Nervous System overview

Nervous System

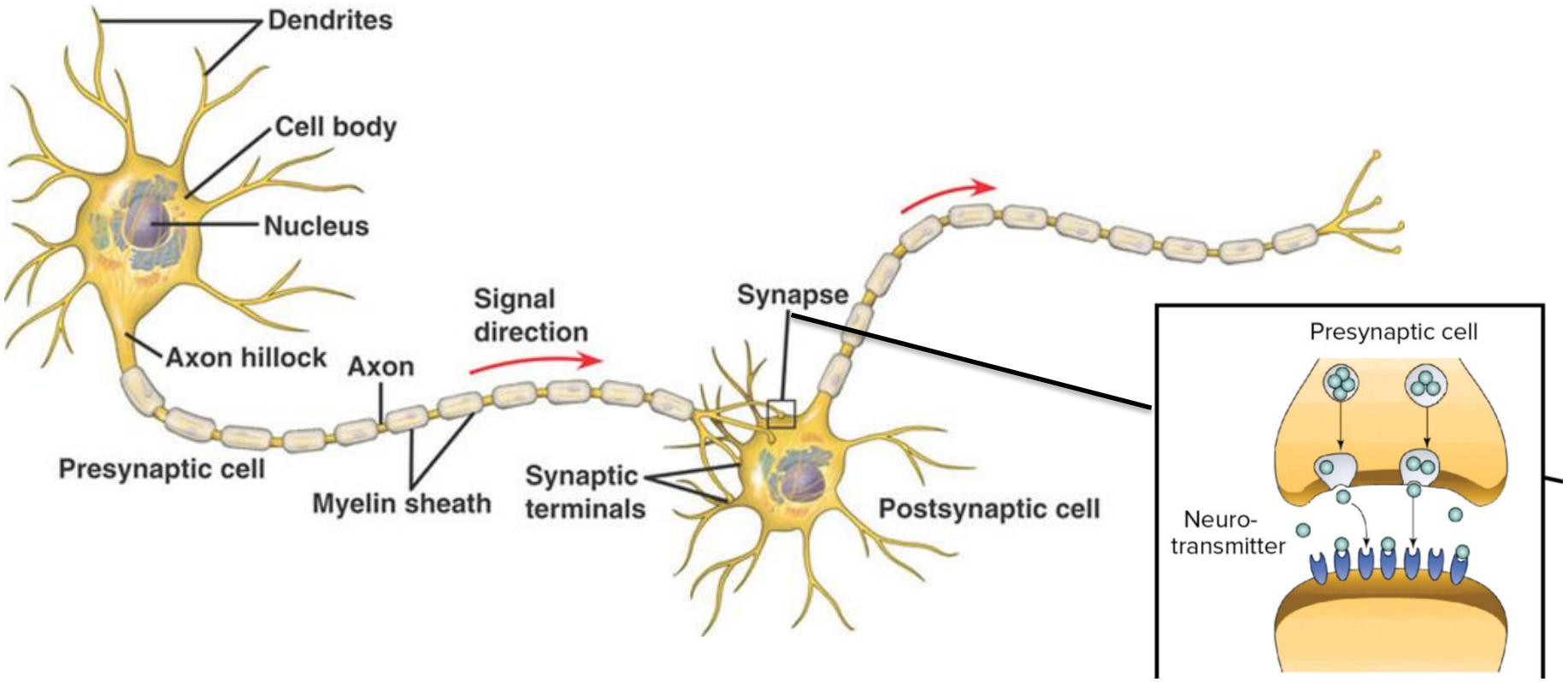
- is a rapid communication system using electrical signals.
- consists of a network of specialized cells called neurons.

Functions of the Nervous System:

- Sensory input – gathering information
  - To monitor changes occurring inside and outside the body
  - Changes = stimuli
- Integration
  - To process and interpret sensory input and decide if action is needed
- Motor output
  - A response to integrated stimuli
  - The response activates muscles or glands

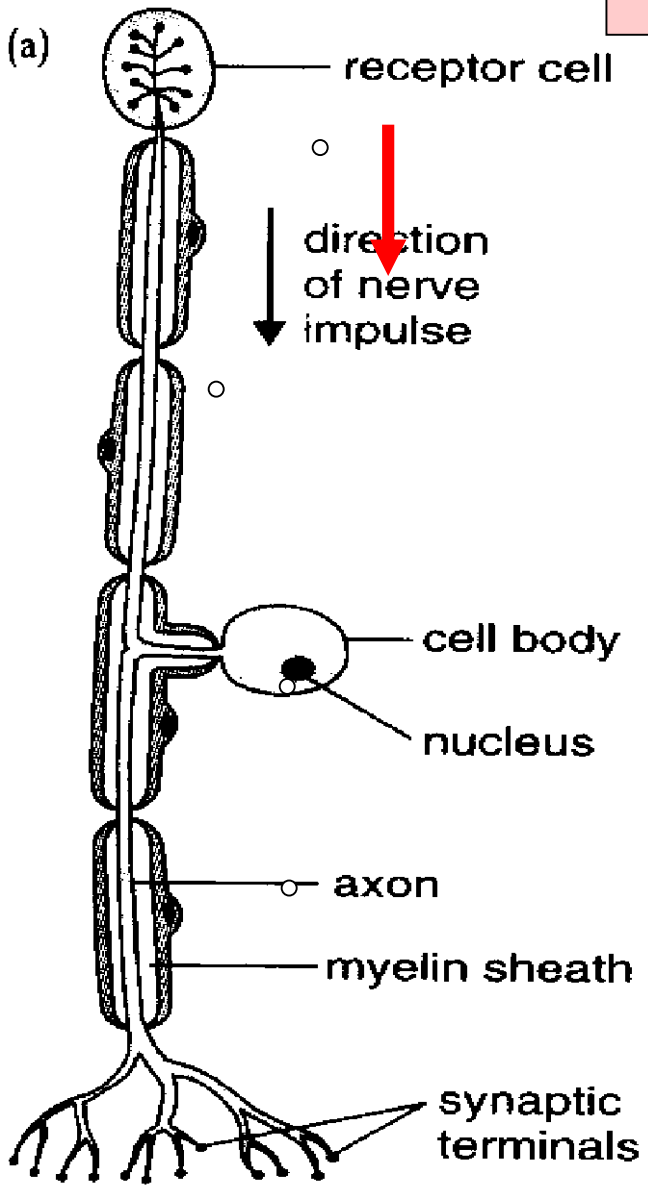
Structure of a neuron

- **Cell body:** central part of neuron, maintains cell function, relays signals from one part of cell to another.
- **Dendrites:** extend from cell body, receive information from other cells.
- **Axon:** long extension from the cell body, transmits signals to other neurons, ends in an axon terminal.
- **Synapse:** where the axon terminal connects with another neuron, separated by a gap called the synaptic cleft



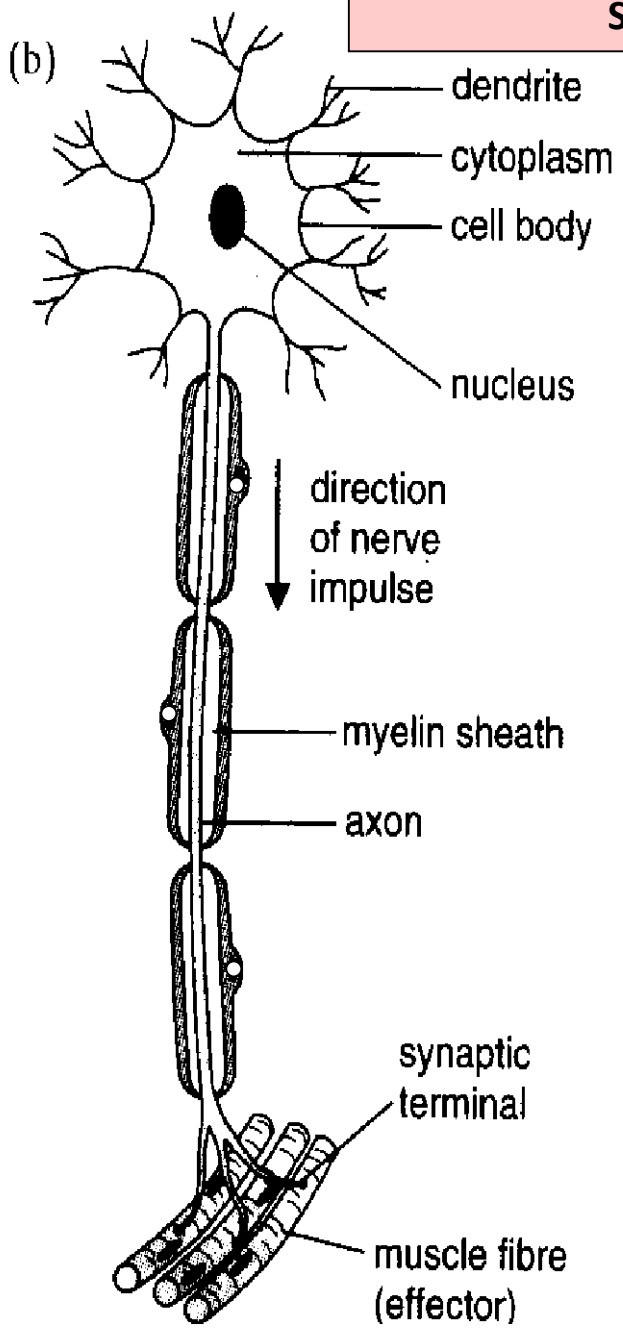
Kinds of Neurons

Structure of an afferent (sensory) neurone



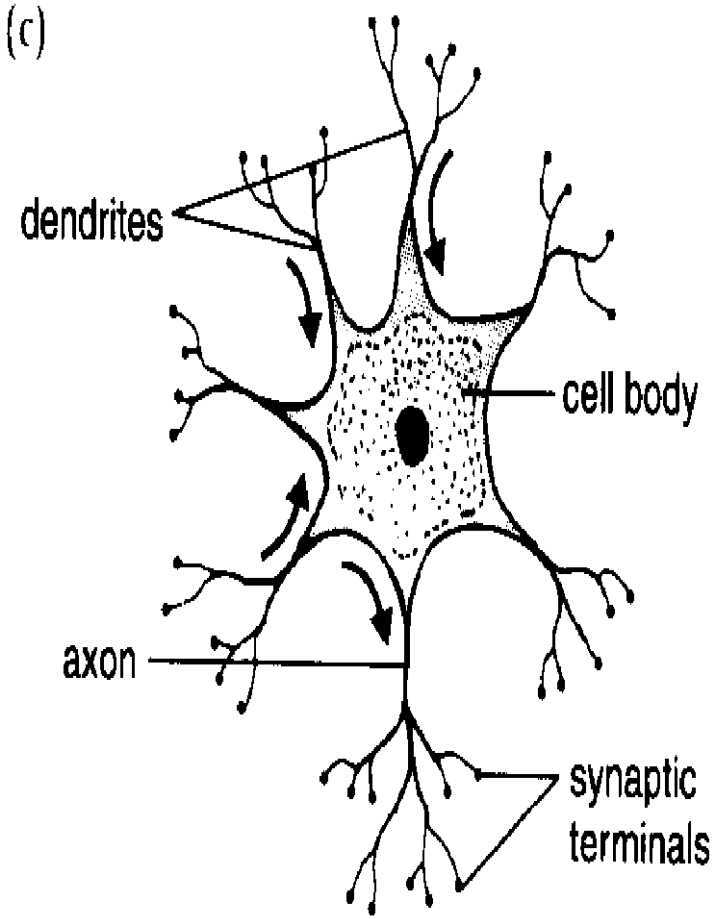
Carry sensory information from receptors cells to the brain & spinal cord

Structure of an efferent (motor) neurone



Carry sensory information from brain & spinal cord to the effectors
[muscle / gland cells]

Structure of an interneurone



- Convey nerve impulses between the various parts of the brain and spinal cord
- Transmit nerve impulses between the afferent neurones and efferent neurones
- Transmit nerve impulses from one side of the spinal cord to the other side, or from the brain to the spinal cord and vice versa

Watch video # 3.1

DIFFERENCE BETWEEN STRUCTURE OF AFFERENT NEURONE & EFFERENT NEURONE

AFFERENT NEURONE	EFFERENT NEURONE
Long dendrite, short axon	Short dendrite, long axon
Cell body at the side of the neurone [not at the end]	Cell body at the end of the neurone
Begins with receptor	Ends with effector

Path of a nerve impulse

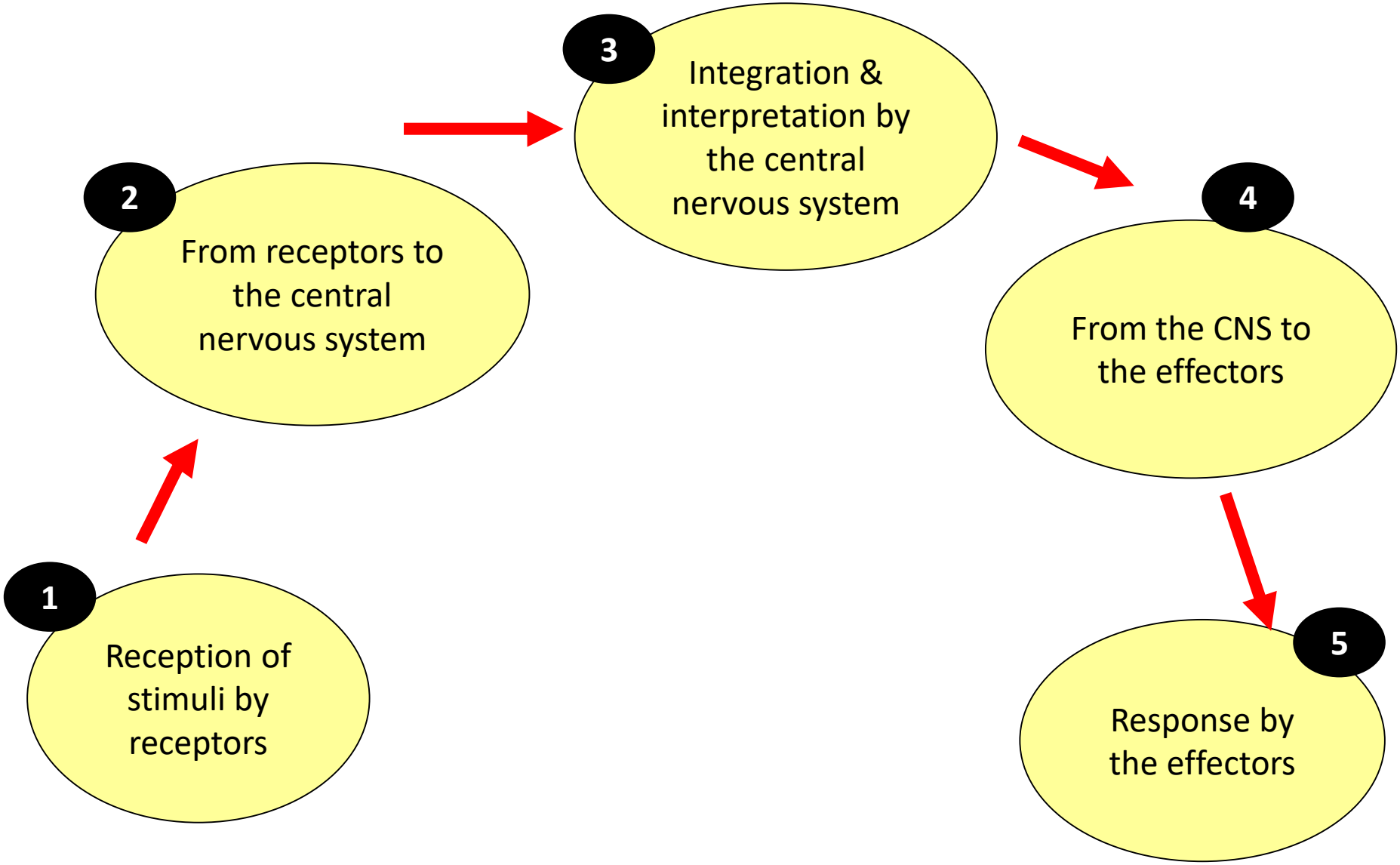
- The transmission of information along the neurone is through electrical signals known as nerve impulses.

