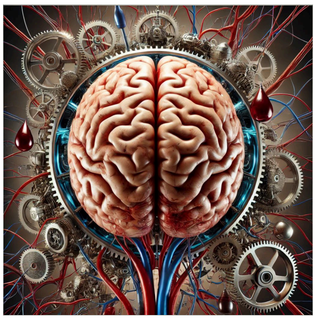


CNS—physiology~1
Written by: Dr.Ali Abujammil

Neurophysiology is a branch of neuroscience that studies how the nervous system functions regarding electrical and chemical activity within neurons. This field focuses on understanding how neural signals travel within the brain, spinal cord, and peripheral nerves and their role in regulating various bodily functions.

Neurophysiology is fundamental for understanding various biological processes, such as the generation and transmission of electrical signals across neurons, how neurons communicate through synapses, the role of neurotransmitters in signal transmission, and how the nervous system responds to internal and external stimuli. It also explains the nervous system's role in controlling movement, perception, and behavior.

Relevance to Neurosurgery, A deep understanding of neurophysiology is crucial for neurosurgeons, as it helps in: Diagnosing neurological disorders such as epilepsy, strokes, and neurodegenerative diseases and Precisely locating brain or spinal cord injuries using techniques like EEG (Electroencephalography) and EMG (Electromyography) and Guiding delicate surgical procedures, such as Deep Brain Stimulation (DBS) for treating Parkinson's disease.

The nervous system has three main functions:

1. Sensory Function: Sensory receptors detect stimuli, whether internal (e.g., blood pressure changes) or external (e.g., touching a hot object); Sensory information is transmitted to the CNS via cranial and spinal nerves.

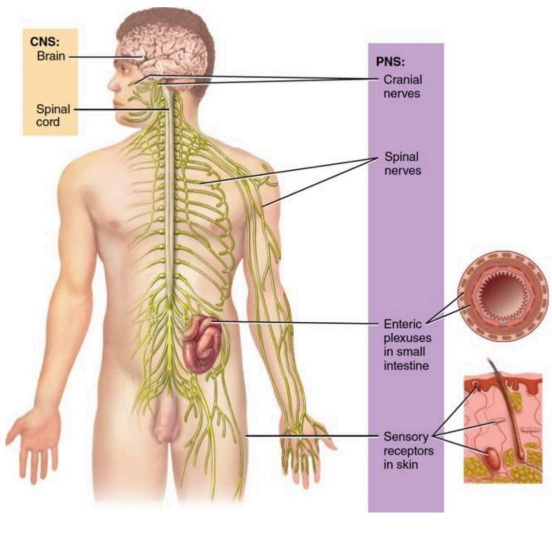
2. Integrative Function: The nervous system processes sensory information by analyzing it, comparing it with past experiences, and making decisions for appropriate responses; This function is responsible for perception, learning, and memory.

3. Motor Function: Effectors (muscles and glands) are activated through cranial and spinal nerves, leading to motor responses such as muscle movement or hormone secretion.

Key Roles of CNS and PNS

1. Central Nervous System (CNS): Collects sensory information and Processes, compares, and integrates information with previous experiences also Decides the appropriate motor response.

2. Peripheral Nervous System (PNS): Transmits sensory information from the periphery to the CNS via the Sensory Nervous System and Transmits motor responses from the CNS to effectors via the Motor Nervous System.



Divisions of the Nervous System

1. **Central Nervous System (CNS): Brain and Spinal Cord.**

2. **Peripheral Nervous System (PNS): The Somatic Nervous System (SNS), Controls voluntary movements and transmits sensory information to the CNS, and the Autonomic Nervous System (ANS), Regulates involuntary functions like heart rate, breathing, and digestion; also we have Enteric Nervous System (ENS), Independently controls digestive system functions.**

Somatic and Special Sensory Receptors

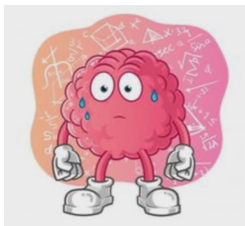
1. Somatic Sensory Receptors: Detect changes in muscles, skin, and joints, such as pain, pressure, and temperature.

