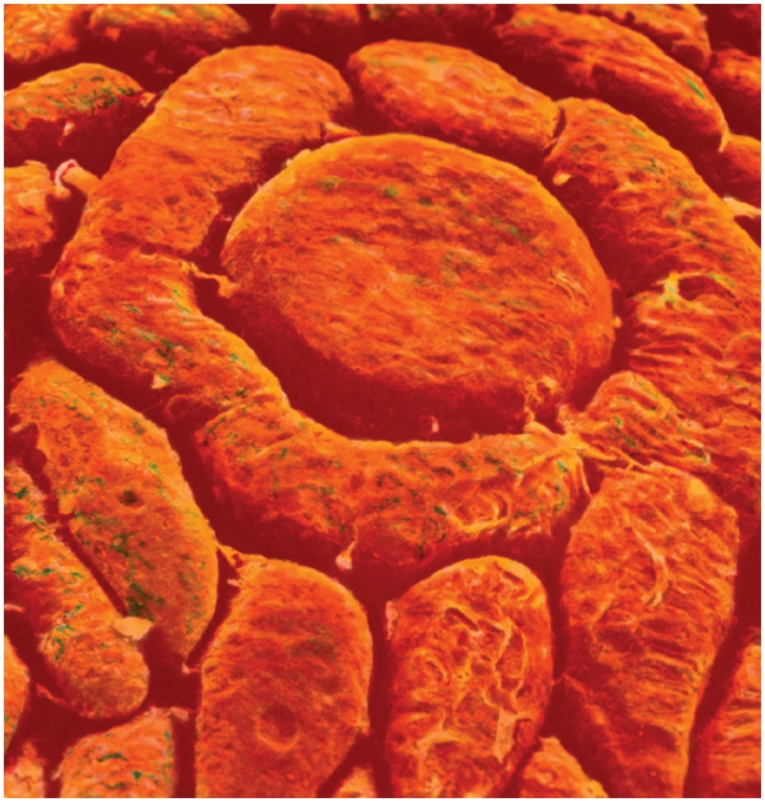
Chapter 16

Introduction to Sensory, Motor, and Integrative Systems



General Properties of Receptors

- **transduction** – the conversion of one form of energy to another
  - fundamental purpose of any sensory receptor
  - conversion of stimulus energy (light, heat, touch, sound, etc.) into nerve signals
  - sense organ, gasoline engine, light bulb are all transducers
- **sensation** // a subjective awareness of the stimulus
  - some do not require conscious awareness like pH and body temperature
  - most sensory signals delivered to the CNS produce no conscious sensation // filtered out in the brainstem

Definitions

- **sensory input** // a stimulus - vital to the integrity of personality and intellectual function

- **sensory receptor** // a structure of a neuron that is specialized to detect a stimulus // commonly a "dendrite"

- **sense organs** – tissues that surround dendrites and enhance the response of dendrites to certain type of stimulus

  – tissue added can be epithelium, muscle or connective tissue

Type of Receptors & Stimuli

- **Mechanoreceptors**
- **Thermoreceptors**
- **Nociceptors (pain)**
- **Photoreceptors**
- **Chemoreceptors**
- **Osmoreceptors**

General Senses vs Special Senses

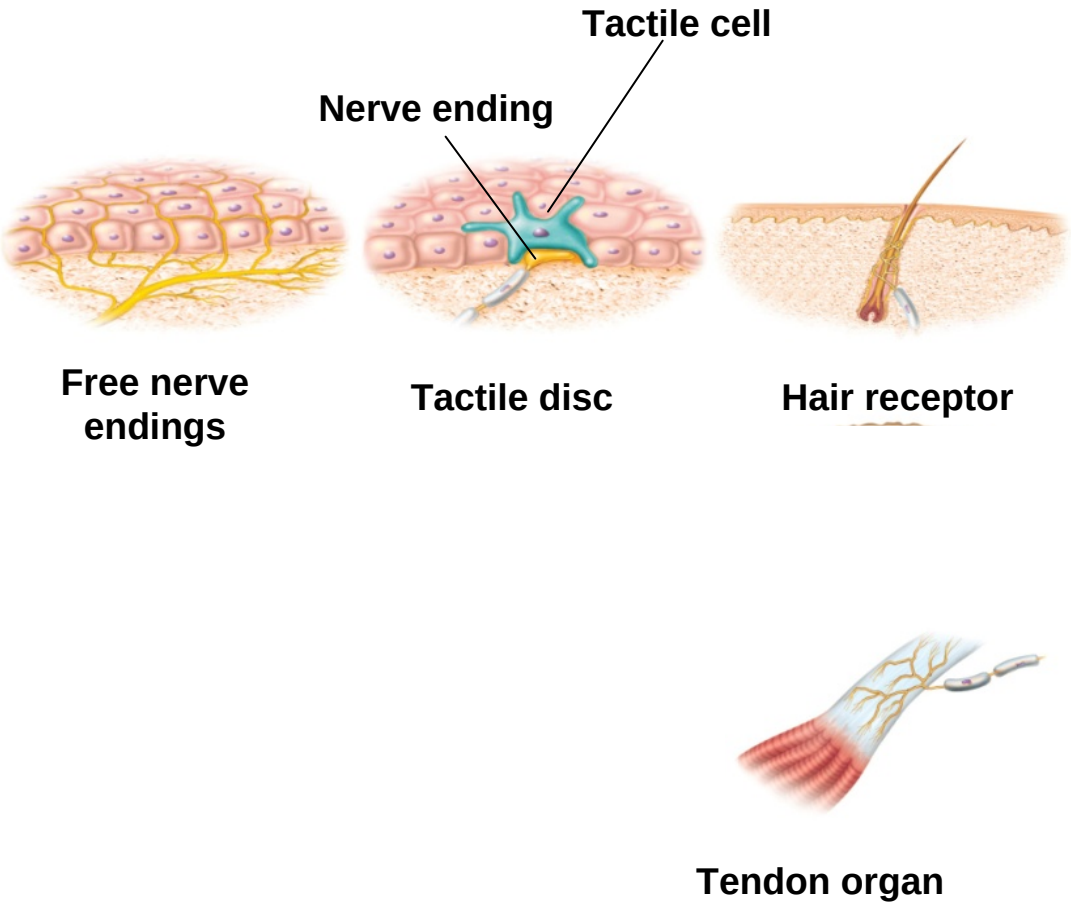
- GS = structurally simple receptors // one or a few sensory fibers // no or little additional tissue surrounding the dendrite

- SS = complex structures / localized in head / sight, hearing, vision, taste, smell // additional tissue surrounding the dendrites

General Senses

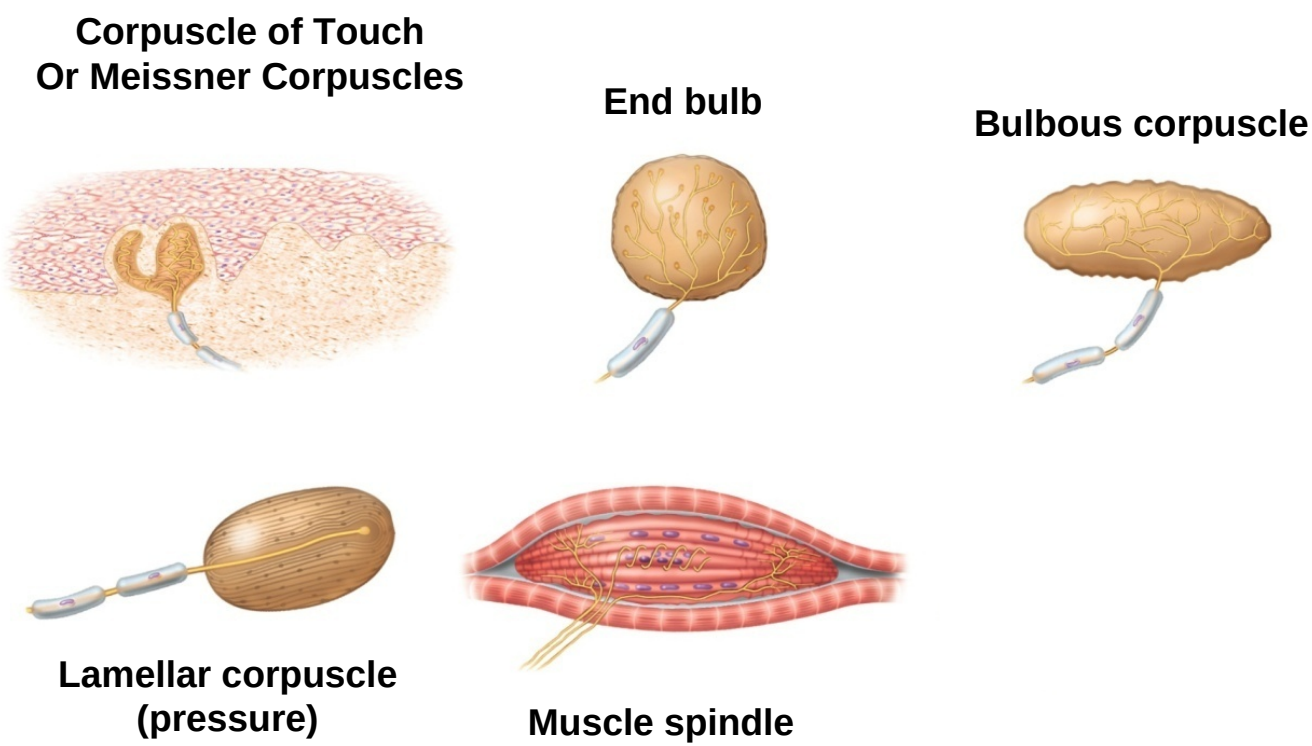
- GS - structurally simple receptors
  - **unencapsulated nerve endings**
    - free nerve endings
    - E.g. tactile (Merkel) discs & hair receptors (peritrichial endings)
  - **encapsulated nerve endings**
    - Krause end bulbs
    - bulbous (Ruffini) corpuscles
    - lamellar (pacinian) corpuscles
    - <u>muscle spindles</u>

