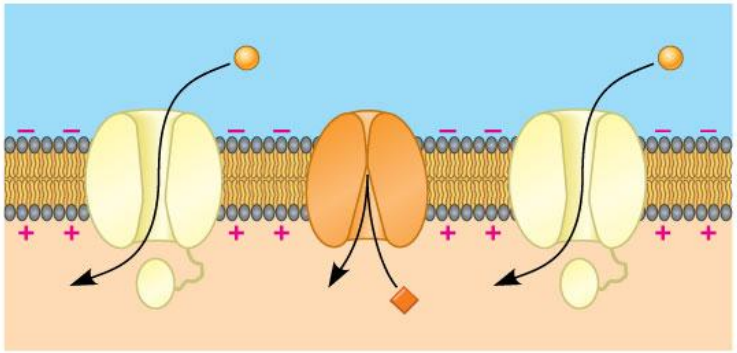
Nervous System: Part III
What Happens at a Synapse?

NATIONAL MATH + SCIENCE INITIATIVE

3.E.2 Continued

- Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.

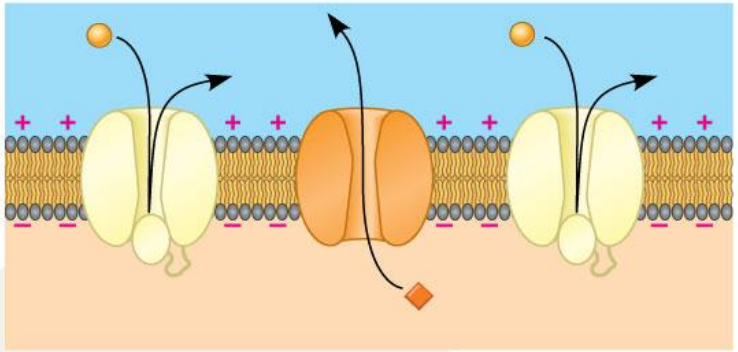


3 Rising phase of the action potential

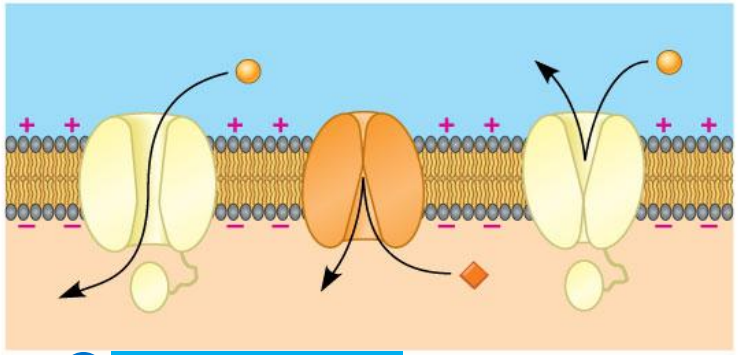
Key

Na^+

