بسم الله الرحمن الرحيم

DOPAMINE SCIENTIFIC TEAM

Somatic Sensations (Pt.1)

MID | Lecture 1

﴿إِنِّي تَوَكَّلْتُ عَلَى اللَّهِ رَبِّي وَرَبِّكُمْ ۚ مَّا مِن دَابَّةٍ إِلَّا هُوَ آخِذٌ بِنَاصِيَتِهَا ۚ إِنَّ رَبِّي عَلَىٰ صِرَاطٍ مُّسْتَقِيمٍ﴾

Written by: Mohammad Khazalah
Mahmoud Aljunaidi

Reviewed by: Mahmoud Aljunaidi

PHYSIOLOGY

رحلة اليقين مع سورة يس

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

إِنَّا جَعَلۡنَا فِيٓ أَعۡنَٰقِهِمۡ أَغۡلَٰلٗا فَهِيَ إِلَى ٱلۡأَذۡقَانِ فَهُم مُّقۡمَحُونَ ٨ وَجَعَلۡنَا مِنۢ بَيۡنِ أَيۡدِيهِمۡ سَدّٗا وَمِنۡ خَلۡفِهِمۡ سَدّٗا فَأَغۡشَيۡنَٰهُمۡ فَهُمۡ لَا يُبۡصِرُونَ ٩

وذكر الموانع من وصول الإيمان لقلوبهم، فقال: {إِنَّا جَعَلْنَا فِي أَعْنَاقِهِمْ أَغْلَالًا} وهي جمع "غل" و "الغل" ما يغل به العنق، فهو للعنق بمنزلة القيد للرجل، وهذه الأغلال التي في الأعناق عظيمة قد وصلت إلى أذقانهم ورفعت رءوسهم إلى فوق، {فَهُمْ مُقْمَحُونَ} أي: رافعو رؤوسهم من شدة الغل الذي في أعناقهم، فلا يستطيعون أن يخفضوها.

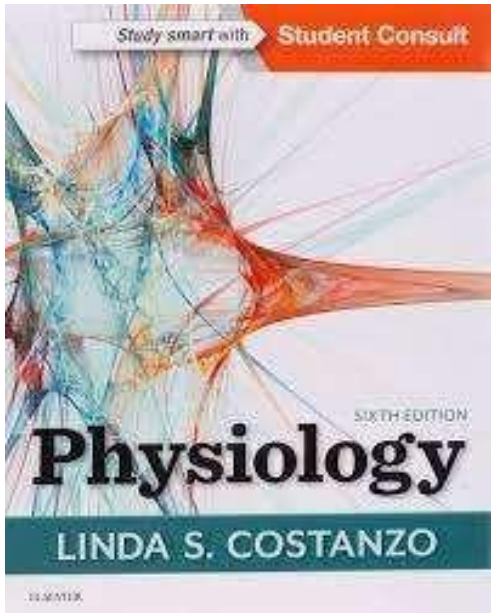
{وَجَعَلْنَا مِنْ بَيْنِ أَيْدِيهِمْ سَدًّا وَمِنْ خَلْفِهِمْ سَدًّا} أي: حاجزا يحجزهم عن الإيمان، {فَهُمْ لَا يُبْصِرُونَ} قد غمرهم الجهل والشقاء من جميع جوانبهم، فلم تفد فيهم النذارة.

Neurophysiology
Sensation 1

Fatima Ryalat, MD, PhD

Assistant Professor, Department of Physiology and Biochemistry
School of Medicine, The University of Jordan

References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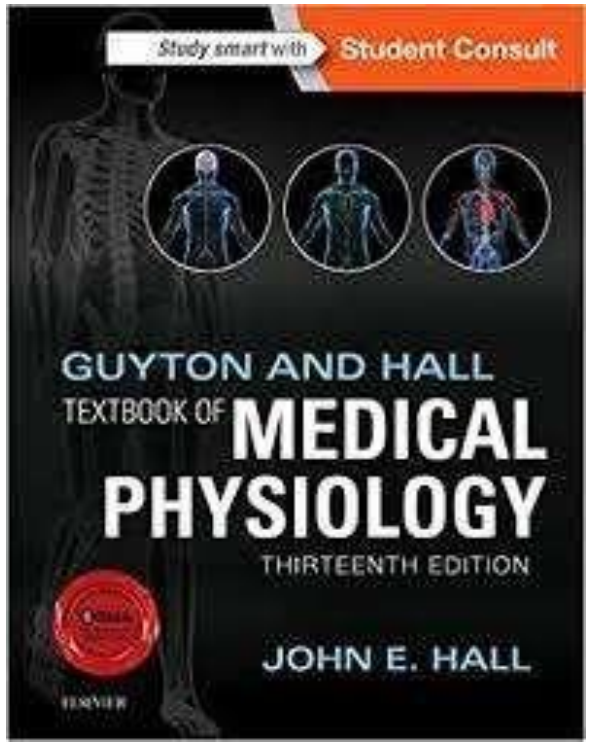
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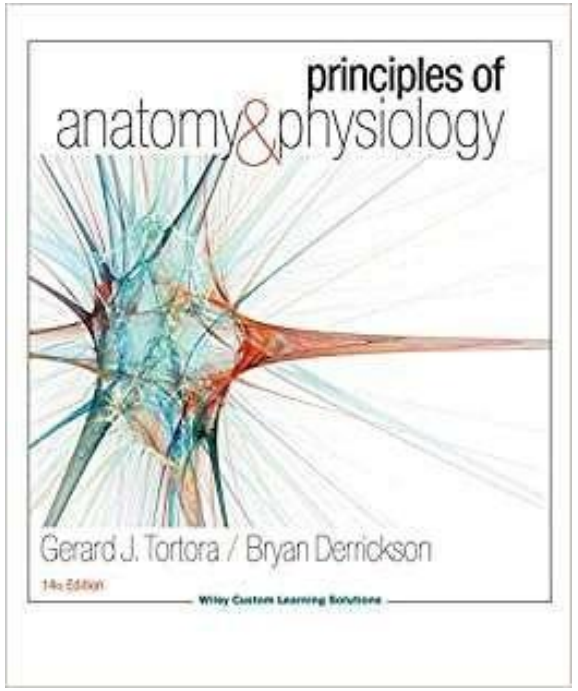
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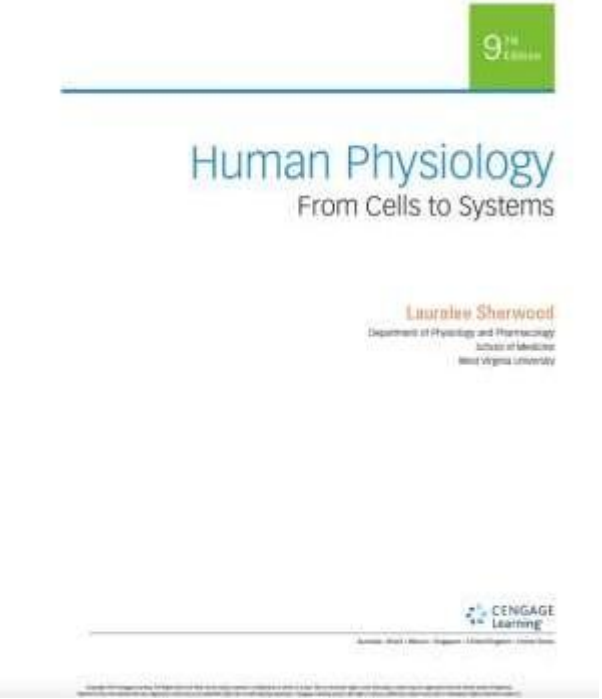
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Introduction and Revision

