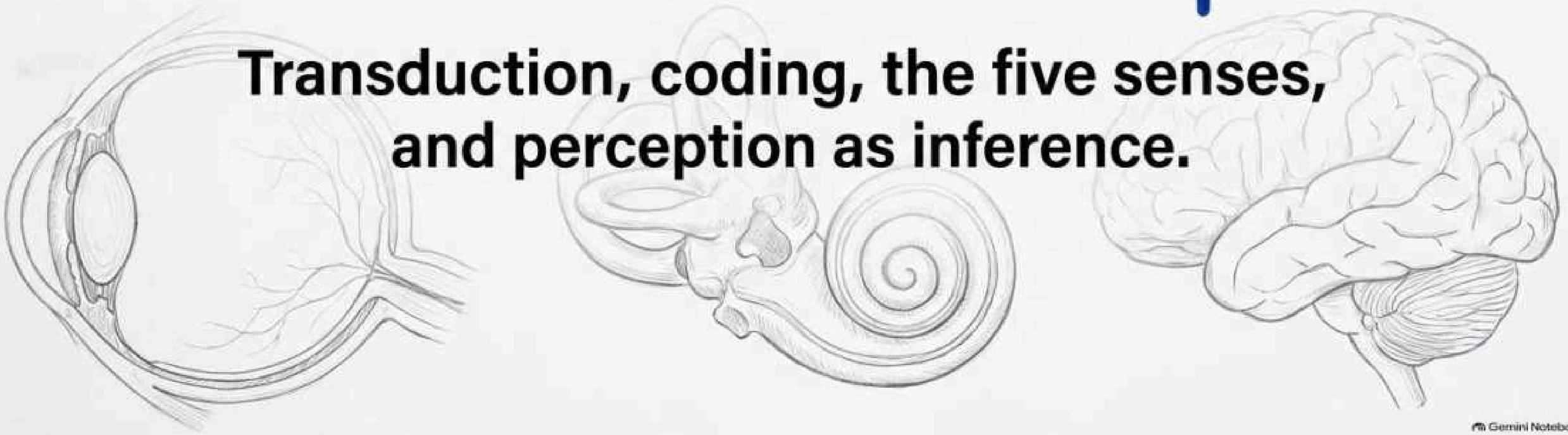
¶ 4.1

NEUR 101 B: Lecture 4

Sensation and Perception

Transduction, coding, the five senses, and perception as inference.



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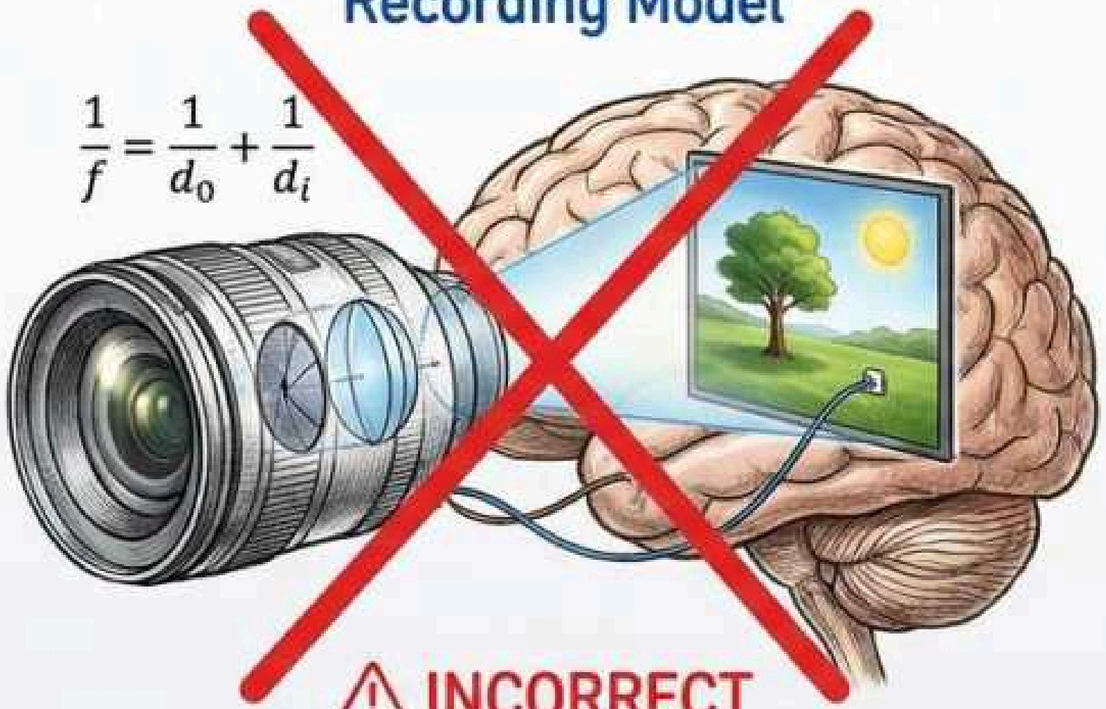
Perception is a Construction, Not a Recording

¶ 4.2

Core Insight: The brain does not passively record the world.
It **actively** builds an experience using sensory signals as evidence.

Recording Model

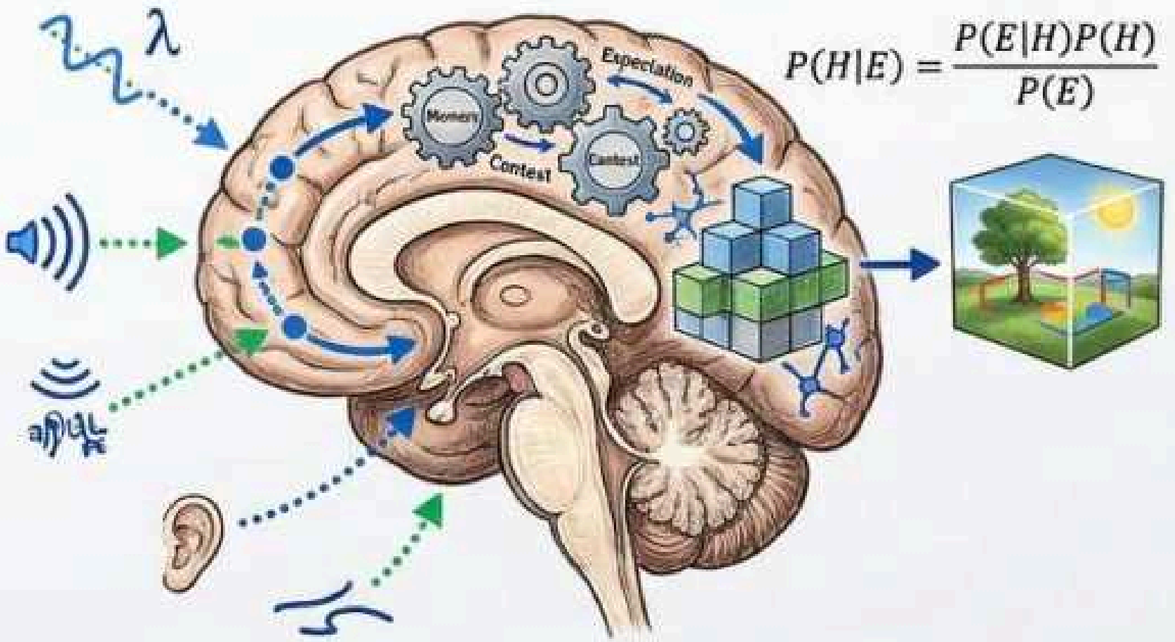
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$



⚠ INCORRECT

Construction Model

$$P(H|E) = \frac{P(E|H)P(H)}{P(E)}$$



Receptor → Transduction → Neural Pathway → Cortex

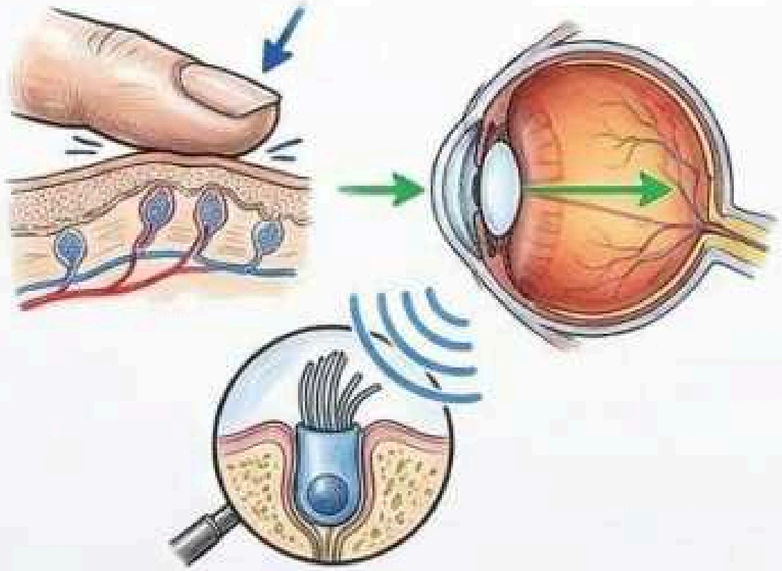
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Transduction: The Universal Translation