2. Special Sensory Receptors: Responsible for special senses like vision, hearing, smell, and taste.

Sensation is the conscious or subconscious awareness of changes in the external or internal environment. These changes may include: Feeling external temperature (e.g., warm air or cold water) or Internal changes such as fluctuations in blood pressure or glucose levels.

Perception vs. Sensation: Sensation can be either conscious or subconscious, meaning the body can respond to stimuli without full awareness while Perception is the conscious interpretation of sensory information, primarily controlled by the cerebral cortex.

Examples of Sensation vs. Perception: When you touch a hot surface, sensory receptors send signals to the brain—this is sensation while When the brain interprets that the surface is hot and triggers a withdrawal response—this is perception.



Perception is the conscious interpretation of sensory input from our environment. However, a fundamental question arises: Is reality exactly as we perceive it?

Does Our Perception Accurately Reflect Reality? The answer is complex because perception is influenced by multiple factors:

1. The Brain Interprets Reality, Not Just Reflects It: The brain processes sensory information based on past experiences, meaning what we perceive may not be an exact representation of reality.

2. The Limits of Human Senses: Human senses are limited; we cannot see ultraviolet light or hear all sound frequencies, indicating that parts of reality are beyond our perception.

3. Psychological and Cognitive Influences: Emotions, expectations, and cognitive biases shape perception, making it subjective rather than purely objective.

4. Sensory and Perceptual Illusions: Optical illusions demonstrate that our brains can be tricked, proving that perception does not always align with objective reality.

Perception is not a perfect mirror of reality but rather a mental representation shaped by sensory input and brain processing. Therefore, the world as we perceive it may not be the world as it truly is.

The Process of Sensation

Stimulation of the Sensory Receptor: Sensory receptors are specialized structures that detect environmental changes and convert them into neural signals; Sensory receptors can be: Free nerve endings found in pain and temperature receptors or Encapsulated nerve endings found in pressure and vibration receptors or Specialized receptor cells found in the retina for vision or cochlea for hearing.

Differential Sensitivity: Each receptor type is specialized to detect a particular stimulus; For Example: Photoreceptors in the retina respond only to light, while pressure receptors respond to mechanical force.

Transduction of the Stimulus: In this step, the sensory receptor converts the stimulus energy into an electrical signal within the neuron; This process occurs by altering the receptor's membrane permeability, leading to the influx of positive ions (e.g., Na^+ or Ca^{2+}), Change in membrane potential, generating a Receptor Potential, If the receptor potential is strong enough, it triggers an Action Potential; Example: Photoreceptors in the eye, Light triggers chemical changes in visual pigments, opening ion channels and generating an electrical signal or Olfactory receptors in the nose, Chemical molecules bind to receptors, triggering electrical responses.

Generation of Nerve Impulses: When the receptor potential reaches the threshold, an action potential is generated in the sensory neuron; The action potential travels through afferent neurons to the CNS, The Mechanism of Nerve Impulse Transmission is A strong receptor potential opens Na^+ channels in the neuron membrane This causes depolarization, leading to an action potential, The action potential travels along the axon using saltatory conduction in myelinated fibers, increasing transmission speed, Signals reach synapses, where they are relayed to other neurons in the CNS.

Integration of Sensory Input: Sensory signals are processed in specialized regions of the central nervous system (CNS), particularly the brain and spinal cord; The location of sensory processing depends on the type of sensation: Somatosensory Cortex Processes touch, pain, and temperature; Visual Cortex Analyzes visual information from the eyes; Auditory Cortex Processes sound signals from the ears; Olfactory Cortex Interprets smells from the nose; Once processed, an appropriate motor response is generated, such as moving a hand away from heat or recognizing an object visually.

Sensory Modalities:

1. General Senses:

A. Somatic Senses: Touch Sensation (Tactile Sensation) Detected by mechanoreceptors such as Meissner's Corpuscles Sensitive to light touch or Pacinian Corpuscles Respond to deep pressure and vibration and Temperature Sensation (Thermal Sensation) Cold receptors Active between 10–40°C and Warm receptors Active between 32–48°C also Pain Sensation Detected by nociceptors, responding to mechanical, thermal, or chemical stimuli that cause tissue damage.