- The defining characteristic of the nervous system is **control**. While the endocrine system also manages body functions, it does so through sustained, prolonged, and often delayed hormonal signals. In contrast, the nervous system is built for **speed**, providing the **rapid-fire responses** necessary for **immediate** action.

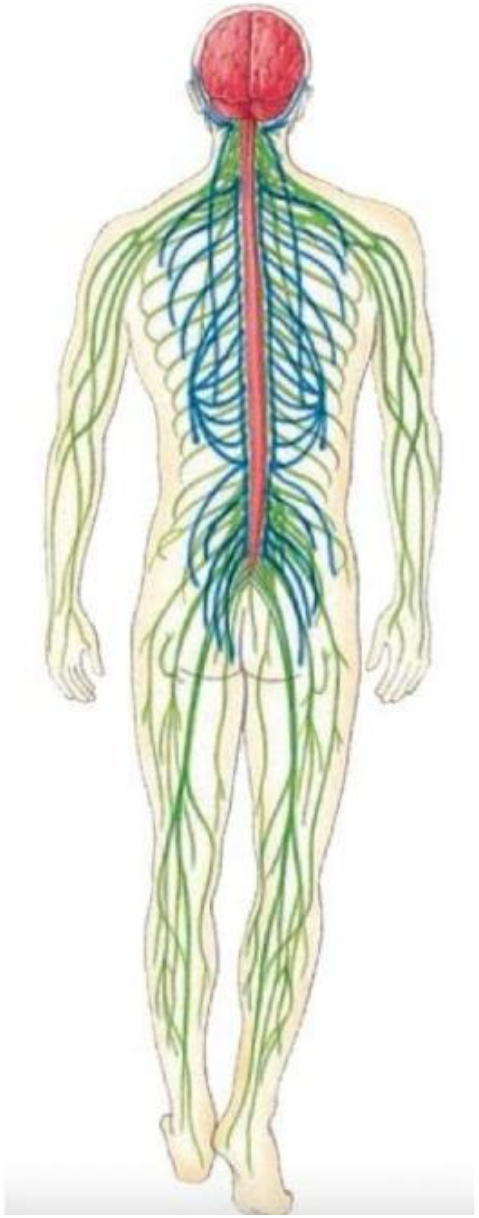
- The ultimate **goal is homeostasis**; Our bodies are constantly striving to maintain a stable internal environment. Regardless of what shifts occur in the external world, the nervous system acts as the primary regulator to pull the body back into a state of balance.

➢ To summarize, the nervous system is the body's **high-speed command center**, ensuring that despite constant environmental changes, our **internal equilibrium remains steady**.

Somatic Sensation(1)

- The primary function of the nervous system is **control**. To achieve this, the body must first obtain information about changes occurring both internally and externally. These changes are detected by specialized sensory receptors, a role known as the **sensory function** of the nervous system.

- Once this information is received, it must be processed to generate appropriate decisions and responses. Processing involves comparing and integrating new sensory input with previously stored information. This role is referred to as the **integrative function**, which takes place within the central nervous system (CNS), including the brain and spinal cord.



Somatic Sensation(2)

- As information is processed at progressively **higher levels** of the CNS, it becomes **more complex** and advanced (integrated). However, our understanding of these higher functions remains limited, because they are influenced not only by **biological** mechanisms but also by cognitive, emotional, and other **psychological** factors.
- After integration, the nervous system may produce several possible outcomes:
  1. One outcome is the **initiation of an immediate response** by altering the activity of effector organs. This includes changes in muscular activity, either contraction or relaxation, as well as modulation of glandular secretion, whether endocrine or exocrine.
  - ➢ This response is known as the **motor function** of the nervous system.

Somatic Sensation(3)

2. Another possible outcome is the **storage of information for future use**, allowing the nervous system to retain experiences and build memory.

- Alternatively, the nervous system may discard information that is not currently relevant. For example, during a lecture, a person is exposed to numerous sensory stimuli, such as the feeling of wearing a watch, the pressure of the chair, the surrounding temperature, or the scent of perfume. Despite this, the most prominent perception is typically the professor's voice, while **most other sensory inputs are filtered out and ignored**. In reality, a large proportion of incoming information is continuously discarded because it is not immediately important.

Somatic Sensation(4)

- The **selection** among these outcomes is **influenced by prior experiences** and existing thoughts. Consequently, the same sensory input may result in different responses in different individuals .