- An impulse is a wave of positive charges that travel along the axon to the synaptic terminal.

- A neurone will not transmit an impulse unless the stimulation is strong enough.

- Once the magnitude or size of the stimulation reaches a threshold level, a full-sized impulse is generated to travel the entire length of the axon.

The transmission pathway of information



The transmission pathway of information

1 **Receptors in the ear pick up the ringing of the doorbell.**

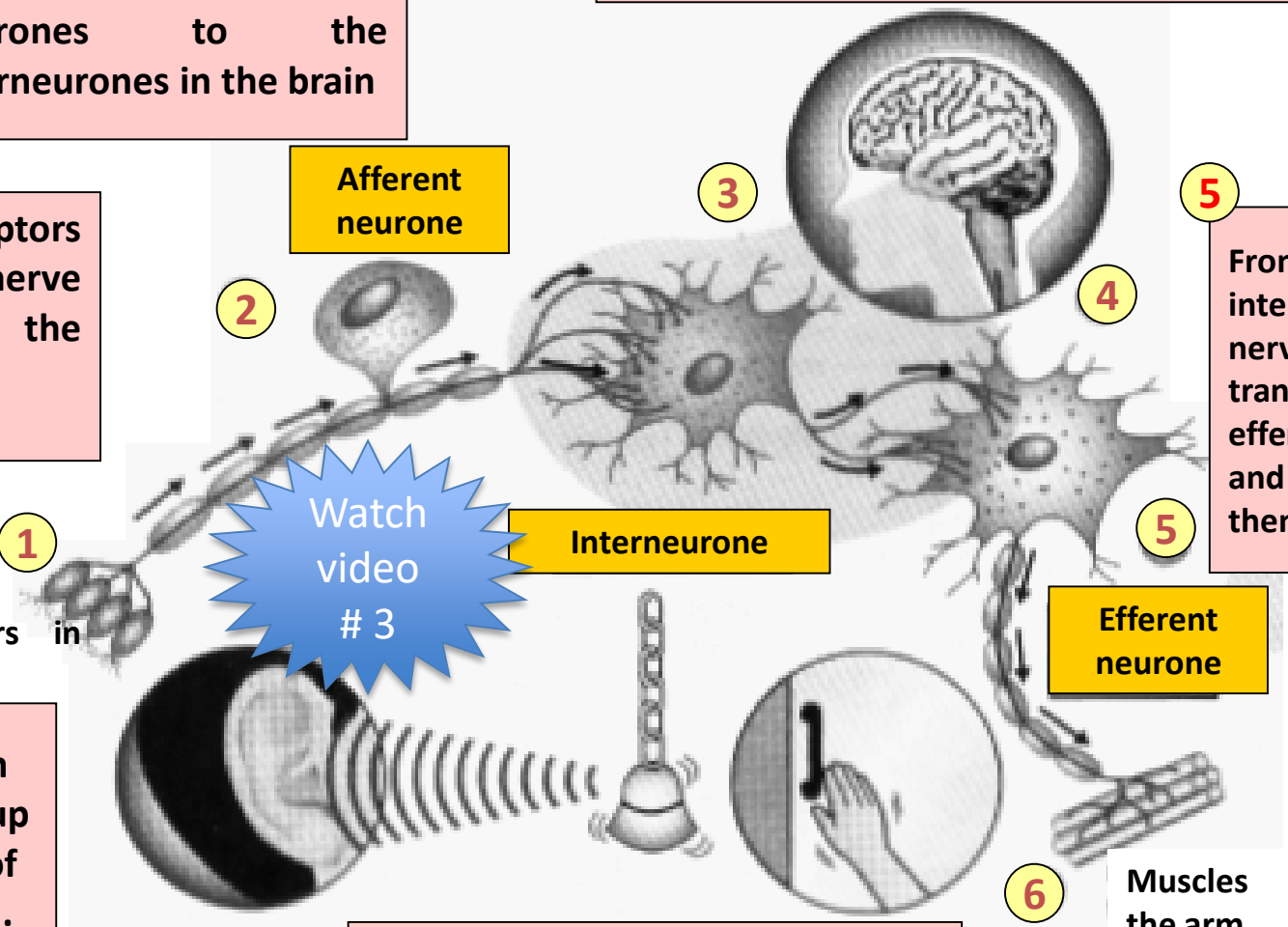
2 **The receptors trigger nerve impulses in the afferent neurones.**

3 **The nerve impulses pass from the afferent neurones to the interneurones in the brain**

4 **The brain interprets the nerve impulses from many interneurones that the doorbell is ringing. The brain also decides that the door should be opened**

5 **From the interneurones, nerve impulses are transmitted to the efferent neurones and then to the muscles**

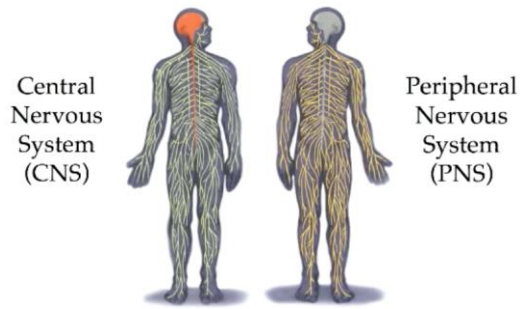
6 **The muscles in the arm carry out the response and open the door**



Divisions of the Nervous System

HUMAN NERVOUS SYSTEM

CENTRAL NERVOUS SYSTEM [CNS]



PERIPHERAL NERVOUS SYSTEM [PNS]

BRAIN

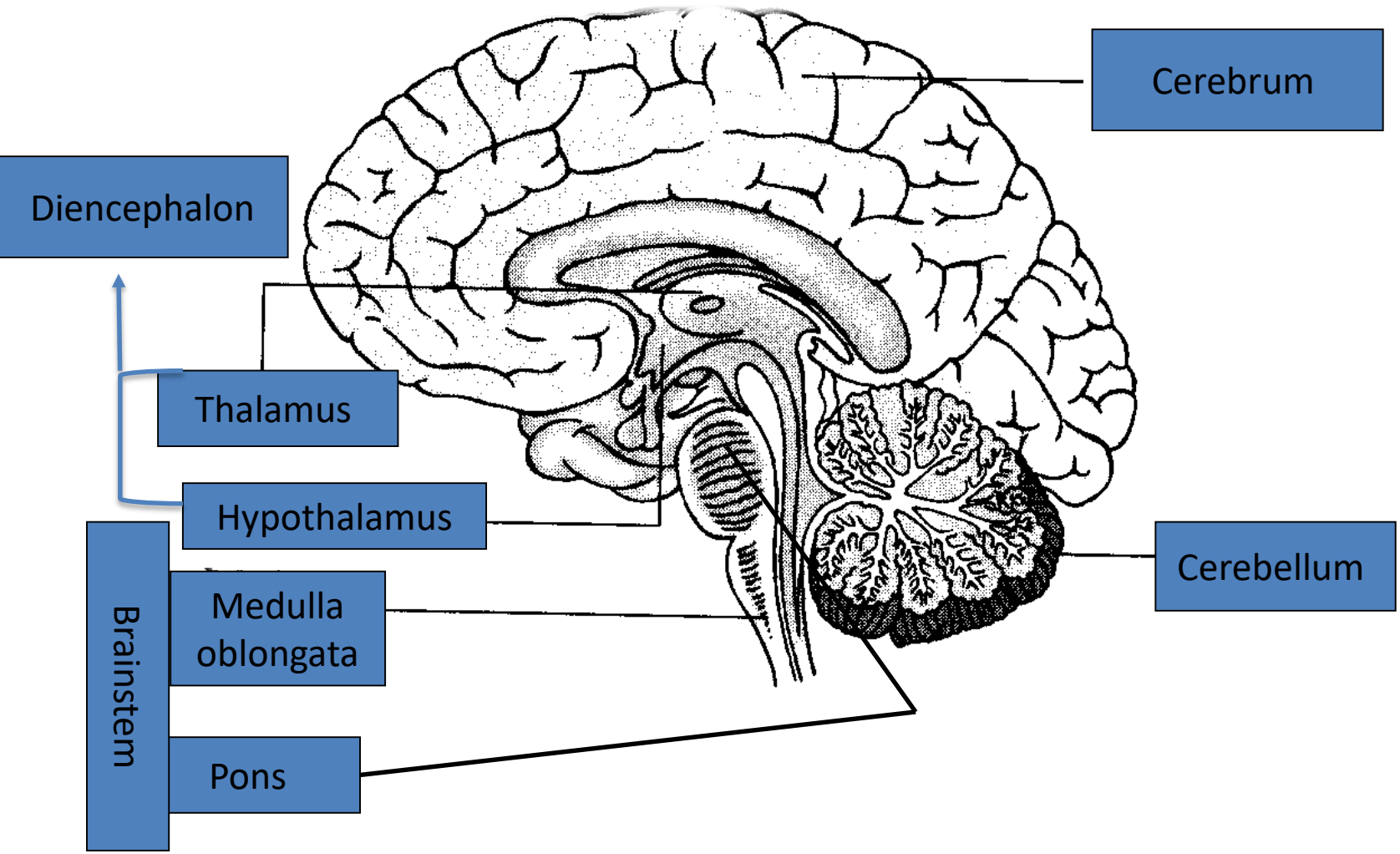
SPINAL CORD

CRANIAL NERVES [12 pairs]

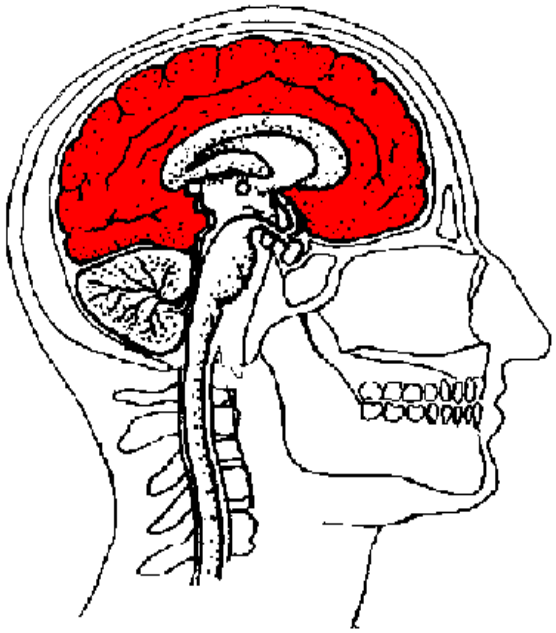
SPINAL NERVES [31 pairs]

Central Nervous System

STRUCTURE OF THE BRAIN

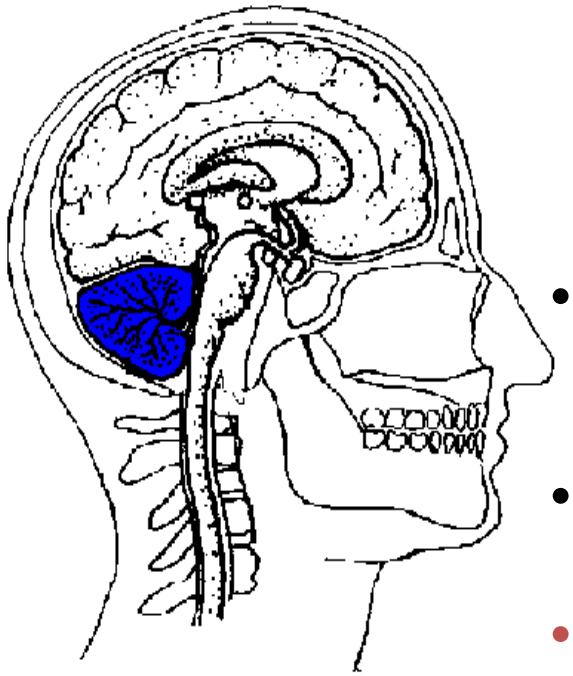


CEREBRUM



- The cerebrum is the largest and most complex part of the brain.
- It is divided into two halves called the **cerebral hemispheres.** These two halves are connected to each other by **corpus callosum.**
- The **left hemisphere** controls the movements on the right side of the body.
- The **right hemisphere** controls the movements on the left side of the body.
- The cerebrum is the centre which receives the sensory input and carries out integrative functions before initiating appropriate motor responses.
- It also coordinates the activities of the other parts of the brain.
- The outer region of the cerebrum is the **cerebral cortex.**
- The cerebral cortex is a structure with many folds which increases the surface area.
- The cerebral cortex directs **voluntary muscle movements**, which result in a **sensory perception** that is, when a person becomes aware of what he sees, hears, smells, tastes or touches.
- It is also responsible for many **mental abilities** such as learning, memorising, reasoning, language skills, speech. mathematical skills, imagination, artistic talent and personality traits.
- Brain damage from trauma, a stroke or a tumour can result in specific defects, such as speech impairment. reading difficulty, or the paralysis of certain parts of the body.

