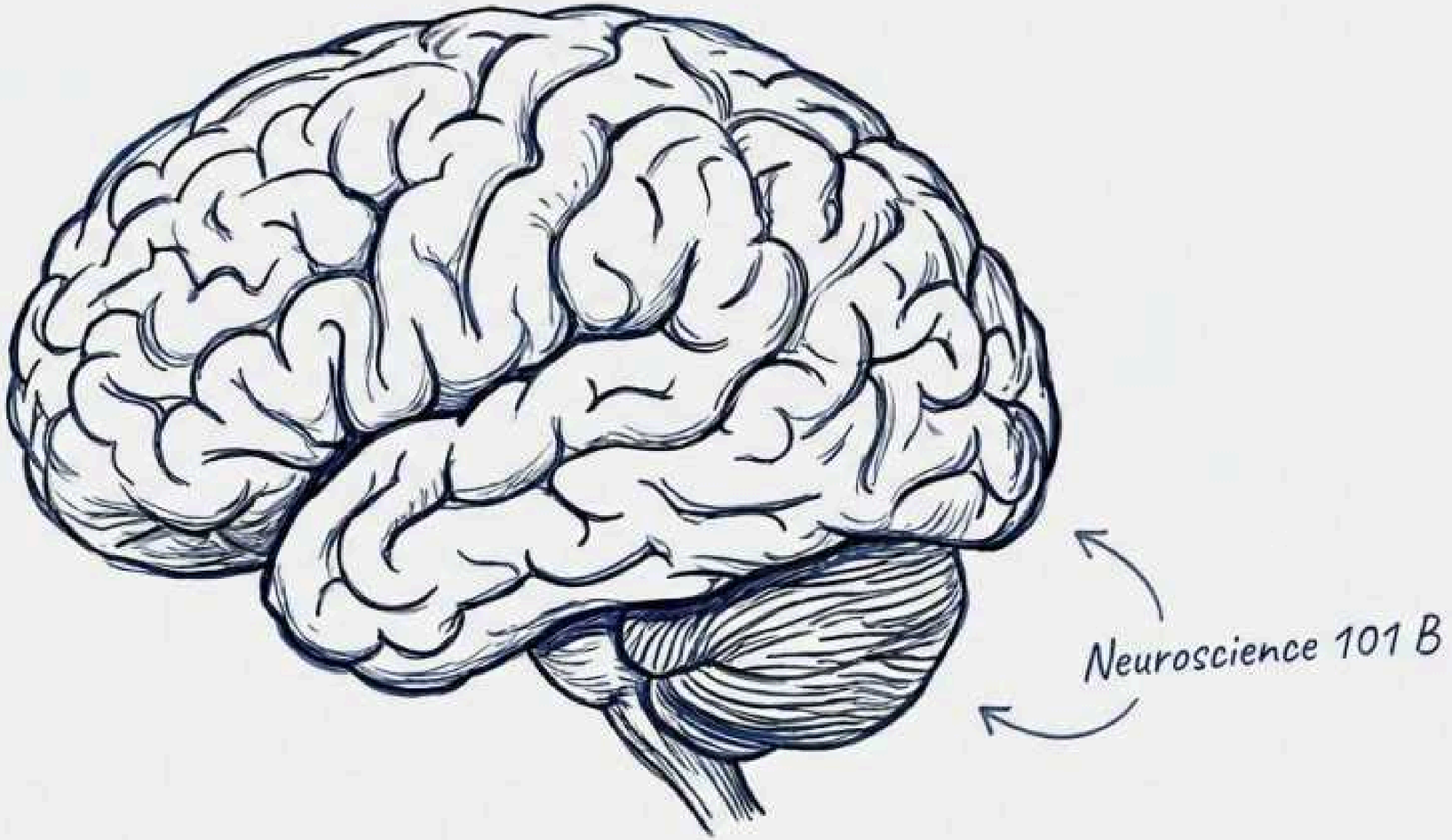
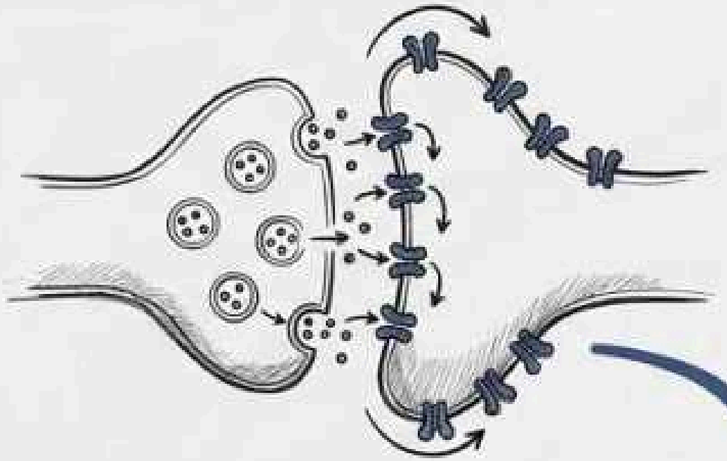
Welcome to Lecture 6

Learning, Memory, Sleep, and the Changing Brain.

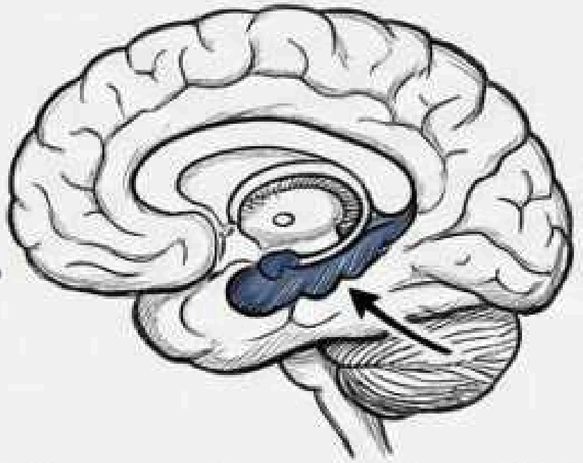


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¶ 6.2

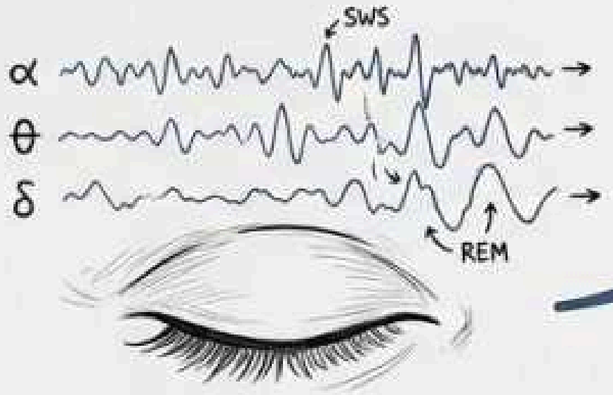


Synaptic Strengthening (Learning)

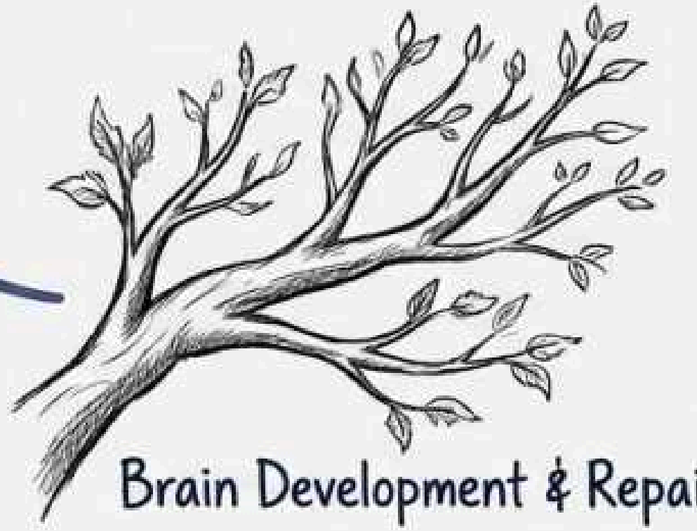


Memory Organization (Patient H.M.)