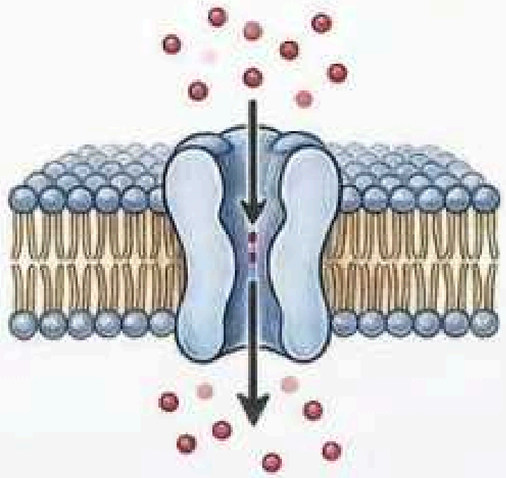
¶ 4.3

$$\Delta V = I \cdot R$$

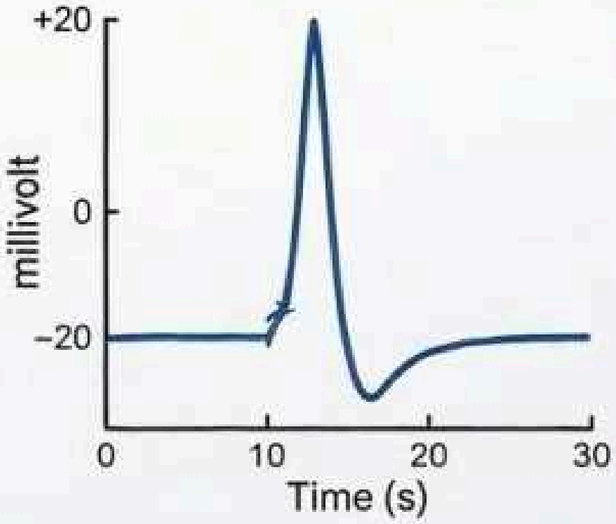
Step 1: Physical Stimulus



Step 2: Receptor Action



Step 3: Electrical Signal



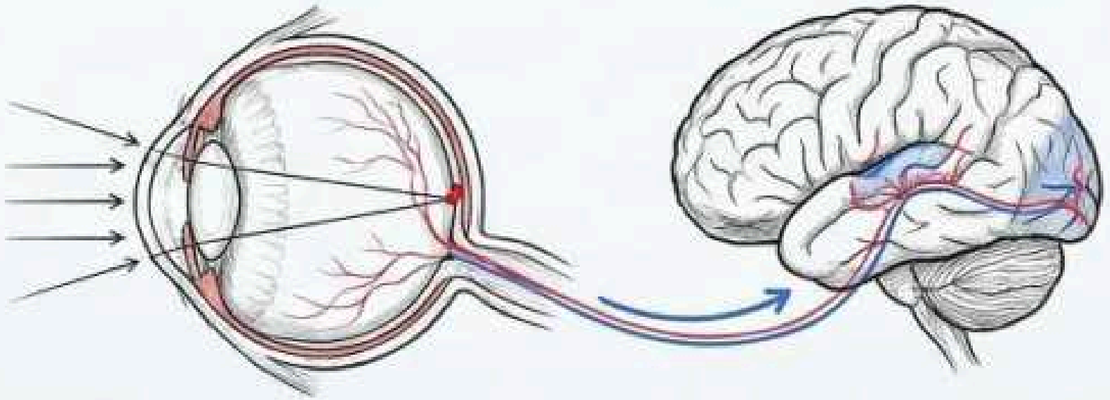
Takeaway: Once the physical stimulus alters the membrane voltage to produce a nerve impulse, all senses speak the exact same electrical language.

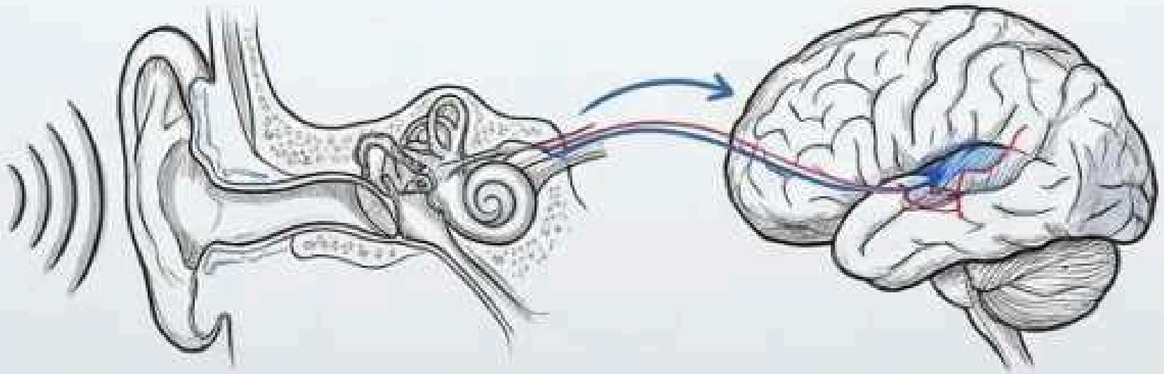
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¶ 4.4

Sensory Coding: Translating Type and Intensity

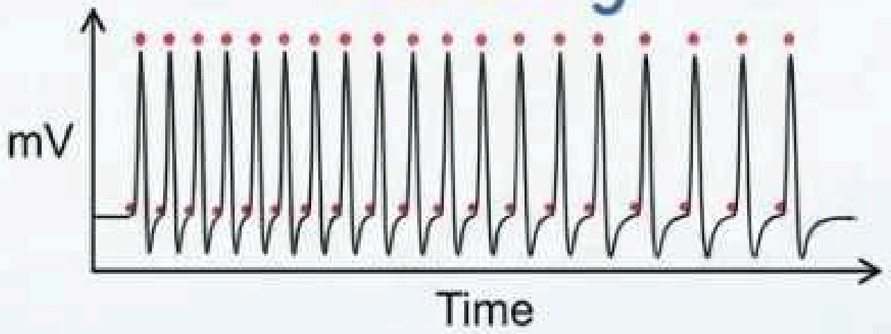
Labeled Lines: Modality (Type)





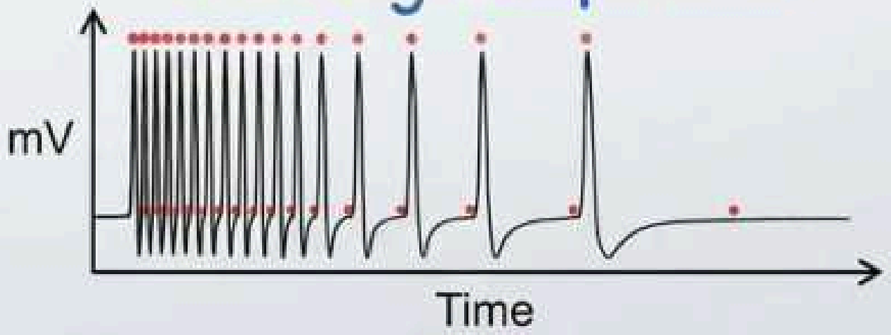
Decoded by the specific pathway the signal travels.

Intensity



Decoded by the firing rate of the neuron.

Sensory Adaptation

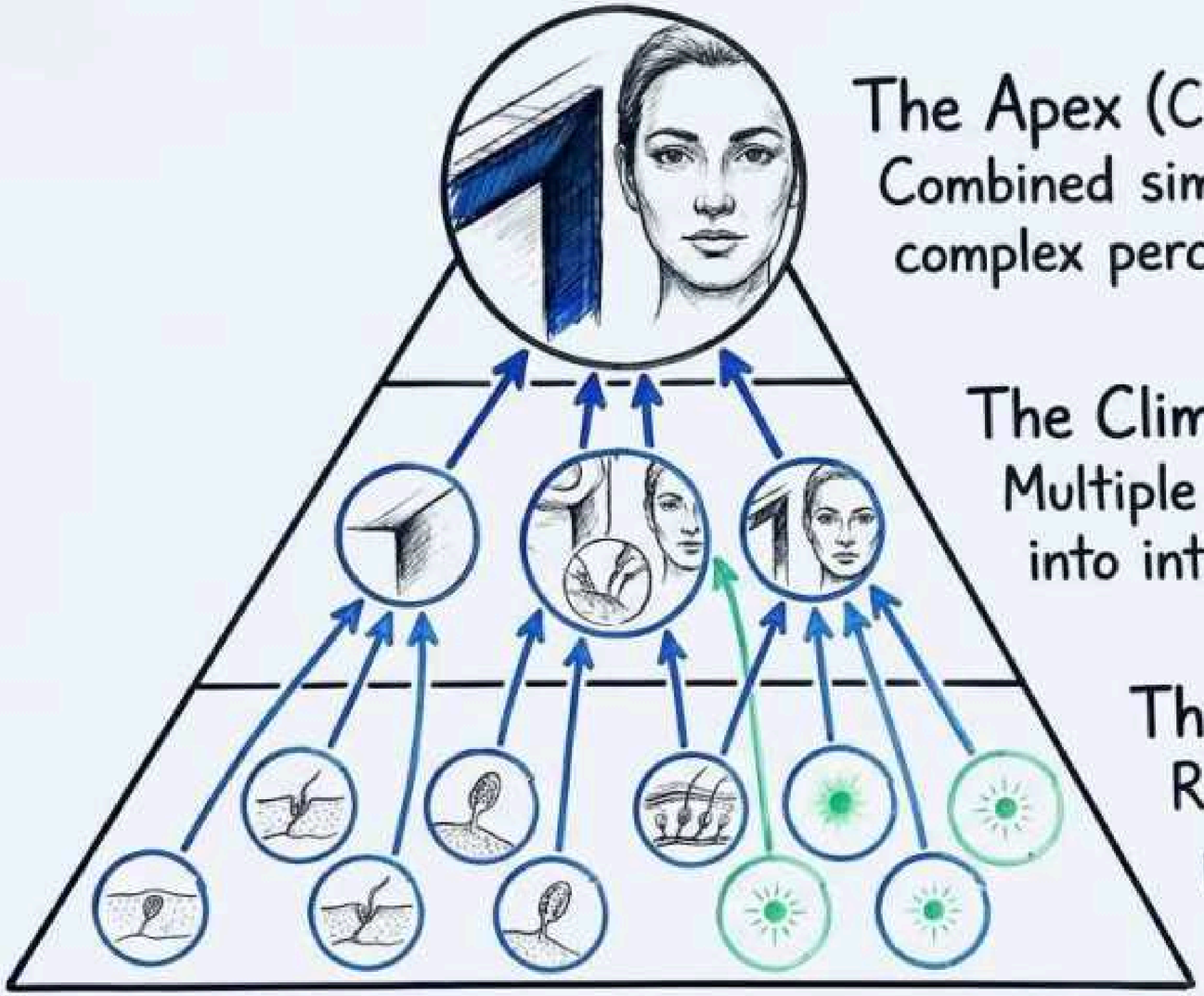


Constant stimuli result in decreased firing rates (why you stop noticing your clothes).

