# Nervous system

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Lec. 9

# Nervous System


- sensory
- integration
- motor signaling


- Receive information from environment and body
- Send it to spinal cord and brain


- Interprets the sensory


- Send signals to effectors tissues

**Nervous system**

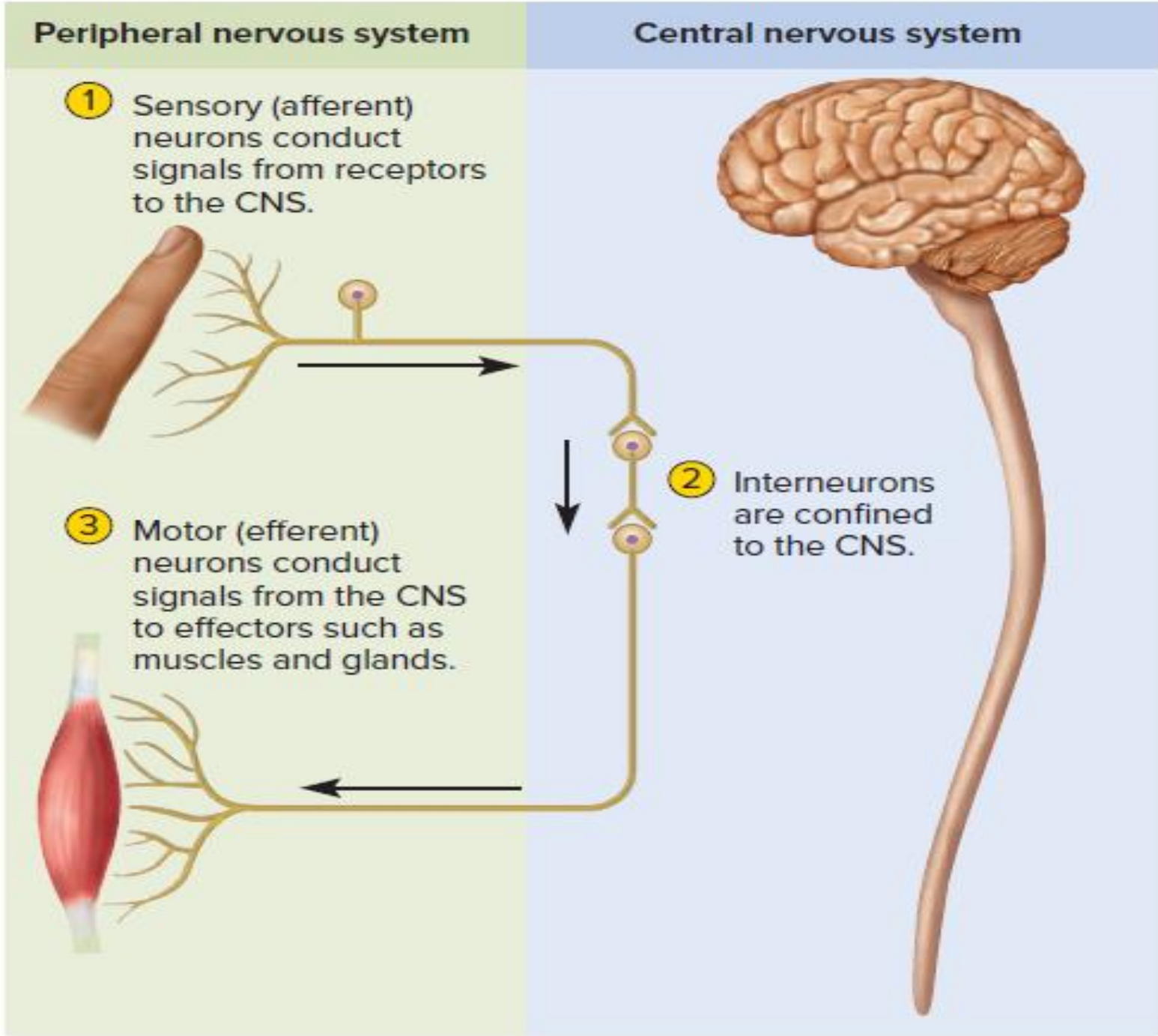
- Central N.S. (CNS)
- Peripheral N.S. (PNS)

