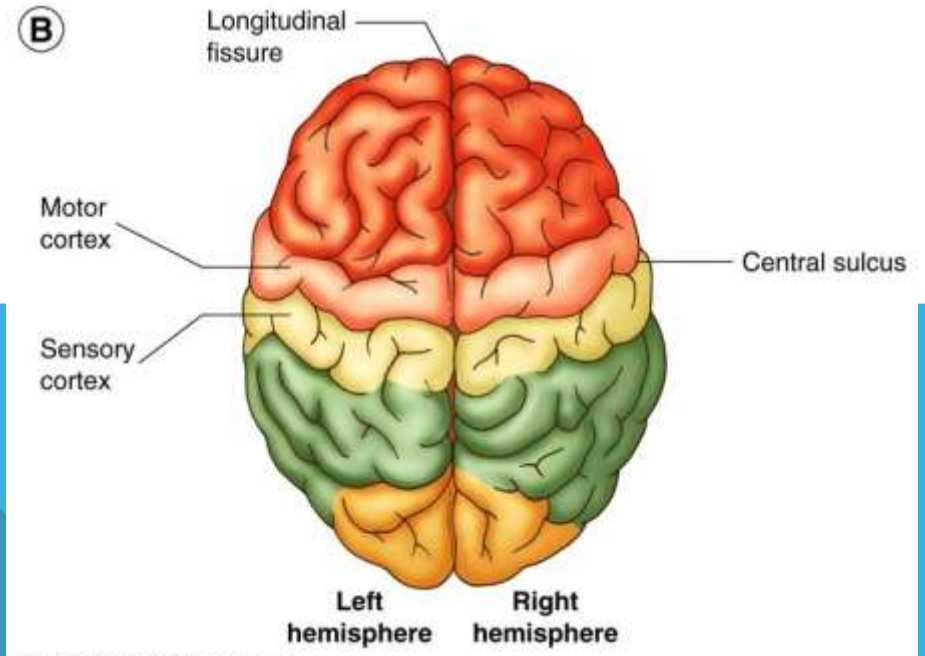
Occipital



FUNCTIONS OF THE CEREBRAL CORTEX

Intellectual processes: thought, intelligence.

Processes sensory information and integrates with past experience to produce appropriate motor response.



DIENCEPHALON - 2 MAJOR PARTS

Thalamus

- Relays stimuli received from all sensory neurons to cortex for interpretation
- Relays signals from the cerebral cortex to the proper area for further processing

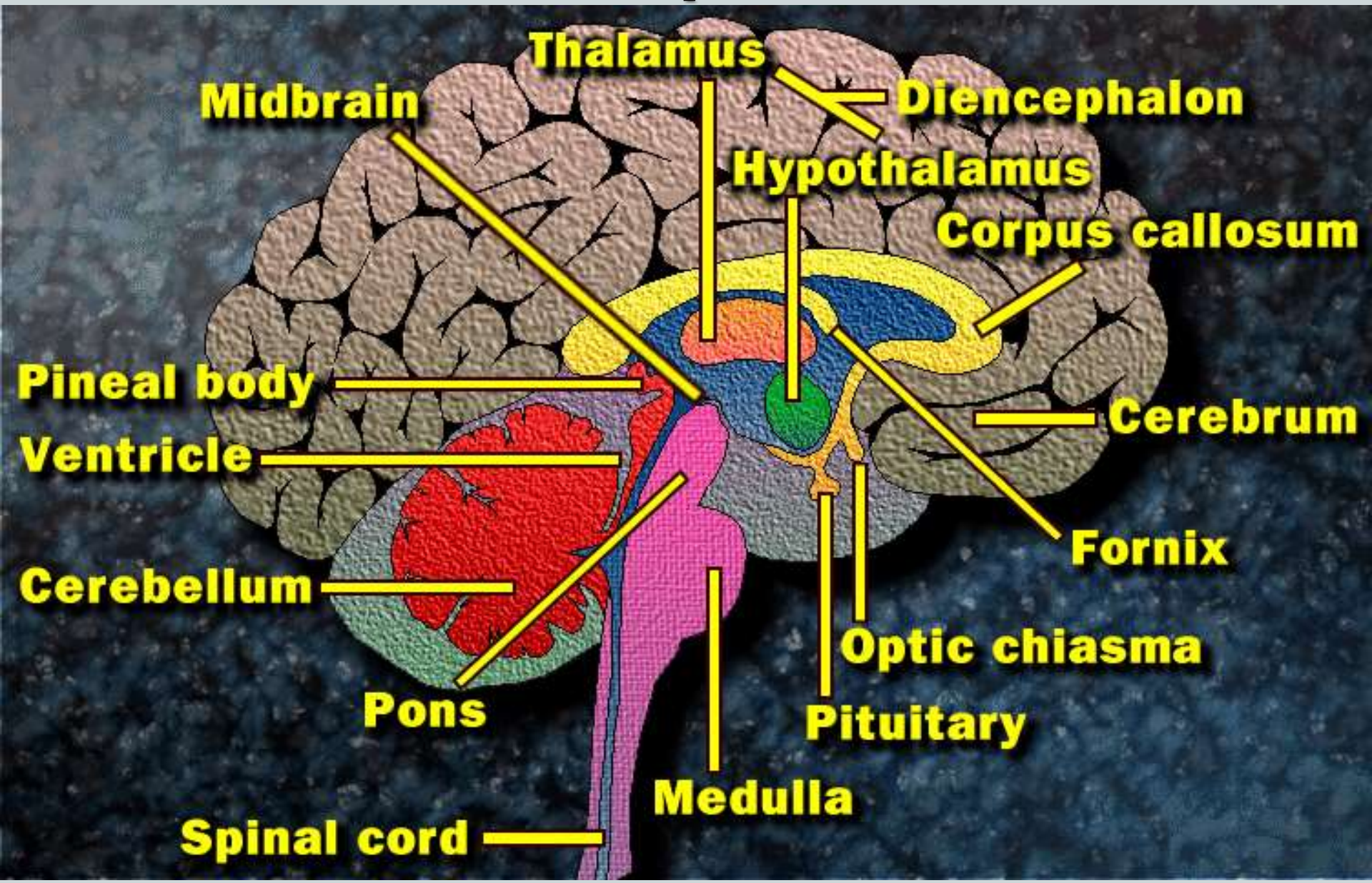
Hypothalamus

- Monitors many parameters
  - temperature, blood glucose levels, various hormone levels

  Helps maintain homeostasis

  Signals the pituitary via releasing factors
- Signals the lower neural centers

Diencephalon

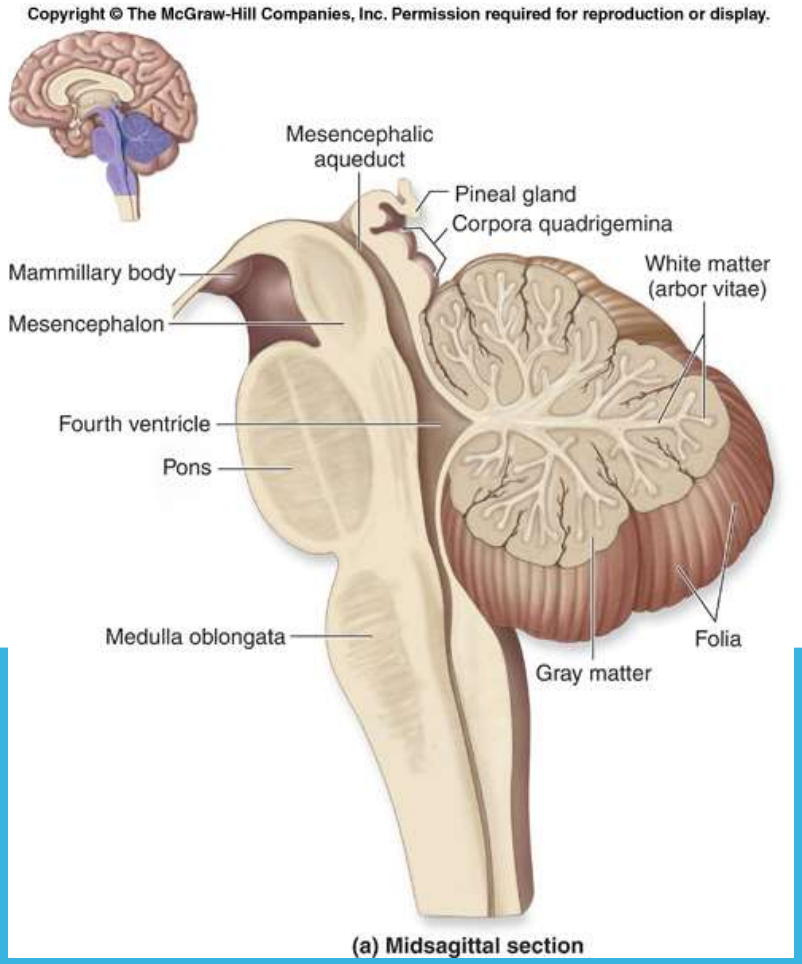


CEREBELLUM

Located behind the brainstem

Helps monitor and regulate movement

Integrates postural adjustments, maintenance of equilibrium, perception of speed, and other reflexes related to fine tuning of movement.