Unencapsulated Nerve Endings



- **dendrites not wrapped in connective tissue**
- **free nerve endings** ***//*** for pain and temperature
  - skin and mucous membrane
- **tactile discs** ***//*** for light touch and texture
  - associated with Merkel cells at base of epidermis
- **hair receptors** ***//*** wrap around base hair follicle
  - monitor movement of hair

Encapsulated Nerve Endings



- dendrites wrapped by glial cells or connective tissue
- connective tissue enhances sensitivity or selectivity of response

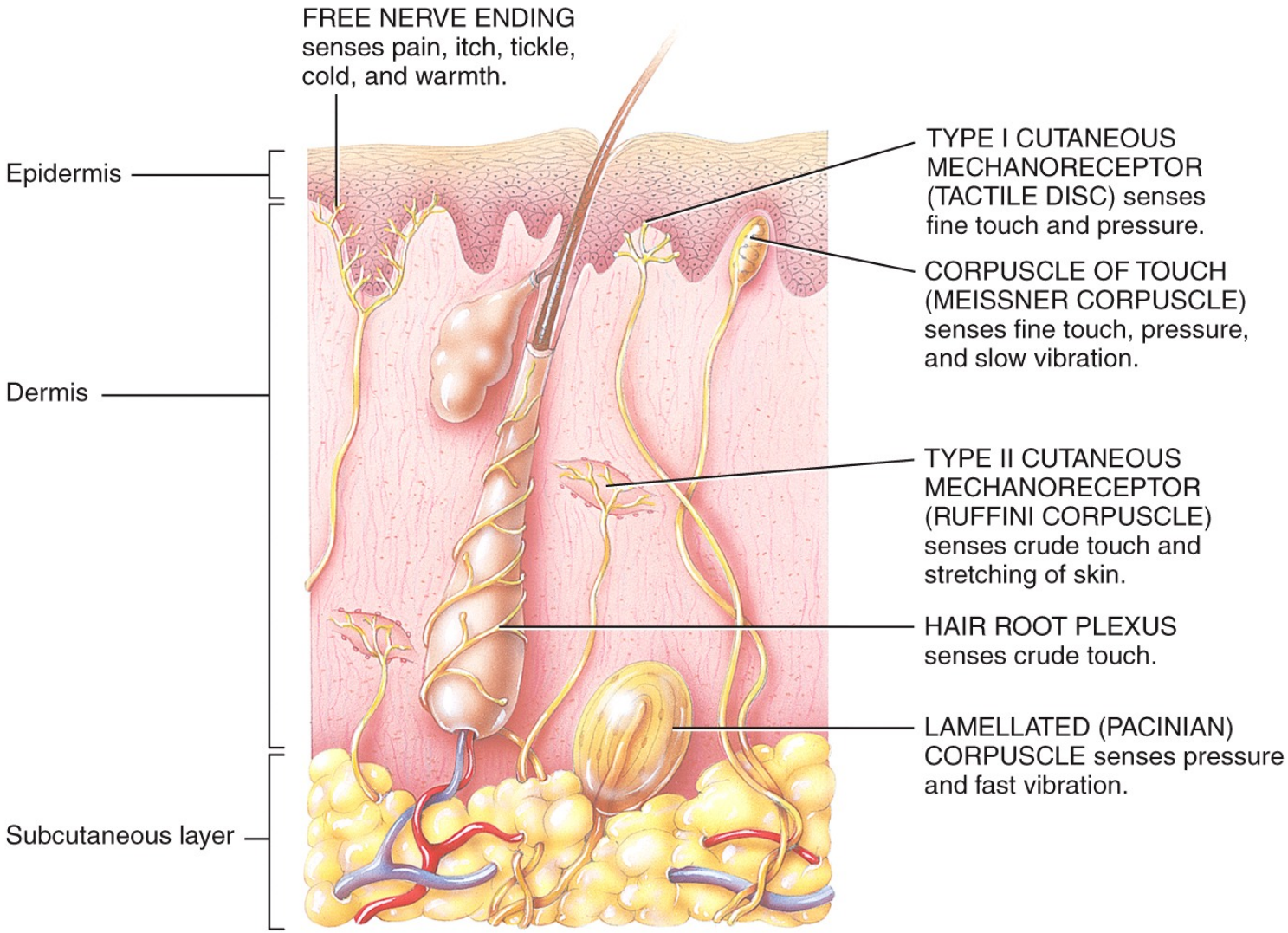
Encapsulated Nerve Endings

- **Krause end bulb** ***//*** tactile; in mucous membranes

- **Lamellated (Pacinian) corpuscles** – phasic
  - deep pressure, stretch, tickle and vibration
  - periosteum of bone, and deep dermis of skin

- **Bulbous (Ruffini) corpuscles** – tonic
  - heavy touch, pressure, joint movements and skin stretching