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Receptive Fields & Neural Hierarchies

¶ 4.5



The Apex (Complex Features): Combined simple spots form complex perceptions.

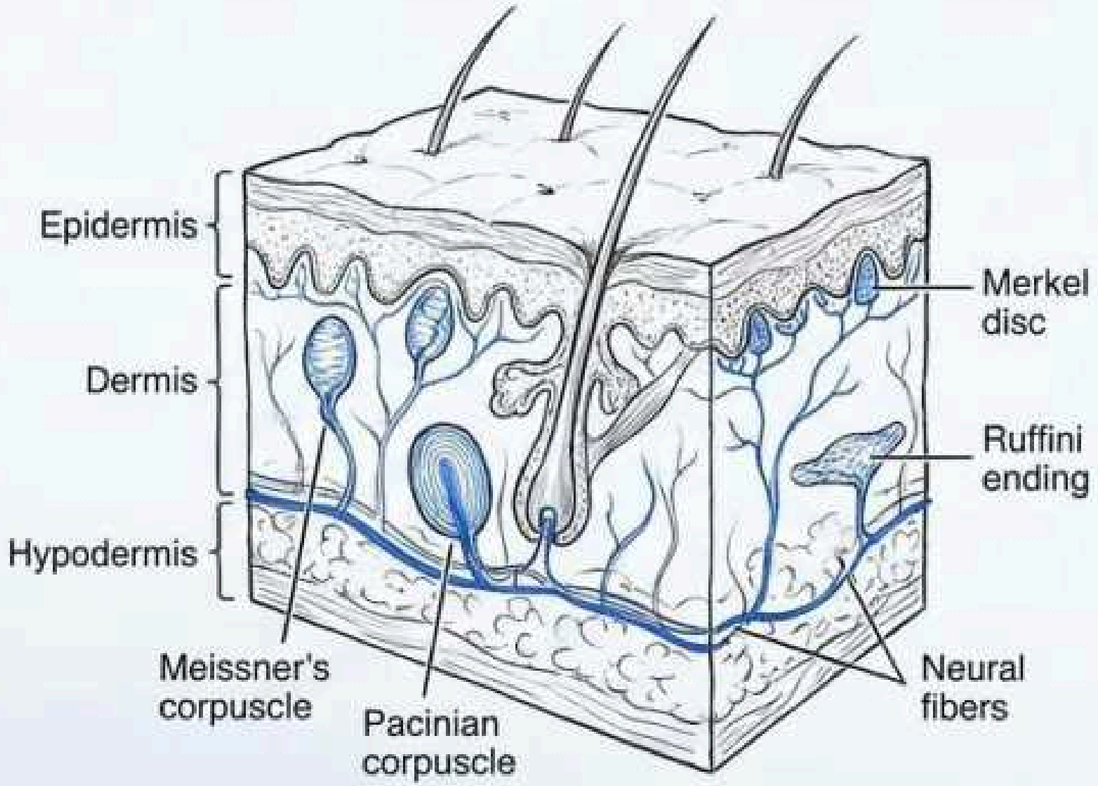
The Climb (Aggregation): Multiple lower neurons feed into intermediate neurons.

The Base (Single Neurons): Respond only to isolated patches of skin or tiny spots in the visual field.

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Touch: Mechanoreceptors and Spatial Resolution

¶ 4.6

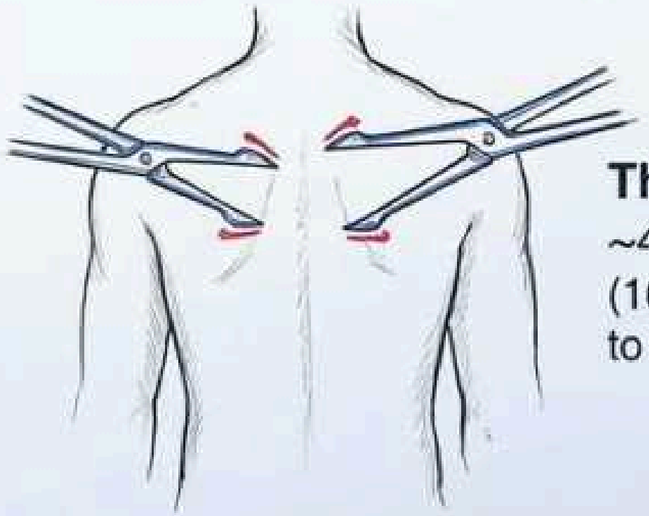


The Receptors:

Mechanoreceptors respond to physical pressure, vibration, and stretch.



Fingertip: 2-3 mm separation
(High density = fine resolution)



The Back:
~40 mm separation
(16x coarser resolution due to low receptor density)

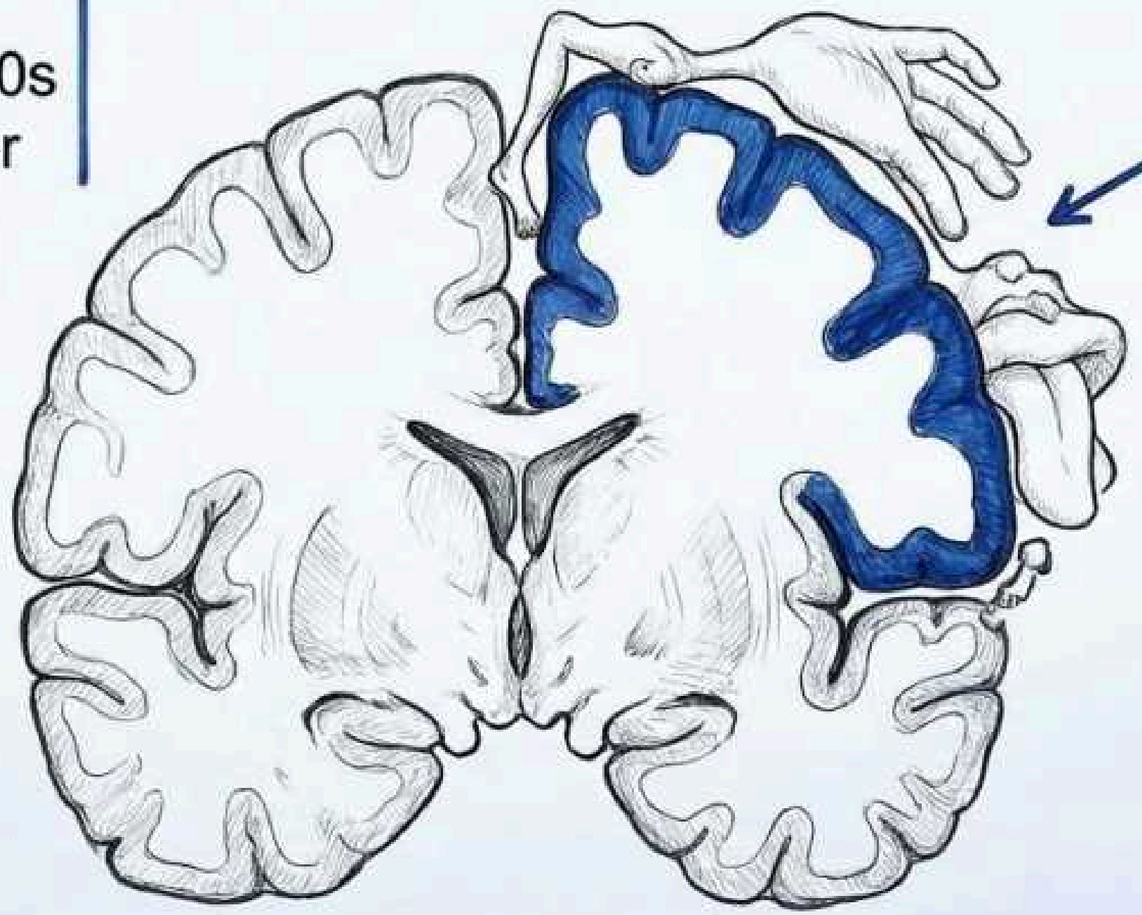
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The Somatosensory Cortex

¶ 4.7

Historical Context:
Mapped in the 1930s/40s by neurosurgeon Wilder Penfield by stimulating conscious patients' brains.

Topographical Map:
The body is mapped spatially onto a specific strip of cortex.

