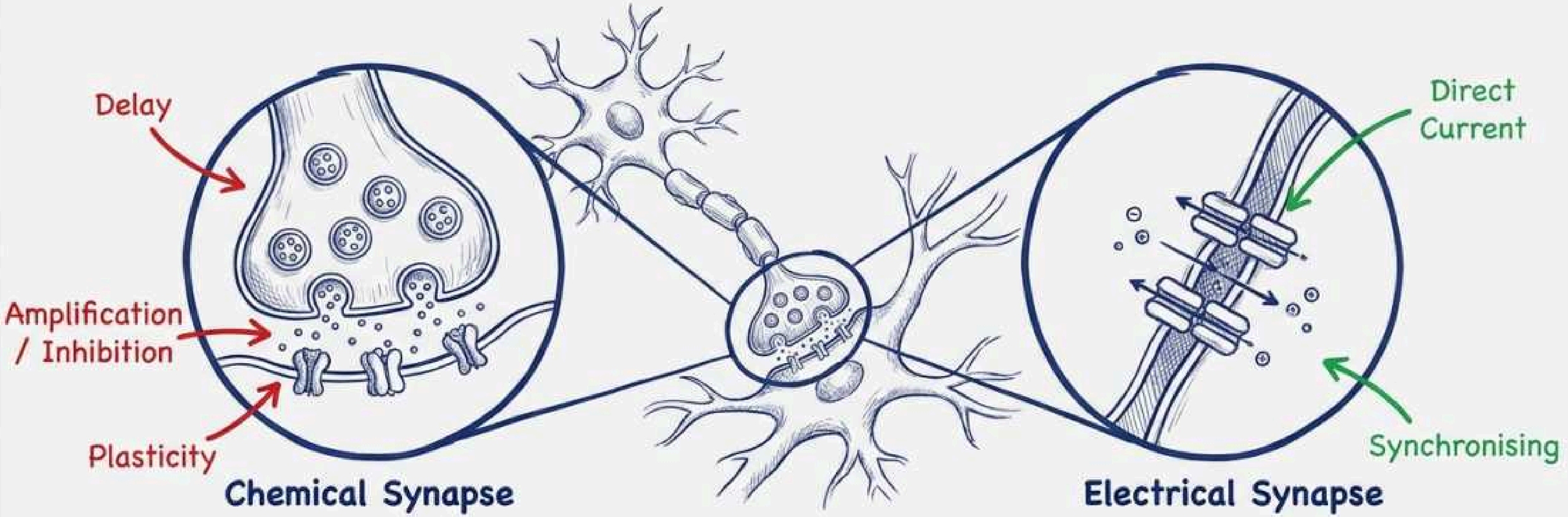
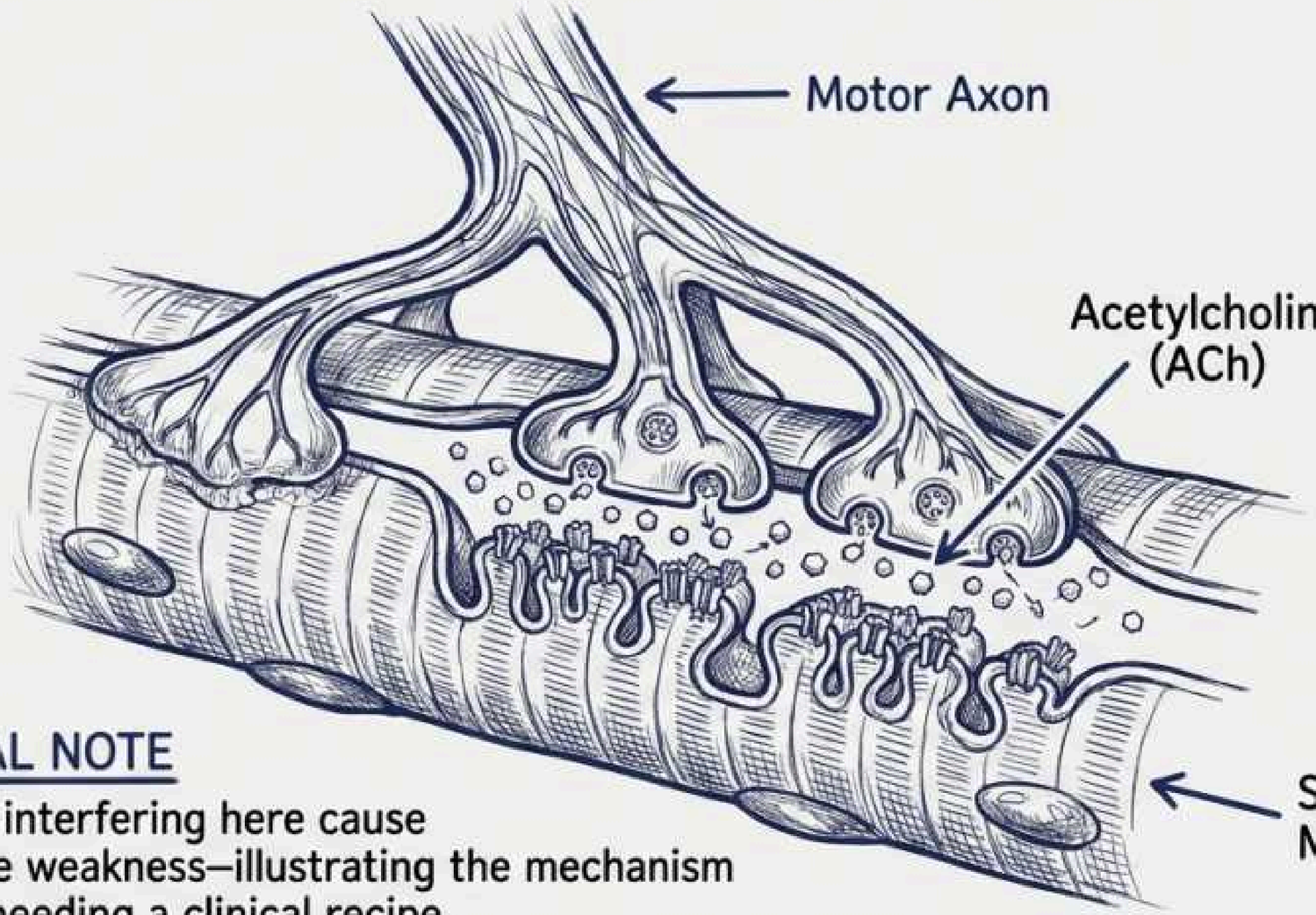
The Language of the Vertebrate Brain is Chemical



