Chapter 16.1

Sensory Receptors
General VS Special Senses
Somatic Sensations

General Properties of Receptors

- **Transduction** – the conversion of one form of energy into another
  - Dendrites are receptors
  - Receptors are transducers
  - Convert stimulus (light, heat, touch, sound, etc.) into local potentials
  - sense organ, gasoline engines, and light bulbs are all examples of transducers

- **Sensation** = is our subjective awareness of the stimulus
  - however, some stimuli do not require conscious awareness to regulate physiology (e.g. pH and body temperature)
  - most sensory signals delivered to the CNS produce no conscious sensation
  - many stimuli are not strong enough to generate an action potential

Definitions

- **sensory input** // the stimulus - vital to the integrity of personality and intellectual function
- **sensory receptor //** neuron's dendrite specialized to detect a stimulus // different dendrite optimally respond to specific stimulus
- **sense organs** – tissues that surround dendrites and enhance the response of dendrites to certain type of stimulus
  - tissue used to make sense organ around dendrite maybe epithelium, muscle or connective tissue

Types of Sensory Receptors

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

All of these sensory receptors are dendrites that create local potentials.

If the stimulus is great enough then an action potential occurs.

What is the stimuli for each receptor type?

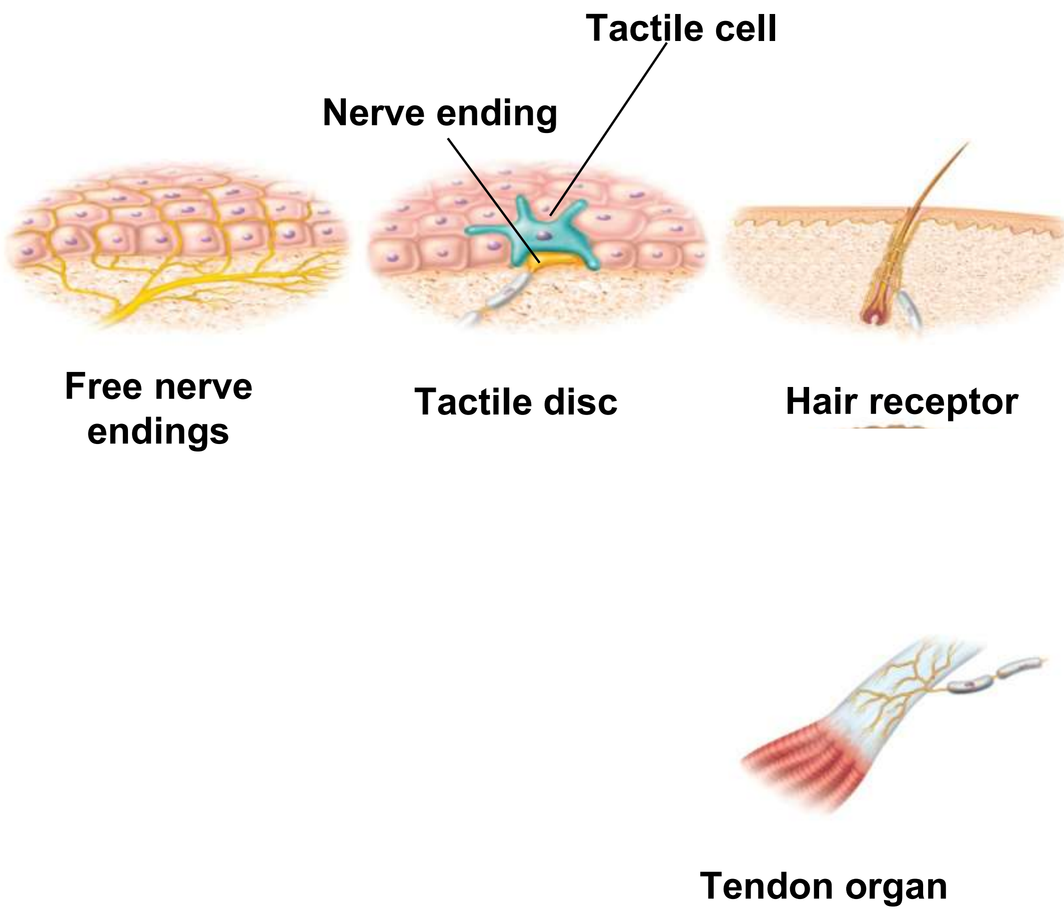
General Senses vs Special Senses

- General Senses (GS) = structurally simple receptors // one or a few sensory fibers // no or little additional tissue surrounding the dendrite
- Special Senses (SS) = complex structures / localized in head / sight, hearing, vision, taste, smell // complex additional tissue surrounds 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>

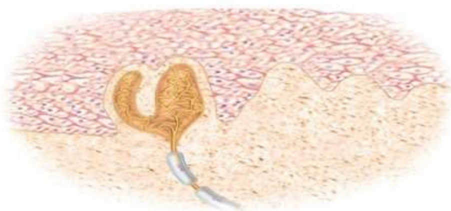
Unencapsulated Nerve Endings



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

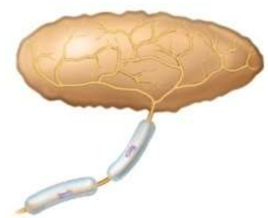
Encapsulated Nerve Endings

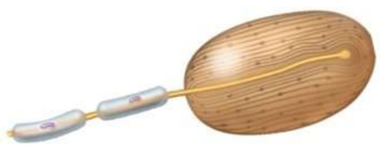
Corpuscle of Touch
Or Meissner Corpuscles