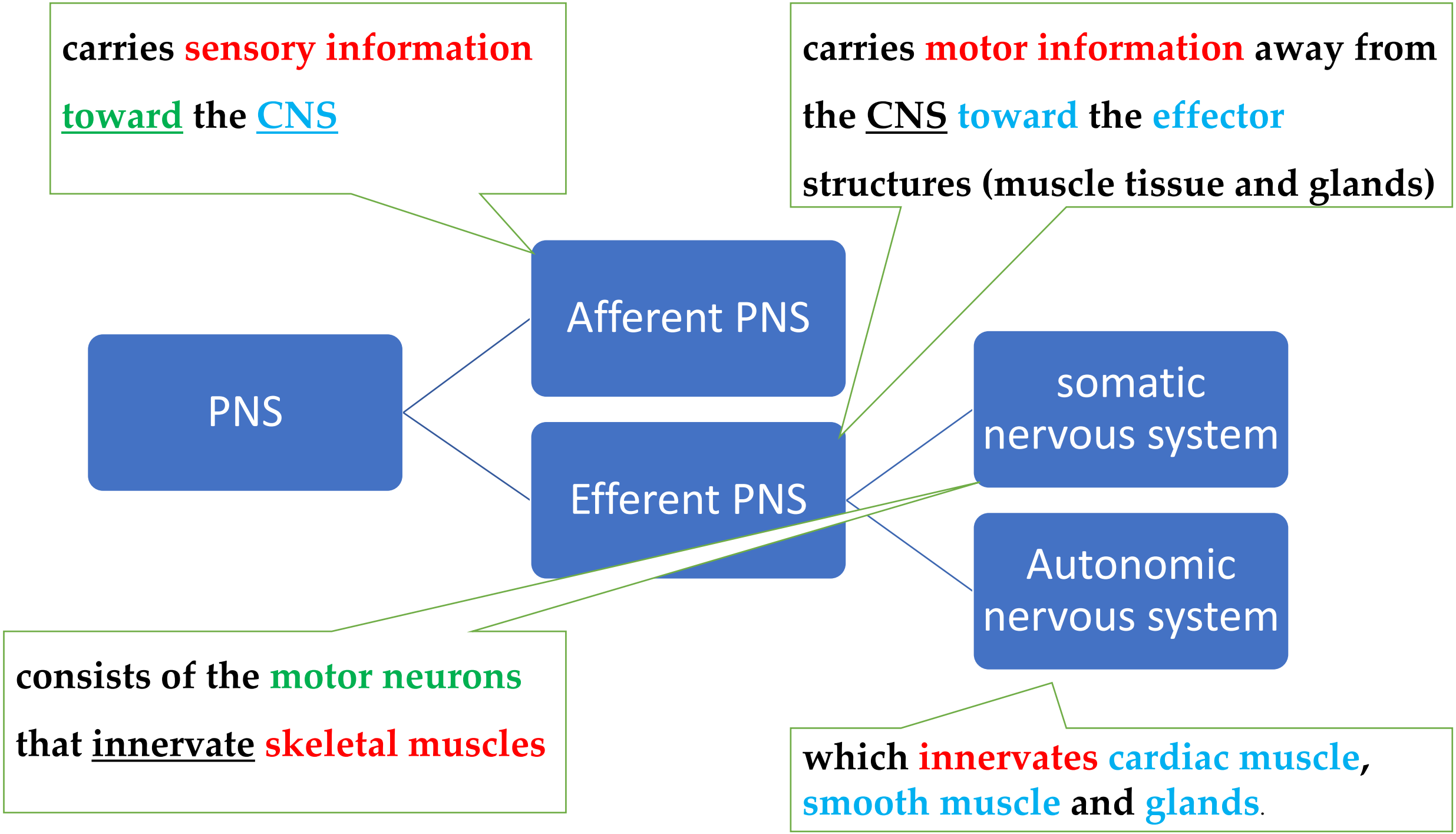
**CNS**

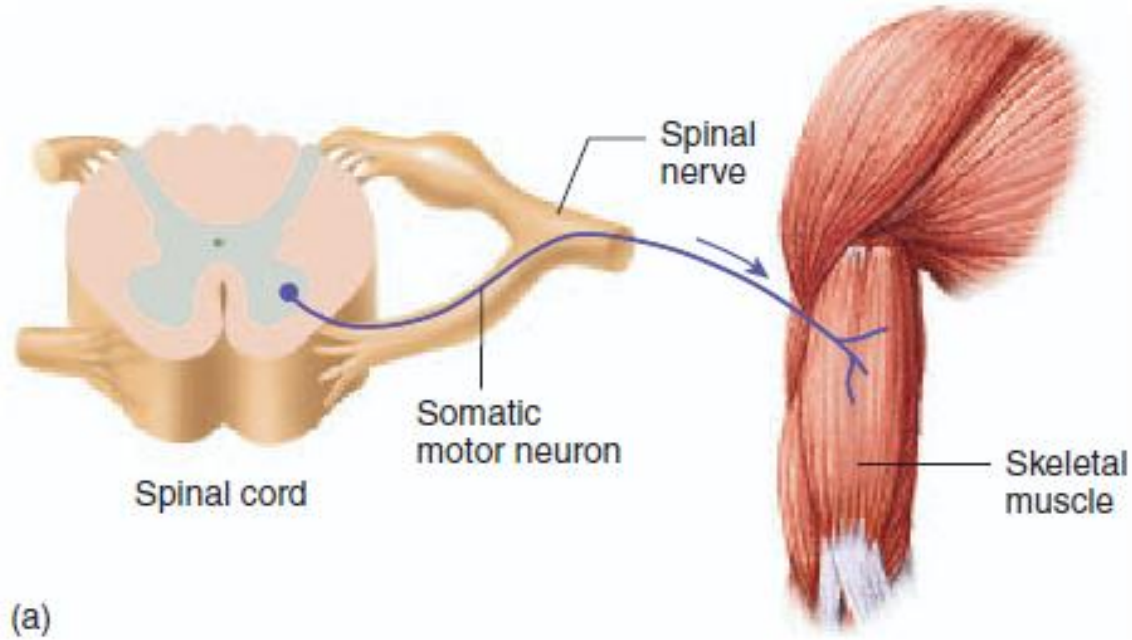
- Brain
- Spinal cord

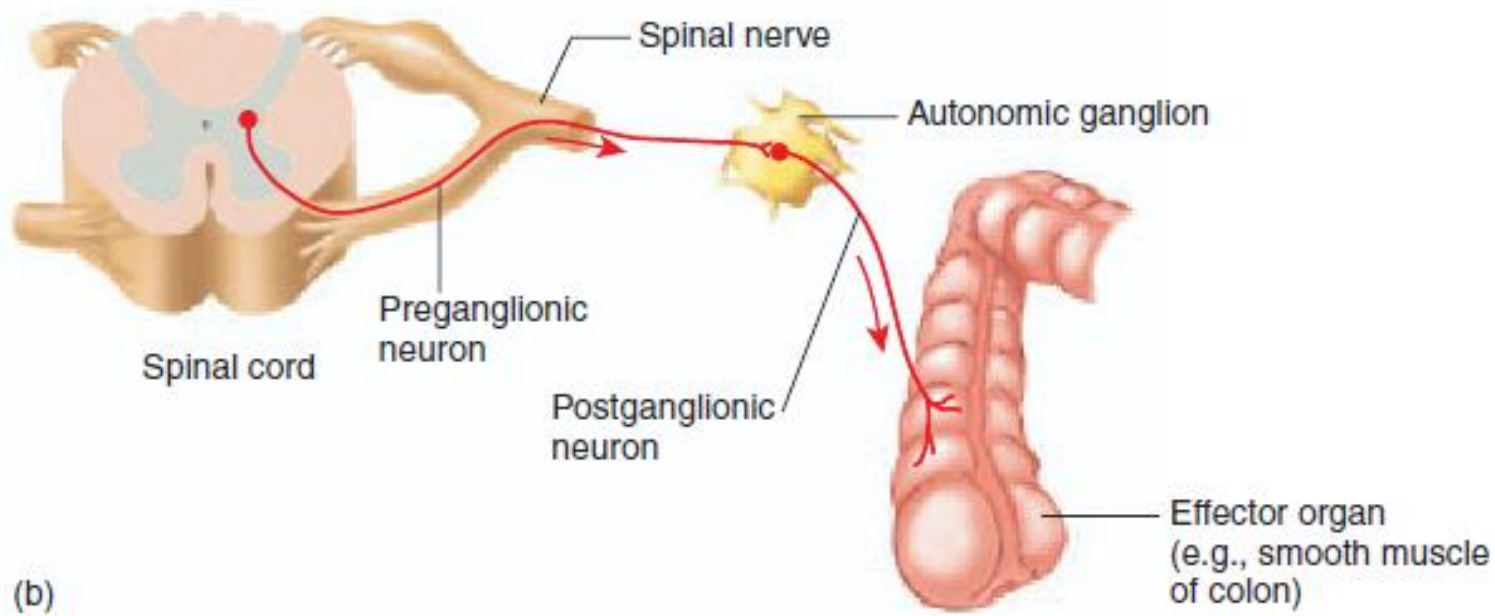
**PNS**

- Afferent P.N.S.
- Efferent P.N.S.


Peripheral nervous system
Central nervous system
1 Sensory (afferent) neurons conduct signals from receptors to the CNS.
2 Interneurons are confined to the CNS.
3 Motor (efferent) neurons conduct signals from the CNS to effectors such as muscles and glands.


carries sensory information toward the CNS
carries motor information away from the CNS toward the effector structures (muscle tissue and glands)
PNS
Afferent PNS
Efferent PNS
somatic nervous system
Autonomic nervous system
consists of the motor neurons that innervate skeletal muscles
which innervates cardiac muscle, smooth muscle and glands.

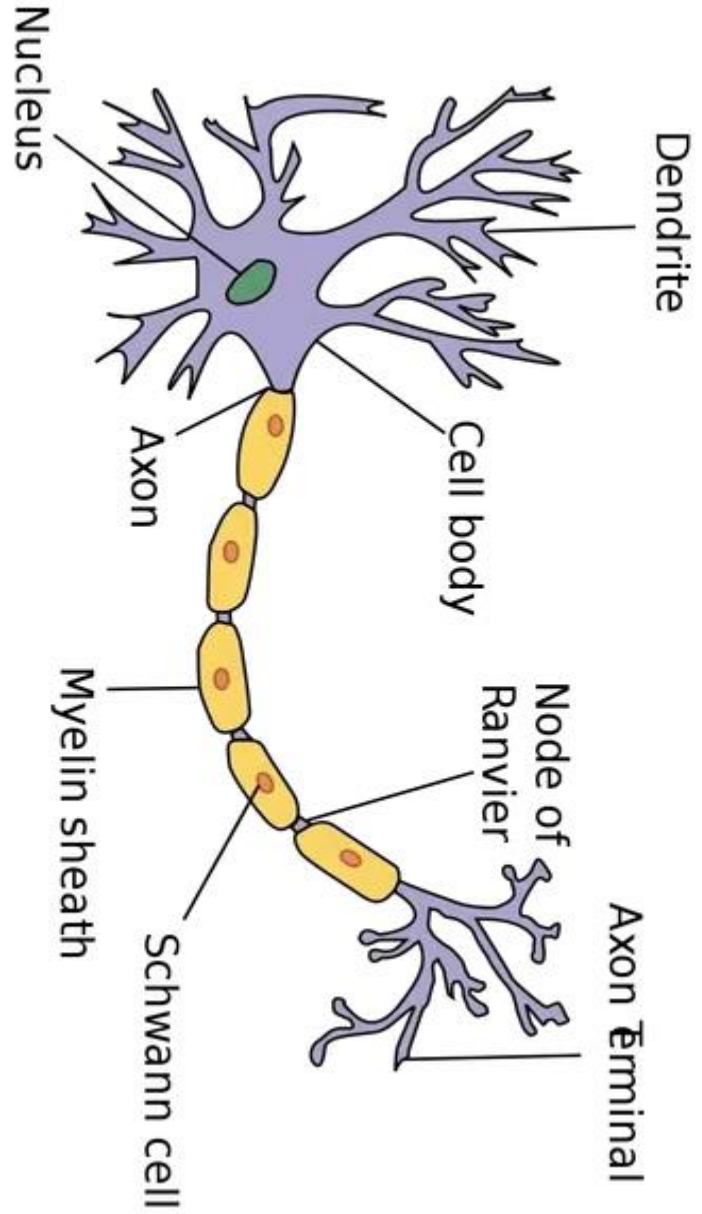

Spinal nerve
Somatic motor neuron
Spinal cord
Skeletal muscle
(a)


Spinal nerve
Autonomic ganglion
Preganglionic neuron
Spinal cord
Postganglionic neuron
Effector organ (e.g., smooth muscle of colon)
(b)

