BIO-311 Neuroscience

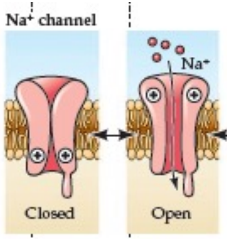
Unit 3: Synaptic Transmission

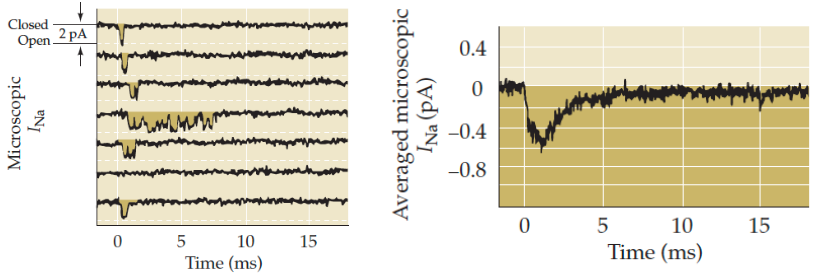
Summary

- Nerve terminal
- Quantized presynaptic transmission
- Ca2+ regulation of vesicle fusion; SNARE proteins, Synaptotagmin
- EPSP versus EPSC
- Glutamatergic receptors: roles and mechanisms for AMPA versus NMDA
- GABA as an inhibitory transmitter; GABAA
- Inhibitory postsynaptic potential, IPSP
- Integration of excitatory and inhibitory synaptic inputs in the dendrite of neurons
- Gap junctions
- Neuromodulation

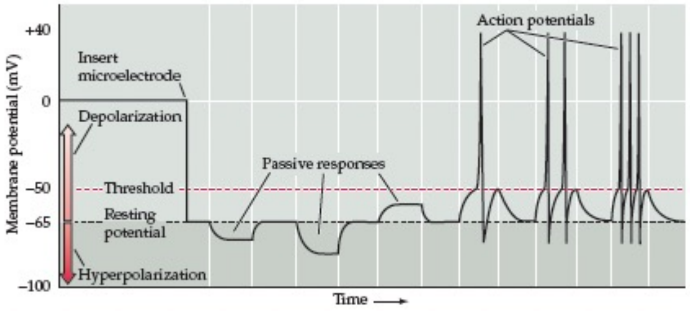
Discrete events throughout neuronal activity