CEREBELLUM



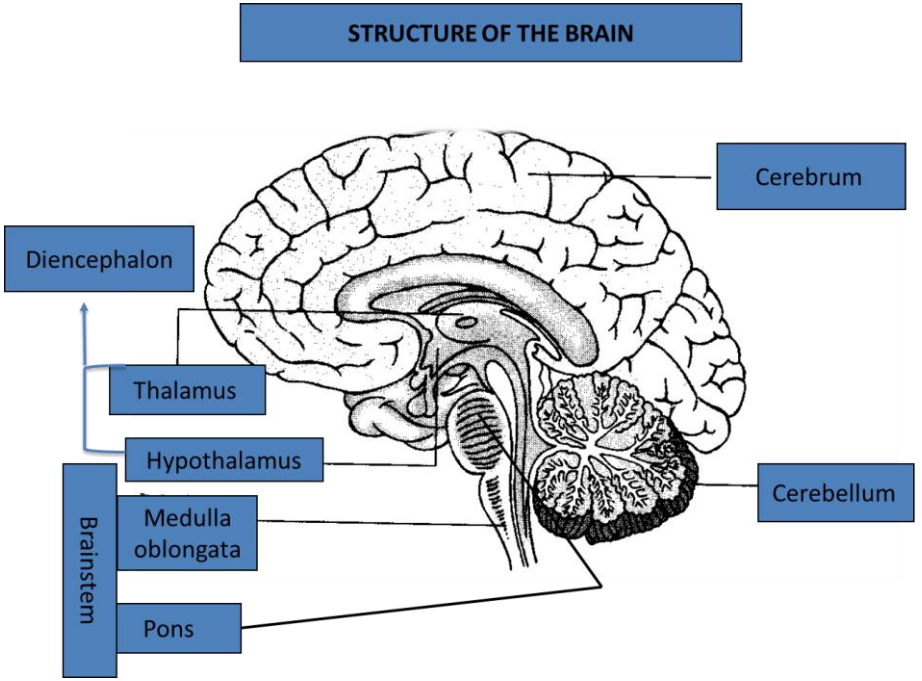
- The cerebellum is located below the cerebrum near the top of the spinal cord.
- The cerebellum is the coordinating centre for **body movement**
- The cerebellum receives information from the sensory receptors on the **positions** of different parts of the body; and, from the cerebrum, an indication of the **need to move.**
- The cerebellum evaluates the information and relays the need for **coordinated movements** back to the cerebrum.
- The cerebrum then sends appropriate commands to the **muscles**
- The cerebellum controls voluntary muscles, posture, balance and the coordination of walking, running and playing sports

Brainstem

MEDULLA OBLONGATA

•The medulla oblongata regulates the internal body processes that do not require conscious effort, that is, automatic functions such as the heartbeat, breathing and vasoconstriction

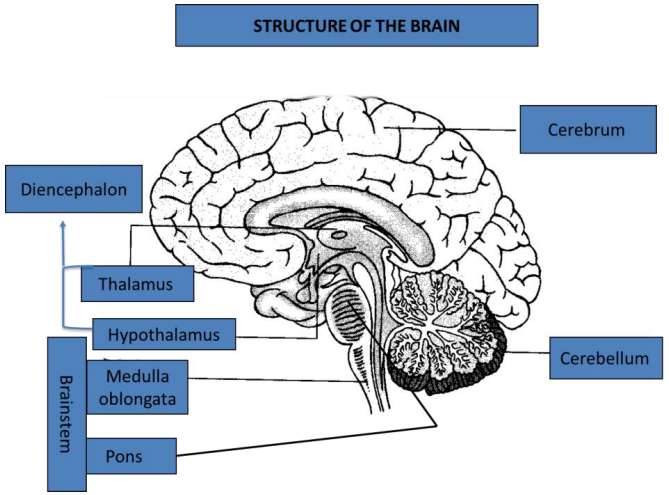
•It is also the reflex centre for vomiting, coughing. sneezing, hiccupping and swallowing.



PONS

- Connects the medulla & midbrain
- Transmit information between spinal cord & higher brain regions via neural circuits
- Relay motor information between cerebral cortex & cerebellum

Diencephalon



HYPOTHALAMUS

- The hypothalamus plays an important role in homeostatic regulation. It acts as a major coordinating centre for regulating sleep. hunger, thirst, body temperature, water balance and blood pressure.

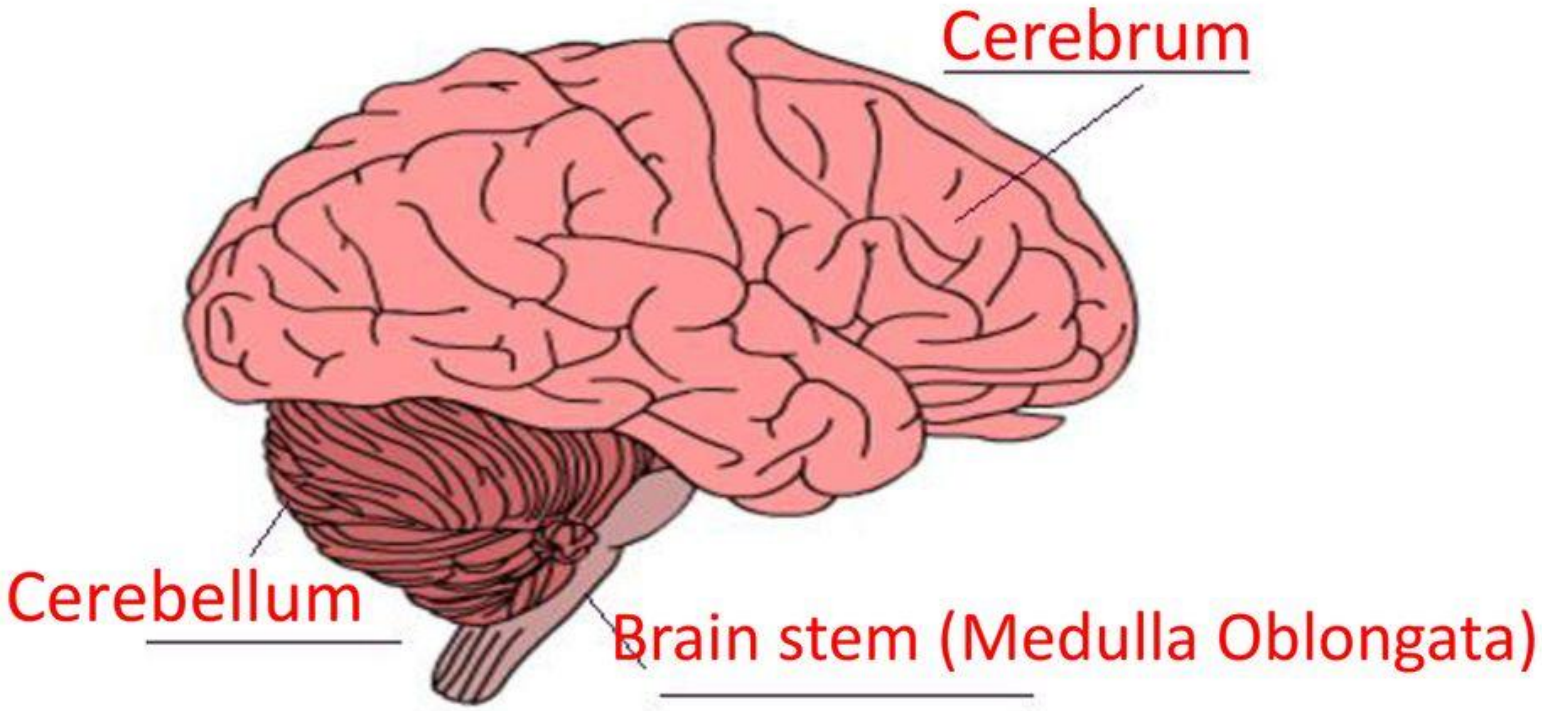
- It is also the control centre of the endocrine system.

THALAMUS

- The thalamus is responsible for sorting the incoming and outgoing information in the cerebral cortex.

- It also integrates the information from the sensory receptors to the cerebrum by enhancing certain signals and blocking others

In brief:



Brain stem

- Changes in heart rate
- Breathing, blood pressure, vomiting, swallowing
- Digestion

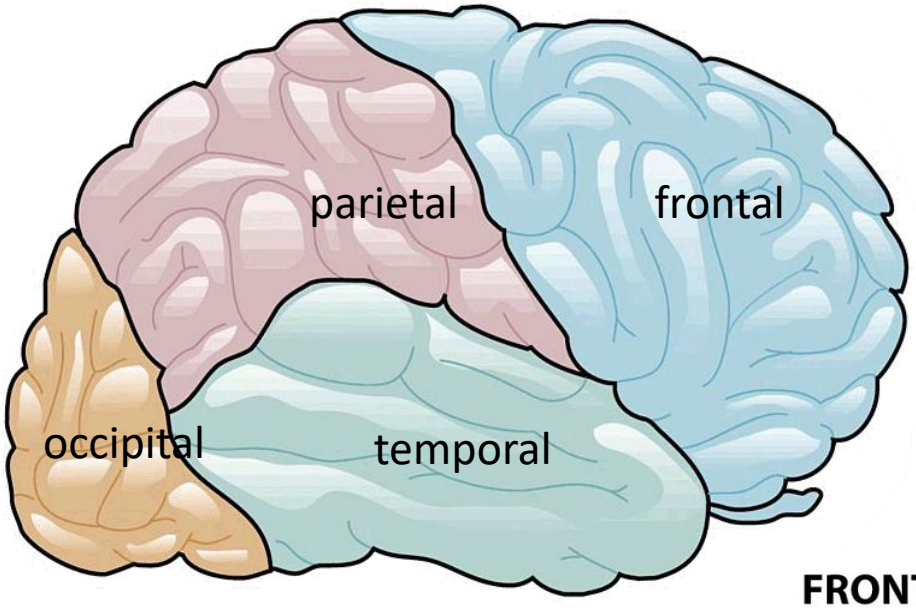
Cerebrum

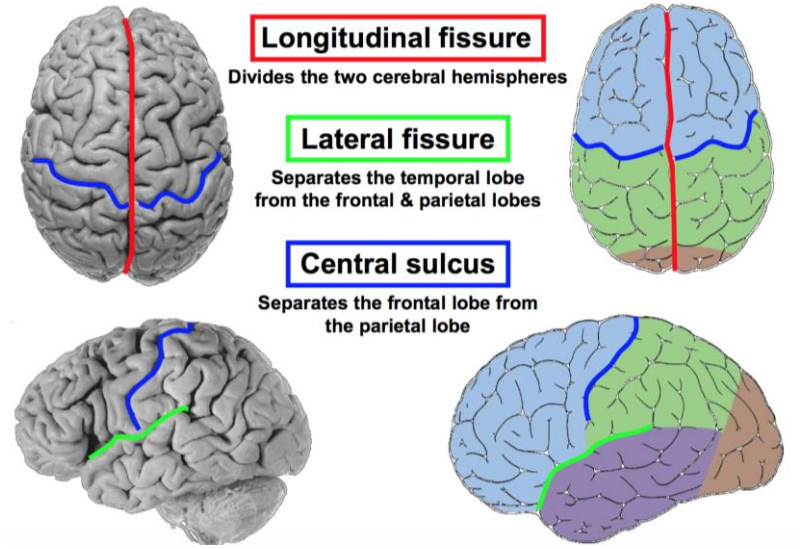
- Intelligence, learning, judgment
- Speech and memory
- Sense of hearing, vision, taste and smell
- Skeletal muscle movements