# *Neurons*

Types of neurons

- **Afferent neurons**
- **Efferent neurons**
- **Interneurons**



# Type of Neurons

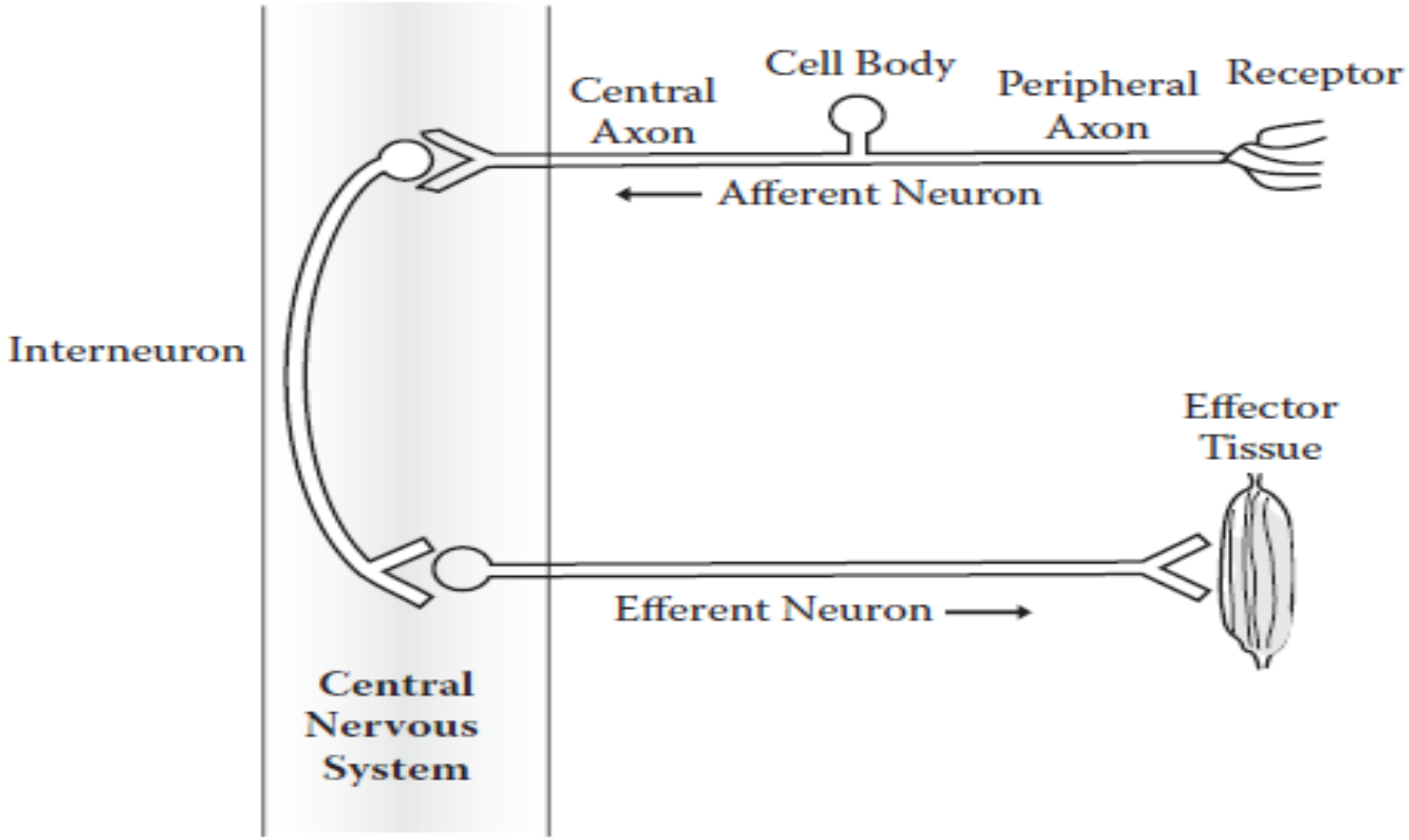
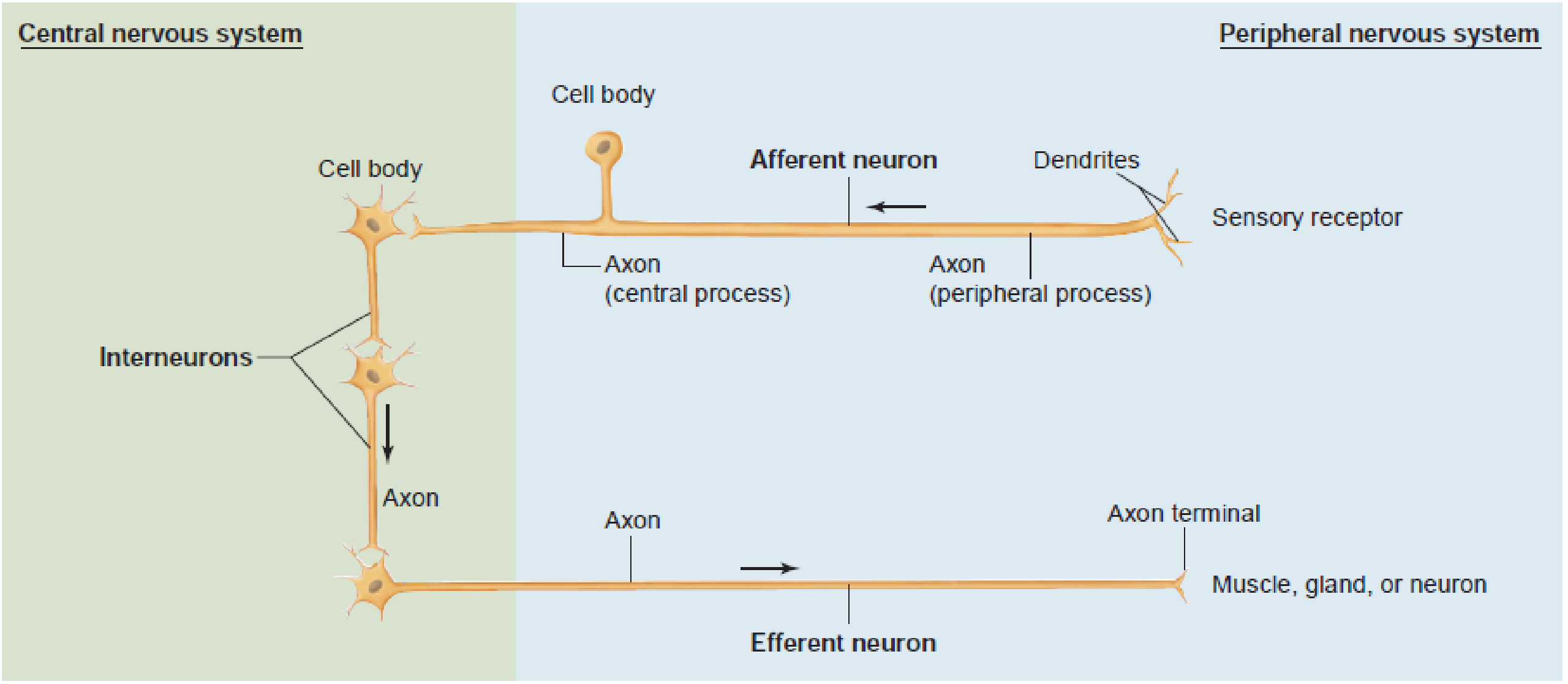
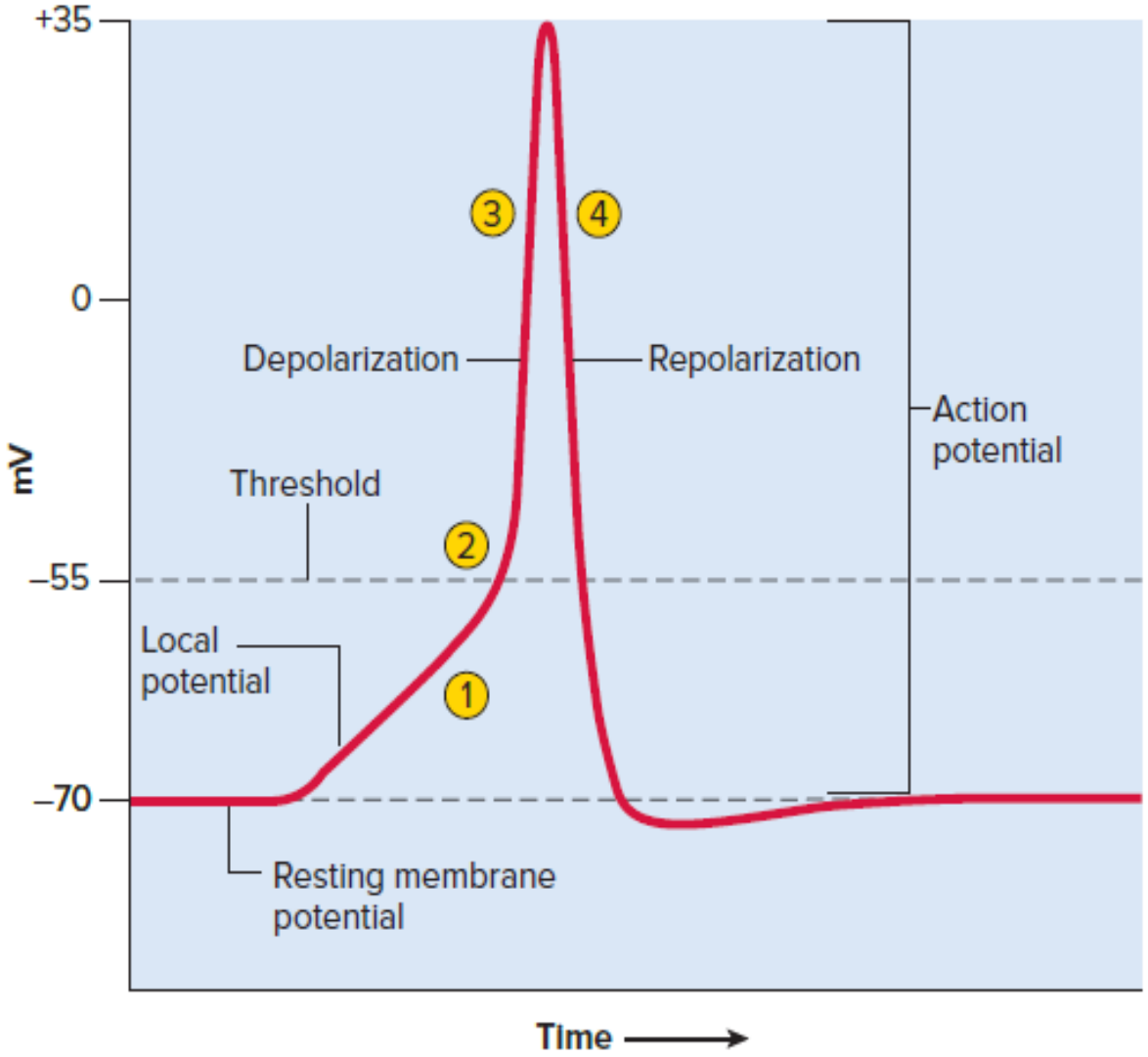



**Figure 13.1** Types of neurons. Afferent neurons, which transmit impulses toward the CNS, and efferent neurons, which transmit impulses away from the CNS, lie predominantly in the peripheral nervous system. Interneurons, which process sensory input and coordinate motor responses, lie entirely within the central nervous system.


Central nervous system
Peripheral nervous system
Cell body
Cell body
Afferent neuron
Dendrites
Sensory receptor
Axon
(central process)
Axon
(peripheral process)
Interneurons
Axon
Axon
Axon terminal
Muscle, gland, or neuron
Efferent neuron

# Generating an Action Potential




1. Stimulation of the neuron creates a gradually rising local potential.

2. If a threshold voltage is reached at the axon hillock, voltage-gated $Na^+$ channels open and initiate an action potential.

3. $Na^+$ inflow causes a rapidly rising voltage. $Na^+$ channels begin to close at 0 mV, but the voltage typically reaches about +35 mV by the time all of them close.

4. $K^+$ outflow causes the voltage to drop back into the negative range, slightly overshooting the original resting membrane potential (RMP).