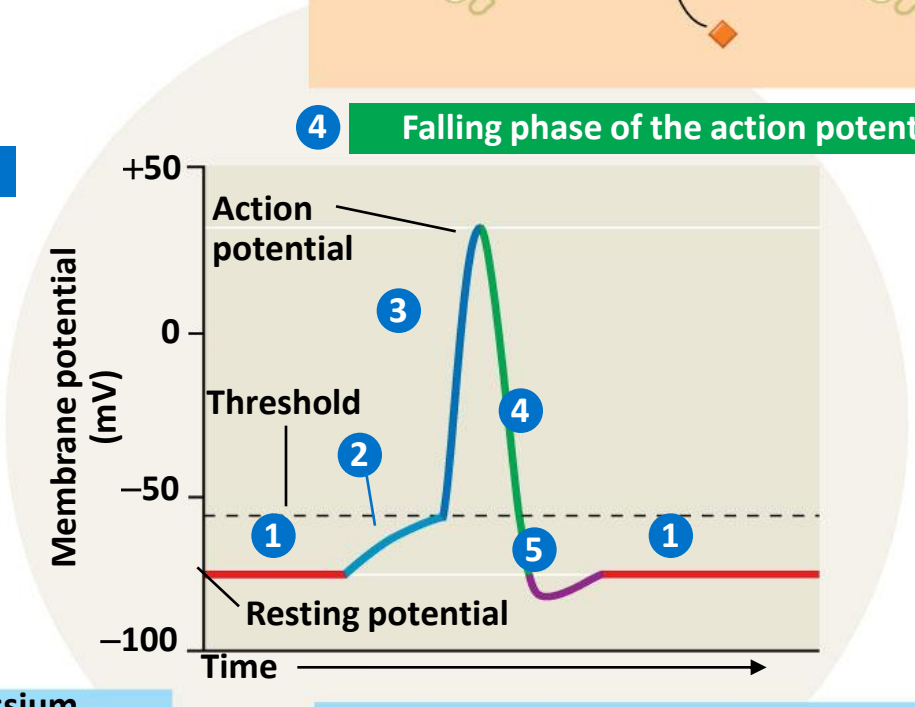
K^+

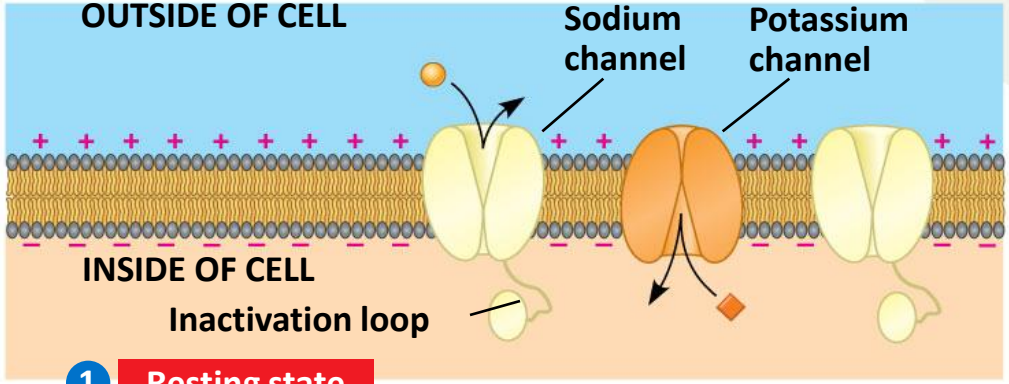


4 Falling phase of the action potential

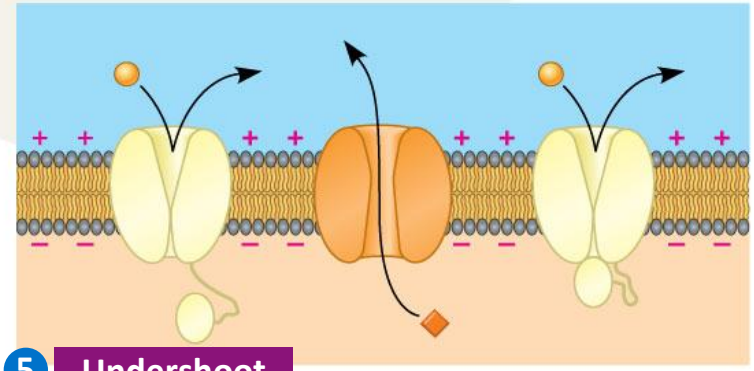


2 Depolarization

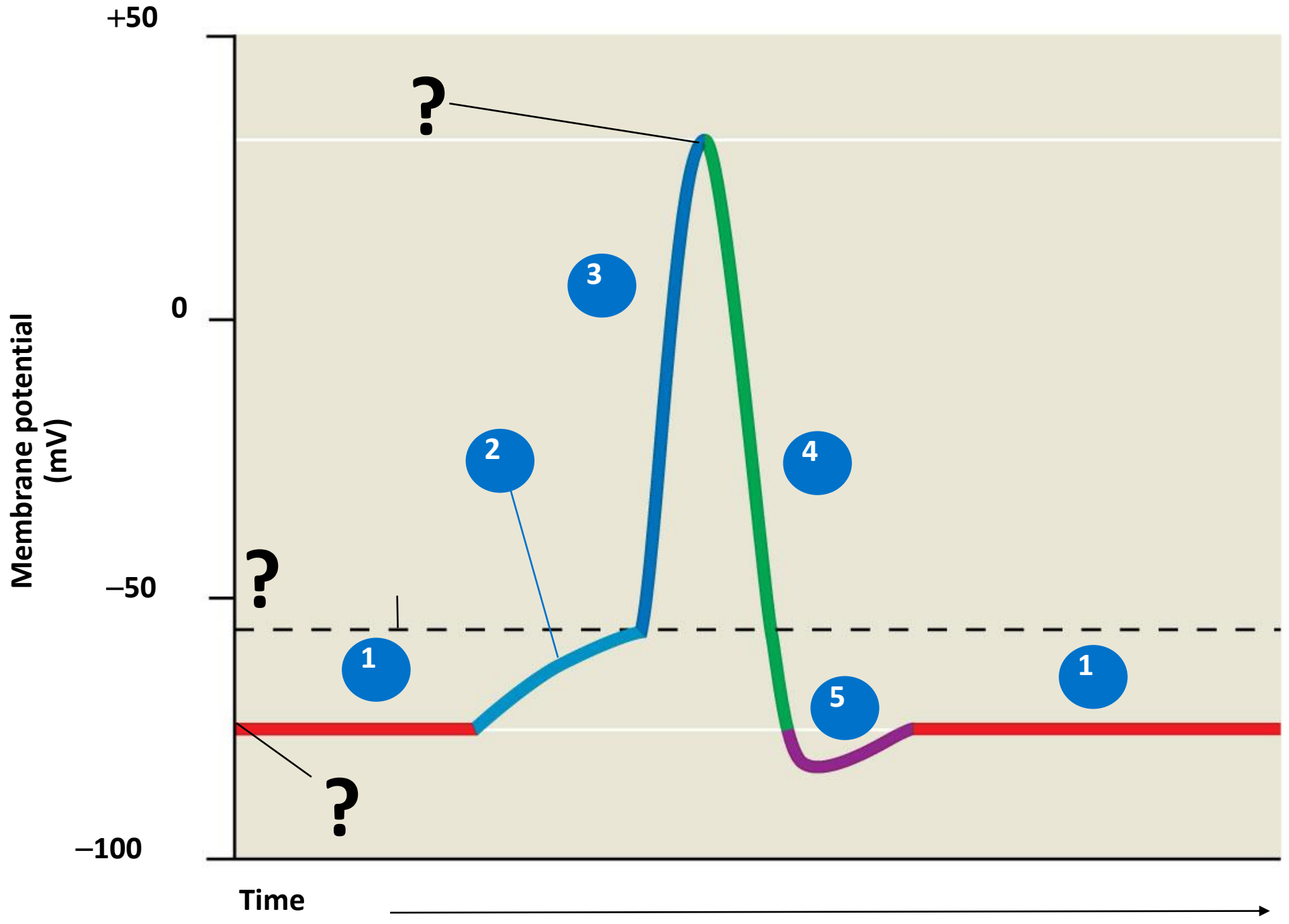




1 Resting state



5 Undershoot



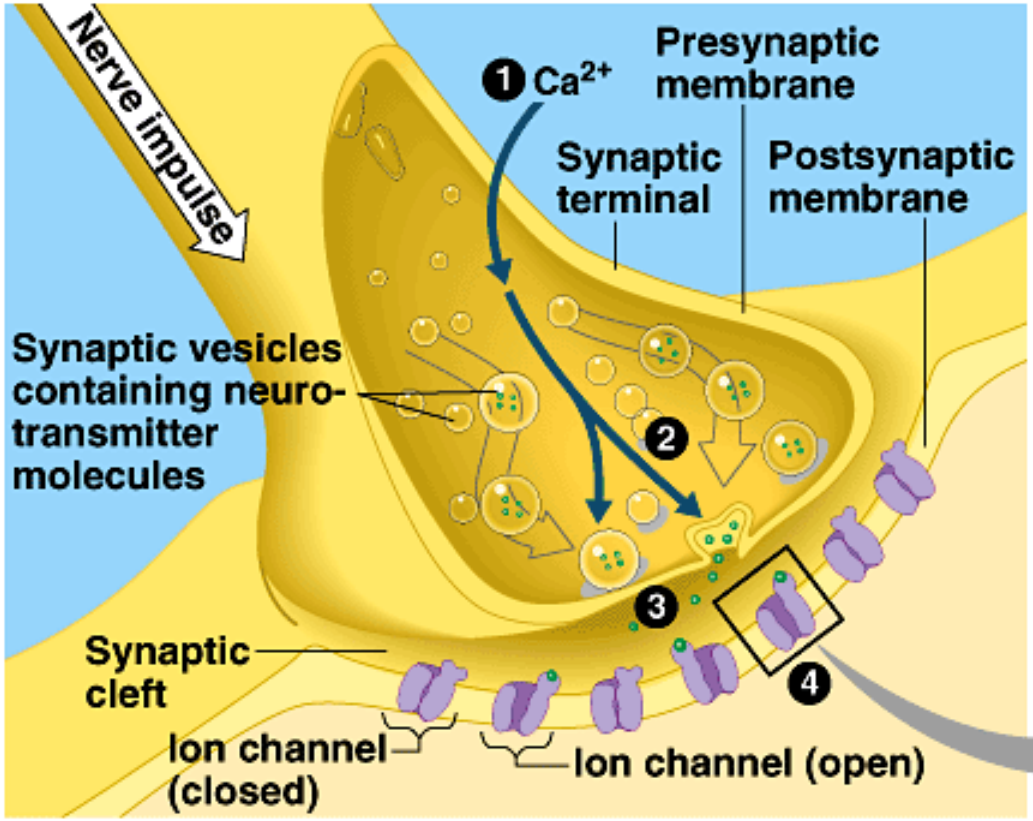