- For example, two friends may see the same dog and receive identical visual stimuli. However, the first person, who associates dogs with the risk of being bitten, may respond by running away. In contrast, the second person, who has a pet dog at home and positive experiences with dogs, may respond by approaching the animal and playing with it.

Functions of the nervous system

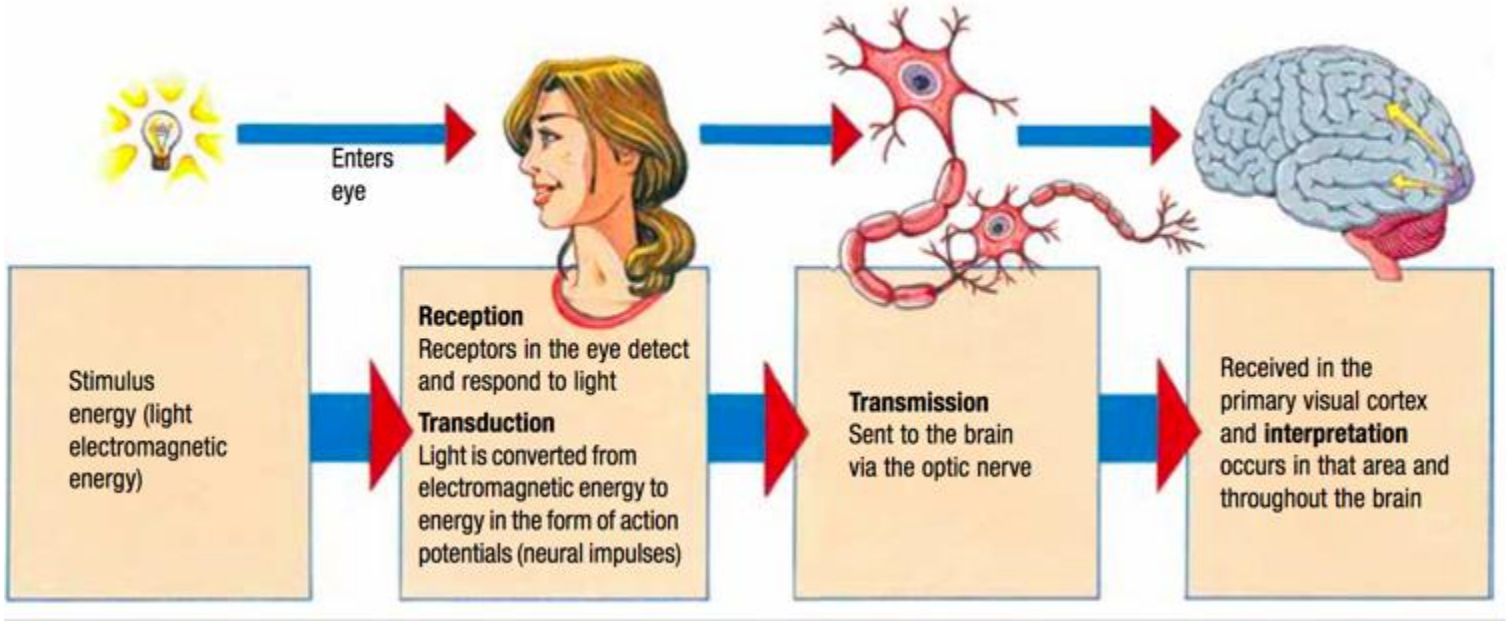
- **Sensory function**: sensory receptors detect internal or external stimuli. The sensory information is carried to the CNS through cranial and spinal nerves.

- **Integrative function**: processes sensory information by analyzing it and making decision for appropriate responses. Also called the decision-making function.

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

Sensation

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



Extra figure

The process of sensation

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

Sensory receptors

- Sensory receptors can be classified in several ways based on their location and the type of stimulus they detect:

1. **By location**:

   Receptors that respond to changes in the **external** environment are called **exteroceptors**, whereas those that monitor conditions within the **internal** environment are known as **enteroceptors**.

2. **By type of stimulus** (Modality):
   - **Mechanical**; **mechanoreceptors** respond to mechanical stimuli such as touch, pressure, vibration, or stretch (tactile sensation). Also, proprioception, hearing, balance, etc.
   - **Chemoreceptors** detect **chemical stimuli**, as in taste and smell.
   - **Thermal**; **thermoreceptors** respond to **changes** in **temperature**.
   - **Visual**; **photoreceptors** detect **light**.

Sensory receptors – Continued

- Classification of sensory receptors based on **sensory modalities** (type of stimulus) divides the senses into general and special senses:
    1. The **special senses** include the five well-defined modalities: vision, smell, taste, hearing, and balance (equilibrium).
    2. The remaining sensations are considered **general senses**, which are further divided depending on their location into:
        a. **Somatic senses,** those arising from the receptors of the skin, muscles, and joints.
        b. **Visceral senses,** for those arising from receptors located within or surrounding the internal organs (viscera).