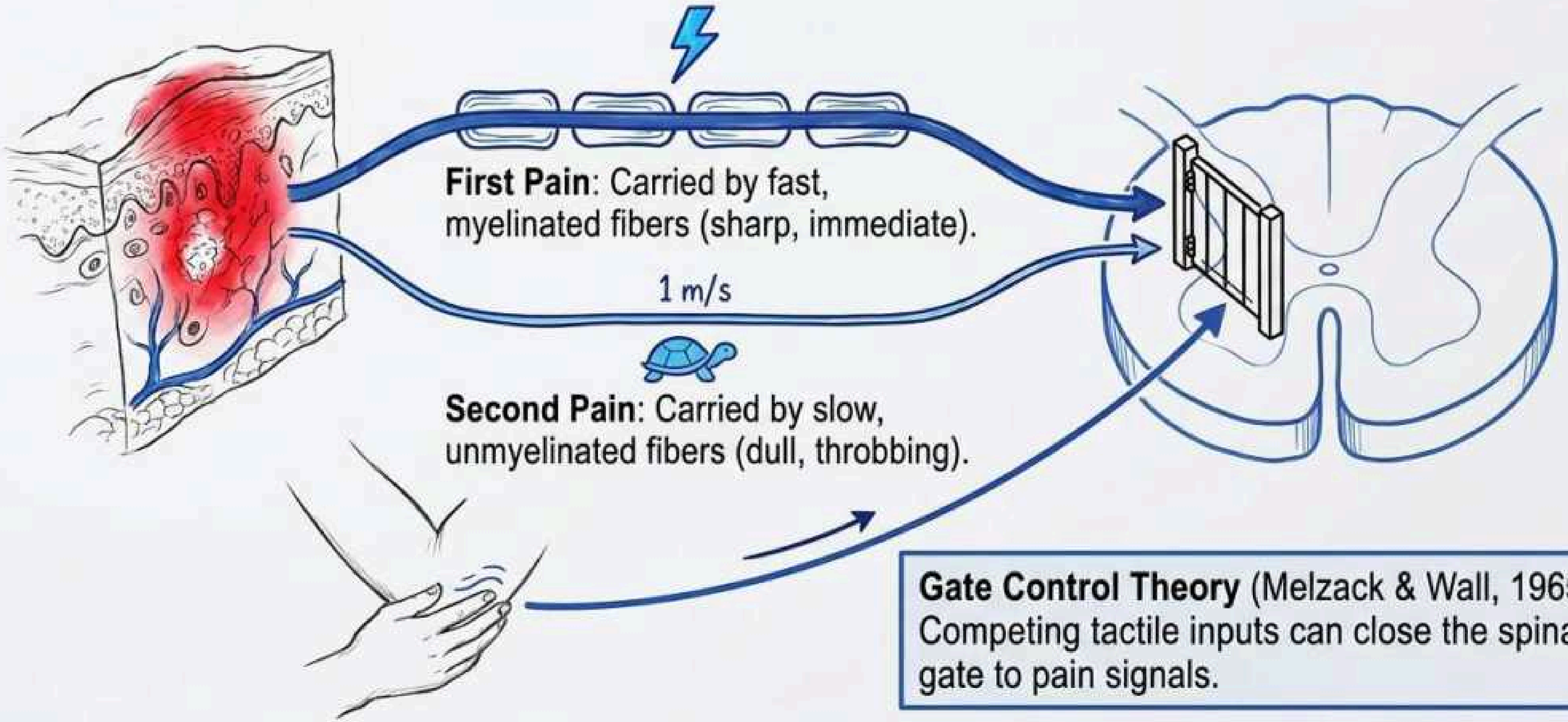


The Distortion:
Cortical real estate is dedicated to receptor density, not physical body size. This is why the hands and lips visually dominate the map.

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Pain: Nociceptors and The Gate Control Theory

¶ 4.8



Gate Control Theory (Melzack & Wall, 1965): Competing tactile inputs can close the spinal gate to pain signals.

Takeaway: Pain is a construction of the brain, not merely a direct injury signal.

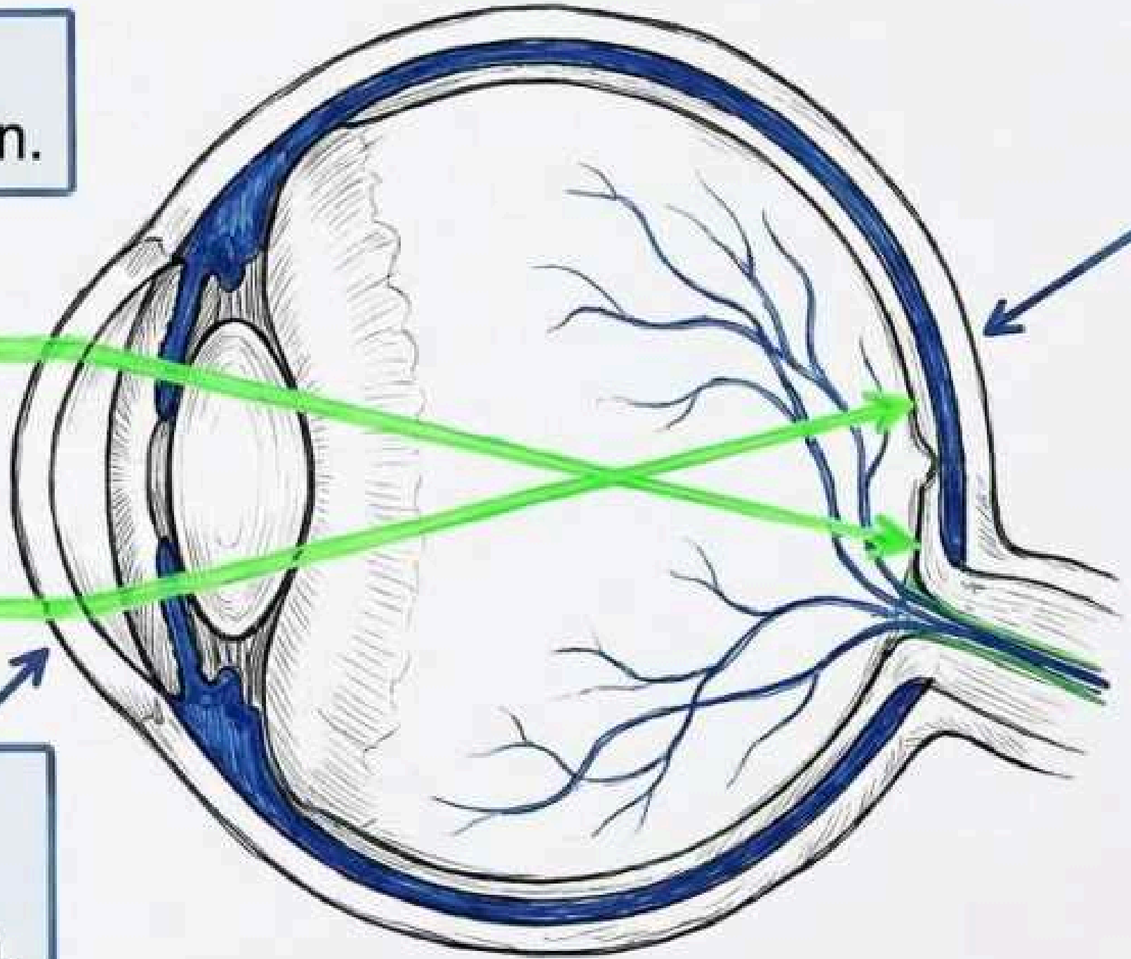
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Vision: Capturing Light

¶ 4.9

The Stimulus:
Electromagnetic radiation.

$\lambda \approx 400\text{–}700$ nm



The Optics:
Cornea and lens act as the focusing mechanism.

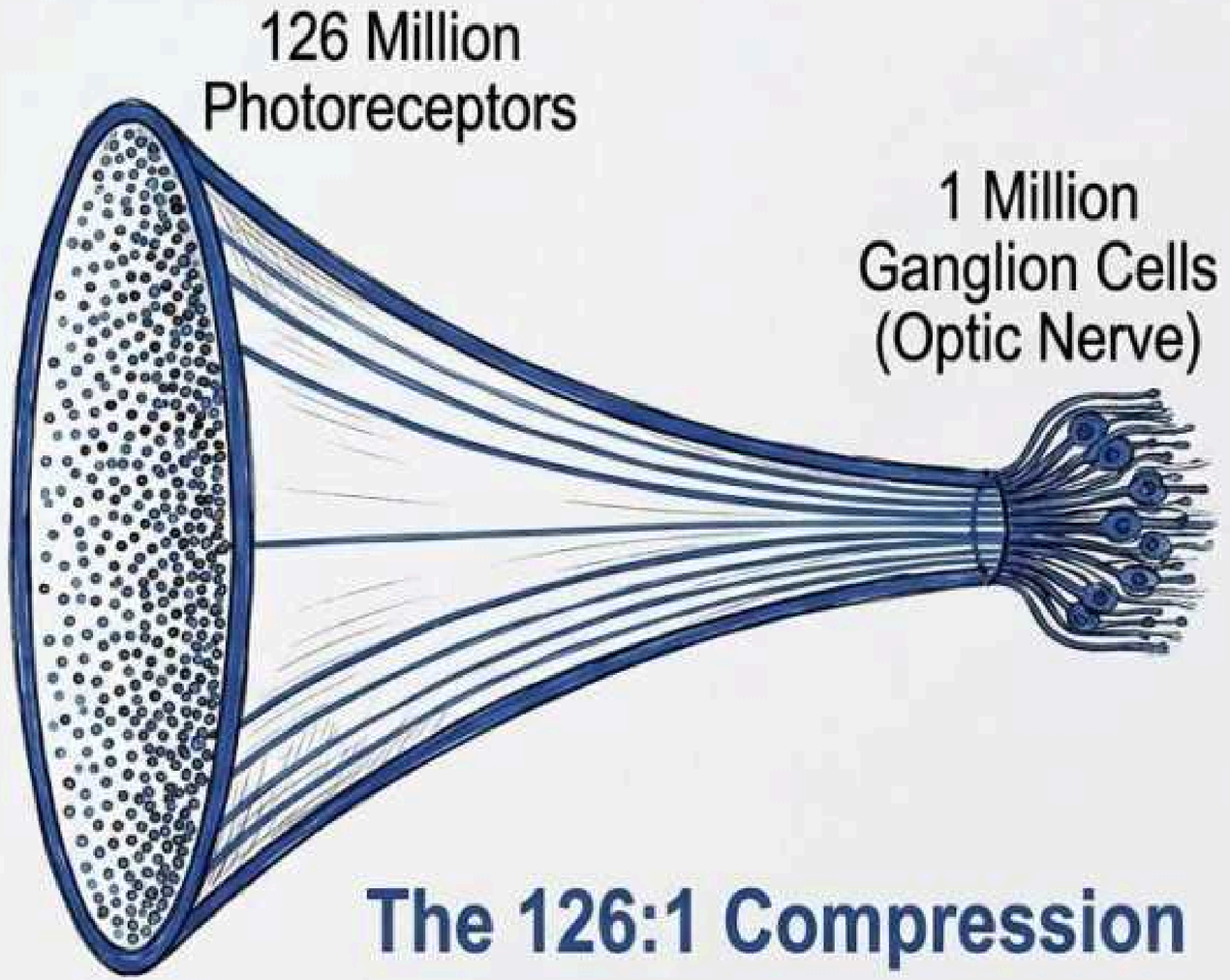
The Retina:
A thin sheet of neural tissue lining the back of the eye. It is an outgrowth of the brain itself and performs significant processing before signals ever exit the eye.