What happens when the impulse reaches the end of the axon?

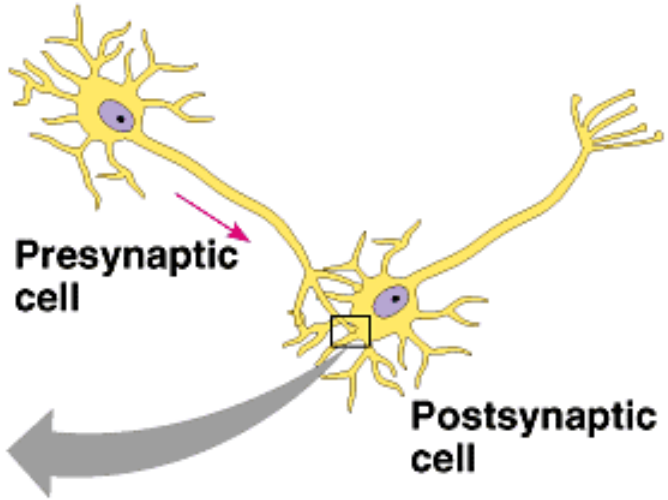
Synapses

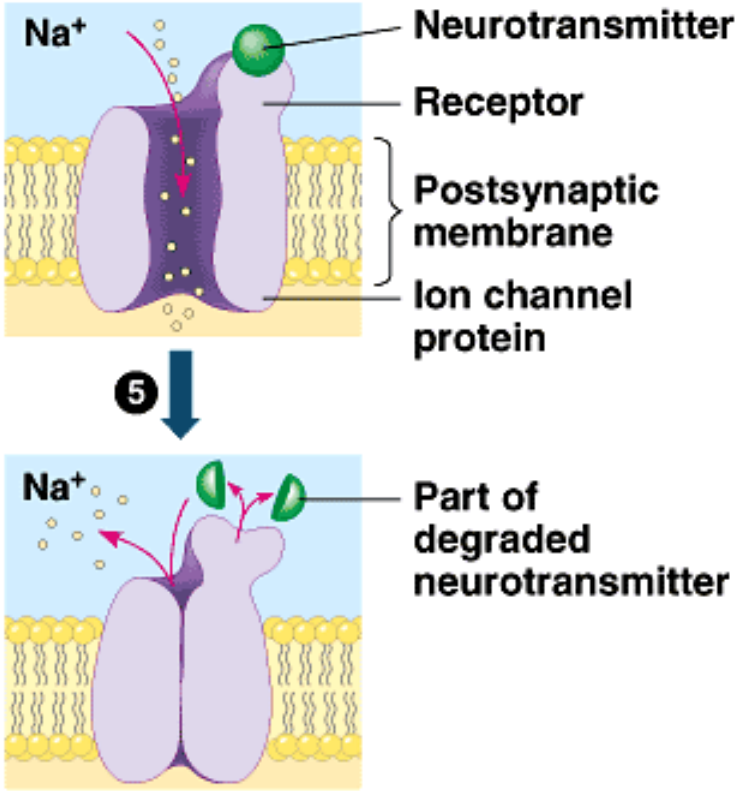
- Transmission of information between neurons occurs across synapses.
- A chemical synapse is a junction between two nerve cells consisting of a *minute* gap across which impulses pass by means of a neurotransmitter.