- While electrical synapses synchronise small groups, chemical synapses provide the crucial opportunities to amplify, inhibit, and change connection strength with use.

The Neuromuscular Junction (NMJ): The Classical Teaching Model



Why the NMJ?

Large, accessible, and stereotyped.

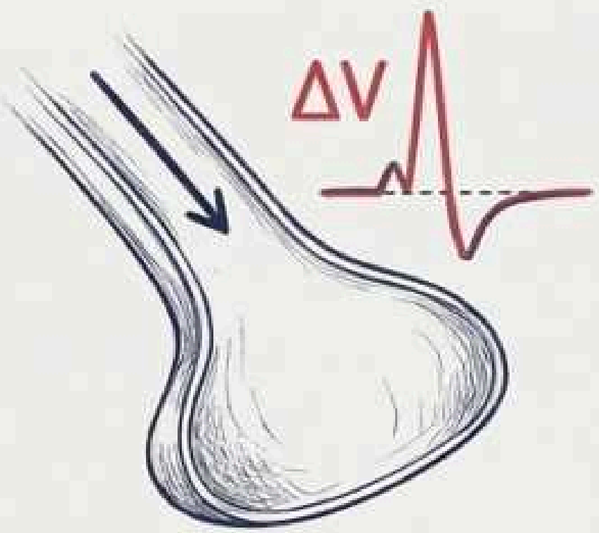
The baseline for understanding all central nervous system synapses.

CLINICAL NOTE

Diseases interfering here cause fatiguable weakness—illustrating the mechanism without needing a clinical recipe.