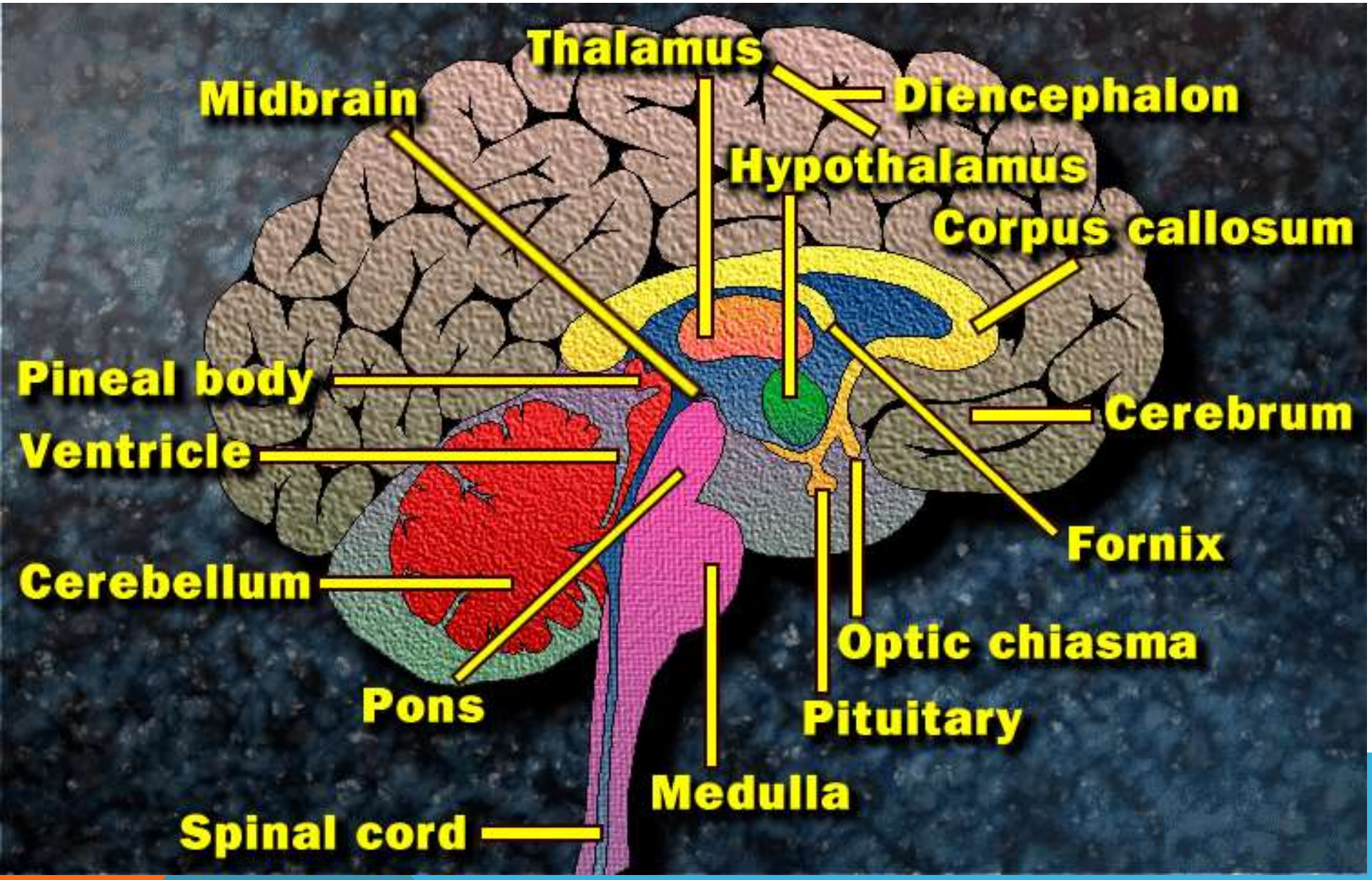
BRAINSTEM

Composed of midbrain, pons, and medulla oblongata

Maintains vegetative functioning

- Where is respiratory control center?
- Where is cardiovascular control center?

Reflexes

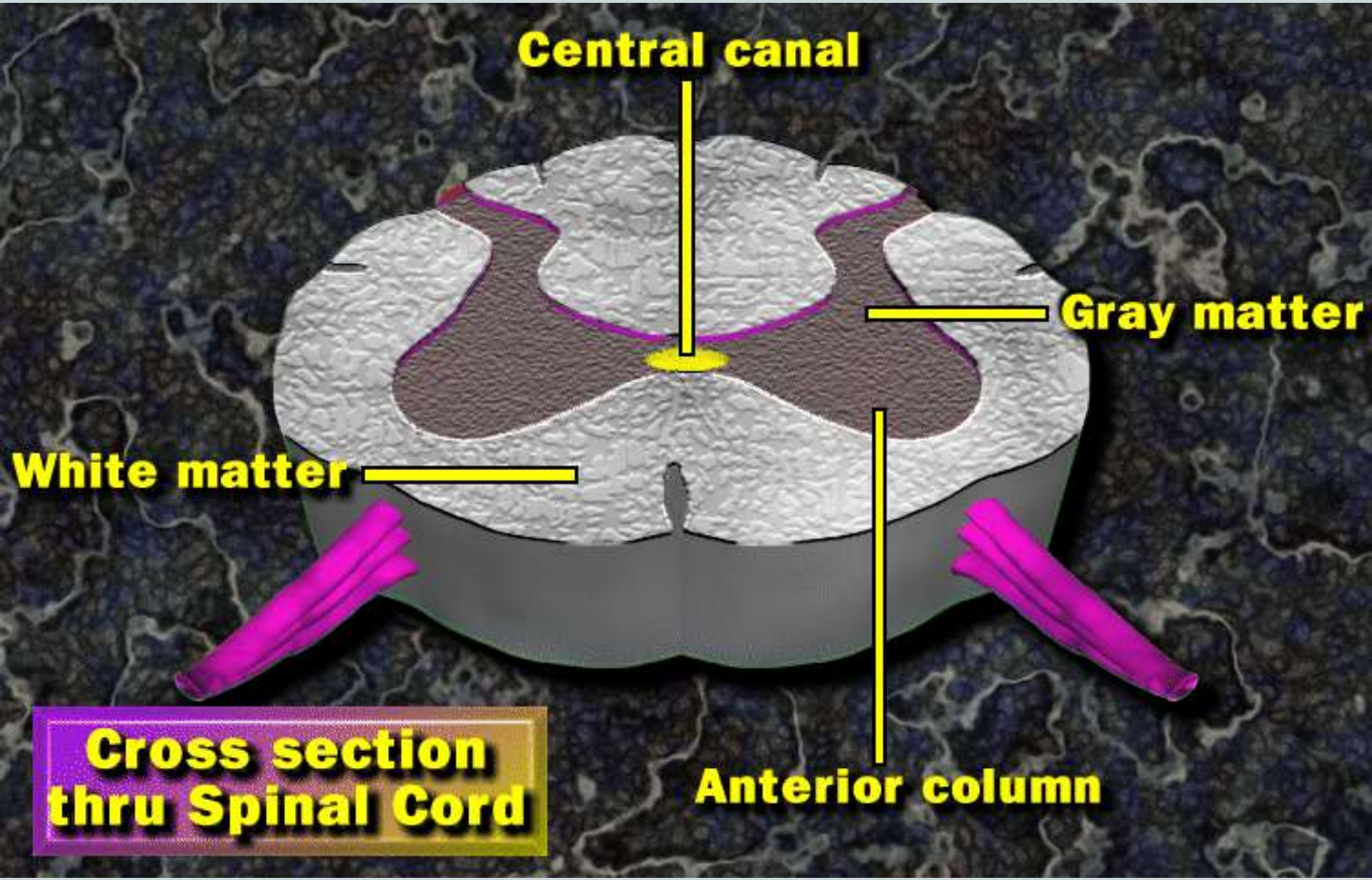

Thalamus
Midbrain
Diencephalon
Hypothalamus
Corpus callosum
Pineal body
Cerebrum
Ventricle
Fornix
Cerebellum
Optic chiasma
Pons
Pituitary
Medulla
Spinal cord

Brain Stem

SPINAL CORD

Contains both gray and white matter

Gray matter is H-shape in core of cord


Central canal
Gray matter
White matter
Anterior column
Cross section thru Spinal Cord

GRAY MATTER

Regions of brain and spinal cord made up primarily of cell bodies and dendrites of nerve cells

Interneurons in spinal cord

- small nerves which do not leave the spinal cord

Terminal portion of axons

WHITE MATTER

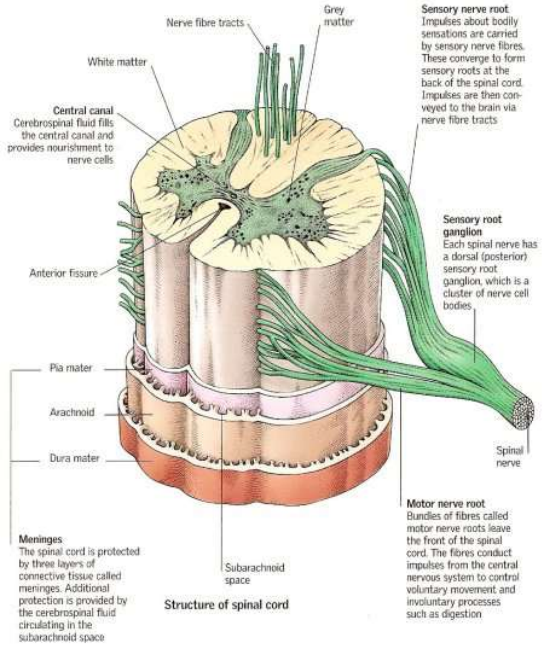
Contains tracts or pathways made up of bundles of myelinated nerves

Carry ascending and descending signals

- Ascending nerve tract from sensory receptors through dorsal root, up cord to thalamus, to cerebral cortex
- Pyramidal tract transmits impulses downward eventually excites motoneurons control muscles.
- Extrapyramidal originate in brain stem descend to control posture.

