NEUR 1520 Neuroscience Study Guide for Exam 2: Book 5.1: Touch and Body Sense

Source: The Mind's Machine, Chapter 5 (no Chapter 5 lecture slides are posted yet). Nothing else.
Each heading is one book learning objective. [MM p148] = book page 148.
(teal italics) = plain meaning of the word before it. ⚠ **Do not mix up = a look-alike pair to keep apart.** **Amber dotted words** = names printed on the figure beside them.

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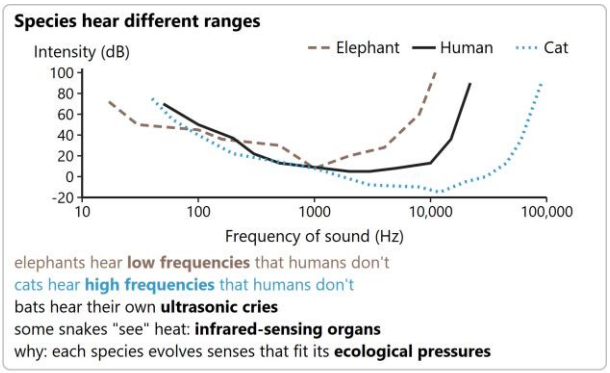
Click a line to jump to it. The PDF side panel (bookmarks) has the same parts.

5.1.1 Understand the concepts of labeled lines and sensory transduction

⚠ **Do not mix up: All senses use the SAME action potentials: the separate line, not the signal, tells the sense.** [MM p144]

Case: a man lost light touch below the neck after a viral infection at age **19.** [MM p143]
The infection hit a very specific set of nerves sending body information to the brain. [MM p143]
Still felt: pain, deep pressure, and warm and cool surfaces on the skin. [MM p143]
Lost: all information about muscle activity and body position, though all muscles still move. [MM p143]
Result: could not walk across a room without falling, nor walk up or down stairs. [MM p143]
The few others with this loss spent the rest of their lives in wheelchairs. [MM p143]
Fix: the man learned to walk by watching the moving body, using **vision** as feedback. [MM p143]
Lights out: the man collapses and must lie still until the lights return. [MM p143]
Pointing repeatedly to one spot in the air, the man beats control participants in accuracy. [MM p143]
Cost: constantly watching the body is a mental drain; in bed, covers tether the limbs. [MM p143]
Shows: losing body sense is devastating, though it is not one of the familiar five senses. [MM p143]
Air molecules are sensed as odors; air vibrations as sounds; reflected light builds vision. [MM p143]
Species differ in what they must sense, so evolution gave each its own capabilities. [MM p144]

System type	Modality	What it senses
Mechanical	Touch	Contact with body surface
	Pain	Tissue damage
	Hearing	Sound vibrations in air or water
	Vestibular	Head movement and orientation
	Joint	Position and movement
	Muscle	Tension
Light	Vision	Photons, from a source or reflected
Thermal	Cold	Decrease in skin temperature
	Warmth	Increase in skin temperature
Chemical	Smell	Odorant molecules in air
	Taste	Substances in contact with the tongue
	Vomeronasal	Pheromones in air or water
Electrical	Electroreception	Differences in current density
Magnetic	Magnetoreception	Magnetic fields for orientation



receptor cells sense some forms of energy (**stimuli**), not others: they act as **filters** and convert the key ones into **electrical signals**

TRAP: each receptor responds to only SOME kinds of energy, NOT every form

Sensory systems and what they detect, and species hearing ranges [MM p144]

On the figure: elephants · cats · ultrasonic · infrared · receptor cells · filters · ecological · stimuli

Bats detect their own **ultrasonic** *(too high-pitched for humans)* cries, which humans cannot hear. [MM p144]
Some **snakes** have **infrared** *(heat radiation)* sensing organs in the face to "see" heat sources in the dark. [MM p144]
Receptor cell: specialized cell that converts a particular energy or substance into a membrane potential change. [MM p144]

Stimulus: a physical event that triggers a sensory response. [MM p144]

Receptor cells sense some forms of energy but not others, so they act as **filters**. [MM p144]

Receptor cells ignore the background and convert key **stimuli** into electrical signals, the nervous system's language. [MM p144]

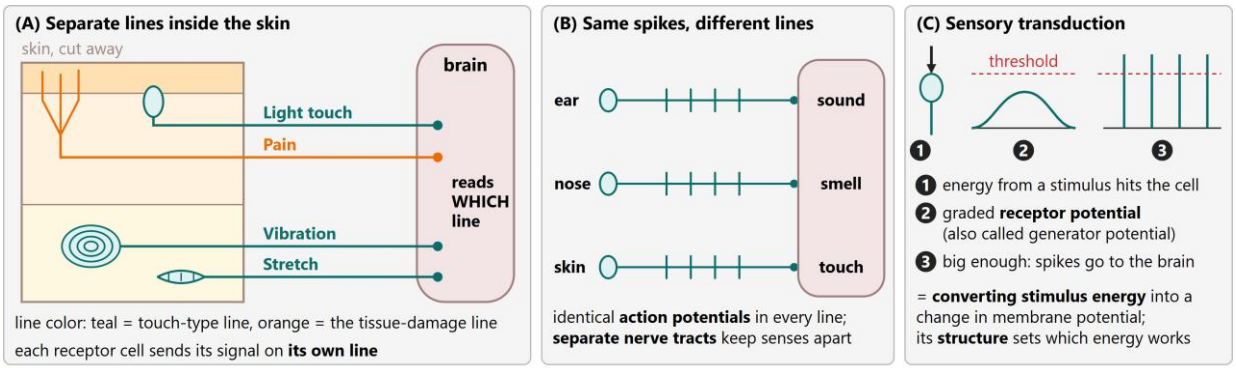
Different energies need different sensory organs, just as a photo needs a camera, not a microphone. [MM p144]