Experience



Sleep States (Active brain)



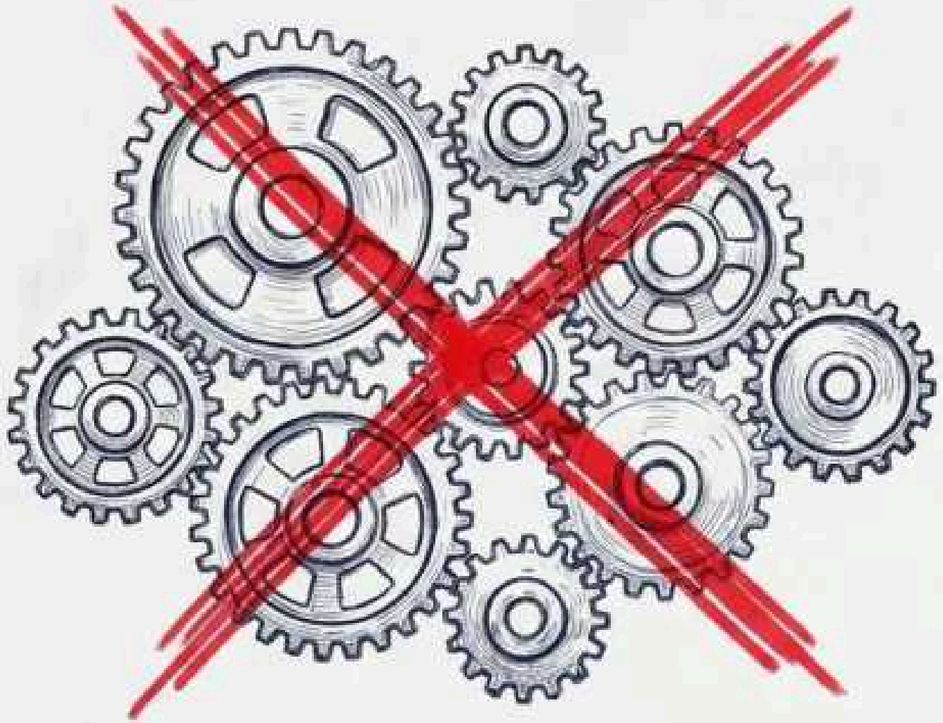
Brain Development & Repair

Bringing together the neurons, signals, and synapses to understand how the brain changes.

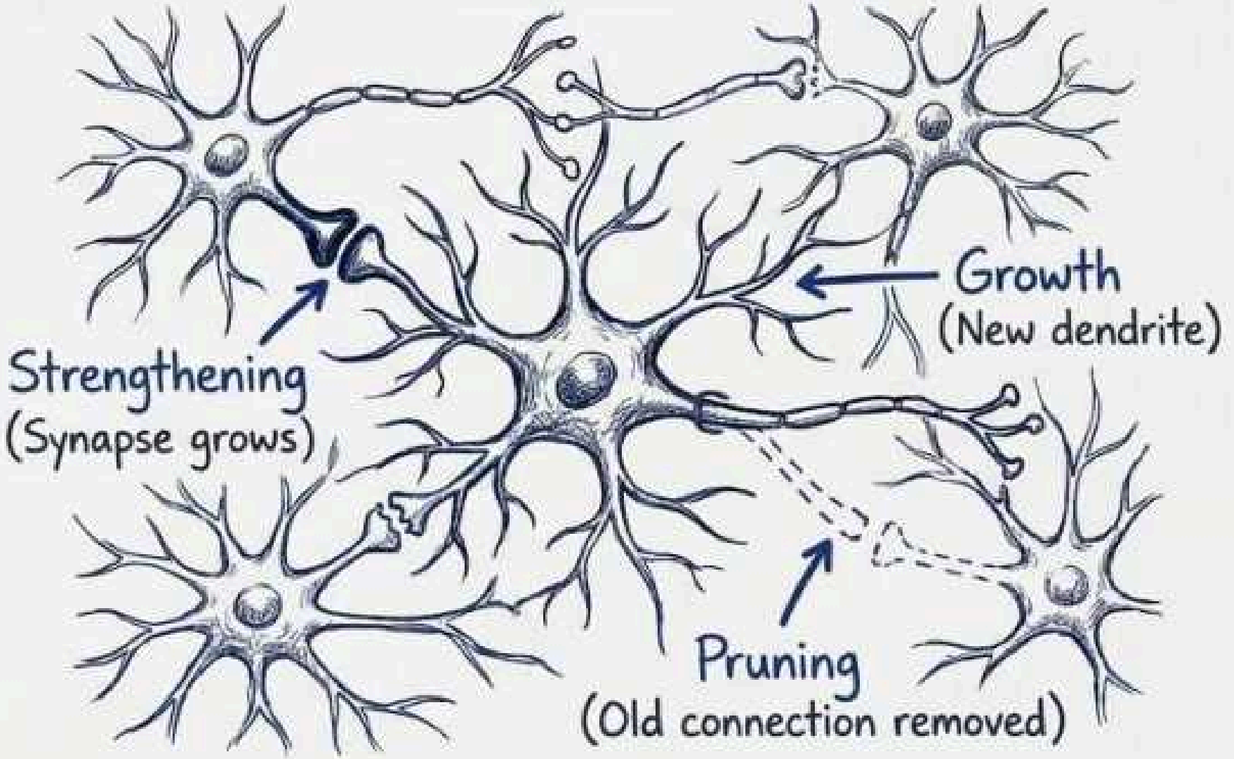
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The Central Idea: Plasticity