DESCENDING NERVE TRACTS

AS



DESCENDING: LATERAL,

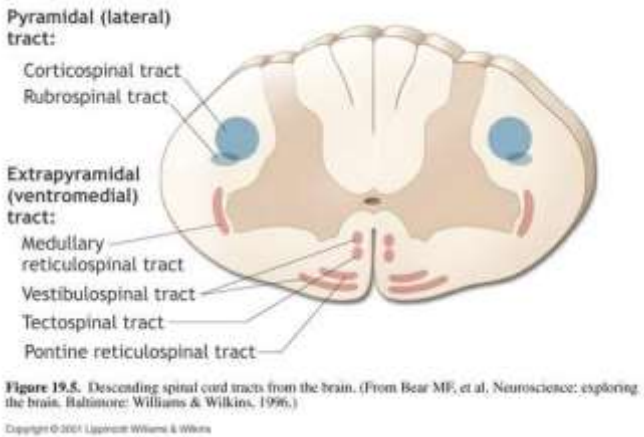
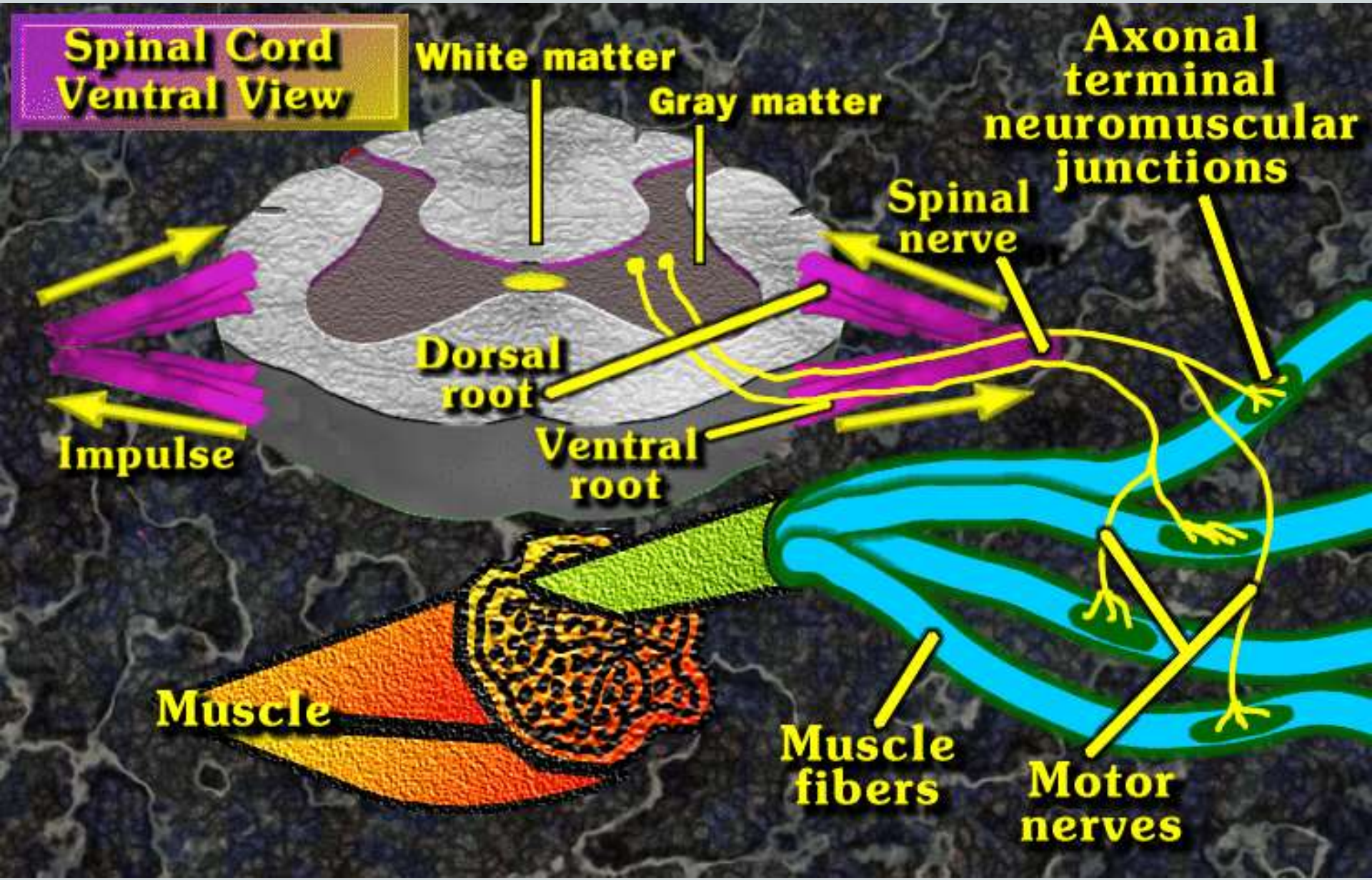
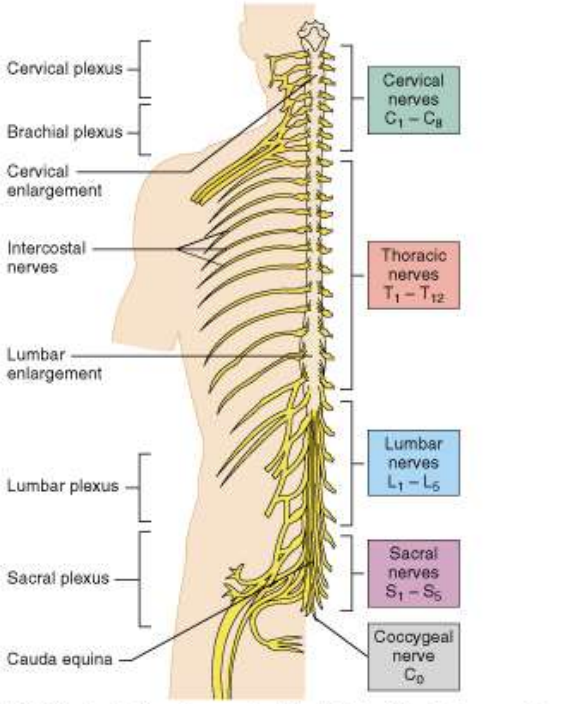


Figure 19.5. Descending spinal cord tracts from the brain. (From Bear MF, et al. Neuroscience: exploring the brain. Baltimore: Williams & Wilkins, 1996.)


Spinal Cord
Ventral View
White matter
Gray matter
Axonal terminal neuromuscular junctions
Spinal nerve
Dorsal root
Ventral root
Impulse
Muscle
Muscle fibers
Motor nerves

PERIPHERAL NERVOUS SYSTEM



Thirty-one pairs of spinal nerves & 12 pairs of cranial nerves.

Each spinal nerve is a mixed nerve containing:

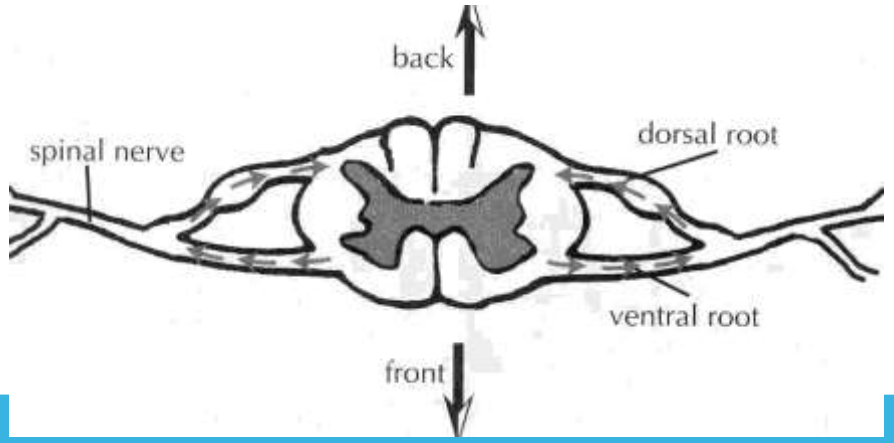
- Somatic afferent
- Visceral afferent
- Somatic efferent
- Visceral efferent

Which is a motor fiber?

SOMATIC NERVOUS SYSTEM

Somatic afferent (sensory): carry sensations from periphery to spinal cord. Includes exteroceptive (pain, temperature, touch) & proprioceptive.

Somatic efferent (motor): communicate from spinal cord to skeletal muscles.



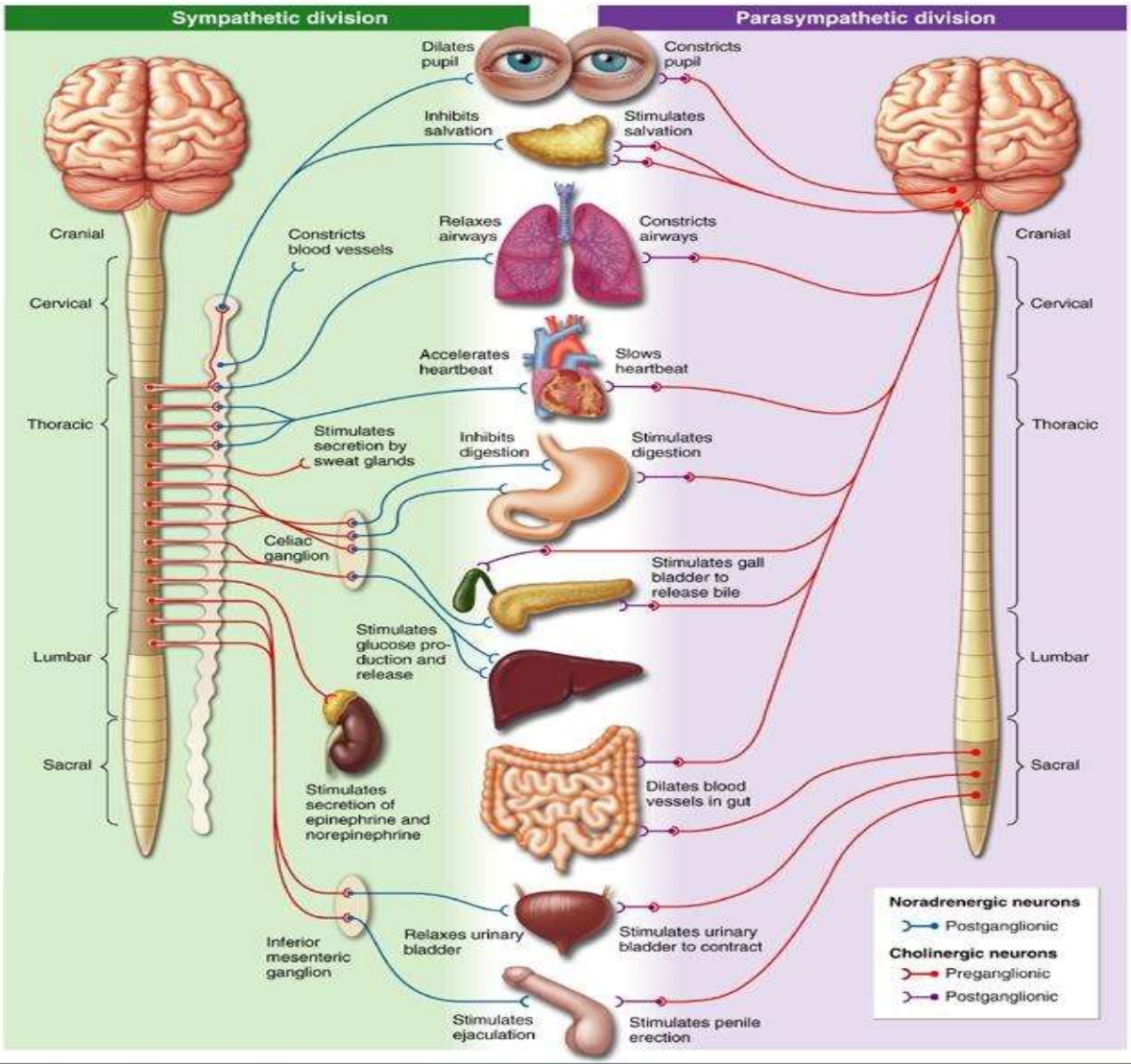
AUTONOMIC NERVOUS SYSTEM SUBDIVISIONS

Sympathetic

- responsible for increasing activity in most systems (except GI)
- adrenergic fibers release epinephrine