Single channels: open or close

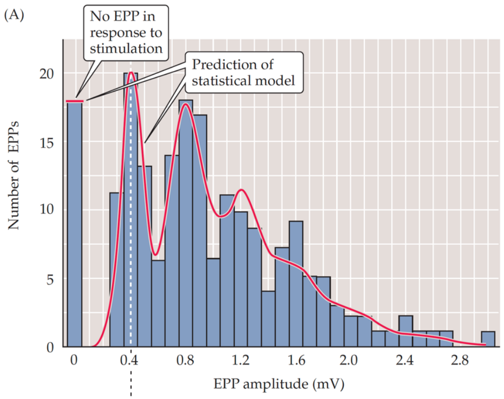




Action potentials: all-or-none

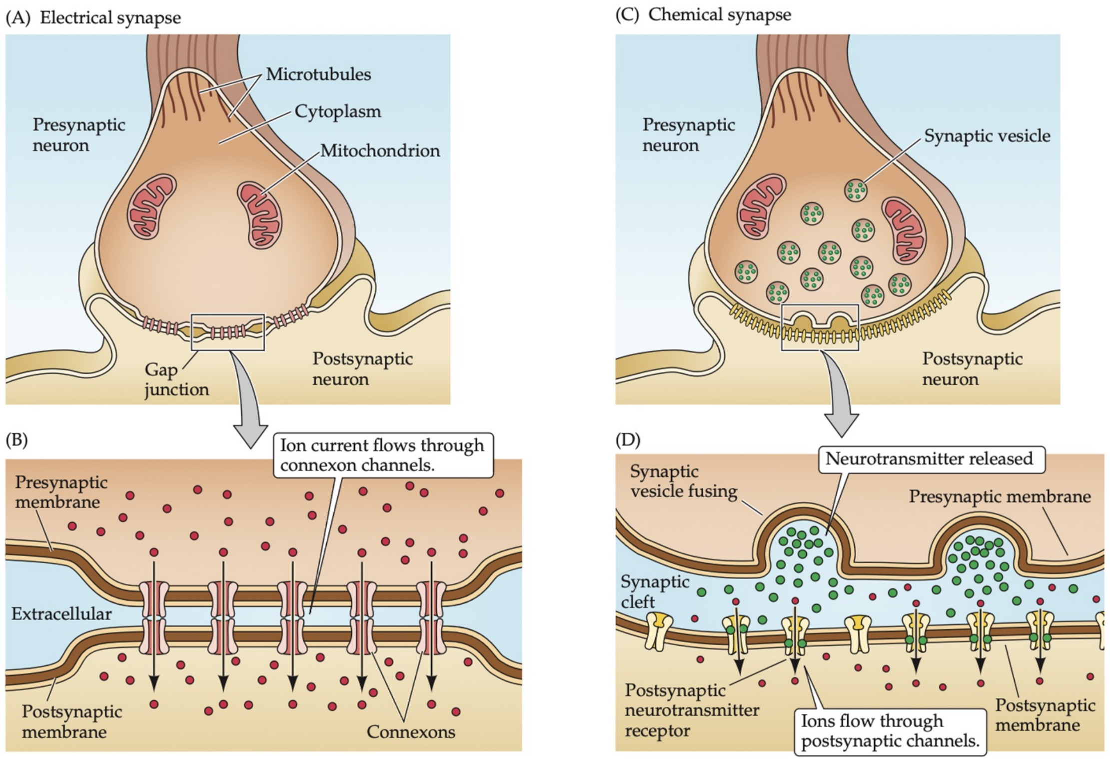


Synaptic transmission: quantized



Synapses: electrical vs. chemical

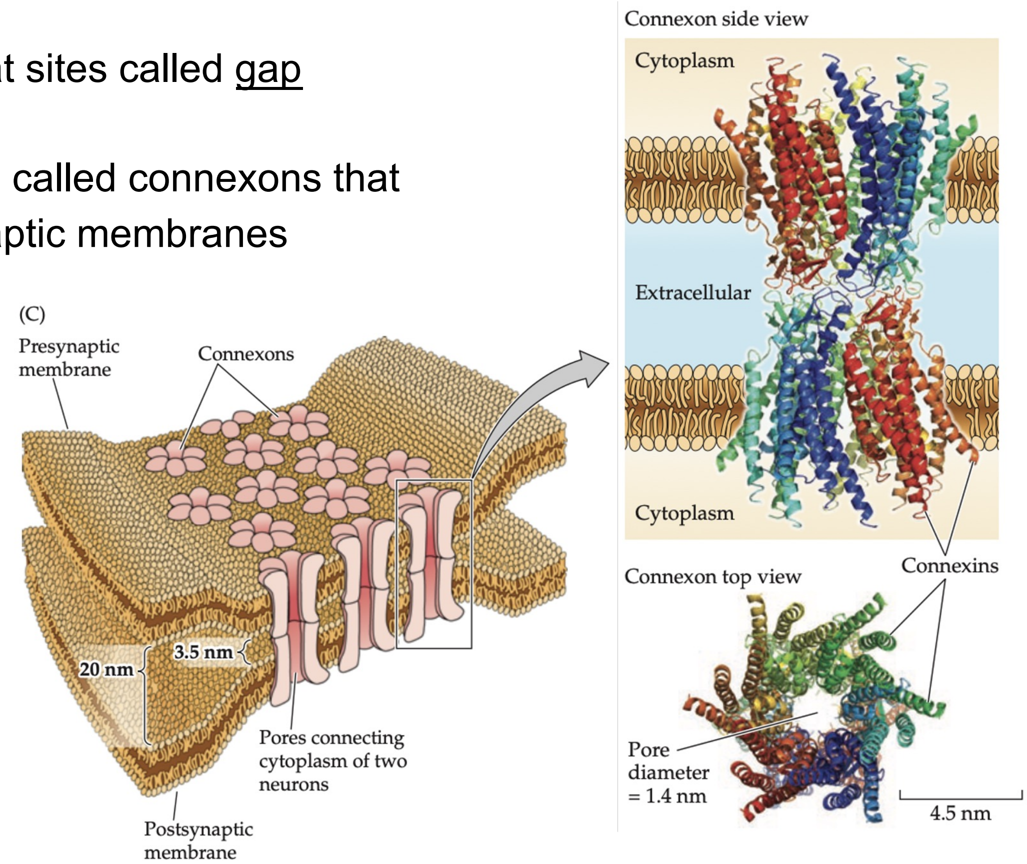
- <u>Chemical synapses</u>: more common, slower, works by signaling through chemical neurotransmitters
- <u>Electrical synapses</u>: less common, much faster, works by direct current flow across cells