The Myth



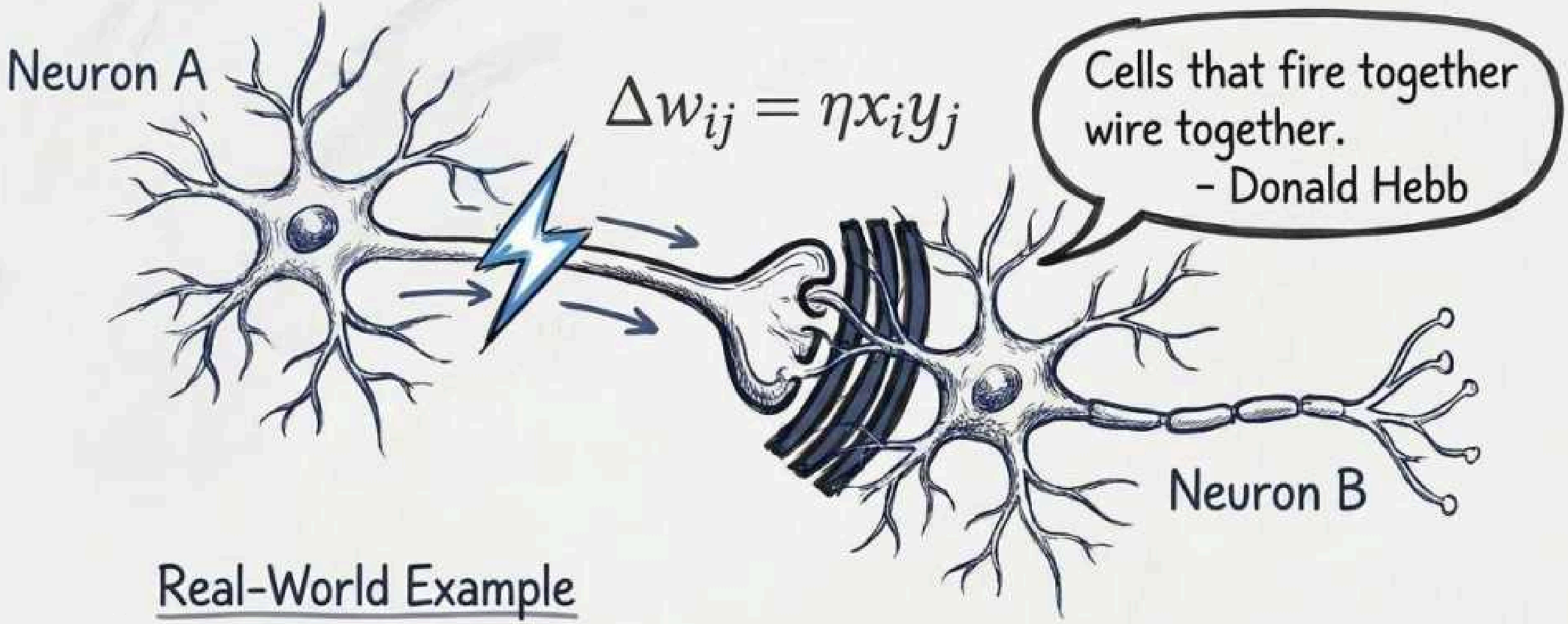
The Reality



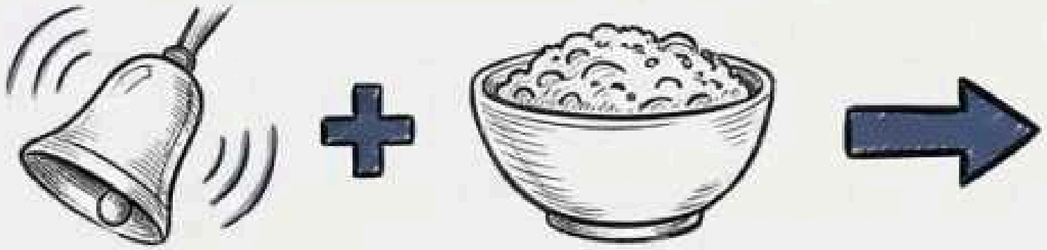
The nervous system constantly rewires its own physical structure in response to every face, word, or skill you learn.

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Hebbian Learning (1949)



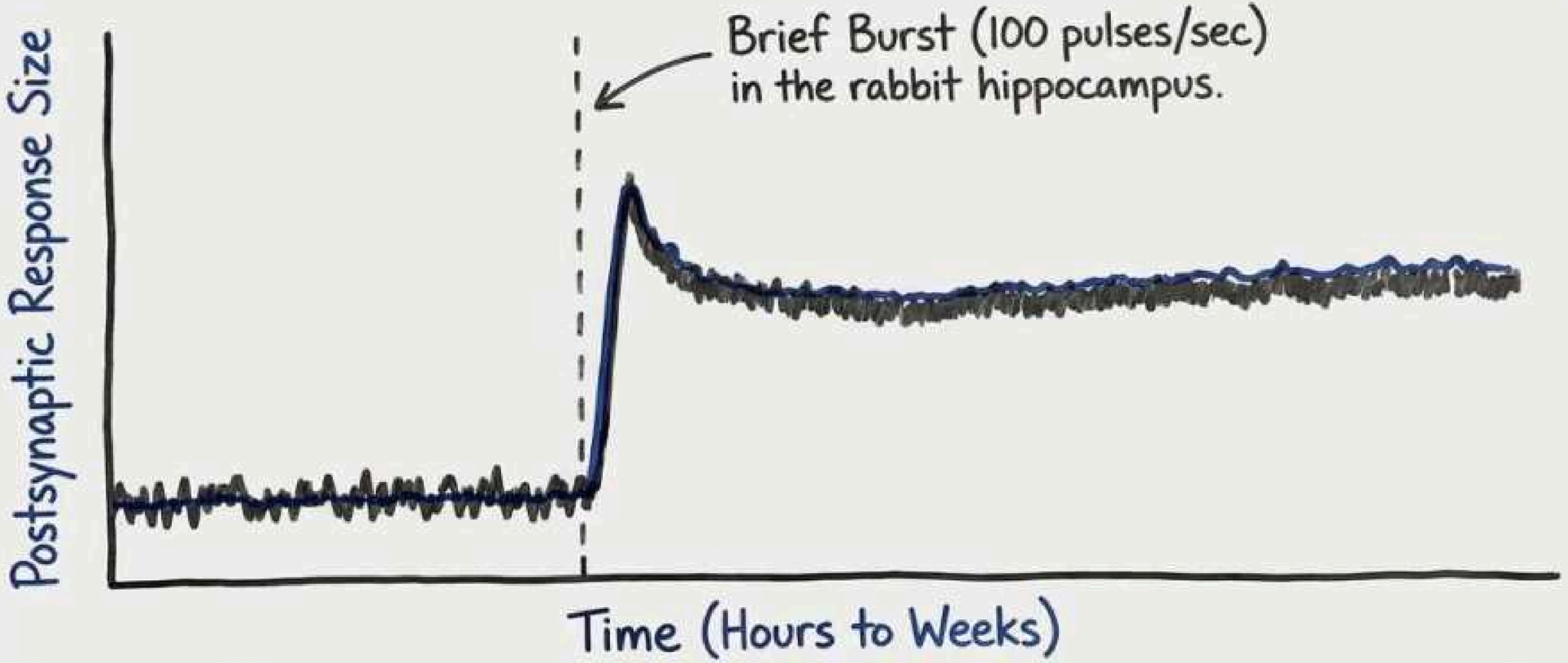
Real-World Example



Association Formation
(Connected neural response)

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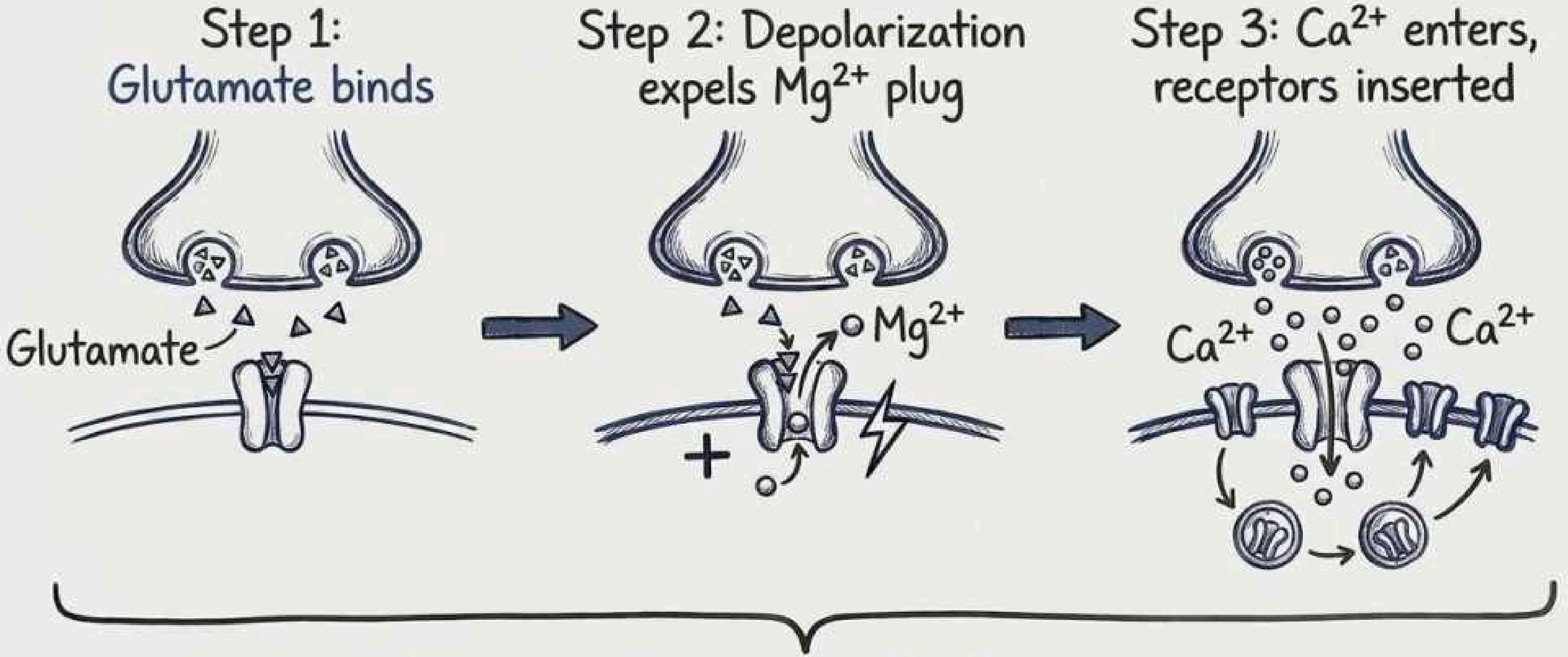
Direct Evidence: Long-Term Potentiation (LTP)



The synapse physically remembers the burst—strengthening its response for weeks afterward.