Positioning of Different Types of Sensory Receptors

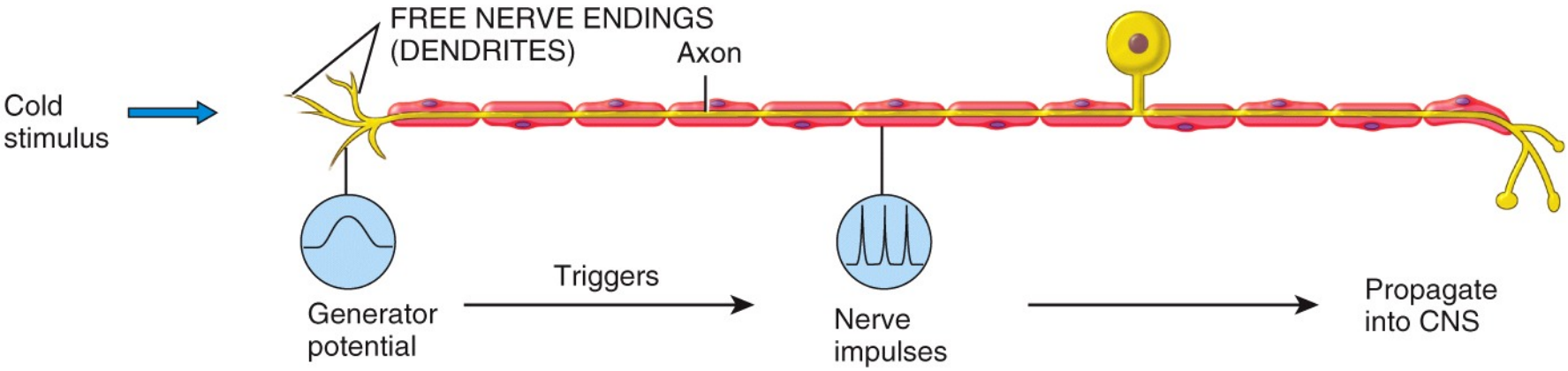


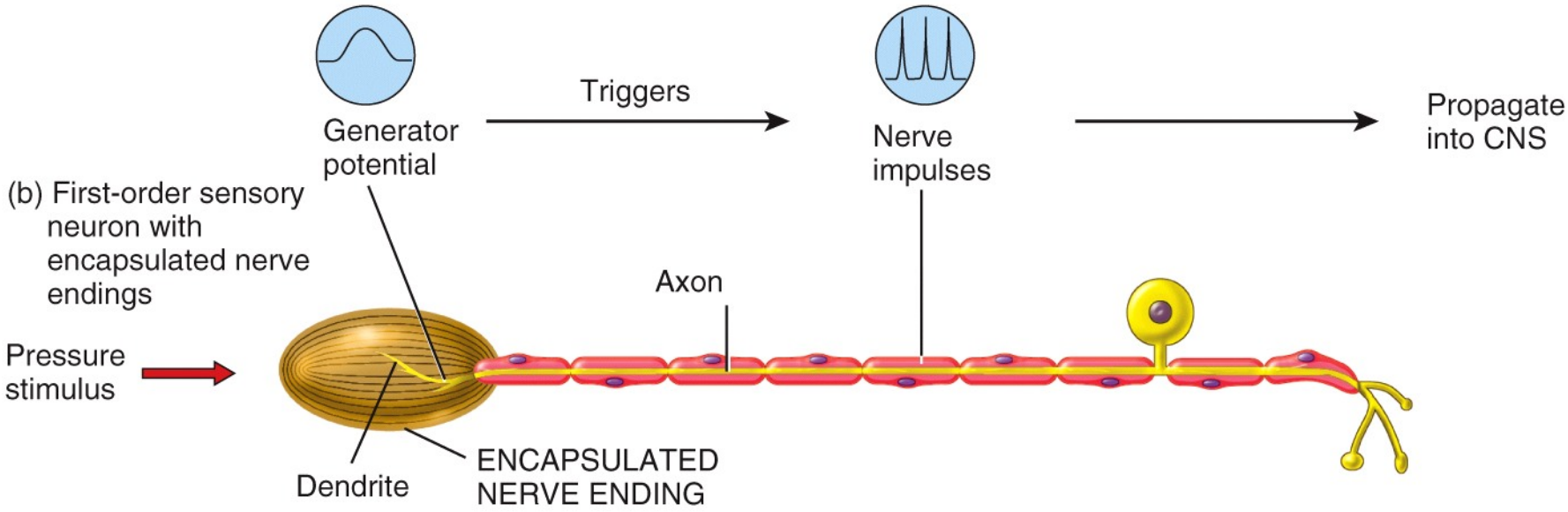
Generator VS Receptor Potentials

Two Kinds of Graded Potentials // These Determine "IF" Action Potential Occur

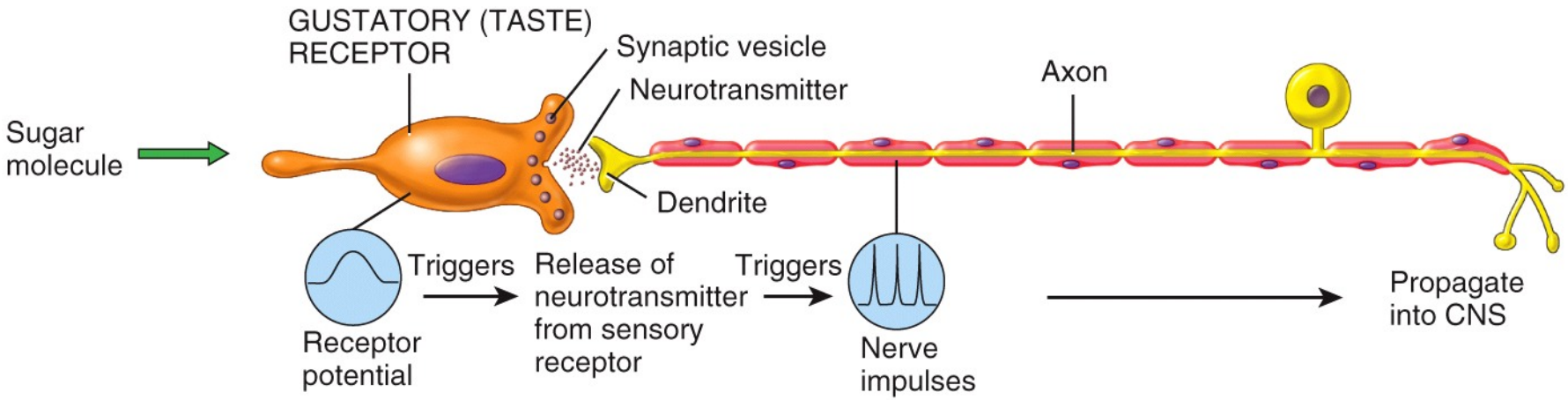
- **Generator Potentials**
  - **Receptors are dendrites of free nerve endings, encapsulated nerve endings, receptive part of olfactory receptors**
  - **Stimulus open ion channels // graded potential**
  - **Stimulus great enough triggers action potential in sensory first order neuron**
  - **GP generate action potentials**
- **Receptor Potentials**
  - **Receptors are separate cells**
  - **Receptor potentials trigger release of neurotransmitter into synaptic cleft // receptor on post synaptic membrane of dedrite**
  - **If stimulus great enough then EPSP generate AP in first order neuron**

(a) First-order sensory neuron with free nerve endings




Generator potential
Triggers
Nerve impulses
Propagate into CNS
(b) First-order sensory neuron with encapsulated nerve endings
Axon
Pressure stimulus
Dendrite
ENCAPSULATED NERVE ENDING

(c) Sensory receptor synapses with first-order sensory neuron



Types of Somatic Sensations // Tactile Sensations

Free nerve endings or encapsulated receptors

Include touch, pressure, vibration, itch, tickle

Tickle is an intriguing sensation

* only occurs when someone else touches you
* you can not tickle yourself
- tickle cancelled by signal sent to cerebellum by your finger

Types of Somatic Sensations // Thermal Sensations

Free nerve endings

Cold receptors // located in basal stratum // stimulated between 10 and 40 degree C (50 – 105 F)

Warm receptors // located in dermis // not as abundant as cold receptors // stimulated between 30 and 48 degree C (90 – 118 F)

Temperature below 30 and above 118 primarily stimulate pain receptors

Types of Somatic Sensations // Pain Sensations

Indispensable for survival // protect by signaling noxious, tissue-damaging conditions

Nociceptors = pain receptors // free nerve endings // Located in all tissue except brain // little adaptation / pain persist

Activated by prostaglandins, kinins (e.g. bradykinin), potassium ions, ATP // also stretch, prolonged muscle contractions & ischemia

Superficial somatic pain = skeletal muscles, joints, tendons

Deep somatic pain = fascia

Visceral pain = visceral organs

Types of Somatic Sensations // Proprioceptive

Project information about position of body and tension/length of muscle // also within inner ear to provide sensory pathway for equilibrium

Located in muscles, tendons, joints, and inner ear

Proprioceptors do not adapt (they are tonic)

Proprioceptors also provide pathway for weight discrimination // how we tell how much something weighs

Three type of proprioceptors: muscle spindles / Golgi tendon organs / synovial joint kinesthetic receptors

Three General Pathways of Somatic Sensory

Posterior column pathway // medial lemmiscus pathway // cuneate (upper limbs) and gracilus (lower limbs) fasciculus tracts // sensation of touch, pressure, vibration, visceral pain, and conscious proprioception

Anterolateral pathway // spinothalamic tract // sensations of pain, temperature, itch and tickle // limbs, truck, neck, posterior head

Trigemiothalamic pathway // first order neuron from face, nasal cavity, oral cavity and teeth enter cranium via CN-5 (thrgeminal) // sensations - tactile, thermal and pain

Somesthetic (Somatic Sensory) Projection Pathways

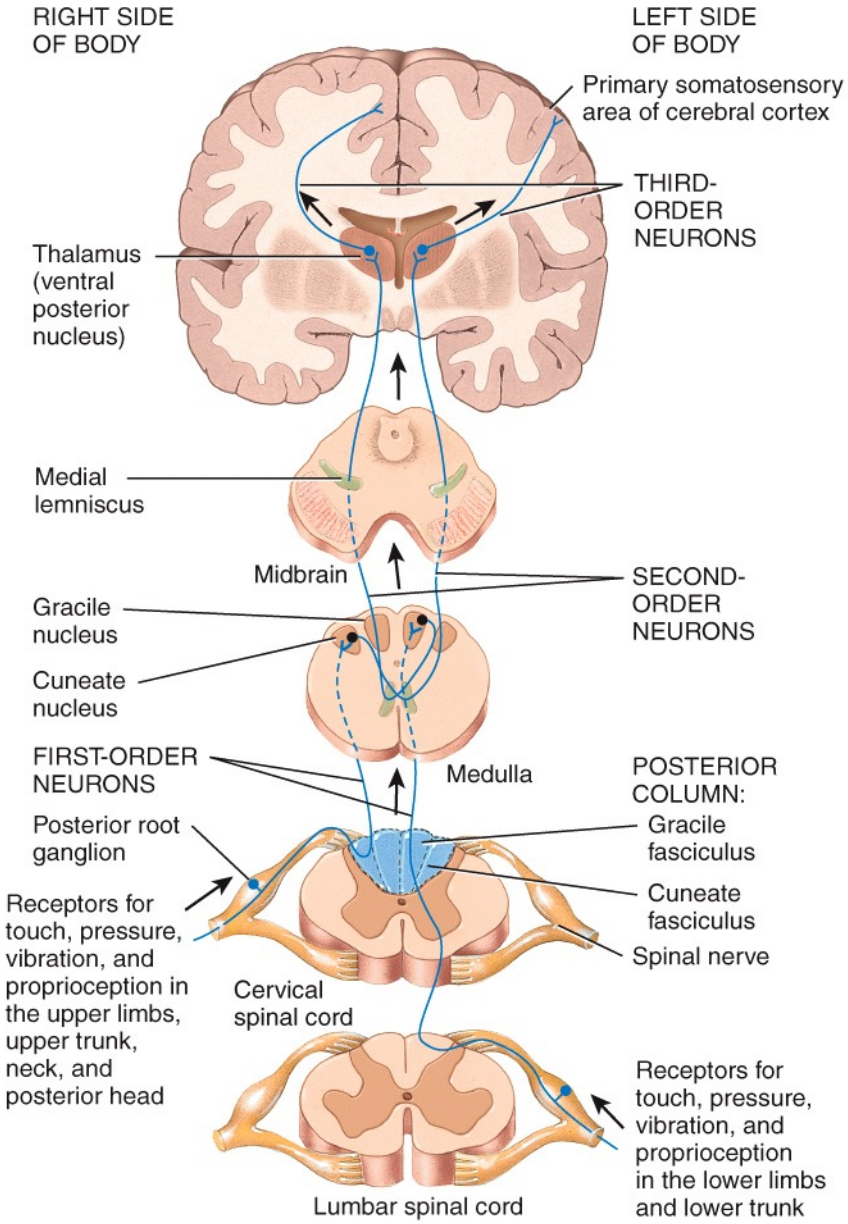
- Pathway from receptor to final destination in the brain // post central gyrus // most somesthetic signals travel by way of **three neurons**

- **1st order neuron** (afferent neuron)
  - from body, enter the dorsal horn of spinal cord via spinal nerves
  - from head, enter pons and medulla via cranial nerve
  - touch, pressure and proprioception on large, fast, myelinated axons
  - heat and cold on small, unmyelinated, slow fibers

- **2nd order neuron**
  - decussation to opposite side in spinal cord, medulla, or pons
  - end in **thalamus**
  - except for *proprioception, which ends in cerebellum*

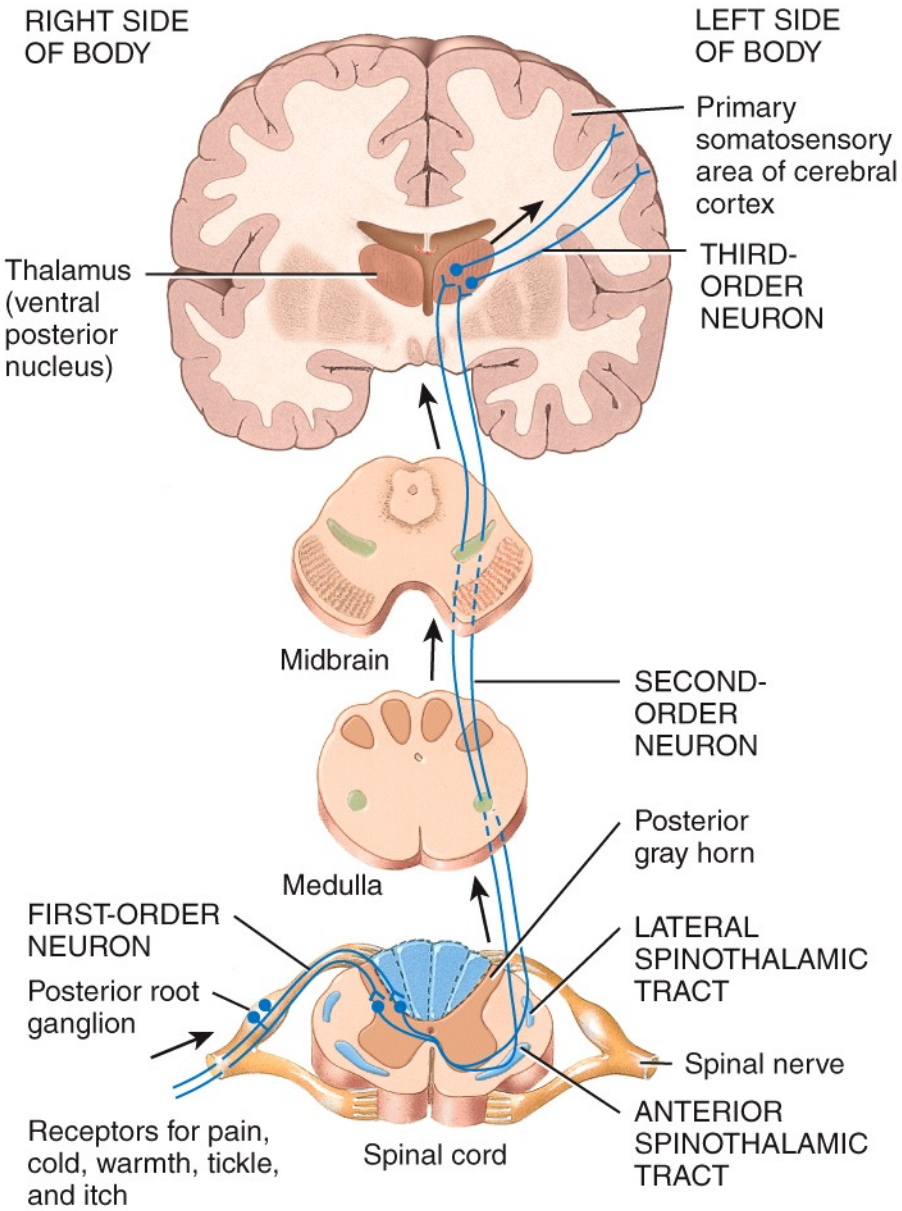
- **3rd order neuron**
  - thalamus to primary somesthetic cortex of cerebrum