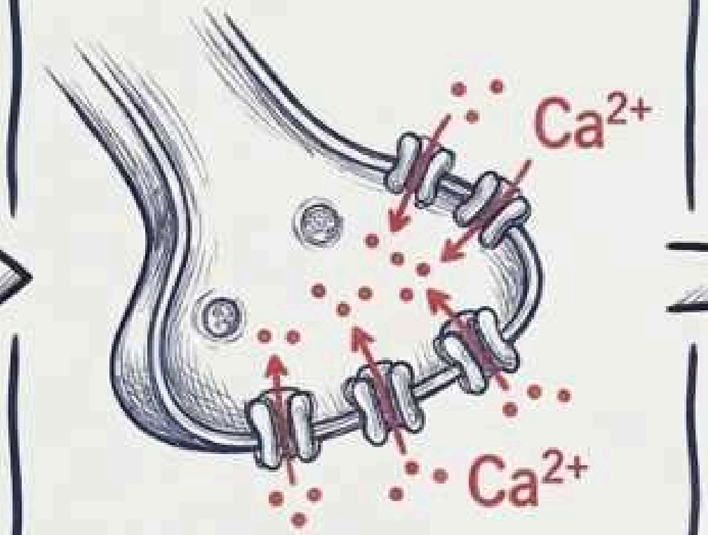
Electricity → Calcium → Chemistry

1. Electricity



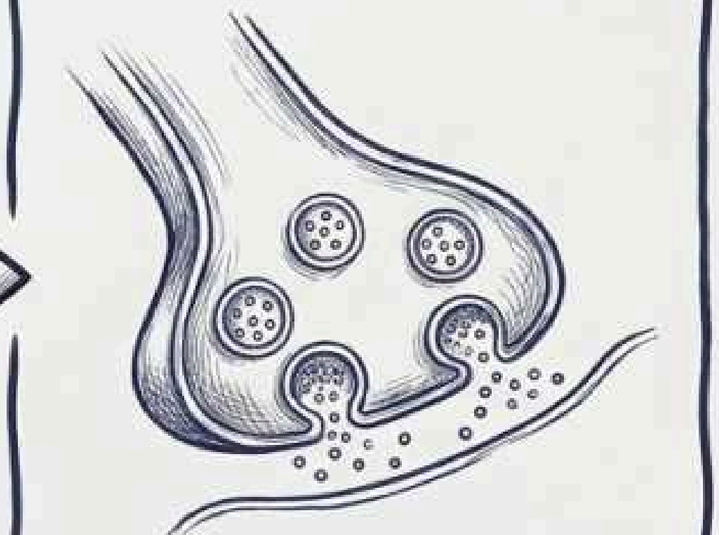
Impulse arrives. Not a leak of electricity, but a trigger.

2. Calcium



Voltage-gated calcium channels open; Ca^{2+} enters.

3. Chemistry

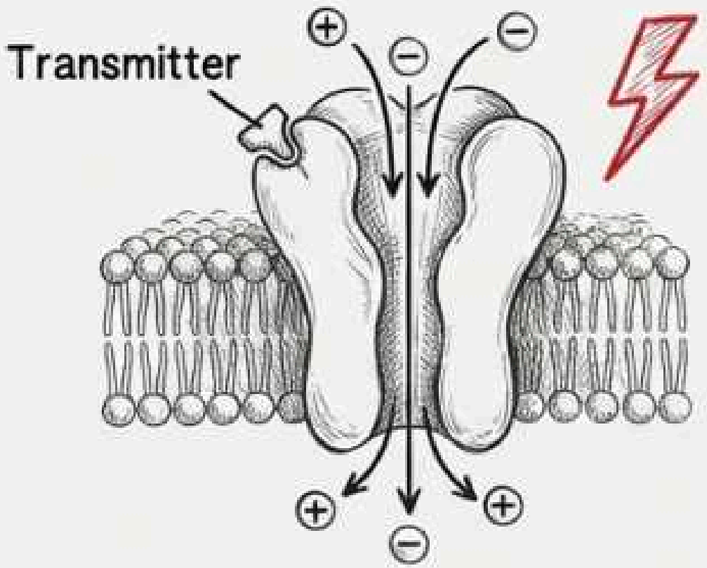


Vesicles fuse and secrete transmitter. Signal is kept brief by rapid breakdown or re-uptake.

The Logic: Electricity in the axon becomes a pulse of calcium, and calcium becomes a pulse of chemistry.

