Neurophysiology

Introduction

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Functions of the nervous system

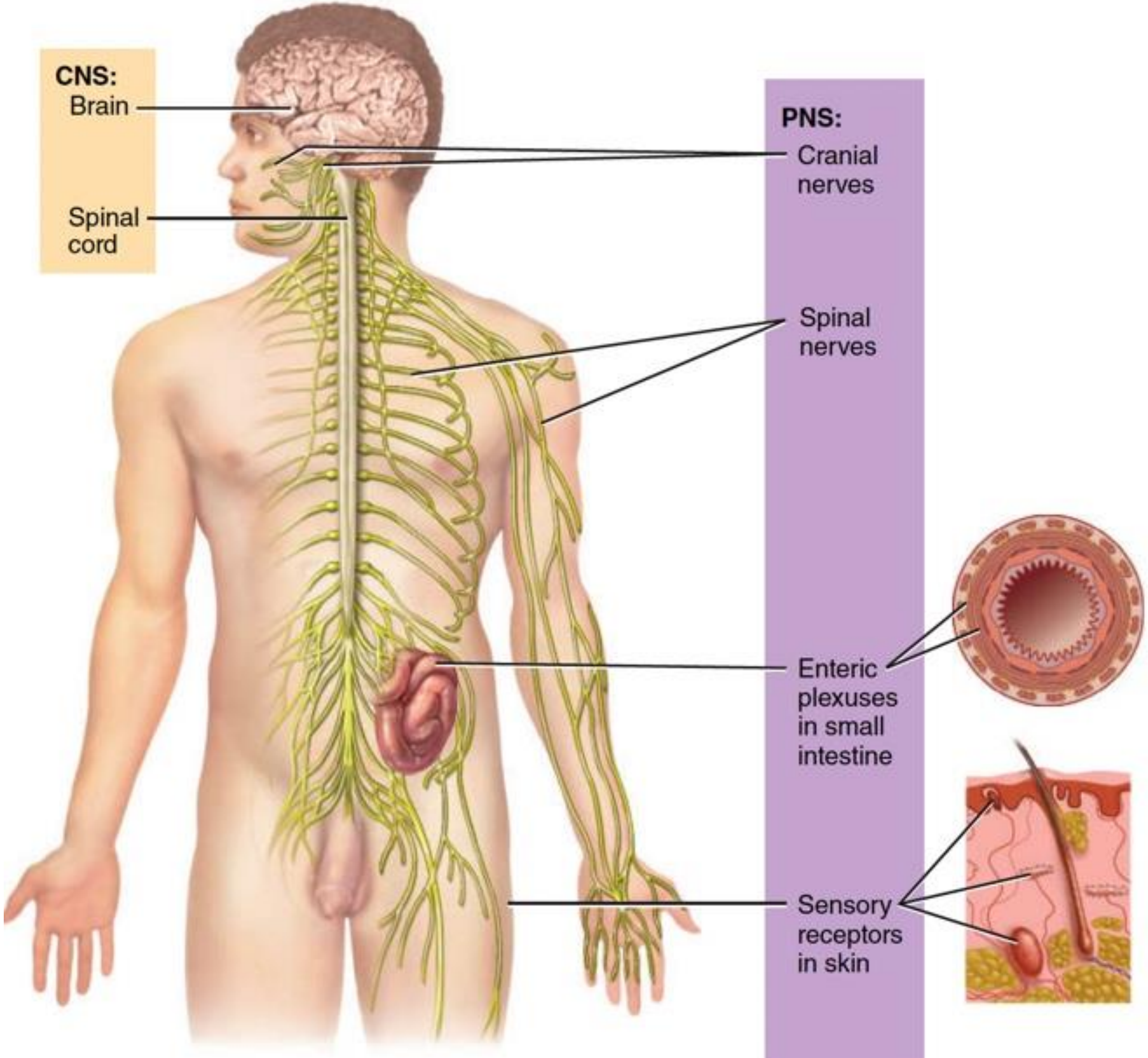
- **Sensory function**: sensory receptors detect internal or external stimuli. The sensory information is carried to the CNS through cranial and spinal nerves.

