THE UNIVERSITY OF MELBOURNE

Faculty of Veterinary and Agricultural Sciences

Nerve Conduction II: The synapse and graded potentials

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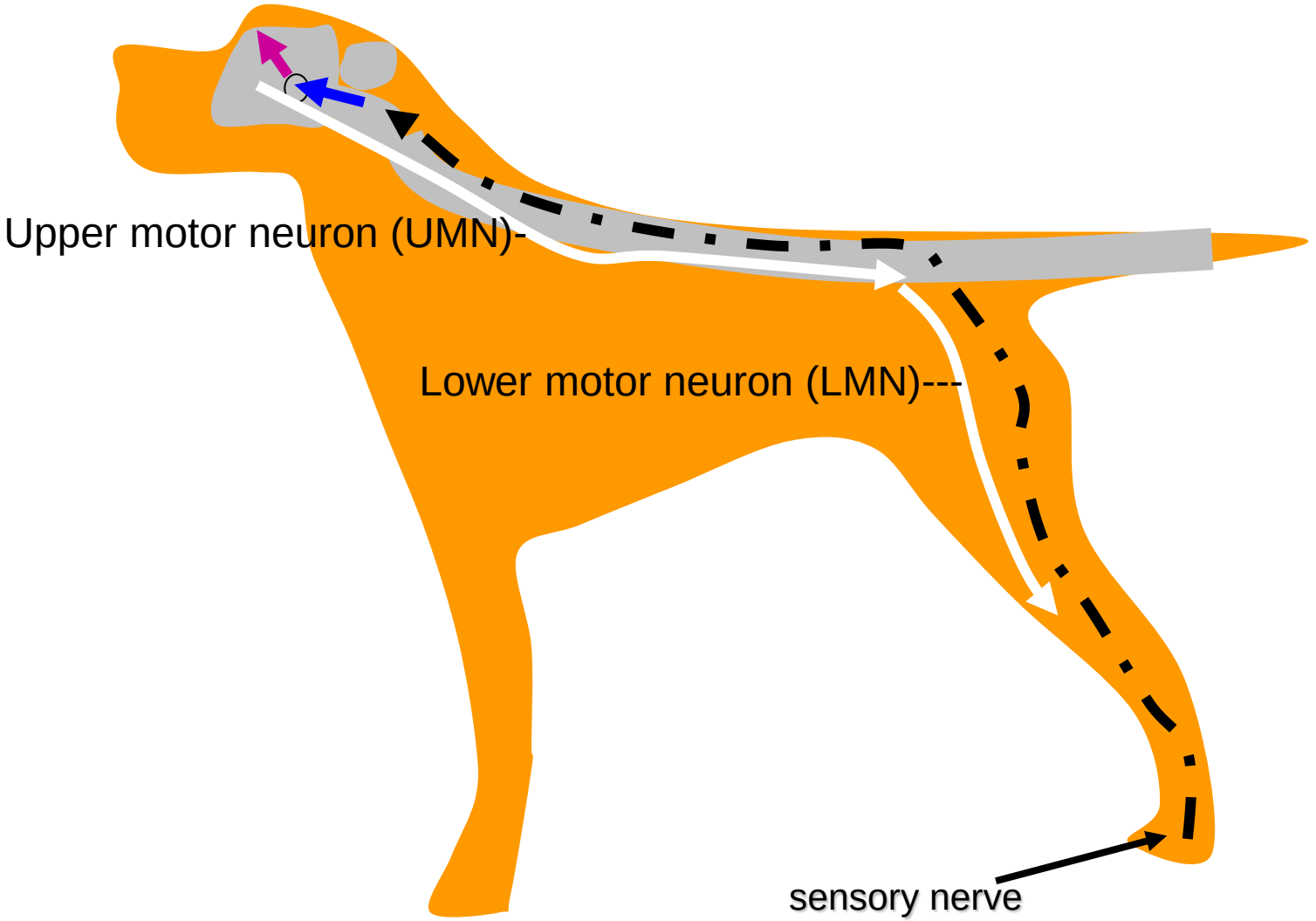
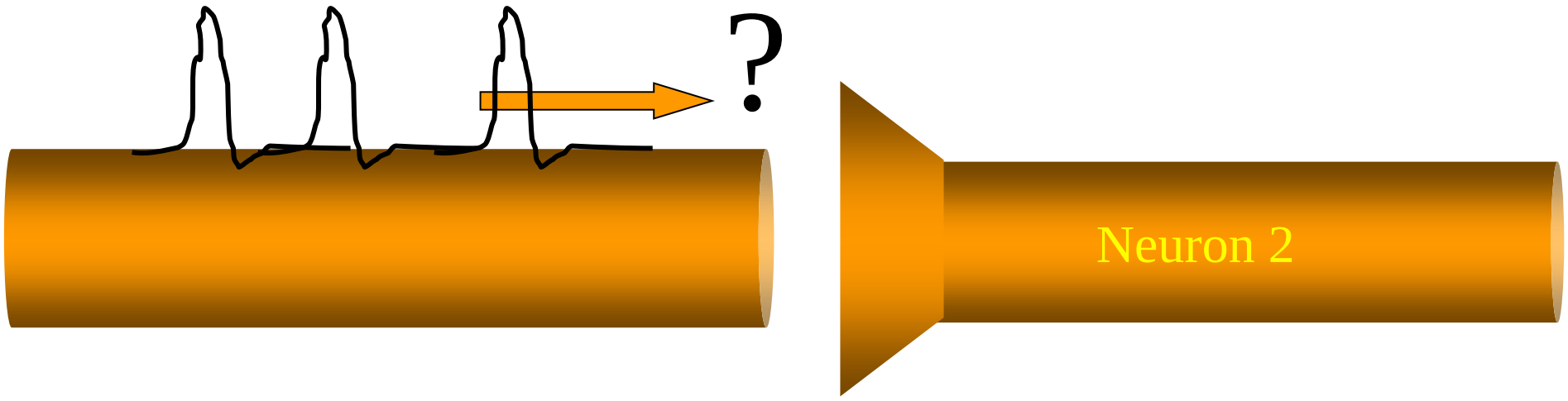
VETS30015 / VETS90121

Nerve connections in a dog



How are signals transferred between cells in the nervous system?