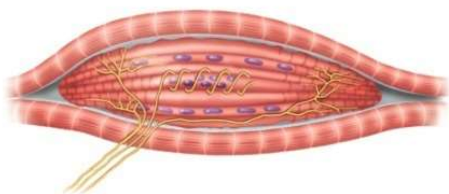
End bulb

Bulbous corpuscle





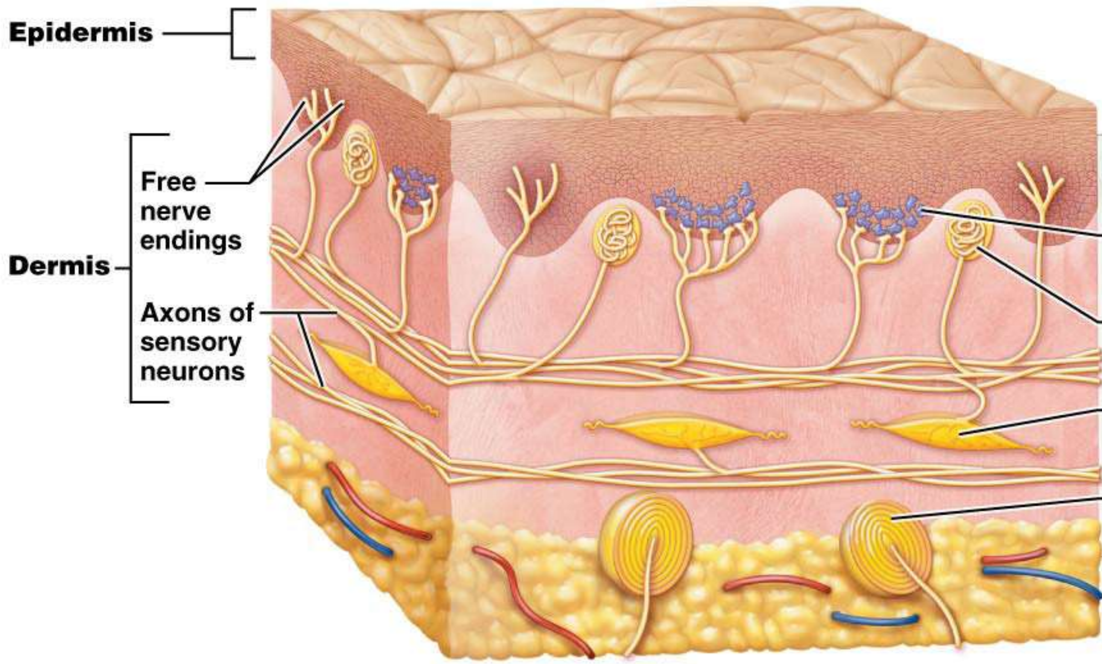
Lamellar corpuscle
(pressure)



Muscle spindle

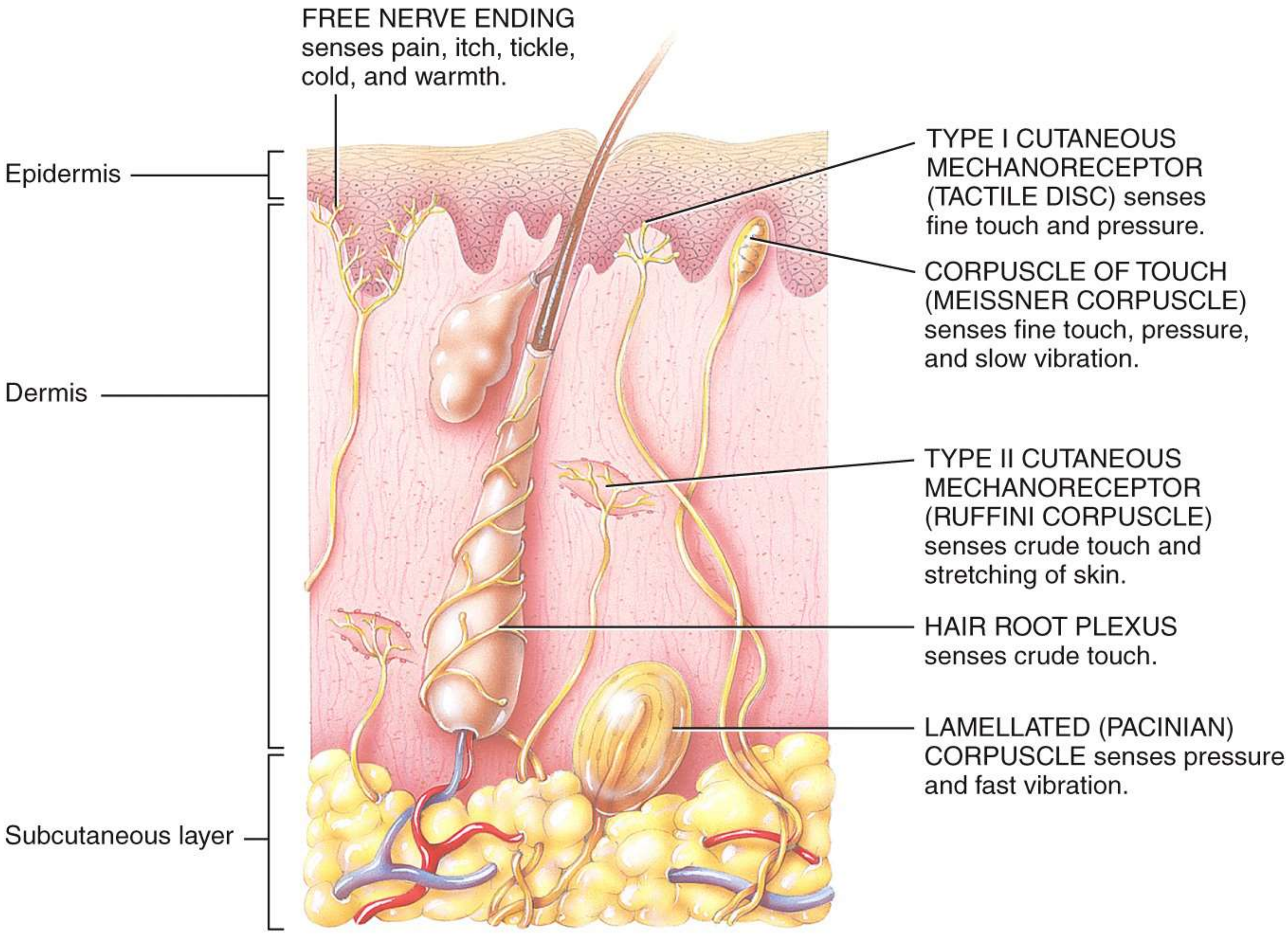
- dendrites wrapped by glial cells or connective tissue
- connective tissue enhances sensitivity or selectivity of response

Mechanoreceptors in the skin.