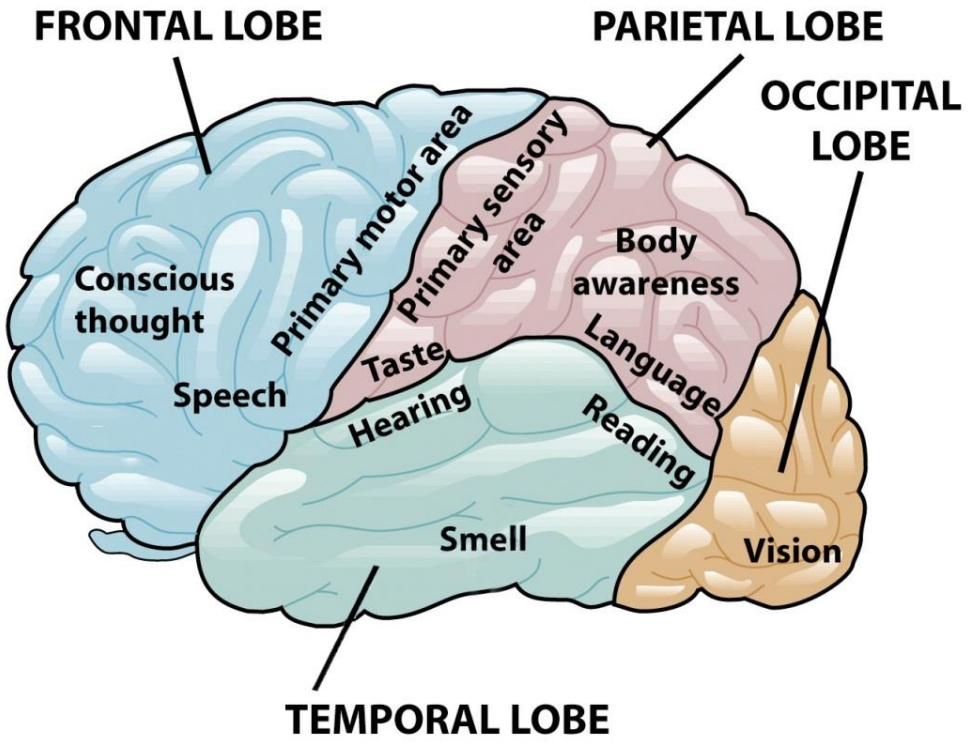
Cerebellum

- Balance and coordination
- Posture

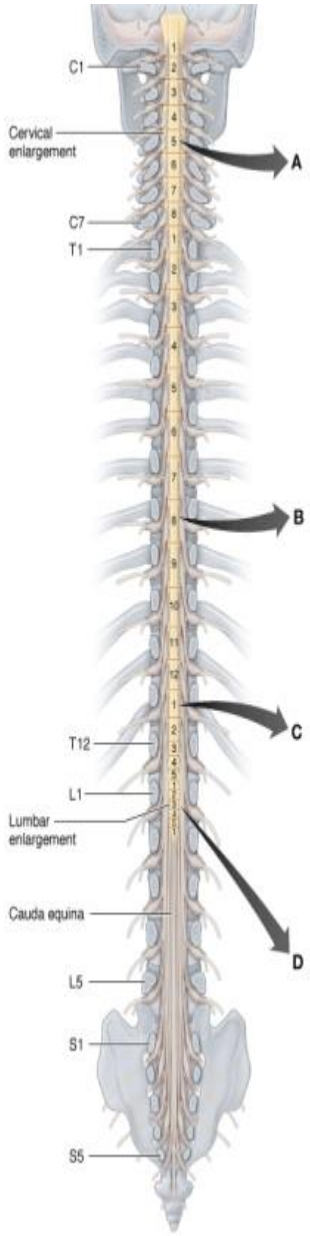
The lobes of the Crebrum

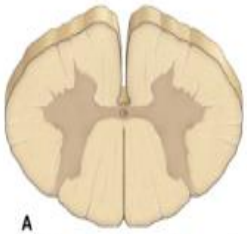






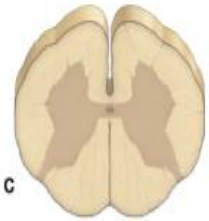
Spinal Cord





C5 spinal cord level

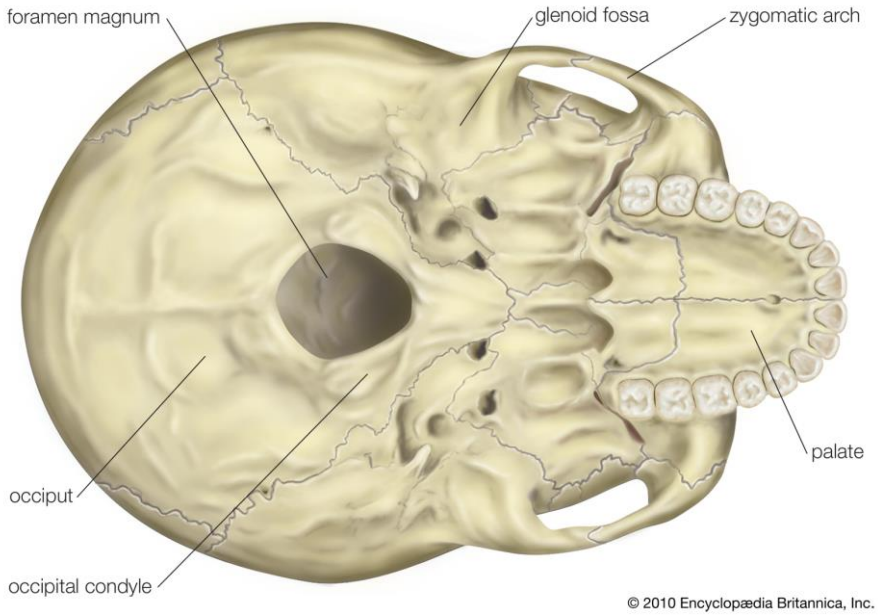
T8 spinal cord level

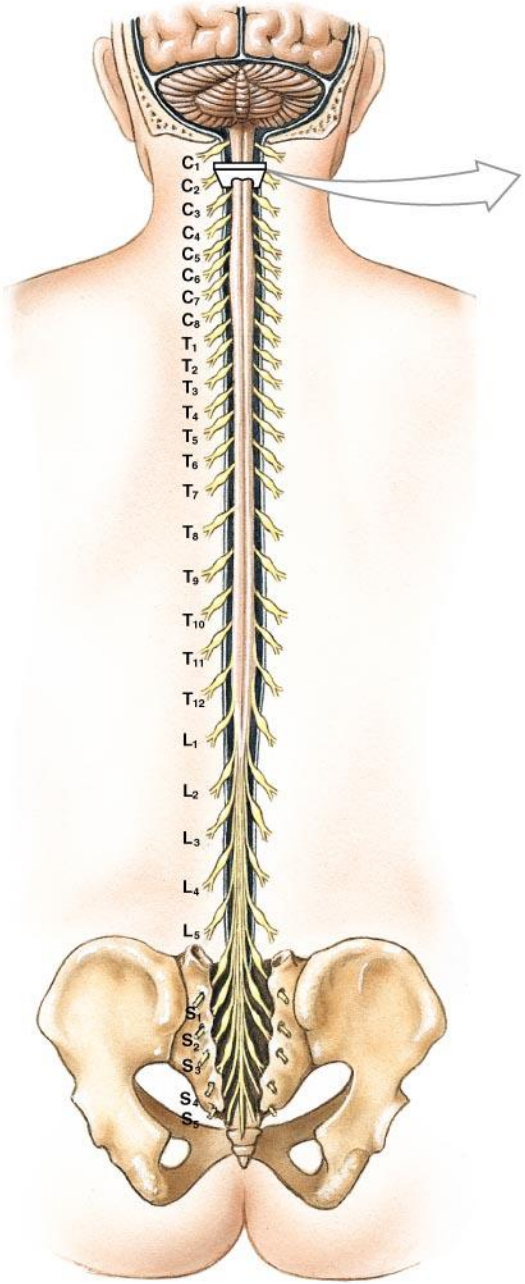


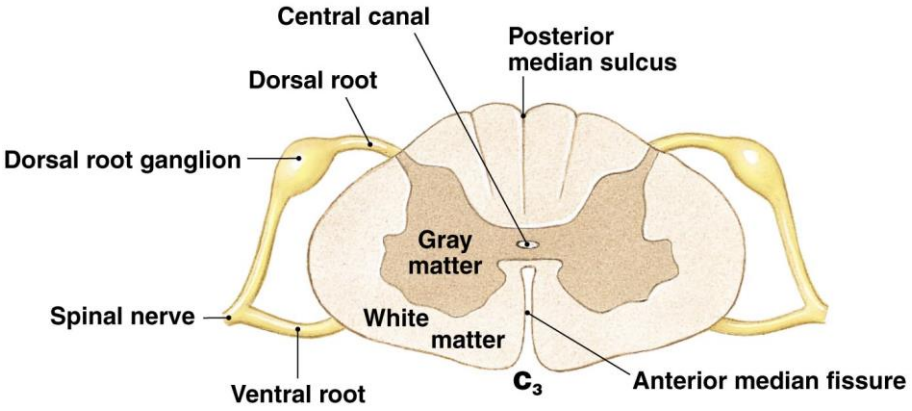
L1 spinal cord level

S3 spinal cord level

- Spinal cord is the pathway for messages sent by the brain to the body and from the body to the brain.
- Begins at foramen magnum & ends at L2 vertebral level
- Has 2 thickened areas-
  - cervical enlargement - supplies nerves to upper extremity
  - lumbar enlargement - supplies nerves to lower extremity
- Made up of 31 spinal cord segments







Each spinal cord segment has a pair of

- *dorsal roots* with their associated *dorsal root ganglia (DRG)*
- *ventral roots*

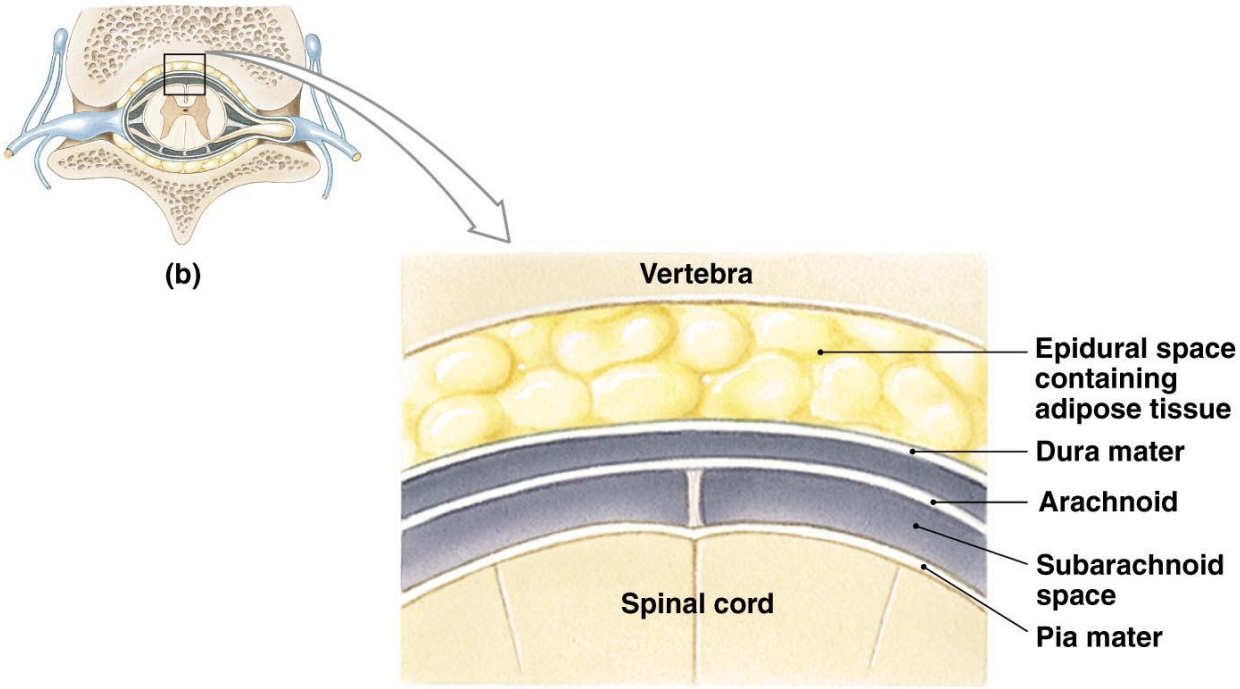
- Each dorsal root contains the axons of sensory neurons
- Each dorsal root ganglion contains the cell bodies of these sensory neurons
- Each ventral root contains the axons of motor neurons
- The dorsal & ventral roots of each segment come together at the intervertebral foramen (IVF) to form a mixed spinal nerve

MENINGES – membranes that surround and protect the CNS. Three layers:

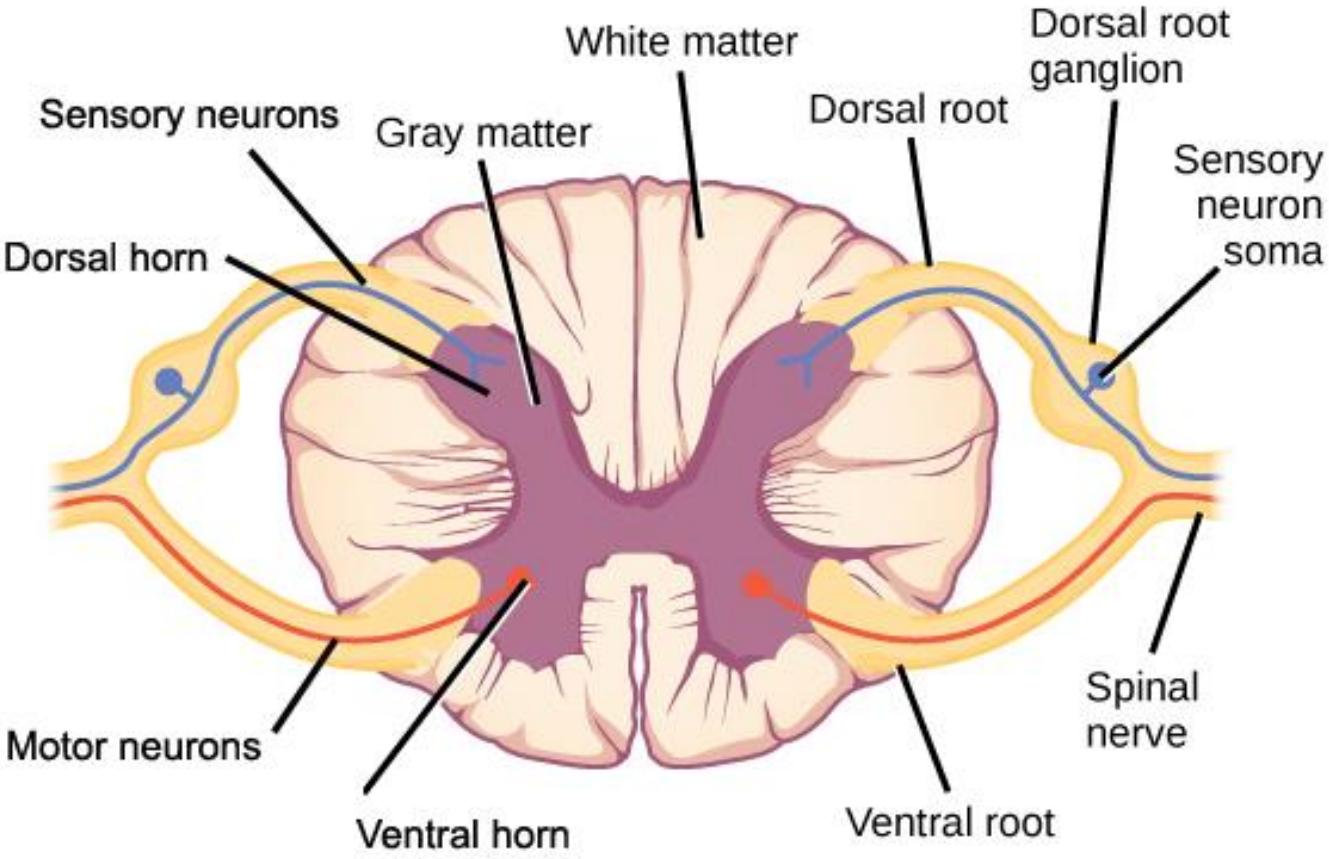
Dura Mater – tough, fibrous CT outer membrane; one layer thick around spinal cord with epidural space external