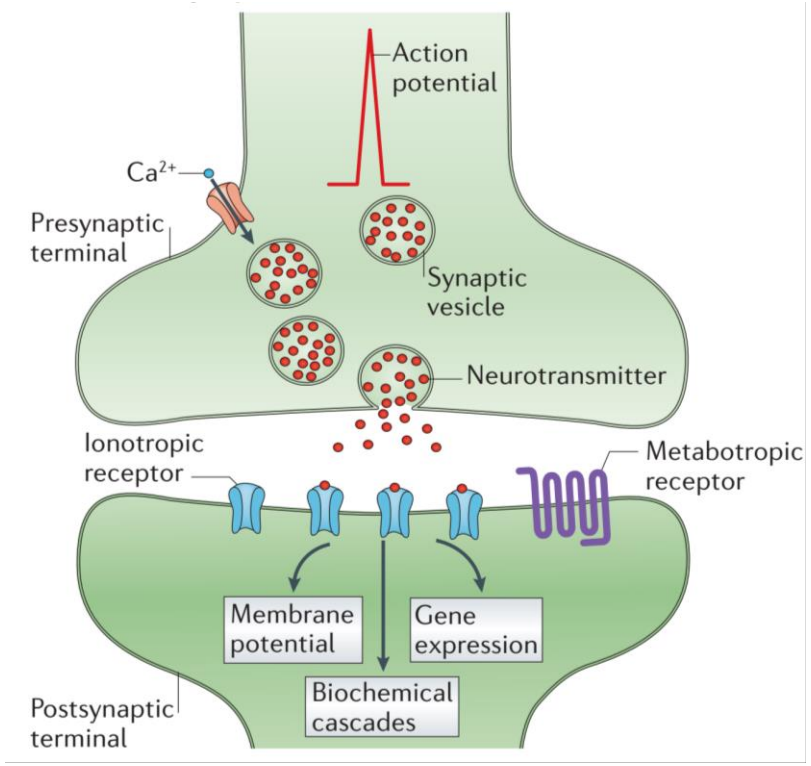


Pre-synaptic neuron

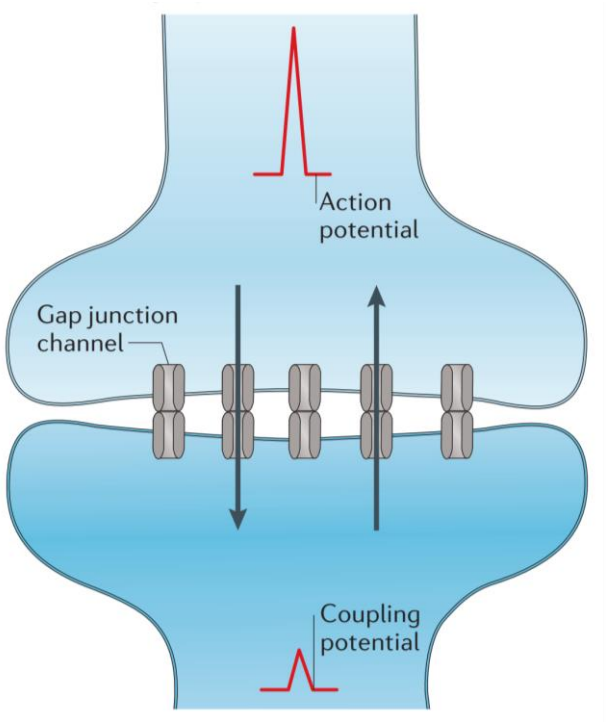
Postsynaptic neuron

Two types of synapses

Chemical Synapse

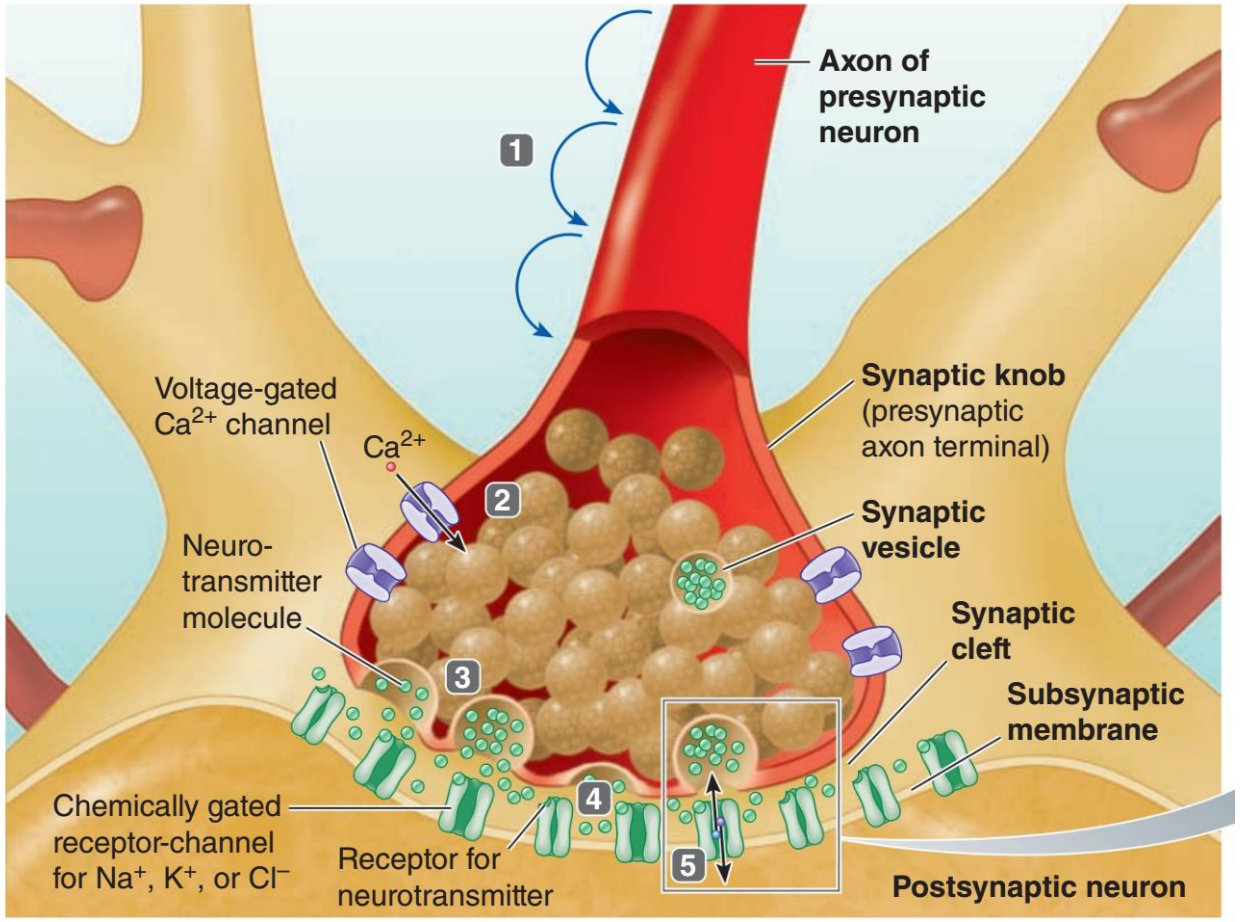


Electrical Synapse



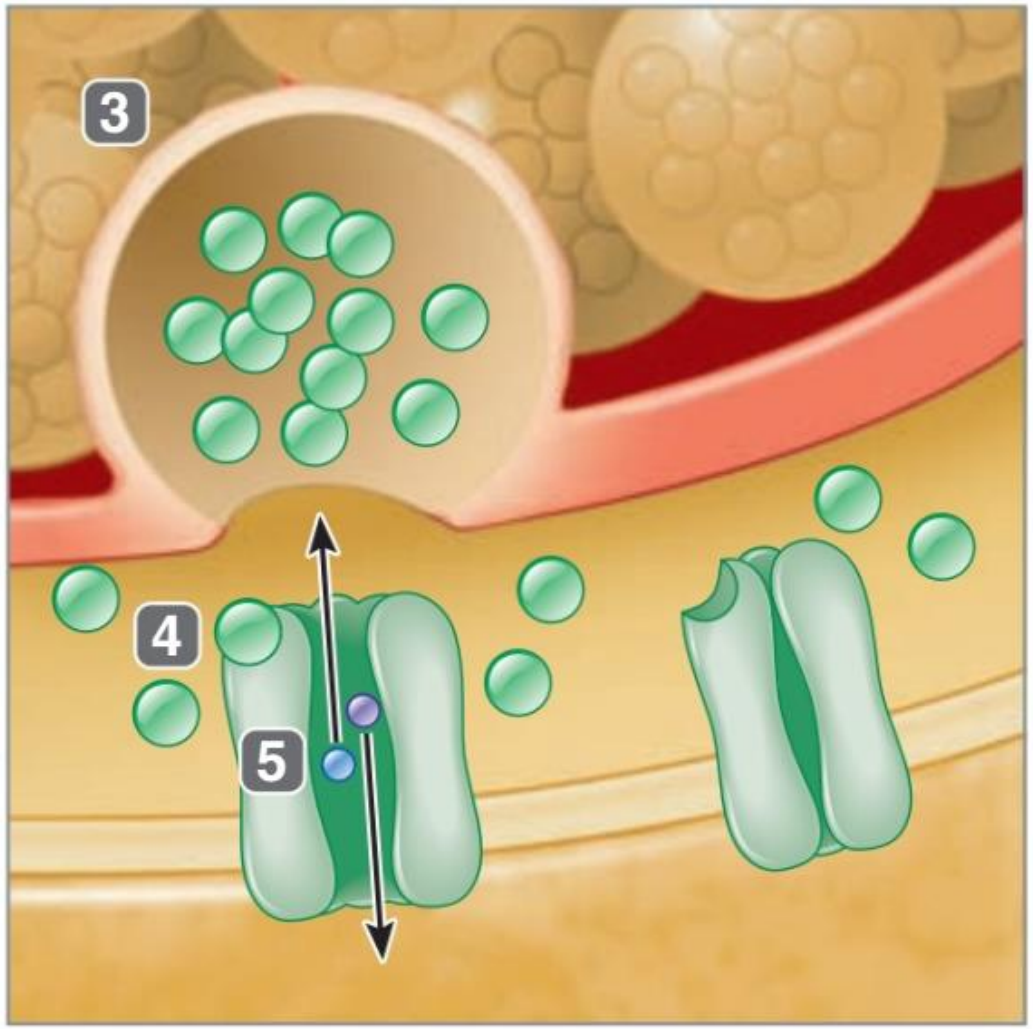
Nat Rev Neurosci. 2014; 15(4): 250–263.