MECHANORECEPTOR	FUNCTION
Merkel cell fiber	Discriminative touch with fine spatial resolution
Tactile corpuscle	Discriminative touch with less spatial resolution
Ruffini ending (bulbous corpuscle)	Stretch and movement
Lamellated corpuscle	Vibration and deep pressure

Positioning of Sensory Receptors



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

Phasic VS Tonic Receptors

Receptors Classified By Rate of Adaptation

Cutaneous mechanoreceptors can also be separated into categories based on their rates of adaptation. When a mechanoreceptor receives a stimulus, it begins to fire impulses or action potentials at an elevated frequency (the stronger the stimulus, the higher the frequency).

The cell, however, will soon "adapt" to a constant or static stimulus, and the pulses will subside to a normal rate. Receptors that adapt quickly (i.e. quickly return to a normal pulse rate) are referred to as "phasic". Those receptors that are slow to return to their normal firing rate are called “tonic”.

Phasic mechanoreceptors are useful in sensing such things as texture or vibrations. ///   Smell deodorant when first applied but after a minute you no longer smell the deodorant.

Tonic mechanoreceptors are useful for temperature and proprioception among others.

Receptors Classified By Rate of Adaptation

Slowly adapting: Slowly adapting mechanoreceptors include Merkel and Ruffini corpuscle end-organs, and some free nerve endings.

Slowly adapting type I mechanoreceptors have multiple Merkel corpuscle end-organs.

Slowly adapting type II mechanoreceptors have single Ruffini corpuscle end-organs

Intermediate adapting: Some free nerve endings are intermediate adapting.

Rapidly adapting: Rapidly adapting mechanoreceptors include Meissner corpuscle end-organs, Pacinian corpuscle end-organs, hair follicle receptors and some free nerve endings.

Rapidly adapting type I mechanoreceptors have multiple Meissner corpuscle end-organs.

Rapidly adapting type II mechanoreceptors (usually called Pacinian) have single Pacinian corpuscle end-organs.

Generator VS Receptor Potentials

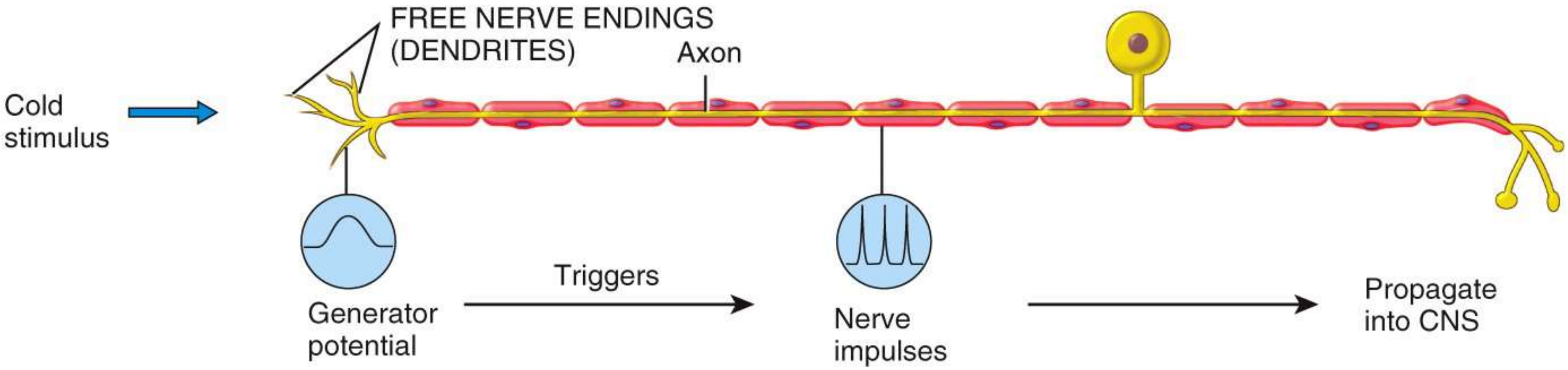
Different Types of "Graded Potentials"
These Determine "IF" an Action Potential Will Occur

- **Generator Potentials**
  - **GP receptors are dendrites**
  - **Dendrites maybe free nerve endings or encapsulated**
  - **receptive part of olfactory receptors**
  - **stimulus open ion channels // graded potential**
  - **generator potentials generate local potentials into action potentials**
  - **if stimulus great enough GP triggers action potential in sensory first order neuron**

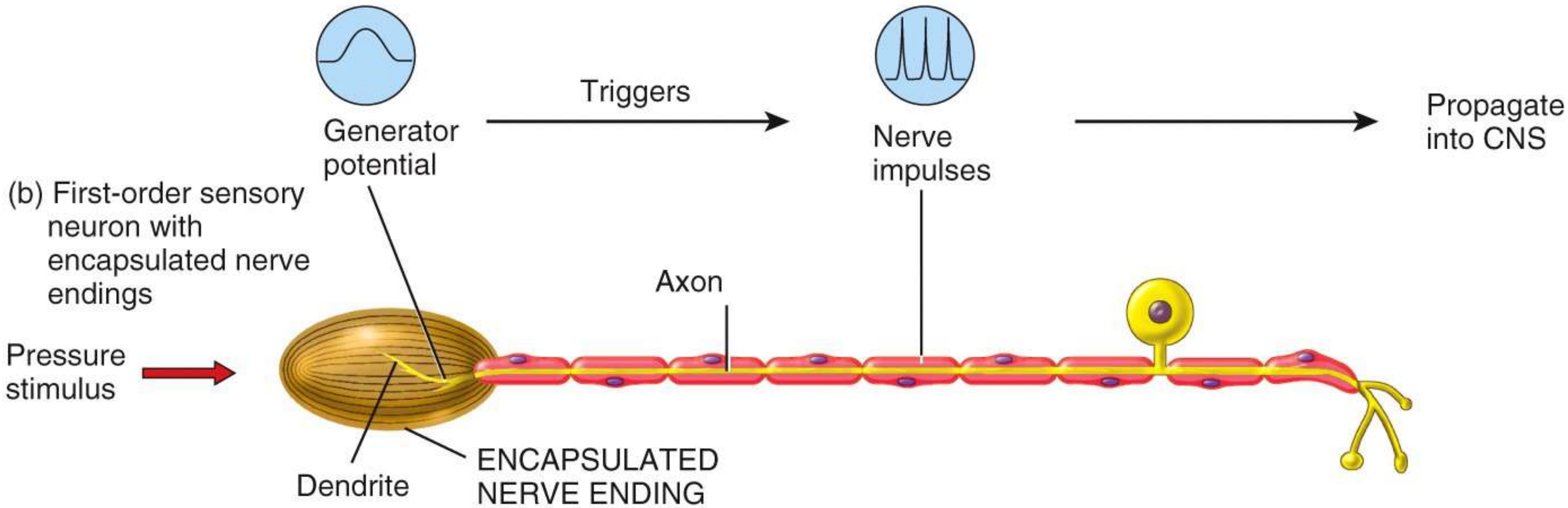
- **Receptor Potentials**
  - **RP receptors are separate cells (epithelial cells)**
  - **stimulated receptor potential cells release neurotransmitter into synaptic cleft next to neuron's dendrite**
  - **ligand receptor on dedrite's post synaptic membrane**
  - **if stimulus great enough RP generate AP in sensory first order neuron**