- **Integrative function**: process sensory information by analyzing it and making decision for appropriate responses.

- **Motor function**: activation of effectors (muscles and glands) through cranial and spinal nerves.

Notes

- **CNS**:
- Collect sensory information
- Process sensory info/ Compare and contrast / integrate the present information to the previous ones.
- Decide about the motor response
- **PNS**:
- Take info from periphery to CNS (sensory NS) and vice versa (motor NS).



CNS:
Brain
Spinal cord
PNS:
Cranial nerves
Spinal nerves
Enteric plexuses in small intestine
Sensory receptors in skin

Divisions of nervous system

Central nervous system (CNS)

- Brain
- Spinal cord

Peripheral nervous system (PNS)

- Somatic system (SNS)
- Autonomic system (ANS)
- Enteric system (ENS)

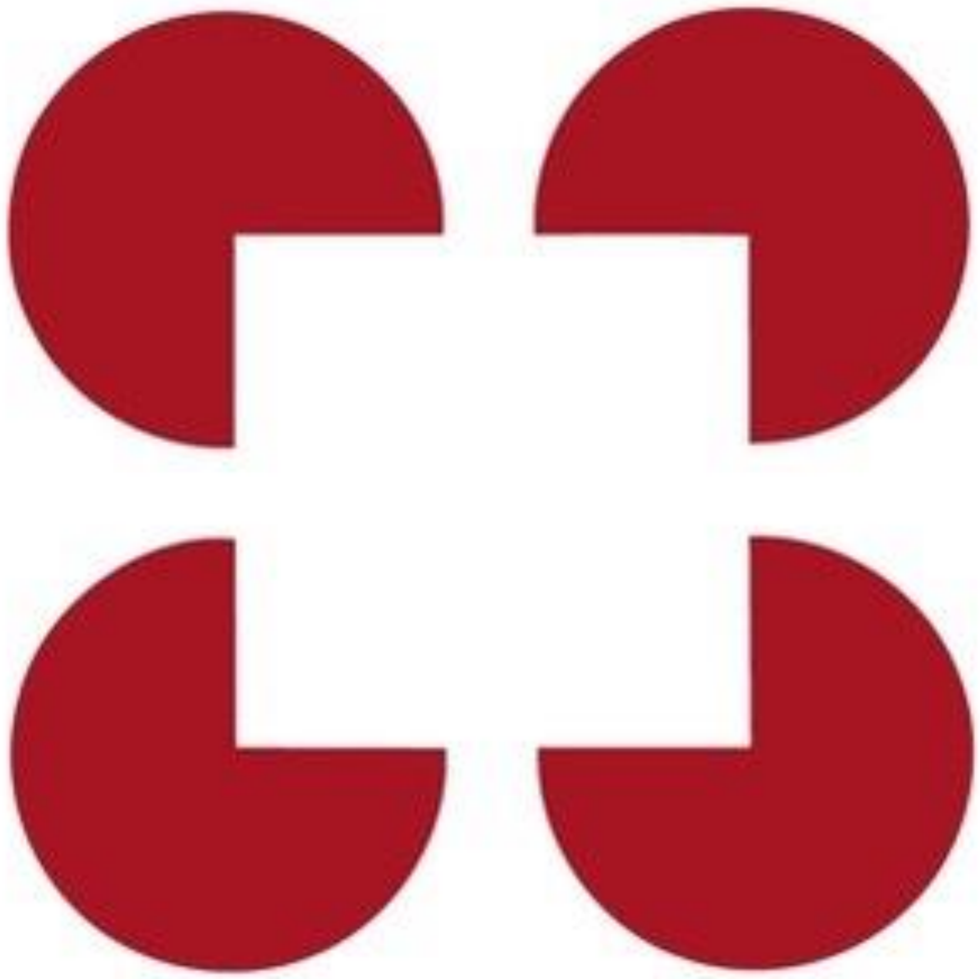
Sensation

- **Sensation** is the conscious or subconscious awareness of changes in the external or internal environment.