The eye alone comes in a dazzling array of sizes, shapes, and forms across animals. [MM p144]

Each species' auditory abilities reflect its unique **ecological** pressures. [MM p144, MM p145]

Elephants hear low sound frequencies that humans do not hear. [MM p145]

Cats hear high sound frequencies that humans do not hear. [MM p145]



Separate lines for each touch type, identical spikes, and transduction steps [MM p145]

On the figure: labeled lines · separate nerve tracts · light touch · vibration · stretch · pain · receptor potential · generator potential

Labeled lines: each nerve input to the brain reports **only** one particular type of information. [MM p144]

The end product of every sensory receptor, the action potential, is the same for all modalities. [MM p144]

The brain tells modalities apart because each sense travels in **separate nerve tracts**. [MM p144]

Lines are labeled right from the outset: one signals a sound, another a smell, others touch. [MM p144]

Labeled lines also exist within touch: separate lines for **light touch**, **vibration**, and skin **stretch**. [MM p144, MM p145]

Each skin receptor signals on its own line, so the brain knows which touch happened. [MM p145]

Separate labeled lines run from hand skin to brain for **pain**, touch, vibration, and stretch. [MM p145]

A receptor cell's **structure** determines which energy or chemical it responds to. [MM p145]

Mechanisms vary, but the outcome is always the same: an electrical change in the receptor. [MM p145]

Receptor potential *(local voltage change in a receptor)*: also called **generator potential**; may start an action potential. [MM p145]

A receptor potential is a local, stimulus-caused change in a receptor cell's resting potential. [MM p145]

A receptor potential resembles an **excitatory postsynaptic potential** *(small excitatory voltage bump)*. [MM p145, MM p146]

Sensory transduction: a receptor cell converts stimulus energy into a change in membrane potential. [MM p146]

Transduction converts environmental stimuli into action potentials the brain can understand. [MM p146]

Review: species ecology shapes sensory abilities; species sense mainly stimuli important to them. [MM p144, MM p147, MM p174]

Review: labeled lines each transmit one type of information, such as sound, smell, or touch type. [MM p144, MM p147]

Review: transduction turns a stimulus into a receptor potential, which can trigger action potentials. [MM p146, MM p147, MM p174]

Summary: receptor cells give the brain **only** selected information; skin has several specialized touch receptors. [MM p174]

Classification of sensory systems

System type	Modality	Sensed stimuli
Mechanical	Touch	Contact with body surface
Mechanical	Pain	Tissue damage
Mechanical	Hearing	Sound vibrations in air or water
Mechanical	Vestibular	Head movement and orientation
Mechanical	Joint	Position and movement
Mechanical	Muscle	Tension
Light	Vision	Photons, from light sources or reflections
Thermal	Cold	Decrease in skin temperature
Thermal	Warmth	Increase in skin temperature
Chemical	Smell	Odorant chemicals in air
Chemical	Taste	Substances contacting tongue or taste receptors
Chemical	Vomeronasal	Pheromones in air or water
Electrical	Electroreception	Differences in electrical current density
Magnetic	Magnetoreception	Magnetic fields for orientation

Table source: [MM p144]

5.1.2 Describe several different types of receptors in the skin and the stimuli they detect

⚠ **Do not mix up: Pacinian corpuscles sense vibration and texture; Merkel's discs and Meissner's corpuscles sense object form.** [MM p146]

> Touch is not just touch: pressure, vibration, tickle, "pins and needles", smoothness, and wetness. [MM p146]

Each is recorded by skin receptors, then sent along **separate axons** to the brain. [MM p146]

Skin layers from outside in: **epidermis**, **dermis**, **hypodermis** *(deepest skin layer)*. [MM p146]

Pacinian corpuscle: also called **lamellated corpuscle**; a skin receptor detecting vibration and pressure. [MM p146]