Two Broad Families of Receptors

Ionotropic Receptors

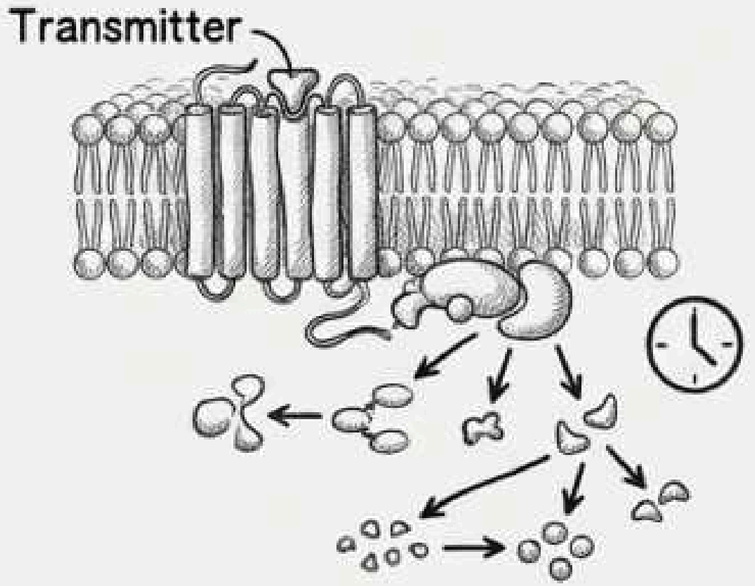


Speed: Fast (milliseconds)

Mechanism: Ligand-gated channel

Function: Fast excitation and inhibition in the brain

Metabotropic Receptors



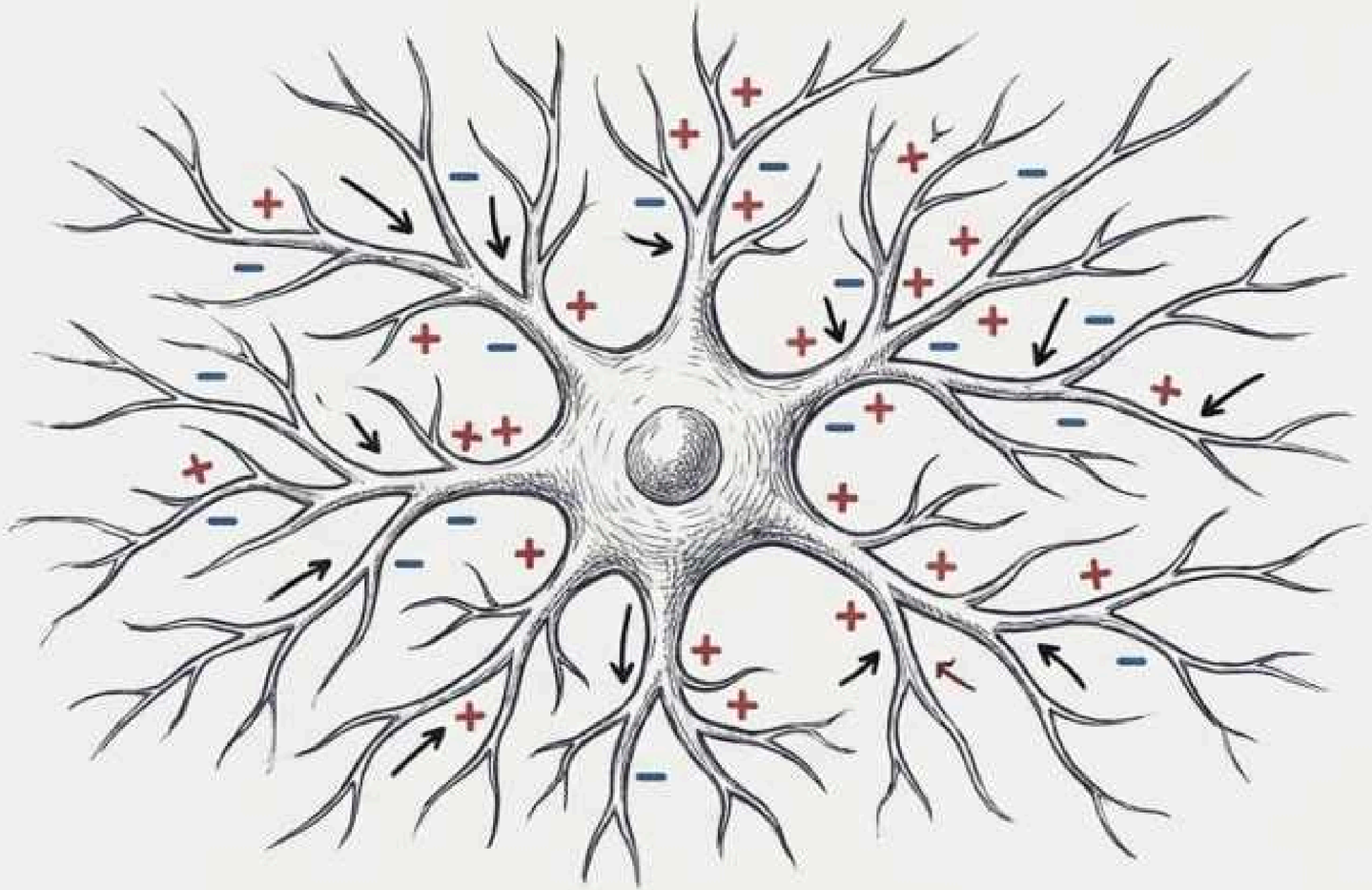
Speed: Slow (and longer-lasting)