- **Perception** is the conscious interpretation of sensations and is primarily a function of the cerebral cortex.

Perception

- Is the world, as we perceive it, reality?



The process of sensation

1. Stimulation of the sensory receptor.

A receptor may be either (1) a specialized ending of the afferent neuron or (2) a separate receptor cell closely associated with the peripheral ending of the neuron.

Each type of receptor is specialized to respond to one type of stimulus: **Differential sensitivity.**

Sensory modalities

- **Sensory modalities** are divided into **general senses and special senses**.

* **General senses are** further divided into:

- **Somatic senses**: include tactile, thermal and pain sensations.
- **Visceral senses**: provide information about conditions within internal organs.

* **Special senses** include smell, taste, vision, hearing, and balance.

Receptor potential

Because the only way afferent neurons can transmit information to the CNS about stimuli is via action potential propagation, receptors must convert these other forms of energy into electrical signals.

Stimulation of a receptor alters its membrane permeability, producing a **receptor potential**.

The process of sensation

- 1. **Stimulation of the sensory receptor**.

- 2. **Transduction of the stimulus**. A sensory receptor converts the energy in the stimulus into a graded potential.

The process of sensation

- 3. **Generation of nerve impulses**. When a graded potential in a sensory neuron reaches threshold, it triggers one or more nerve impulses, which then propagate toward the CNS.

- 4. **Integration of sensory input**. A particular region of the CNS receives and processes the sensory nerve impulses.

Receptive Field

- Each sensory neuron responds to a stimulus only within a specific region surrounding it, this region is called its **receptive field**.

- The size of a receptive field varies inversely with the density of receptors in the region.

- The smaller the receptive field is in a region, the greater its acuity or discriminative ability: **2 point discrimination**

Somatic sensory receptors distribution

- Receptors are **distributed unevenly**.

- The areas with the highest density of somatic sensory receptors are the tip of the tongue, the lips, and the fingertips.

Lateral Inhibition

- To facilitate localization and sharpen contrast, lateral inhibition occurs within the CNS.