Posterior Column Pathway



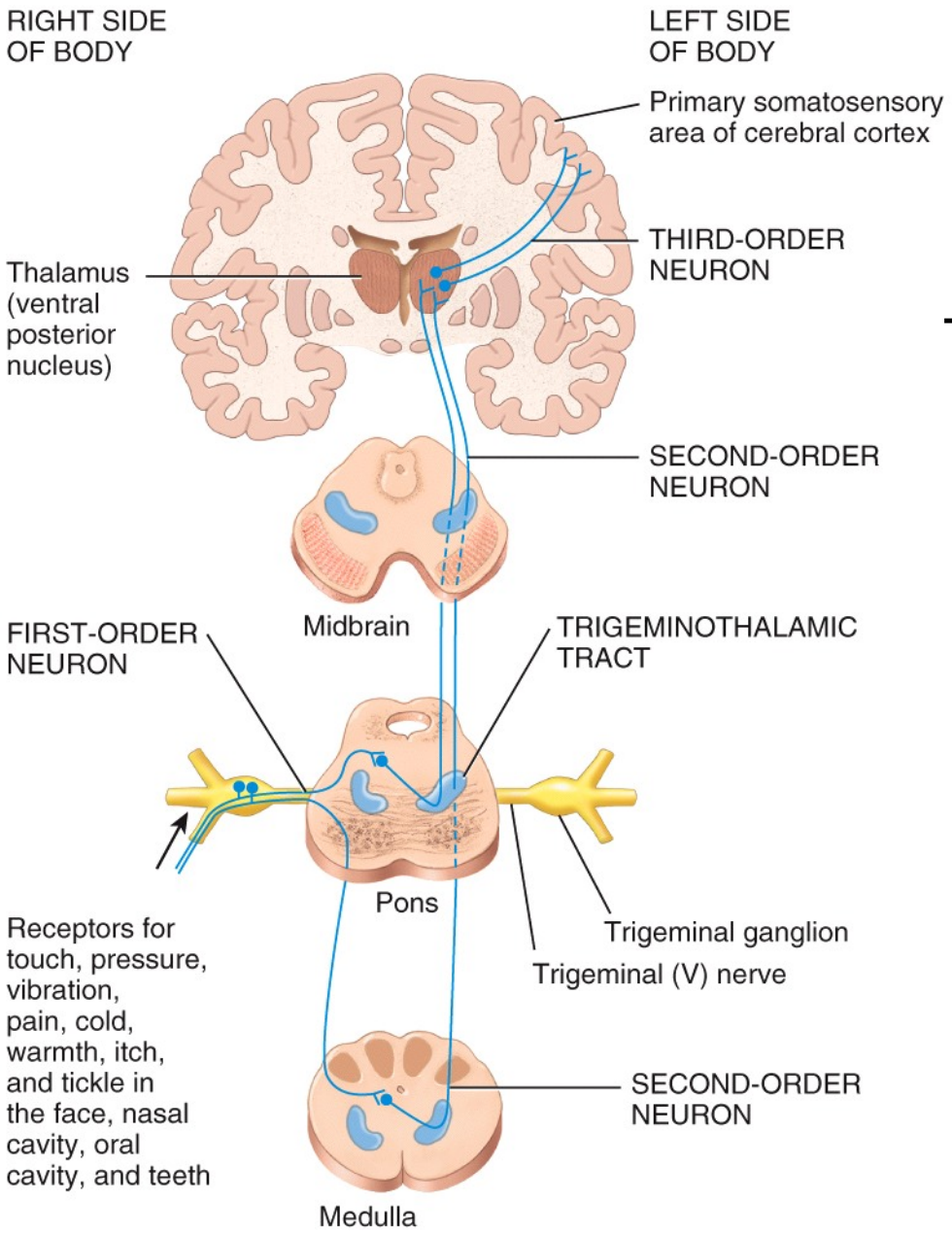
Posterior column–medial lemniscus pathway

Spinothalamic Pathway

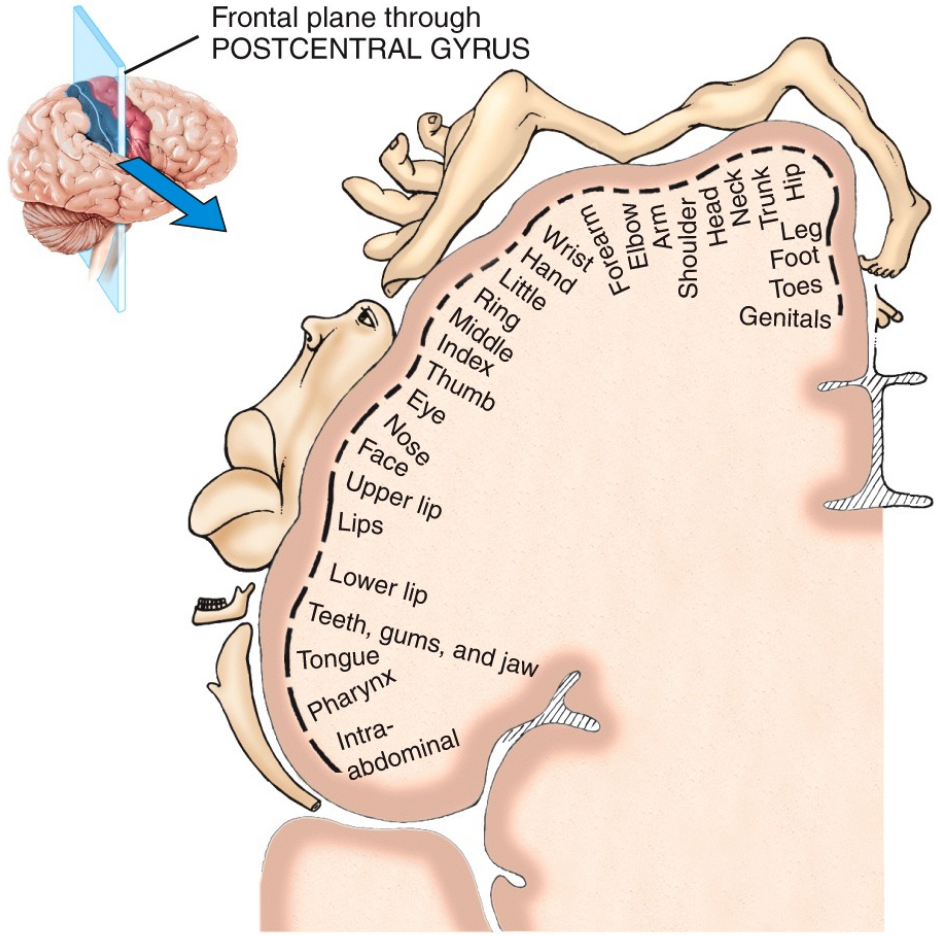


Anterolateral (spinothalamic) pathways

Trigeminothalamic Pathway



Postcentral Gyrus = Somatic Sensory Gyrus



(a) Frontal section of primary somatosensory area in right cerebral hemisphere

Illustrates Somatotopy

Motor Control

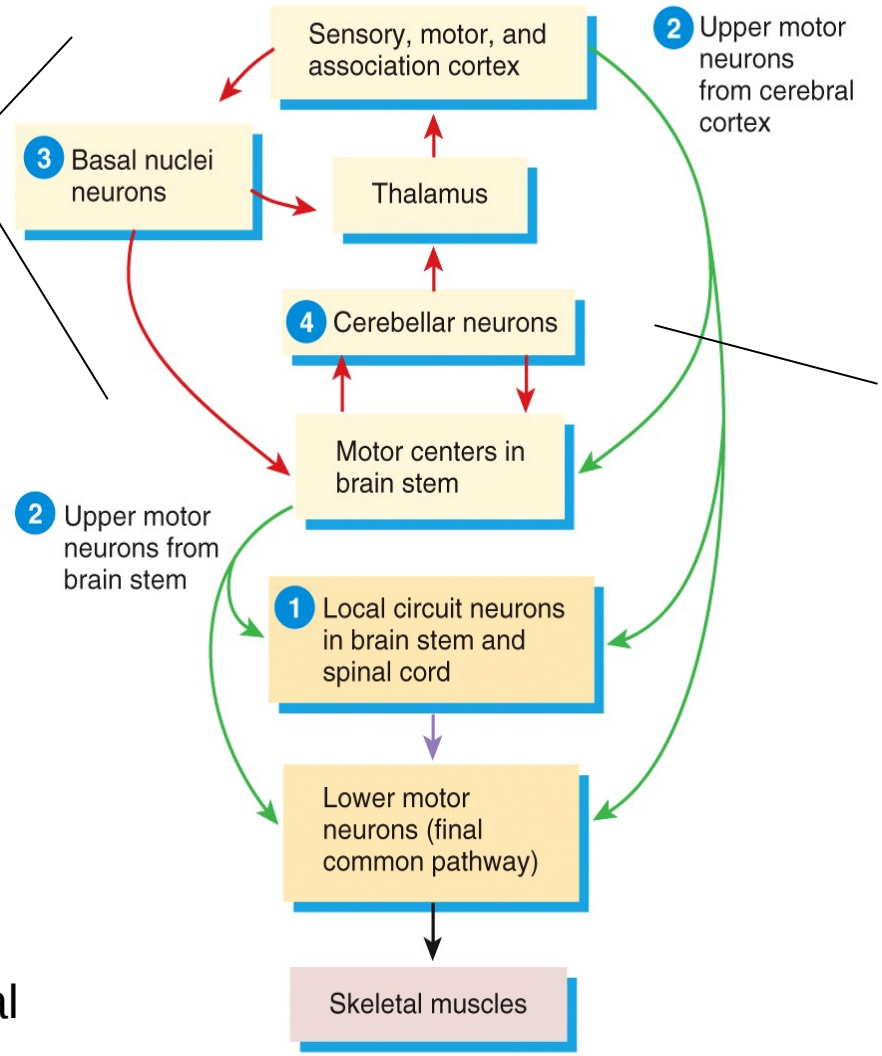
(How we regulate our skeletal muscles)