Parasympathetic

- responsible for slowing activity in most systems (except GI)
- cholinergic fibers release acetylcholine



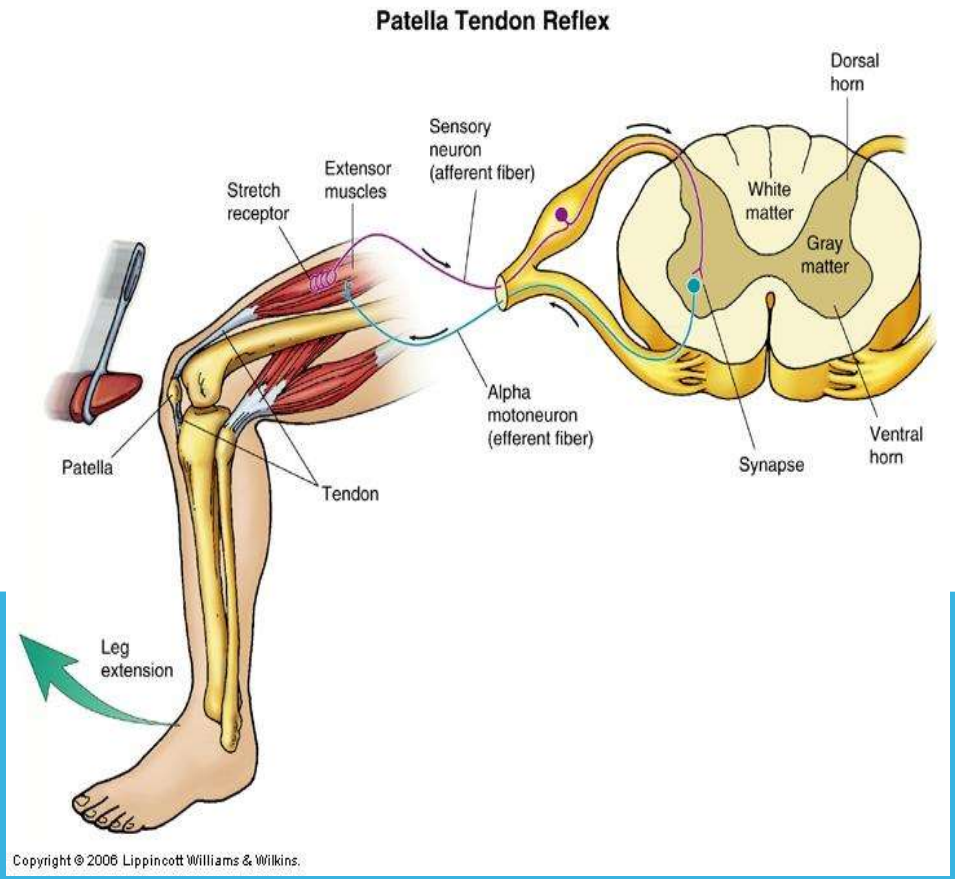
Comparison of effects of sympathetic and parasympathetic activation on end organs

End organ	Sympathetic effects	Parasympathetic effects
Skeletal muscle	Increase blood flow	Decrease blood flow
Ventilation	Increase	Decrease
Sweat glands	Increase perspiration	No effect
Heart	Increase force and contraction rate	Decrease force and contraction rate
GI tract motility	Decrease	Increase
Eyes	Dilate pupils	Constrict pupils
Secretion of digestive juices	Decrease	Increase
Blood pressure	Increase mean pressure	Decrease mean pressure
Airways	Increase diameter	Decrease diameter

AUTONOMIC REFLEX

Monosynaptic reflex arc

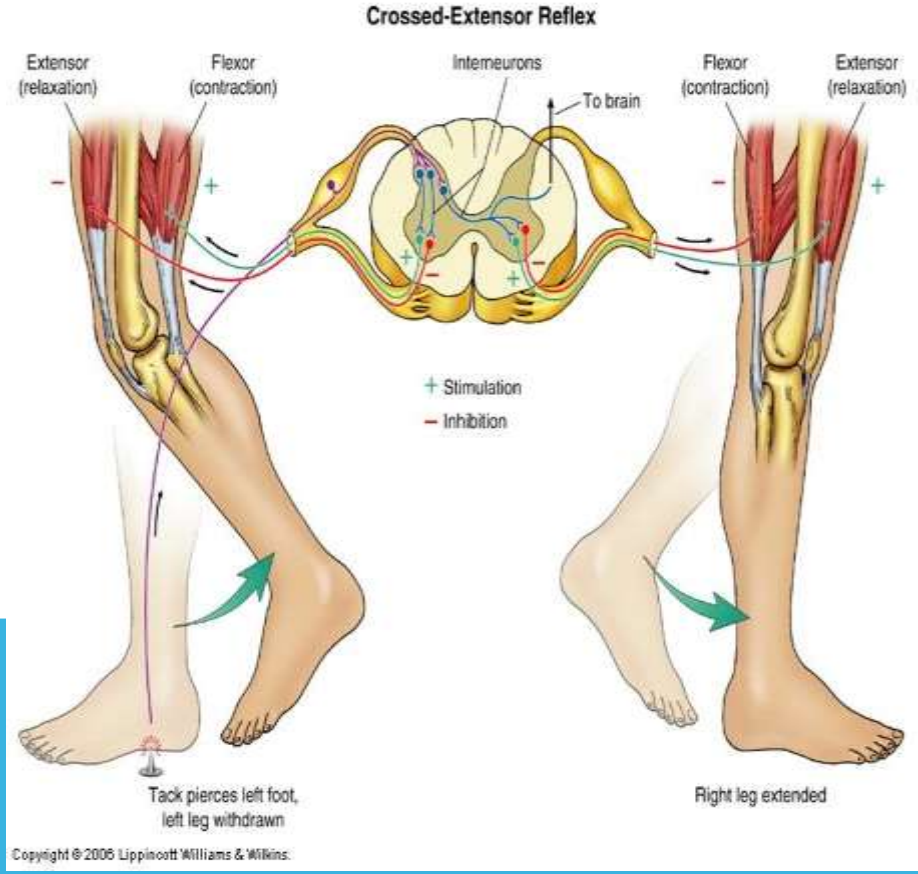
Knee jerk response



COMPLEX REFLEXES

Involve multiple synapses

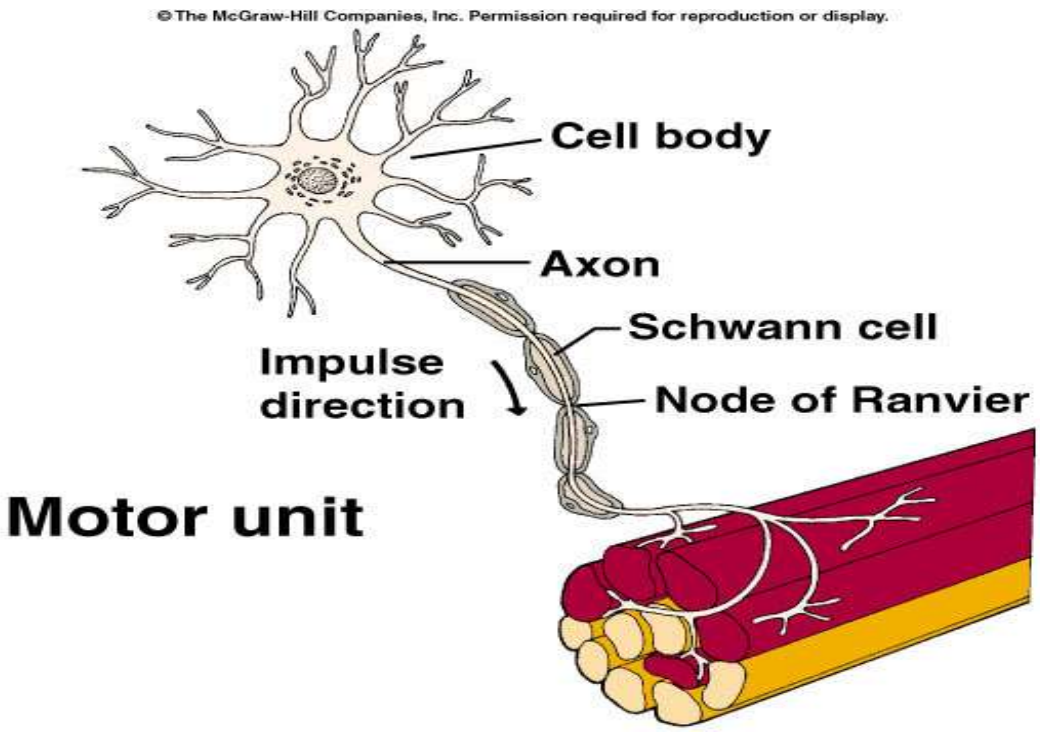
Crossed extensor reflex



MOTOR UNIT

A single motor neuron and all of the muscle fibers which it innervates. Represents functional unit of movement.

Ratio of muscle fibers to nerve relates to muscle's movement function.