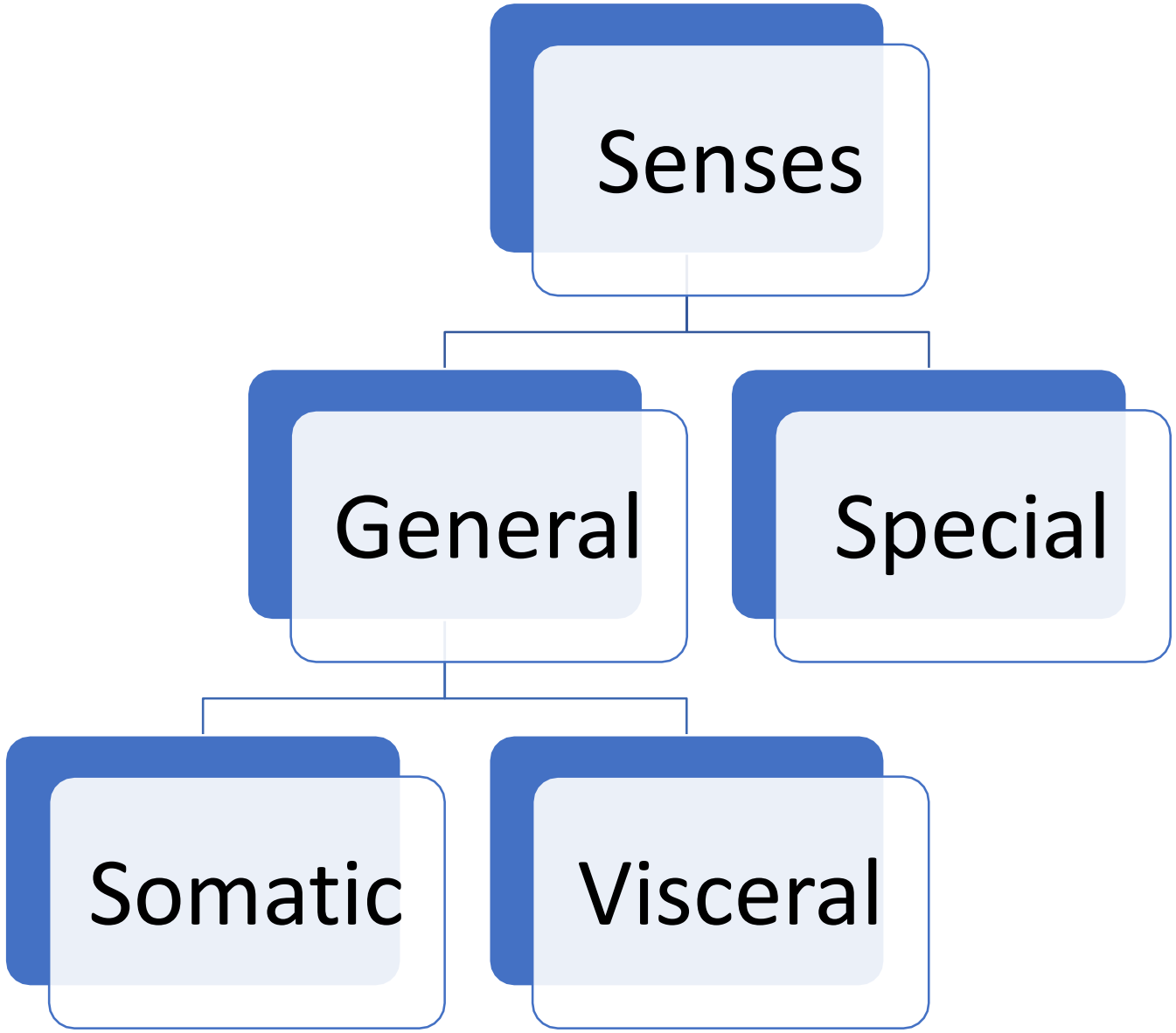
Further clarification in the next few slides.

Characteristics of sensory receptors

Differential sensitivity (Each type of receptor is specialized to respond to one type of stimulus)

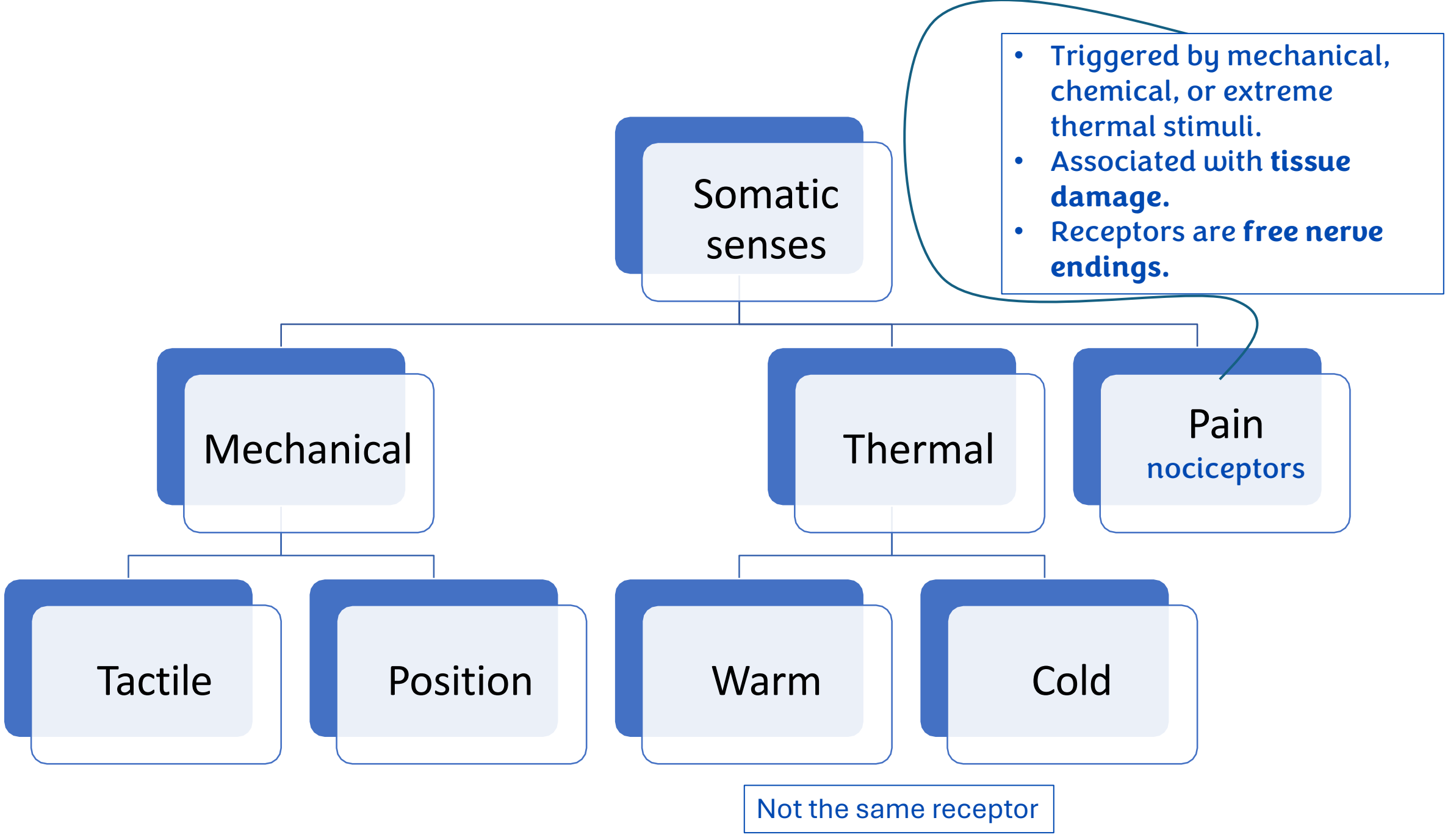
- While receptors were once called selective, now the term differential sensitivity is used.
- This means that while a receptor is **most sensitive to one type of stimulus**, it can occasionally respond to others if the force is strong enough.
  - ✓ For example:

    Photoreceptors in the eye's retina are designed for **light** (electromagnetic waves). However, if you are hit in the eye, the **physical pressure** deforms the eyeball and triggers those receptors. Because the brain only knows how to interpret signals from these cells as "light," you "see stars" or flashes, even in the dark.


Senses
General
Special
Somatic
Visceral

Somatic sensory receptors

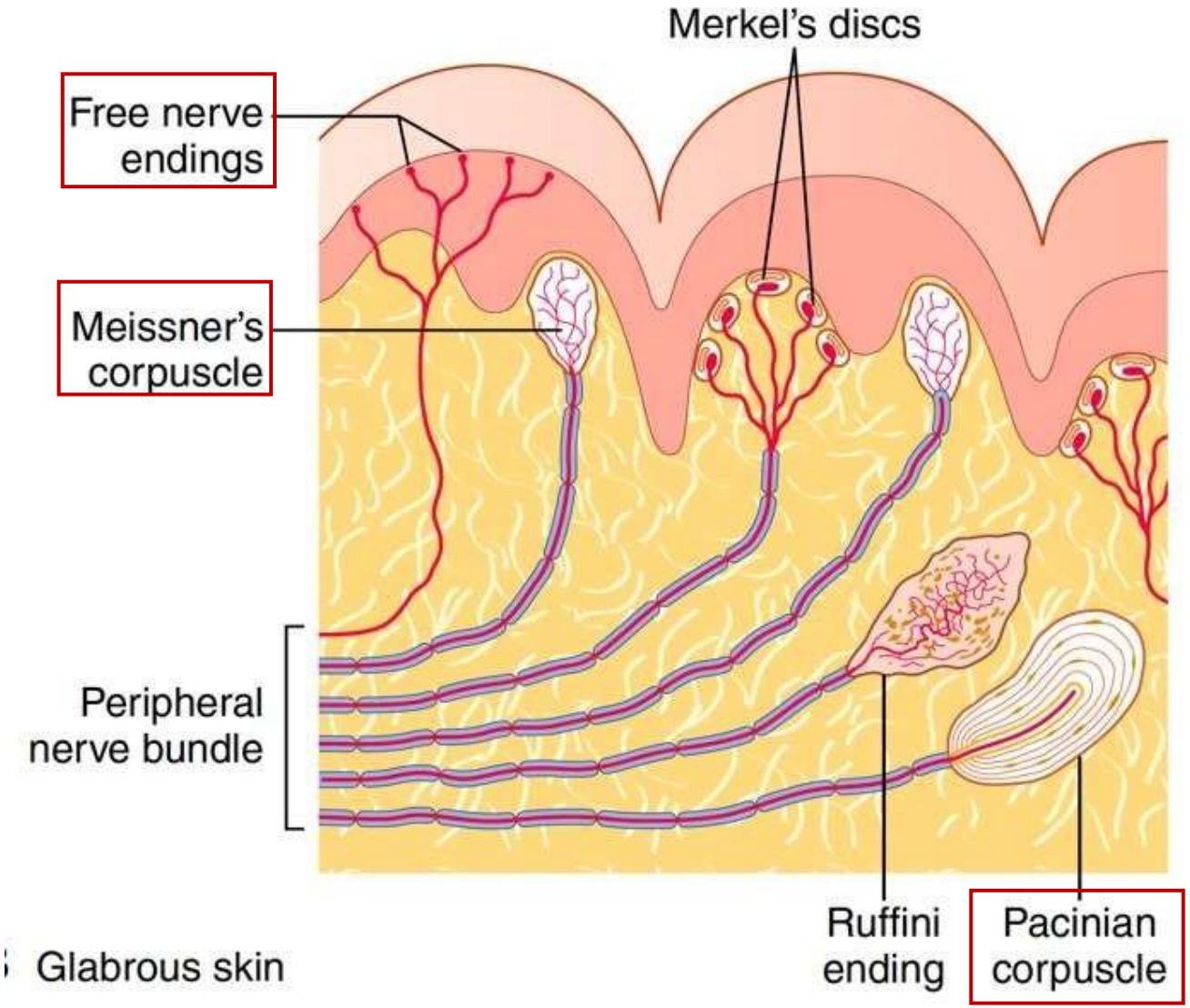
- Somatic sensations arise from stimulation of sensory **receptors embedded in** the:
  - Skin.
  - Subcutaneous layer.
  - Mucous membranes.
  - Skeletal muscles.
  - Tendons.
  - Joints.
- Somatic sensations can also be classified according to sensory modality. One major category is mechanical sensation, which includes **tactile** and **position** (proprioceptive) senses.


Somatic senses
Mechanical
Thermal
Pain
nociceptors
Tactile
Position
Warm
Cold
• Triggered by mechanical, chemical, or extreme thermal stimuli.
• Associated with **tissue damage.**
• Receptors are **free nerve endings.**
Not the same receptor

Somatic Sensation – **Tactile sensation**

- **Tactile sensations** consist of several modalities:
  - **Touch**: produced by slight deformation of the skin
  - **Pressure**: caused by deeper or more sustained deformation
  - **Vibration**: produced by repetitive or oscillatory stimuli
  - **Tickle**: caused by light movement across the skin.
  - **Itch**: typically triggered by mild chemical or mechanical irritation.
- Tactile receptors are widely distributed in the skin, subcutaneous tissue, and mucous membranes.