Chemical Synapse



Sherwood p93

Signal transfer in synapses



The chemical Synapse

- Neuron – neuron communication
- Presynaptic neuron stimulates the postsynaptic neuron
- There is a time lag (synaptic delay) of 0.5 to 1.0 msec

Neurotransmitters

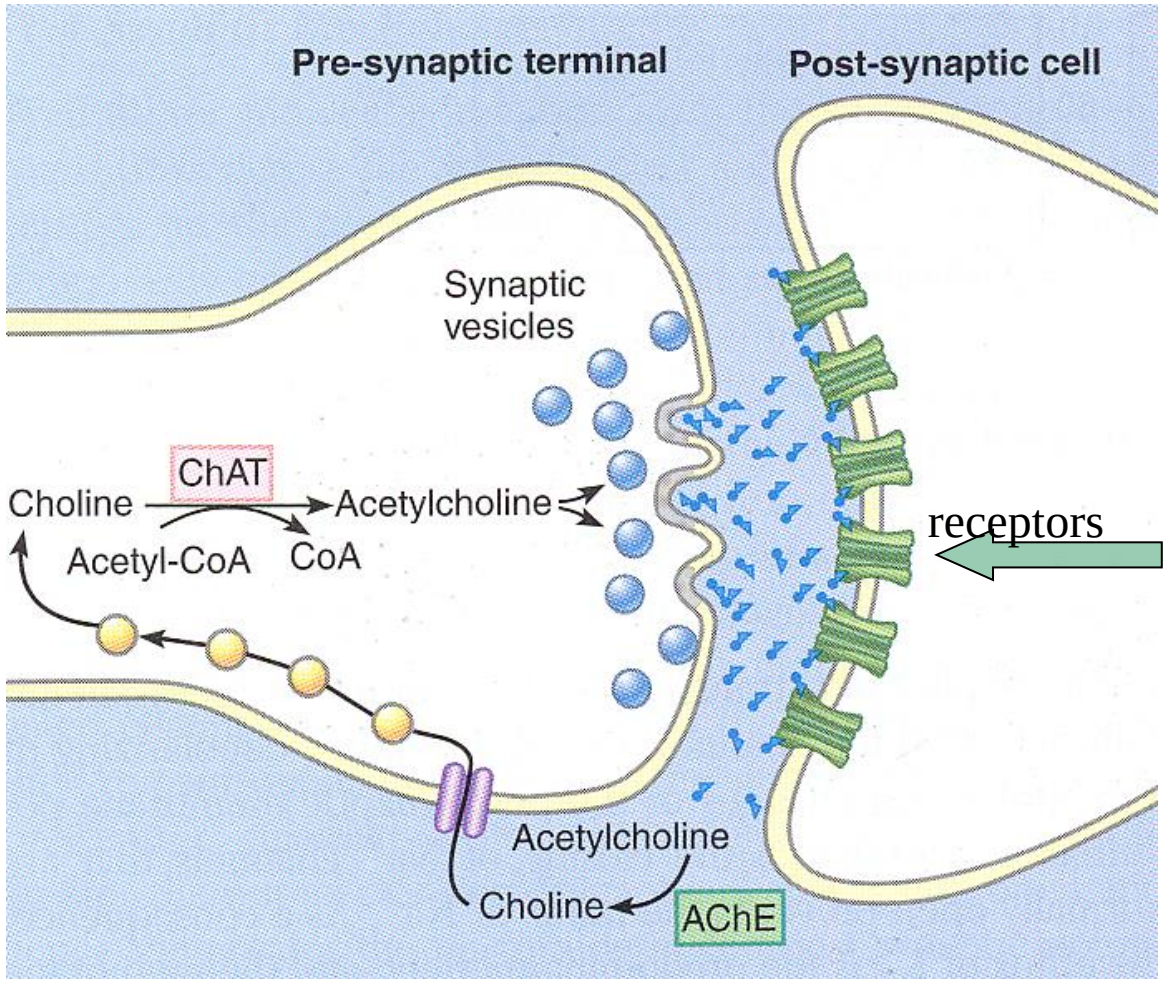
Classical neurotransmitters

- Acetylcholine
- Dopamine
- Norepinephrine
- (noradrenaline)
- Epinephrine (adrenaline)
- Serotonin
- Gamma-aminobutyric acid (GABA)

Neuropeptides

- Vasoactive intestinal peptide VIP
- Cholecystokinin, Enkephalin
- Somatostatin, Enkephalin, Neurotensin
- Enkephalin
- Substance P
- Thyrotropin-releasing hormone