Generator Potential (not encapsulated)

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

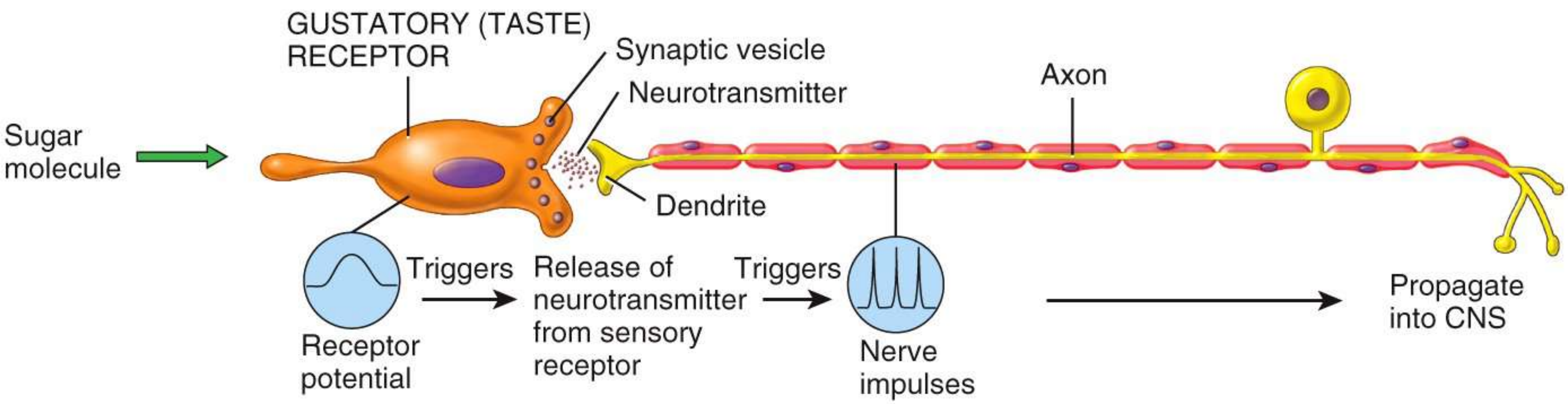


Generator Potential Encapsulated



Receptor Potential

(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
- If you try to tickle yourself the pathway is cancelled by signal sent to cerebellum by your finger
- Is this an evolutionary adaptatiion? If we could tickle ourself then me may end up giving ourself pleasure instead of hunting for food!

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)

Note: overlap so cold receptors may not be able to distinguish between something cold feeling like it is hot

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 // these receptors 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 locations 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

Anteriolateral 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

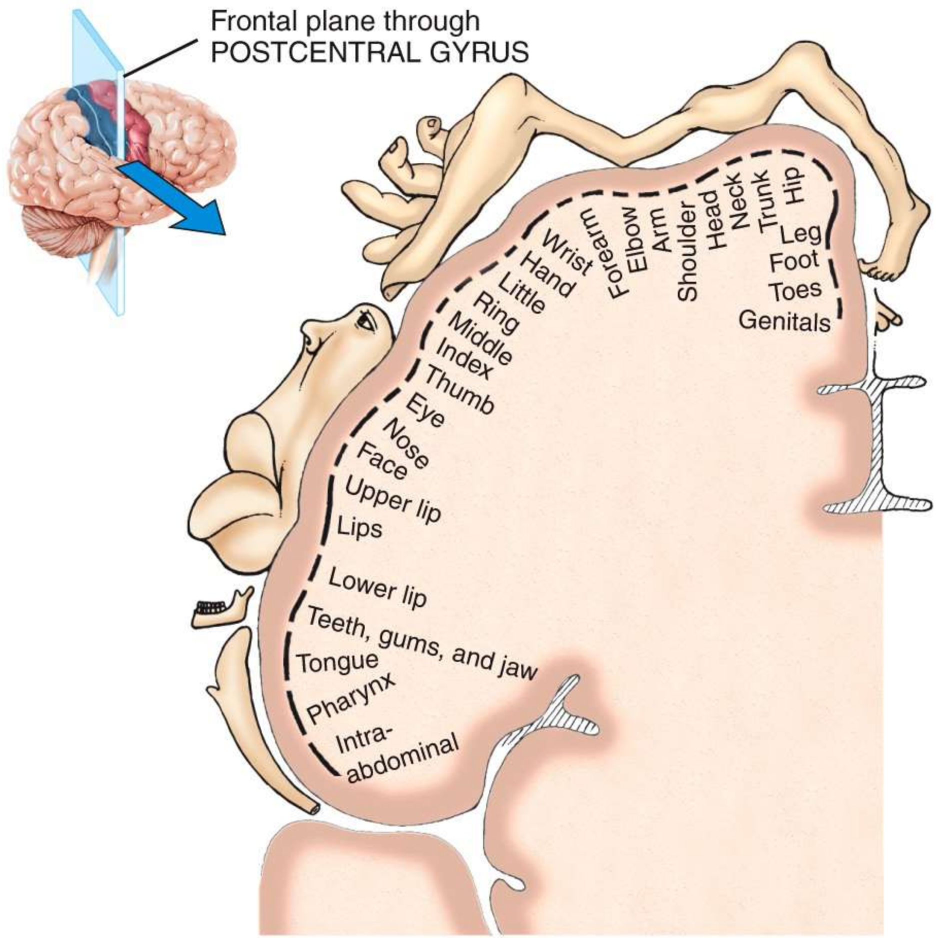
- Pathway from receptor to final destination in the brain // post central gyrus // most somesthetic signals travel by way of **three neurons**