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The NMDA Receptor acts as a Coincidence Detector

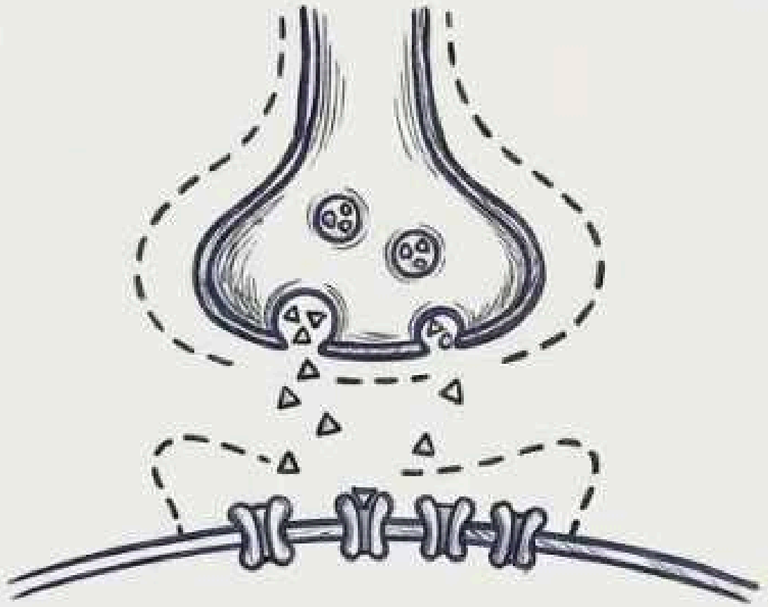


The synapse is now structurally enhanced.
It "remembers" it was recently useful.

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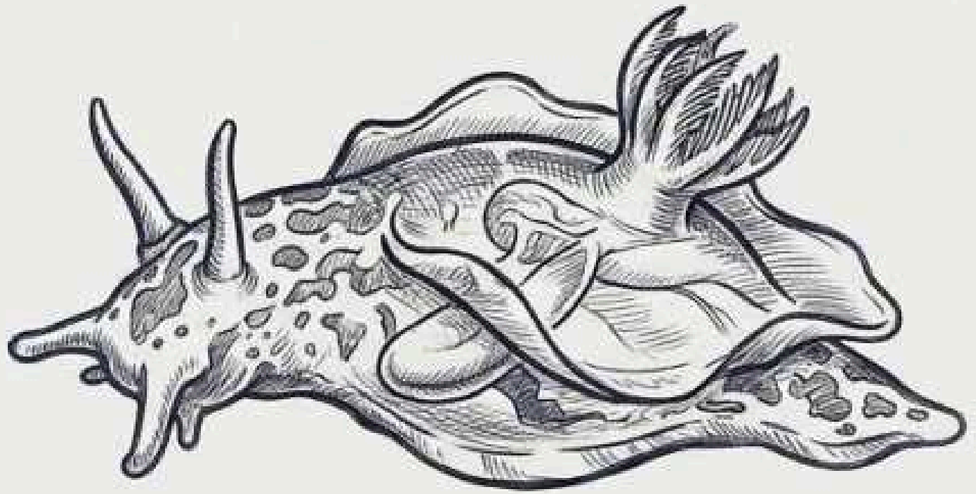
Long-Term Depression & The Aplysia Model

Long-Term Depression (LTD)



Rare or out-of-step use triggers LTD. Essential to prevent network saturation.

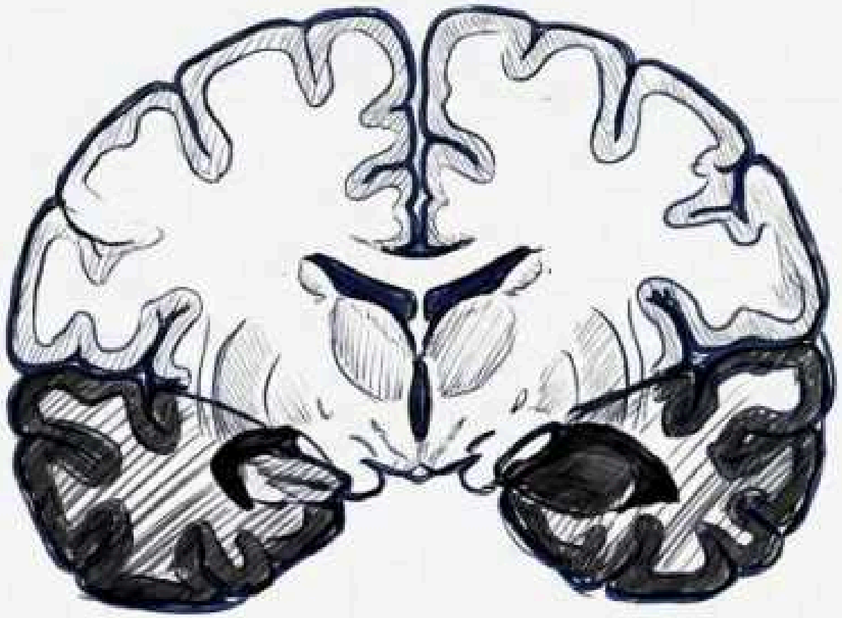
Eric Kandel's Research



Short-Term Learning	Alters existing proteins.
Long-Term Learning	Requires new protein synthesis & growth of entirely new synapses.

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The Case of Patient H.M. (Henry Molaison)



1953

Surgery to treat severe epilepsy. Seizures stop, but the ability to form new memories of facts/events vanishes.

"Lived in an unchanging present."