Feedback loop

Direct Pathway

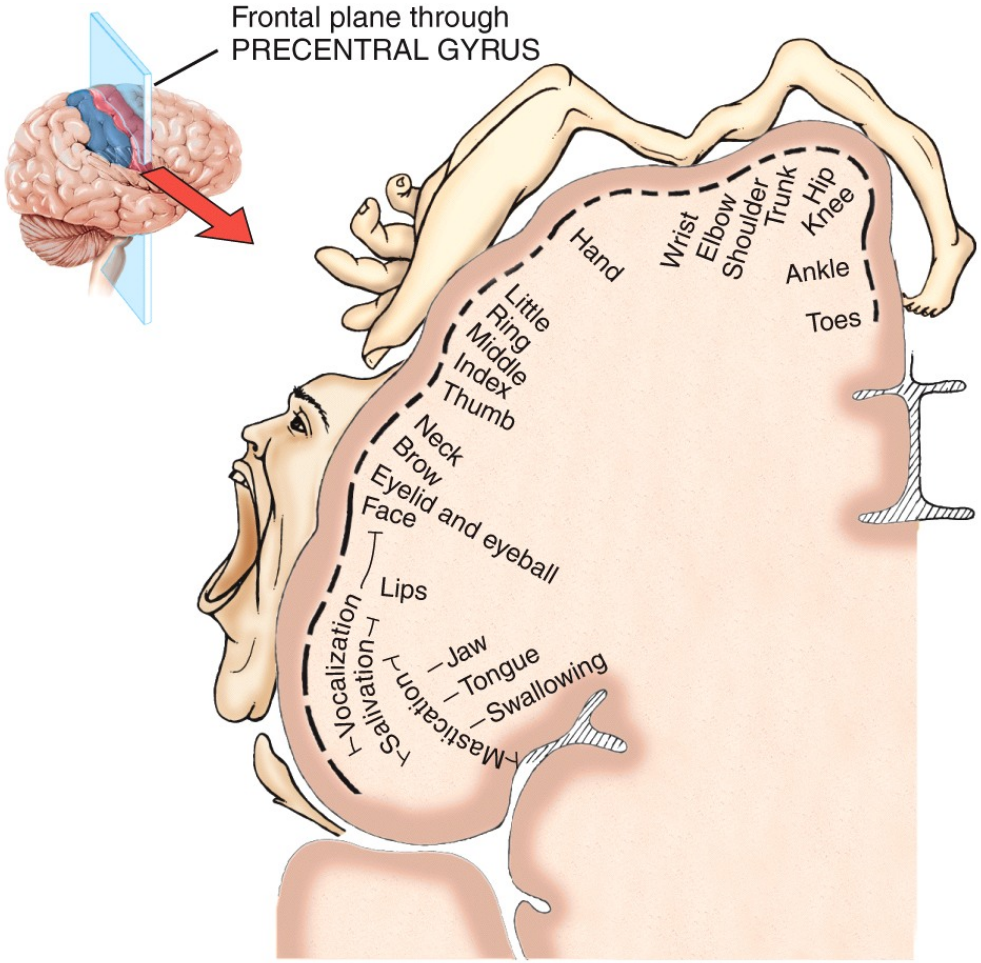
Compares Intent to performance

Indirect Pathway



Note: motor programs are stored in motor association area, basal nuclei, cerebellum