Mechanism: Intracellular cascade (alters channels, chemistry, or genes)

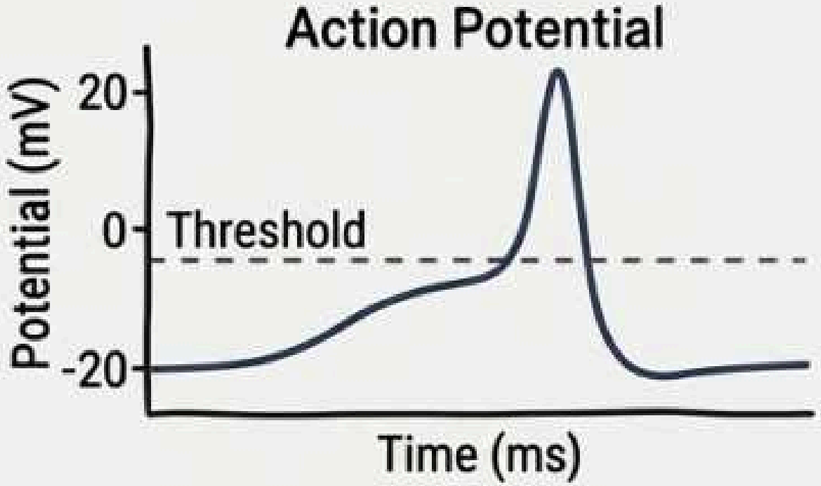
Function: Mood, arousal, and the gain of circuits

Note: A single transmitter may act on both types of receptors depending on the target cell.