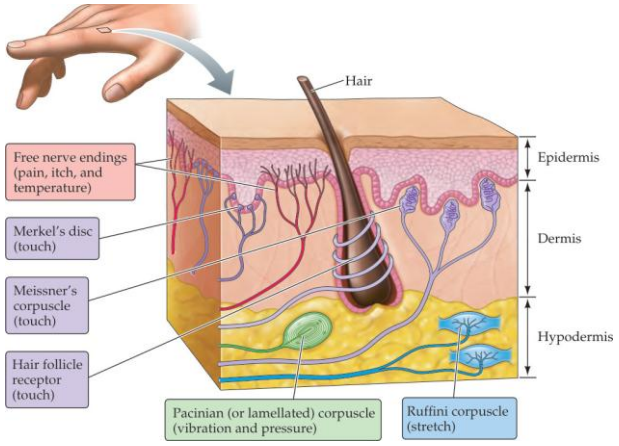
A Pacinian corpuscle is a tiny onion-like structure embedded in the innermost layer of skin. [MM p146]

Its onion-like **layered capsule** wraps the nerve ending. [MM p146]

As a filter, **only** vibrations above about **200 cycles per second** stimulate its nerve ending. [MM p146]

Vibrations above about **200** cycles per second are created when we feel a **texture** against skin. [MM p146]

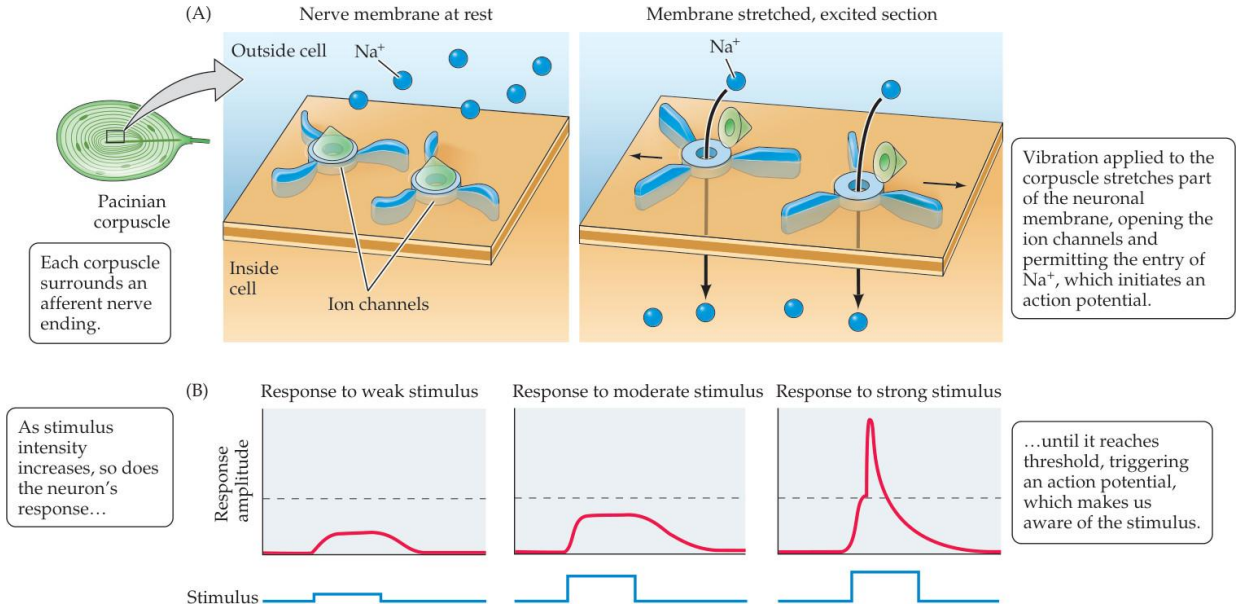
At rest, before any stimulus: the nerve membrane keeps its ion channels **closed**. [MM p147]



Skin layers with the touch, stretch, and pain receptors in each [MM p146]

On the figure: epidermis · dermis · hypodermis · Pacinian corpuscle · Meissner's corpuscle · Merkel's disc · Ruffini corpuscle · hair follicle receptor

> With the channels closed, Na+ stays outside the cell. [MM p147]



Pacinian corpuscle: stretch opens sodium channels, receptor potential grows until threshold [MM p147]

On the figure: Pacinian corpuscle · afferent · Na+ · threshold

1. Each corpuscle surrounds an **afferent** *(carrying signals toward the CNS)* nerve ending. [MM p147]
2. Vibration or pressure stretches part of the nerve ending's membrane. [MM p146, MM p147]
3. Stretch pops open **mechanically gated sodium channels**; **Na+** enters the cell. [MM p146, MM p147]
4. A **graded receptor potential** forms; its amplitude is directly proportional to stimulus strength. [MM p146]
5. If it exceeds **threshold**, action potentials travel via sensory nerves to the spinal cord. [MM p146]

Threshold: here, the stimulus intensity just adequate to trigger an action potential in a sensory cell. [MM p146]

Weak and moderate stimuli: generator potential grows with intensity but stays below threshold, no action potential. [MM p147]

A strong stimulus reaches threshold, triggering an action potential that makes us aware of the stimulus. [MM p147]

Meissner's corpuscle: also called **tactile corpuscle**; light touch, especially **changes** in stimuli. [MM p146]

Meissner's corpuscles are more numerous and detect localized movement between skin and a surface. [MM p146]

Merkel's disc: light touch, especially **edges** and isolated **points** on a surface. [MM p146]

Meissner's corpuscles and Merkel's discs mediate most of our ability to perceive object **forms**. [MM p146]