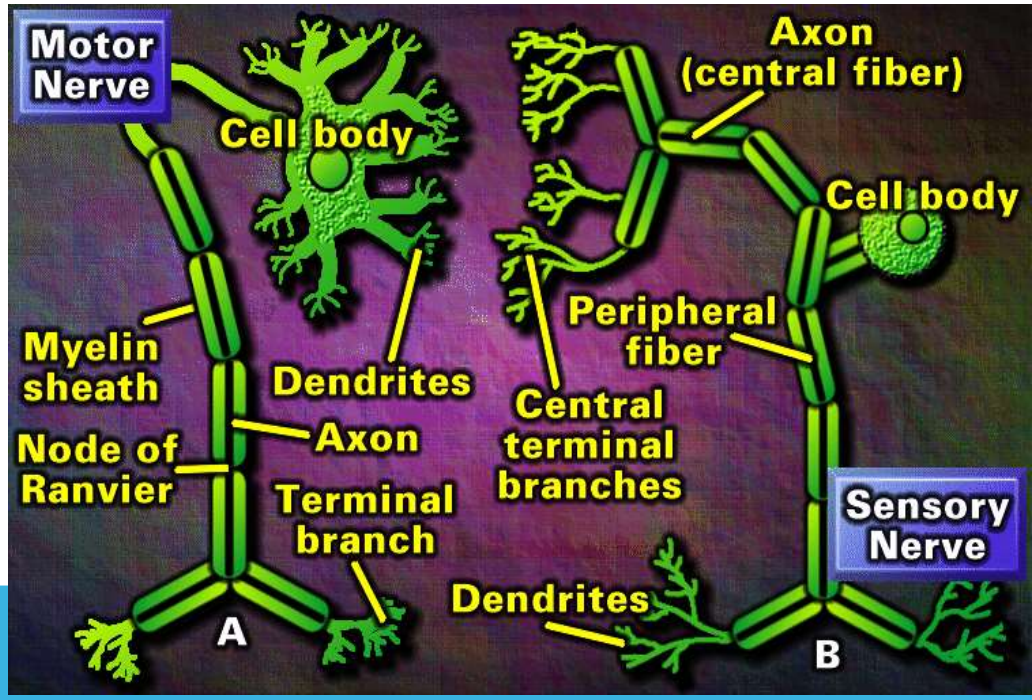
NEURONS

Two basic types

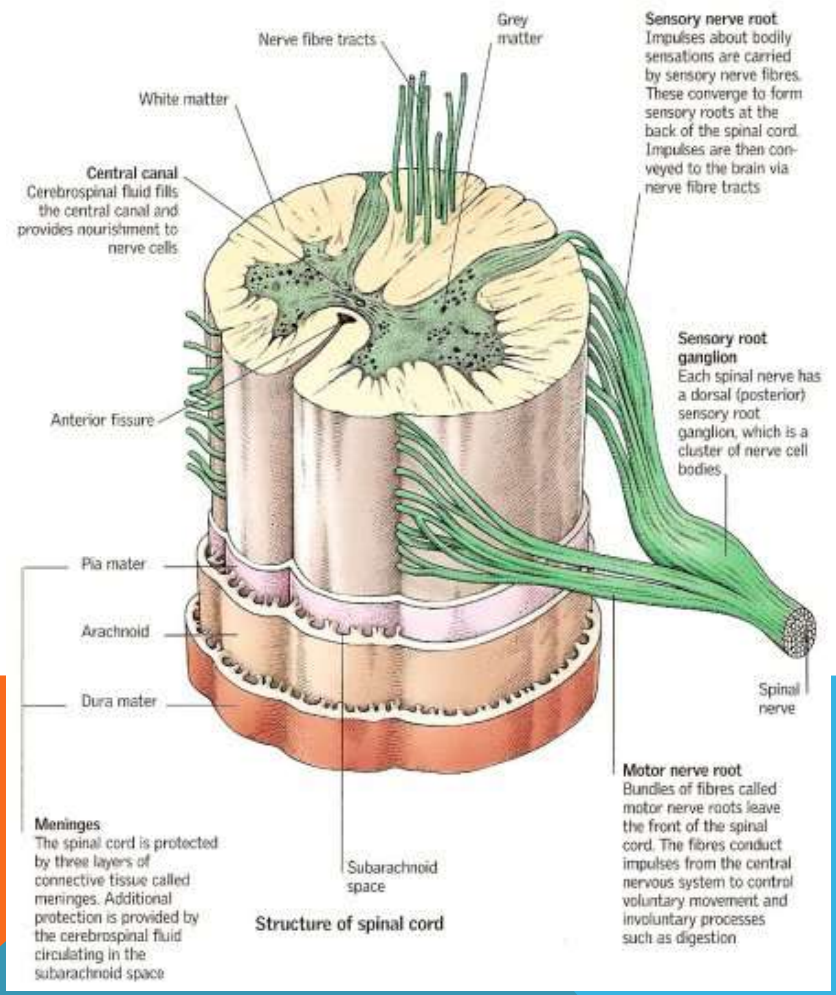
1. Motor
2. Sensory

Three basic parts

1. Axons
2. Dendrites
3. Soma or Cell Bodies



SENSORY NERVES



Structure of spinal cord

Enter the spinal cord on the dorsal side

Cell bodies lie outside the spinal cord in Dorsal Root Ganglia

MOTOR NERVES

Exit the spinal cord on the ventral side

Cell bodies lie within grey matter of spinal cord

Somatic

- innervates skeletal muscle

Autonomic (visceral)

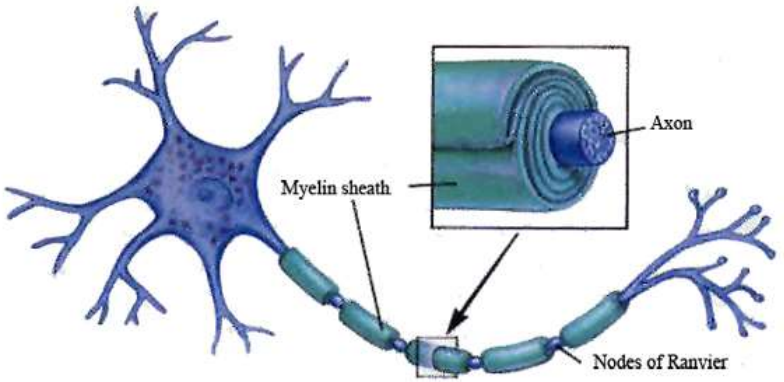
- innervates organs / smooth muscle

NEURON PART: AXONS

Carry impulses away from the cell body

MYELIN

Schwann cells wrapped around the axon of some neurons



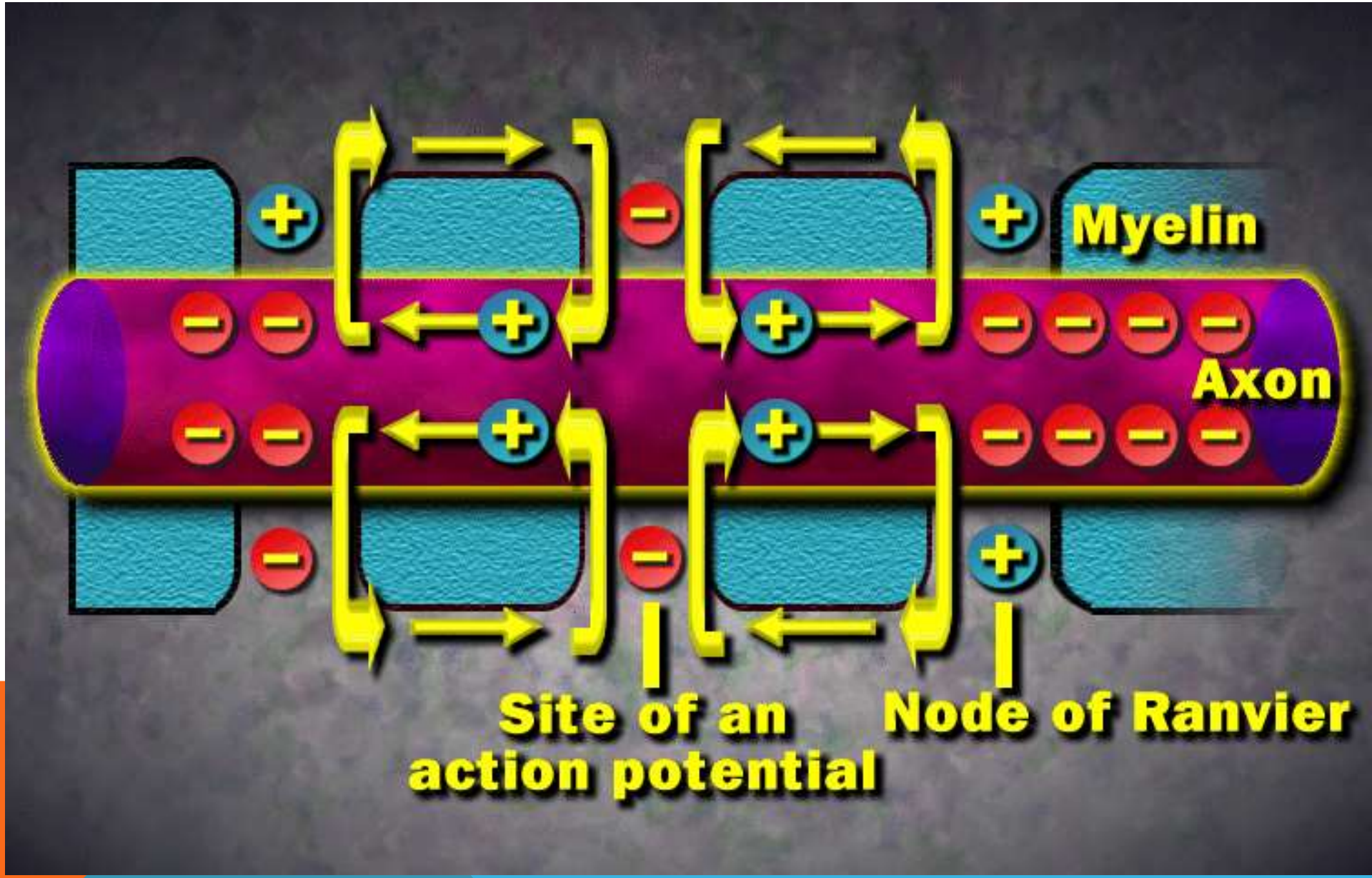
- appear as multiple lipid-protein layers
- are actually a continuous cell

  increase the speed of action potential conduction

NODES OF RANVIER

Gaps between Schwann Cells

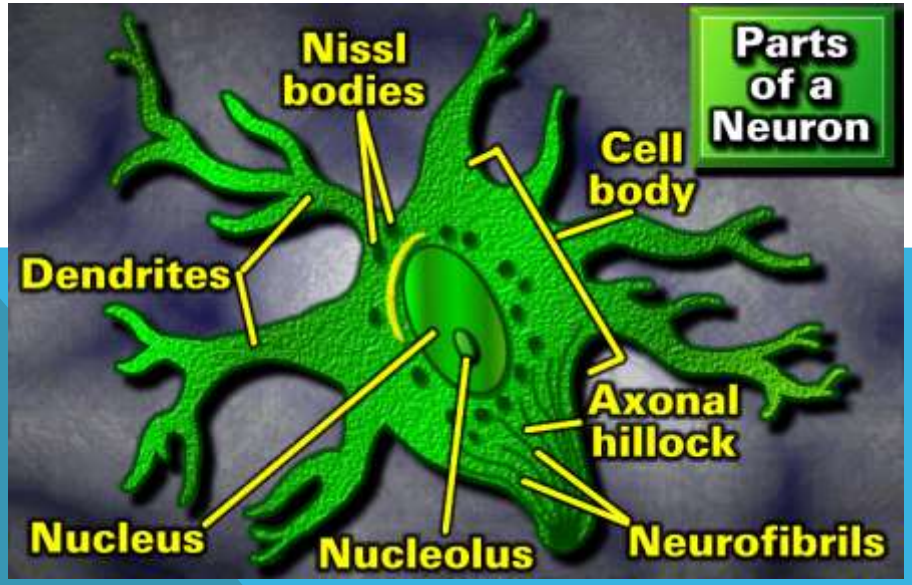
- impulse jumps from node to node
- saltatory conduction