Electrical synapses

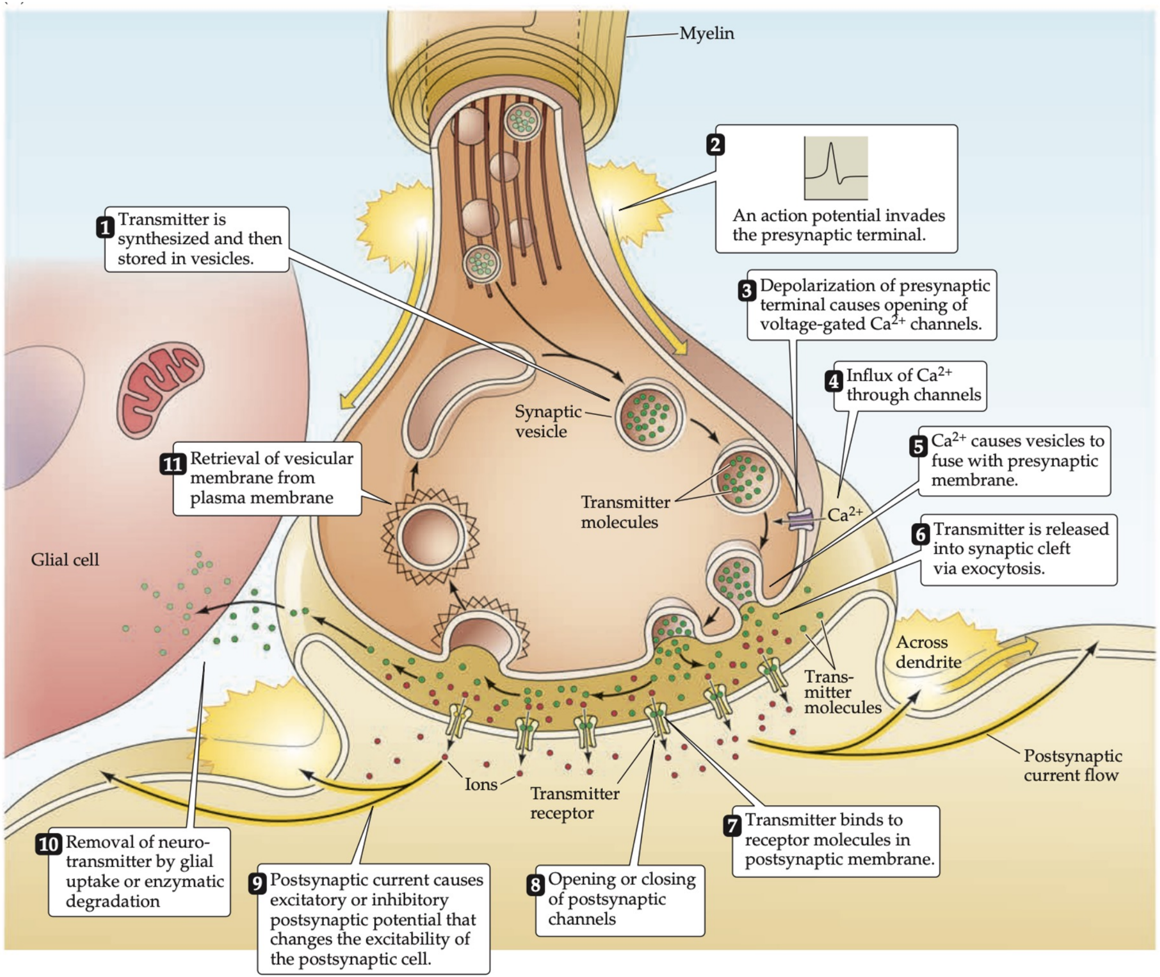
- Neurons physically touch each other at sites called <u>gap junctions</u>
- Ion current flows through ion channels called connexons that are present on both pre- and postsynaptic membranes