Synaptic Integration



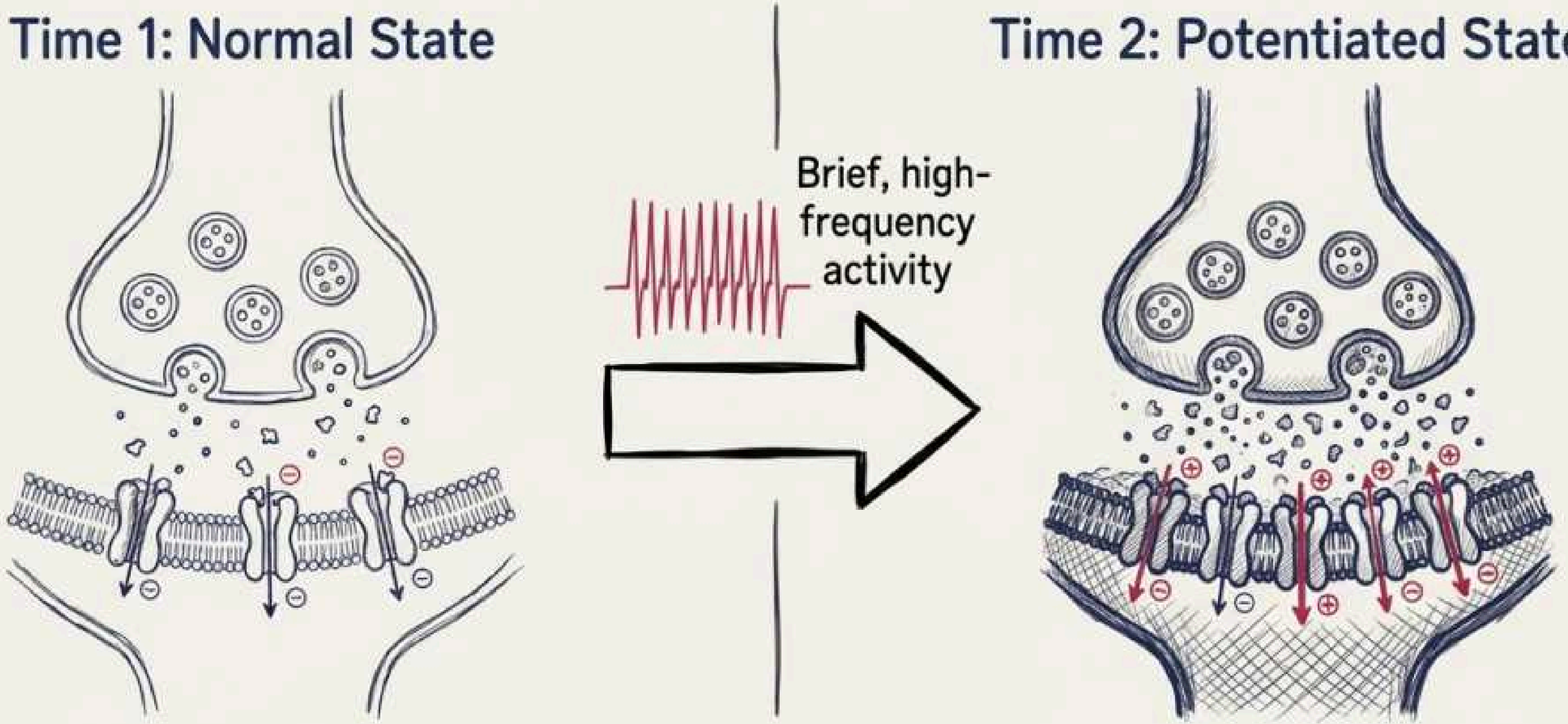
$$V_m = \sum EPSP - \sum IPSP$$



- EPSP (Excitatory Postsynaptic Potential): Nudges membrane towards threshold.
- IPSP (Inhibitory Postsynaptic Potential): Nudges membrane away from threshold, or short-circuits excitation.

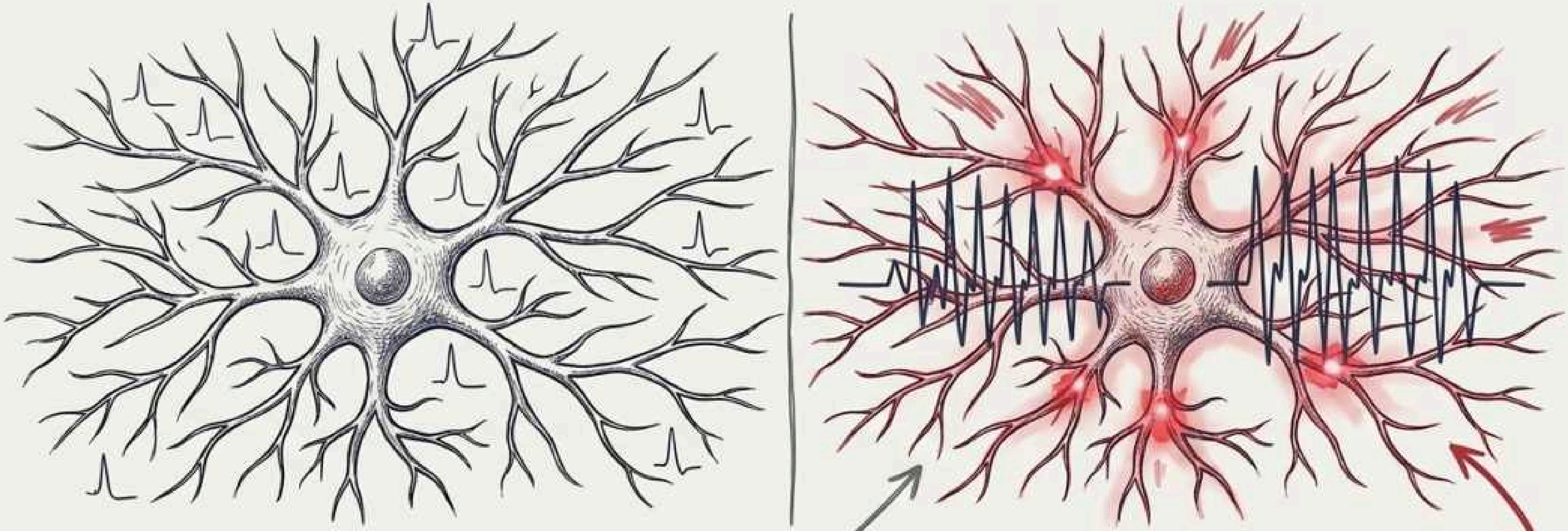
The Neuron's Elementary Computation. Shifting this delicate balance of excitation and inhibition—via drugs, disease, sleep, or attention—determines if a circuit is quiet or over-active.