Ruffini corpuscle: detects **stretching** of the skin; **only** sparsely distributed. [MM p146]

Ruffini corpuscles detect stretch of skin patches when we move fingers or limbs. [MM p146, MM p147]

Hair follicle receptor: wraps the hair root and signals touch. [MM p146]

Free nerve ending: an axon ending in the skin with no specialized cell attached. [MM p147]

Free nerve endings detect **pain, itch, heat, and cold** (changes in temperature). [MM p146, MM p147]

All these receptors are most concentrated where touch is finest: **fingertips, tongue, and lips**. [MM p147]

Review: Pacinian senses vibration, Meissner's changes, Merkel's edges and points, Ruffini stretch. [MM p146, MM p147]

Receptors in the skin

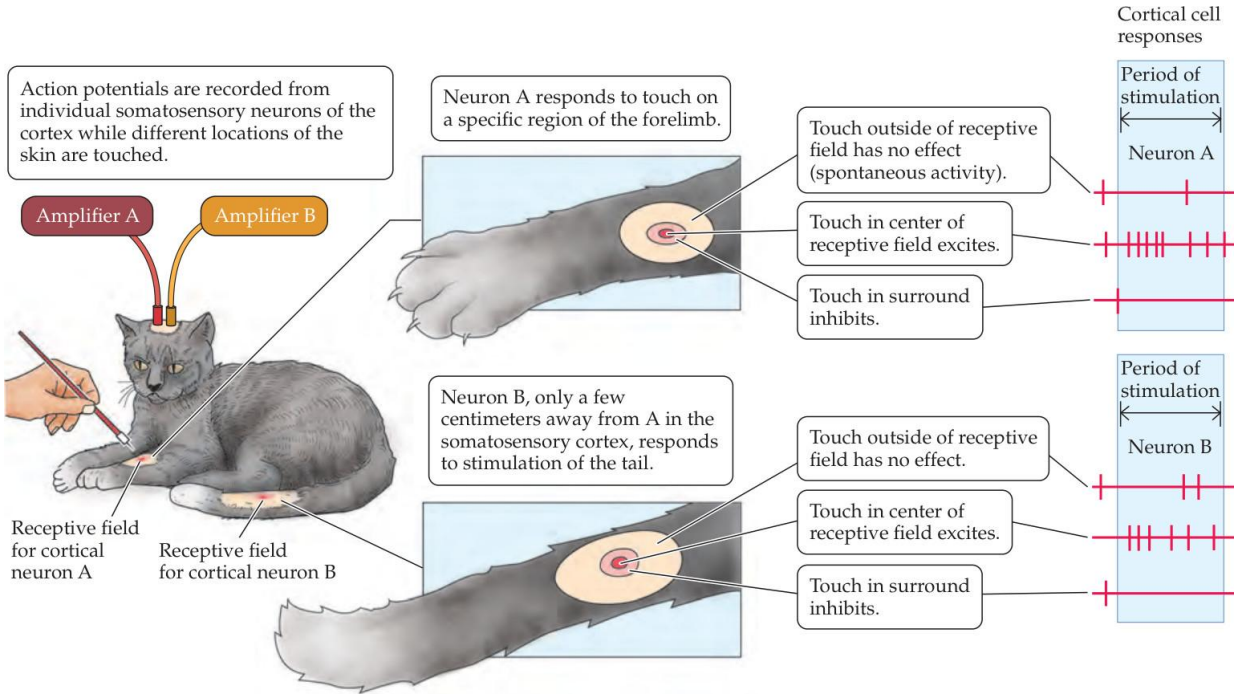
Receptor	Location in skin	Detects	Note
Free nerve endings	Reach into epidermis	Pain, itch, temperature	Bare axon, no specialized cell
Merkel's disc	Base of epidermis	Light touch	Edges and isolated points
Meissner's corpuscle	Top of dermis	Light touch	Changes; skin moving on surface
Hair follicle receptor	Around hair root	Touch	Touch at the hair
Pacinian corpuscle	Innermost layer (hypodermis)	Vibration and pressure	Texture; above about **200** cycles per second
Ruffini corpuscle	Deepest layer (hypodermis)	Skin stretch	Finger and limb movement; sparse

Table source: [MM p146, MM p147]

5.1.3 Relate the concepts of receptive fields and sensory adaptation

⚠ Do not mix up: PHASIC receptors adapt fast; TONIC receptors keep firing and signal duration, like many pain sensors. [MM p149]