- Advantages:
    - Very fast — direct current flow(hence “electrical” synapse). This is useful for critical tasks like escape.
    - Can be bidirectional. This is useful for synchronization.

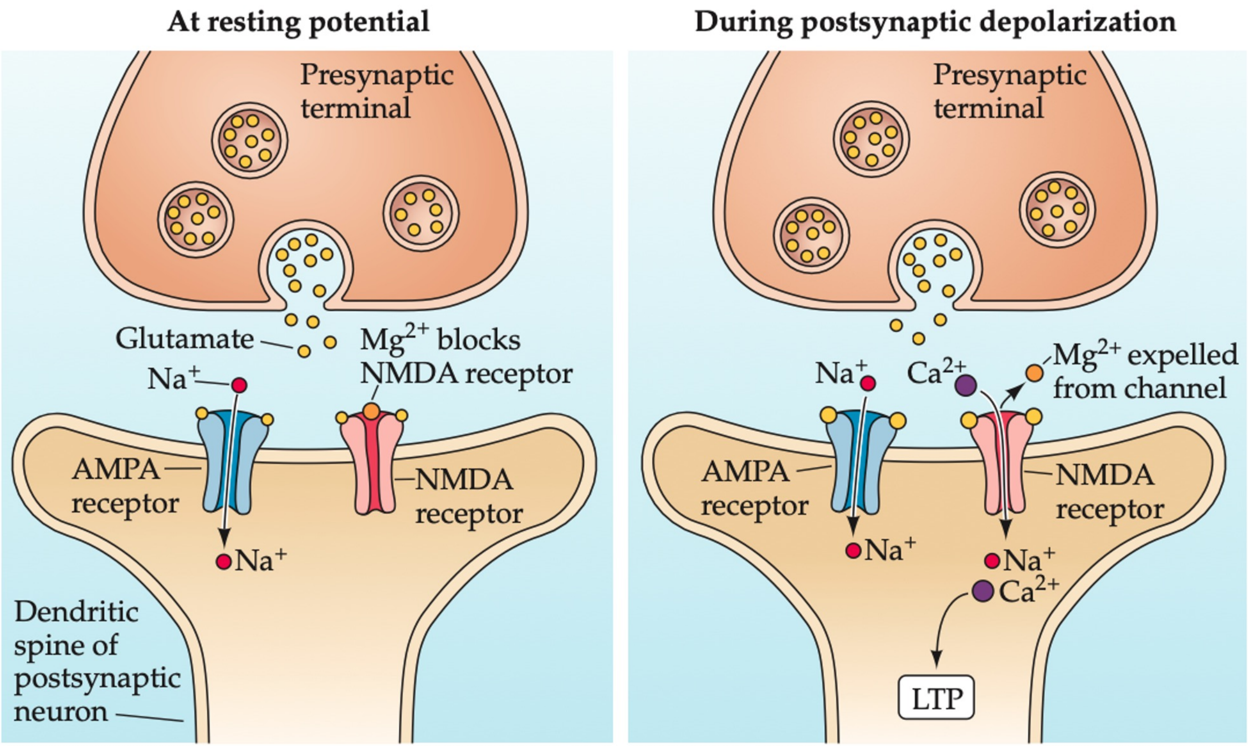


Chemical synapses

- Works by chemical signaling via neurotransmitters
- Ca^{2+} channels
  - Open when an action potential reaches the presynaptic terminal