B. Visceral Senses: Detect changes in internal organs, such as blood vessel dilation or oxygen levels; These signals are mostly unconscious but are used to regulate bodily functions.

2. Special Senses: Olfaction (Smell) is Detected by receptors in the olfactory epithelium and Gustation (Taste) is Processed by taste buds on the tongue Vision Occurs through photoreceptors in the retina and Hearing is Detected by receptors in the cochlea of the inner ear and Balance Maintained by the vestibular system in the inner ear.

Expanded Steps of the Sensation Process

1. Stimulation of the Sensory Receptor: The receptor detects a specific stimulus from the environment.

2. Transduction of the Stimulus: The receptor converts stimulus energy into a graded potential (electrical signal).

3. Generation & Transmission of Nerve Impulses: If the graded potential reaches the threshold, an action potential is sent to the CNS.

4. Processing & Integration in the CNS: The brain or spinal cord receives, analyzes, and interprets the signal, leading to an appropriate response.

A receptive field refers to the specific area in which a sensory neuron can detect and respond to a stimulus; Each sensory neuron is activated only when a stimulus occurs within its receptive field; is crucial in understanding sensory perception, spatial resolution, and discrimination ability.

The size of a receptive field is inversely proportional to the density of sensory receptors in that region; High receptor density → Small receptive fields → Greater sensory precision while Low receptor density → Large receptive fields → Lower sensory precision; For Example: Fingertips and lips have small receptive fields and high receptor density, making them highly sensitive to touch while The back and thighs have large receptive fields and low receptor density, leading to lower tactile resolution.

Sensory acuity refers to the ability to distinguish between two closely spaced stimuli; Two-Point Discrimination Test: This test determines how well an individual can differentiate between two points of contact on the skin; If two stimuli fall within the same receptive field, they are perceived as one stimulus while If they fall into separate receptive fields, they are perceived as two distinct stimuli; Regions with smaller receptive fields (e.g., fingertips) have better two-point discrimination, meaning they can distinguish between two close stimuli more accurately.

Receptive Fields in Different Sensory Systems:

1. Somatosensory System (Touch and Pressure): The receptive field of mechanoreceptors determines touch sensitivity; Example: Merkel cells (high precision) vs. Pacinian corpuscles (low precision).

2. Visual System (Vision and Light Detection): Retinal ganglion cells have receptive fields where they detect light and contrast; Smaller receptive fields in the fovea allow for sharp vision, while larger receptive fields in the peripheral retina detect motion and low-light stimuli.

3. Auditory System (Hearing): Cochlear hair cells have frequency-specific receptive fields that allow the detection of different sound frequencies.

4. Olfactory and Gustatory Systems (Smell and Taste): Olfactory neurons have overlapping receptive fields that detect various chemical compounds; Taste buds have receptive fields for different taste modalities (sweet, sour, bitter, salty, umami).

Uneven Distribution of Somatic Sensory Receptors: Somatic sensory receptors are not evenly distributed across the body; Certain areas have a higher density of receptors, making them more sensitive to touch, pressure, temperature, and pain; Other areas have fewer receptors, leading to reduced sensory perception.

Regions with the Highest Density of Somatic Sensory Receptors:

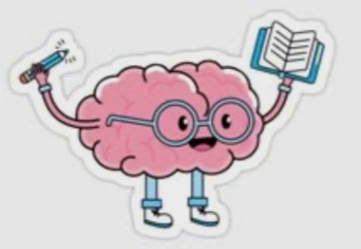
1. Tip of the Tongue: Contains a high concentration of mechanoreceptors and thermoreceptors, making it extremely sensitive to touch and temperature changes; Also has numerous taste receptors, enhancing gustatory perception.

2. Lips: Packed with tactile receptors (Meissner's corpuscles), making them highly responsive to light touch and vibrations; Essential for speech, eating, and sensory exploration.