- **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*

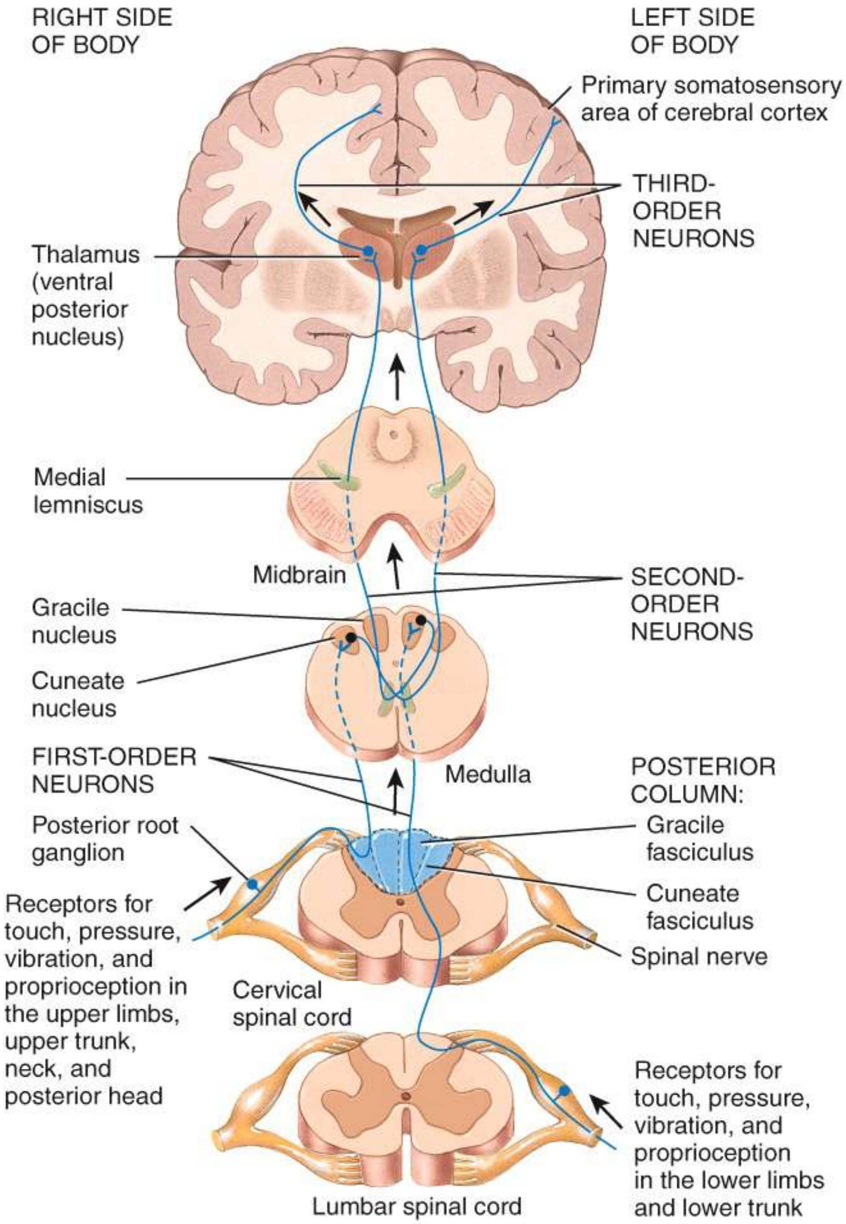
- **3rd order neuron**
  - thalamus to primary somesthetic cortex of cerebrum