  - Ca^{2+} cause the release of neurotransmitters into the synaptic cleft (exocytosis)
- Neurotransmitter causes ion channels to open/close in postsynaptic neuron
- This causes an action potential in the postsynaptic neuron



Excitatory neurotransmitters and post synaptic receptors



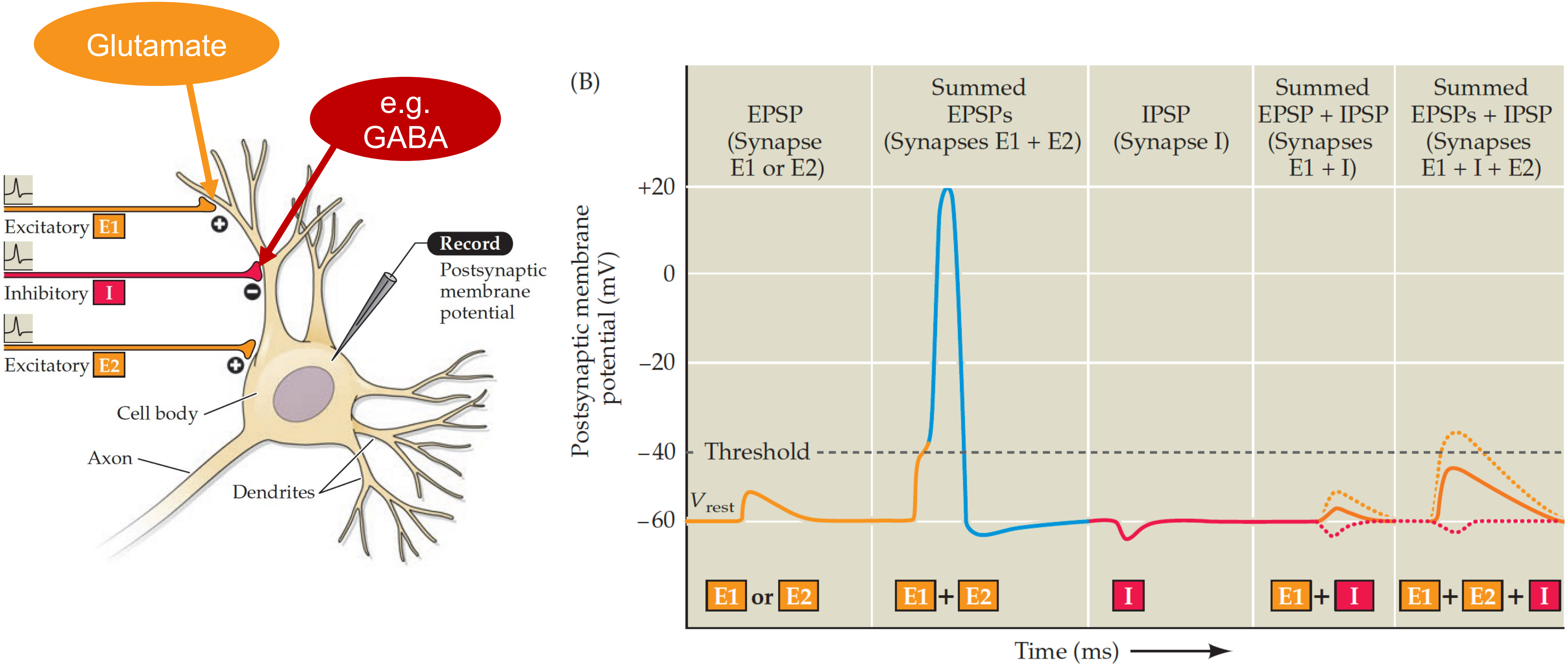
Voltage-dependent Mg^{2+} ion block of NMDA channel means the channel can only function if