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Photoreceptors and Neural Compression

¶ 4.10

	Count	Lighting	Color	Resolution
Rods	120 Million	Dim Light	No Color	Low Detail
Cones	6 Million	Bright Light	Color	Sharp Detail



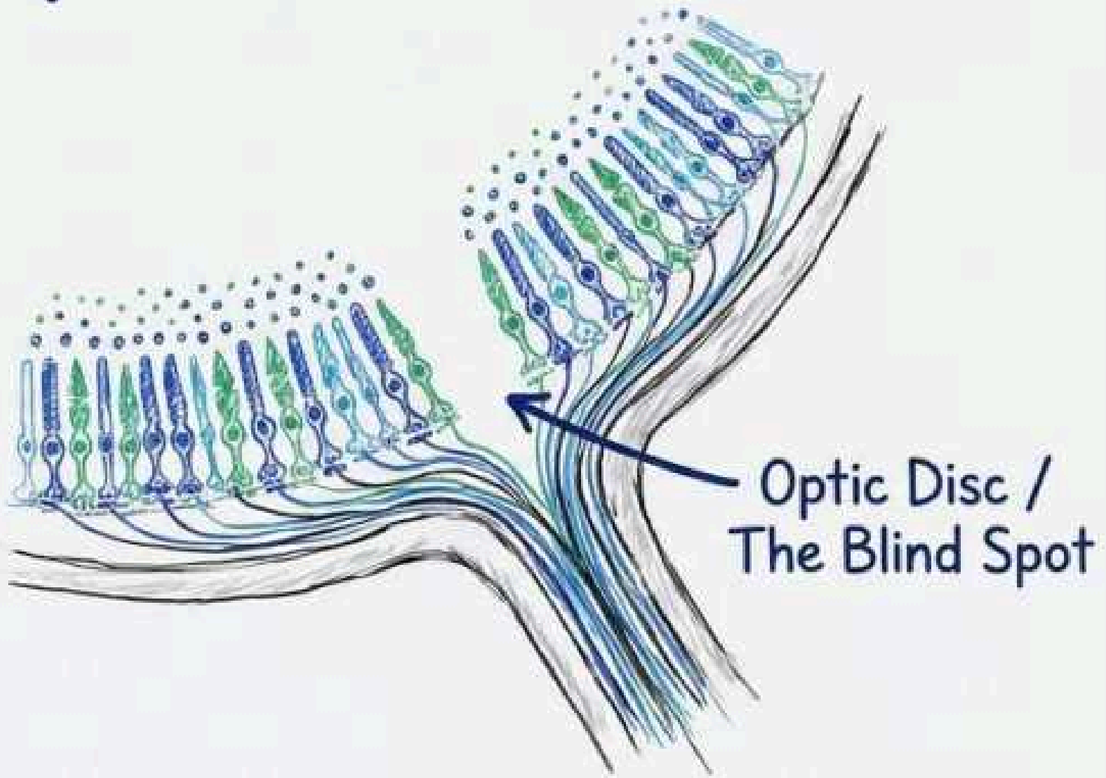
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The Fovea and The Blind Spot

¶ 4.11



Active Sampling: The eye constantly darts around to sample the blurry scene.



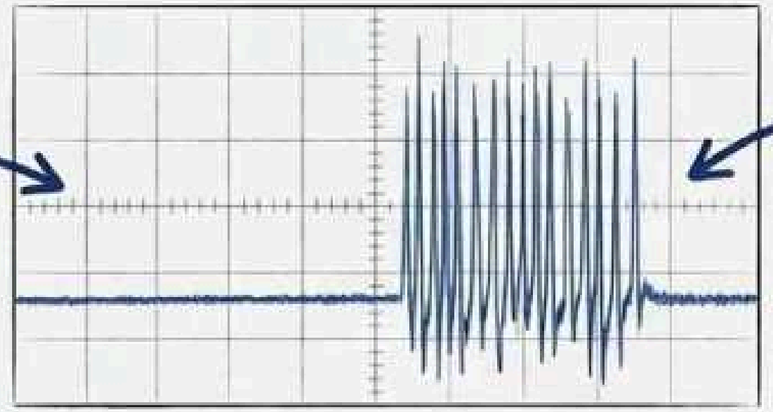
The Blind Spot: A gap with no receptors where the optic nerve exits the eye. The brain "paints in" the missing visual data using surrounding patterns, ensuring we never notice the gap.

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Primary Visual Cortex: Building Edges

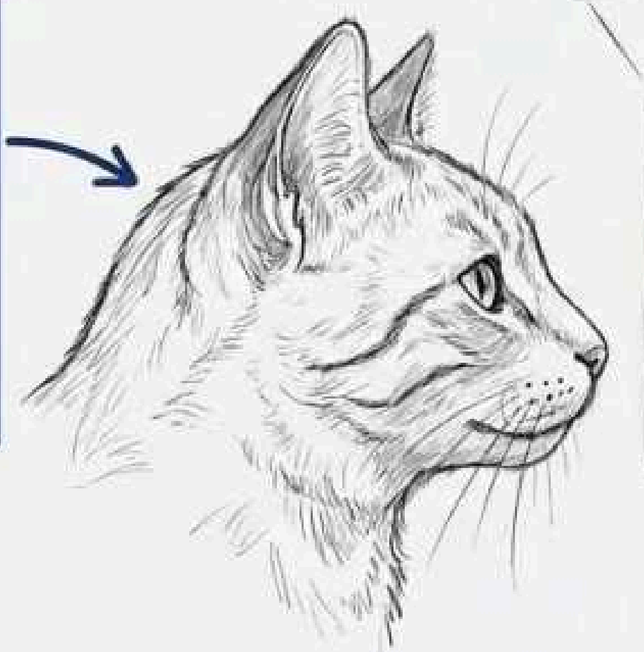
¶ 4.12

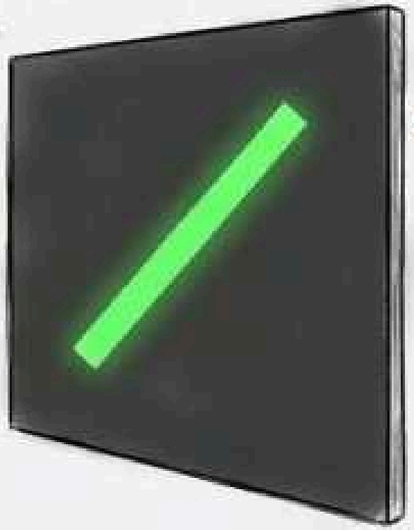
Orientation Tuning: They discovered that a primary visual cortex neuron fires optimally for a bar of light at one particular orientation.



Neuronal Firing Spikes

The Pioneers: David Hubel & Torsten Wiesel (Nobel Prize 1981) recorded single visual cortex neurons in neurons in cats.



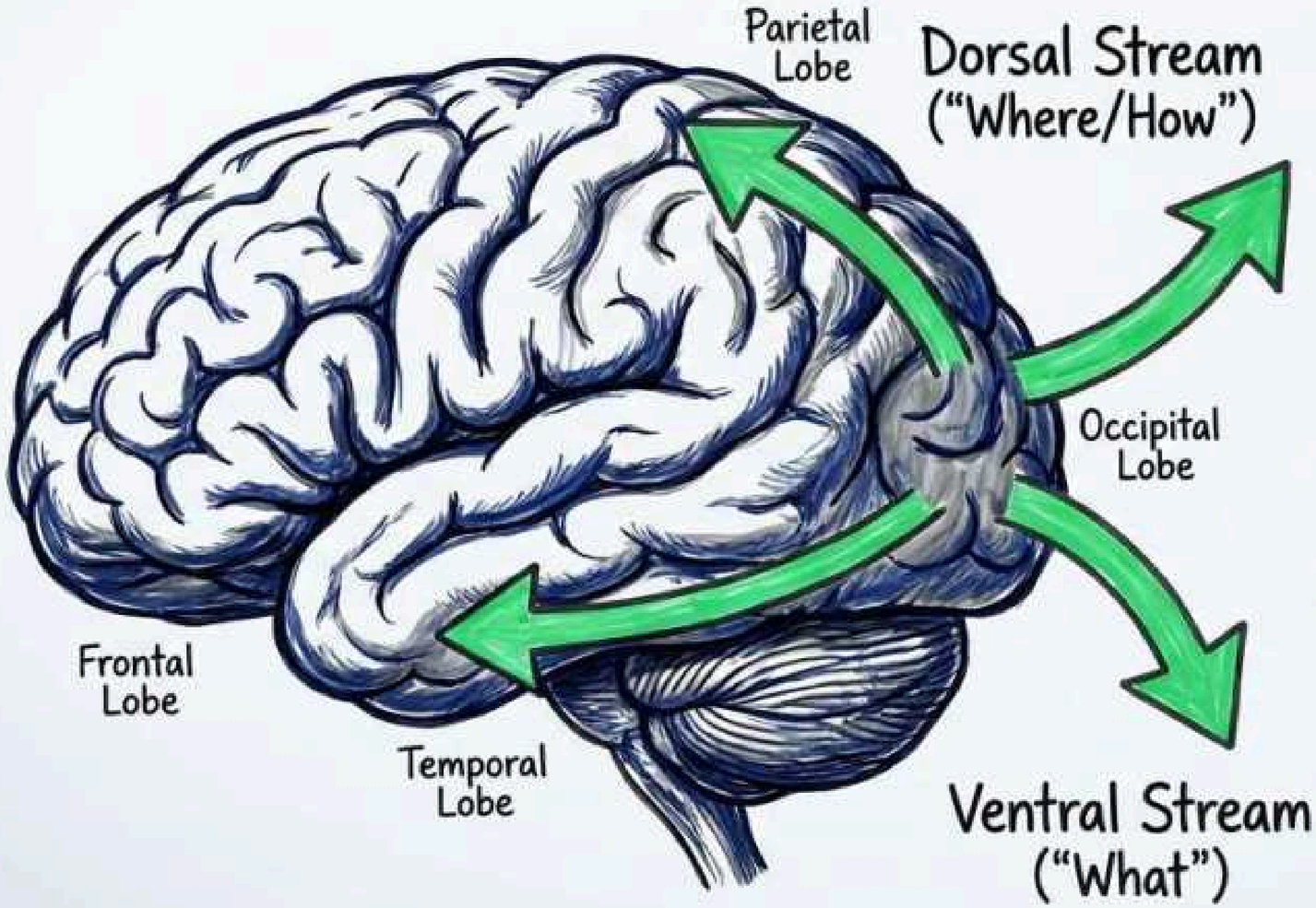


Synthesis: Cortical neurons actively build complex edges from the simple spots of light reported by the retina.