Acetylcholine synapse



Source Rhoades p236

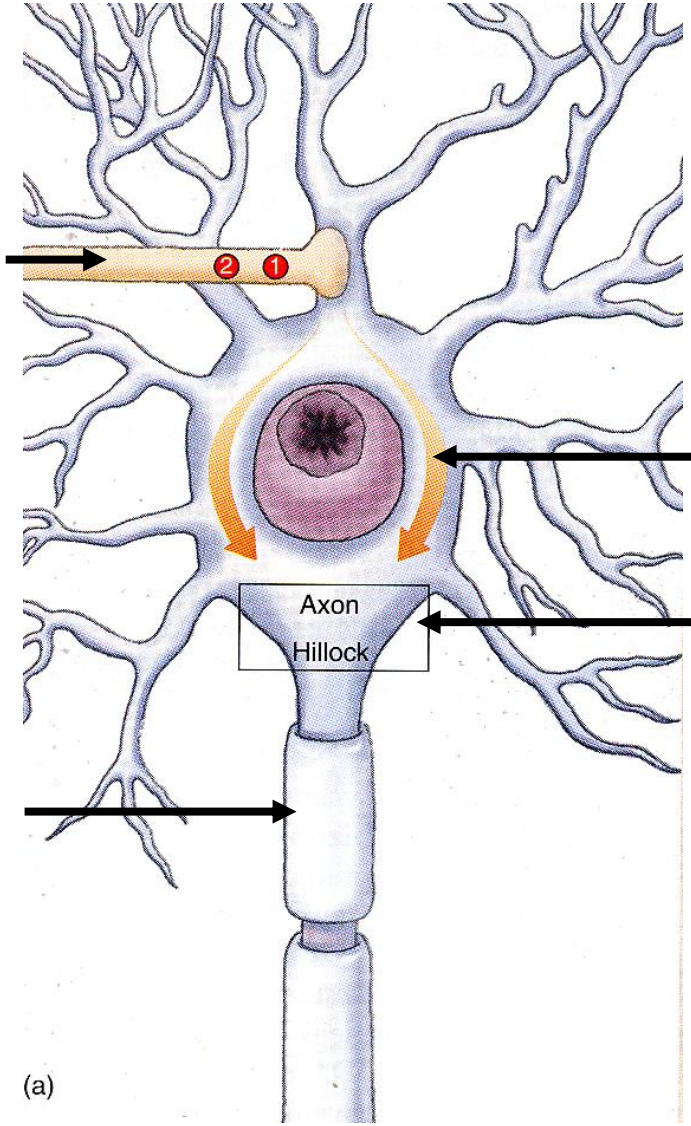
The neurotransmitter acetylcholine

- A cholinergic synapse
- Receptors in the postsynaptic neuron
  - Nicotinic

    increases Na+ permeability, drives membrane closer to threshold
  - Muscarinic
    - M1 decreases K+ permeability, drives membrane closer to threshold (e.g. exocrine glands)
    - M2 increases K+ permeability, drives membrane further from threshold (e.g. Heart)

Postsynaptic potentials

Presynaptic axon

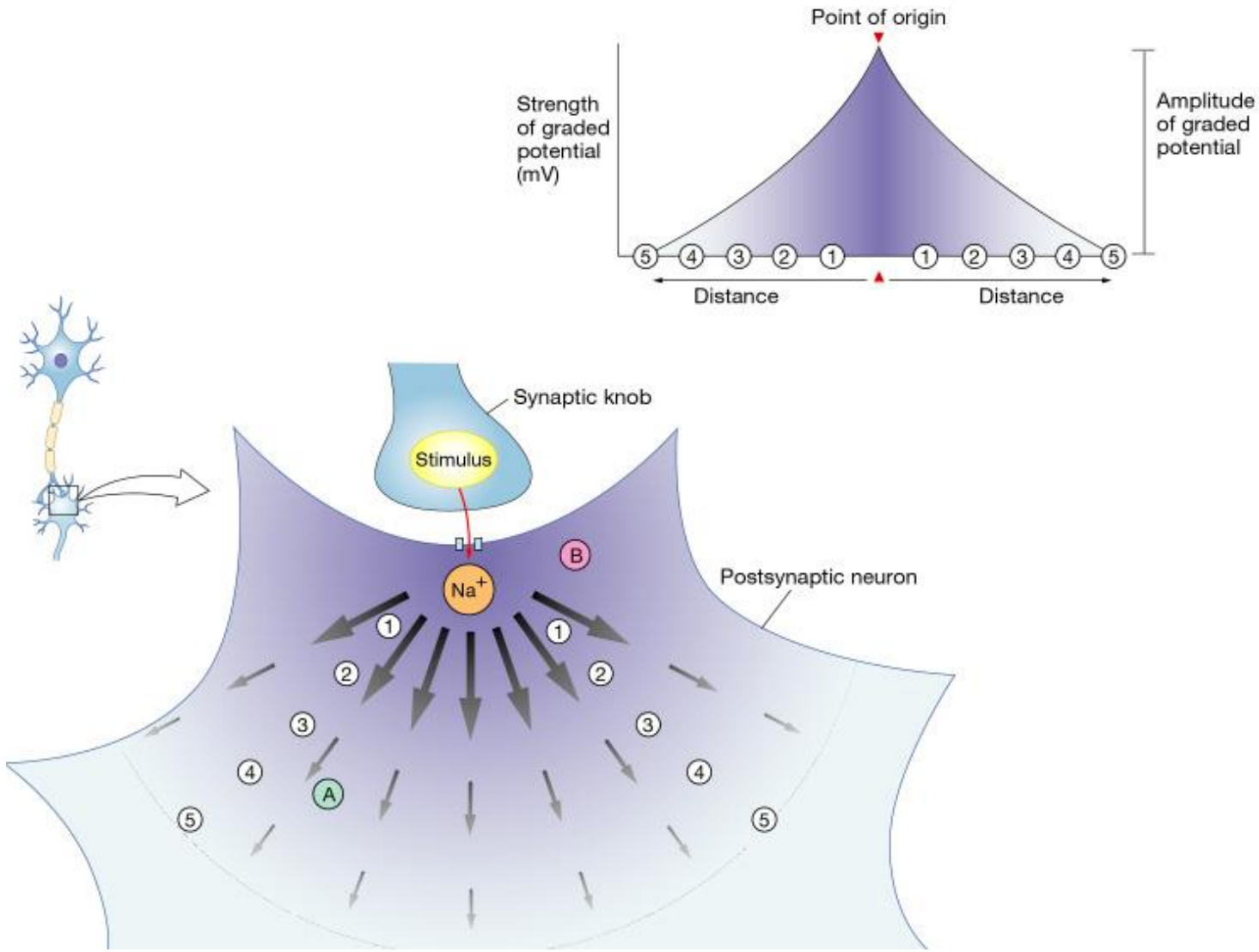


Graded potentials

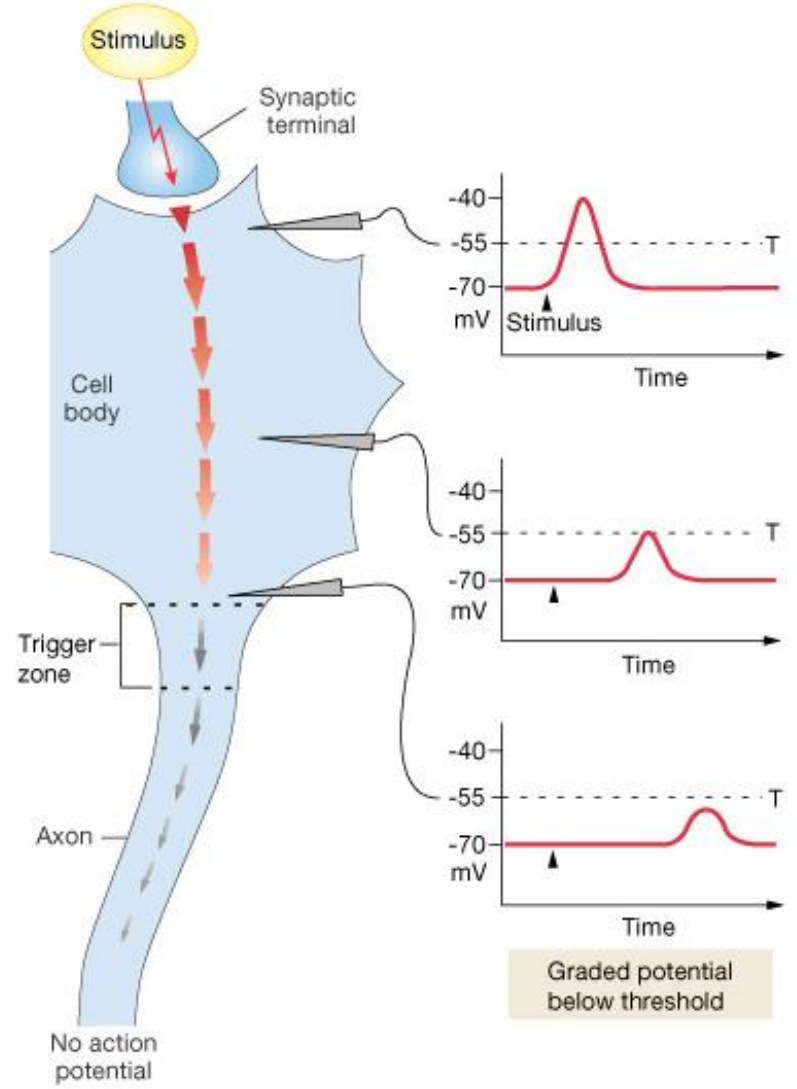
Axon hillock has low threshold where action potentials are generated