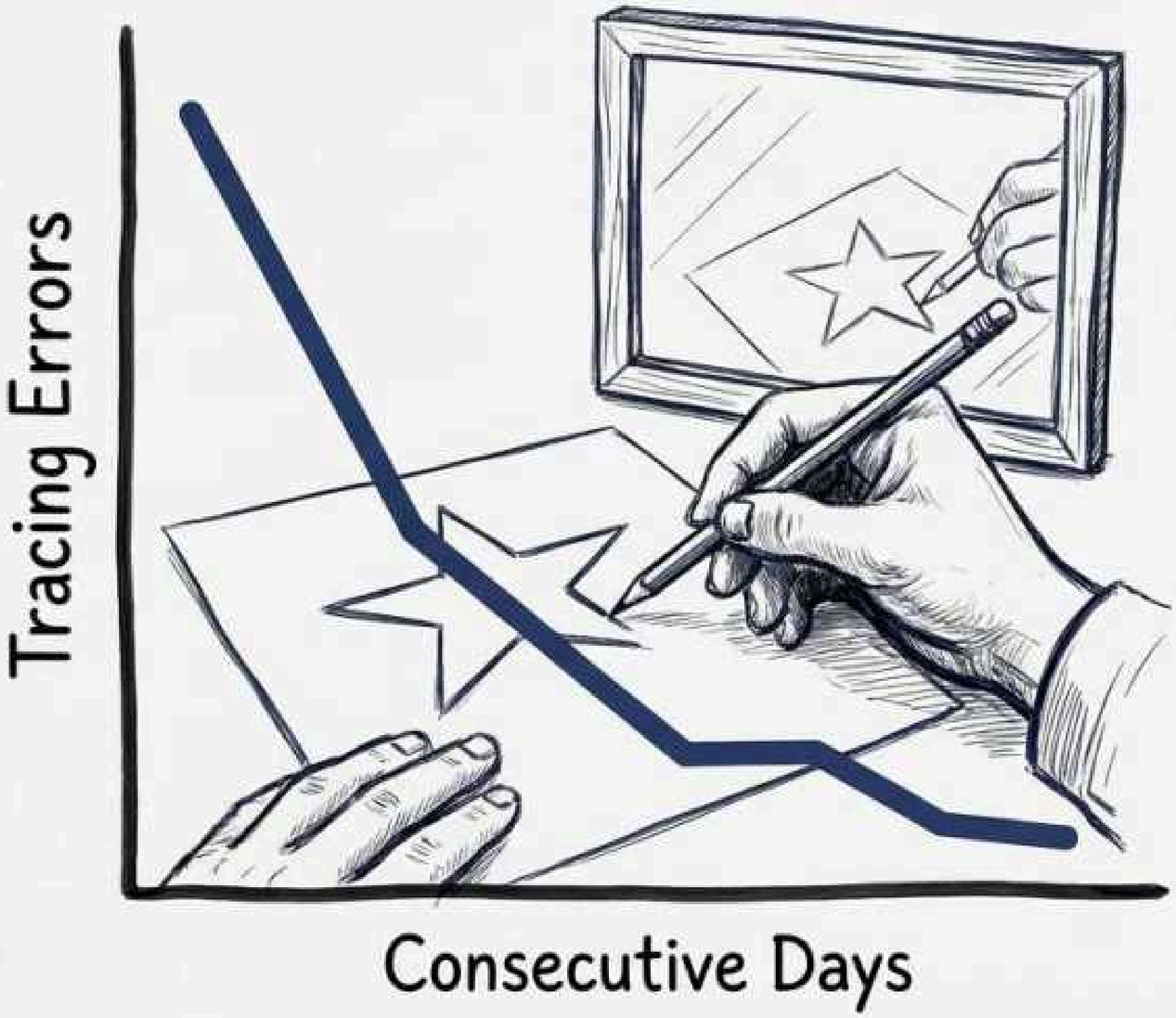
The ultimate proof that specific brain regions control specific memory functions.

2008

Death.

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Discovering Distinct Memory Systems



H.M. improved at the skill daily, despite insisting each day he had never seen the task before.

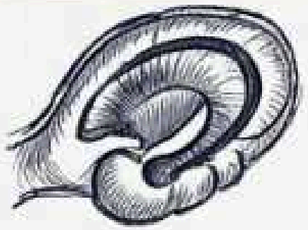
Skill learning worked perfectly while episodic memory failed entirely. **is <u>not</u>** a single system.

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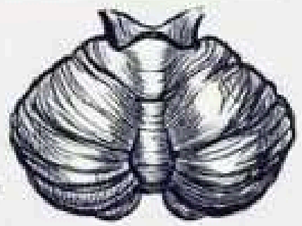
The Taxonomy of Human Memory

Memory

- **Working Memory**
  (Holds items for seconds, e.g., a phone number)
- **Long-Term Memory**
  - **Explicit / Declarative (Events, Facts)**
    → Location: Hippocampus



  - **Implicit (Skills, Habits, Conditioned responses)**
    → Locations: Cerebellum, Basal Ganglia, Amygdala



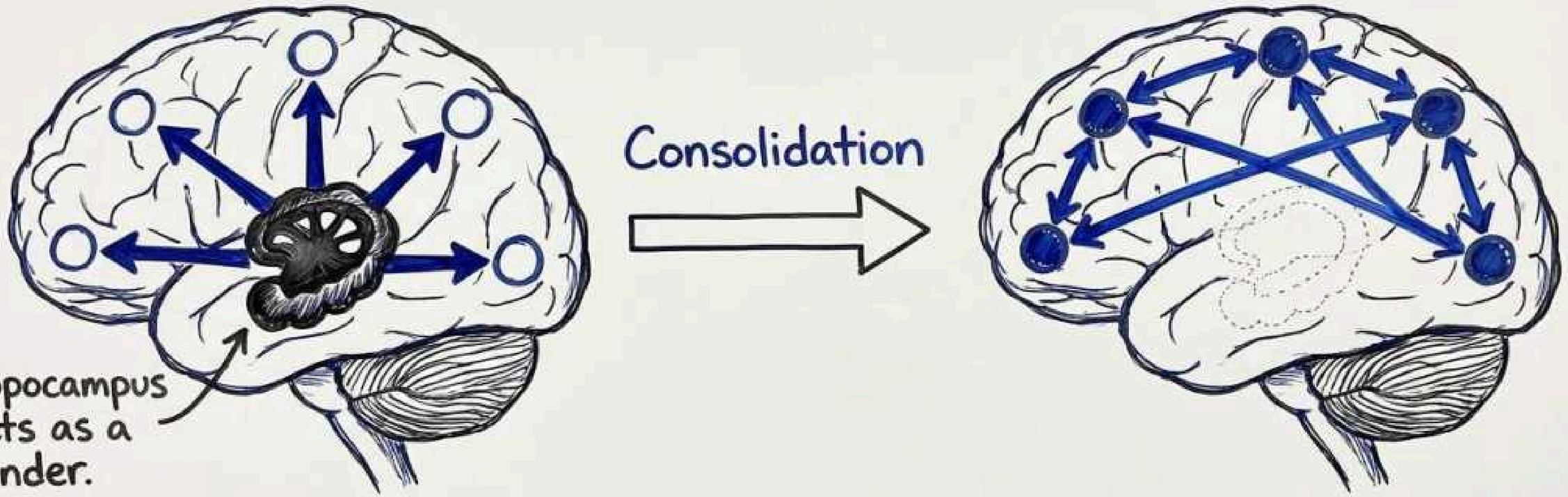
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Memory Consolidation Over Time

¶ 6.11

Time 1 (Now)

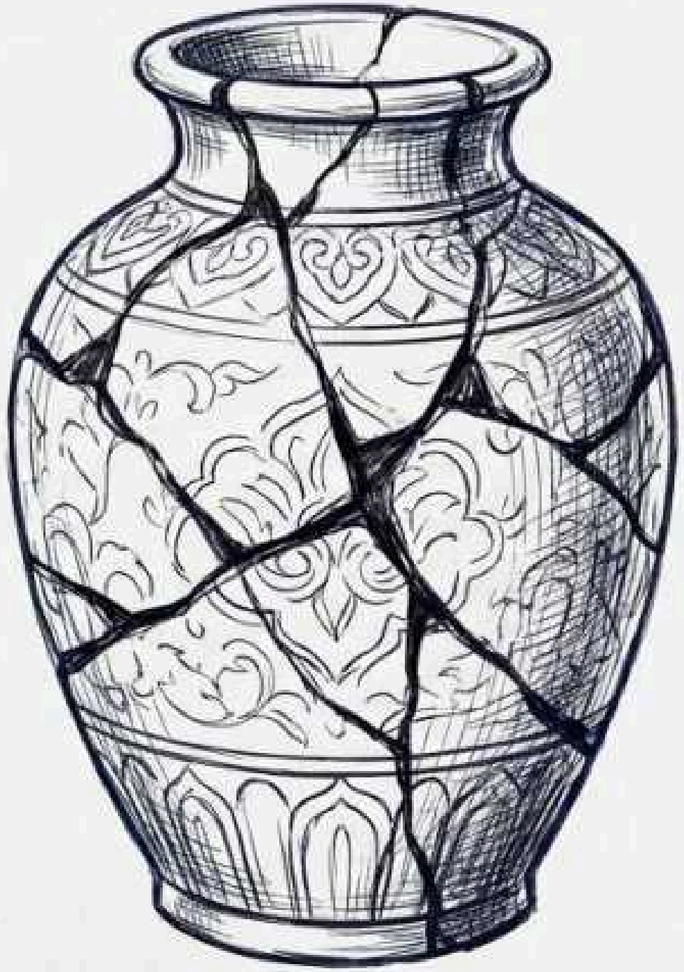
Time 2 (Days/Years later)



The cortex eventually holds the memory on its own. Explains why H.M. retained old memories (already in the cortex) but couldn't consolidate new ones.