3. Fingertips: Contain a high density of mechanoreceptors, especially Merkel cells (fine touch) and Meissner's corpuscles (light touch); Allow for precise tactile discrimination, enabling activities like reading Braille and detecting small texture differences.

Regions with Lower Density of Sensory Receptors: The back, arms, and legs have fewer somatic sensory receptors, leading to lower tactile sensitivity; These areas have larger receptive fields, making it difficult to distinguish between closely spaced stimuli.

Functional Significance of Uneven Distribution: The high density of sensory receptors in certain areas enhances tactile discrimination and sensitivity; The somatosensory cortex of the brain allocates more processing power to regions with high receptor density (as seen in the sensory homunculus).



Lateral inhibition is a neural mechanism used by the central nervous system (CNS) to sharpen contrast and enhance sensory perception, helps in precisely localizing a stimulus by inhibiting adjacent, less excited pathways, thus improving the clarity of sensory signals.

Mechanism of Lateral Inhibition:

1. Sensory neurons in a receptive field detect a stimulus and send signals to the CNS.

2. The strongest (most activated) neuron—typically located at the center of the stimulus—inhibits weaker neighboring neurons by stimulating inhibitory interneurons.

3. Inhibitory interneurons reduce the activity of adjacent, weaker sensory pathways.

4. This enhances the contrast between the primary stimulus and the surrounding area, allowing for sharper perception and better spatial resolution.

Functional Importance of Lateral Inhibition: Enhances contrast between stimuli by reducing "noise" from surrounding areas and Improves spatial resolution, allowing the brain to pinpoint the exact location of a stimulus also Refines sensory information, making perception more precise.

Lateral inhibition is particularly important in sensory systems that require high spatial resolution, such as:

1. Touch (Somatosensory System): Occurs in the somatosensory cortex, where tactile signals from the skin are processed; Helps distinguish between two closely spaced touch stimuli (two-point discrimination); Example When touching a sharp object, the brain can accurately determine the precise contact point.

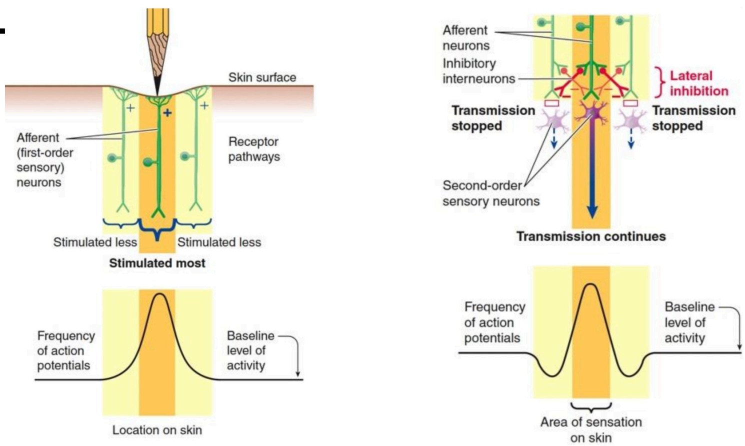
2. Vision (Visual System): Occurs in the retina, where photoreceptors (rods and cones) interact with horizontal and amacrine cells to enhance contrast; Sharpens edges and borders in images, allowing us to see clear, well-defined objects; For Example Reading text—lateral inhibition helps distinguish between letters and spaces.

Lateral Inhibition in Other Sensory Systems:

Hearing (Auditory System): Helps differentiate between similar sound frequencies.

Olfaction (Smell): Enhances contrast between different odor molecules to improve scent discrimination.

The image depicts the mechanism of lateral inhibition in the nervous system. This mechanism demonstrates how the precision of sensory perception is enhanced by inhibiting neural signals



from neurons adjacent to the primarily stimulated neuron; The diagram shows two main aspects:

Left side: This side represents the effect of a stimulus (e.g., pressure from a pencil) on the skin's surface. It shows that the sensory neurons (Afferent neurons) directly under the point of pressure are strongly stimulated (Stimulated most) while neighboring neurons are stimulated to a lesser extent (Stimulated less). The graph below this side shows the distribution of action potential frequency across the skin area, with the highest frequency at the point of pressure and gradually decreasing as the distance from this point increases Right side: This side illustrates the mechanism of lateral inhibition. When sensory neurons are strongly stimulated, they release neural signals that inhibit neighboring neurons via inhibitory interneurons. This inhibition reduces the activity of neighboring neurons, preventing them from sending strong signals to the central nervous system. The graph below this side shows that the sensory area on the skin becomes sharper due to this inhibition, with a reduced frequency of action potentials in areas adjacent to the pressure point.