Neurotransmitters: Chemical Messengers

- 3.E.2.c.
- In most animals, transmission across synapses involves chemical messengers called neurotransmitter such as:
  - Acetylcholine
  - Epinephrine
  - Norepinephrine
  - Dopamine
  - Serotonin
  - GABA

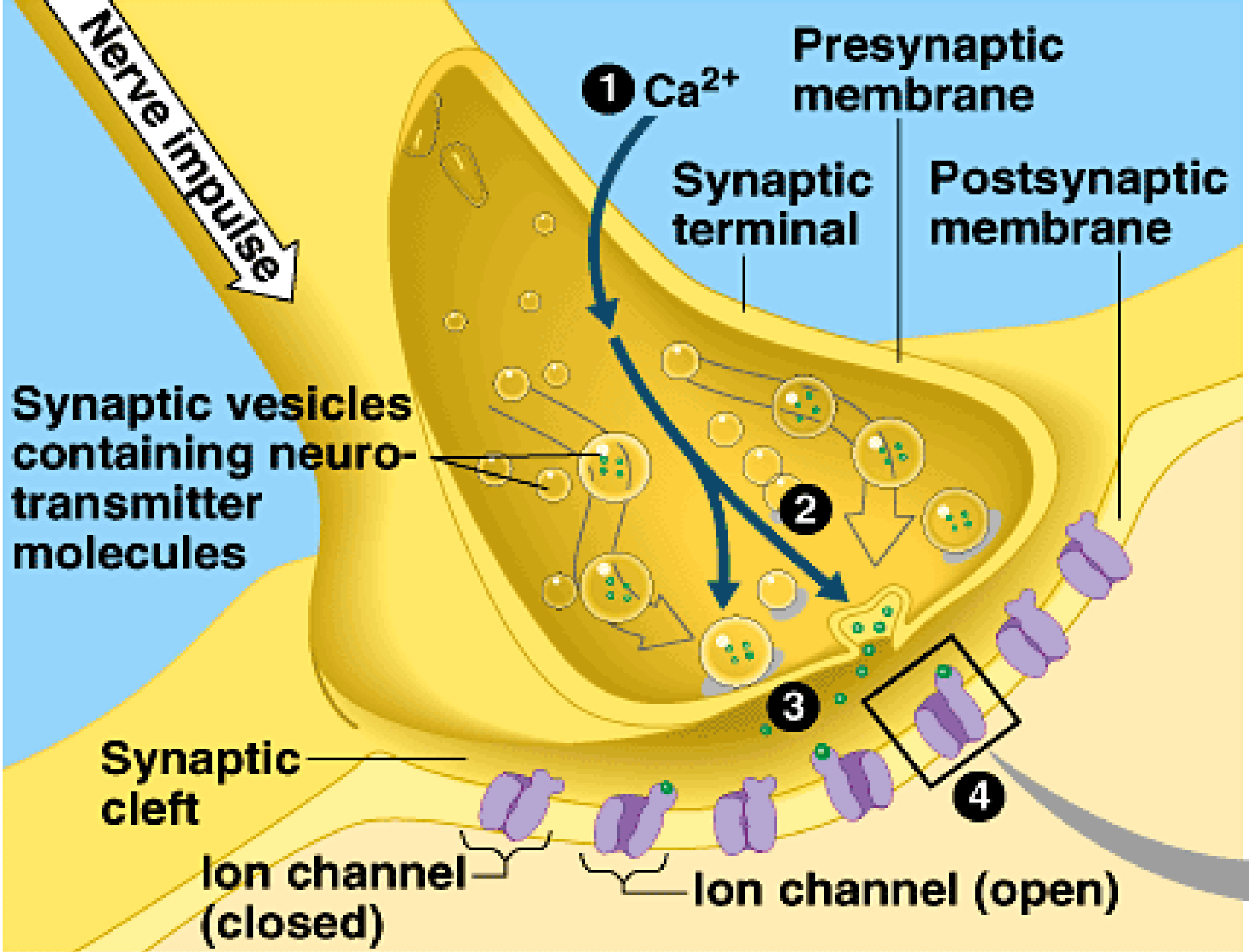






Note the structural features that allow the cell to cell communication to occur in the synaptic region:

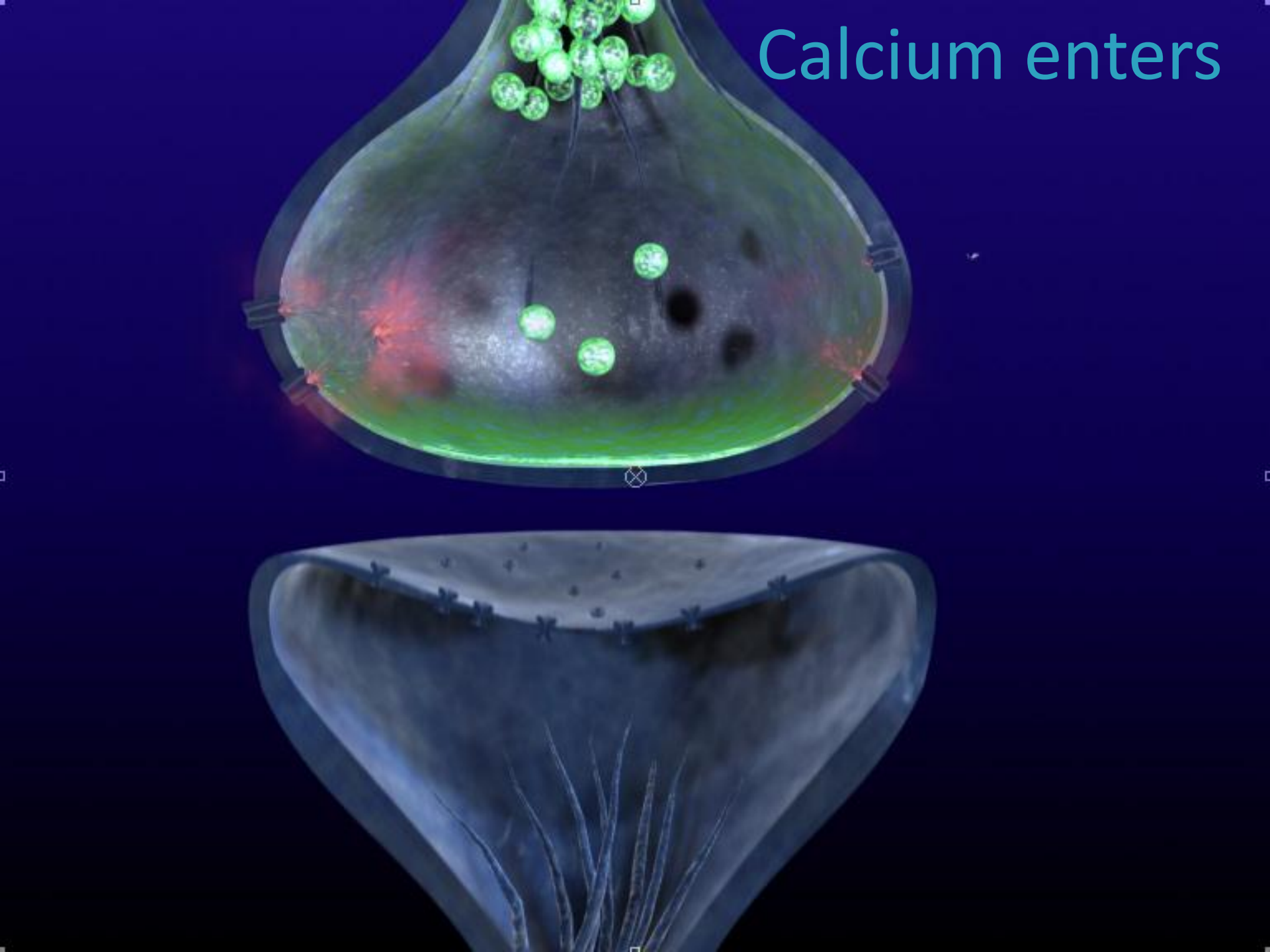
- Calcium gated channels in the synaptic knob
- Sodium channels in the post-synaptic membrane
- Fluidity of the lipid bi-layer allows for exocytosis of the neurotransmitter


Nerve impulse
1 Ca2+
Presynaptic membrane
Synaptic terminal
Postsynaptic membrane
Synaptic vesicles containing neuro-transmitter molecules
2
3
4
Synaptic cleft
Ion channel (closed)
Ion channel (open)

Cell To Cell Communication Events

1. Action potential depolarized the membrane of synaptic terminal, this triggers an influx of Ca^{2+}.
2. That causes synaptic vesicles to fuse with the membrane of the pre-synaptic neuron.
3. Vesicles release neurotransmitter molecules into the synaptic cleft.
4. Neurotransmitters bind to the receptors of ion channels embedded in the postsynaptic membrane.