Postsynaptic axon

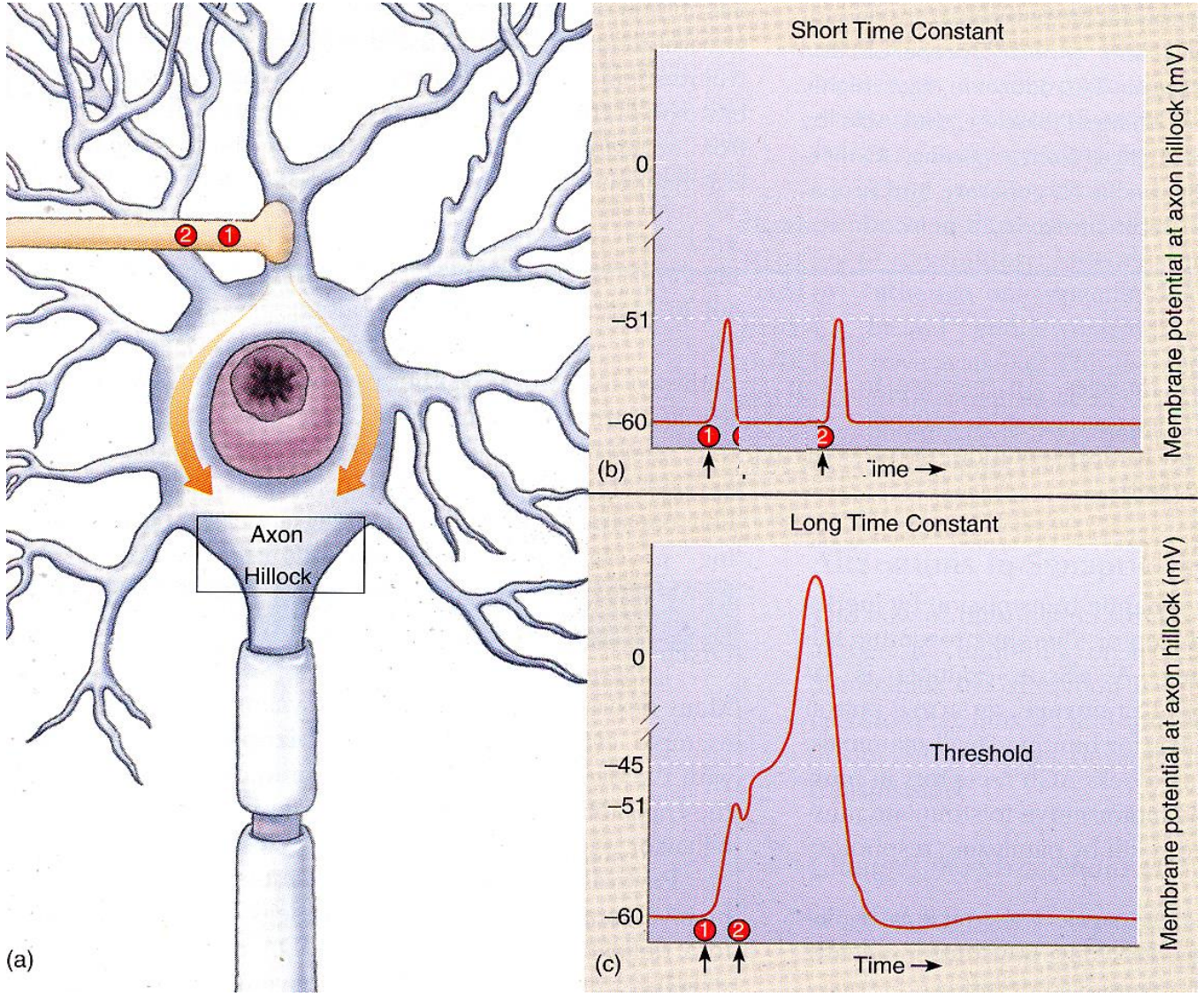
Graded potentials



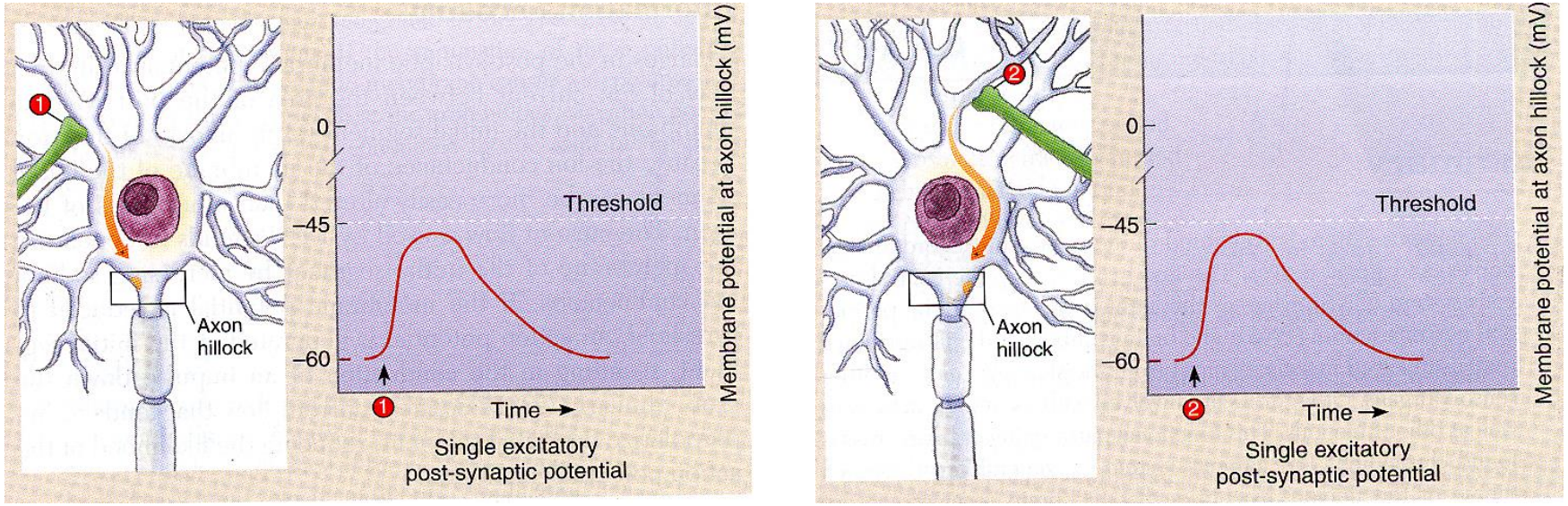
The initiation of action potentials by graded potentials