Senses are **NOT** an accurate snapshot: they send limited, even distorted, information to the brain. [MM p147]
Much **selection and analysis** happens along sensory pathways before information reaches the brain. [MM p147]
The brain gets a filtered picture: survival-critical stimuli emphasized over less important ones. [MM p147]
Filtering appears in stimulus coding, receptive fields, adaptation, and active suppression by the brain. [MM p147]
Labeled lines code stimulus **type**; intensity and location need other coding. [MM p147]
A sensory neuron's action potentials always have the same size and duration. [MM p147, MM p148]
So **intensity** is coded in the number and frequency of action potentials and their rhythm. [MM p148]
Neurons fire up to maybe **1,200 action potentials per second**, probably less in most. [MM p148]
So frequency in one neuron could represent **only** a very limited range of intensities. [MM p148]
Fix: multiple receptor cells, each specializing in one part of the intensity range. [MM p148]
Stronger stimuli **recruit** extra neurons sensitive to higher intensities. [MM p148]
Intensity is then represented by the number and thresholds of activated cells. [MM p148]
Somatosensory system *(body sensation system)*: receptors and neural mechanisms for body sensations like touch and pain. [MM p148]
Somatosensory **location** is coded by the position of the stimulated receptors on the sensory surface. [MM p148]
Labeled lines carry location: we know which skin patch a mosquito bites, to aim the slap. [MM p148]
Vision: an object's location determines which receptors in the eye are stimulated. [MM p148]
Bilateral systems (two eyes, ears, nostrils) code left versus right differences as location cues. [MM p148]
In visual and touch pathways, neurons at all levels, receptors to cortex, form orderly **maplike** arrangements. [MM p148]
Maps are not exact but reflect both spatial position and **receptor density**. [MM p148]
Sensitive, densely innervated sites like the lips get more cells than the skin of the back. [MM p148]
Each cell in a sensory map responds best to one stimulus type in one place. [MM p148]
Receptive field: the stimulus region and features that affect a sensory cell's activity. [MM p148]
A neuron's receptive field is the region of space where a stimulus alters its firing rate. [MM p148]
Receptive fields are found by recording responses to many stimuli: which ones change the resting rate? [MM p148]
Somatosensory receptive fields are **doughnut-shaped**: a center and a surround. [MM p148]
Either an excitatory center with inhibitory surround, or an inhibitory center with excitatory surround. [MM p148]
The center and surround shape makes **edges** on the objects we feel easier to detect. [MM p148]
Fields differ in size, shape, and the quality of stimulation that activates them. [MM p148]
Some neurons prefer light touch, others fire most to painful stimuli, others to cooling. [MM p148]
Neurons at every level of the pathway have their own receptive field. [MM p148]
Receptive fields change considerably at each successive level as neurons add processing. [MM p148, MM p174]



Cat cortex neurons A and B: center touch excites, surround inhibits, outside does nothing [MM p149]

On the figure: receptive field · Neuron A · Neuron B · forelimb · tail · center · surround · spontaneous activity

Cat experiment: record single somatosensory cortex neurons while touching different skin locations. [MM p149]

Neuron A responds to touch on a specific region of the **forelimb**. [MM p149]

Neuron B, **only** a few centimeters away in cortex, responds to touch on the **tail**. [MM p149]

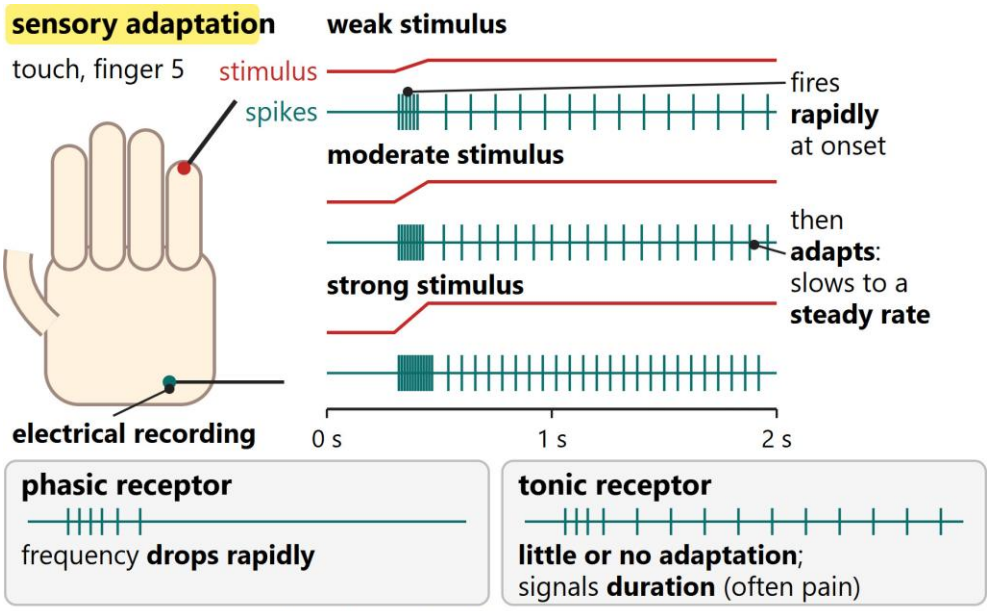
Touch in the **center** excites; touch in the **surround** inhibits. [MM p149]

Touch outside the **receptive field** has no effect: **only** **spontaneous activity** continues. [MM p149]

Sensory adaptation: progressive loss of receptor response as stimulation is maintained. [MM p148]

Adaptation lets us ignore unchanging stimuli: clothes on our skin, the buzz of overhead lights. [MM p148]

Adaptation helps senses avoid overload and stay vigilant for critical events. [MM p148, MM p149]