Postcentral Gyrus = Somatic Sensory Gyrus



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

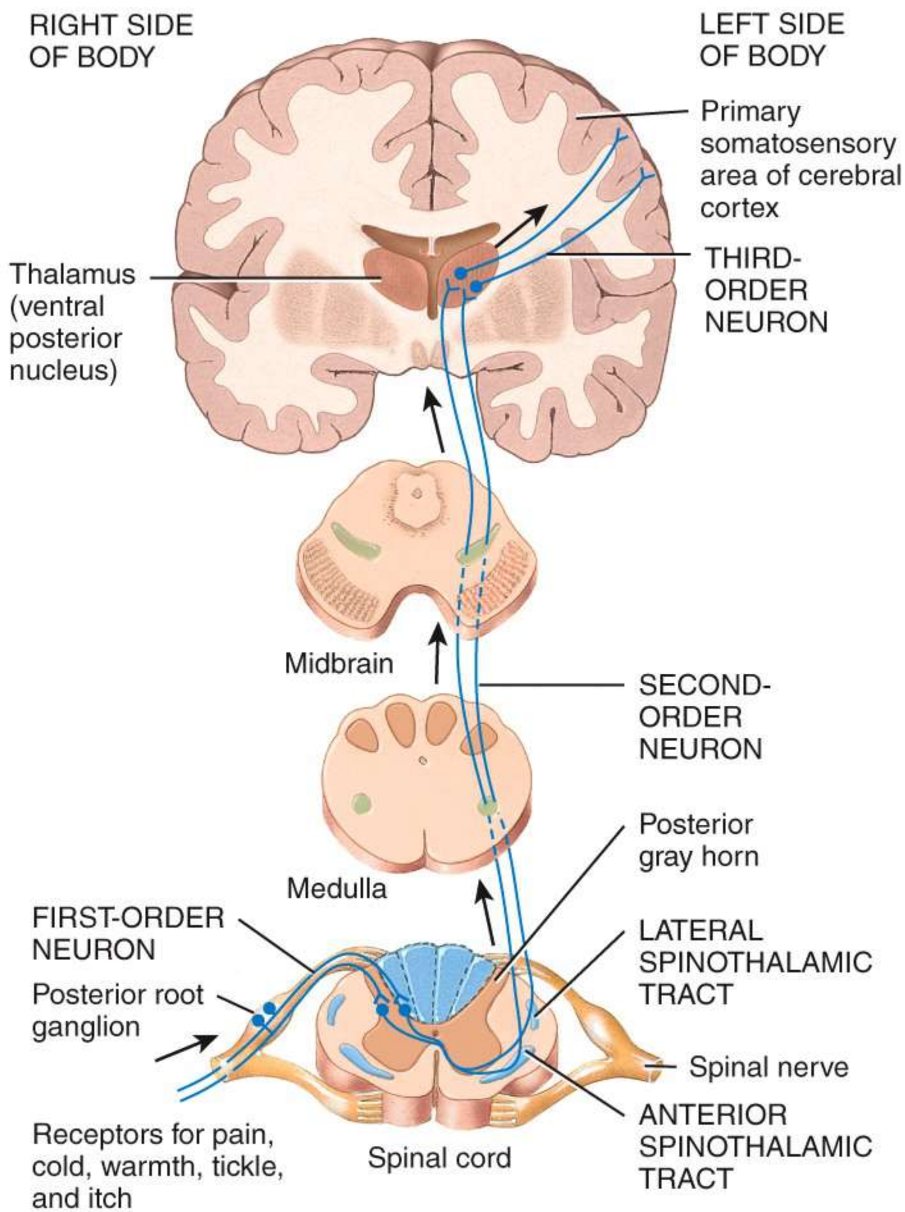
Illustrates Somatotopy



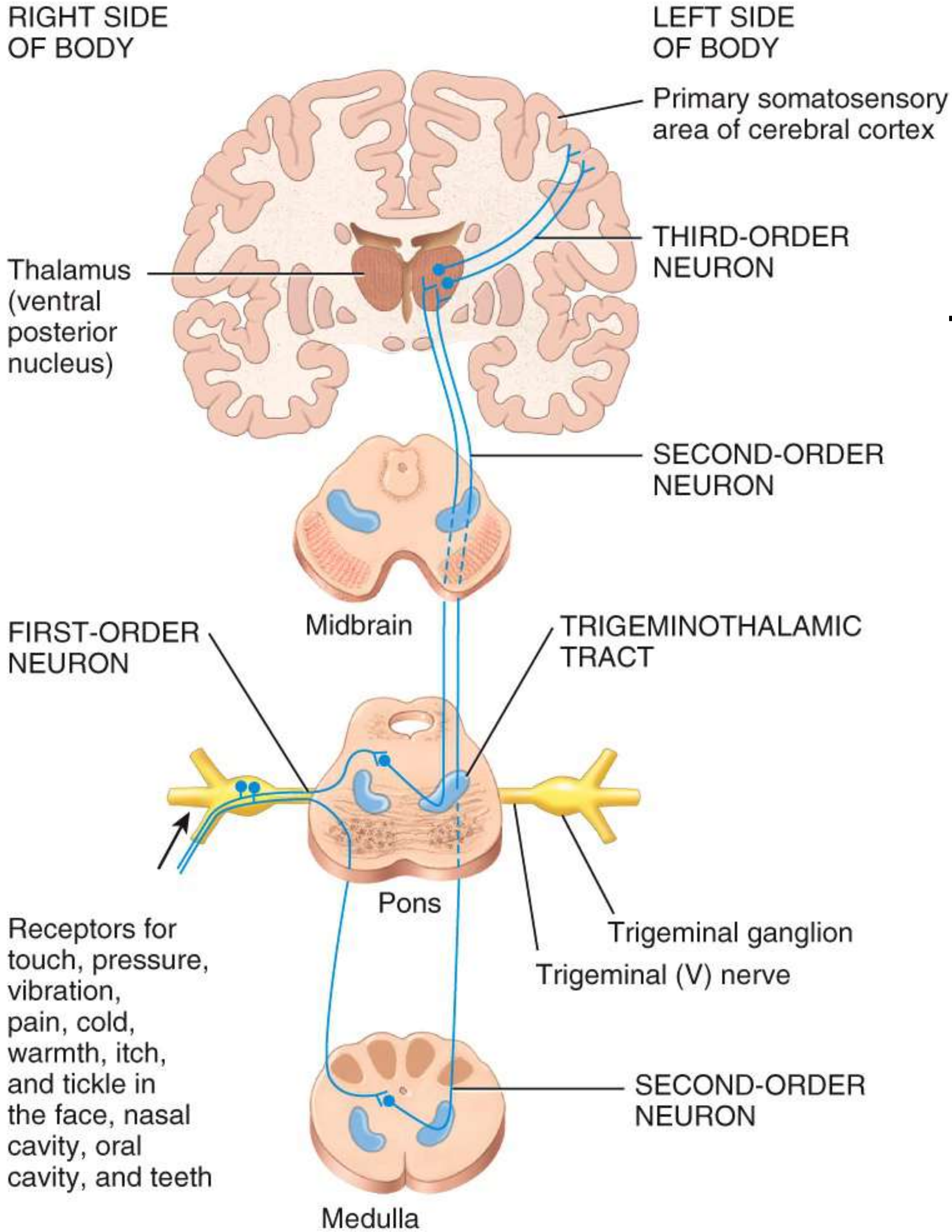
Posterior column–medial lemniscus pathway