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Visual Pathways: The Two Streams

¶ 4.13



Routes upward to the parietal lobe.

Handles spatial location and action planning (e.g., how to reach for an object).

Routes downward to the temporal lobe.

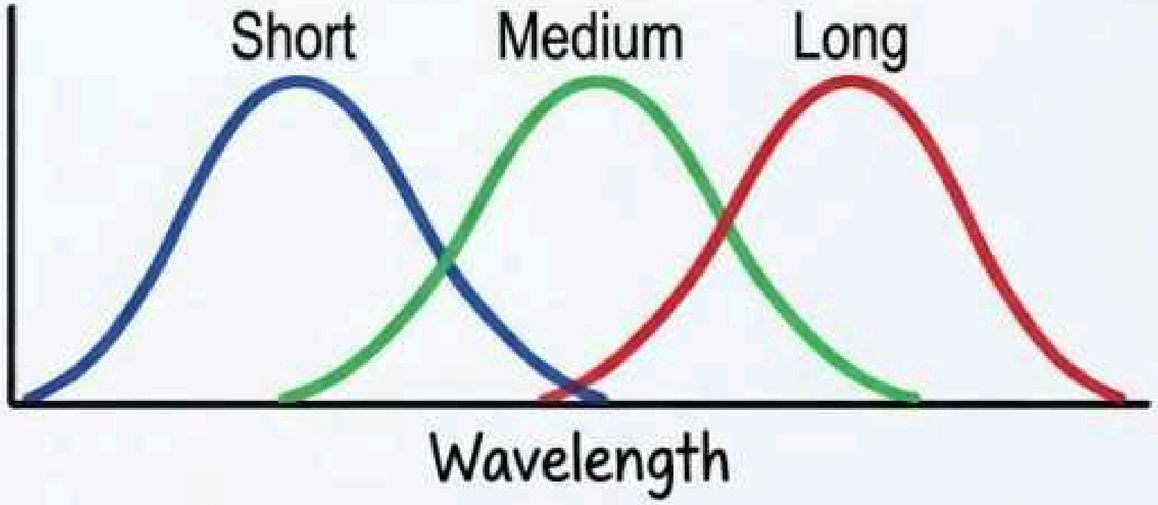
Handles object and facial recognition.

Prosopagnosia: Damage here causes face blindness, even when general vision is perfectly intact.

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¶ 4.14

Color Vision: Trichromacy

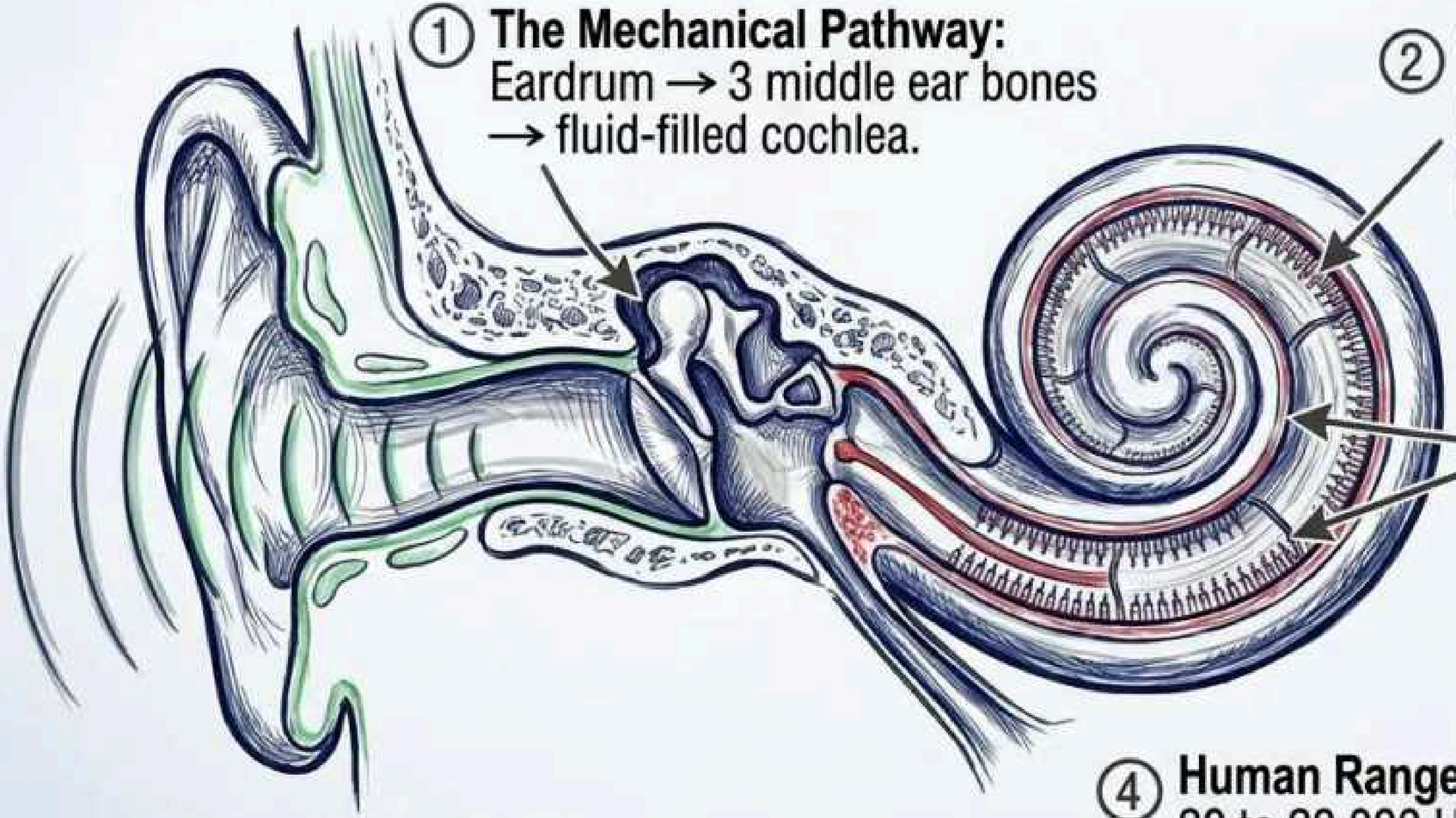


The Mechanism	Color Blindness	Demographics
Color perception depends on three cone types tuned to long, medium, and short wavelengths. The brain deduces color by comparing their relative responses.	Occurs if one cone type is missing or altered, most commonly resulting in **red/green confusion**.	This condition affects roughly **8%** of men of northern European descent, compared to only about **0.5%** of women.

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¶ 4.15

Hearing: Sound Waves to Pitch



① **The Mechanical Pathway:** Eardrum → 3 middle ear bones → fluid-filled cochlea.

② **Transduction:** Vibration moves a membrane lined with approximately 3,500 **inner hair cells**.

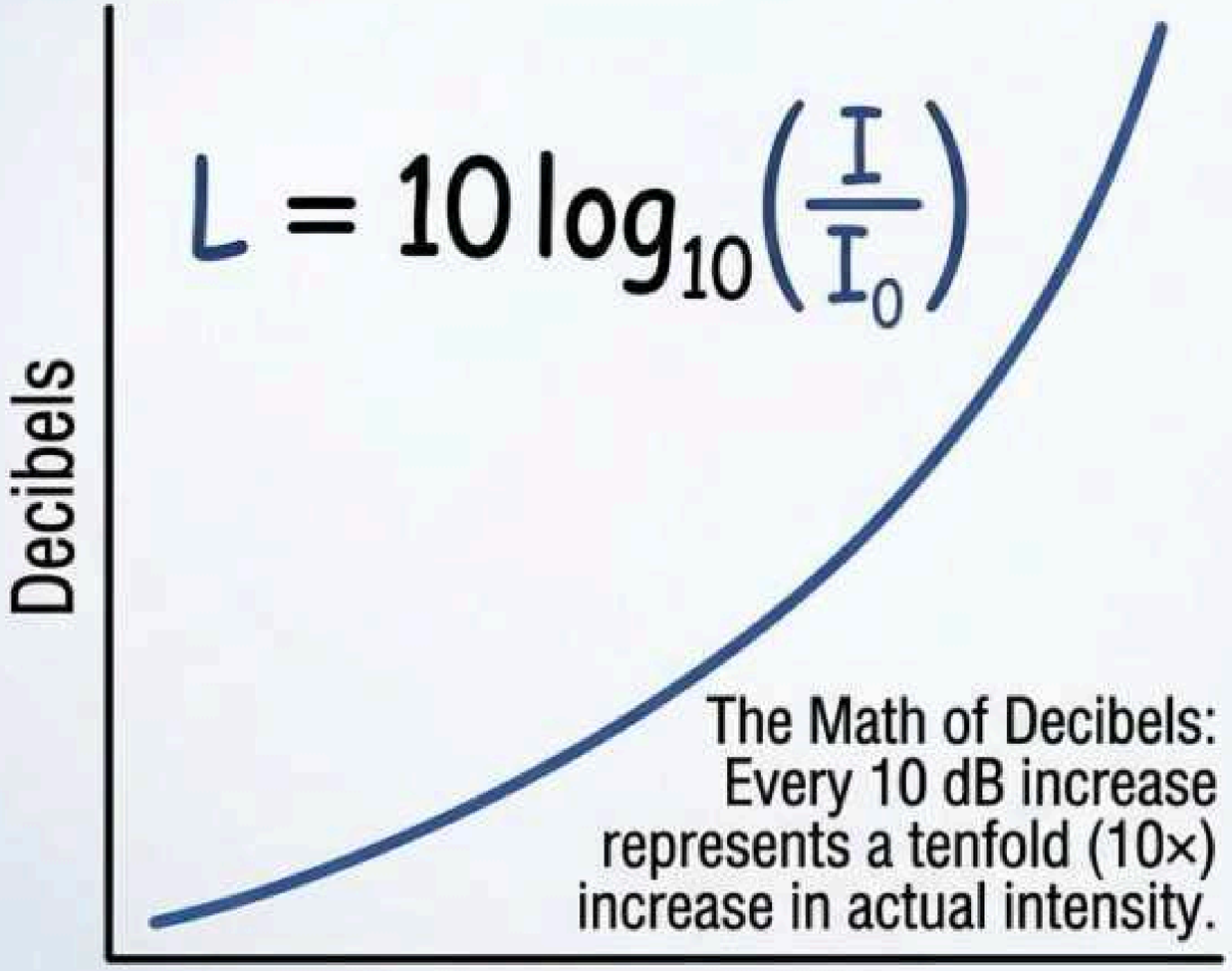
③ **Coding Pitch:** Operates via "place coding" — different physical different physical stretches of the membrane respond exclusively to different frequencies.