Myelin
Axon
Site of an action potential
Node of Ranvier

NEURON PARTS: DENDRITES AND CELL BODY

Dendrite: receives stimuli and carry it to the cell body

Cell body: site of cellular activity

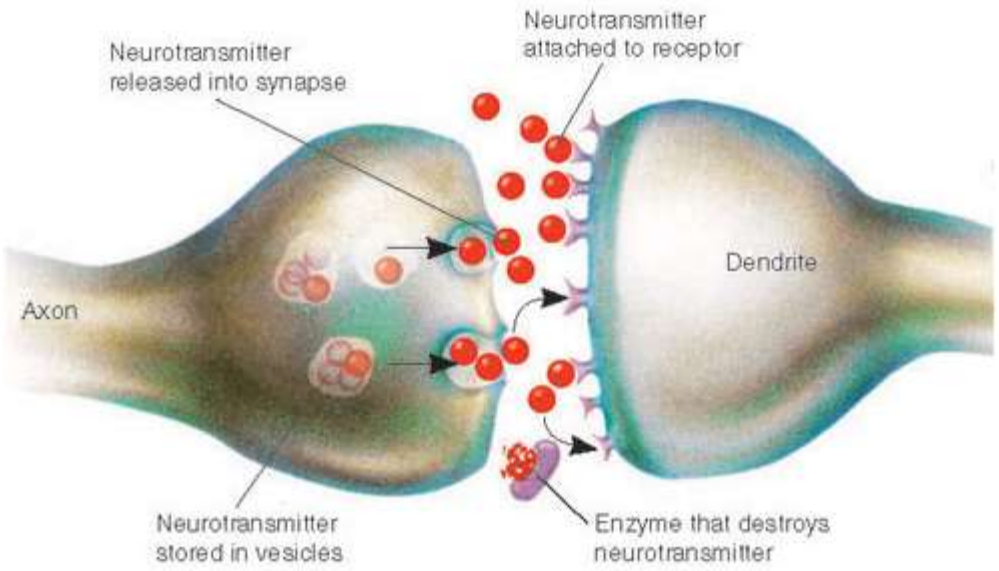


SYNAPSE

Junction between the dendrites of one neuron and the axon of a second neuron

Nerves communicate by releasing chemical messenger at synapse

SYNAPSE



Important neurotransmitters:

- Monoamines
- Neuropeptides
- Nitric oxide

MOTOR NERVES - SIZE

Alpha motor nerves

- Larger fibers
- Conduct impulses faster
- Innervate regular muscle fibers

Gamma Motor nerves

- smaller fibers
- conduct impulses more slowly
- Innervate proprioceptors such as muscle spindles

NERVE PROPERTIES RELATED TO FUNCTION

Irritability

- able to respond to stimuli

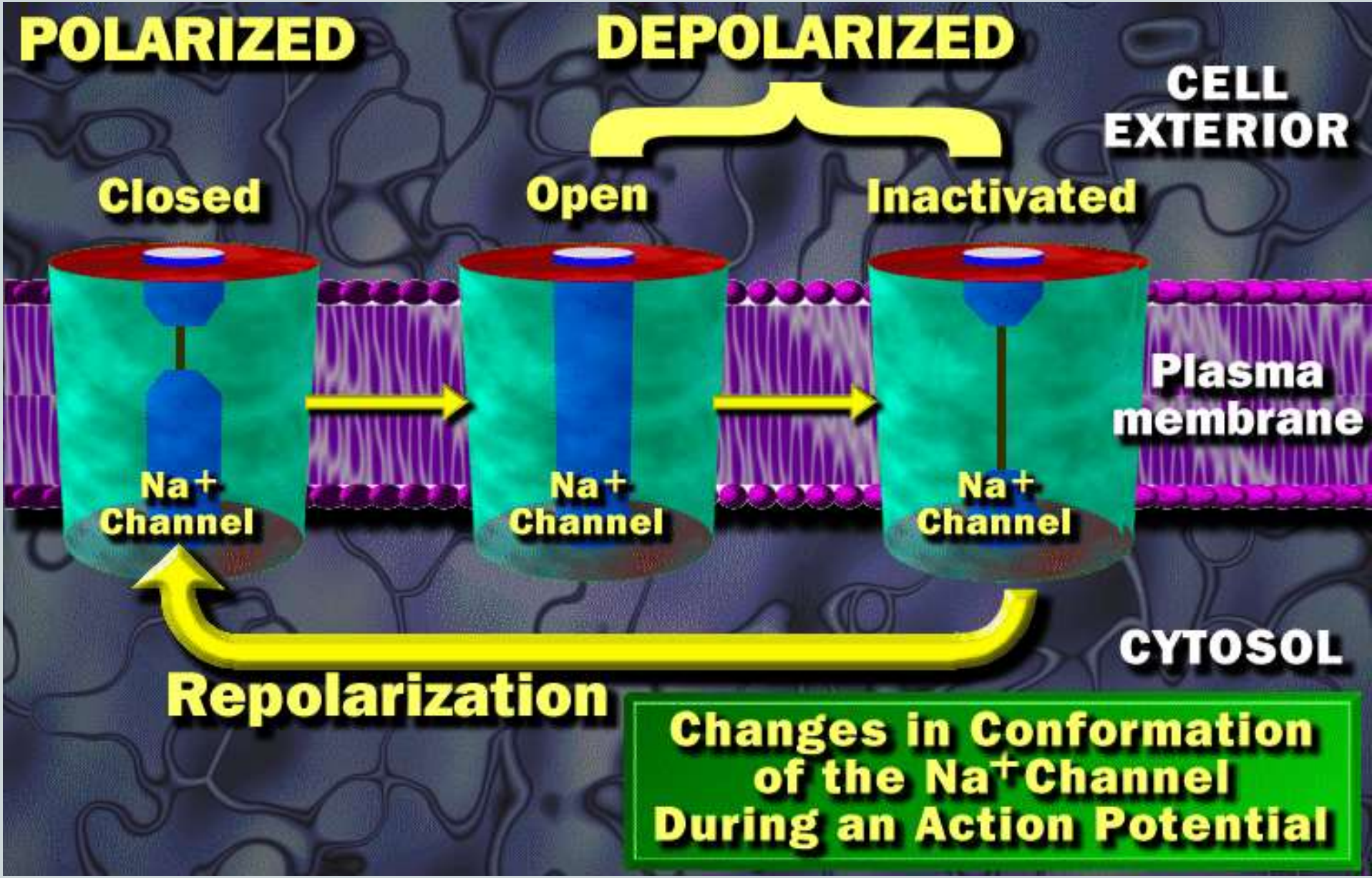
Conductivity

- able to transmit electrical potential along the axon

RESTING MEMBRANE POTENTIAL

Difference in charge between the inside and outside of the cell

- sodium in greater concentration outside
- potassium in greater concentration inside
- anions in greater concentration inside
- membrane permeability greater for potassium than sodium
- Na^+ / K^+ pump moves sodium out, potassium in


POLARIZED
DEPOLARIZED
CELL EXTERIOR
Closed
Open
Inactivated
Plasma membrane
Na+ Channel
Na+ Channel
Na+ Channel
CYTOSOL
Repolarization
Changes in Conformation of the Na+ Channel During an Action Potential

GENERATING ACTION POTENTIALS

Voltage gated ion channels

- sodium channels open --- sodium rushes in
- sodium channels close --- stops inward flow of sodium
- potassium channels open --- potassium rushes out