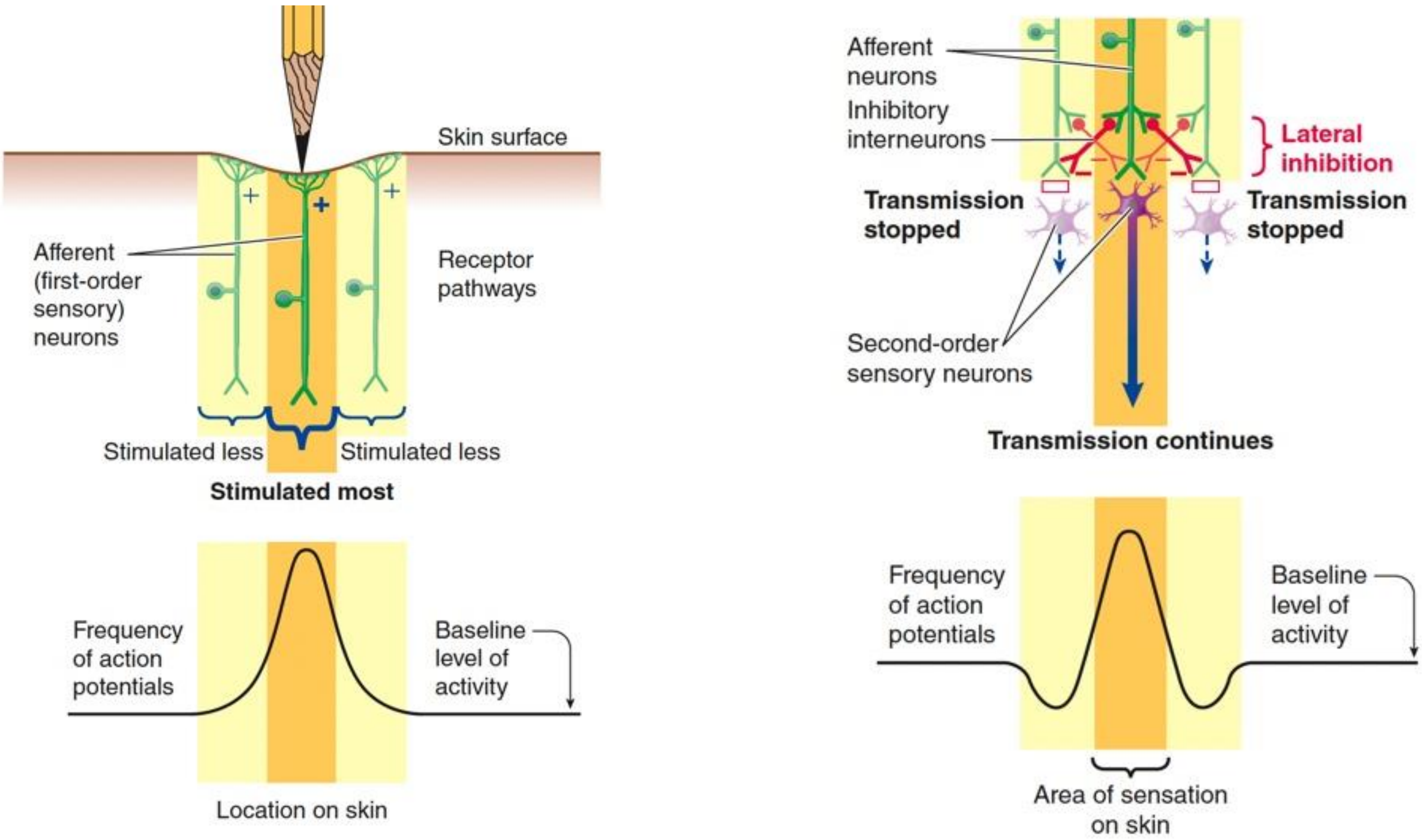
- With lateral inhibition, each activated signal pathway inhibits the pathways next to it by stimulating inhibitory interneurons that pass laterally between ascending fibers serving neighboring receptive fields.

- The most strongly activated pathway originating from the center of the stimulus area inhibits the less excited pathways to a greater extent than the weakly activated pathways inhibit the more excited central pathway.

Lateral Inhibition

- Blockage of further transmission in the weaker inputs increases the contrast between wanted and unwanted information so that the stimulus precisely localized.

- The extent of lateral inhibitory connections within sensory pathways varies for different modalities. Those with the most lateral inhibition: touch and vision



Skin surface
Afferent (first-order sensory) neurons
Receptor pathways
Stimulated less
Stimulated less
Stimulated most
Frequency of action potentials
Baseline level of activity
Location on skin
Afferent neurons
Inhibitory interneurons
Lateral inhibition
Transmission stopped
Transmission stopped
Second-order sensory neurons
Transmission continues
Frequency of action potentials
Baseline level of activity
Area of sensation on skin

Stimulus intensity

- The intensity of the stimulus is reflected by the magnitude of the receptor potential.
- The larger the receptor potential, the greater the frequency of action potentials generated in the afferent neuron.
- A larger receptor potential cannot bring about a larger action potential but it can induce more rapid firing of action potentials.

Stimulus intensity

- Stimulus strength is also reflected by the size of the area stimulated: Stronger stimuli usually affect larger areas, so correspondingly more receptors respond.
- **Temporal and spatial summation**.

True or false

- Stimuli of the same intensity always result in receptor potentials of the same magnitude in the same receptor.

Adaptation in sensory receptors

- A characteristic of most sensory receptors is **adaptation**, in which the receptor potential decreases in amplitude during a maintained, constant stimulus.

- Because of adaptation, the perception of a sensation may fade or disappear even though the stimulus persists.

- Receptors vary in how they adapt and how quickly they adapt (tonic vs phasic).