Sensory adaptation: phasic receptors drop fast, tonic receptors keep firing [MM p148]

On the figure: sensory adaptation · phasic receptor · tonic receptor · electrical recording · duration · adapts

Phasic receptor: action potential frequency drops **rapidly** as stimulation is maintained. [MM p149]

Tonic receptor: frequency declines slowly or not at all; can signal stimulus **duration**. [MM p149]

Pain sensors are often tonic: sustained high activity helps us avoid further injury. [MM p149]

Fifth-finger touch: the neuron fires rapidly at onset, whether the stimulus is weak, moderate, or strong. [MM p149]

An **electrical recording** of the fifth-finger neuron shows its action potentials over time. [MM p149]

Then the fifth-finger neuron **adapts**, slowing to a steady rate. [MM p149]

Adaptation shows senses shift **away from accurate portrayal** of the external world. [MM p149]

Pacinian corpuscle adaptation comes from the **elasticity** of the corpuscle itself. [MM p149, MM p150]

Remove the corpuscle (a separate accessory structure): the bare fiber does **NOT** adapt, firing on. [MM p150]

Survival depends more on sensitivity to important **changes** than on exact reporting of stimuli. [MM p150]

Three ways to quiet senses: adaptation, physically blocking stimuli, and neural suppression. [MM p150]

Blocking stimuli: closing eyelids; tiny **middle-ear muscles** reduce sound reaching the inner ear. [MM p150]

Neural: reciprocal connections descend from the brain to lower levels, inhibiting ascending sensory axons. [MM p150]

Central modulation of sensory information: higher centers like cortex and thalamus suppress some inputs, amplify others. [MM p150]

Central modulation is a feature of many sensory and pain pathways. [MM p150]

Central modulation helps the brain attend to some stimuli more than others. [MM p150]

Review: intensity is coded by action potential number, frequency, rhythm, and recruitment of cells. [MM p148, MM p150]

Review: cells for strong stimuli extend the range, since one neuron can fire **only** so fast. [MM p148, MM p150]

Review: receptive fields are found by recording a cell while stimulating many skin spots. [MM p148, MM p149, MM p150]

Review: adaptation and central modulation both change a sensory neuron's response to stimuli. [MM p148, MM p150]

Phasic vs tonic receptors

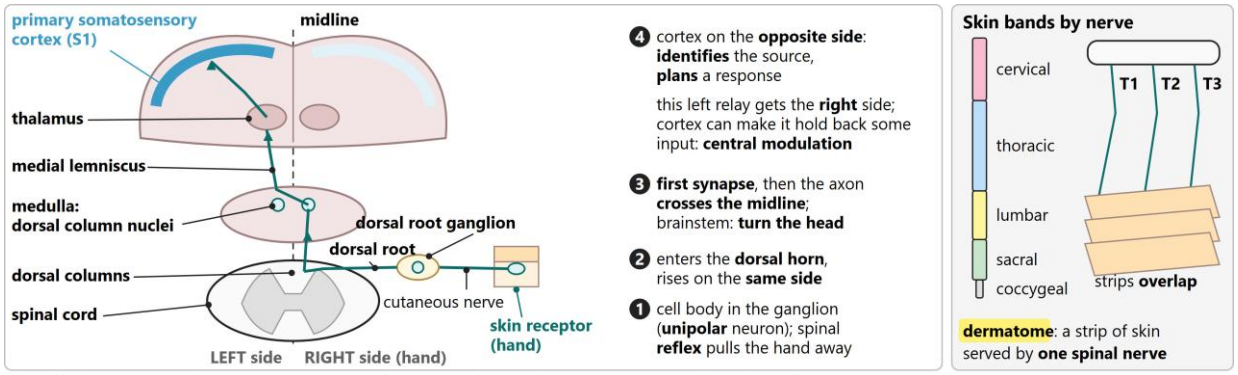
Feature	Phasic receptor	Tonic receptor
Adaptation	Yes, rapid	Little or none
Firing with steady stimulus	Drops rapidly	Declines slowly or not at all
Signals	Changes, onset	Stimulus duration
Example	Pacinian corpuscle (adapts)	Pain sensors (often)

Table source: [MM p149, MM p150]

5.1.4 Describe the neural pathway for the system reporting touch information from the body

⚠ Do not mix up: Touch crosses the midline in the MEDULLA; pain, temperature, and itch cross in the spinal cord. [MM p151, MM p174]

Pain, temperature, and itch use a separate route: the **anterolateral system** (spinothalamic system). [MM p151, MM p174]
Each sensory system has its own pathway from the periphery to successively higher levels. [MM p150]
Touch receptor axons are bundled into sensory nerves running to the **dorsal** *(rear)* spinal cord. [MM p150]
Dorsal column system: carries most touch to the brain in dorsal columns of spinal white matter. [MM p150]
Dorsal columns: a large wedge of white matter in the dorsal spinal cord. [MM p150]



Touch pathway from skin to cortex, and skin strips served by each spinal nerve [MM p151]

On the figure: primary somatosensory cortex · thalamus · medial lemniscus · dorsal column nuclei · dorsal columns · medulla · cutaneous · dorsal root