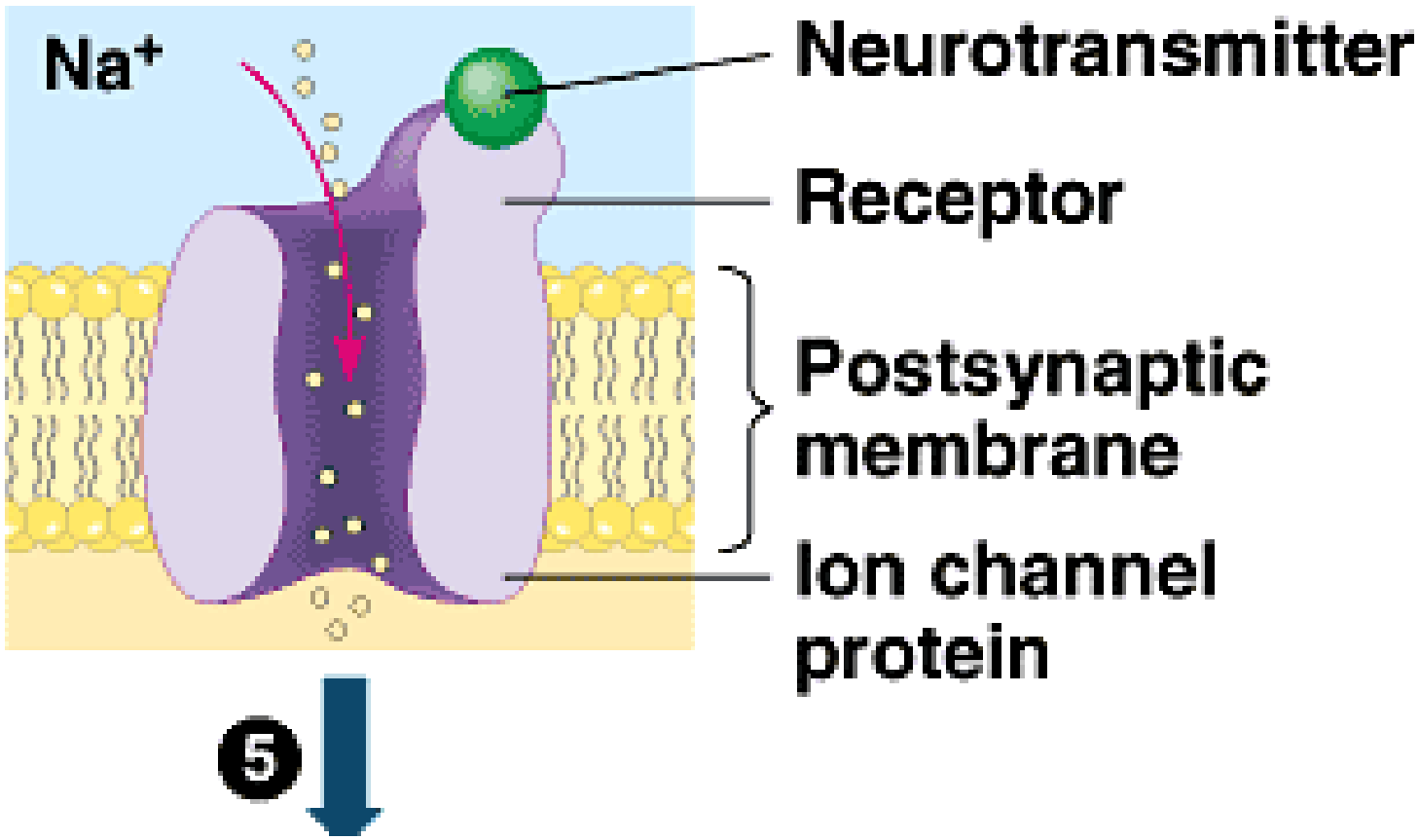
Calcium enters




At synaptic cleft

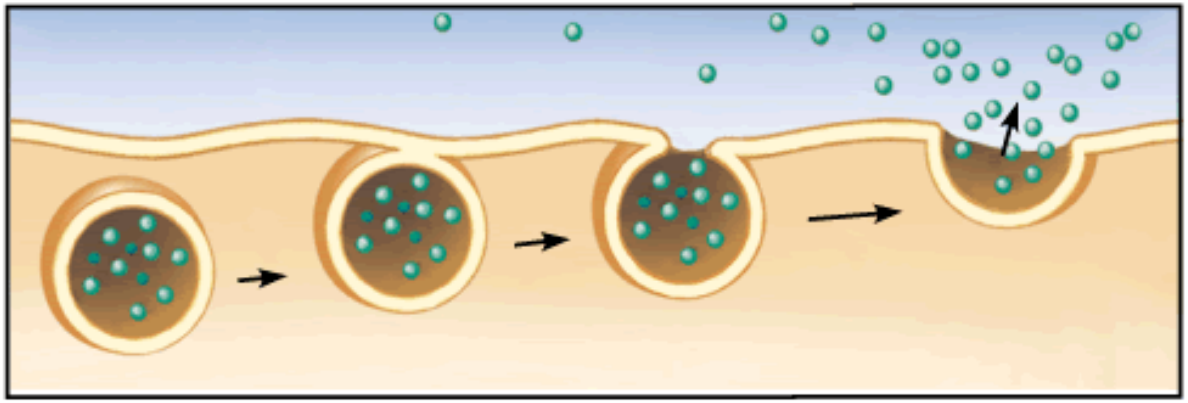
BioFlix™
How Synapses Work

Neuron Transmitter Binds With A Receptor On The Postsynaptic Membrane

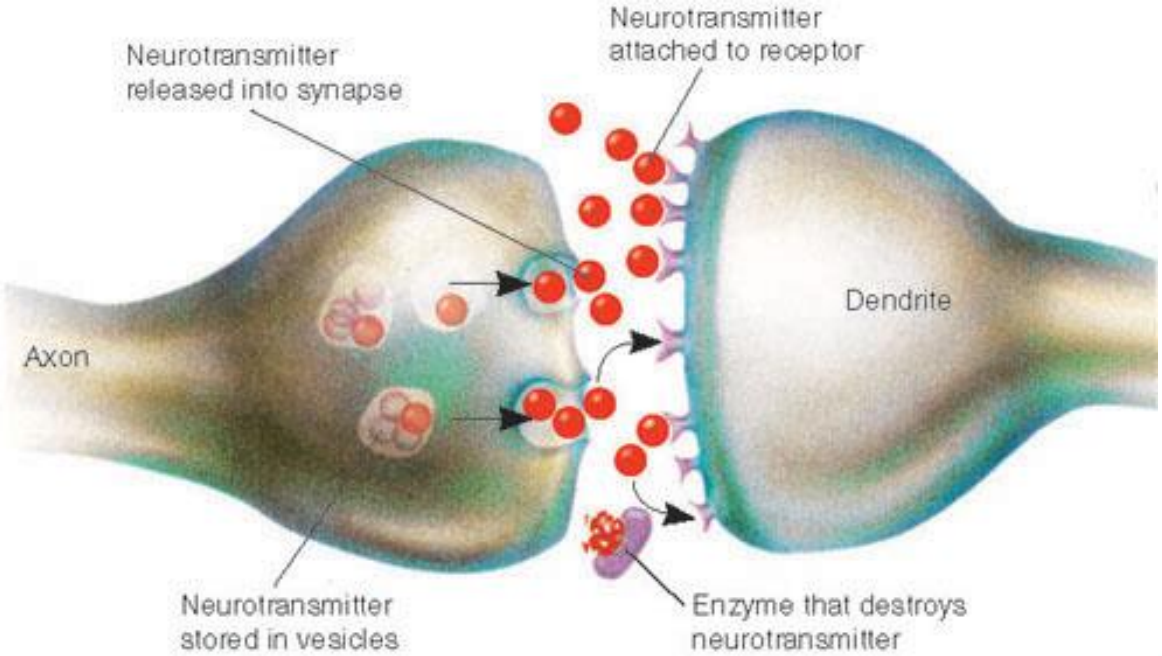


Exocytosis

- Neurotransmitter release is a form of exocytosis.
- In exocytosis, internal vesicles fuse with the plasma membrane to secrete macromolecules out of the cell.