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Memory is a Reconstruction, Not a Recording



(Ref: Elizabeth Loftus's wording effect)

Study Optimization Matrix

Spacing > Cramming

Spaced practice works better

Testing > Rereading

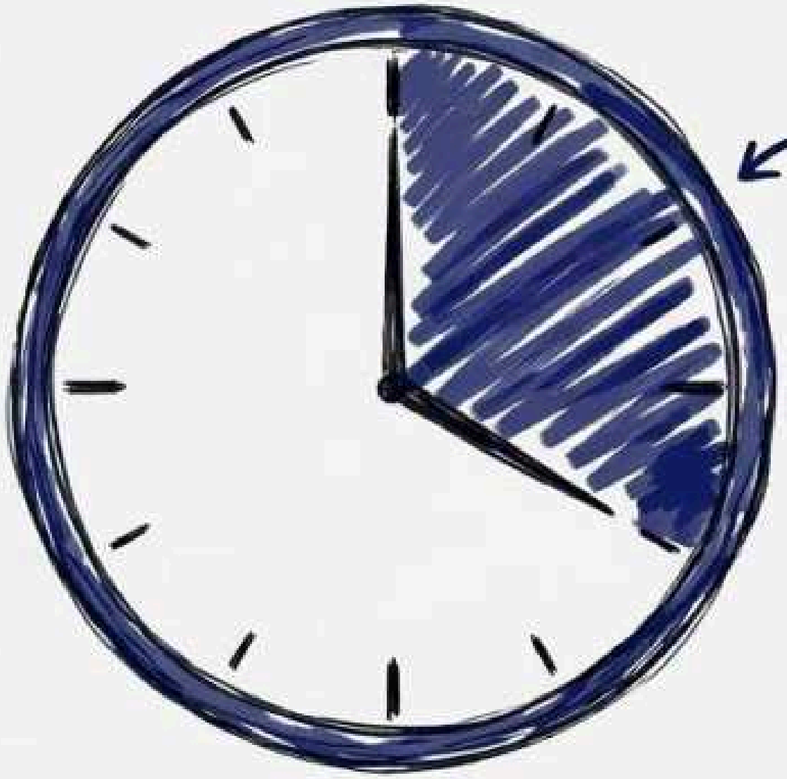
Self-testing works better

Underlying Mechanism:

Both spacing and testing force the brain to work harder at retrieval, which physically strengthens the neural pathway.

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The Active State of Sleep



~1/3 of life spent sleeping (7-9 hours for adults)

Diagnostic Deprivation Symptoms:

- ✓ Poor attention
- ✓ Weak memory
- ✓ Impaired mood

Sleep is highly active, not a biological shutdown. Understanding why we sleep remains a major open question in neuroscience.

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The EEG Stages of the Brain

Awake/Alert

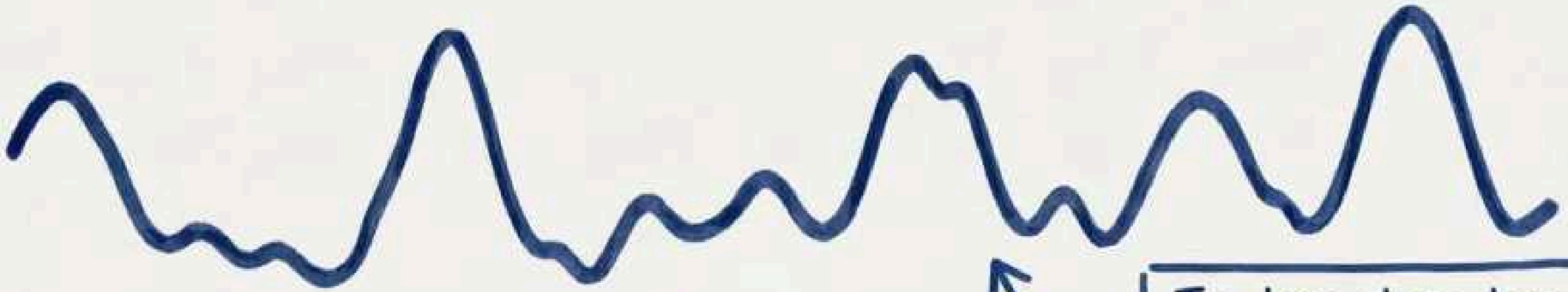


Relaxed/Eyes Closed



Alpha waves (α) | 8–12 Hz

Deep Non-REM



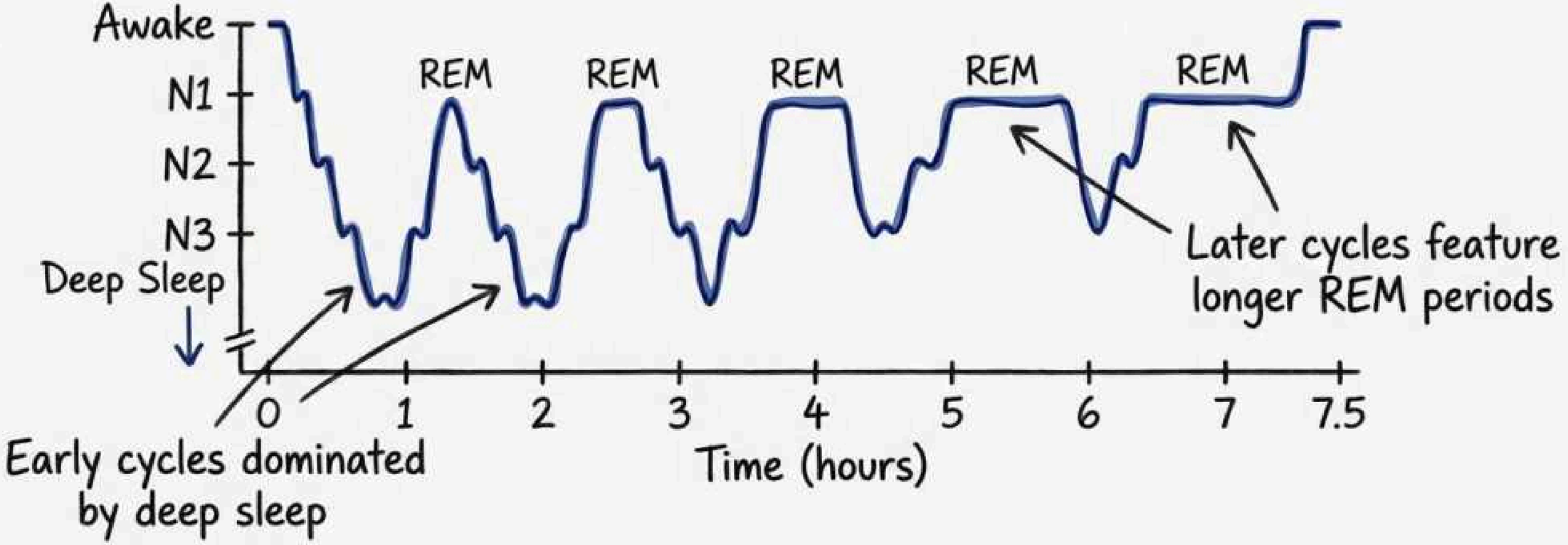
Delta waves (δ) | 0.5–4 Hz

In deep sleep, huge populations of neurons are firing together in synchronized lockstep.