Arachnoid mater – "spidery" web-like middle layer

Pia Mater – delicate, thin inner layer



Subarachnoid space – between arachnoid & pia mater; contains ***cerebrospinal fluid (CSF)***



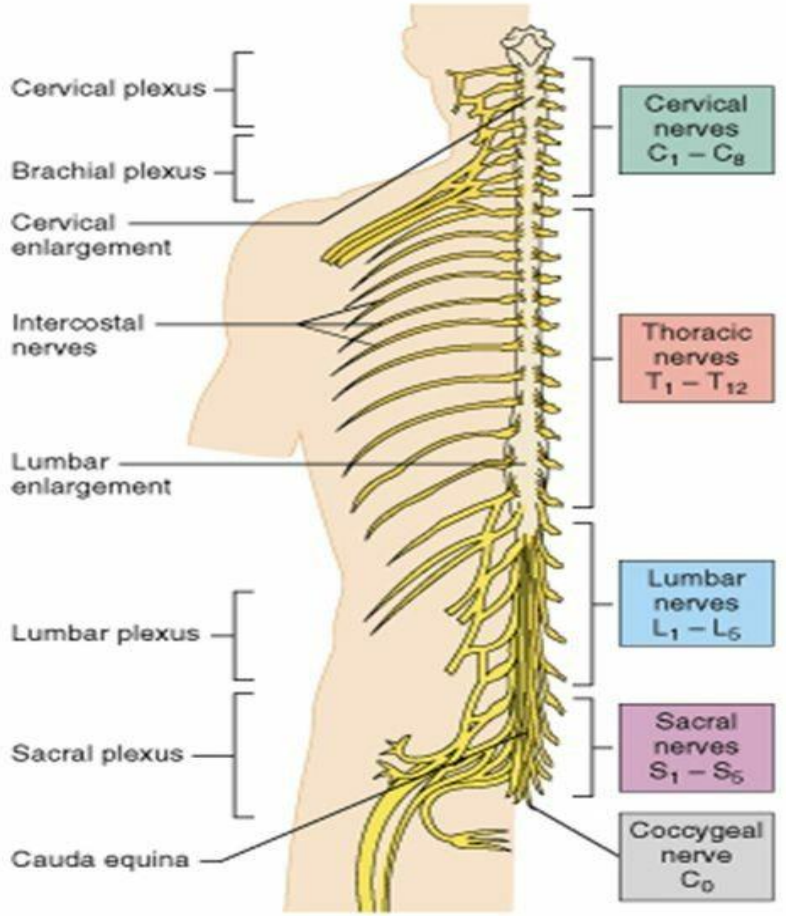
Cross Section of Spinal Cord

Peripheral Nervous System

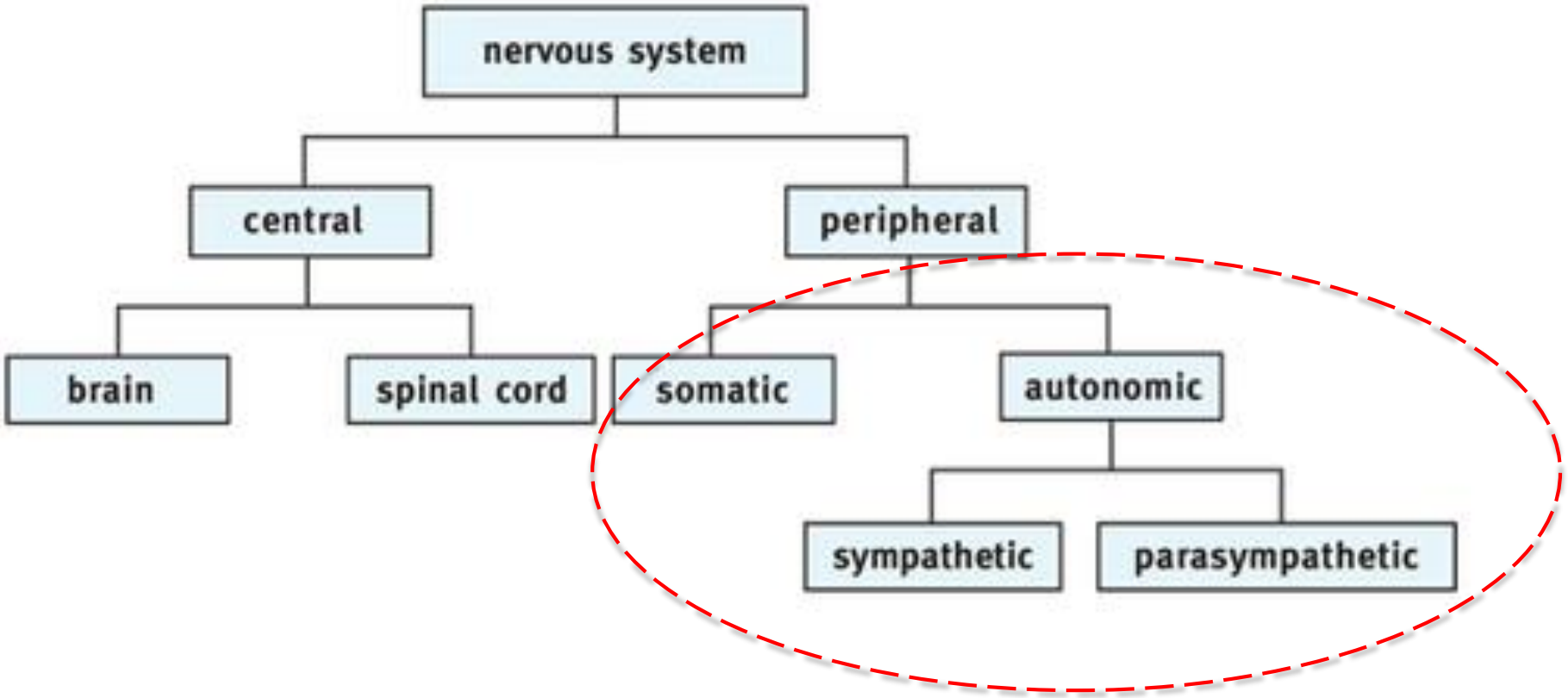
Peripheral Nervous System (PNS) is composed of the sensory and motor neurons that connects the central nervous system (CNS) to the rest of the body:

- cranial nerves (12 pairs
- spinal nerves (31 pairs)

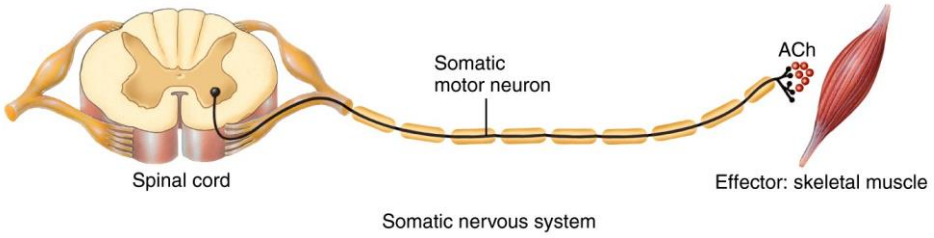
- 31 nerves connecting the spinal cord and various body regions.
  - 8 paired cervical nerves
  - 12 paired thoracic nerves
  - 5 paired lumbar nerves
  - 5 paired sacral nerves
  - 1 pair of coccygeal nerves



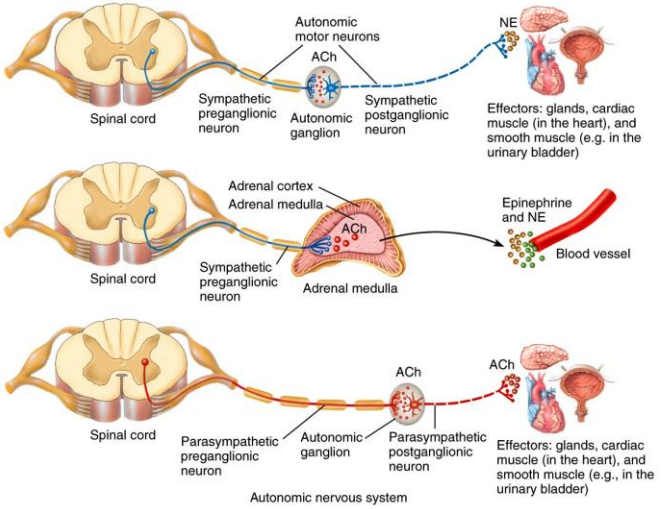
Peripheral Nervous System



- SNS
  - Controls skeletal muscle
  - Conscious, voluntary control
  - Motor pathway: one neuron from CNS to effector
  - Does include sensory neurons (from skin, skeletal muscles, and special sense organs)
  - All release the neurotransmitter ACh



- ANS
  - Controls viscera: smooth and cardiac muscle, and glands
  - Unconscious, involuntary
  - Motor pathway: series of two neurons from CNS to effector
  - Does include sensory neurons (monitors viscera)
  - Release either ACh or NE
  - Two divisions: sympathetic, parasympathetic



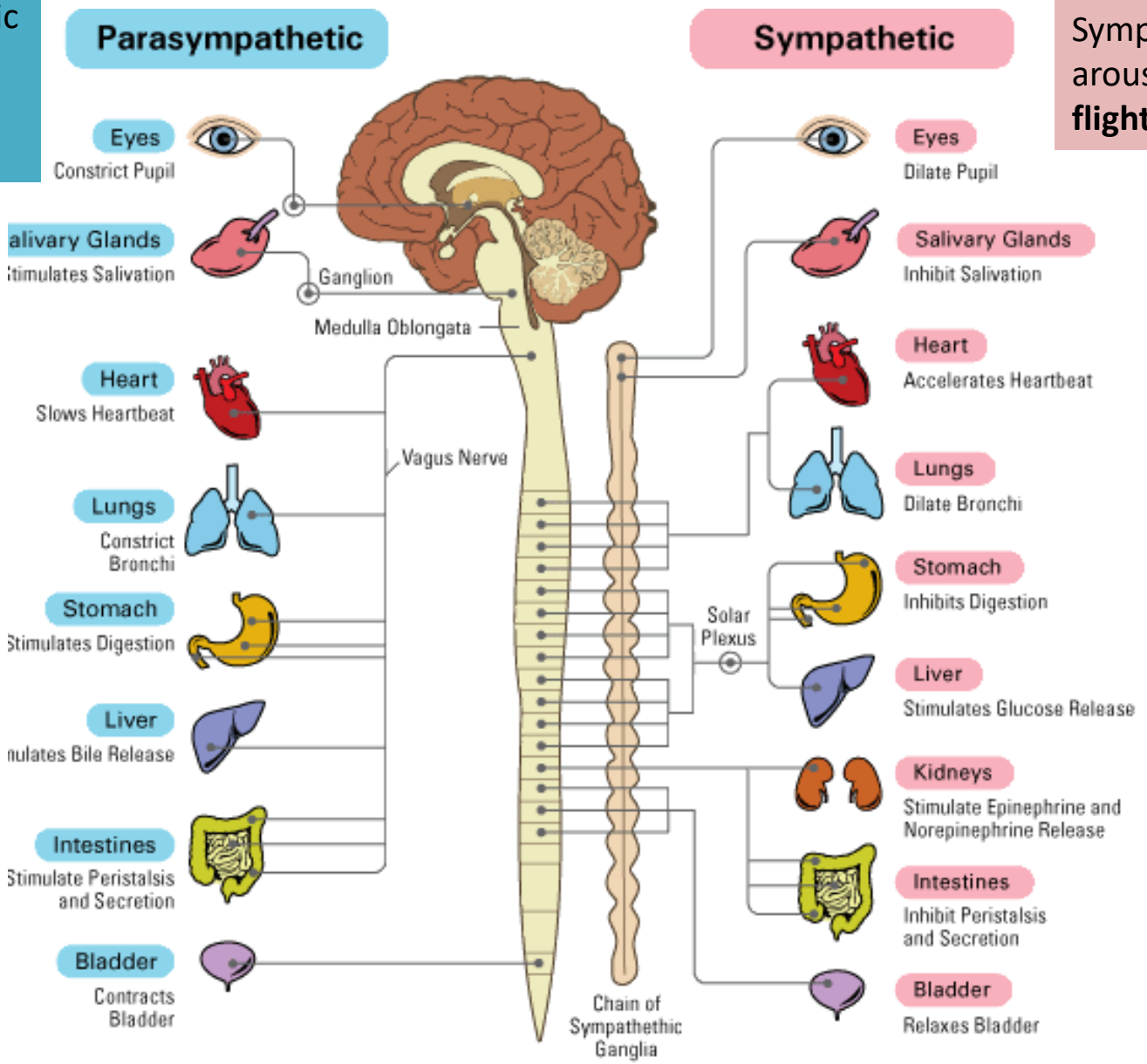
Sympathetic Nervous System: Divisions of the ANS that arouses the body, mobilizing its energy in stressful situations.

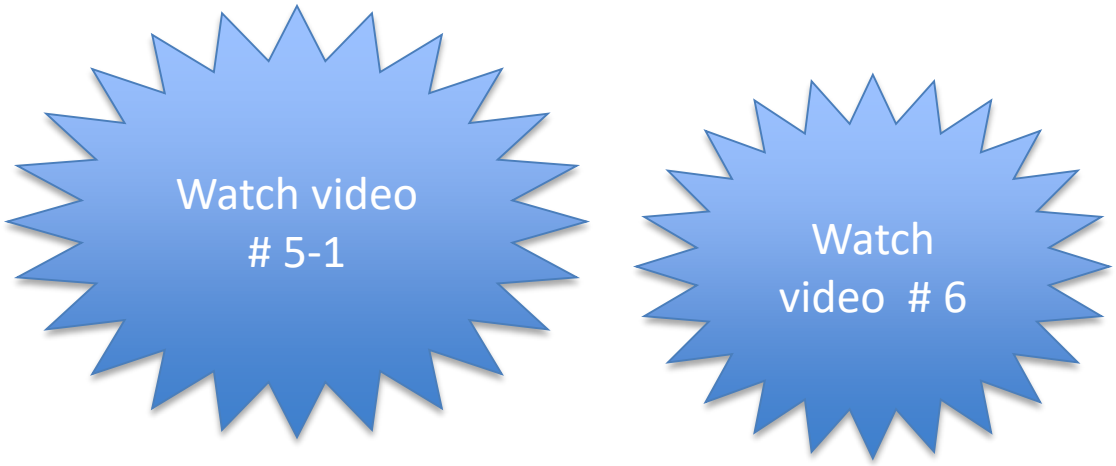
Parasympathetic Nervous System: Division of the ANS that calms the body, conserving its energy.