Synaptic Plasticity: The Foundation of Learning and Memory



- Long-Term Potentiation (LTP): The synapse is left stronger for hours or longer.
- The junction is not a fixed, soldered join, but a living, adjustable contact.

Seizures: When the Balance is Lost



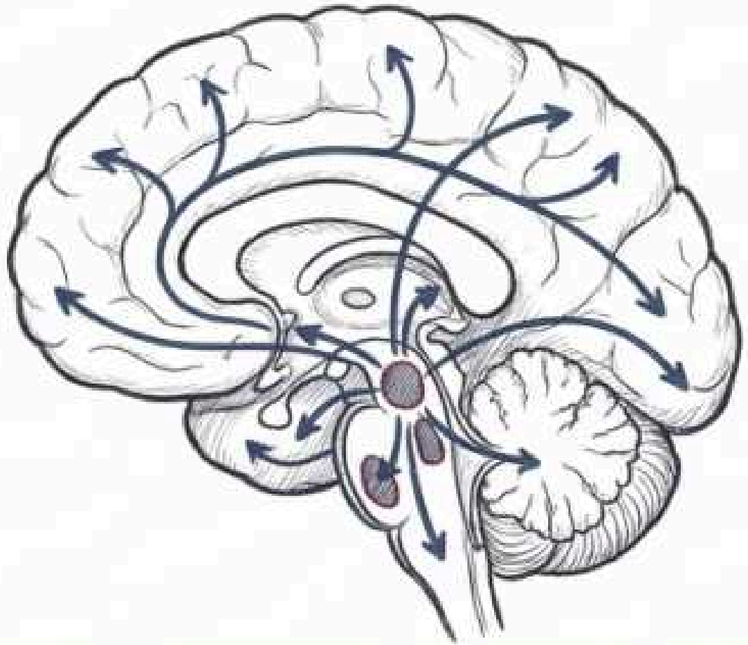
Balanced Excitability → Excessive, Synchronised Firing (The Storm)

Pathology: A channel or circuit that is slightly mistimed can turn a normal network into a storm. Inherited or acquired ion channel disorders make this more likely.

Emergency Red Flags: Seek immediate help for a first seizure, a seizure lasting more than a few minutes, or consecutive seizures without recovery.