# Conducting a Nerve Signal to Its Destination

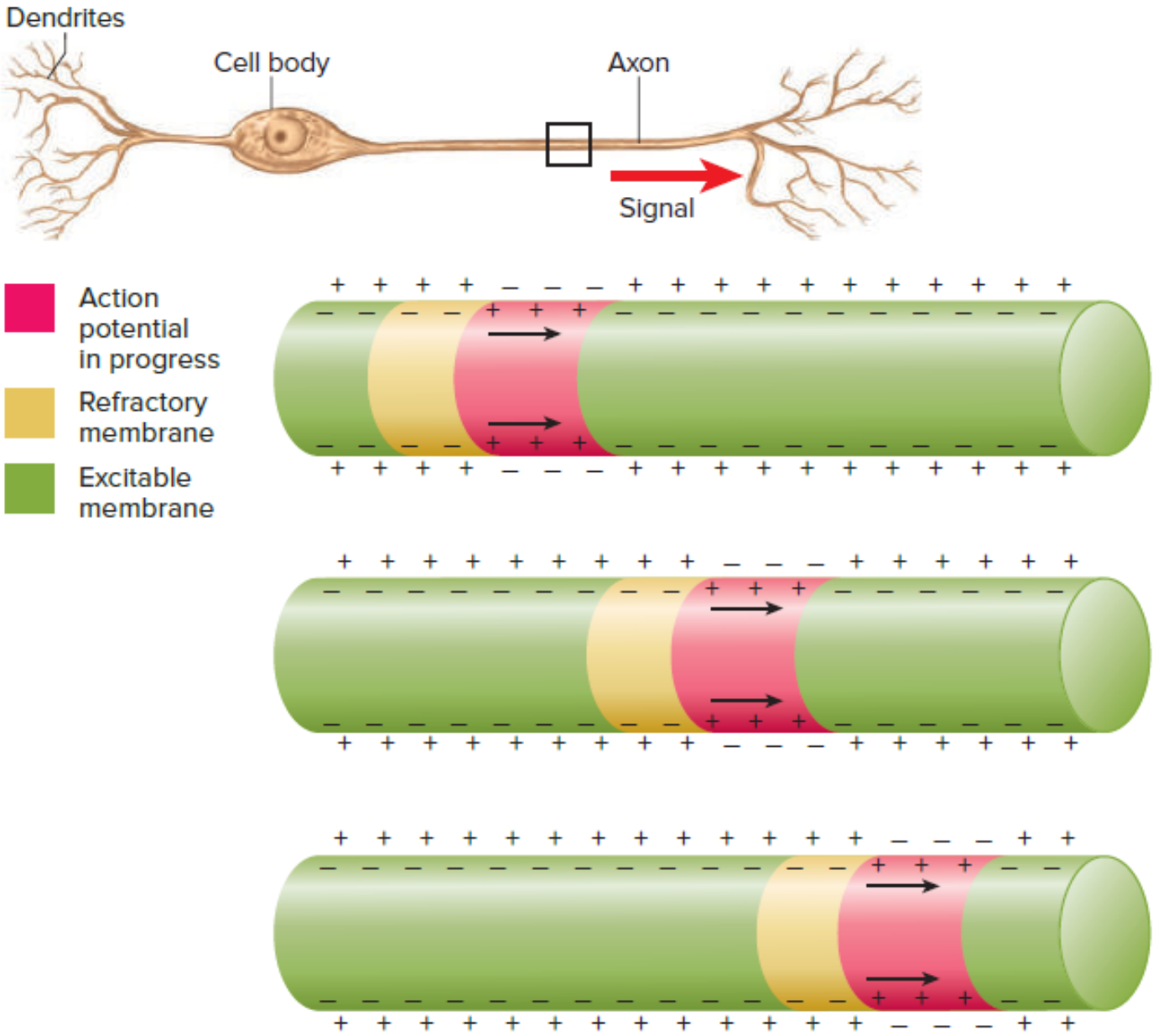


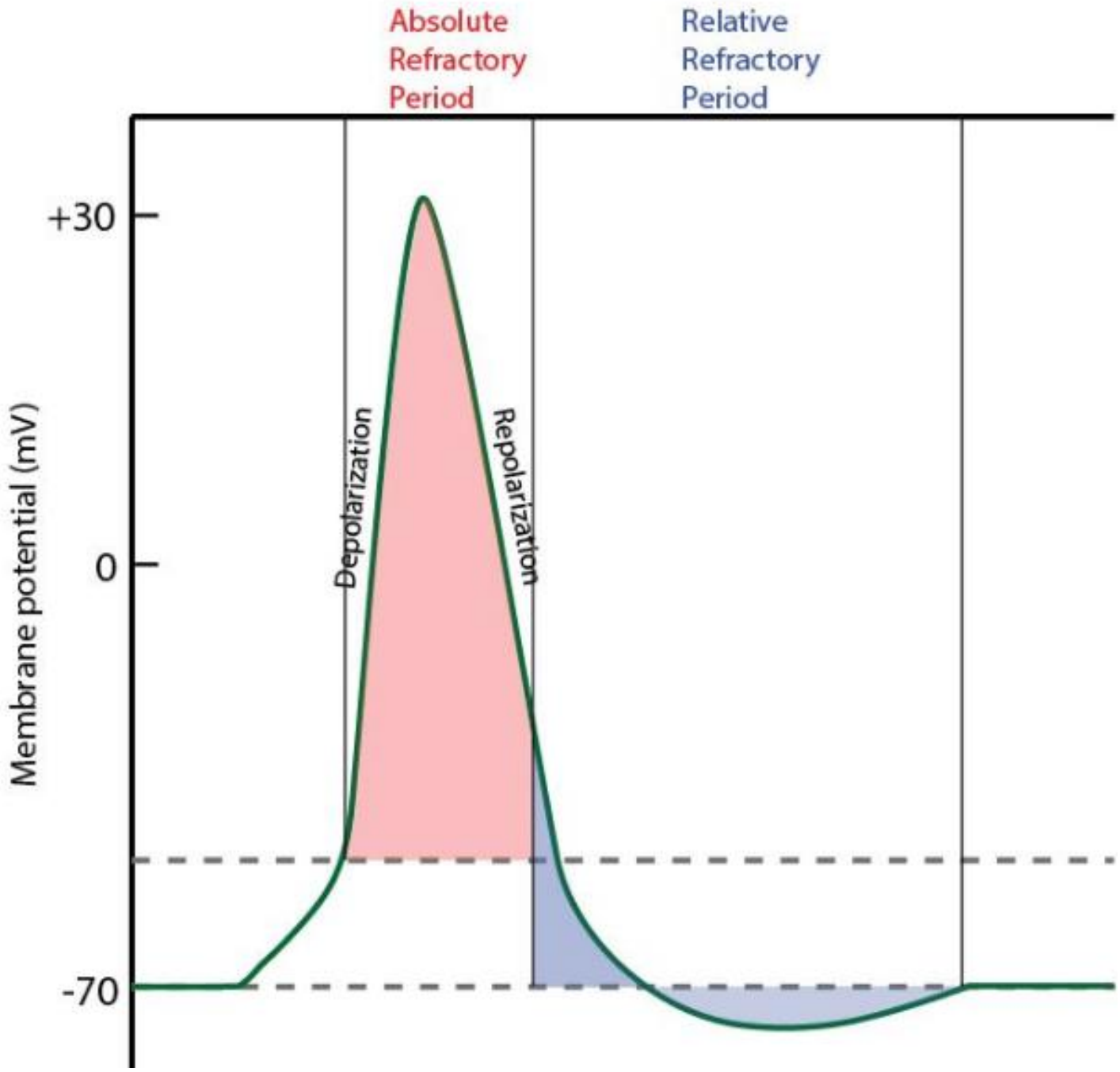

**Figure 8.10 Continuous Conduction of a Signal in an Unmyelinated Nerve Fiber.** Action potentials are occurring in areas colored red; note the reversal of membrane polarity in those areas. Yellow areas are in a refractory period of reduced excitability, and green areas of membrane are fully excitable, ready to respond. AP|R

❑**refractory period** is a period of time during which a cell is incapable of repeating an action potential.

❖**There are two types of refractory periods:**

➢the **absolute refractory period**, which corresponds to depolarization and repolarization, and the

➢**relative refractory period**, which corresponds to hyperpolarization.


Absolute
Refractory
Period
Relative
Refractory
Period
+30
0
-70
Membrane potential (mV)
Depolarization
Repolarization

- **Moreover,** the **absolute refractory period** is the interval of time during which a **second action potential** cannot be initiated, **no matter** how large a stimulus is repeatedly applied.

- **The relative refractory period** is the interval of time during which **a second action potential** can be initiated, **but initiation** will require a greater stimulus than before.

## ❖NOTE

- Refractory periods are caused by the inactivation gate of the $Na^+$ channel.
- Once inactivated, the $Na^+$ channel cannot respond to another stimulus **until** the gates are reset.