How sympathetic and parasympathetic nervous systems regulate functioning organs?

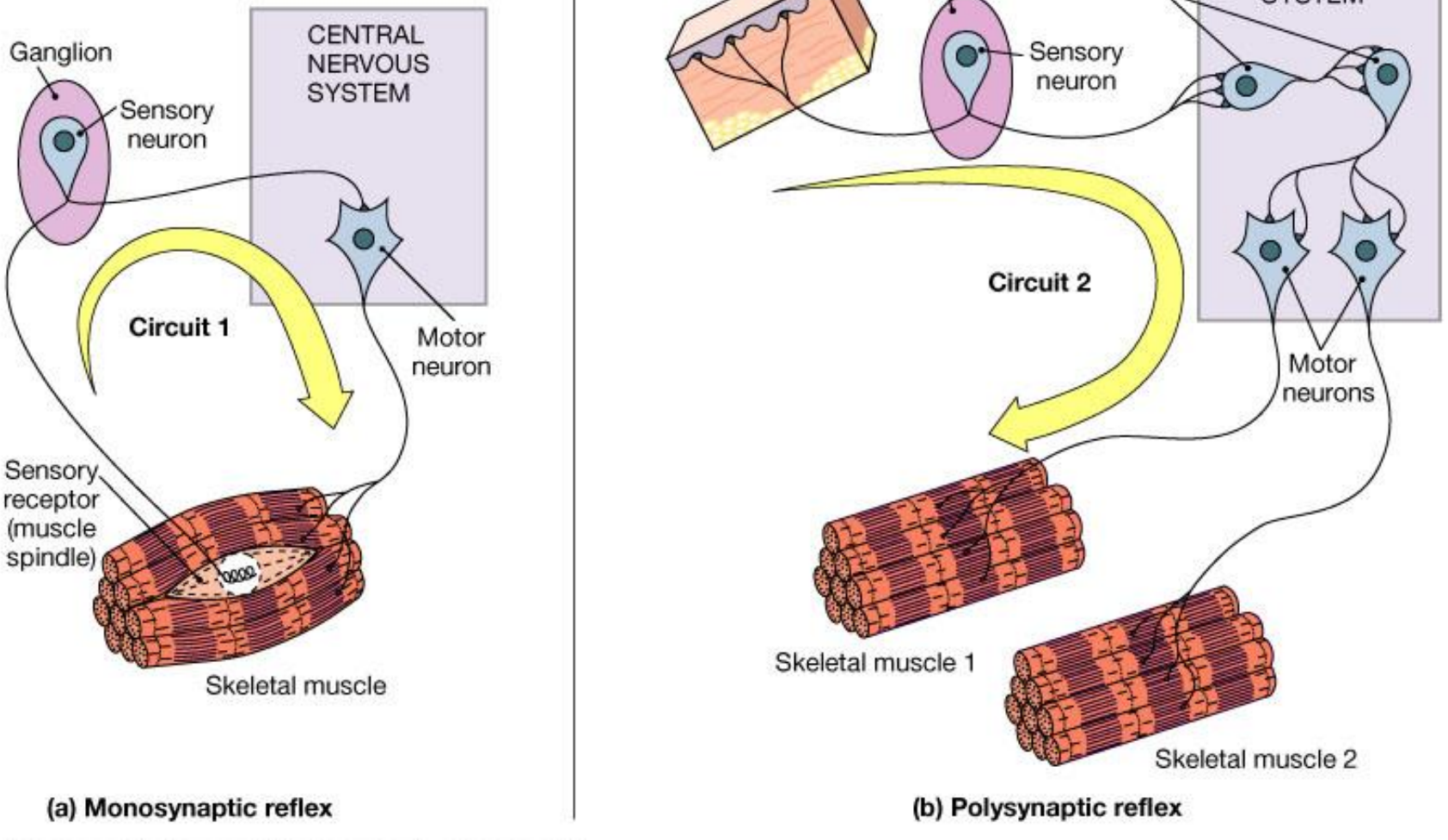
Parasympathetic NS calms **(rest and digest activites)**

Sympathetic NS arouses **(fight or flight activites)**




Watch video
5-1
Watch
video # 6

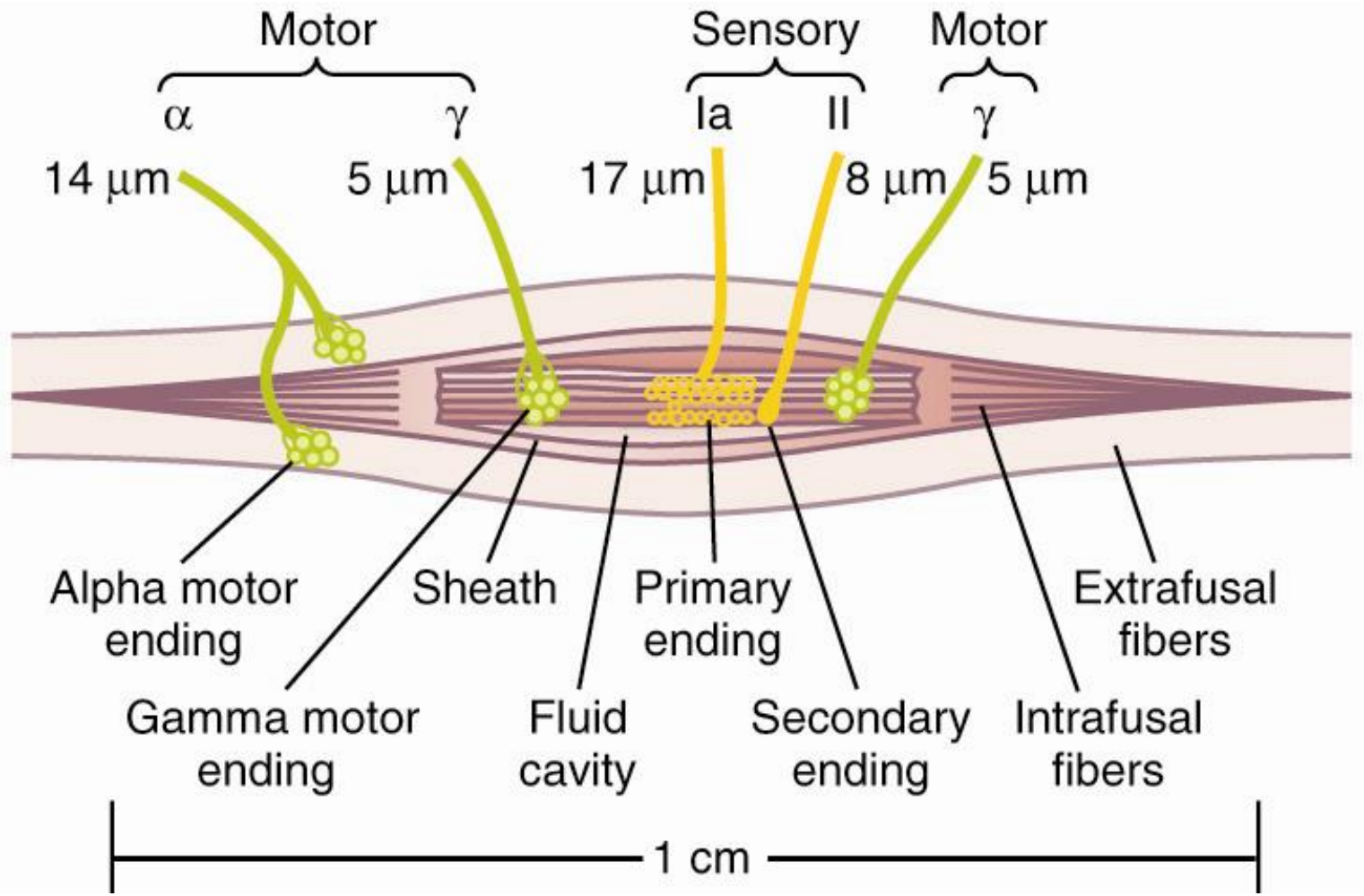
Neural Organization and Simple Reflexes



Anterior Motor Neurons

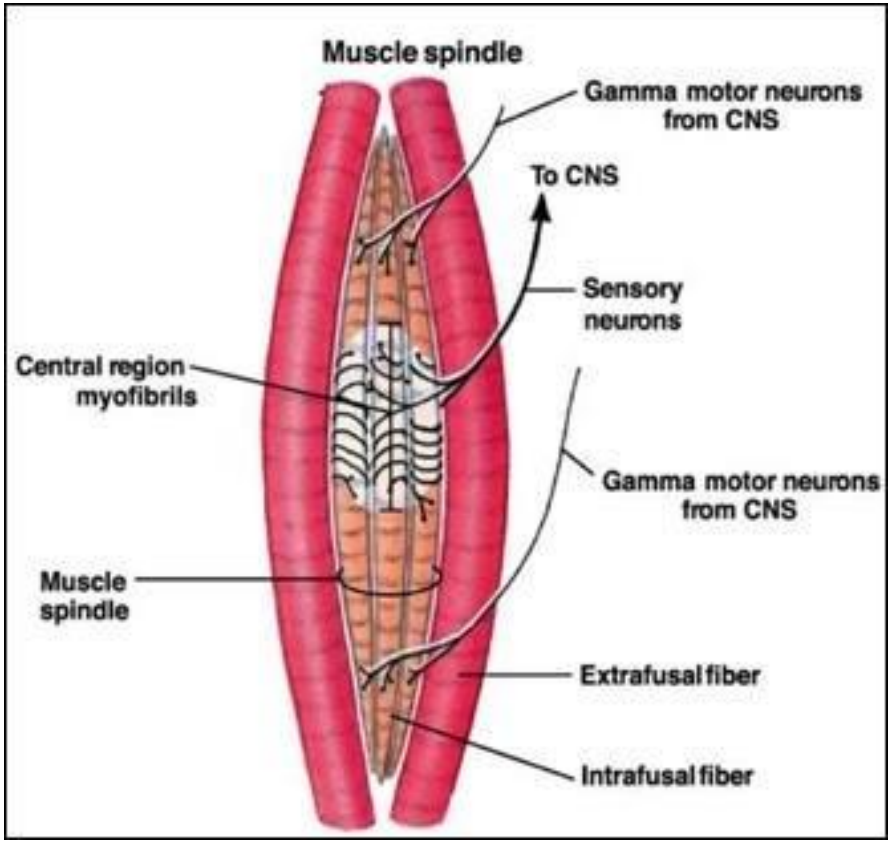
- Alpha motor neurons
  - give rise to large type A alpha fibers (~14 microns).
  - stimulation can excite 3 - 100 ***extrafusal*** muscle fibers collectively called a motor unit
- Gamma motor neurons
  - give rise to smaller type A gamma fibers (~5 microns)
  - stimulation excites ***intrafusal fibers***, a special type of sensory receptor