Net effect - Depolarization then Repolarization

- electrical flow created by ionic flow, not electron flow

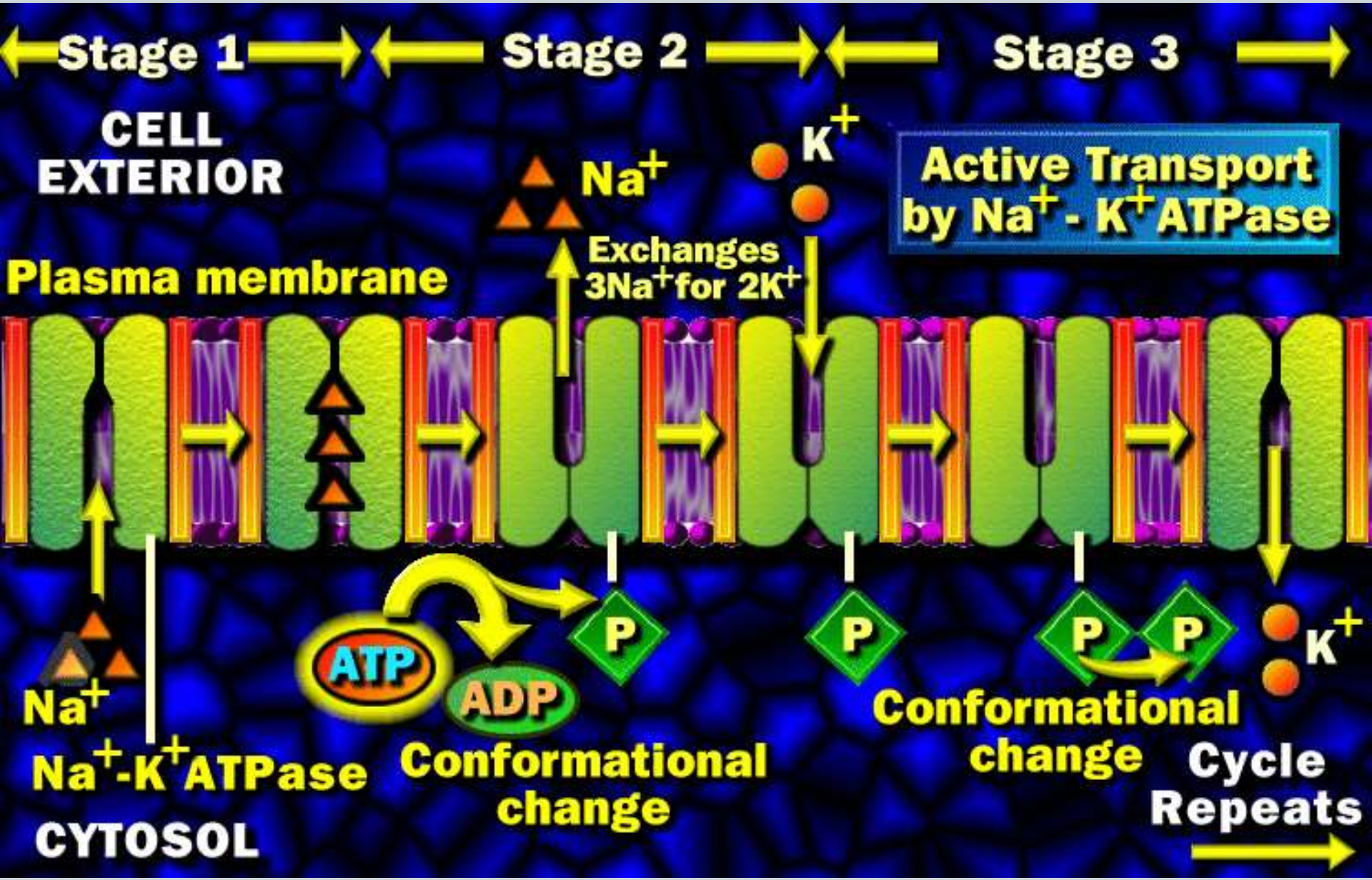
NA^+ / K^+ PUMP

Membrane bound proteins

Utilizes ATP

Maintains resting membrane potential

Establishes sodium & potassium concentration gradients


Stage 1
Stage 2
Stage 3
CELL EXTERIOR
Na+
K+
Active Transport by Na+ - K+ ATPase
Exchanges 3Na+ for 2K+
Plasma membrane
ATP
ADP
P
P
P
P
K+
Na+
Na+-K+ ATPase
CYTOSOL
Conformational change
Conformational change
Cycle Repeats

NEUROMUSCULAR JUNCTION

Motor neuron cell body and dendrites in gray matter of spinal cord

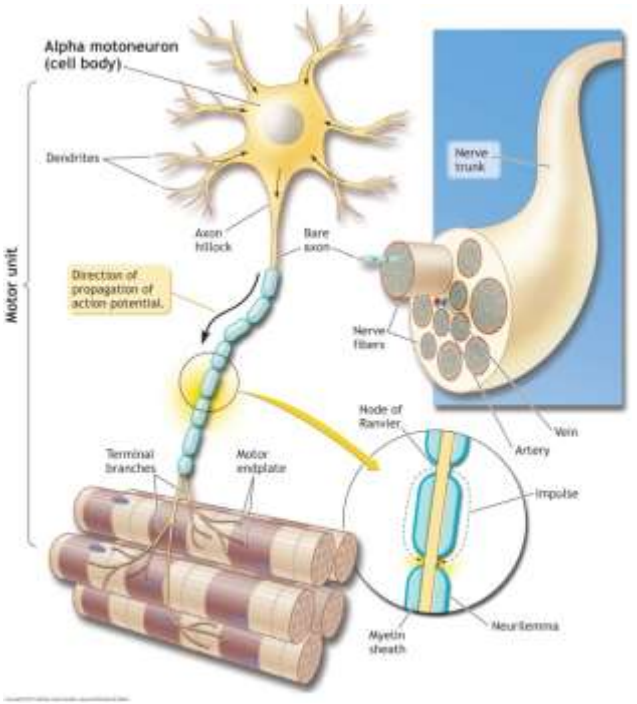
Axons extend to muscle

Axon's terminal end contains a synaptic knob

Synaptic knob has synaptic vesicles containing acetylcholine

NEUROMUSCULAR JUNCTION

- Axon leaves spinal cord.
- Extends to skeletal muscle.
- Terminal branche end in synapti knob.