Temporal summation of graded potentials

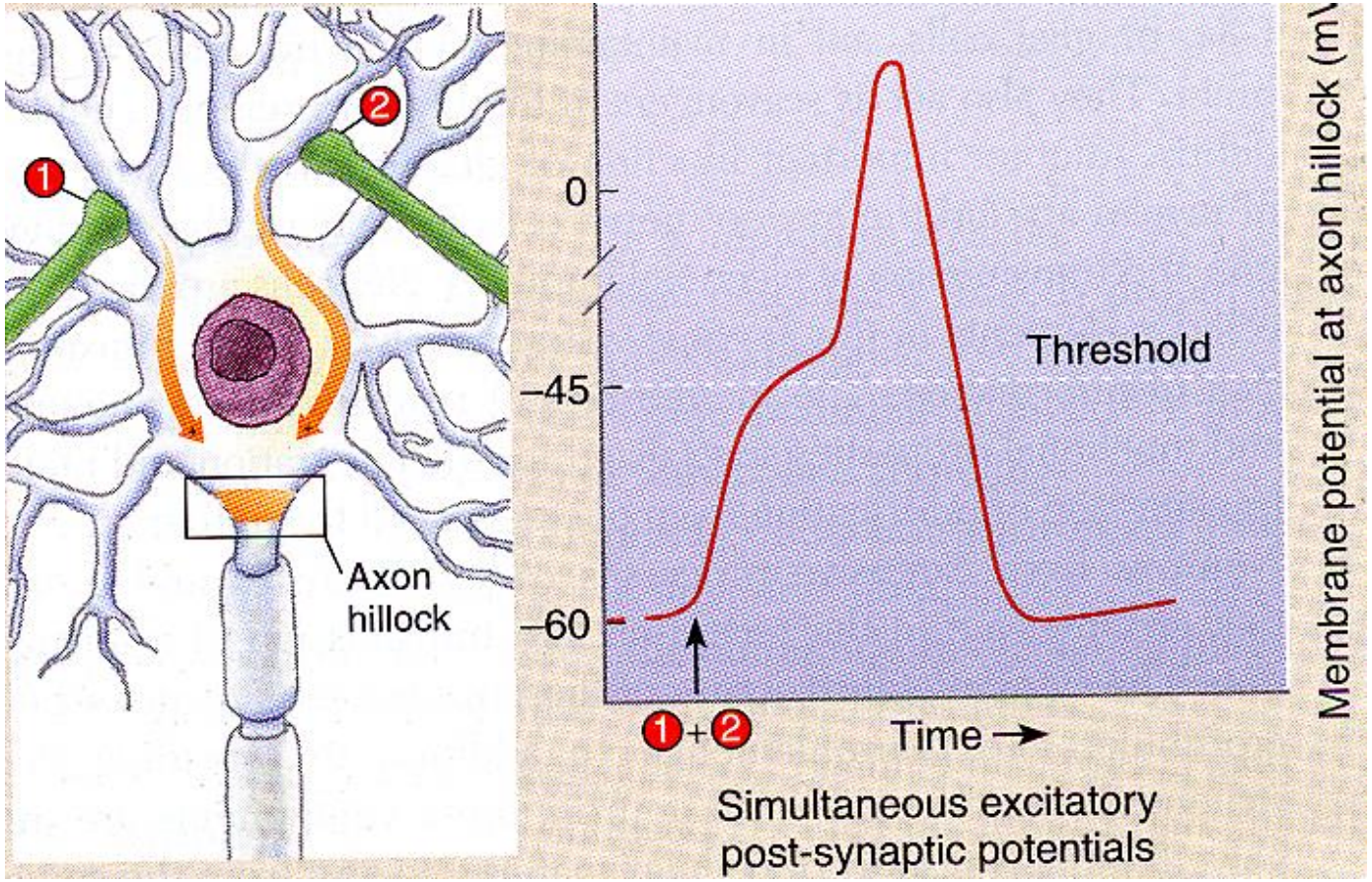


Spatial summation of graded potentials



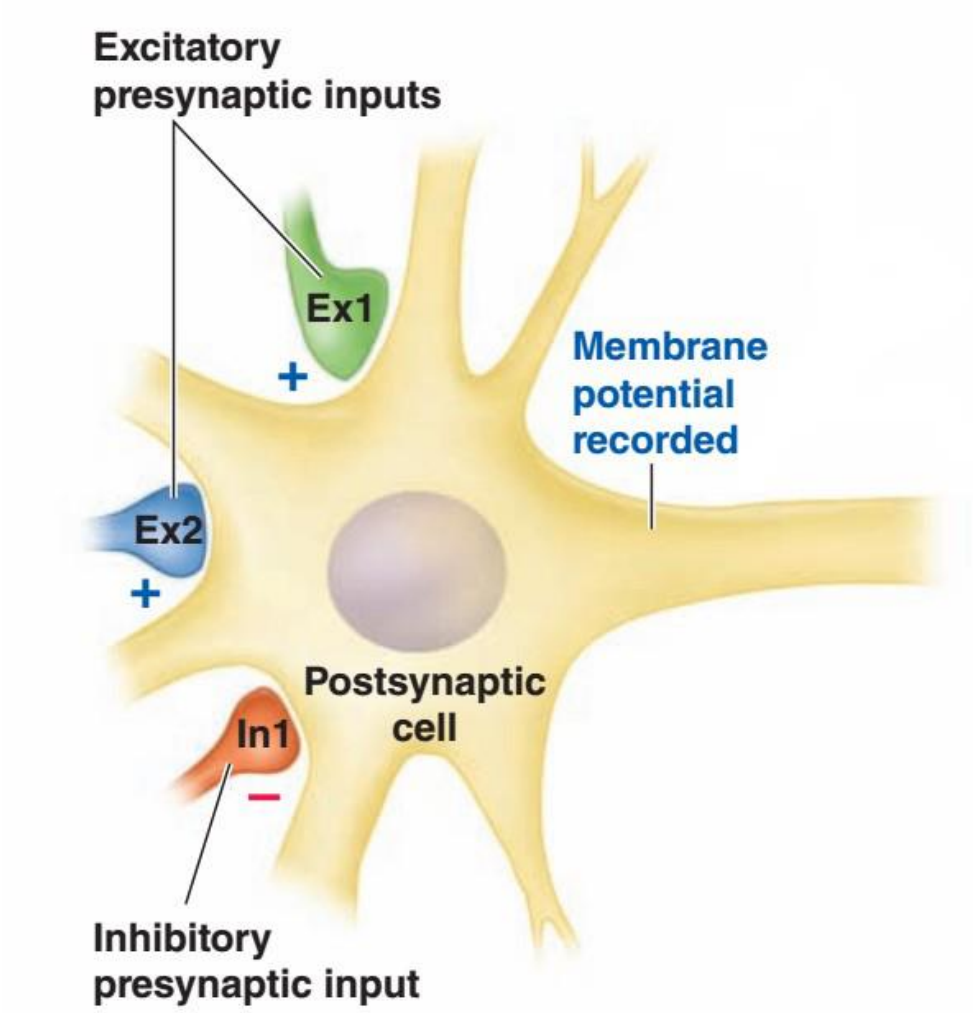
Source Rhoades p 247

Spatial Summation of two post-synaptic