④ **Human Range:** 20 to 20,000 Hertz.

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Loudness and Permanent Damage

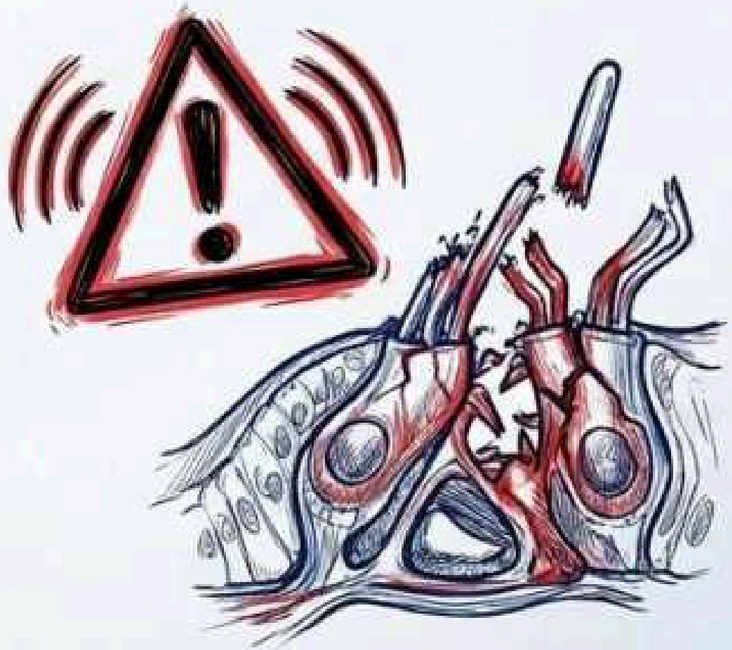
$$L = 10 \log_{10}\left(\frac{I}{I_0}\right)$$



The Math of Decibels: Every 10 dB increase represents a tenfold (10×) increase in actual intensity.

Scale Example

A 60 dB conversation vs. a 120 dB loud concert. This 60 dB difference means the concert is 1,000,000 times more intense (10^6).

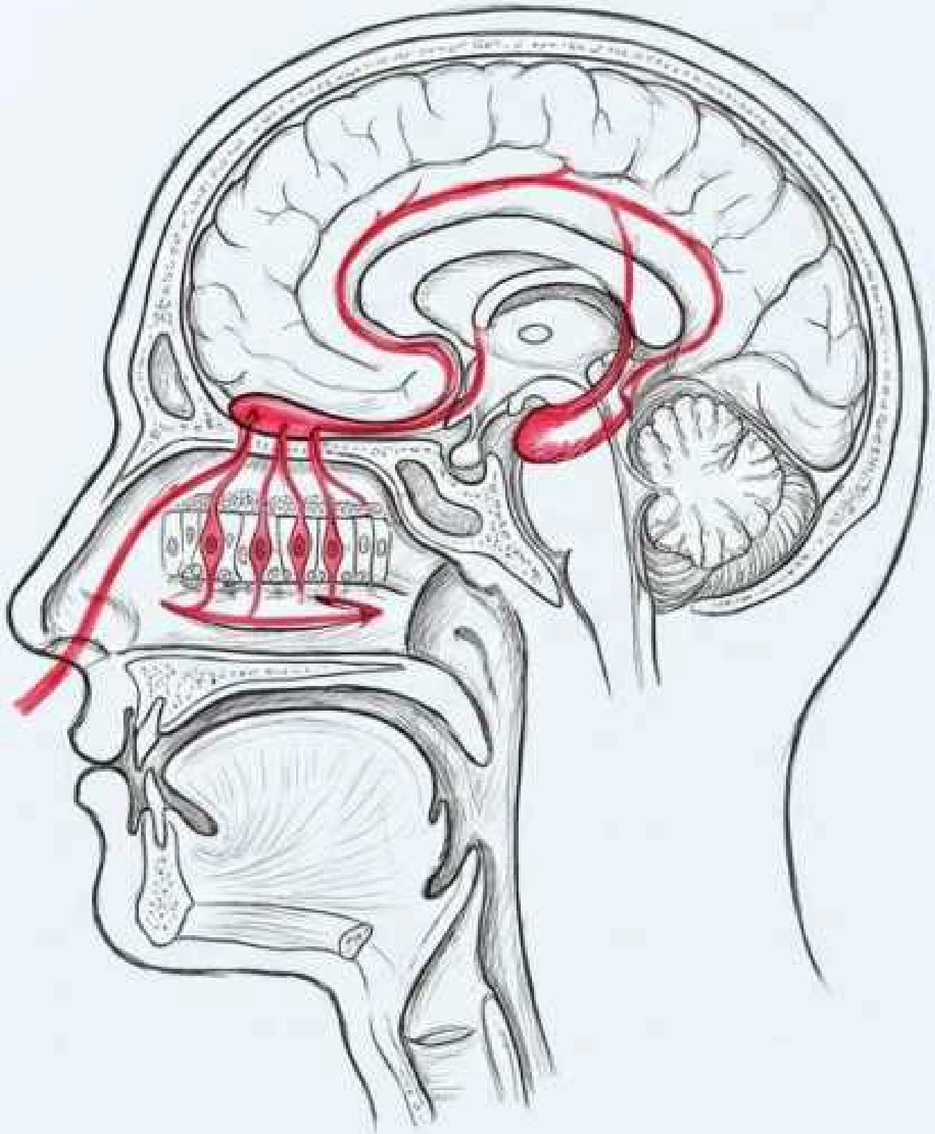


Warning: Human hair cells do not regrow. Noise damage is strictly permanent.

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The Chemical Senses: Smell, Taste, and Flavor

¶ 4.17



Olfaction (Smell): ~400 kinds of working receptors (Nobel Prize 2004: Richard Axel & Linda Buck). Signals route directly to the limbic system, explaining why odors trigger vivid memories.

Gustation (Taste): 5 distinct basic tastes (Sweet, sour, salty, bitter, and umami/glutamate).



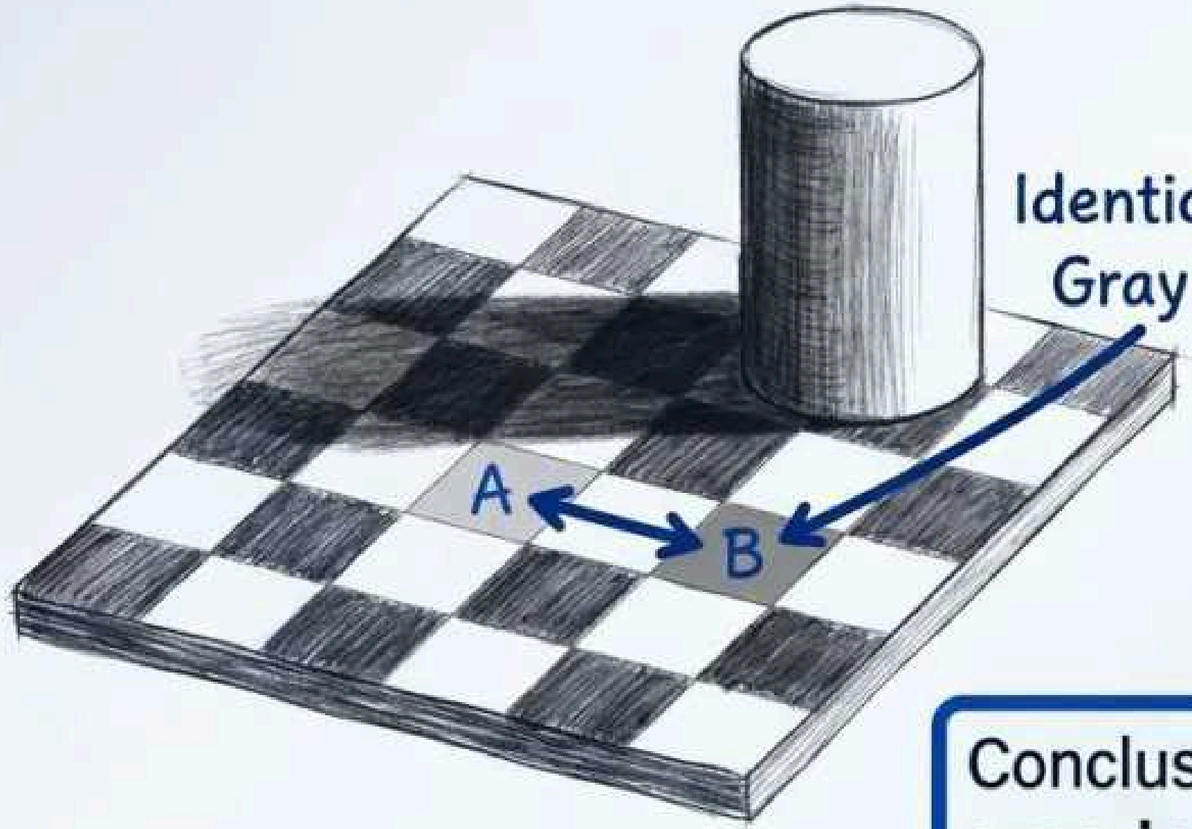
Flavor Synthesis: What we experience as “flavor” is actually a brain-constructed combination of taste and smell (which is why food seems bland when a cold blocks the nasal pathway).