1. Skin touch receptors fire; action potentials travel along a **cutaneous** *(skin)* nerve. [MM p151]
2. The axon's **unipolar neuron** has its cell body in the **dorsal root ganglion**. [MM p151]
3. The axon enters the spinal cord through the **dorsal root**, into the dorsal horn. [MM p151]
4. It joins the **dorsal column** and ascends to the brainstem with no synapse yet. [MM p150, MM p151]
5. In the **medulla**, first synapse onto a neuron of the **dorsal column nuclei**. [MM p151]
6. The medullary neuron's axon **crosses the midline** and rises in the **medial lemniscus**. [MM p150, MM p151]
7. It reaches the **thalamus**: the left thalamus now receives right-side body information. [MM p151]
8. The thalamus sends it to **primary somatosensory cortex** (S1). [MM p150, MM p151]

At all levels, inputs follow a somatosensory map dividing the body surface into discrete bands. [MM p150]
Dermatome *(skin strip of one nerve)*: strip of skin innervated by a particular spinal nerve. [MM p150]
From Greek derma, "skin", and tome, "part" or "segment". [MM p150]
Spinal segments in order: cervical, thoracic, lumbar, sacral, coccygeal. [MM p151]
Body bands map to cervical, thoracic, lumbar, and sacral segments in an orderly sequence. [MM p151]
Cervical bands cover the neck and arms; thoracic bands the trunk; lumbar and sacral bands the legs. [MM p151]
Each dorsal root (T1, T2, T3) serves its own skin strip; adjacent dermatomes overlap somewhat. [MM p151]
Maplike organization also appears in vision and hearing. [MM p150]
Each station in a sensory pathway does a basic part of information processing. [MM p150]
Spinal cord: a painful finger triggers reflexive hand withdrawal before we even feel pain. [MM p150]
Brainstem: circuits turn the head toward the source of pain. [MM p150]
Cortex: most complex processing, such as identifying the source (a sliver) and planning a response. [MM p150]
Thalamus: regions at the top of the brainstem that trade information with the cortex. [MM p150]
For most senses, information reaches the thalamus before being relayed to cortex. [MM p150, MM p152]
Each sensory modality is sent to a separate division of the thalamus. [MM p152]
Cortex can direct the thalamus to emphasize some sensory information and suppress other information. [MM p152]

1. Sensory information enters the CNS via spinal cord (peripheral nerves) or brainstem (cranial nerves). [MM p152]
2. It travels to the thalamus. [MM p152]

3. The thalamus shares it with cortex; cortex directs the thalamus to suppress some sensations. [MM p152]

4. Primary sensory cortex swaps information with nonprimary sensory cortex. [MM p152]

Primary sensory cortex: region receiving most of a modality's information from the thalamus. [MM p152]

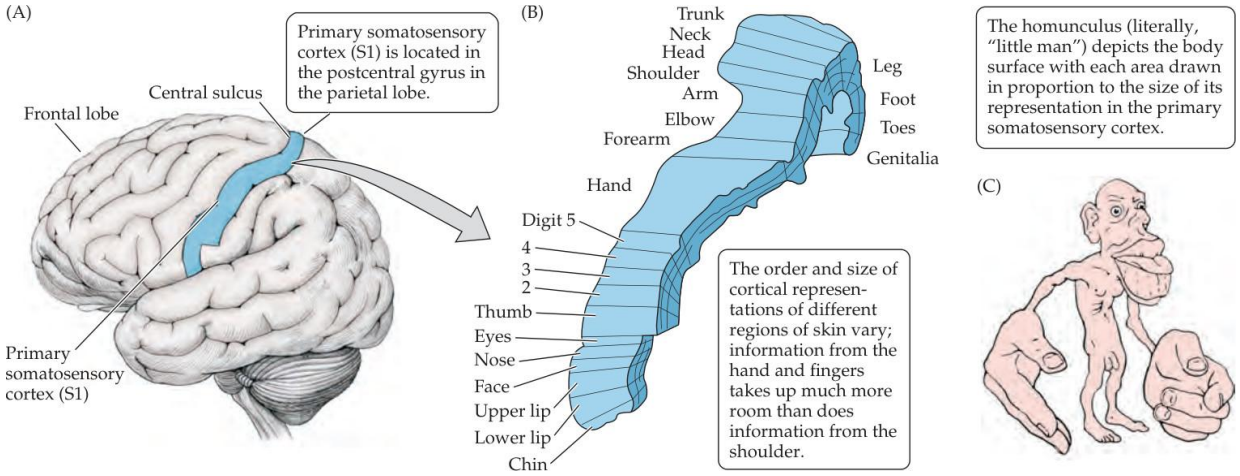
Exception: in **olfaction** *(smell)*, primary cortex gets input directly from secondary sensory neurons. [MM p152]

Primary sensory cortex is generally the first cortical destination of sensory inputs. [MM p152]

Nonprimary sensory cortex: also called secondary sensory cortex; gets direct projections from primary cortex. [MM p152]

Nonprimary areas often process the same information in collaboration with primary cortex. [MM p152]