Labeled Line Principle

- Even though all information is propagated to the CNS via the same type of signal (action potentials), the brain can decode the type and location of the stimulus.

- A particular sensory modality detected by a specialized receptor type is sent over a specific afferent and ascending pathway to excite a defined area in the somatosensory cortex.

- Thus, different types of incoming information are kept separated within specific labeled lines between the periphery and the cortex.

Divisions of nervous system

Central nervous system (CNS)	• Brain • Spinal cord
Peripheral nervous system (PNS)	• Somatic system (SNS) • Autonomic system (ANS) • Enteric system (ENS)

Somatic system (SNS) → Somatic and special sensory receptors

Somatic sensory receptors

- Somatic sensations arise from stimulation of sensory **receptors embedded in** the:
- Skin
- Subcutaneous layer
- Mucous membranes
- Skeletal muscles
- Tendons
- Joints.

Classification of somatic senses

- 1- **Mechanoreceptive senses**:
- Tactile: touch, pressure, vibration, tickle, (itch).
- Position: static position sense, rate of movement sense.

- 2- **Thermoreceptive senses**.

- 3- **Pain sense**.

Tactile senses

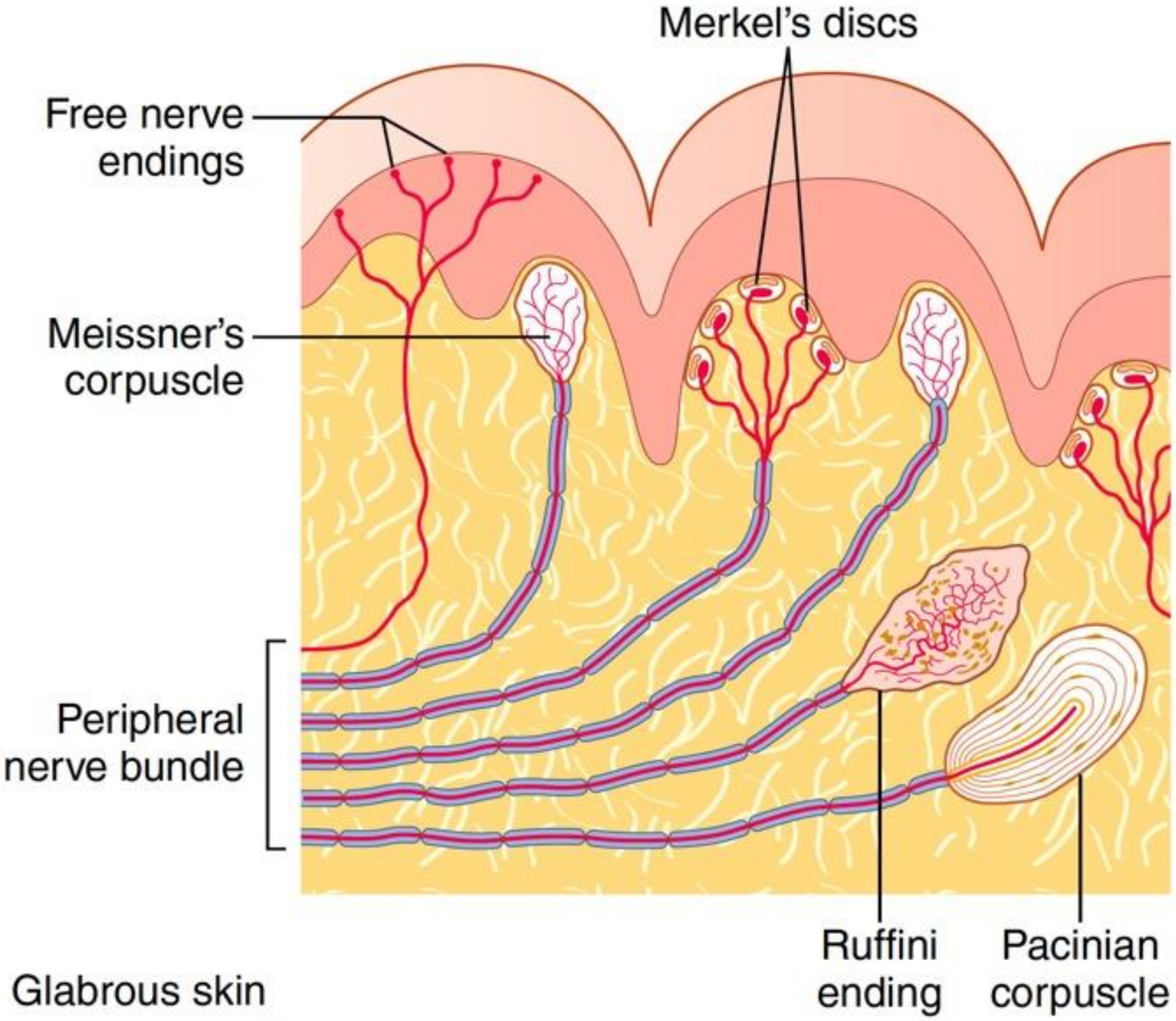
- **Touch:** generally results from stimulation of tactile receptors in the skin or in tissues immediately beneath the skin.
- **Pressure**: A sustained sensation that is felt over a larger area than touch, and generally results from deformation of deeper tissues.
- **Vibration**: results from rapidly repetitive sensory signals.