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Perception is More Than Reception

¶ 4.18

The Inference Engine: The brain combines raw sensory signals with **structural expectations** and past experiences to **infer what is most likely out there.**



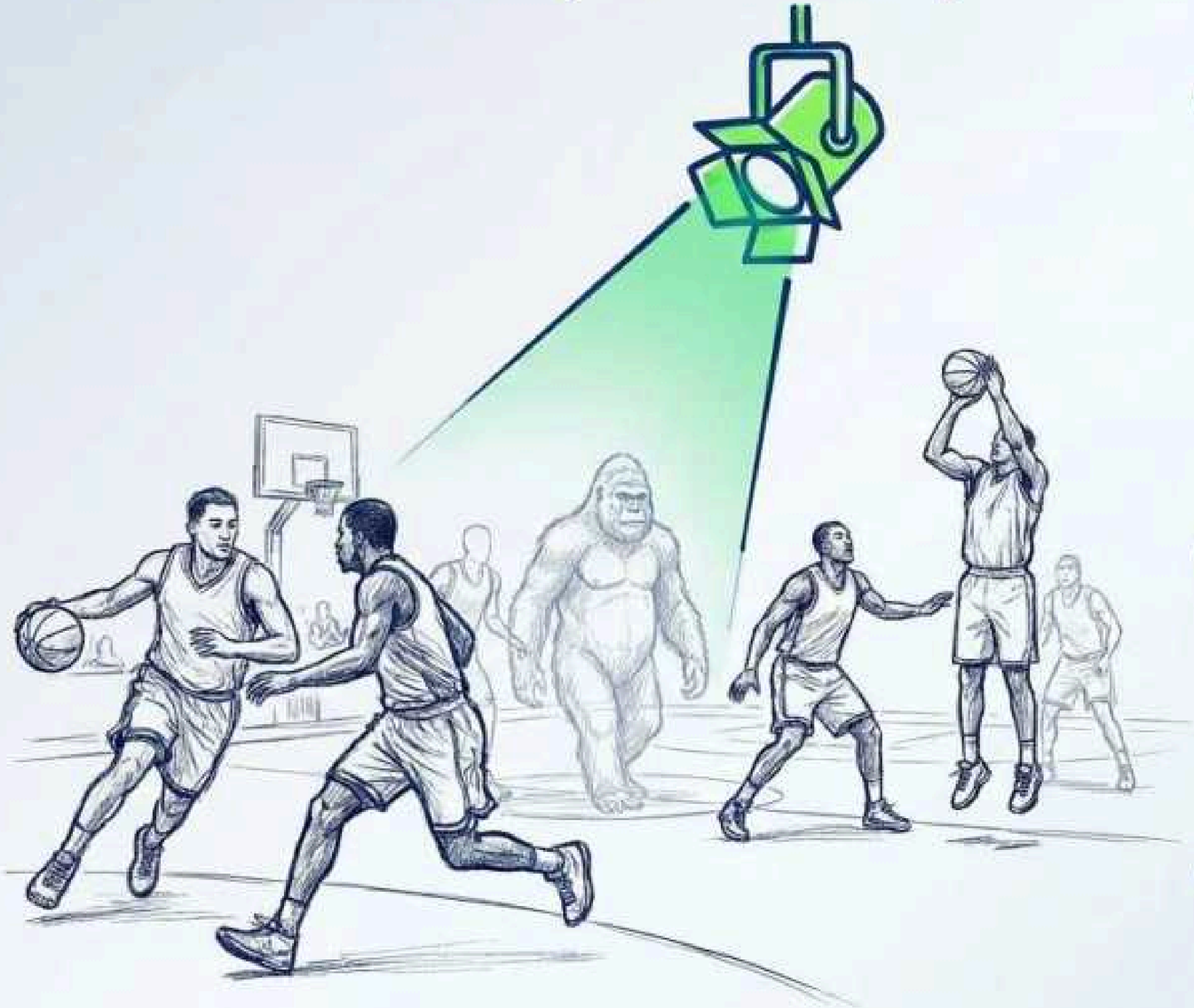
Discounting Shadows: Identical squares look vastly different in brightness because the brain automatically compensates for perceived shadows.

Conclusion: We never see the raw signal; we only **experience** the brain's **best interpretation** of it.

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Attention Shapes Perception

¶ 4.19

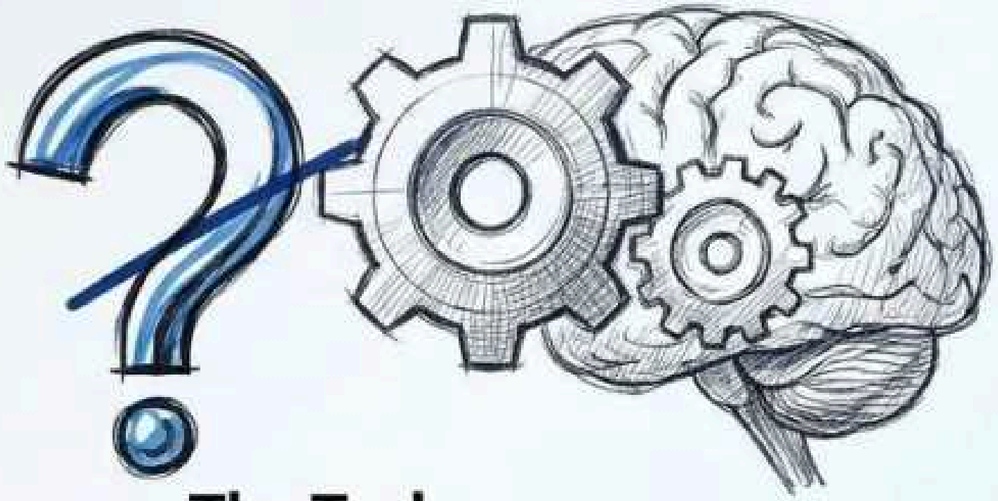


- **The Invisible Gorilla:** In a 1999 experiment, Daniel Simons and Christopher Chabris asked viewers to coun basketball passes. Roughly half of the viewers completely failed to notice a person gorilla suit walking through the scene.
- **Inattentional Blindness:** The visual data of the gorilla reached the retina and entered the brain, but without attention, it was never perceived.
- **Takeaway:** Seeing requires the alignment of cognitive attention, not just optical reception.

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Lecture Synthesis Challenge

¶ 4.20



The Task:

The Prompt:
A friend argues that colors and sounds exist exactly as we experience them in the outside world, and our senses simply act as video/audio recorders.

The Task: Explain why this picture is incomplete. You " explicitly use the follo concepts to debunk their claim:

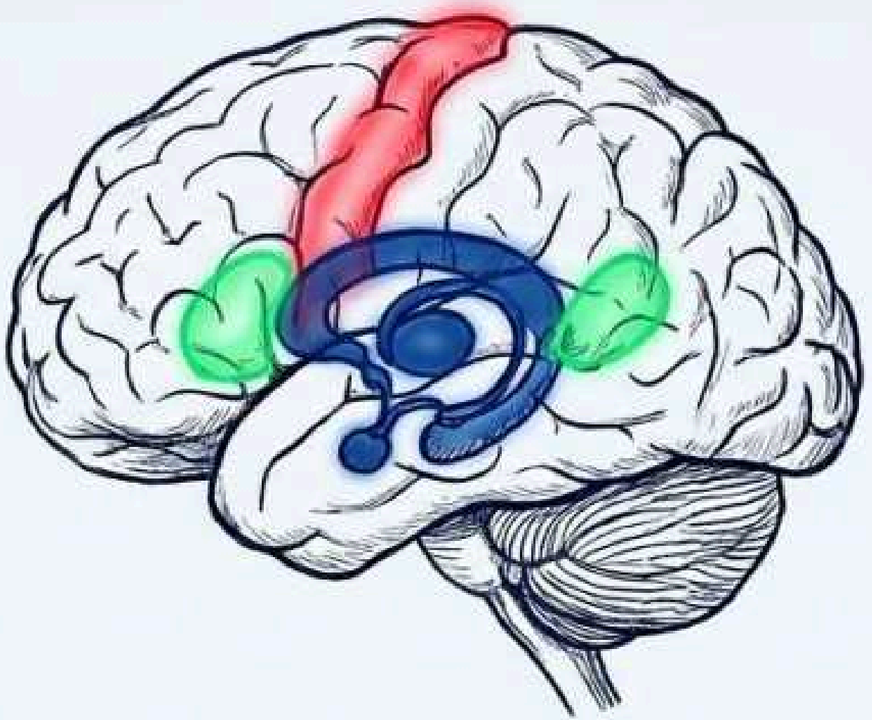
1. Transduction
2. Coding by firing rate
3. Perception as inference

Final Requirement:
Provide one concrete example (like the checkerboard shadow or the gate control of pain) to prove them wrong.

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Looking Ahead: Lecture 5

¶ 4.21



Core Focus: Transitioning from how the brain receives the world to how it is organized to produce output.

Upcoming Topics: Movement, Emotion, and Language.

Methodology: We will explore the major structural regions of the brain and study the historical patients with localized brain damage who fundamentally taught us what these specific regions do.

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