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The Architecture of REM Sleep (Aserinsky & Kleitman, 1953)

¶ 6.15



REM Characteristics:

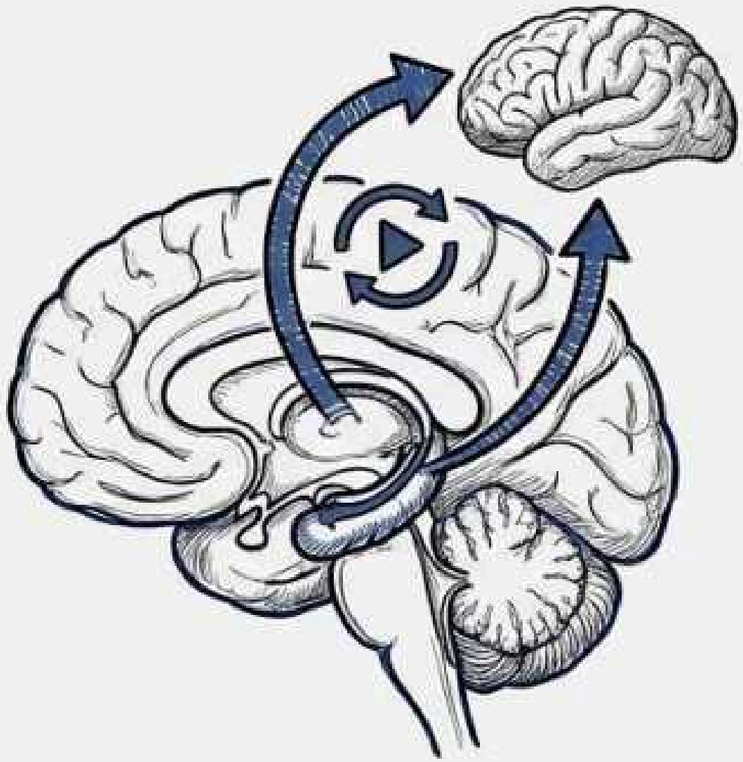
- EEG resembles awake state.
- Rapid darting eyes & vivid dreams.
- Brainstem paralyzes body muscles to prevent acting out dreams.

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Why Do We Sleep? Three Key Roles

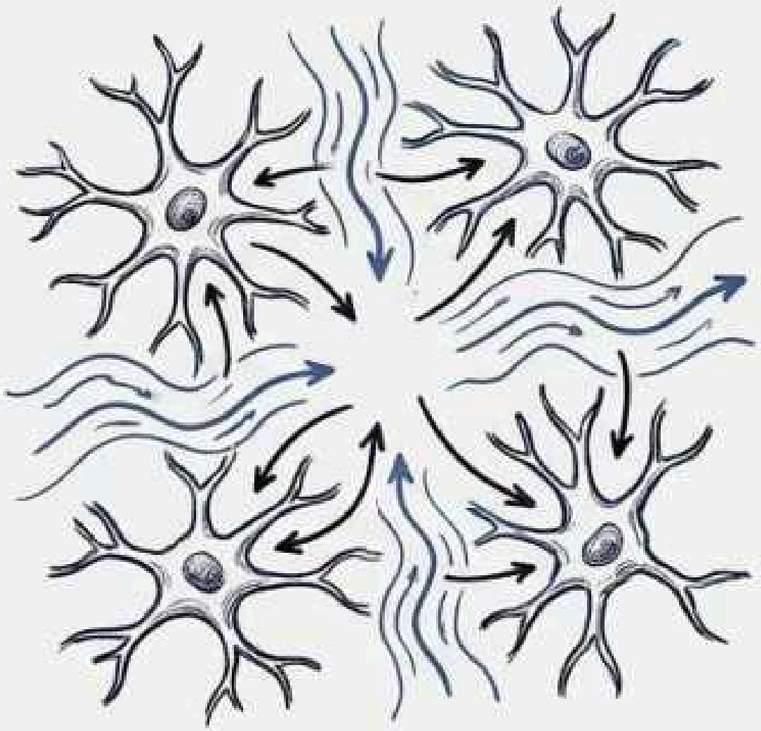
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1. Memory Consolidation



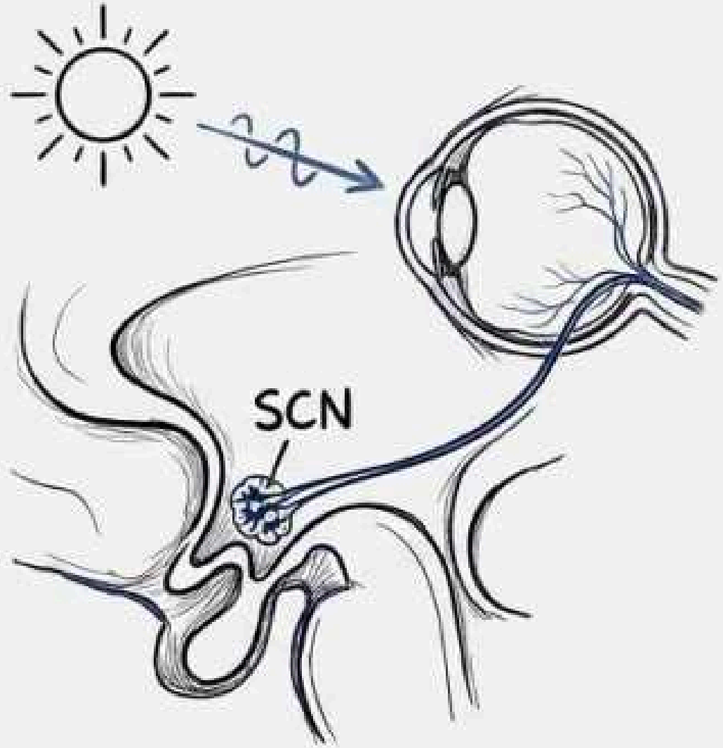
Replaying daily experiences for storage.

2. Biological Maintenance



Flushing out metabolic waste (observed in mice).

3. Circadian Rhythm



The master 24-hour clock, reset daily by light.

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Development and Critical Periods



Experience prunes the excess.



The Developing Brain
(Producing excess synapses)