Each cortical sensory region processes different aspects of our perceptual experiences. [MM p152]



Primary somatosensory cortex strip and the body map ordered along it [MM p153]

On the figure: central sulcus · postcentral gyrus · homunculus · genitalia · thumb · chin · elbow · trunk

Primary somatosensory cortex (S1) *(first body touch area)*: the **postcentral gyrus** of the parietal lobe. [MM p152, MM p153]

Postcentral gyrus lies just posterior to the **central sulcus**, which divides parietal from frontal lobe. [MM p152]

S1 of each hemisphere receives touch from the **opposite** (contralateral) side of the body. [MM p152, MM p174]

S1 is a distorted body map: region size is proportional to skin receptor density. [MM p152]

Hand and fingers get large S1 areas; the less sensitive shoulder gets a small one. [MM p152, MM p153]

Sensory homunculus *("little man")*: each body part drawn in proportion to its share of S1. [MM p152, MM p153]

S1 body map order, from the midline outward: **genitalia**, toes, foot, leg, **trunk**, neck, head, shoulder. [MM p153]

S1 next: arm, **elbow**, forearm, hand, digits **5** to **2, thumb**, eyes, nose, face, lips, **chin**. [MM p153]

Using one sense can influence perception from another sense. [MM p152]

Humans detect a visual signal more accurately when a sound comes from the same place. [MM p152]

Association areas: sensory areas that process a mixture of inputs from different modalities. [MM p153]

Some "visual" cells also respond to auditory or touch stimuli. [MM p153]

Polymodal neuron: a neuron on which information from more than one sensory system converges. [MM p153]

Convergence on polymodal neurons lets different sensory systems interact. [MM p153]

Synesthesia: a stimulus in one modality evokes an involuntary extra sensation in another modality. [MM p153]

Synesthesia examples: seeing a number evokes a color; each music note has a sound and flavor. [MM p153]

Synesthesia occurs in **only** a few people. [MM p153]

Old view: sensory cortex fixed early in life. Now: cortical maps are highly **plastic**. [MM p153]

Cortical maps change considerably as a result of experience. [MM p153]

Two artists born without arms, using their toes extensively, had distinct maps of each toe. [MM p153]

Control participants did not have distinct maps of each toe. [MM p153]

String musicians have expanded cortical maps of the **left fingers**, which press the strings. [MM p153]

Losing a **hand** in adulthood: brain imaging shows cortical reorganization. [MM p153]

Normally, S1's hand region lies between the upper **arm** and **face** regions. [MM p153]

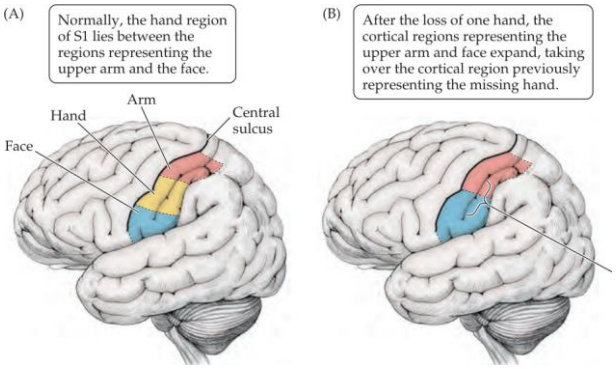
After losing one hand, the arm and face regions expand into the former hand region. [MM p153]

The former hand region now responds to touch on the face or arm. [MM p153]

A man got a transplanted hand **35 years** after losing the original hand. [MM p153, MM p154]

Within a few months, S1 reorganized to receive the new hand's sensation in the right place. [MM p154]

Some map changes follow weeks or months of use or disuse. [MM p154]



Hand region of S1 before and after hand loss: arm and face take over [MM p153]

On the figure: **hand** · **arm** · **face** · **central sulcus**

Map changes may come from growth of new synapses and dendrites, or loss of others. [MM p154]

Review: the main touch pathway is the **dorsal column system**. [MM p150, MM p154]

Review: dorsal column parts: dorsal root ganglion, **dorsal columns**, dorsal column nuclei, medial lemniscus, thalamus, S1. [MM p151, MM p154]

Review: S1 sits in the postcentral gyrus, mapping the contralateral body by receptor density. [MM p152, MM p154]

Review: senses interact; a sound from the same place improves visual detection. [MM p152, MM p154]

Summary: successive pathway levels allow increasingly elaborate processing. [MM p174]

Summary: the cortex holds multiple body maps; S1 overrepresents highly sensitive body regions. [MM p174]

Touch pathway stations

Station	What happens
Skin receptor	Touch transduced to action potentials
Dorsal root ganglion	Cell body of the unipolar sensory neuron
Dorsal column (spinal cord)	Axon ascends to medulla, no synapse yet
Dorsal column nuclei (medulla)	First synapse; next axon crosses midline
Medial lemniscus	Crossed axons rise to thalamus
Thalamus	Relays opposite-side body touch to cortex
S1 (postcentral gyrus)	Distorted contralateral body map

Table source: [MM p150, MM p151, MM p152]