Posterior Column Pathway

Spinothalamic Pathway

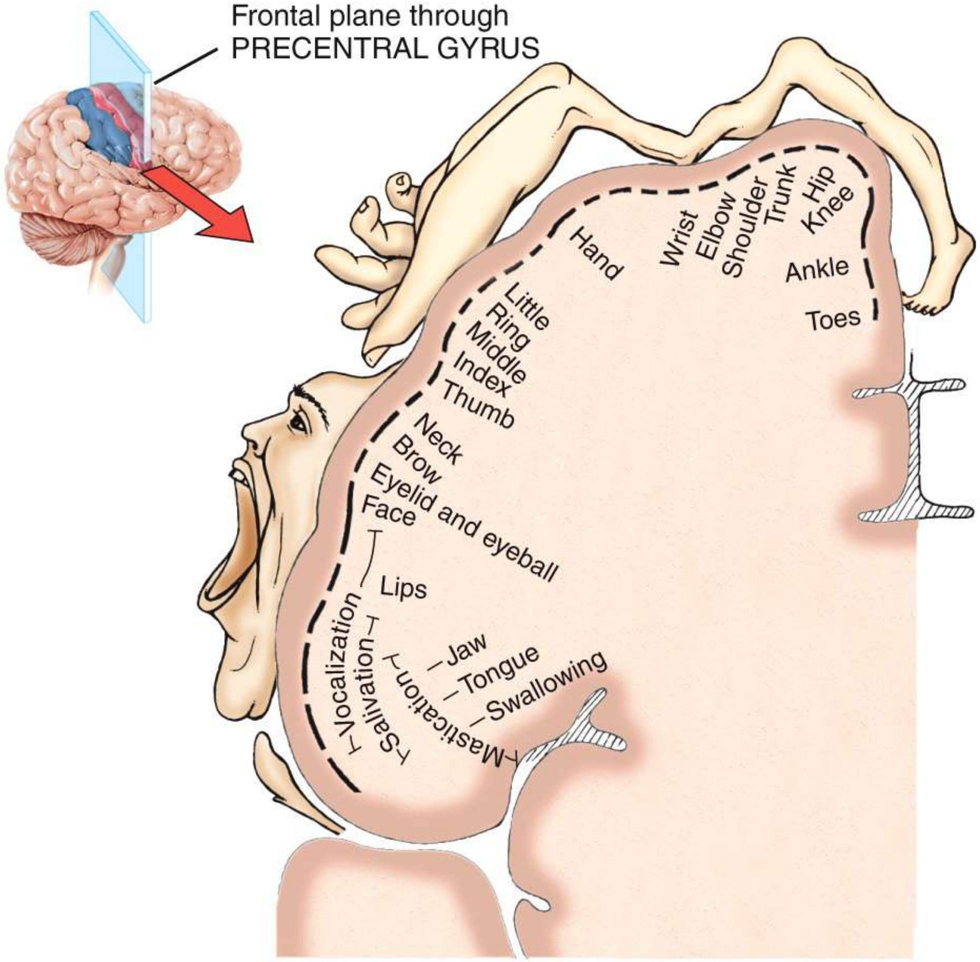


Anterolateral (spinothalamic) pathways



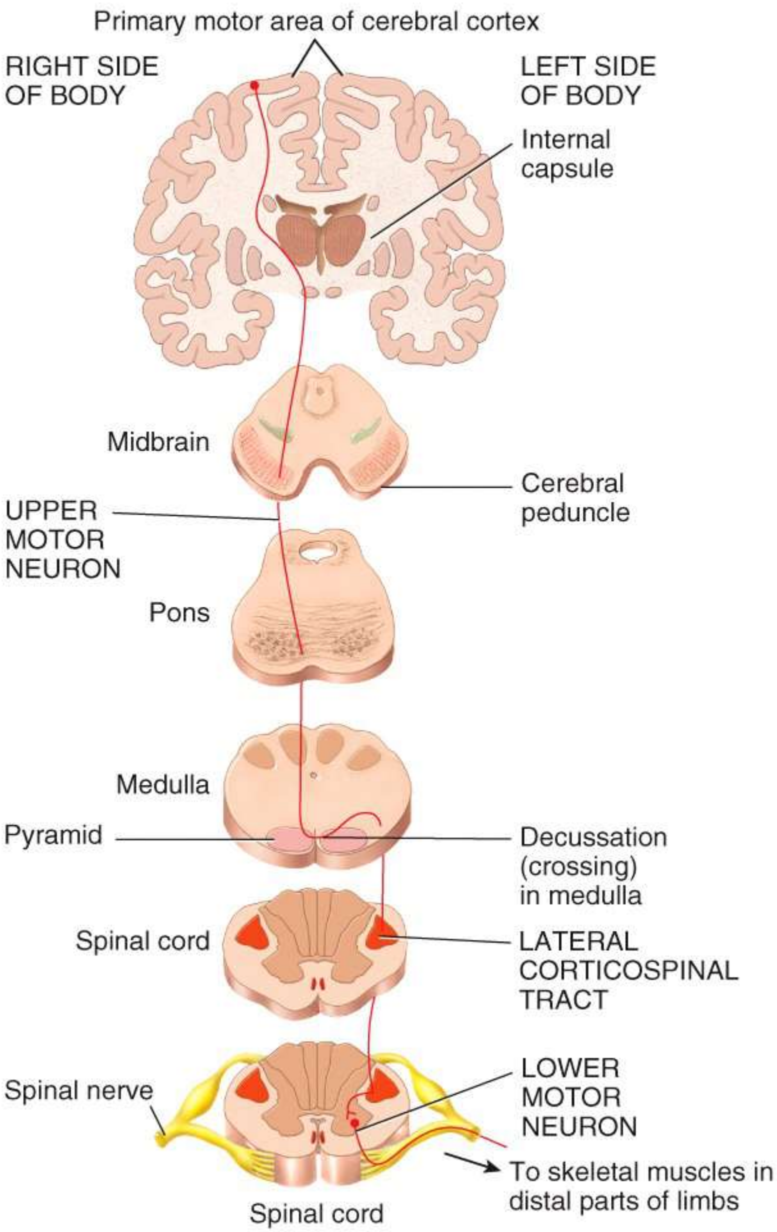
Trigeminothalamic Pathway

Precentral Gyrus = Motor Sensory Gyrus



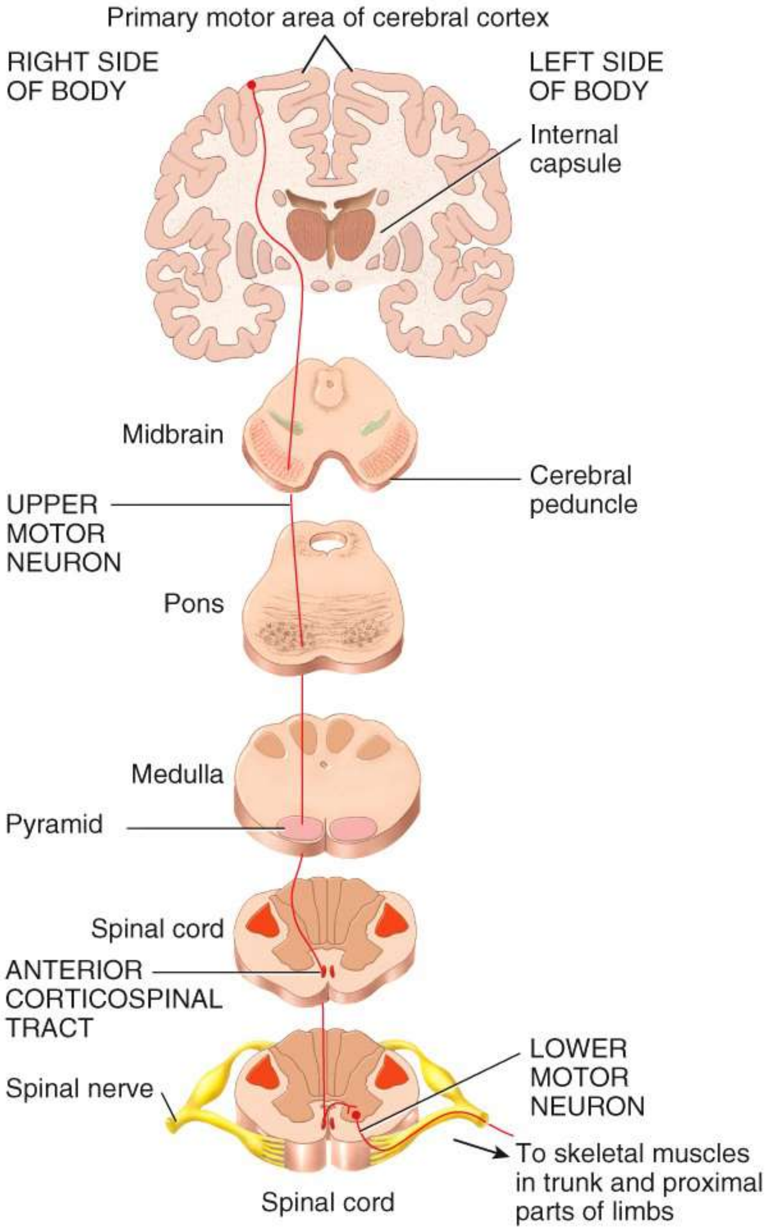