- glutamate is bound (presynaptic activity) AND
- the Mg^{2+} block is relieved (postsynaptic depolarization)

This serves as a means of "coincidence detection" for pre- and postsynaptic activity

The resulting Ca^{2+} influx induces synaptic plasticity via long-term potentiation (LTP)

The dendritic summation of postsynaptic potentials



Purves, Figure 5.20

Neurotransmitters

Dale‘s rule: A given neuron usually uses only 1 small neurotransmitter

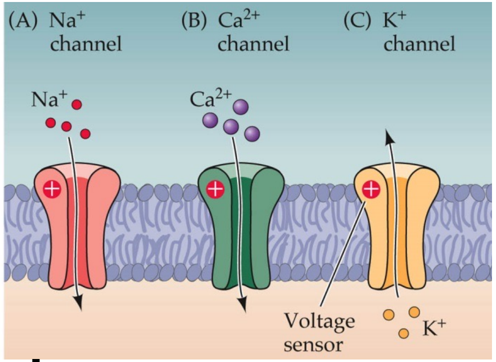
Neuron is called	Transmitter	important (defining) enzyme/transporter	
"glutamatergic"	**glutamate**	**vesicular glutamate transporter, VGluT**	
"GABA-ergic"	**GABA**	**Glutamic acid decarboxylase, GAD (vesicular GABA transporter, VGAT)**	
"glycinergic"	**glycine**	**(vesicular GABA transporter, VGAT)**	
"cholinergic"	ACh	choline acetyltransferase (ChAT) vesicular aceytcholine transporter (VAChT)	
"dopaminergic"	dopamine	Tyrosine-Hydroxylase, TH	in vertebrates these transmitters only act on Metabotropic receptors
"noradrenergic"	noradrenaline (=norepinephrine)	Tyrosine-Hydroxylase, TH AND Dopamine-β-Hydroxylase	

Dale's rule is only a first approximation. There are many exceptions.

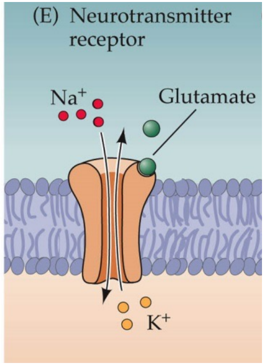
- Excitatory NT:
  - Glutamate
- Inhibitory NT:
  - GABA
  - Glycine

Summary: ion channels, and membrane receptors

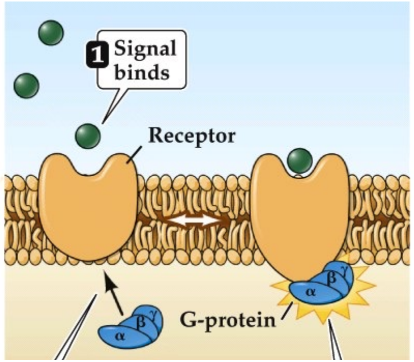
Voltage-gated channel



Ligand-gated channels
or "ionotropic receptor"



G-Protein coupled receptor (GPCR)
or "metabotropic receptor"



Ion channels

Membrane receptors

Purves, Figure 4.4

Purves, Figure 7.4C