# Transmitting a Nerve Signal to the Next Cell

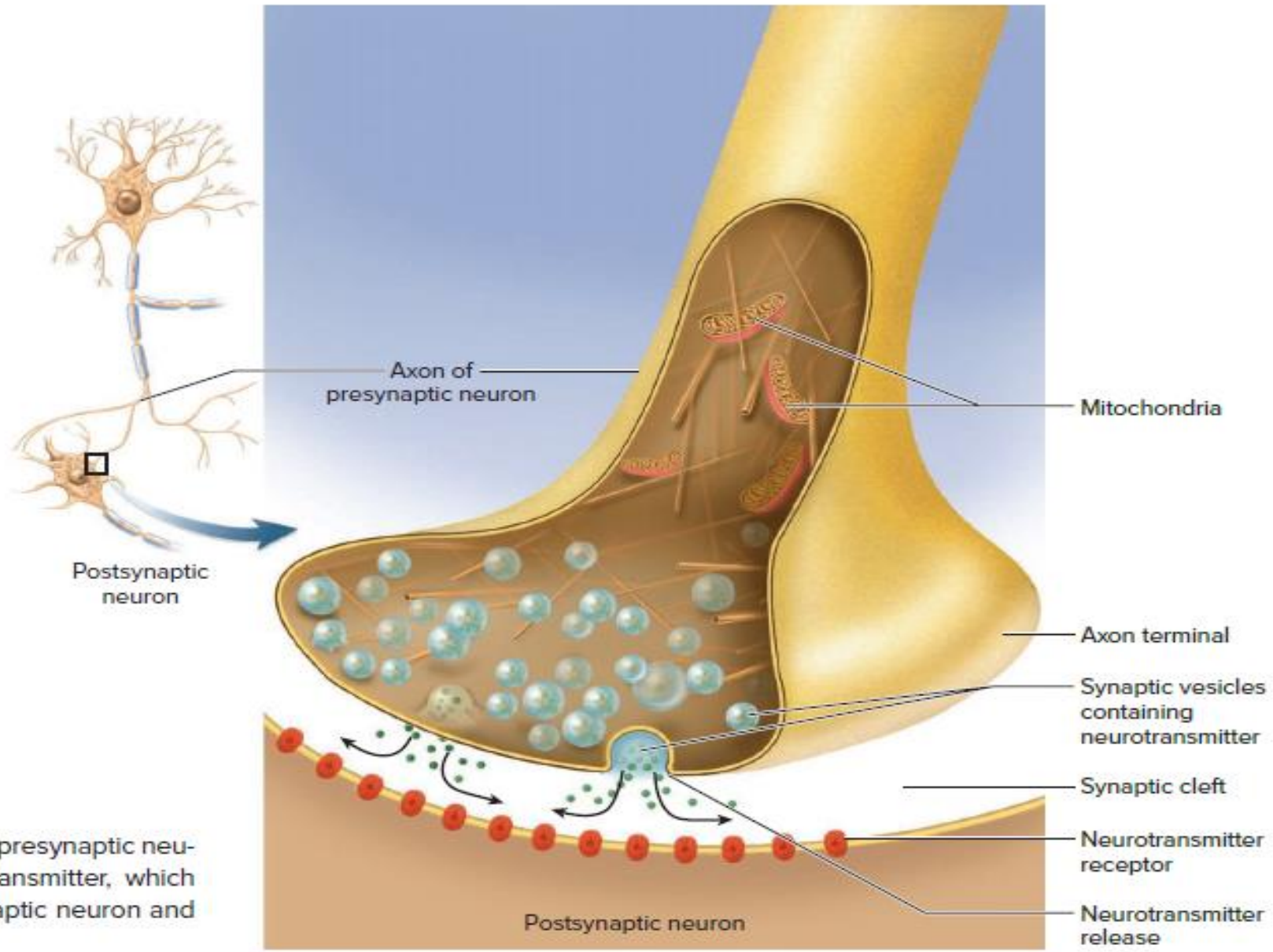


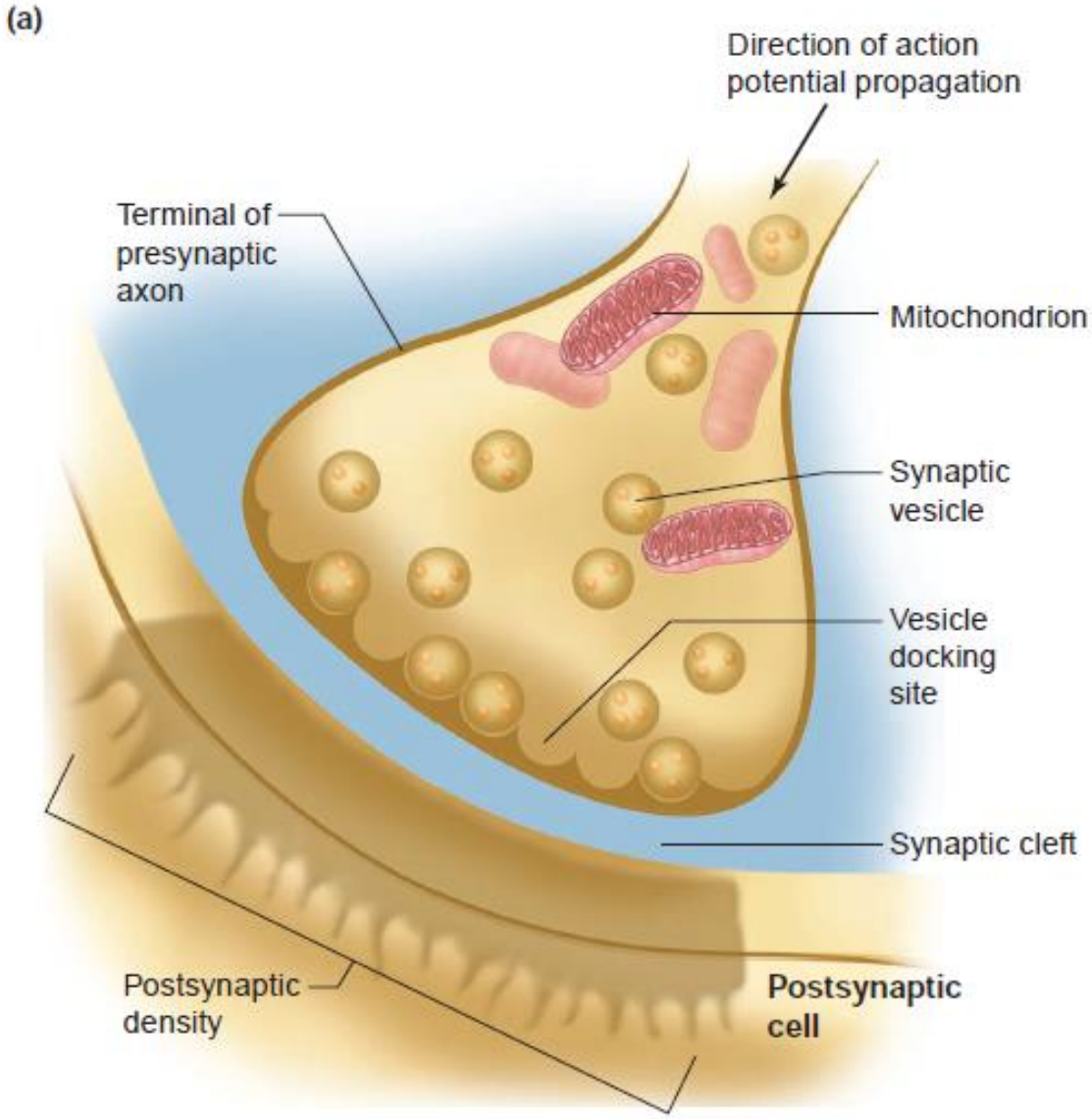

**Figure 8.12 The Synapse.** The presynaptic neuron is shown releasing a neurotransmitter, which binds to receptors on the postsynaptic neuron and may excite the latter cell. AP R

- **Synapses** is an anatomically specialized junction between **two** neurons
- at which the electrical activity in a presynaptic neuron **influences the** electrical activity of a postsynaptic neuron.

## ❑There are two types of synapses:

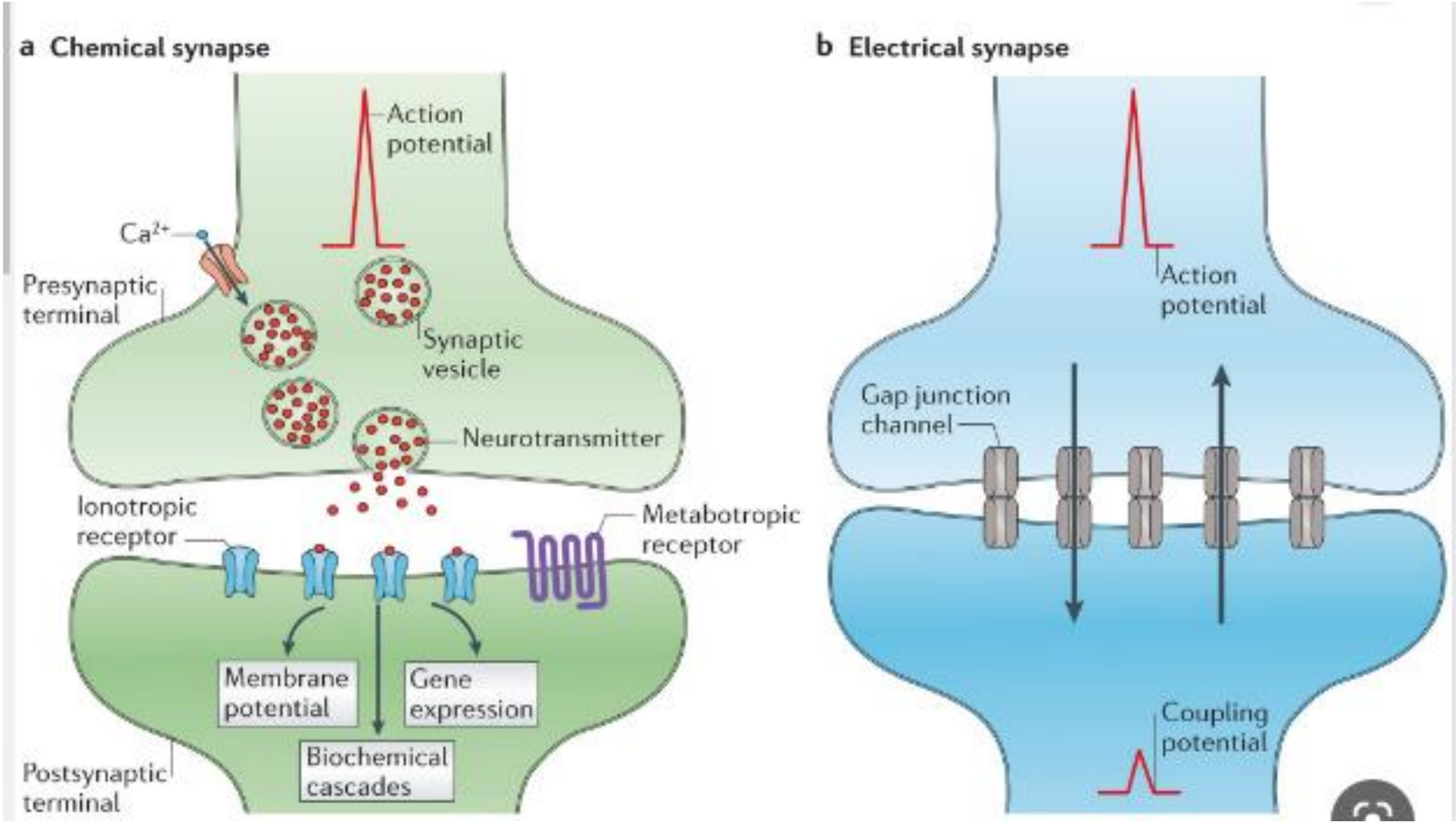
➢**electrical synapses** and

➢**Chemical synapses**.(by neurotransmitters)



- At **electrical synapses** , the plasma membranes of the *presynaptic* and *postsynaptic* cells are **joined by** gap junctions.