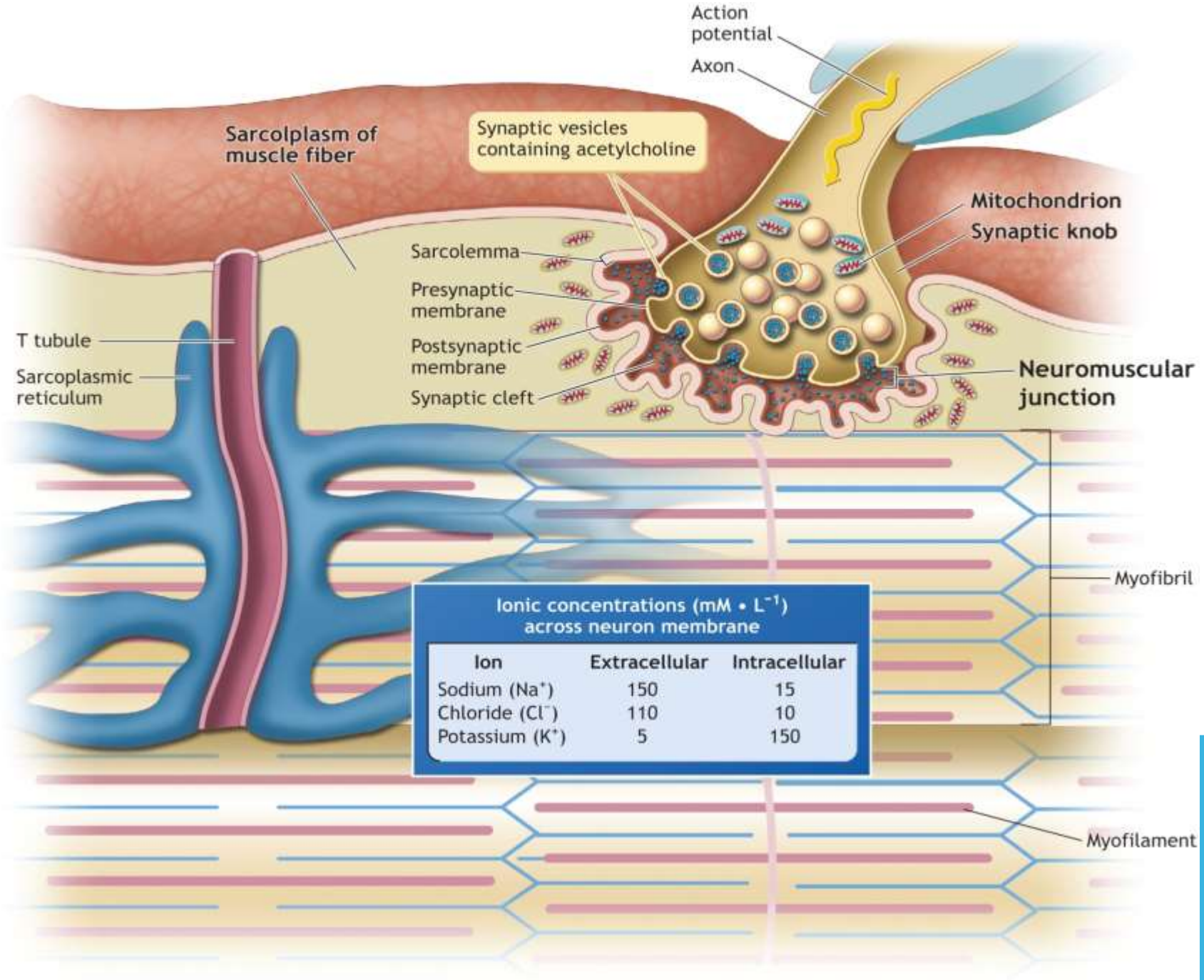
MOTOR END PLATE

Area beneath the terminal branches of the axons

Contains acetylcholine receptor complexes

Acetylcholine binding opens the receptor complex

Cholinesterase degrades acetylcholine into acetate and choline

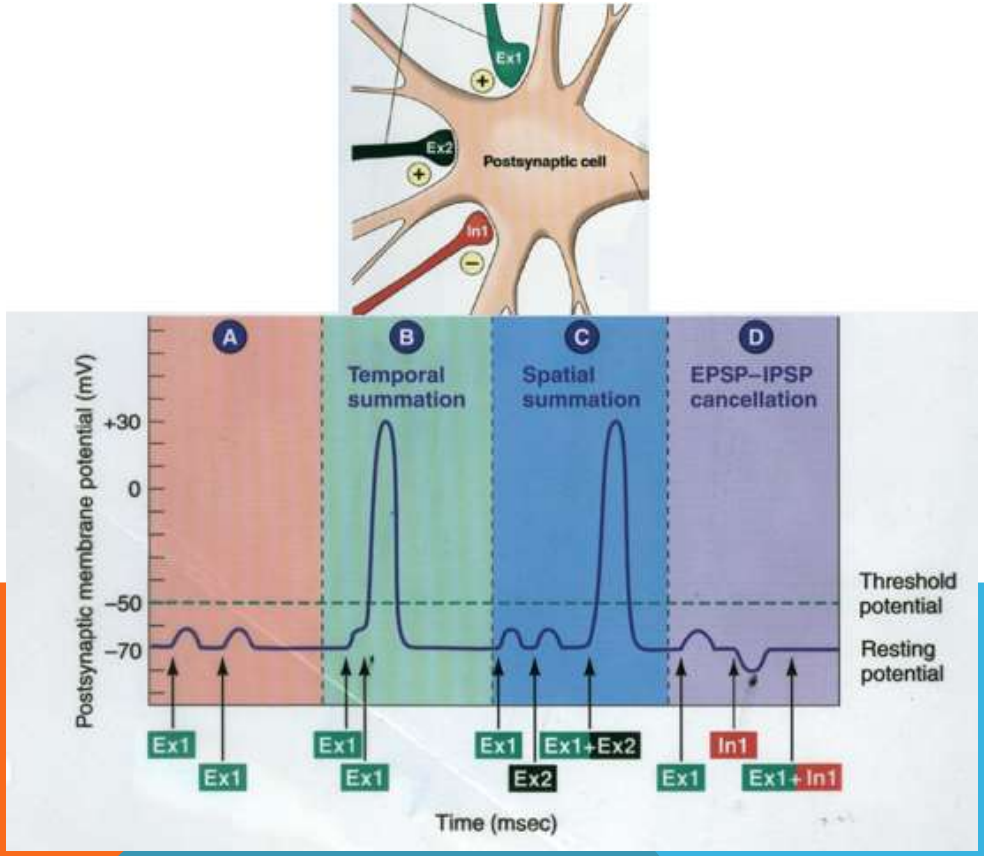

Action potential
Axon
Sarcolplasm of muscle fiber
Synaptic vesicles containing acetylcholine
Mitochondrion
Synaptic knob
Sarcolemma
Presynaptic membrane
Postsynaptic membrane
Synaptic cleft
T tubule
Sarcoplasmic reticulum
Neuromuscular junction
Myofibril
Myofilament
Ionic concentrations (mM • L⁻¹) across neuron membrane
Ion | Extracellular | Intracellular
Sodium (Na⁺) | 150 | 15
Chloride (Cl⁻) | 110 | 10
Potassium (K⁺) | 5 | 150

TENSION GENERATING CHARACTERISTICS

All or None Law

- when a neuron reaches threshold it generates an action potential which is conducted the length of the axon without any voltage change
- when the nerve fires, all the muscle fibers it innervates contract

SUMMATION OF LOCAL GRADED POTENTIALS



Temporal Summation

- additive effect of successive stimuli from an axon

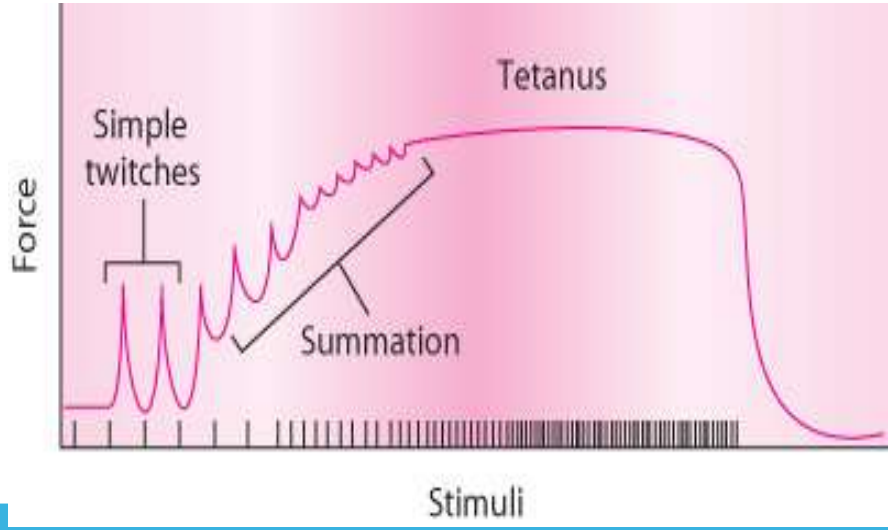
Spatial Summation

- additive effect of stimuli from various axons

GRADATION OF FORCE

Force of muscle varies from slight to maximal:

- Increase number of motor units recruited
- Increase frequency of motor unit discharge.



PROPRIOCEPTORS

Muscle Spindles

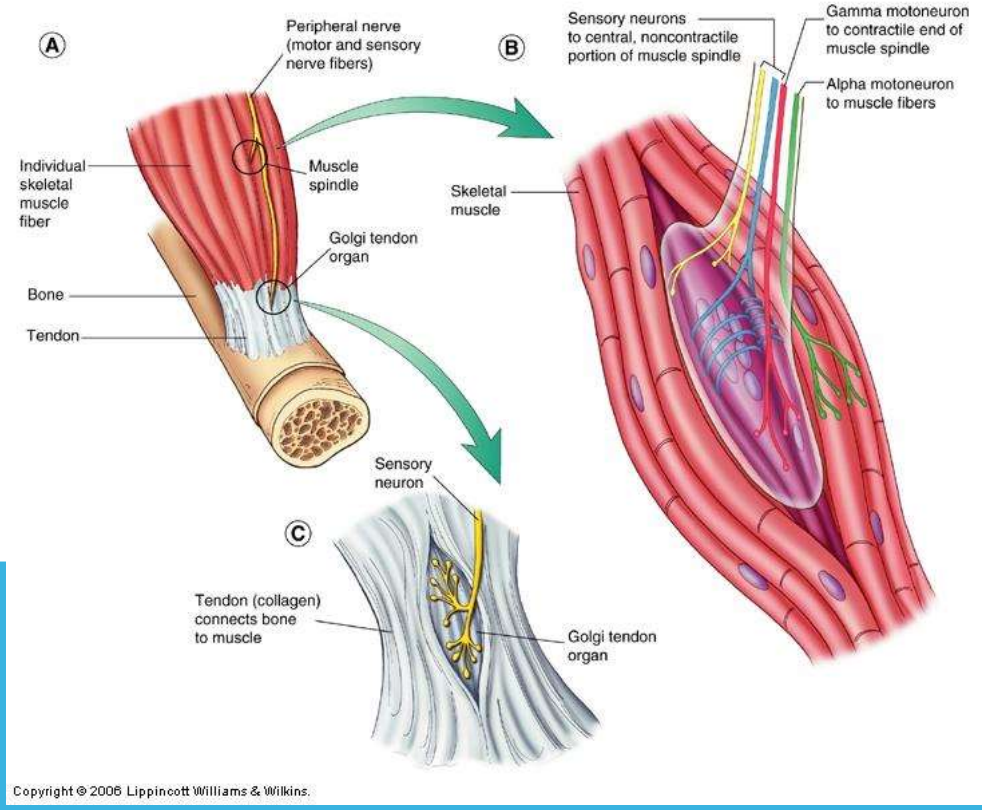
Golgi Tendon Organs

Pacinian Corpuscles

Ruffini Endings

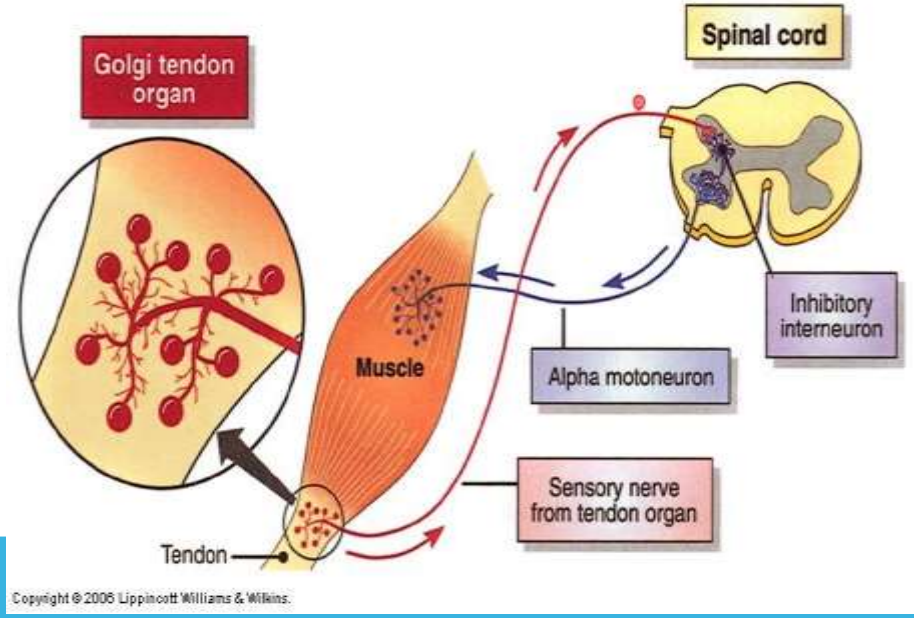
MUSCLE SPINDLES

- Encapsulated fibers within the muscle belly
- Monitor changes in muscle length
- Monitor the rate of change in muscle length
- Respond by causing muscle contraction

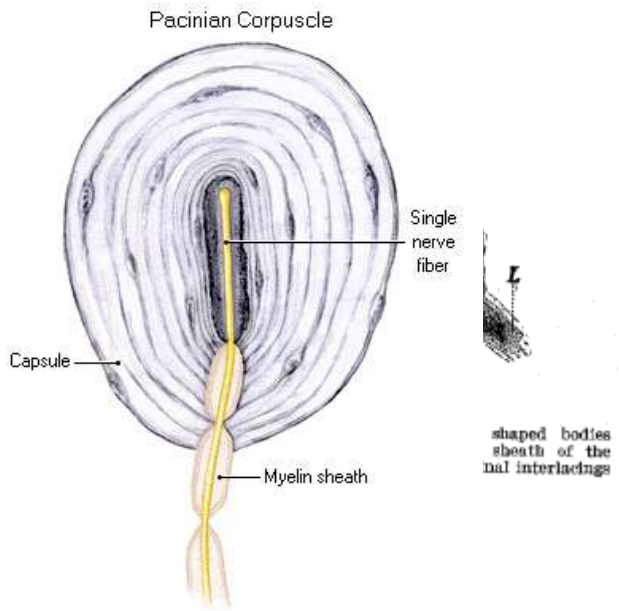


GOLGI TENDON ORGANS

- Encapsulated receptors
- Located at the musculotendinous junction
- Monitor tension within the tendon
- Respond by causing the muscle to relax



PACINIAN CORPUSCLES & RUFFINI ENDINGS



Encapsulated receptors

Located near joints, in muscle, tendon, and bone