The Process of Lateral Inhibition:

1. Stimulation: When a sensory receptor (e.g., pressure receptors in the skin) is stimulated, the sensory neurons (Afferent neurons) release neural signals.

2. Inhibition: In addition to sending signals to the central nervous system, the strongly stimulated sensory neurons also release signals that inhibit neighboring neurons through inhibitory interneurons.

3. Effect: This inhibition reduces the activity of neighboring neurons, enhancing the spatial resolution of sensation. In other words, the sensation becomes sharper and more focused at the stimulation point, while signals from neighboring areas reduce blurring.

Importance of Lateral Inhibition: improved spatial resolution in various senses, including touch, vision, and hearing. It helps to distinguish edges and fine details in sensory stimuli. Without lateral inhibition, the sensation would be less precise and less distinct.

Receptor Potential and Stimulus Intensity

Receptor potential refers to the change in membrane potential that occurs when a sensory receptor is activated by a stimulus; The magnitude of the receptor potential reflects the intensity of the stimulus: Stronger stimuli produce larger receptor potentials while Weaker stimuli result in smaller receptor potentials; Larger receptor potentials lead to a greater frequency of action potentials in the afferent (sensory) neuron; The frequency of action potentials is a key mechanism for encoding the strength of the stimulus; A larger receptor

potential cannot increase the size of the action potential (since action potentials are all-or-nothing events), but it can cause faster firing rates of action potentials.

Stimulus Strength and Area Stimulated

The size of the area affected by a stimulus is also an important factor in determining stimulus intensity: Stronger stimuli generally activate a larger area of receptors; More receptors being activated leads to a stronger perception of the stimulus; For example, painful stimuli often activate multiple pain receptors over a larger area, enhancing the perceived intensity.

Temporal and Spatial Summation

1. Temporal Summation: Refers to the rate of action potentials generated in a sensory neuron; A stronger stimulus causes higher frequency firing of action potentials in a given neuron, summing up over time; This increase in firing rate conveys the intensity of the stimulus to the CNS.

2. Spatial Summation: Involves the activation of multiple sensory receptors across a larger area; The more receptors activated by the stimulus, the greater the intensity perceived; This helps the brain interpret the spatial extent of the stimulus.

True or False Question: “Stimuli of the same intensity always result in receptor potentials of the same magnitude in the same receptor.”

False: Although stimuli of the same intensity generally result in similar receptor potentials, the exact magnitude of the receptor potential can vary slightly due to individual receptor characteristics (e.g., receptor sensitivity or adaptation); Additionally, factors such as receptor adaptation, the time duration of stimulus application, and the specific type of receptor involved can influence the magnitude of the receptor potential.

Adaptation in Sensory Receptors

Adaptation refers to the process by which a sensory receptor becomes less responsive to a constant, unchanging stimulus over time. The receptor potential decreases in amplitude as the stimulus persists, meaning the receptor responds less to the stimulus the longer it is applied; As a result, the perception of the sensation may fade or disappear, even though the stimulus remains; Adaptation allows the sensory system to focus on new or changing stimuli rather than constantly responding to background or unchanging stimuli.

Types of Sensory Receptor Adaptation, Sensory receptors can be categorized based on how they adapt to a stimulus:

1. Tonic Receptors: slowly adapt to a constant stimulus but continue to fire action potentials for as long as the stimulus is present; They provide continuous information about the stimulus, allowing the CNS to monitor the intensity and duration of the stimulus; Example: Pain receptors (nociceptors) and proprioceptors in muscles and joints, which help the body maintain posture and awareness of body position; Example in practice: A person may feel continuous pain from a bruise, but the intensity may not change over time, even though the stimulus (pressure or injury) persists.