- These allow the local currents resulting from arriving action potentials to flow directly across the junction through the connecting channels from one neuron to the other.

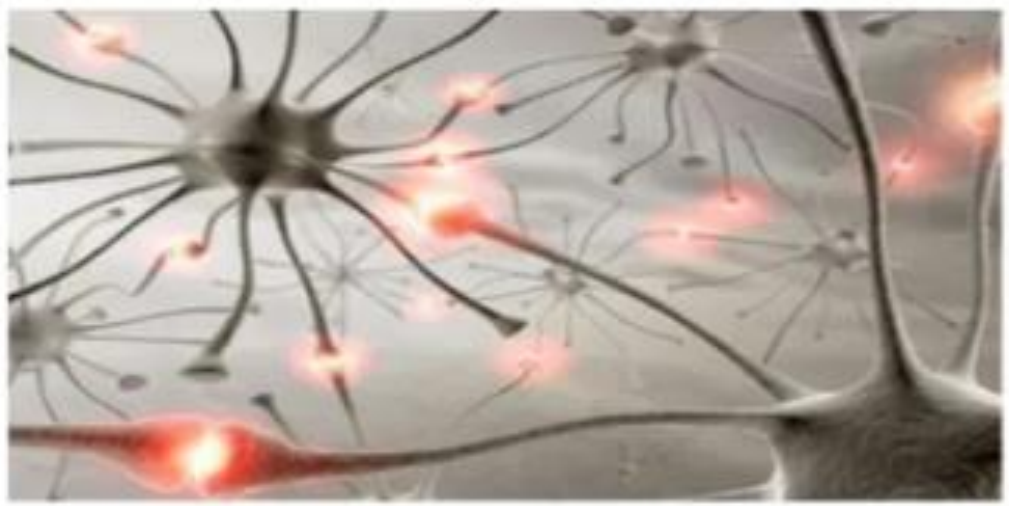

a Chemical synapse
Action potential
$Ca^{2+}$
Presynaptic terminal
Synaptic vesicle
Neurotransmitter
Ionotropic receptor
Metabotropic receptor
Membrane potential
Gene expression
Biochemical cascades
Postsynaptic terminal
b Electrical synapse
Action potential
Gap junction channel
Coupling potential

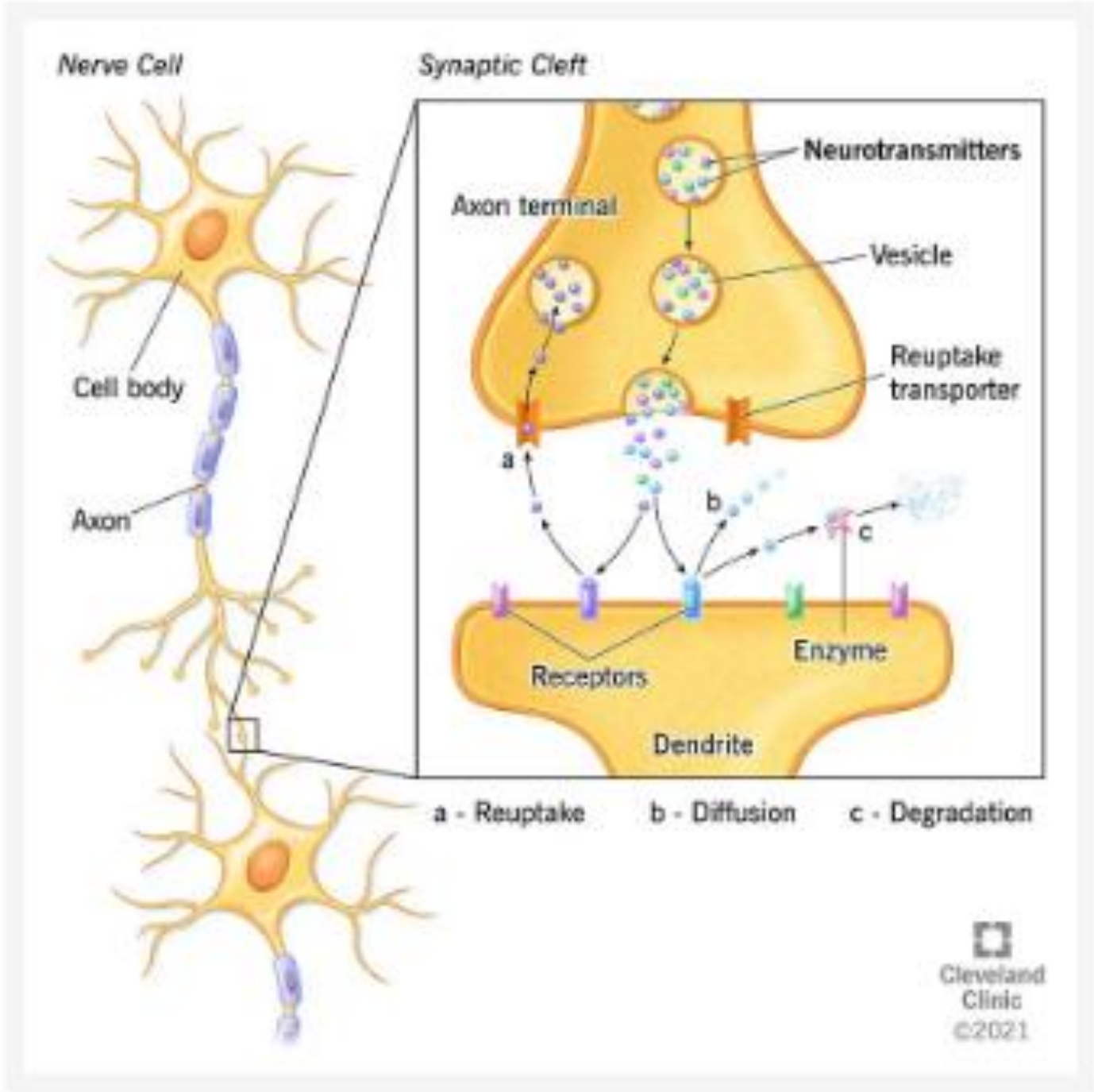
- **Neurotransmitters** are chemical messengers that transmit signals from a neuron to a target cell across a **synapse**.

- Target cell may be a neuron or some other kind of cell like a muscle or gland cell.

- Necessary for rapid communication in synapse.

- Neurotransmitters are packaged into **synaptic vesicles** - presynaptic side of a synapse.




Nerve Cell
Synaptic Cleft
Cell body
Axon
Axon terminal
Neurotransmitters
Vesicle
Reuptake transporter
a
b
c
Receptors
Enzyme
Dendrite
a - Reuptake
b - Diffusion
c - Degradation
Cleveland Clinic
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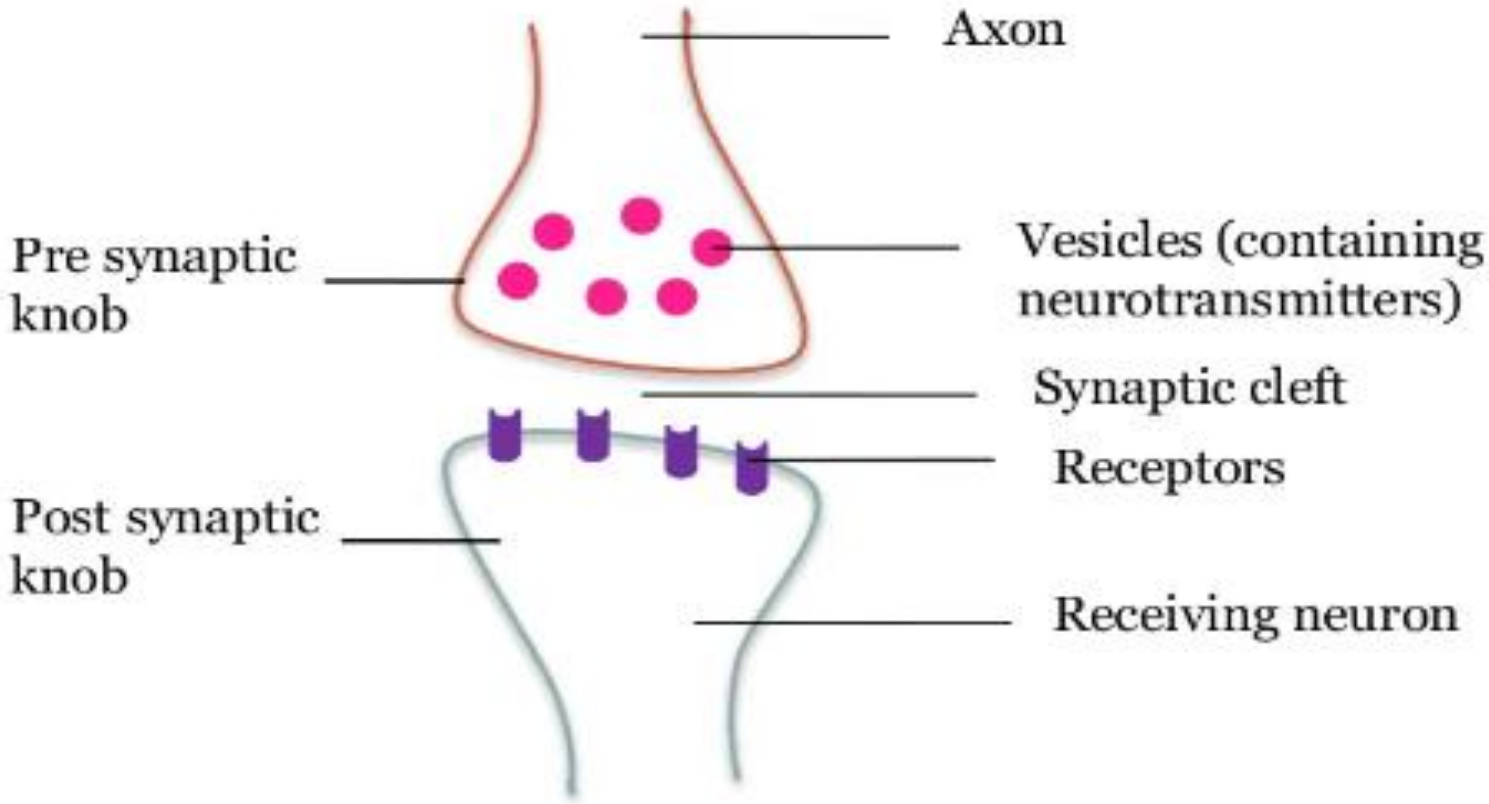
# *A schematic representation of a chemical synapse*