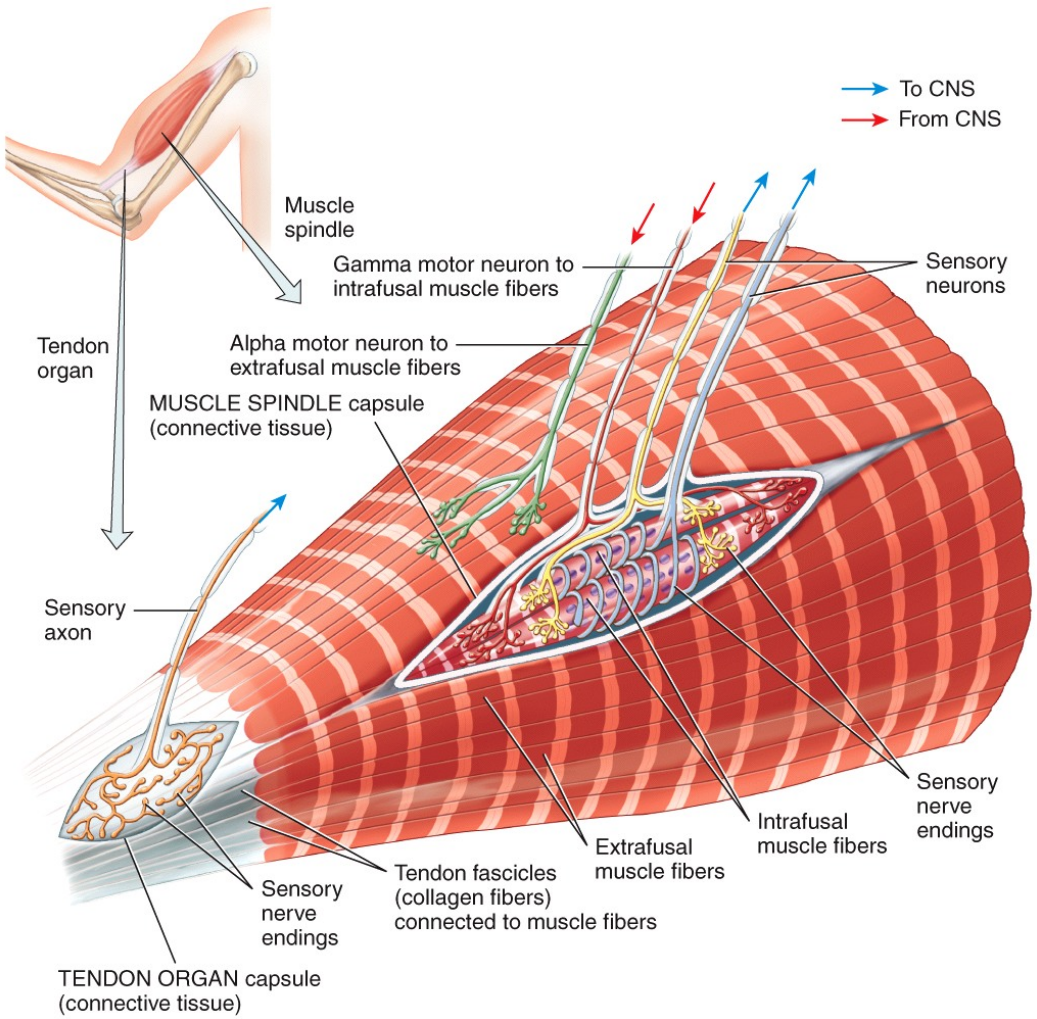
Precentral Gyrus = Motor Sensory Gyrus



(b) Frontal section of primary motor area in right cerebral hemisphere

Illustrates Somatotopy

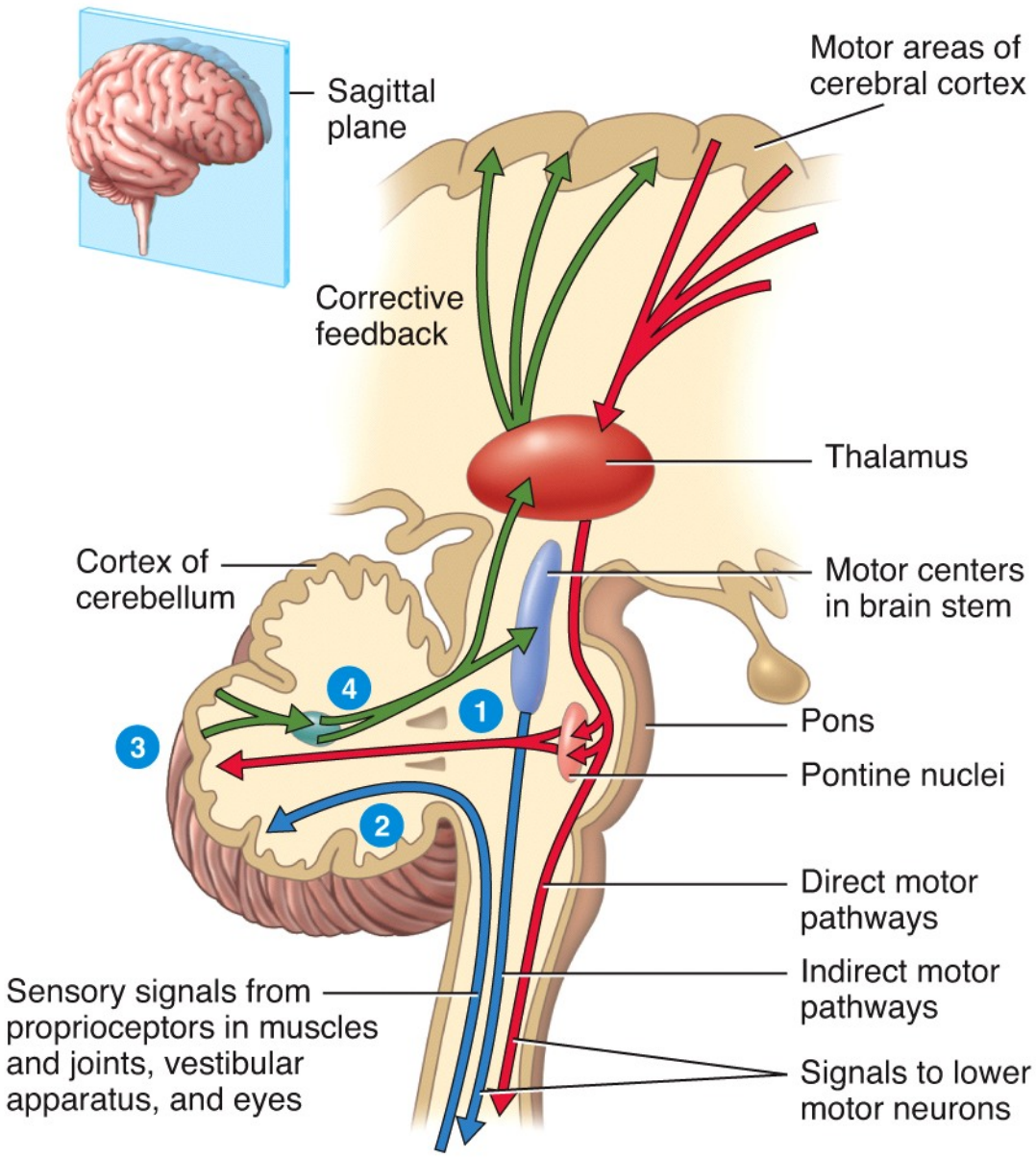
Muscle Spindle Structure & Function



Sensor which sends signal to spinal cord which results in a spinal cord reflex

Adjust tension within groups of muscles as muscles are stretched // requires feedback integration within the brain

Muscle spindles are proprioceptors

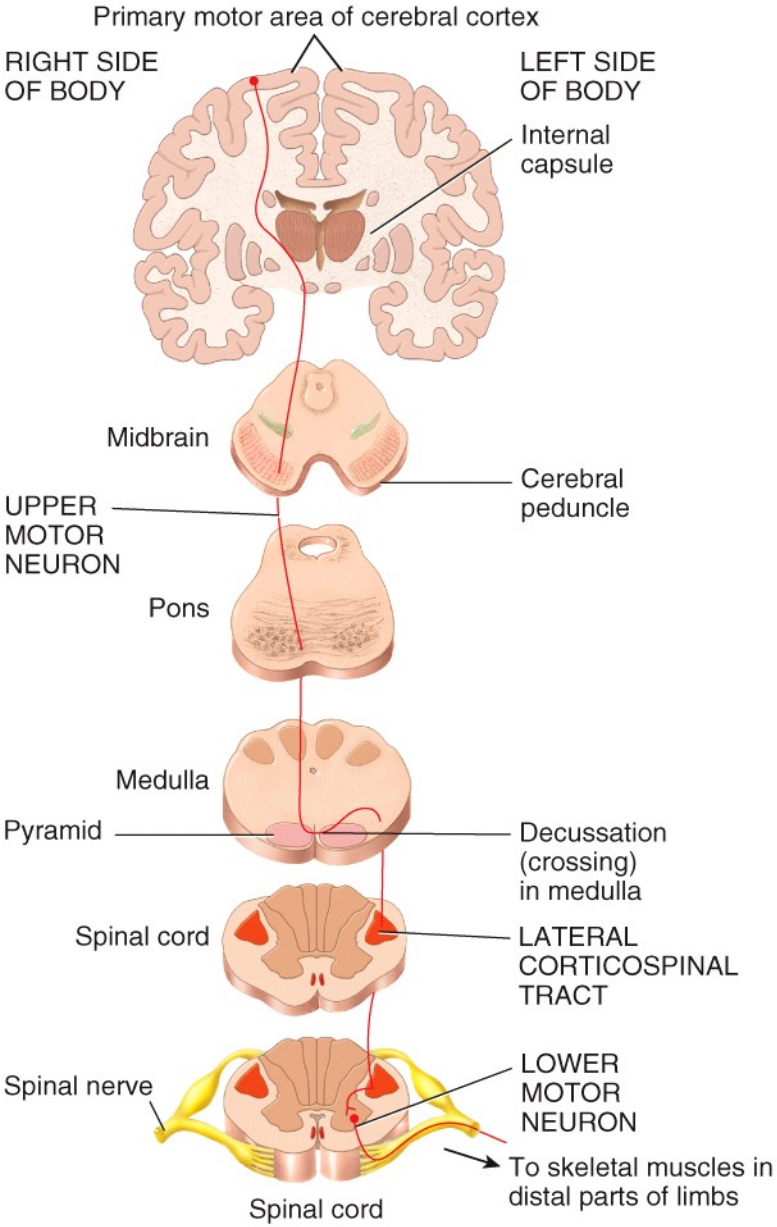


Sagittal section through brain and spinal cord

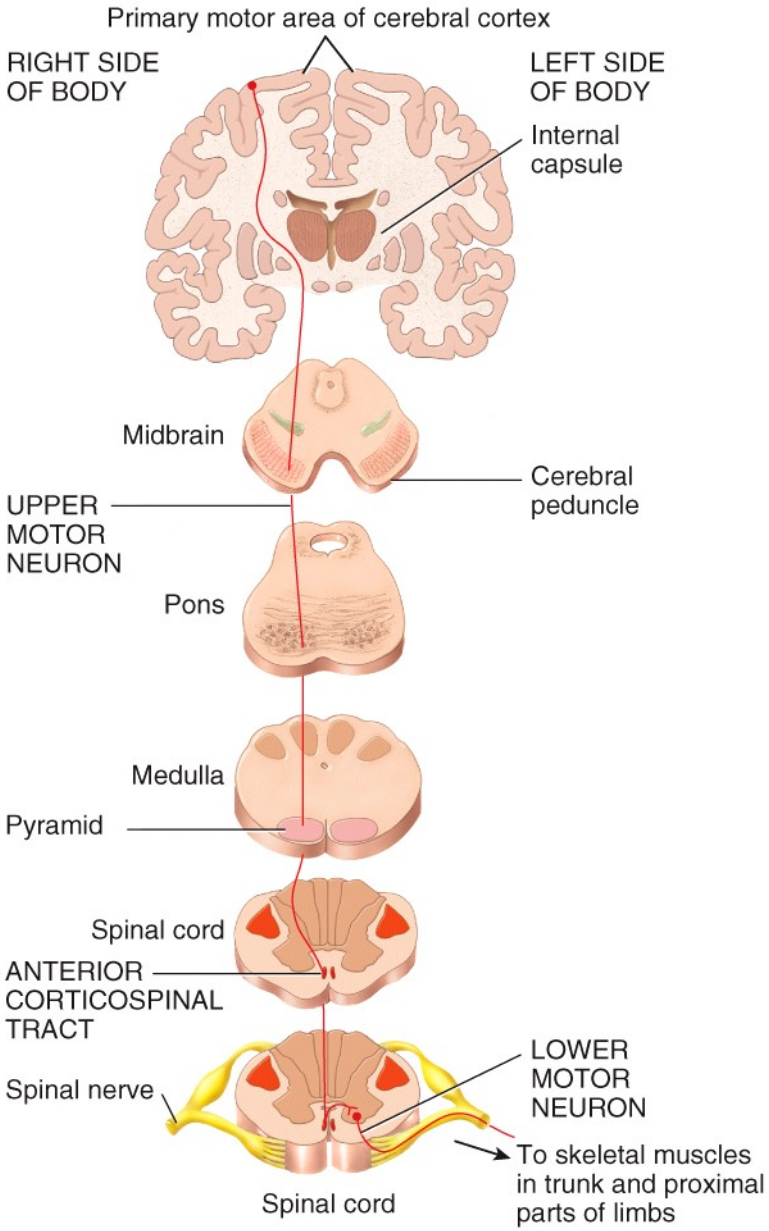
Illustrates how cerebellum's integrates information from different parts of the CNS to regulate Motor Control

Not shown is basal nuclei which also plays role in feedback mechanism which helps to regulate Motor Control