- The neurotransmitter will then be released from the postsynaptic membrane and degraded.

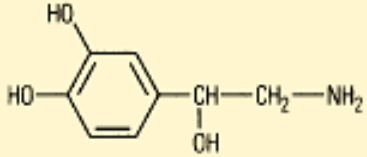
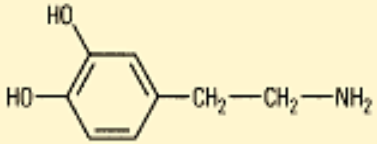
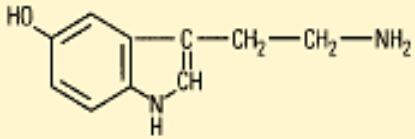


Neurotransmitters

- There are more than 100 neurotransmitters, belonging to five groups: acetylcholine, biogenic amines, amino acids, neuropeptides, and gases

- A single neurotransmitter may have more than a dozen different receptors

Table 48.1 The Major Known Neurotransmitters

Neurotransmitter	Structure	Functional Class	Secretion Sites
Acetylcholine	$H_3C—C(=O)—O—CH_2—CH_2—N^+—(CH_3)_3$	Excitatory to vertebrate skeletal muscles; excitatory or inhibitory at other sites	CNS; PNS; vertebrate neuromuscular junction
Biogenic Amines			
Norepinephrine		Excitatory or inhibitory	CNS; PNS
Dopamine		Generally excitatory; may be inhibitory at some sites	CNS; PNS
Serotonin		Generally inhibitory	CNS
Amino Acids			
GABA (gamma aminobutyric acid)	$H_2N—CH_2—CH_2—CH_2—COOH$	Inhibitory	CNS; invertebrate neuromuscular junction
Glycine	$H_2N—CH_2—COOH$	Inhibitory	CNS
Glutamate	$H_2N—CH(COOH)—CH_2—CH_2—COOH$	Excitatory	CNS; invertebrate neuromuscular junction
Aspartate	$H_2N—CH(COOH)—CH_2—COOH$	Excitatory	CNS
Neuropeptides			
Substance P	Arg—Pro—Lys—Pro—Gln—Gln—Phe—Phe—Gly—Leu—Met	Excitatory	CNS; PNS
Met-enkephalin (an endorphin)	Tyr—Gly—Gly—Phe—Met	Generally inhibitory	CNS