# PROPERTIES OF NEUROTRANSMITTERS

1) Synthesized in the presynaptic neuron

2) Localized to vesicles in the presynaptic neuron

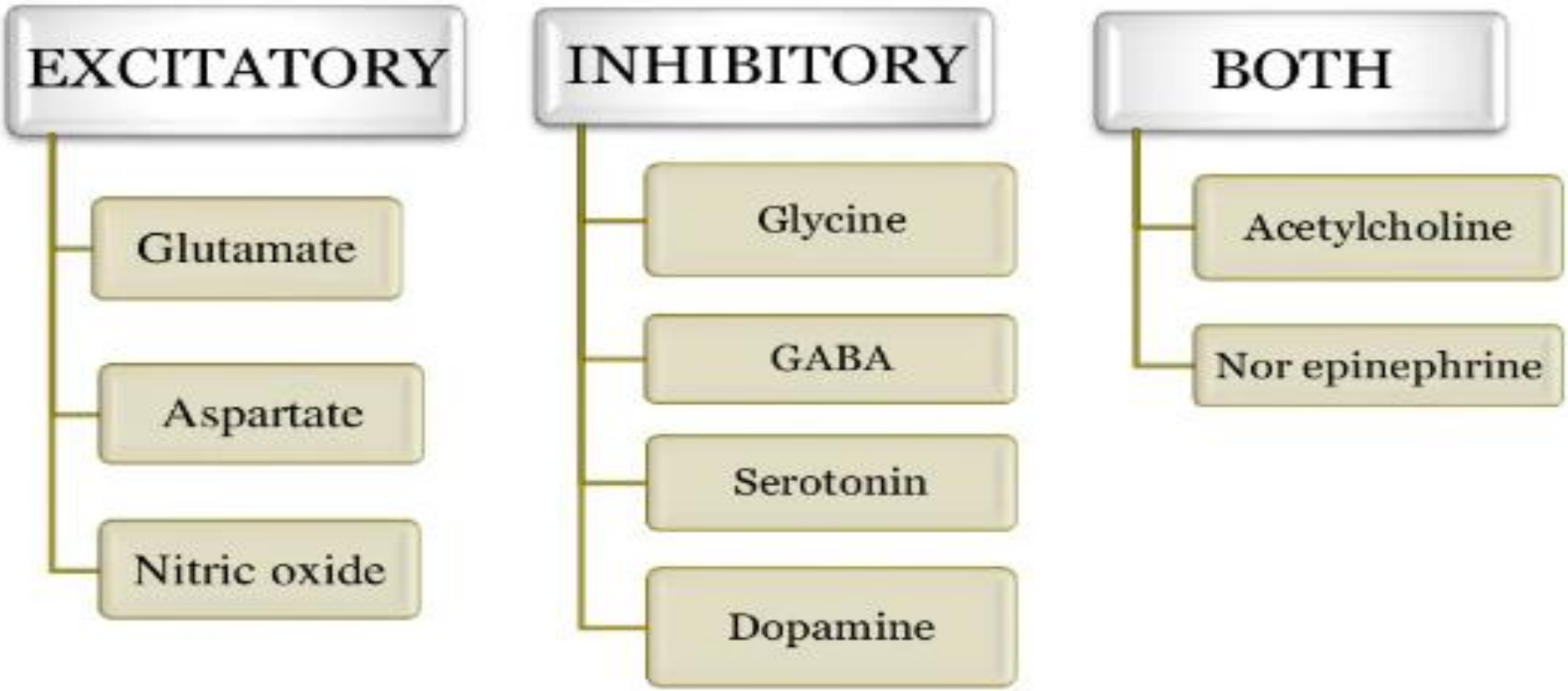
3) Released from the presynaptic neuron under physiological condition

4) Rapidly removed from the synaptic cleft by uptake or degradation

5) Presence of receptor on the post-synaptic neuron.

6) Binding to the receptor elicits a biological response

# TYPES OF NEUROTRANSMITTERS



# MODE OF ACTION

## ► Seven Processes in Neurotransmitter Action

1.Neurotransmitters are synthesized from precursors under the influence of enzymes

2. Stored in vesicles

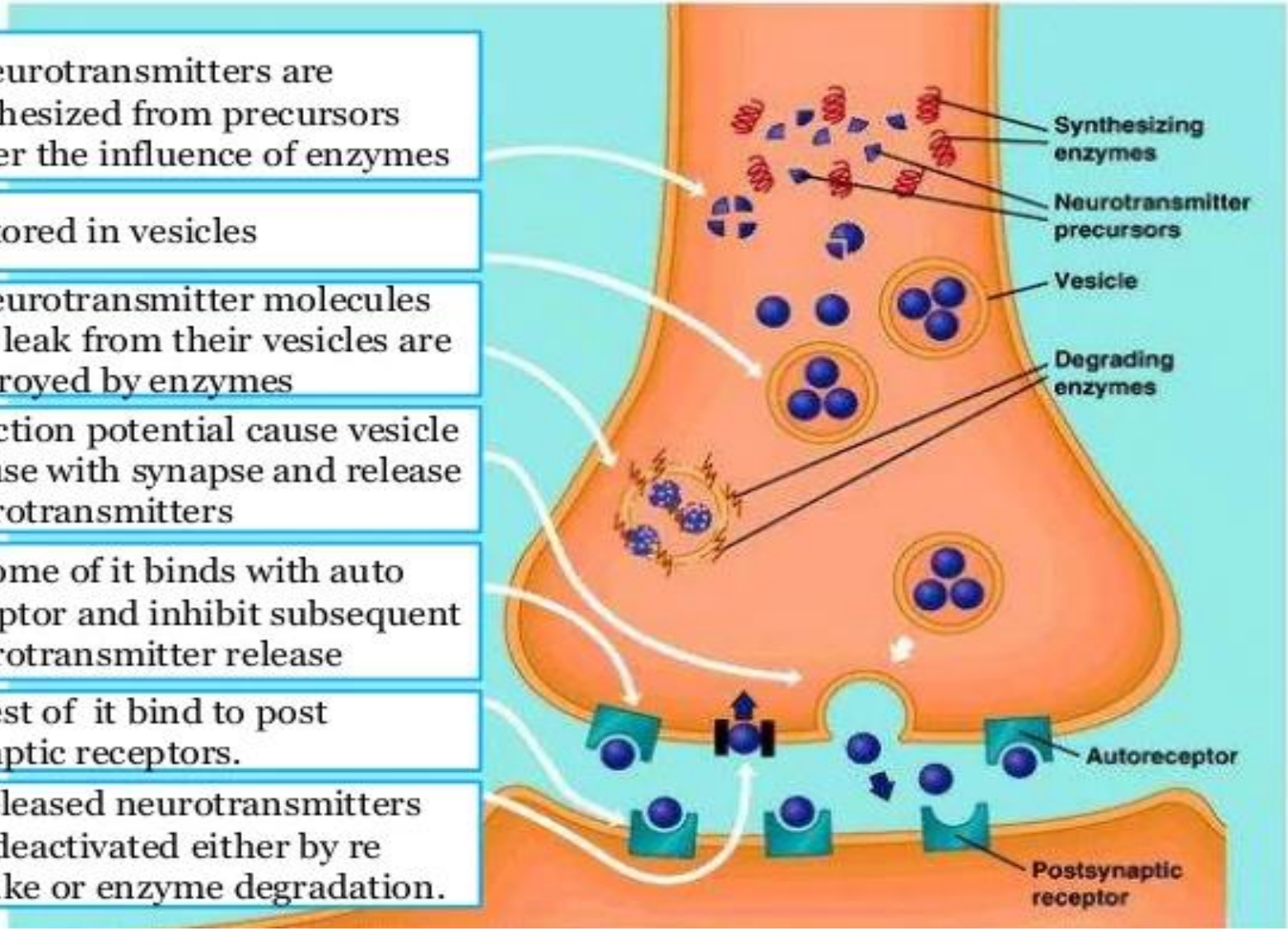
3.Neurotransmitter molecules that leak from their vesicles are destroyed by enzymes