potentials to reach threshold

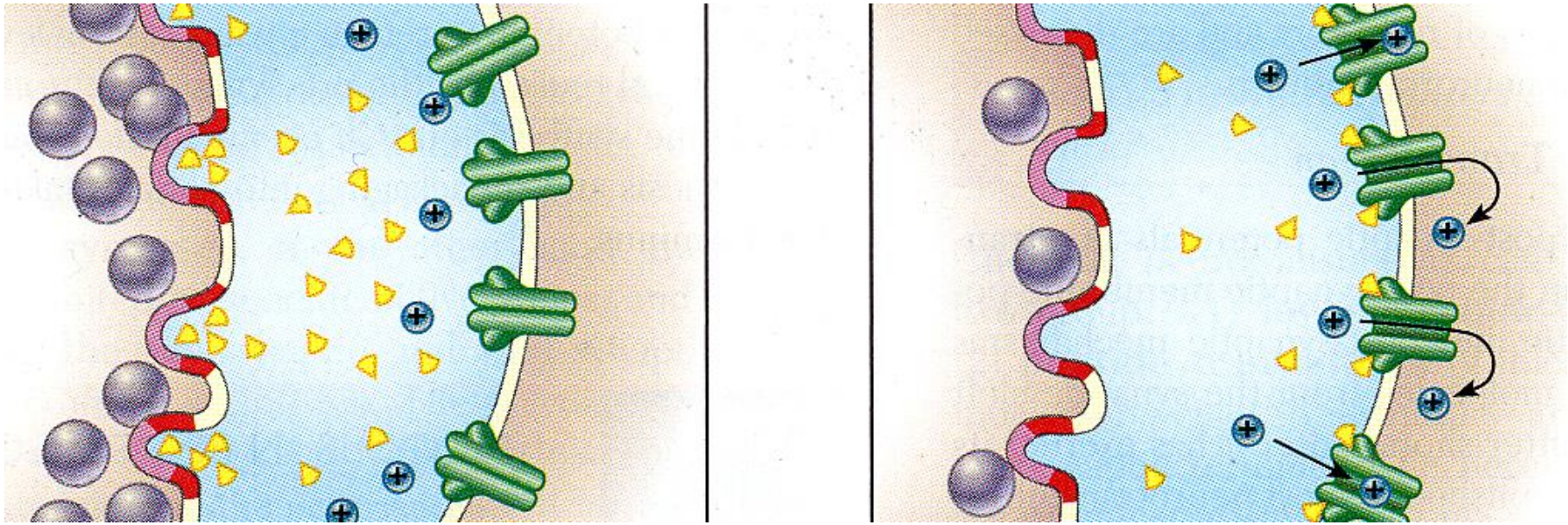


Source Rhoades p 247

Excitatory and inhibitory synapses

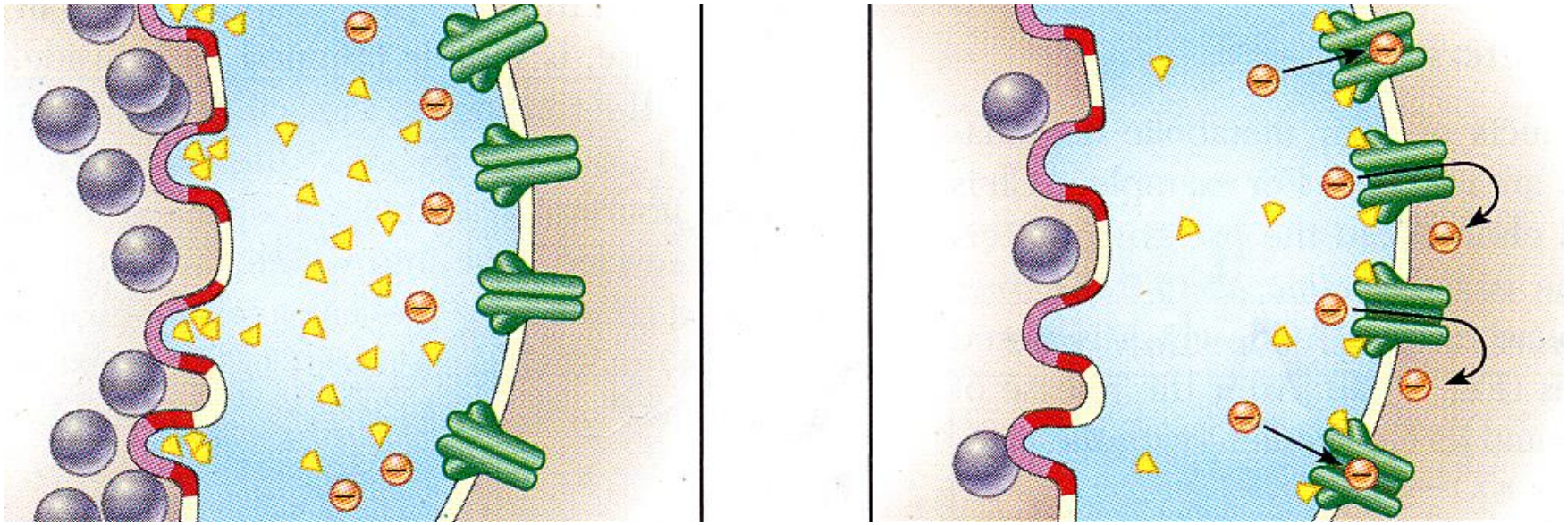


Excitatory postsynaptic potentials (EPSP)