- sense muscle length and change in length

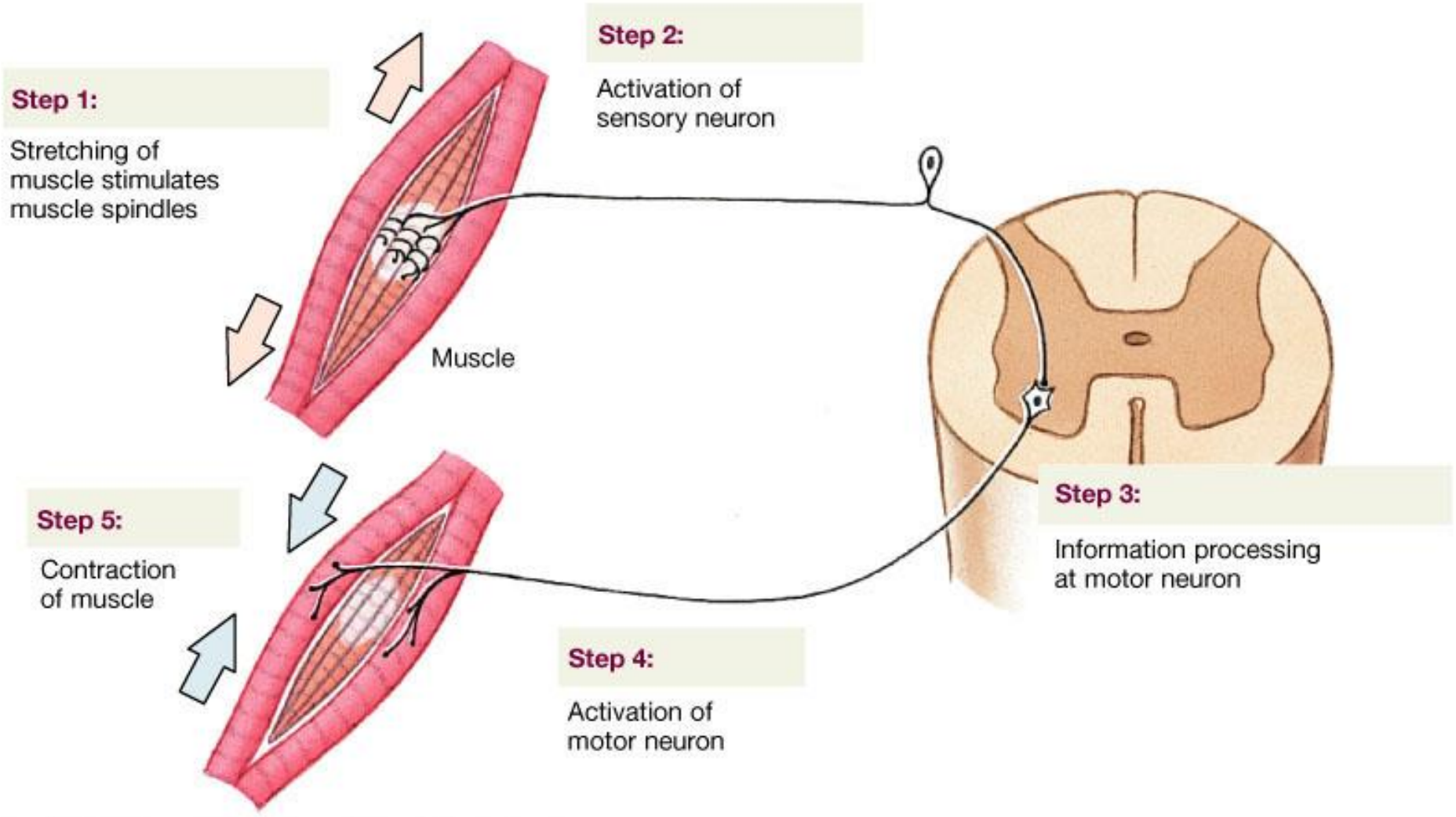


Physiologic Function of the Muscle Spindle

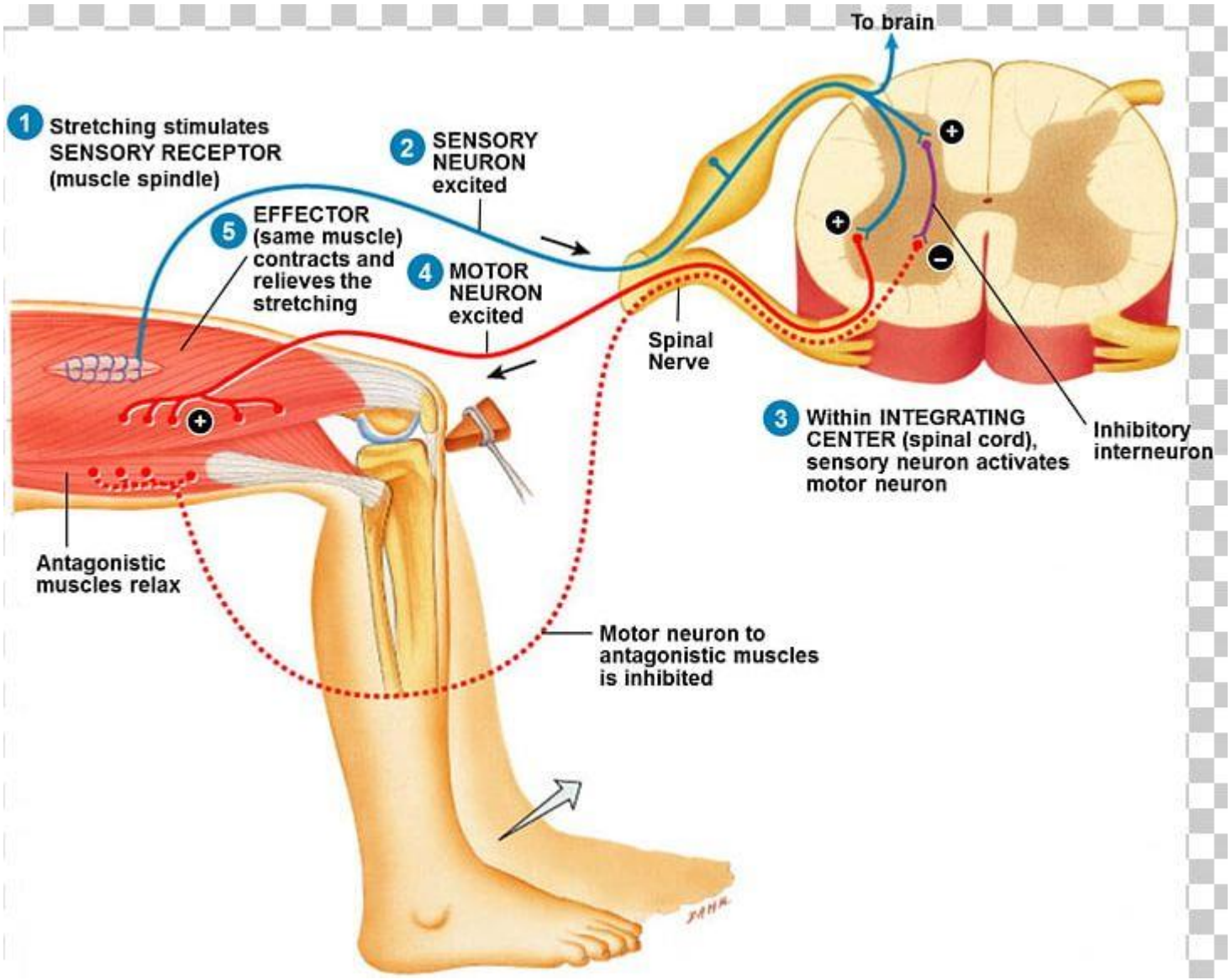
- **Muscle spindles** can be defined as small, spindle-shaped sensory receptors located in skeletal muscle tissue.
- Compares length between the intrafusal and extrafusal muscle fiber.
- Opposes a change in length of the muscle.
- When the muscle is stretched, the spindle returns it to its original length.
- Leads to the stretch reflex.



Components of the Stretch Reflex



The Patellar Reflex (**knee**-jerk **reflex)**



The Withdrawal Reflexes

- A painful stimulus causes the limb to automatically withdraw from the stimulus.
- Neural pathways for reflex:
  - nociceptor activation transmitted to the spinal cord
  - synapses with pool of interneurons that diverge to the muscles for withdrawal, inhibit antagonist muscles, and activate reverberating circuits to prolong muscle contraction
  - duration of the after discharge depends on strength of the stimulus

FLEXION vs EXTENSION

Flexion – forward movement that diminishes a joint angle and shortens the angle between two bones.

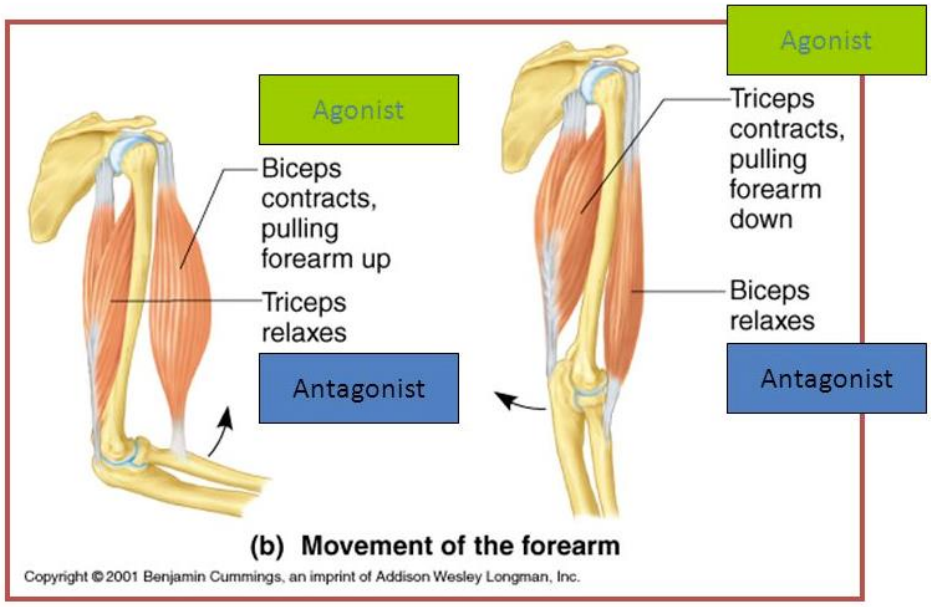
Extension – backward movement that increases a joint angle and lengthens the angle between two bones.

For example

- **Antagonist** and **agonist muscles** often occur in pairs, called **antagonistic pairs**. As one muscle contracts, the other relaxes.
- An example of an antagonistic pair is the biceps and triceps; to contract - the triceps relaxes while the biceps contracts to lift the arm.

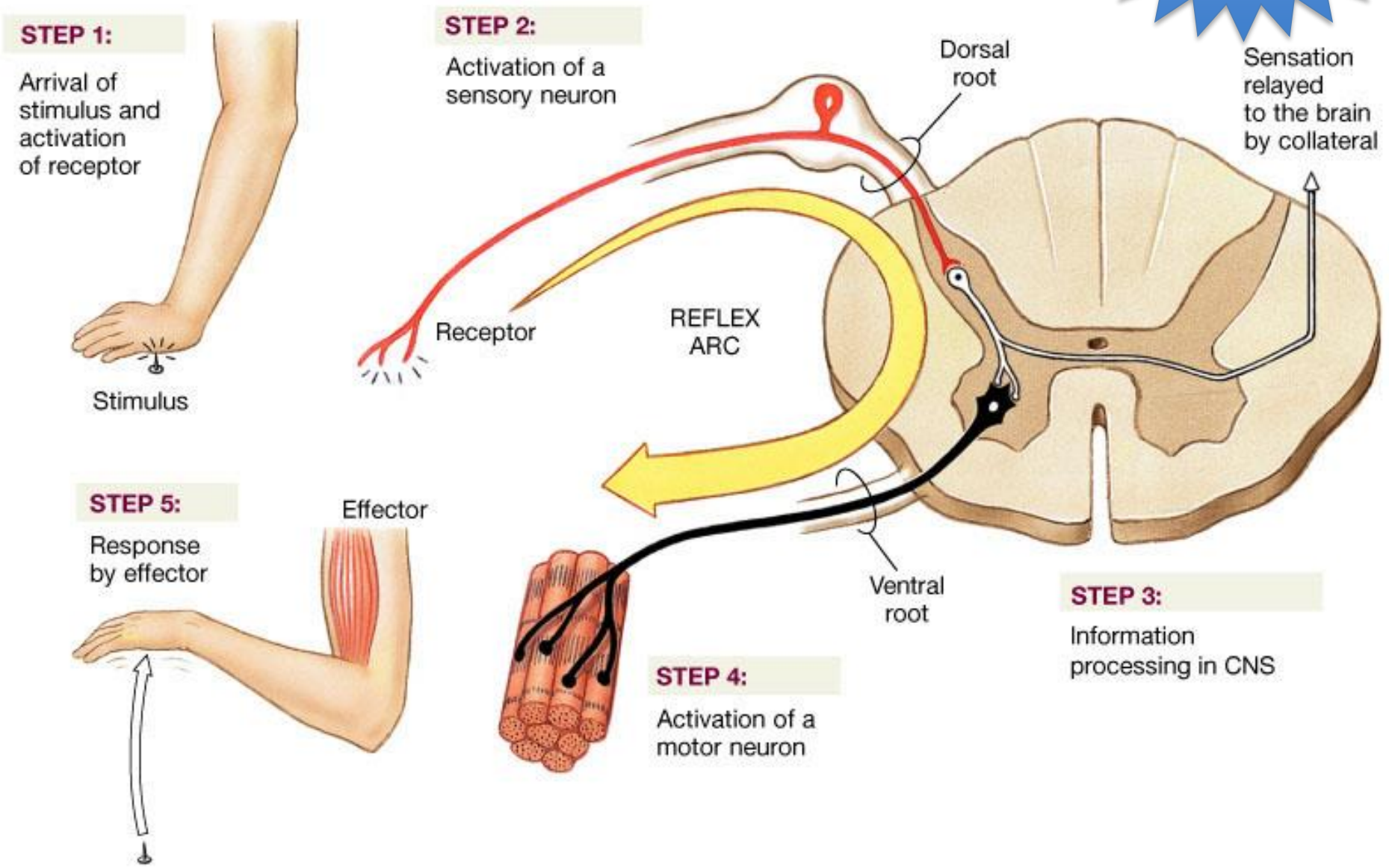
Agonist and Antagonist

Watch video # 7



Components of a Flexor Withdrawal Reflex

Watch video # 8

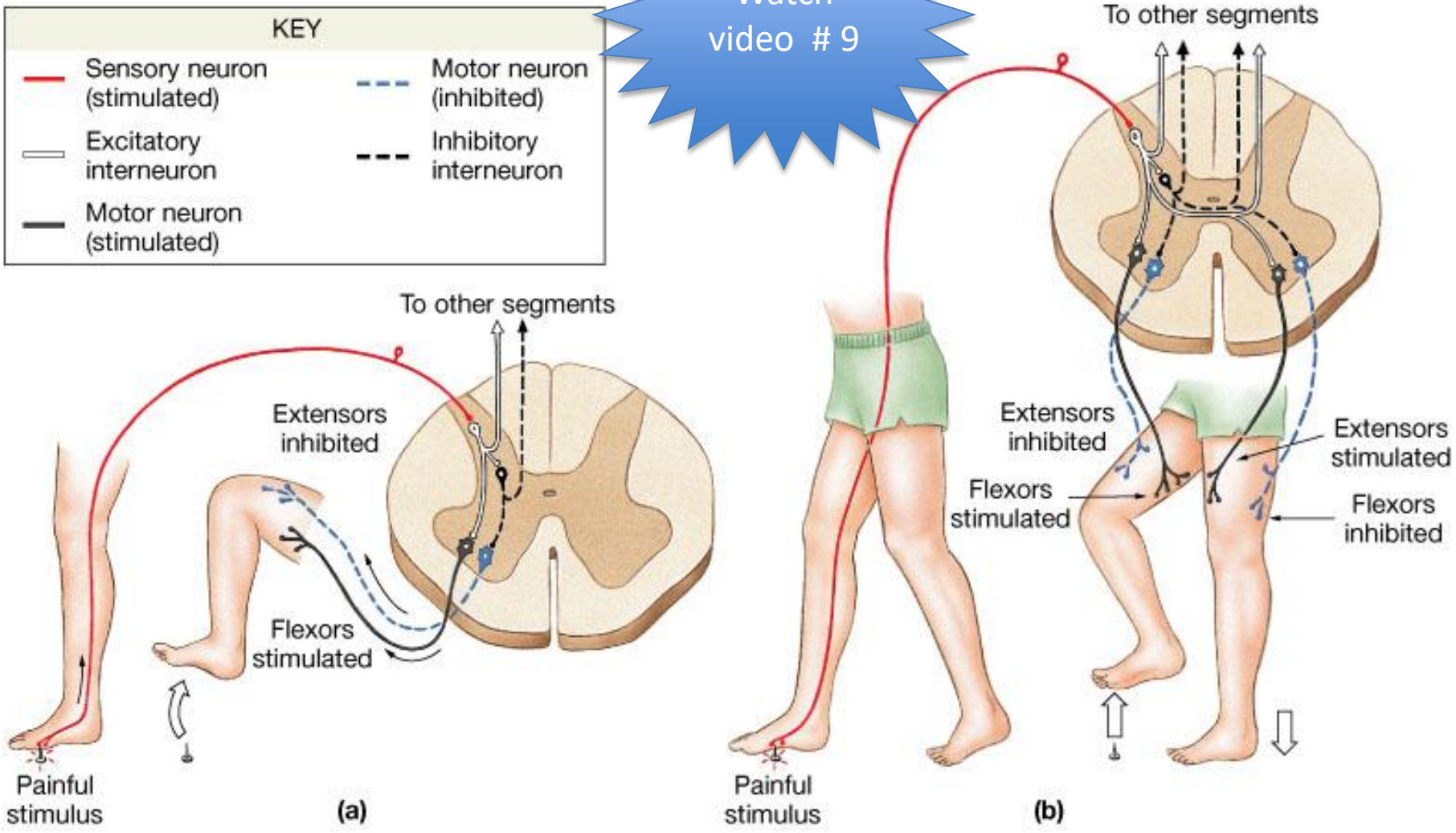


Crossed Extensor Reflex

- Painful stimulus elicits a flexor reflex in affected limb and an extensor reflex in the opposite limb.
- Extensor reflex begins 0.2 - 0.5 seconds after the painful stimulus.
- Serves to push body away from the stimulus, also to shift weight to the opposite limb.