(b) Frontal section of primary motor area in right cerebral hemisphere

Illustrates Somatotopy



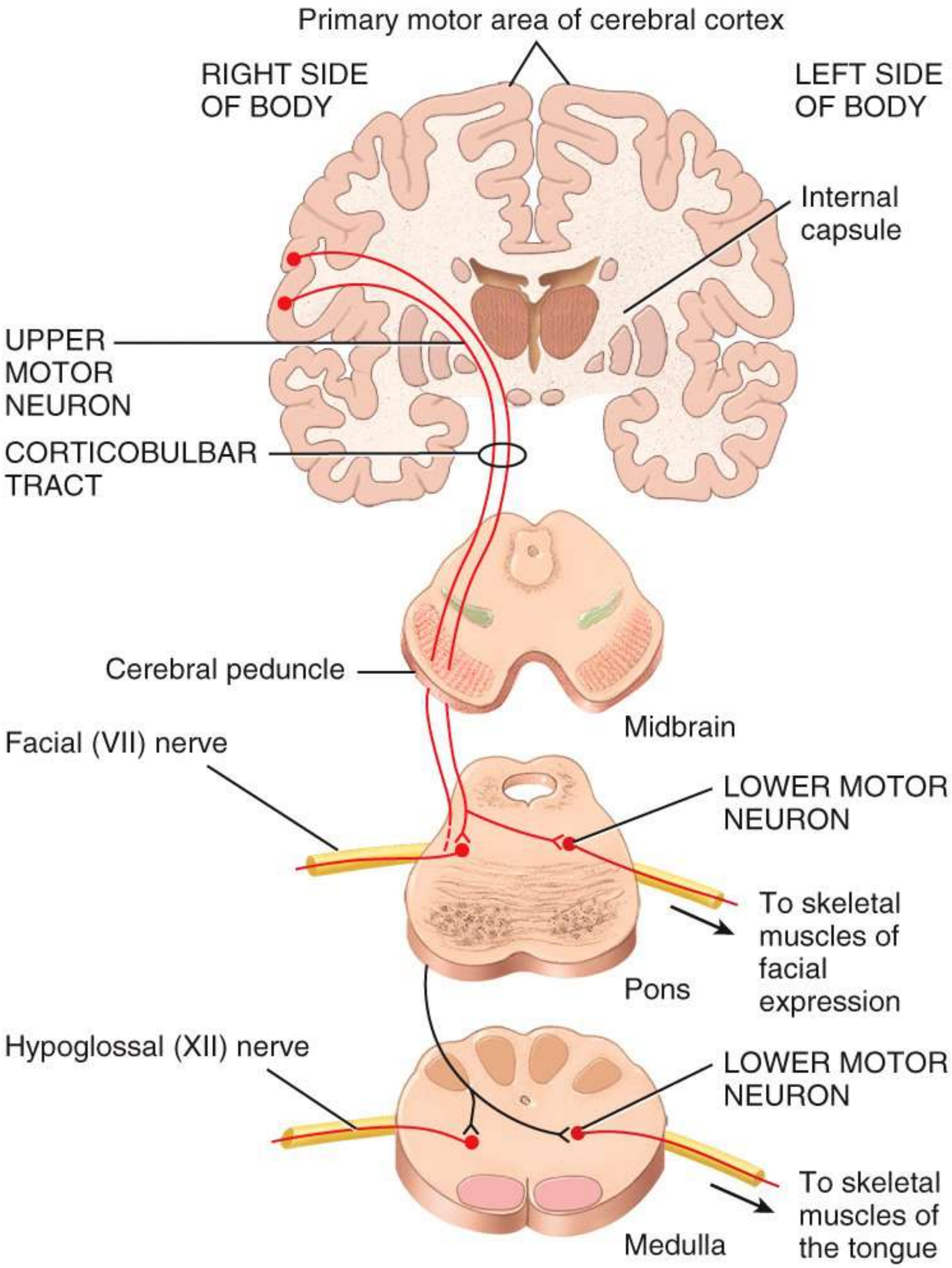
(a) The lateral corticospinal pathway

Lateral Corticospinal Pathway



(b) The anterior corticospinal pathway

Anterior Corticospinal Pathway



Corticobulbar Tract