The Mature Brain

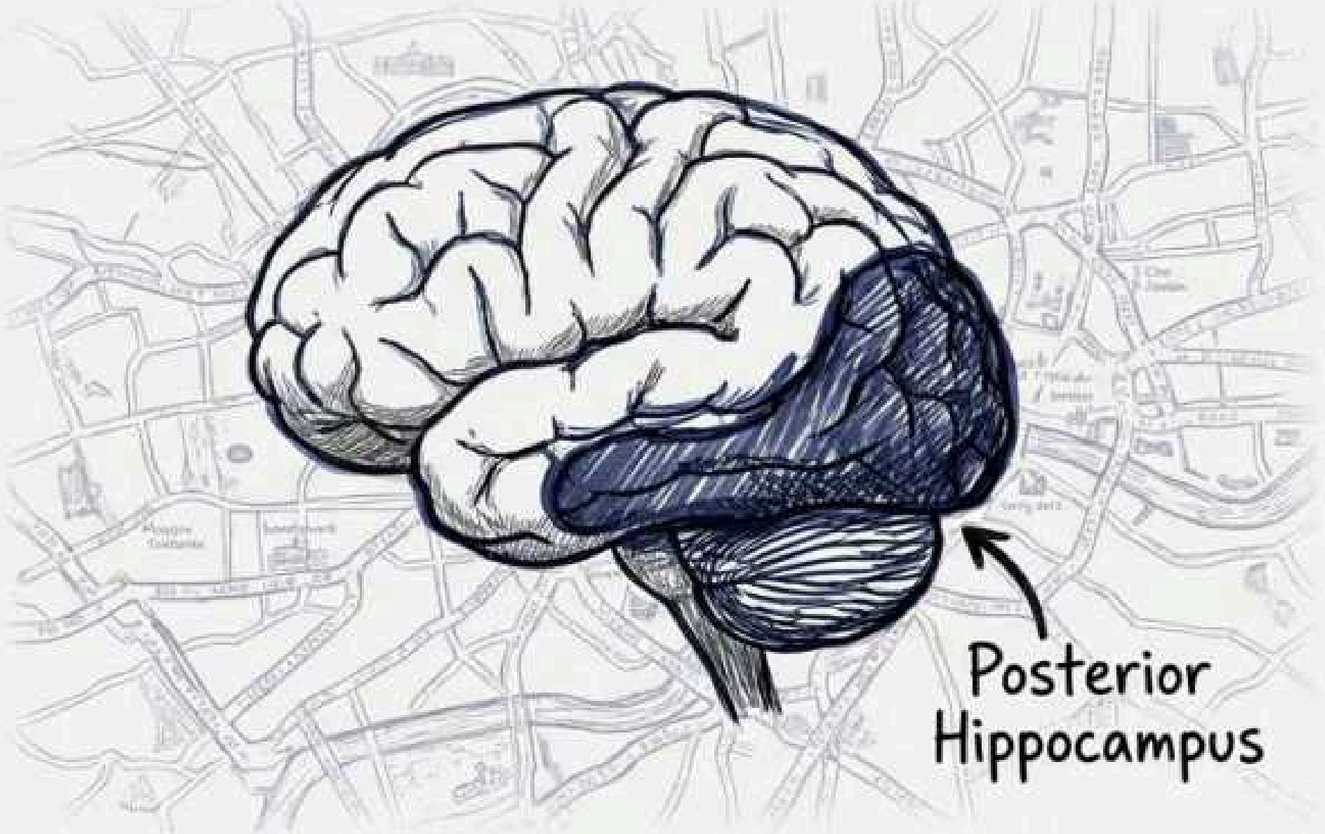
Case Study Box

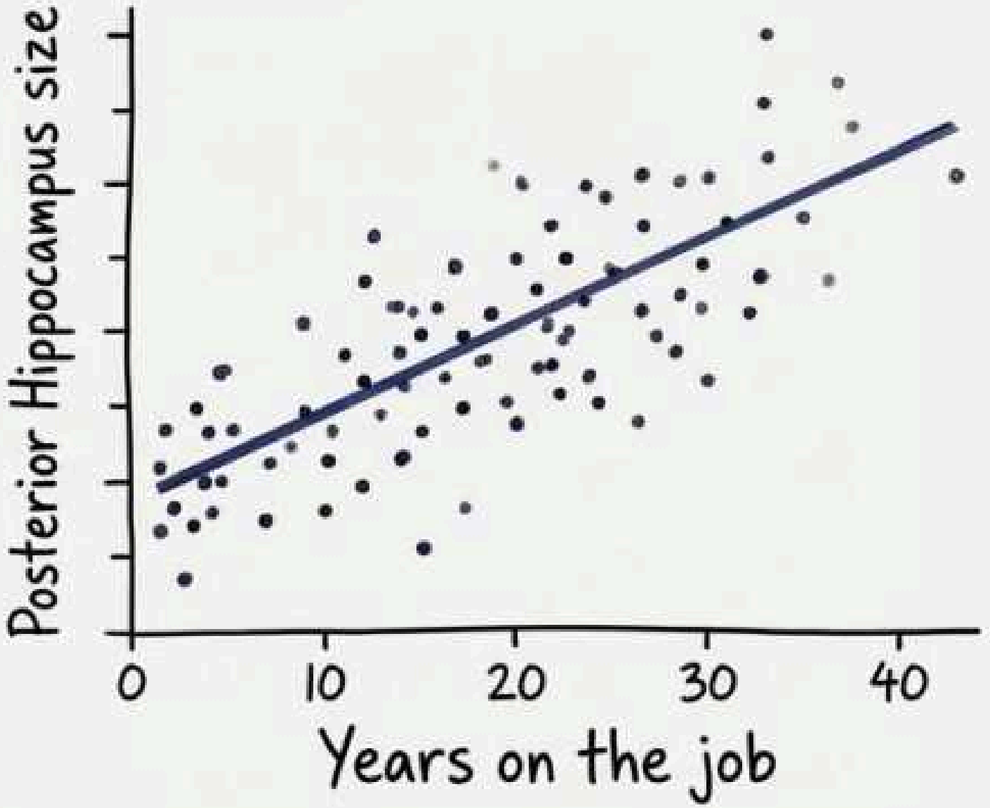


Hubel and Wiesel's research: Closing one eye during a critical window leaves it permanently weak. Early experience is vital for vision and language.

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Adult Plasticity: The London Taxi Driver (Maguire, 2000)

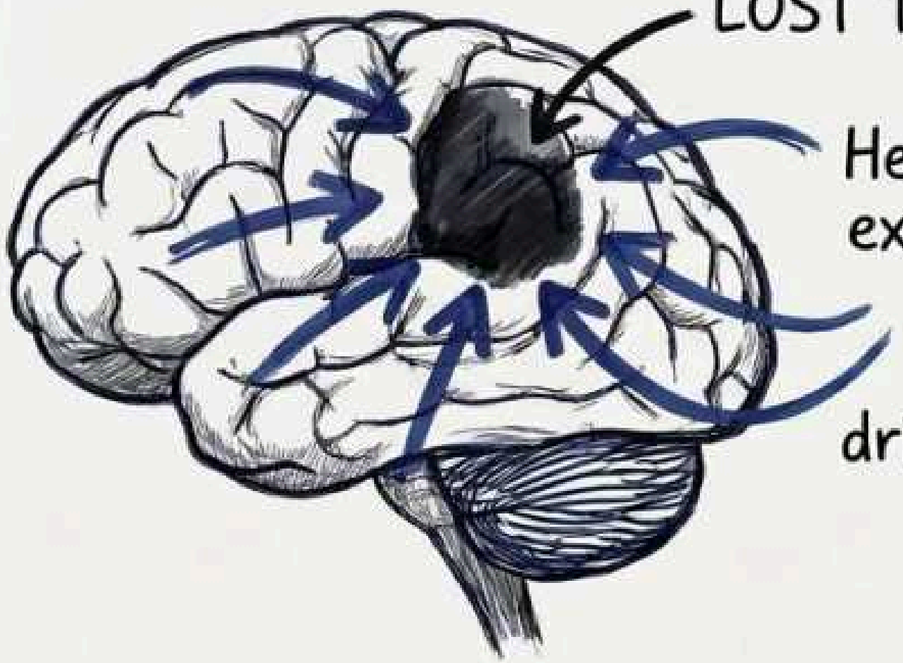




Memorizing thousands of streets causes physical brain growth.
Intensive practice leaves a visible anatomical trace in adulthood.

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Brain Repair and Biological Limits



Healthy regions expand to take over lost functions, driven by rehab exercises.



Adult Neurogenesis? Still heavily debated among scientists.

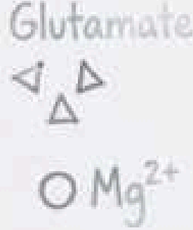
Takeaway: The brain remains changeable and plastic throughout the entire human lifespan.

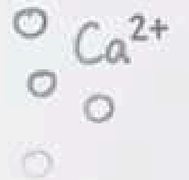
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Synthesis Question for Lecture 6

Part A: Explain how the NMDA receptor acts as a coincidence detector directly enabling Hebb's rule ("two neurons firing together").

Part B: What would be lost if the receptor opened for glutamate *alone*, without requiring depolarization? Link to LTP and learning.





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Course Conclusion: Neuroscience 101 B

Mastery Checklist

- ✓ The Neuron & Action Potential
- ✓ The Synapse & Chemical Signaling
- ✓ The Senses
- ✓ Major Brain Regions
- ✓ The Plastic, Learning Brain

Next Steps: Cognitive Neuroscience, Neuropharmacology, & Brain Disorders.

Email: garyanderson@mail.grokbot.com | X: @garyanderson

Thank you for taking Neuroscience 101 B.

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