The Flexor Withdrawal/Crossed Extensor Reflexes

Watch video # 9

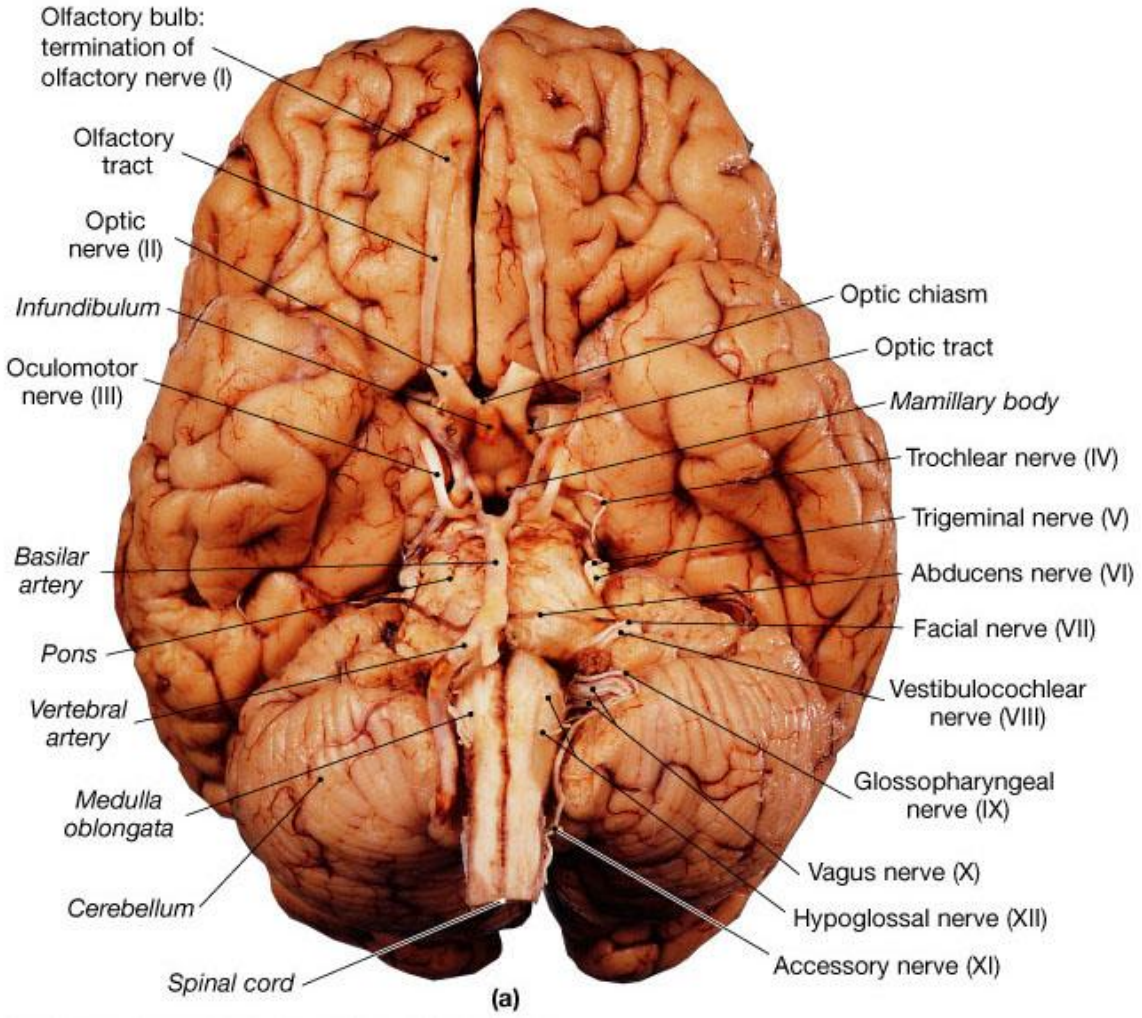


Reflexes that Cause Muscle Spasm

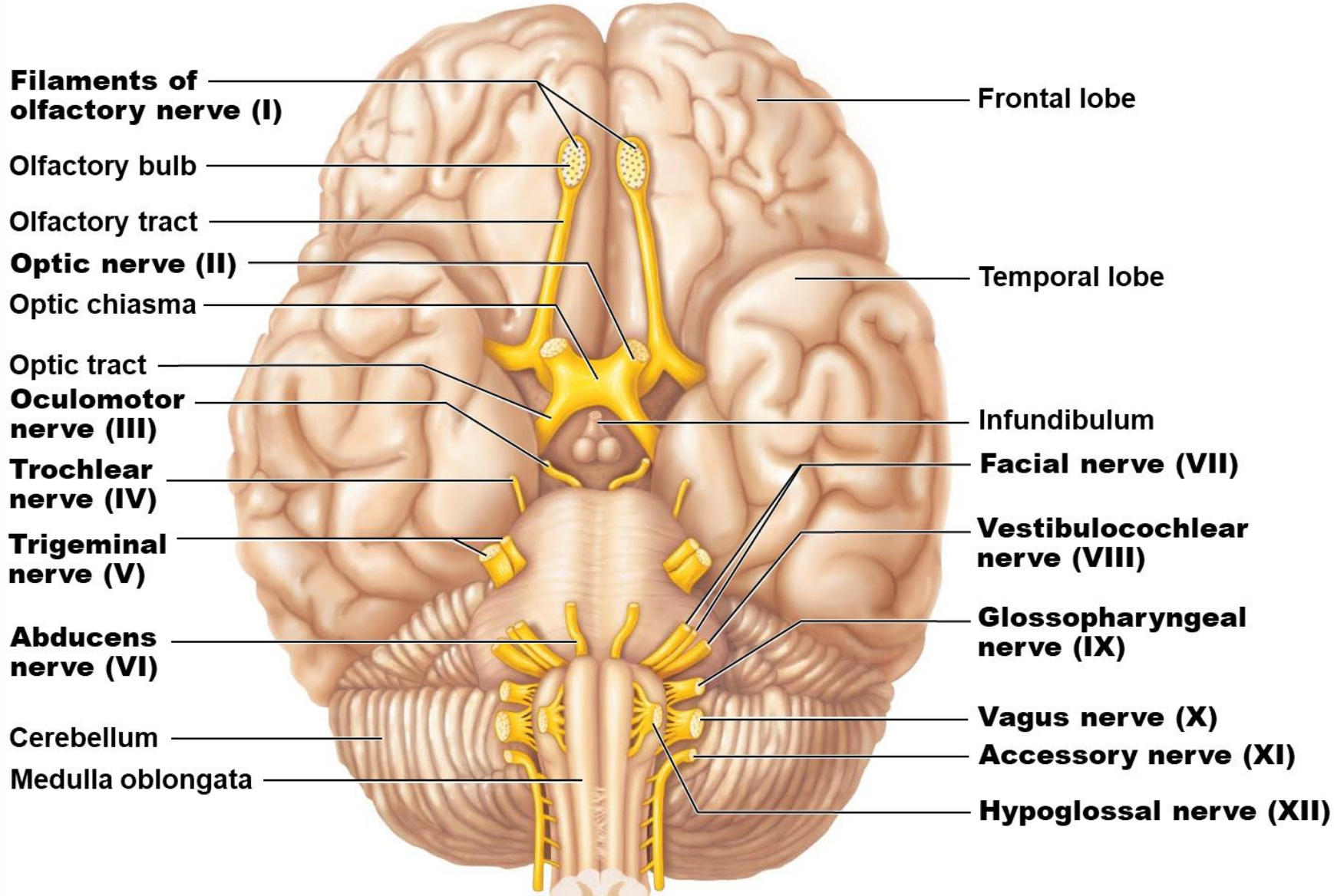
- Pain signals can cause reflex activation and spasm of local muscles.
- Inflammation of peritoneum can cause abdominal muscle spasm.
- Muscle cramps caused by painful stimulus in muscle:
  - can be due to cold, ischemia, of overactivity
  - reflex contraction increases painful stimulus and causes more muscle contraction

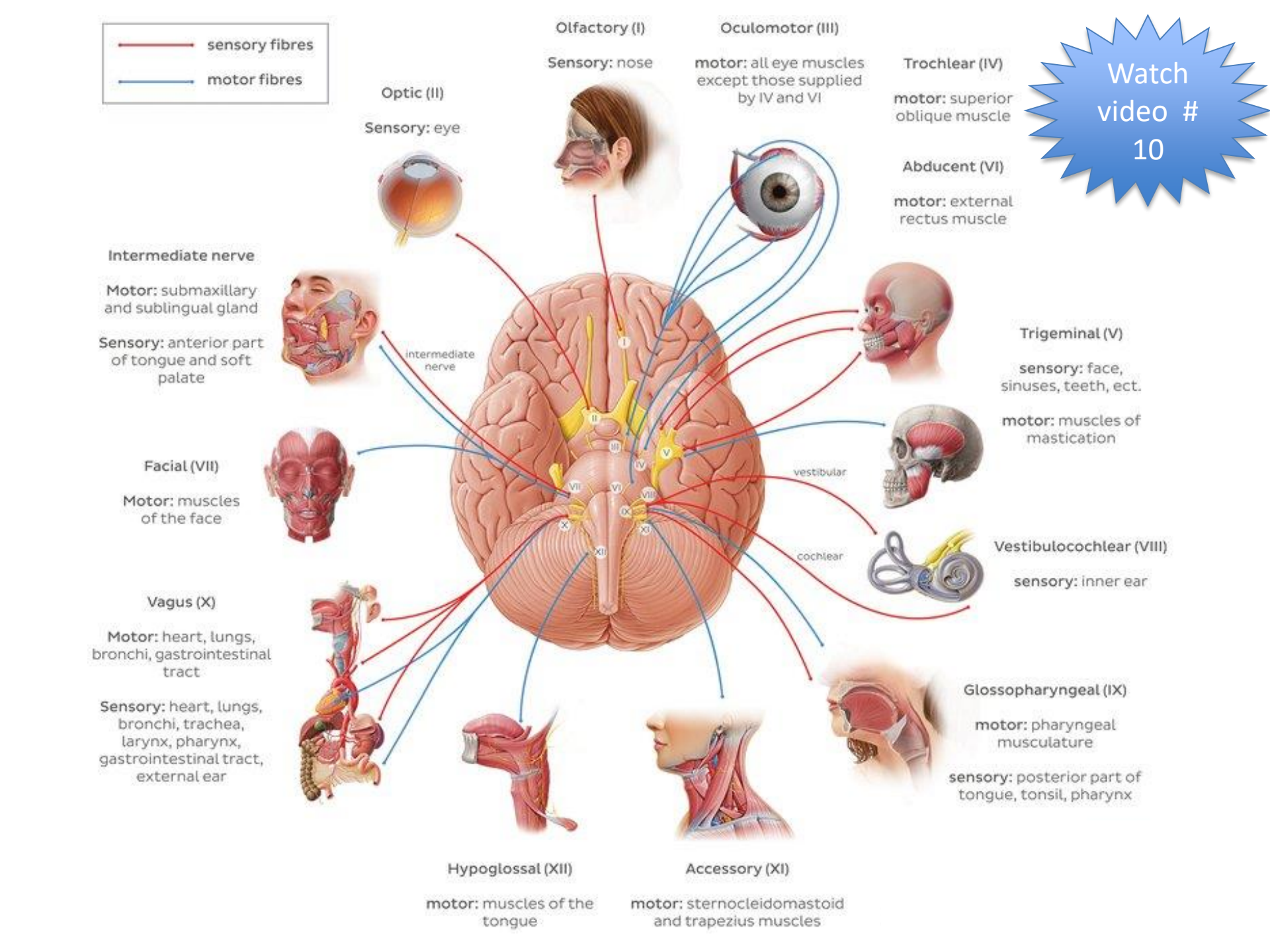
Origins of the Cranial Nerves

The **cranial nerves** are a set of 12 paired **nerves** that arise directly from the brain. The first two **nerves** (olfactory and optic) arise from the cerebrum, whereas the remaining ten emerge from the brain stem.



Origins of the Cranial Nerves




sensory fibres
motor fibres
Olfactory (I)
Sensory: nose
Oculomotor (III)
motor: all eye muscles except those supplied by IV and VI
Trochlear (IV)
motor: superior oblique muscle
Abducent (VI)
motor: external rectus muscle
Optic (II)
Sensory: eye
Intermediate nerve
Motor: submaxillary and sublingual gland
Sensory: anterior part of tongue and soft palate
intermediate nerve
Trigeminal (V)
sensory: face, sinuses, teeth, ect.
motor: muscles of mastication
Facial (VII)
Motor: muscles of the face
vestibular
cochlear
Vestibulocochlear (VIII)
sensory: inner ear
Vagus (X)
Motor: heart, lungs, bronchi, gastrointestinal tract
Sensory: heart, lungs, bronchi, trachea, larynx, pharynx, gastrointestinal tract, external ear
Glossopharyngeal (IX)
motor: pharyngeal musculature
sensory: posterior part of tongue, tonsil, pharynx
Hypoglossal (XII)
motor: muscles of the tongue
Accessory (XI)
motor: sternocleidomastoid and trapezius muscles
Watch video # 10