2. Phasic Receptors: rapidly adapt to a stimulus and cease firing action potentials once the stimulus becomes constant; They are highly sensitive to changes in the stimulus but do not respond well to a sustained stimulus also They are critical for detecting temporal changes and new stimuli rather than maintaining continuous awareness of the same stimulus; Example: Touch receptors (e.g., Meissner's corpuscles) that respond to vibration or light touch, and olfactory receptors that detect odors; Example in practice: When you put on a shirt, you feel the sensation of the fabric initially, but after a few moments, the sensation fades because your skin's touch receptors adapt.

Importance of Adaptation in Sensory Systems:

Focus on change: Adaptation helps the nervous system prioritize new or changing stimuli; For example, if you walk into a room with a strong odor, your olfactory receptors initially respond, but quickly adapt to the smell, allowing you to focus on other stimuli in the environment.

Prevents sensory overload: Continuous stimuli that do not change are filtered out, preventing the nervous system from being overwhelmed with irrelevant information; Example: Your body adapts to the sensation of your clothes on your skin so you are not constantly aware of them.

Practical Examples of Sensory Adaptation:

Vision: When you enter a dark room, your photoreceptors adapt to the low light, allowing you to see better after a few moments.

Touch: If you hold a cup in your hand for a prolonged period, you may no longer feel its weight, as your touch receptors adapt.

Hearing: After a loud noise, the auditory system may adapt, and the initial perception of loudness decreases, even though the sound continues at the same intensity.

The Labeled Line Principle refers to the concept that, although all sensory information is transmitted to the central nervous system (CNS) through the same type of signal (action potentials), the type and location of the stimulus can still be uniquely identified by the brain; This is possible because each sensory modality (such as touch, pain, or temperature) is transmitted along a specific pathway that corresponds to that specific type of sensory information.

How the Labeled Line Principle Works:

1. Sensory Receptors: Specialized sensory receptors are sensitive to specific types of stimuli. For example, thermoreceptors detect temperature, nociceptors detect pain, and mechanoreceptors detect touch; Each type of receptor converts the stimulus into an electrical signal, known as a receptor potential, which can then trigger action potentials.

2. Afferent Pathways: Each type of receptor is linked to a specific afferent (sensory) neuron. These neurons form ascending pathways in the spinal cord and brainstem, which carry the action potentials to the somatosensory cortex in the brain; These pathways are distinct for

each sensory modality, meaning that touch information does not travel along the same pathway as pain information, and so on.

3. Cortex Processing: The action potentials from the specific pathways are processed by the brain, which decodes both the type of stimulus and the location from which it originated; The brain can map each pathway to a specific location in the somatosensory cortex, which corresponds to different parts of the body (e.g., hands, lips, etc.).

4. Separation of Information: The brain keeps different types of sensory information separated by maintaining distinct labeled lines between the periphery (sensory receptors) and the cortex (processing area); This separation ensures that the brain can accurately interpret different types of sensory input without interference, allowing for precise perception.

Significance of the Labeled Line Principle:

Specialization of Pathways: Different sensory modalities are encoded through distinct neural pathways, allowing the brain to process and interpret each type of information separately and accurately.

Localization of Stimuli: The brain can identify where a stimulus is located on the body, thanks to the somatotopic organization of the sensory pathways (represented as the sensory homunculus).

Efficient Sensory Processing: By keeping sensory modalities in separate "labeled lines," the brain can quickly process and respond to different types of sensory input without confusion.

Example of Labeled Line Principle

Touch vs. Pain: When you touch something hot, thermoreceptors and nociceptors will be activated. These receptors will send signals through separate pathways—the thermoceptive pathway and the nociceptive pathway; The brain will receive these signals and know that the sensation is related to temperature or pain based on the specific pathway and receptor that was activated. This helps the brain process the stimulus as hot or painful without confusion.

Somatic sensations arise from the activation of sensory receptors embedded in various tissues of the body. These sensations provide important information about the body's external and internal environment, helping us respond to stimuli like touch, pain, temperature, and body position, sensory receptors for somatic sensations are located in the following areas: Skin, Subcutaneous layer (beneath the skin), Mucous membranes (lining body cavities), Skeletal muscles, Tendons, Joints.