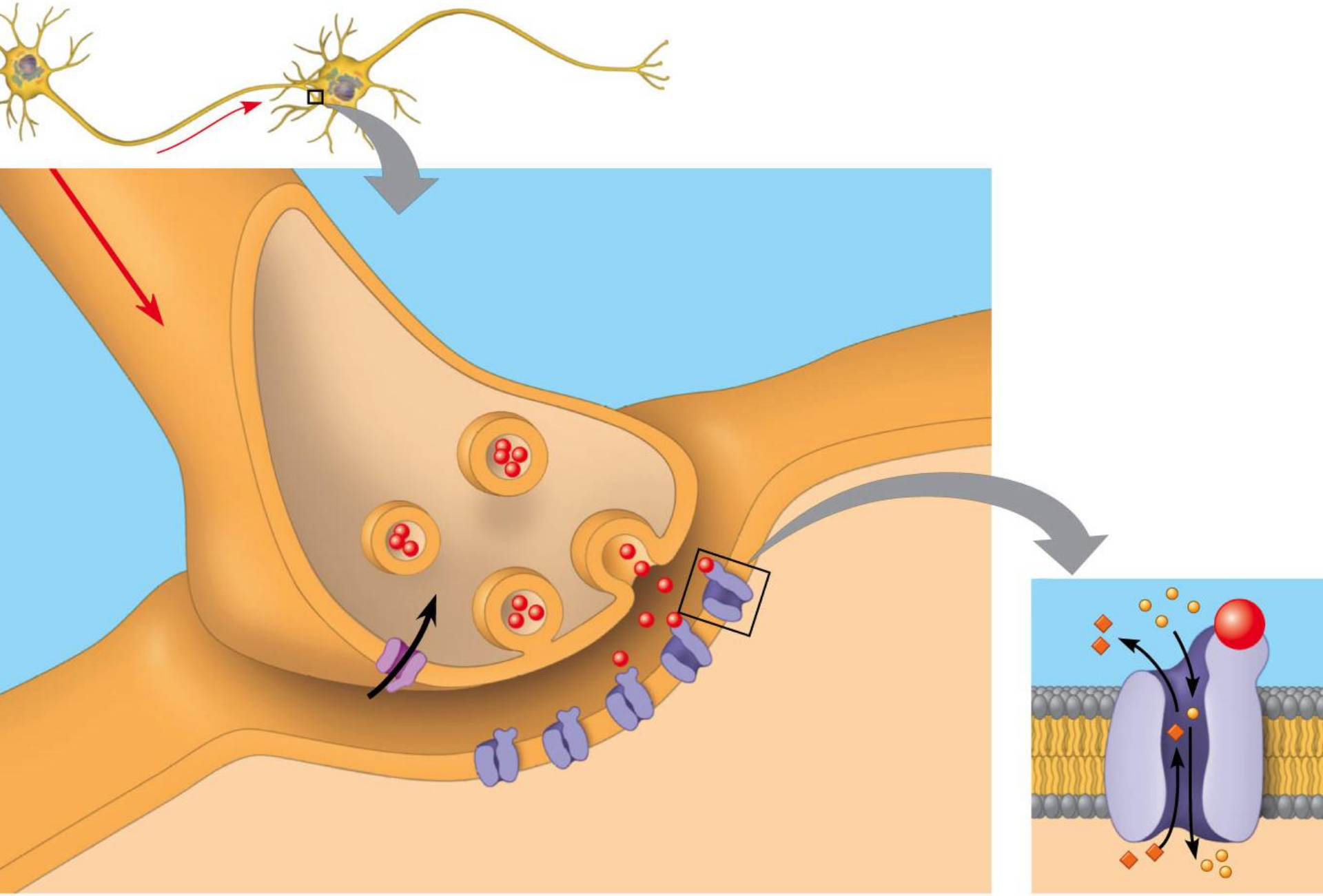
Acetylcholine

- **Acetylcholine** is a common neurotransmitter in vertebrates and invertebrates.
- It is involved in muscle stimulation, memory formation, and learning.
- Vertebrates have two major classes of acetylcholine receptor, one that is ligand gated and one that is metabotropic, requiring a second messenger.


Post synaptic

Response

- Transmission of information along neurons and synapses results in a response.
- The response can be stimulatory or inhibitory.



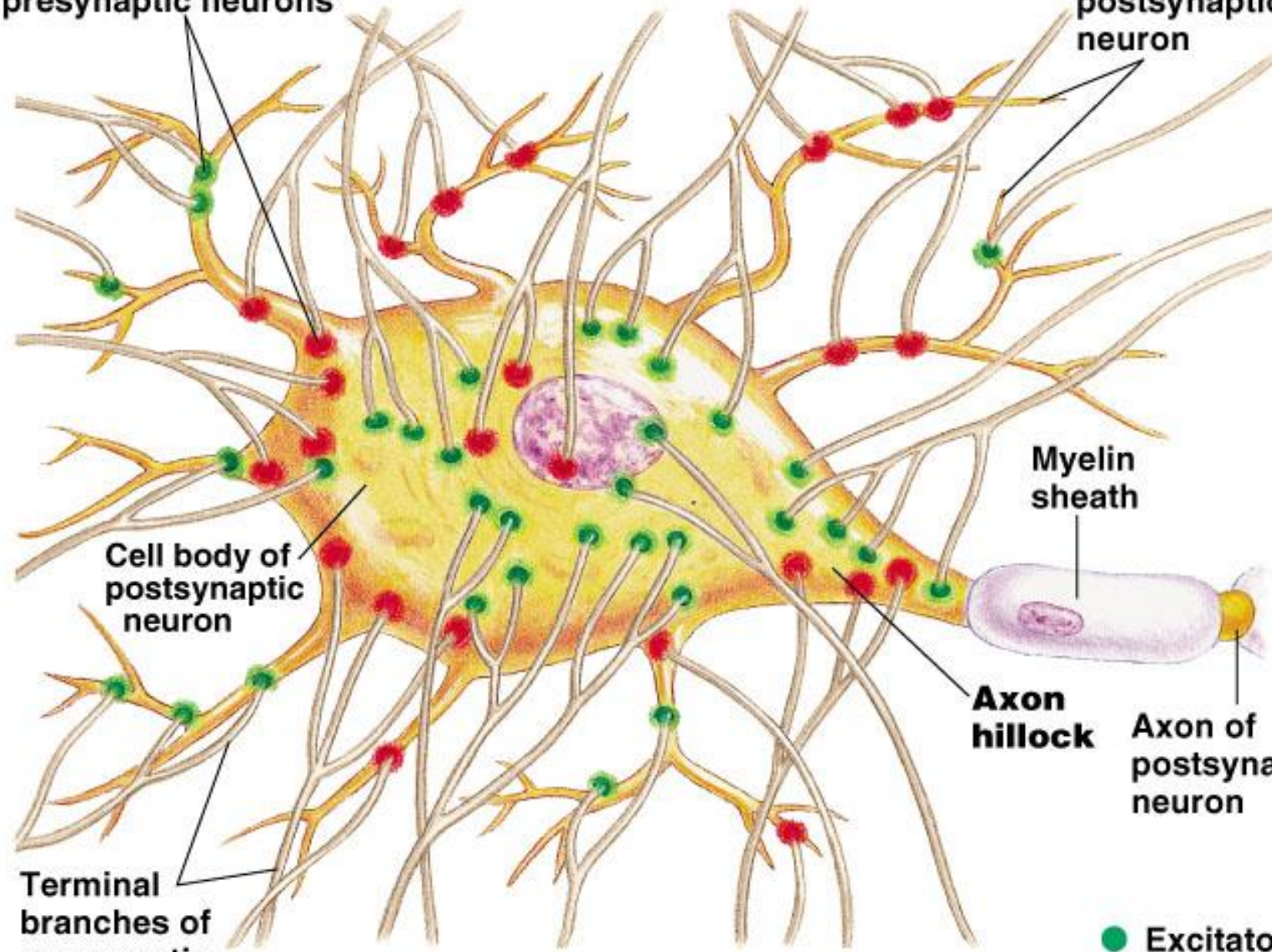
Injecting ethylene glycol tetraacetic acid (EGTA), a chelating agent that prevents calcium ions from moving across membranes, to a synaptic region would likely

a. increase the release of neurotransmitters by the presynaptic neuron.

b. decrease the release of neurotransmitters by the presynaptic neuron.

c. result in neurotransmitters being released, but could not bind to its receptors on the post synaptic neuron.

d. result in the lack of calcium ions keeping the ligand-gated ion channels open on the post synaptic neurons.



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