Tactile receptors



Has a sliced onion appearance

Sensory Receptors

❖ Structurally, sensory receptors may exist in two main forms:

1. **Specialized endings** of sensory neurons themselves.
2. **Separate specialized cells** (often epithelial in origin) that communicate with the first-order sensory neuron by releasing neurotransmitters.
   - ✓ An example is found in **taste receptors**, which are separate cells that synapse with sensory neurons.

➢ When the receptor is part of the neuron, it appears as a nerve ending, which may be either **free nerve endings** or **encapsulated endings**.

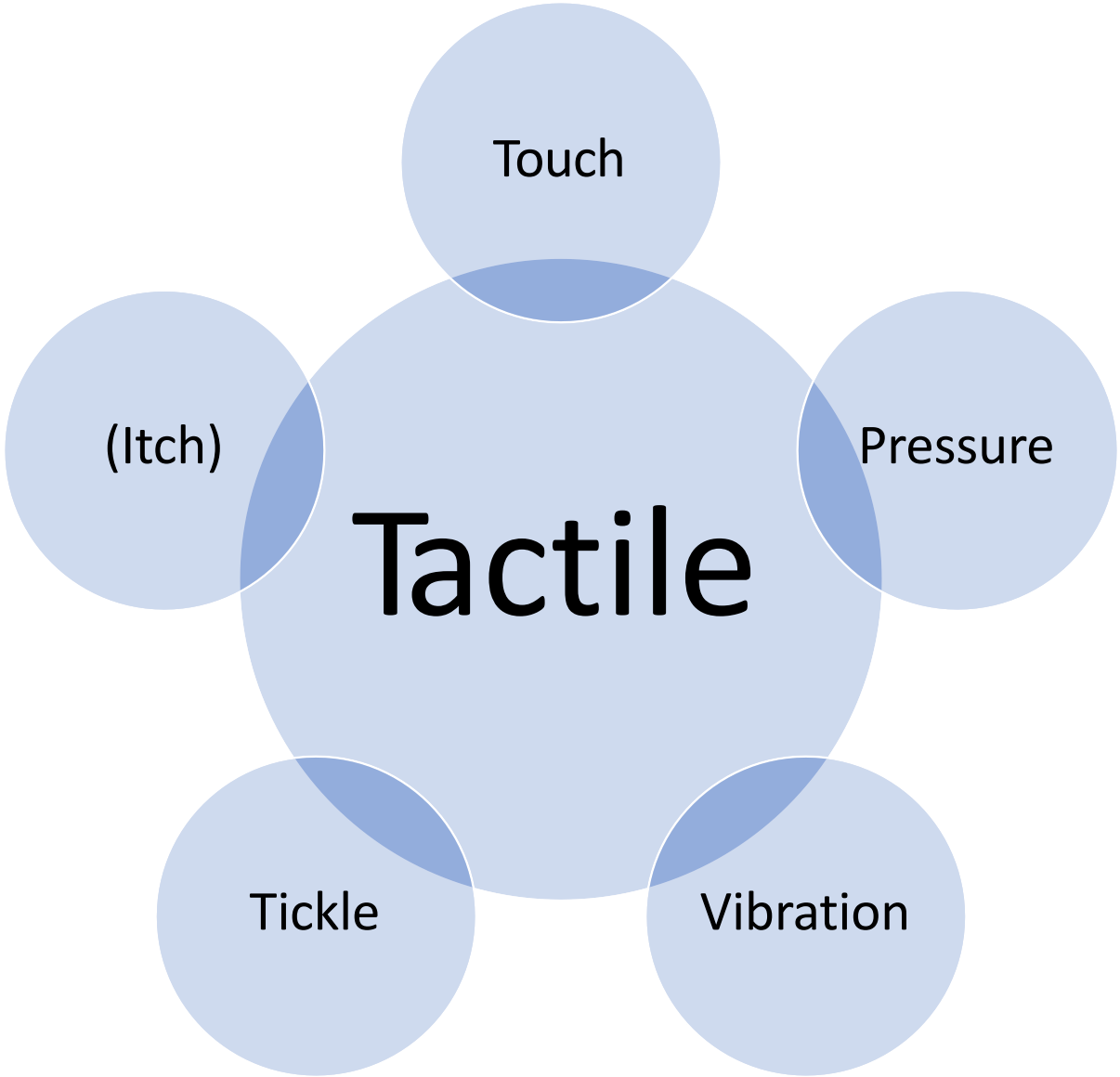
- **Most tactile mechanoreceptors are encapsulated**.
- For example, Pacinian corpuscles, located deep in the dermis and subcutaneous tissue, are specialized for sensing deep pressure and high-frequency vibration. In contrast, Meissner's corpuscles, which are positioned more superficially in the skin, are responsible for detecting light touch and low-frequency vibration.

Tactile senses

1. **Touch:** generally results from stimulation of tactile receptors in the skin or in tissues immediately beneath the skin.
2. **Pressure**: usually results from deformation of deeper tissues.
3. **Vibration**: results from rapidly repetitive sensory signals.
4. **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.
5. **Itch**

Tactile senses - **Itch**

- The purpose of the itch sensation is presumably to **call attention to mild surface stimuli** such as a flea crawling on the skin.
- The signals elicited then **activate the scratch reflex** or other maneuvers that rid the host of the irritant.
- Itch can be relieved by **scratching** if this action removes the irritant or if the scratch is **strong enough to elicit pain**.
- The pain signals are believed to suppress the itch signals in the cord by **lateral inhibition** (next lecture).


Touch
(Itch)
Pressure
Tactile
Tickle
Vibration

Position receptors (proprioceptors)

- Allow us to know **where our body parts are located** and **how they are moving** even if we are not looking at them, so that we can walk, type, or dress without using our eyes.

- Proprioceptors also allow **weight discrimination**, the ability to assess the weight of an object. This type of information helps to determine the muscular effort necessary to perform a task.