Somatic senses can be divided into three primary categories based on the types of stimuli they detect:

1. Mechanoreceptive Senses: These senses detect mechanical changes in the environment, such as touch, pressure, vibration, and body movement. Mechanoreceptors are sensitive to physical forces like deformation, vibration, and stretching.

• Tactile Senses: Touch Detects light contact with the skin, Pressure Senses sustained force or deep touch applied to the skin, Vibration Detects oscillations or rapid changes in pressure, Tickle sensation caused by light, repetitive touch, often resulting in reflex responses like laughter, Itch sensation triggered by chemical irritants, typically in the skin.

• Position Senses: These senses help detect the position and movement of body parts in space; Static position sense (proprioception): Monitors the position of body parts at rest and Rate of movement sense Detects the speed at which body parts move.

Examples of mechanoreceptors: Merkel discs Detect pressure and texture, Meissner's corpuscles Detect light touch and vibration, Pacinian corpuscles Detect deep pressure and vibration, Ruffini endings Detect skin to stretch and joint position.

2. Thermoreceptive Senses: detect temperature changes. These sensations are provided by thermoreceptors, which are sensitive to heat and cold; Cold receptors are Found mostly in the skin and are sensitive to temperatures lower than body temperature while Warm receptors are Also found in the skin and respond to temperatures higher than body temperature; These receptors are typically free nerve endings found in the dermis and epidermis of the skin; Examples: Free nerve endings in the skin Detect both cold and warmth.

3. Pain Senses (Nociception): Pain is a crucial somatic sense that alerts the body to potential damage or injury. Pain receptors, called nociceptors, detect harmful stimuli; Mechanical pain is Caused by physical damage like cutting or squeezing, Thermal pain is Caused by extremes in temperature (e.g., burning or freezing) and Chemical pain is Caused by the release of chemicals (e.g., from inflammation or injury); Polymodal nociceptors These receptors respond to multiple types of noxious stimuli (mechanical, thermal, and chemical); Examples: Nociceptors in the skin, muscles, and internal organs detect painful stimuli and transmit the signal to the CNS for processing.

Tactile sensations refer to the perception of touch, pressure, vibration, and tickling, all of which are detected by specialized sensory receptors in the skin and tissues beneath the skin. These sensations provide essential information about the body's interaction with the external environment, including physical contact and texture.

Types of Tactile Sensations

1. Touch: generally arises from the stimulation of tactile receptors located in the skin or in tissues just beneath the skin, sensation is typically associated with light, local contact with an object, such as a gentle tap or brushing sensation.

2. Pressure: a more sustained sensation felt over a larger area, usually from the deformation of deeper tissues, resulting from force applied to the skin that compresses deeper layers, such as pressing on your skin with your hand.

3. Vibration: results from repetitive sensory signals generated by rapid oscillations or movement, such as the feeling of a vibrating phone or a vibrating surface; Different frequencies of vibration are detected by specific types of receptors.

Common Tactile Receptors, Although touch, pressure, and vibration are often classified separately, they are all detected by similar types of mechanoreceptors in the skin. These receptors vary in their sensitivity to different types of tactile stimuli, including frequency and depth of stimulation; Some tactile receptors are specifically tuned to detect vibrations at specific frequencies of oscillation; Types of tactile receptors involved in detecting these sensations include:

1. Meissner's Corpuscles: Detect light touch and vibration (especially low-frequency vibration); Located in dermal papillae (the upper layer of the dermis), especially in areas like fingertips and lips.

2. Pacinian Corpuscles: Detect deep pressure and high-frequency vibration; Found in the deeper layers of the skin and tissues like joints and the peritoneum.

3. Merkel Discs: Detect sustained pressure and texture; Located in the epidermis, particularly in areas sensitive to touch like fingertips.

4. Ruffini Endings: Detect skin stretch and joint position; Located in the deep layers of the skin and around joint capsules.