4. Action potential cause vesicle to fuse with synapse and release neurotransmitters

5. Some of it binds with auto receptor and inhibit subsequent neurotransmitter release

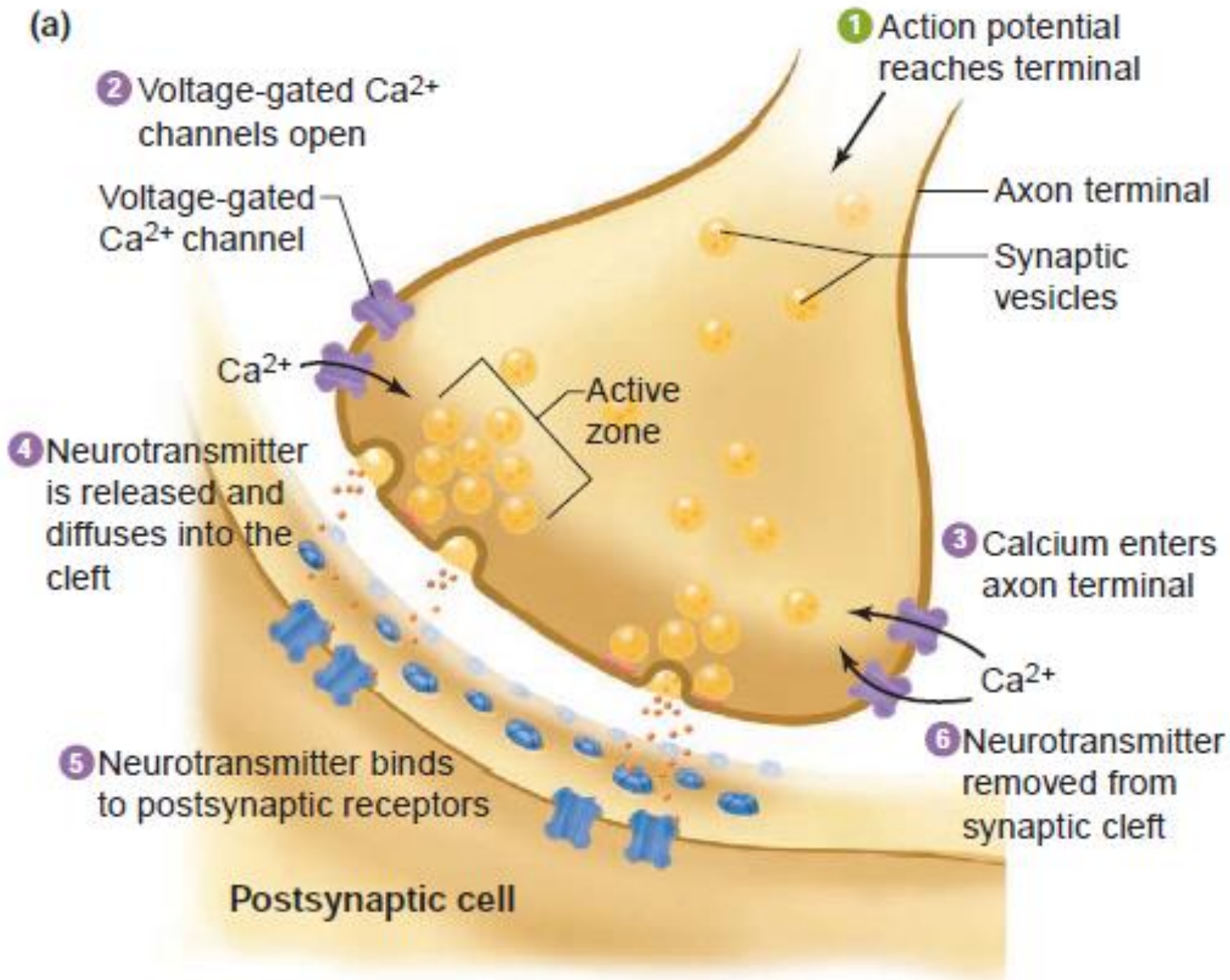
6.Rest of it bind to post synaptic receptors.

7.Released neurotransmitters are deactivated either by re uptake or enzyme degradation.



# Mechanism by Which an Action Potential Causes Transmitter Release from the Presynaptic Terminals—Role of Calcium Ions

- ***presynaptic membrane*** contains large numbers of ***voltage-gated calcium channels***.
- When an **action potential depolarizes** the presynaptic membrane, these calcium channels open and allow large numbers of calcium ions to flow into the terminal.
- The quantity of **neurotransmitter** that is then released from the terminal into the synaptic cleft is **directly** related to the number of **calcium ions** that enter.


(a)
1 Action potential reaches terminal
2 Voltage-gated $Ca^{2+}$ channels open
Voltage-gated $Ca^{2+}$ channel
Axon terminal
Synaptic vesicles
$Ca^{2+}$
Active zone
4 Neurotransmitter is released and diffuses into the cleft
3 Calcium enters axon terminal
$Ca^{2+}$
6 Neurotransmitter removed from synaptic cleft
5 Neurotransmitter binds to postsynaptic receptors
Postsynaptic cell

# Action of the Transmitter Substance on the Postsynaptic Neuron—Function of "Receptor Proteins"

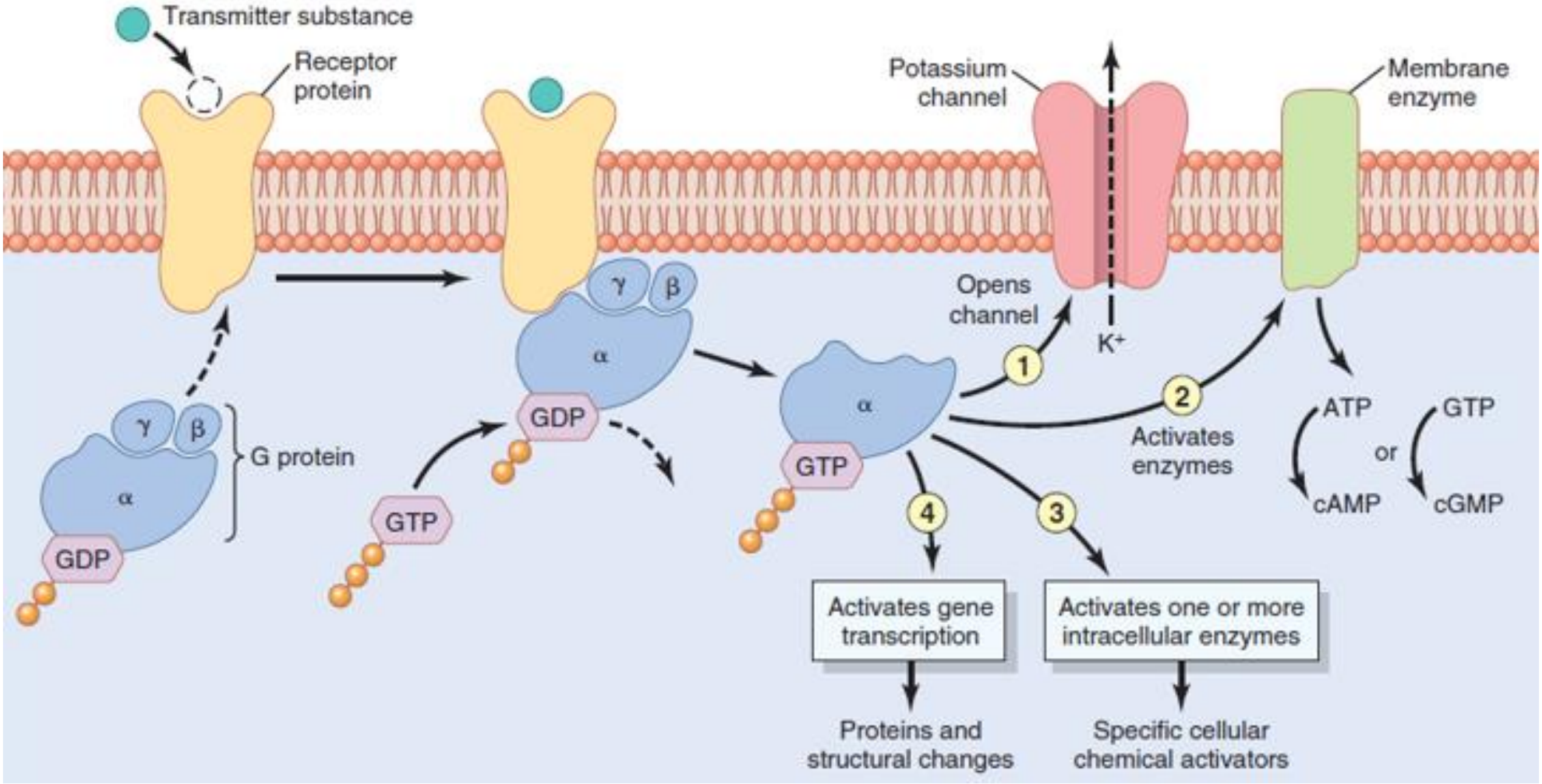
❖The membrane of the **postsynaptic neuron** contains large numbers of ***receptor proteins.***

❑**The molecules of these receptors have two important components:**

- **(1)** a ***binding component.***
- **(2) an *intracellular component.***

❑**Receptor activation controls the *opening of ion channels* in the postsynaptic cell in one of two ways:**

- **(1)** by ***gating ion channels directly*** and **allowing passage of specified types of ions through the membrane**
- **(2)** by ". The **second messengers** that **increase** or **decrease specific cellular functions**.


Transmitter substance
Receptor protein
Potassium channel
Membrane enzyme
Opens channel
K+
γ
β
α
GDP
G protein
GTP
1
2
Activates enzymes
ATP
GTP
or
cAMP
cGMP
4
3
Activates gene transcription
Activates one or more intracellular enzymes
Proteins and structural changes
Specific cellular chemical activators

- **NOTE**

- Neurotransmitter receptors that directly **gate ion channels** are often **called ionotropic receptors**,

- whereas those that act through **second messenger** systems are **called metabotropic receptors**.


Thank
You