- For head position specifically, there are proprioceptive receptors in the inner ear that help maintain balance.

Position receptors (proprioceptors)

- Knowledge of position, both **static** and **dynamic**, depends on knowing the degrees of angulation of all joints in all planes and their rates of change.

- Therefore, multiple different types of receptors help to determine joint angulation and are used together for position sense. Both **skin tactile receptors** and **deep receptors near the joints** (most importantly) are used. Also, receptors located in the tendons, skeletal muscles and deep tissues participate.

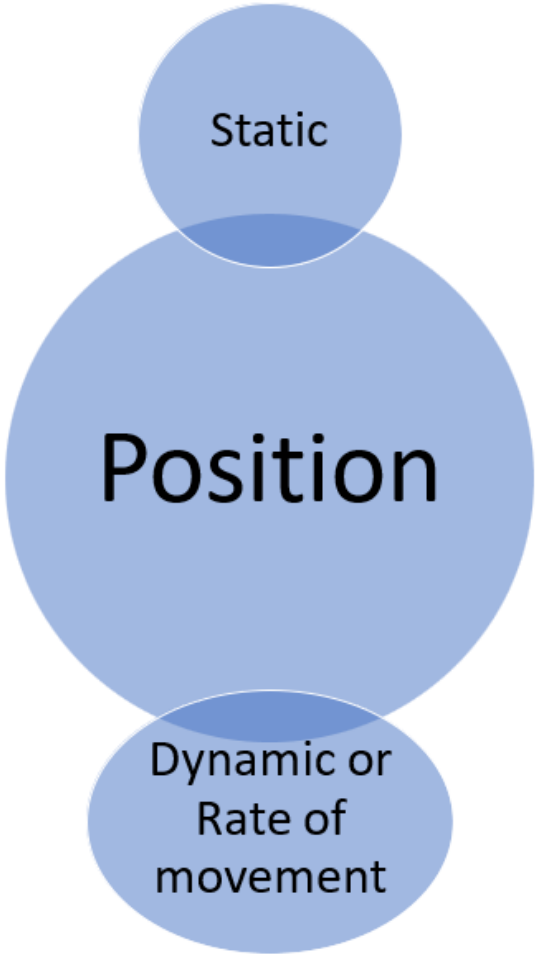
Position receptors (proprioceptors)

- Signals from these receptors must reach the central nervous system continuously and on time so that you can:
  - Maintain posture.
  - Maintain muscle tone.
  - Stay balanced even when static (even while sleeping).
  - Predict the next movement during motion.
- During movement, proprioceptive input helps the motor system calculate the current joint angles and body position, so it can predict and plan the next movement to maintain balance.

Position senses

- They are divided into two subtypes:

1. **Static position sense**, which means conscious perception of the orientation of the different parts of the body with respect to one another.
2. **Rate of movement sense**, also called kinesthesia or dynamic proprioception.



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 (receptor) potential, electrical energy, which is the main function of the receptor.

Graded potential vs Action potential

Types of changes in membrane potential

Feature	Graded (receptor) Potential	Action Potential
Amplitude	**Variable** (depends on stimulus strength)	Constant (**All-or-none**)
Polarity	Can be either depolarizing or hyperpolarizing	Always involves depolarization/repolarization
Distance	**Local** (short distance; decays over time)	Long-distance **propagation** (self-regenerating)
Summation	**Can summate** (temporal or spatial), No refractory period	**No summation** (due to refractory period)
Threshold	**No threshold** required to initiate	Requires reaching a **specific threshold**
Intensity Coding	Encoded by **amplitude**	Encoded by **frequency** of pulses
Voltage gated Channels requirement	None	Channels needed

If receptor potential reaches threshold, an action potential is generated and propagated along ascending sensory pathways to the integrating center.

The process of sensation

1. Stimulation of the sensory receptor.

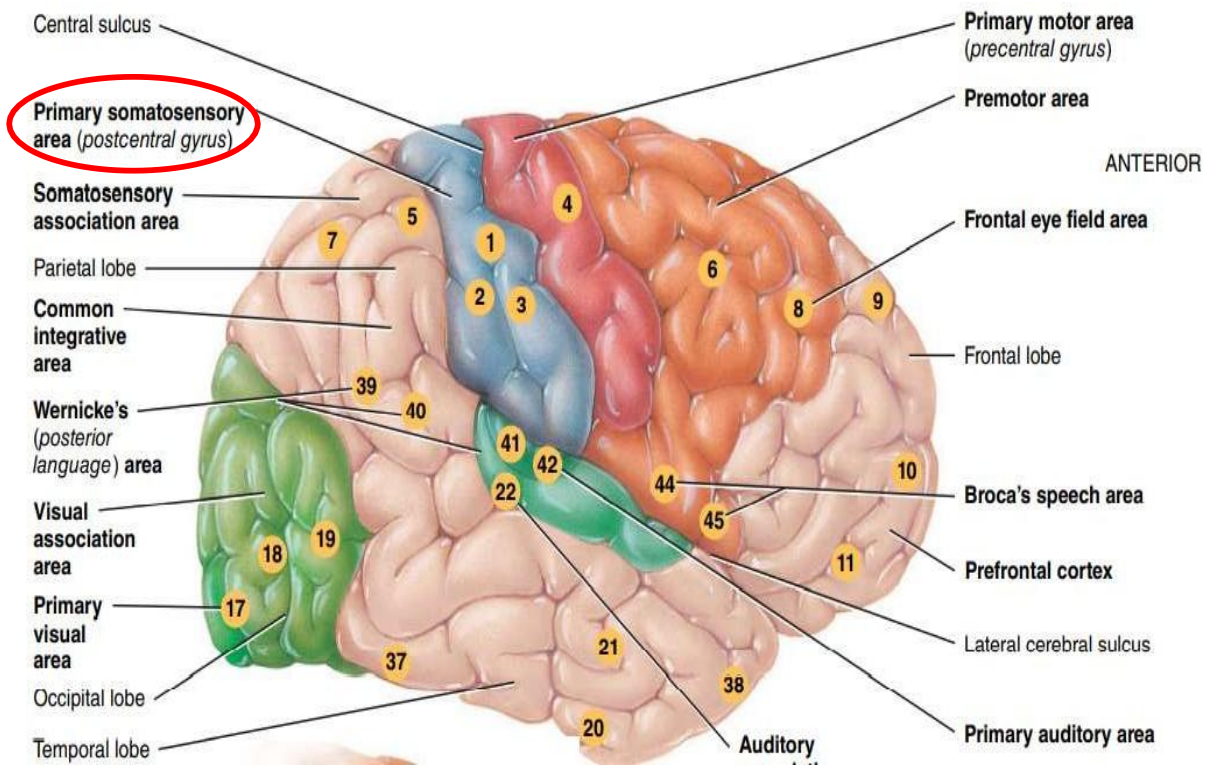
2. Transduction of the stimulus.