Lateral Corticospinal Pathway

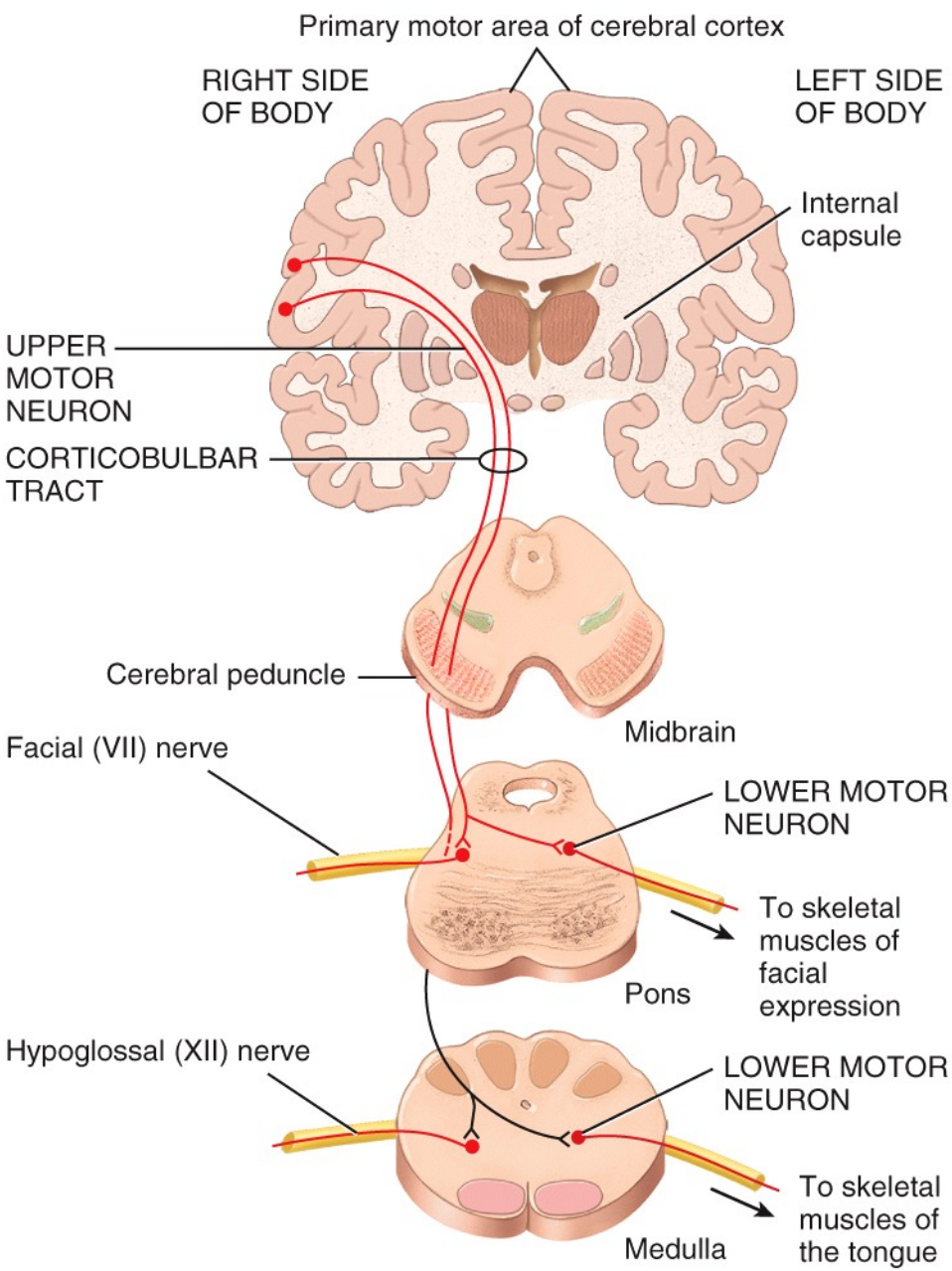


(a) The lateral corticospinal pathway



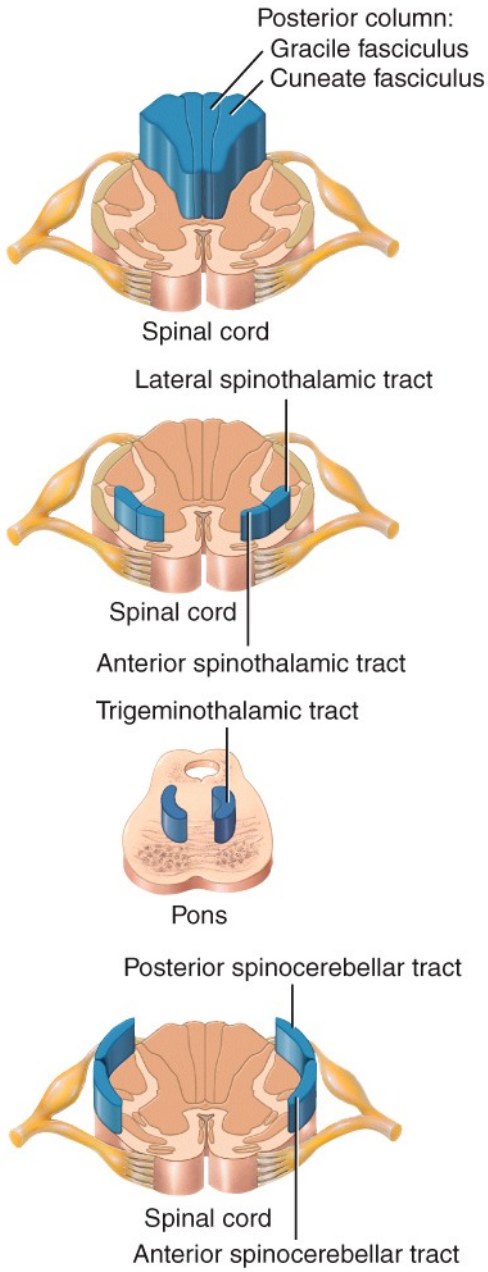
(b) The anterior corticospinal pathway

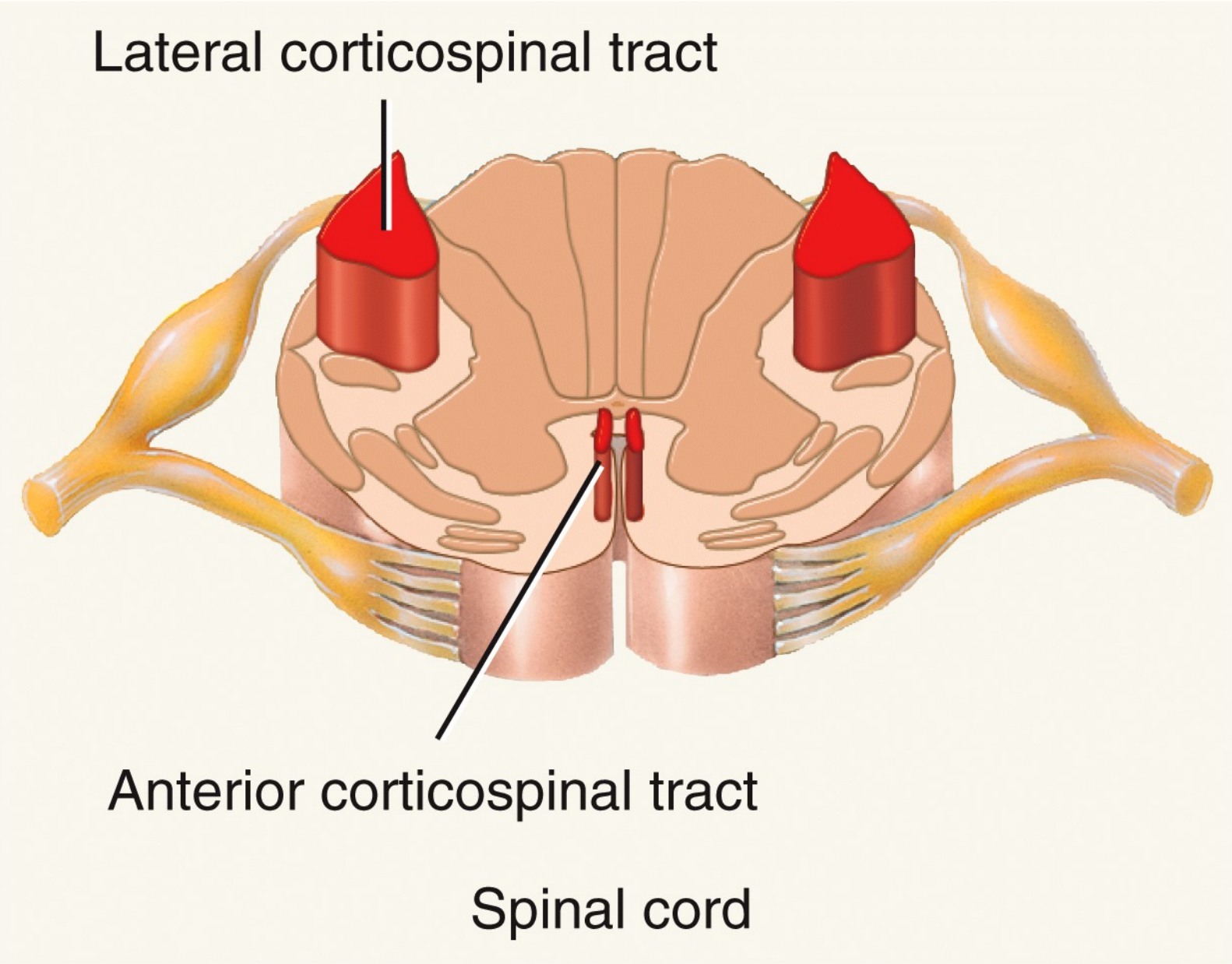
Anterior Corticospinal Pathway

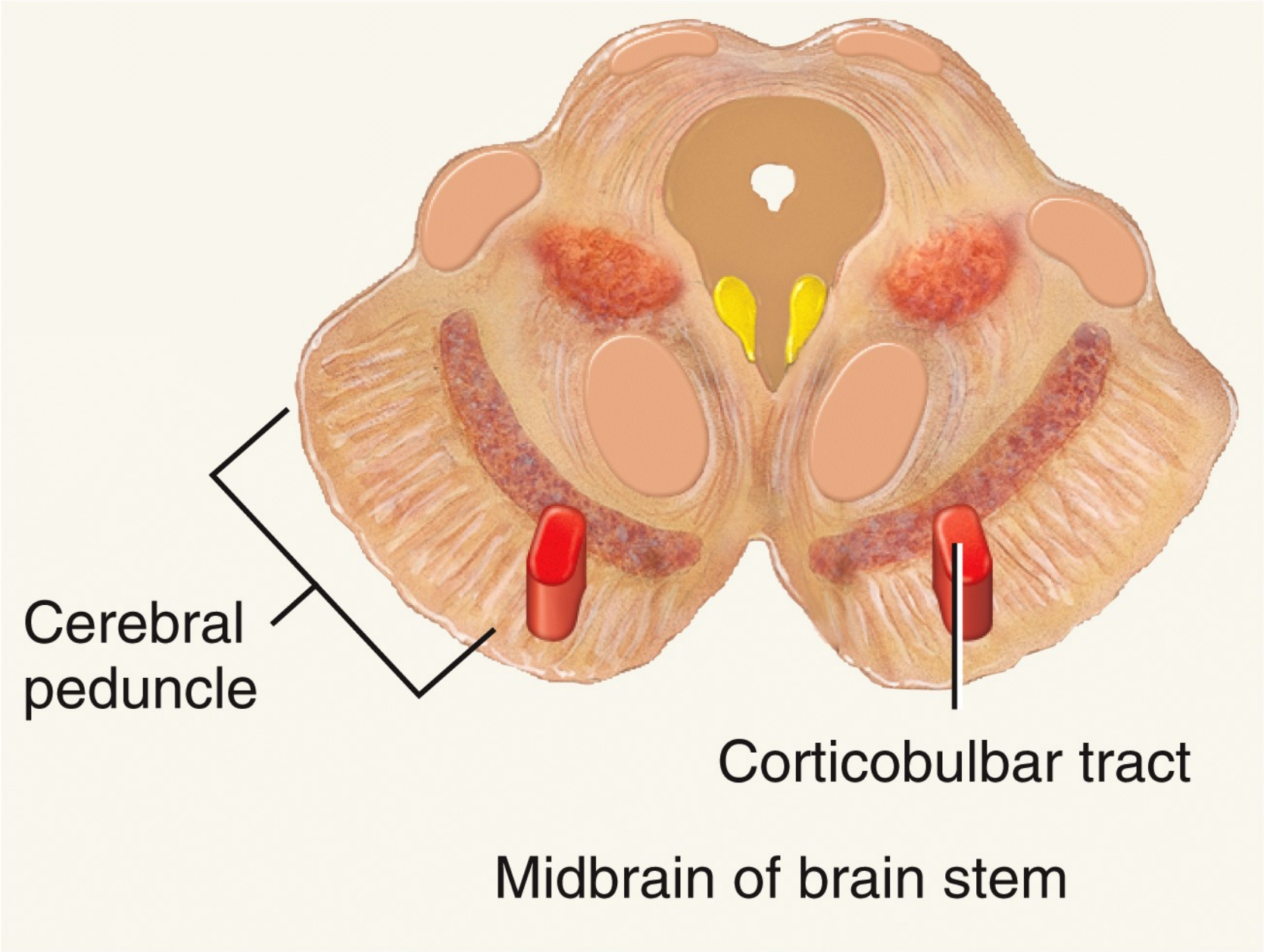


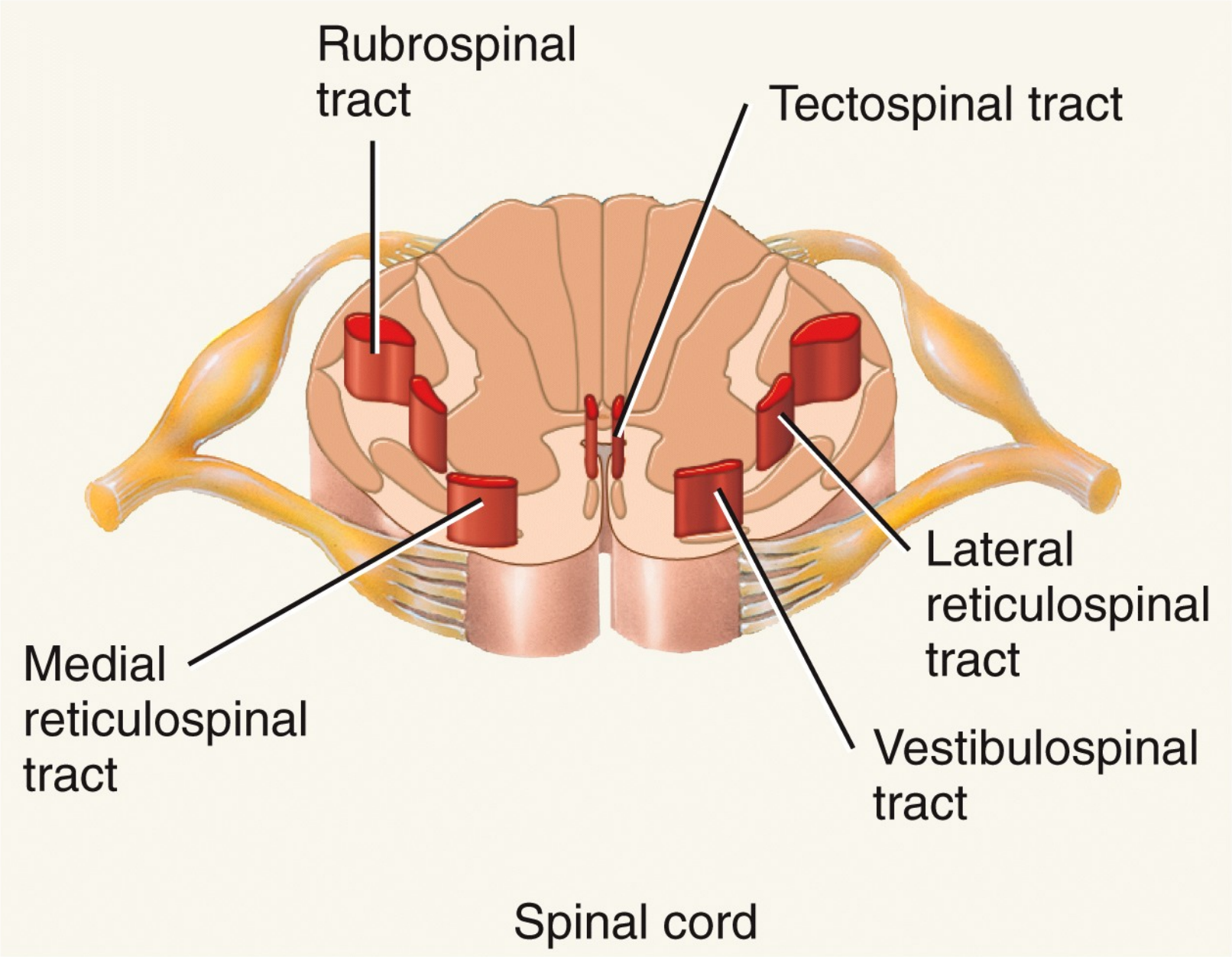
Corticobulbar Tract

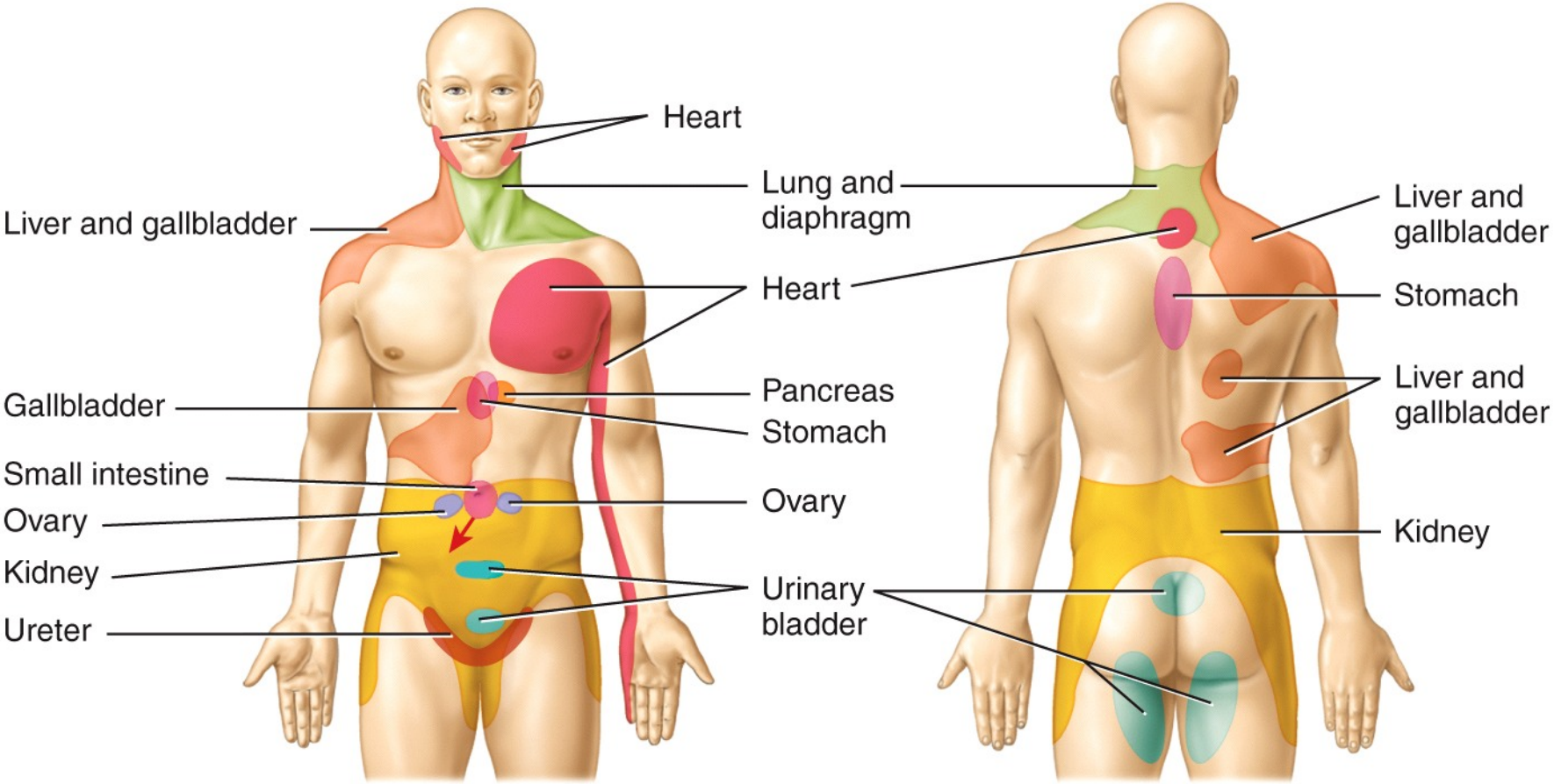
Stop


Posterior column:
Gracile fasciculus
Cuneate fasciculus
Spinal cord
Lateral spinothalamic tract
Spinal cord
Anterior spinothalamic tract
Trigeminothalamic tract
Pons
Posterior spinocerebellar tract
Spinal cord
Anterior spinocerebellar tract


Lateral corticospinal tract
Anterior corticospinal tract
Spinal cord


Cerebral
peduncle
Corticobulbar tract
Midbrain of brain stem


Rubrospinal tract
Tectospinal tract
Lateral reticulospinal tract
Medial reticulospinal tract
Vestibulospinal tract
Spinal cord



(a) Anterior view

(b) Posterior view