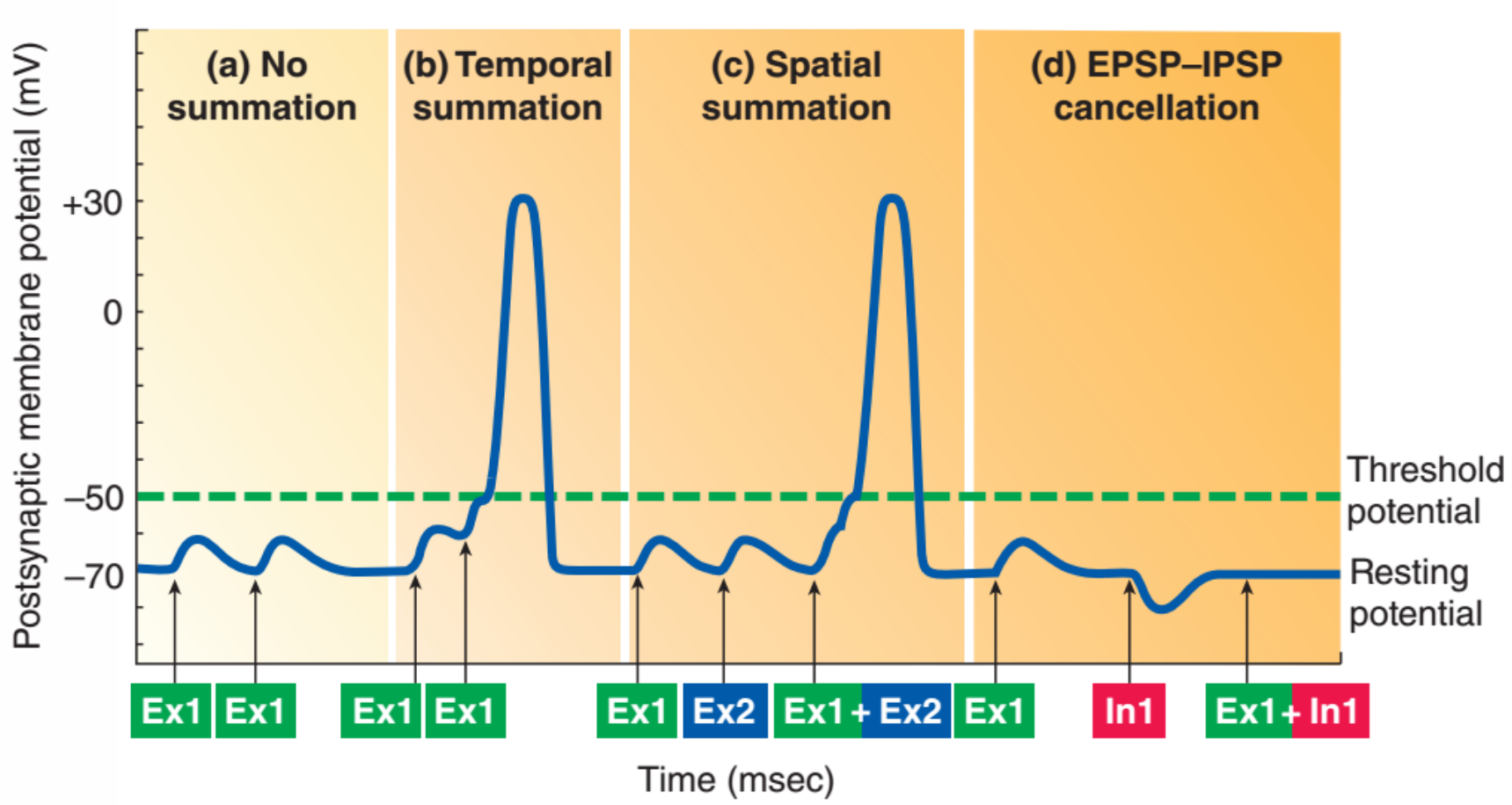
Source Rhoades p235

Inhibitory postsynaptic potentials
IPSPs

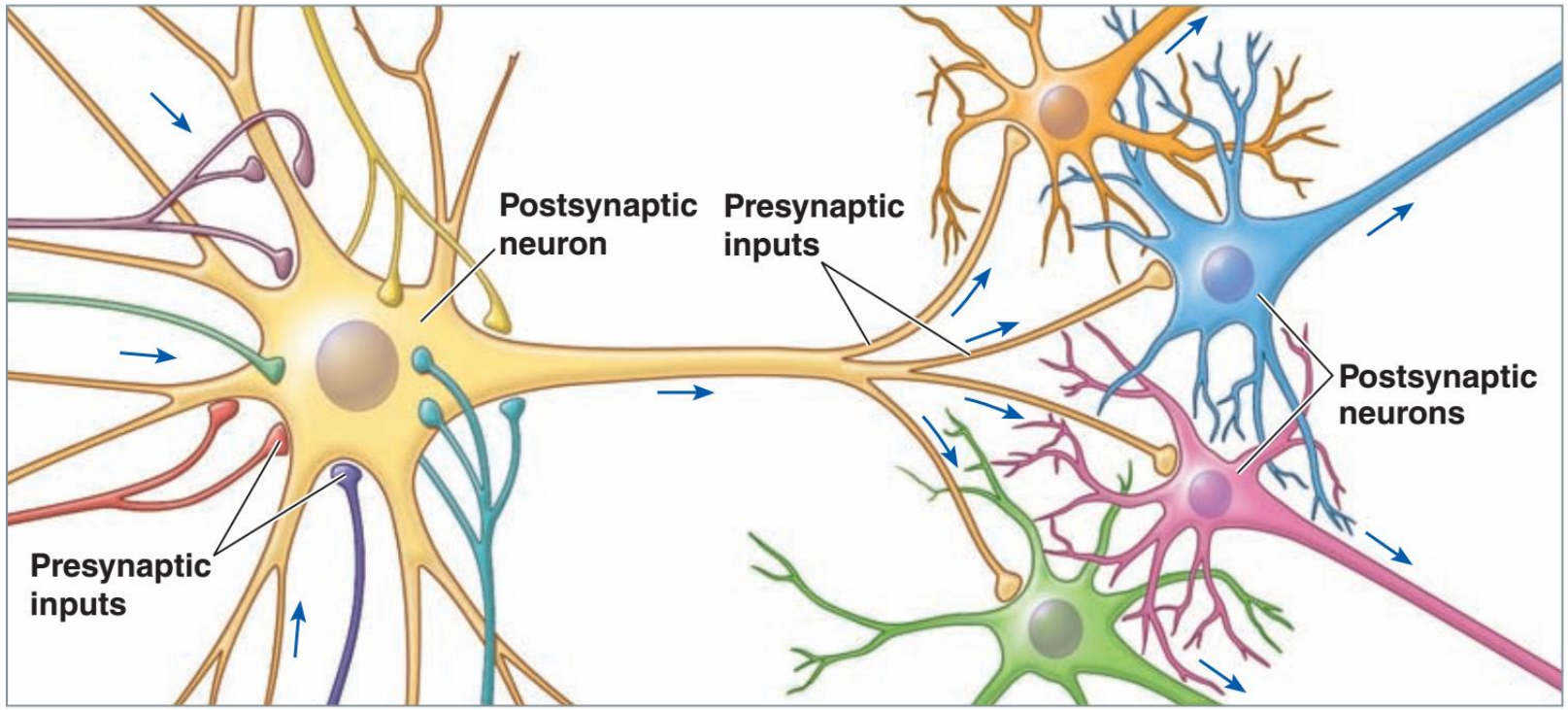


Source rhoades p235

Postsynaptic integration



Neuronal connection and pathway is complex



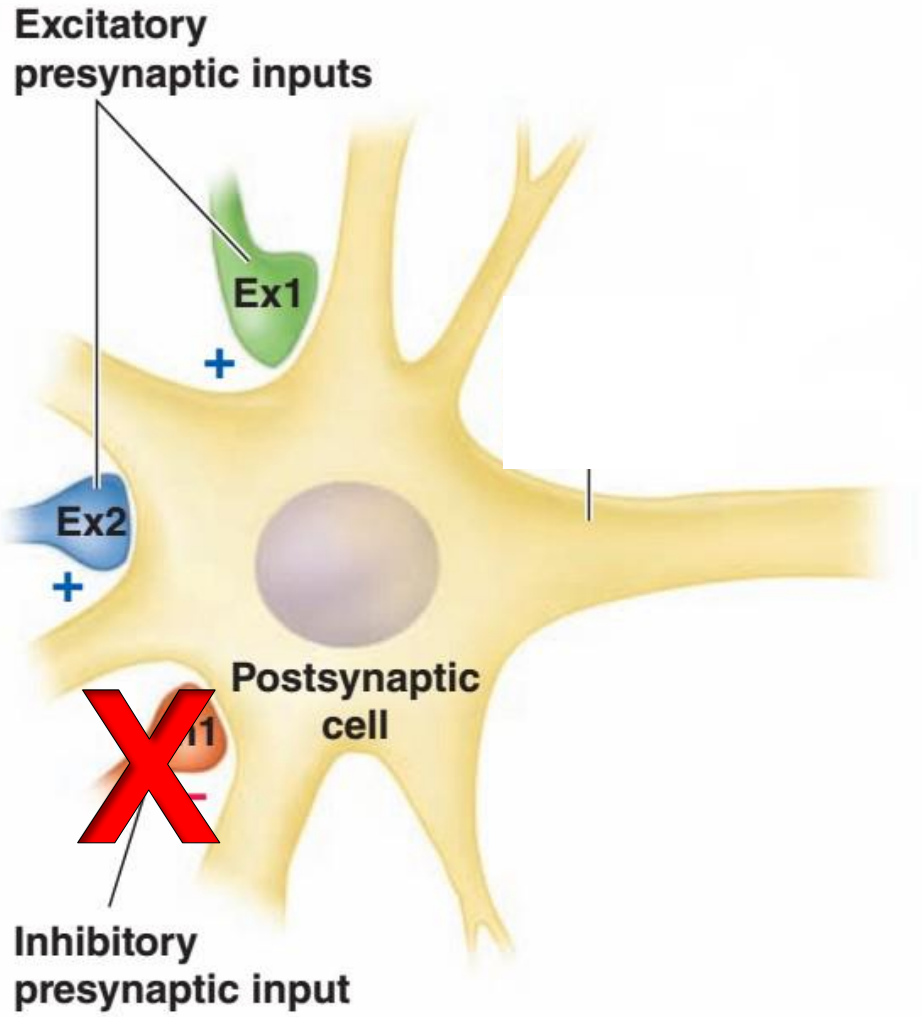
Convergence of input
(one cell is influenced by many others)

Divergence of output
(one cell influences many others)

Case study

https://wagwalking.com/

Tetanus toxin (tetanospasmin)



- Binds to presynaptic membrane and blocks the release of inhibitory neurotransmitters (GABA and glycine).
- The excitatory signals in the postsynaptic neurons are unchecked
- Uncontrolled muscle contractions and spasm
- Lockjaw

Lecture Summary

Synapses between presynaptic and post synaptic neurons

- AP ➪ Ca^{++} ➪ neurotransmitter release
- Graded potentials in postsynaptic neurons
- Post synaptic potentials ➪EPSP(+ve), IPSP (-ve)
- Post synaptic integration
- Axon hillock threshold ➪AP in post synaptic neuron

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