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.

Cerebral cortex

- The cerebral cortex is divided functionally into:
  - Sensory areas.
  - Motor areas.
  - Integrative (association) areas.
- From a sensory perspective, cortical areas are divided into:
  - Primary sensory areas.
  - Association sensory areas.
- The blue area is the primary somatosensory area in the postcentral gyrus of the parietal lobe.
  - It is the **first cortical area** that receives information from the periphery, through specific ascending pathways (**somatosensory pathways**).
  - It can tell the type and the location of the stimulus but does not provide a full interpretation.



- Whereas the **somatosensory associated area** is where more complex processing occurs. It gathers information from **multiple cortical regions** and other brain areas. And helps determine the intensity, duration, meaning of the stimulus, and specifically what caused it.

Perception

- The conscious interpretation of sensations and is primarily a function of the cerebral cortex.
- **Perception requires cortical integration.**
- **Somatic sensations** integrate in the **primary somatosensory area** in the cerebral cortex, thereby consciously. Association areas further interpret intensity, duration, and meaning.

✓ Special senses also have primary and association areas in the cortex.

- Visceral sensations integrate **subcortically**, so there is usually no conscious perception.

➢ Not every stimulus causes perception. It must be **strong enough** to generate receptor potential reaching threshold and produce action potentials.

Perception Vs. Sensation

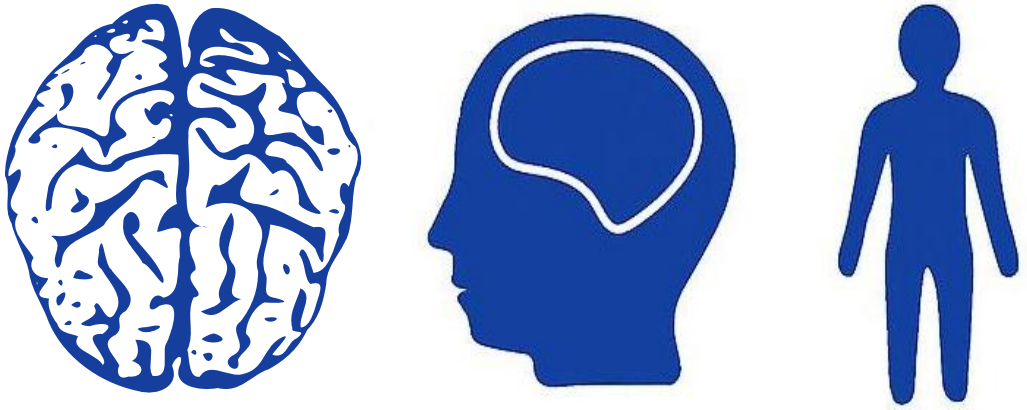
- **Sensation:** The awareness (conscious or subconscious) of a change.

  For example, **baroreceptors** sense blood pressure changes constantly, but you aren't "aware" of it.

- **Perception:** The conscious interpretation of a sensation. This only happens when the signal reaches the **Cerebral Cortex**.

✓ For a stimulus to reach the level of perception, it must be strong enough. A tiny insect might walk on your arm without you noticing (sub-threshold), but once it bites and causes an itch; the signal becomes strong enough for your cortex to perceive it.

Thank you



PHYSIOLOGY QUIZ LECTURE 1

External Resources

رسالة من الفريق العلمي

اللهم إن عمر عطية في ذمتك وحبل جوارك، فقِه من فتنة القبر وعذاب النار،
أنت أهل الوفاء والحق، فاغفر له وارحمه إنك أنت الغفور الرحيم.

يستحب للصائم الإكثار من الدعاء؛ لقوله صلى الله عليه وسلم: (ثَلَاثَةٌ لَا تُرَدُّ دَعْوَتُهُمْ: الْإِمَامُ الْعَادِلُ، وَالصَّائِمُ حَتَّى يُفْطِرَ، وَدَعْوَةُ الْمَظْلُومِ) رواه أحمد.
قال الإمام النووي رحمه الله: "يُسْتَحَبُّ لِلصَّائِمِ أَنْ يَدْعُوَ فِي حَالِ صَوْمِهِ بِمُهِمَّاتِ الْآخِرَةِ وَالدُّنْيَا لَهُ وَلِمَنْ يُحِبُّ وَلِلْمُسْلِمِينَ" [المجموع:6/ 375].

روى البخاري عن ابن عباس رضي الله عنهما قال: " كَانَ رَسُولُ اللَّهِ صَلَّى اللهُ عَلَيْهِ وَسَلَّمَ أَجْوَدَ النَّاسِ، وَكَانَ أَجْوَدُ مَا يَكُونُ فِي رَمَضَانَ حِينَ يَلْقَاهُ جِبْرِيلُ، وَكَانَ يَلْقَاهُ فِي كُلِّ لَيْلَةٍ مِنْ رَمَضَانَ فَيُدَارِسُهُ القُرْآنَ، فَلَرَسُولُ اللَّهِ صَلَّى اللهُ عَلَيْهِ وَسَلَّمَ أَجْوَدُ بِالخَيْرِ مِنَ الرِّيحِ المُرْسَلَةِ".

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Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			