Tactile sensations

- Although touch, pressure, and vibration are frequently classified as separate sensations, they are detected by the same types of receptors.

- All tactile receptors are involved in detection of vibration, although different receptors detect different frequencies of vibration.

Tactile receptors



Glabrous skin

Tactile senses

- **Tickle**: Typically arises only when someone else touches you, not when you touch yourself.

- The reason could be due to the impulses to and from the cerebellum when you are moving your fingers and touching yourself that don’t occur when someone else is tickling you.

Tactile receptors

- Tickle and itch are elicited by very sensitive, rapidly adapting mechanoreceptive free nerve endings, that are located in the superficial layers of the skin. Or chemically induced (such as antigens, histamine… for itch)

- The purpose of the itch sensation is presumably to call attention to mild surface stimuli (or chemical) such as a flea crawling on the skin.

Tactile receptors

- This activates scratch reflex. And if the scratch is strong enough, it will elicit pain.

- The pain signals are believed to suppress the itch signals in the spinal cord by lateral inhibition.

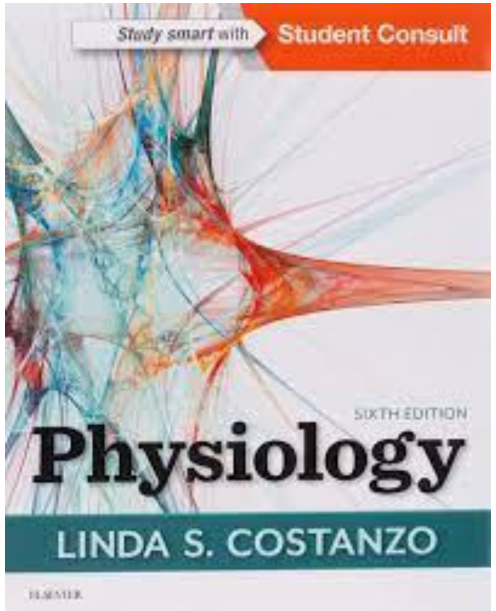
Transmission of tactile signals in peripheral nerve fibers

- Almost all specialized sensory receptors, such as Meissner's corpuscles, transmit their signals in type **Aβ** nerve fibers.

- Free nerve ending tactile receptors transmit signals mainly via the small type **Aδ** myelinated fibers.

- Some tactile free nerve endings transmit via type **C** unmyelinated fibers such as in itch and tickle senses.