Additional Tactile Sensations

1. Tickling: occurs when someone else touches you, rather than when you touch yourself, may be due to the impulses traveling to the cerebellum (involved in movement control) when you touch yourself, which doesn't happen when someone else tickles you, leading to the unique sensation.

2. Itch: usually induced by chemicals, such as histamine released during allergic reactions or irritation, arises from mechanoreceptive free nerve endings located in the superficial layers of the skin, and may also result from the activation of antigen-presenting cells (e.g., mast cells) in response to an irritant, purpose of itching is believed to alert the body to mild surface stimuli (like insects crawling on the skin) that could indicate a potential threat, prompting the scratch reflex.

Transmission of Tactile Signals, Type of Nerve Fibers:

Specialized receptors like Meissner's corpuscles transmit tactile signals through type Aβ nerve fibers. These are large, myelinated fibers that conduct signals rapidly.

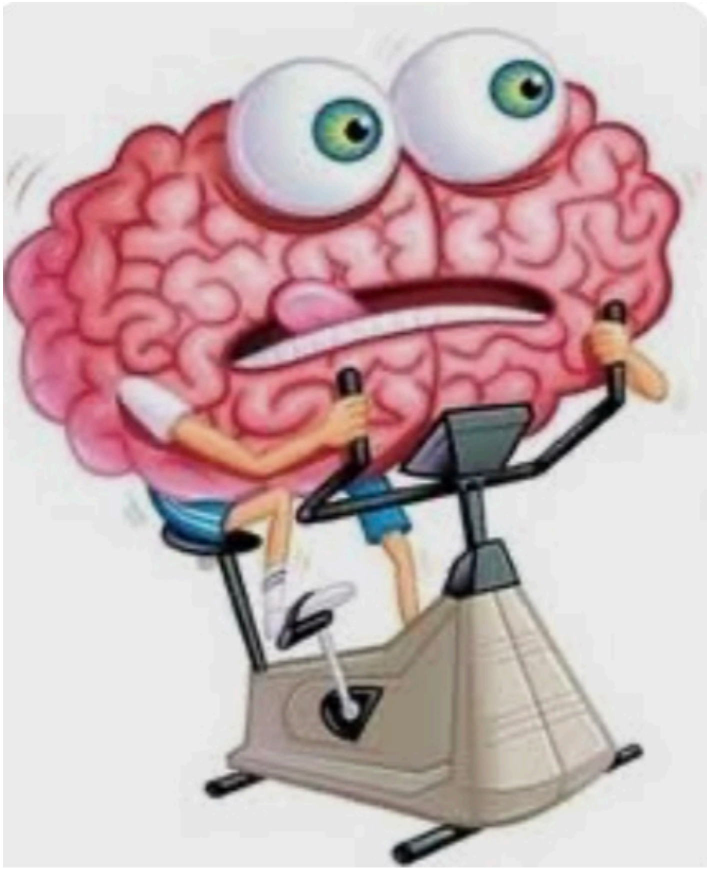
Free nerve endings (responsible for detecting light touch, itch, and tickle) generally use smaller fibers for signal transmission.

Aδ fibers: Small, myelinated fibers used for transmitting signals related to pain and some tactile sensations like cold and fast pain.

C fibers: Unmyelinated fibers, often associated with the itch and tickle sensations. These fibers conduct signals more slowly.

Mechanism of Signal Transmission: Signals from these tactile receptors are transmitted via nerve fibers to the spinal cord, where they are processed and relayed to the somatosensory cortex in the brain for perception and interpretation.

Lateral Inhibition in Tactile Sensations: When tactile stimuli are detected, lateral inhibition helps to sharpen contrast and improve the localization of the sensation, This process involves the inhibition of neighboring sensory pathways, helping to focus on the most intense stimulus; For example, in the case of vibration detection, lateral inhibition can help you identify the precise location and frequency of the vibration more clearly.



Surgical skill alone is not enough; a deep understanding of neurophysiology is essential for patient safety. Respect neural pathways, as even minor damage can cause permanent functional loss. Utilize intraoperative neurophysiological monitoring to minimize risks and leverage neuroplasticity to enhance post-surgical recovery.