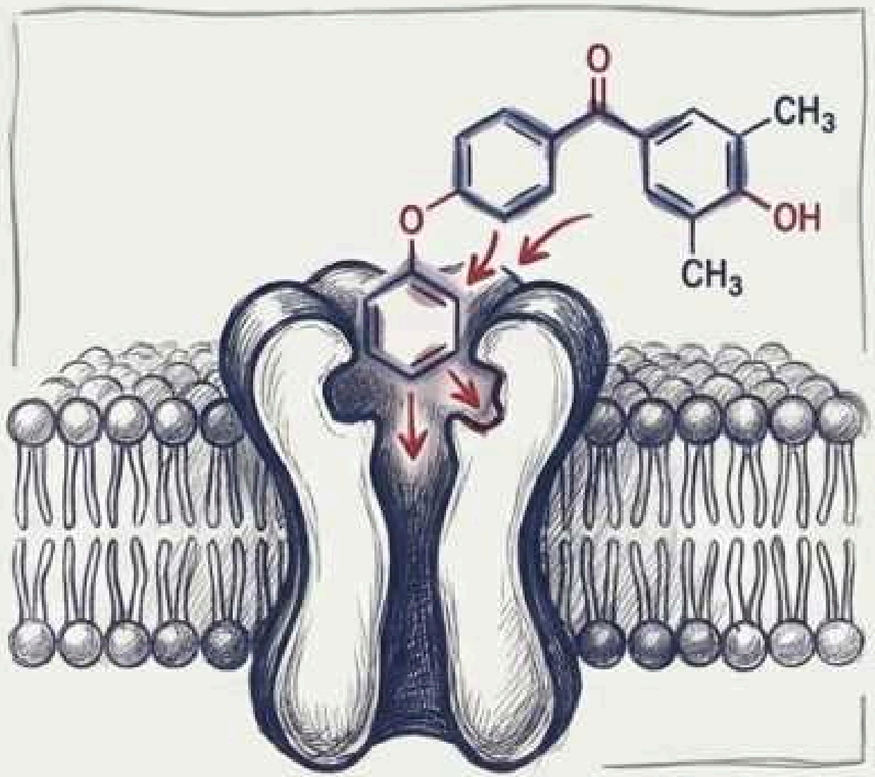
Major Chemical Systems of the Brain

¶ 2.8



Glutamate	Principal fast excitatory transmitter (CNS).
GABA / Glycine	Principal fast inhibitory transmitters (GABA in Brain, Glycine in Spinal Cord).
Acetylcholine	Serves NMJ, autonomic synapses, and central pathways for attention and memory.
Dopamine, Serotonin, Noradrenaline	Arise from small brainstem/midbrain origin, fan out widely. Adjust mood, motivation, arousal, and movement.

The Scope of Psychopharmacology: Biology, Not a Licence to Prescribe

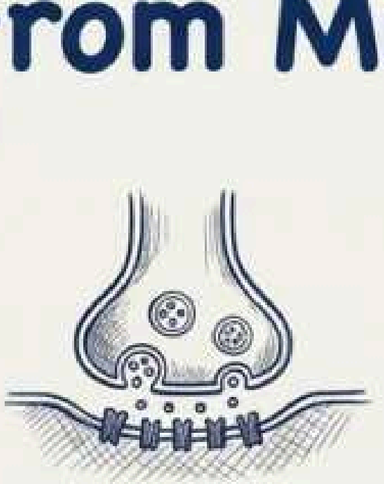


Medicines that alter mood, attention, alertness, or seizure risk act directly on these exact receptors, transporters, and channels.

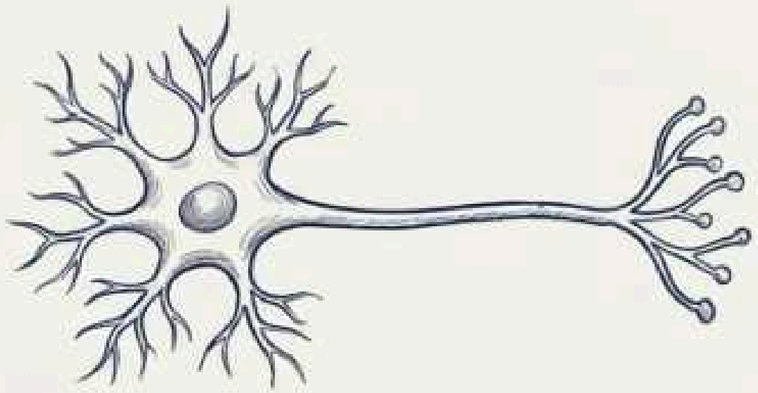


This is a way of seeing the chemical systems at work. No doses. No drug shopping lists. Questions about treatments and combinations belong strictly to qualified clinicians.

Mapping the Road Ahead: From Micro to Macro



Micro: Synapse



Cellular: Neuron



Macro: Anatomy

Lecture 3 Checklist:

- ☐ Meninges
- ☐ Spinal Cord
- ☐ Brainstem
- ☐ Cerebellum
- ☐ Thalamus
- ☐ Basal Ganglia
- ☐ Cortex
- ☐ Limbic Circuits
- ☐ Blood Supply

Building a working map of the nervous system—a guide to structural organisation, not a manual for dissection.