References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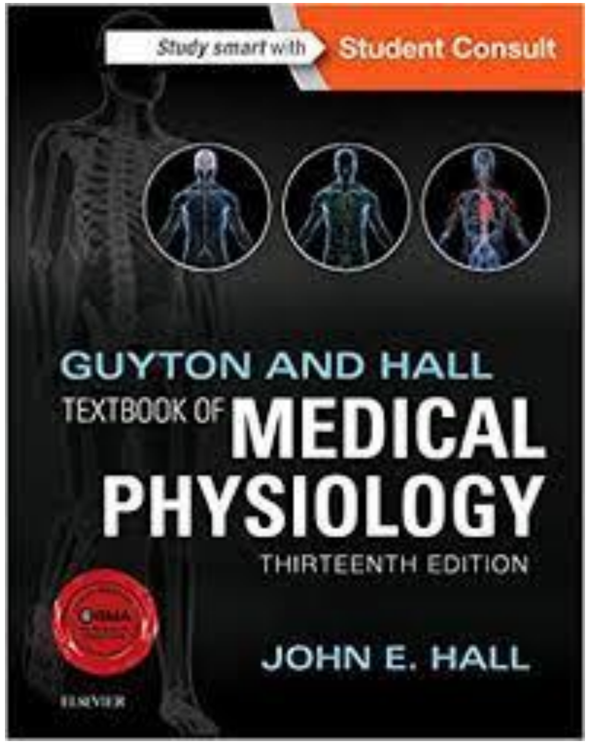
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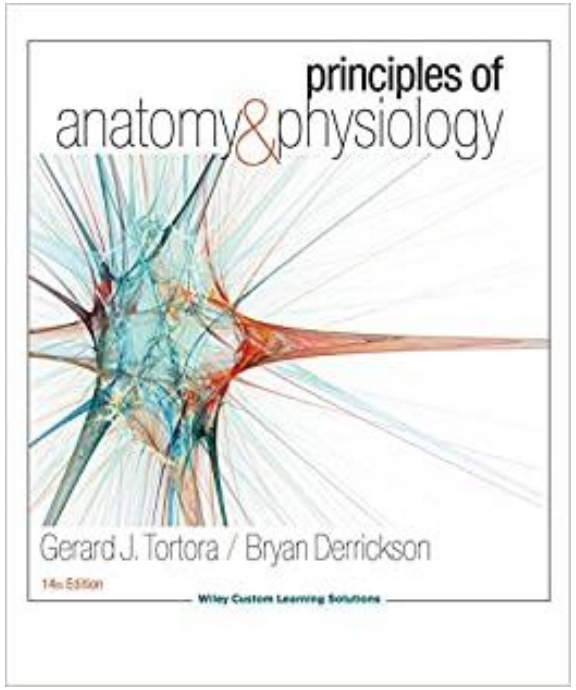
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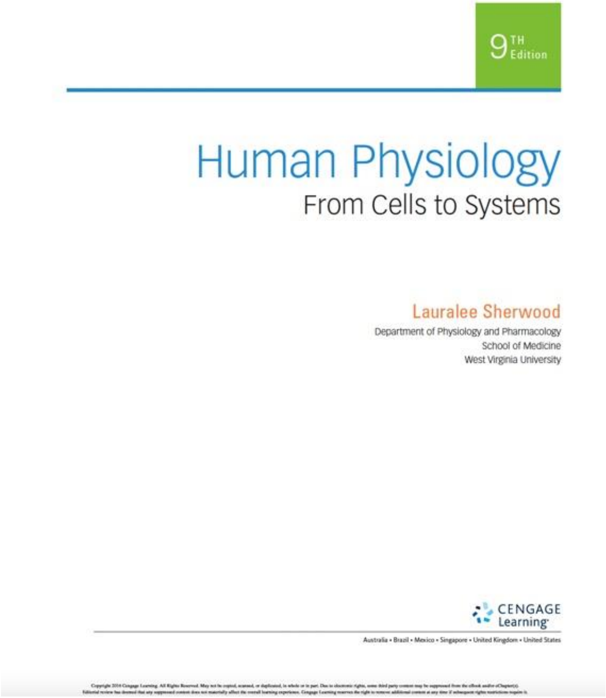
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