

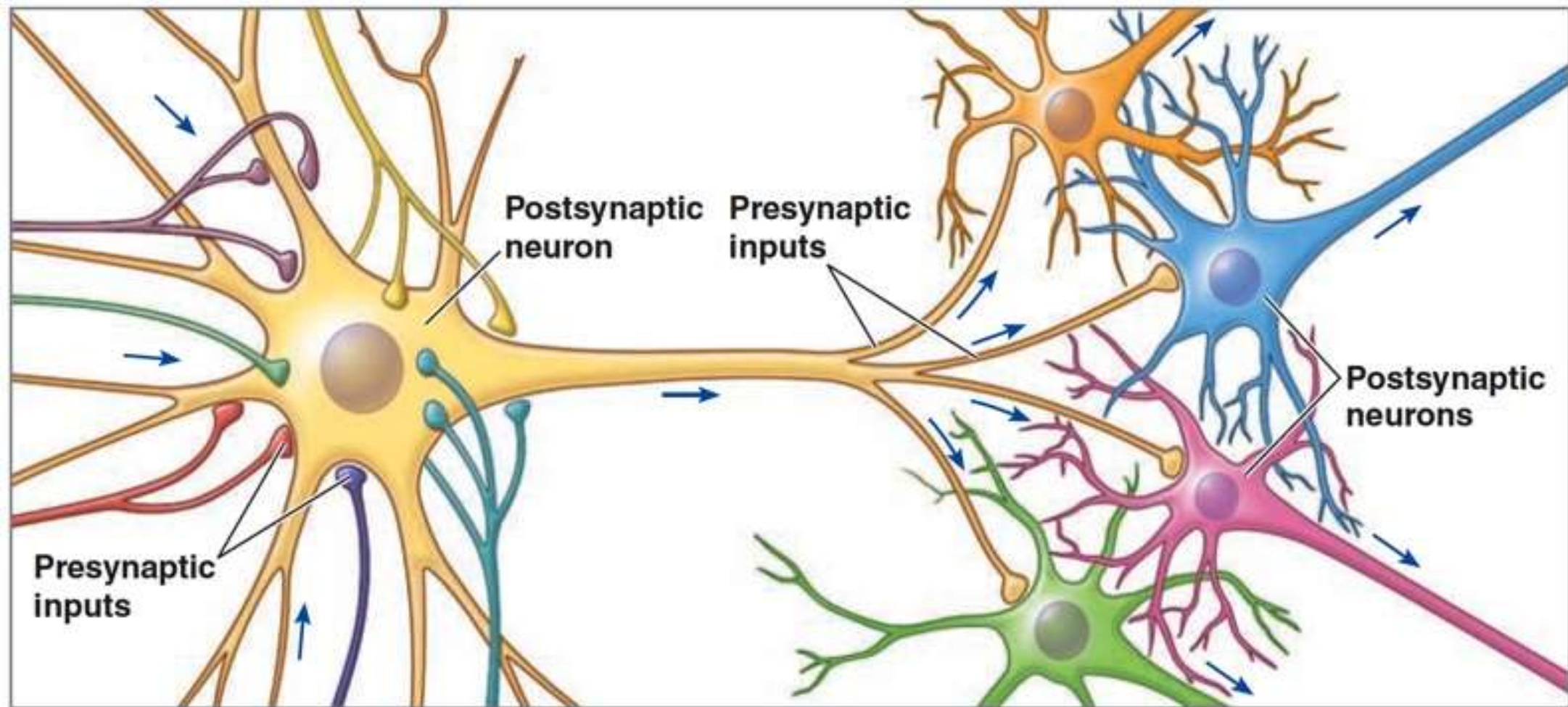
# Introduction to Neurophysiology 2

## Synapses

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# Synapses

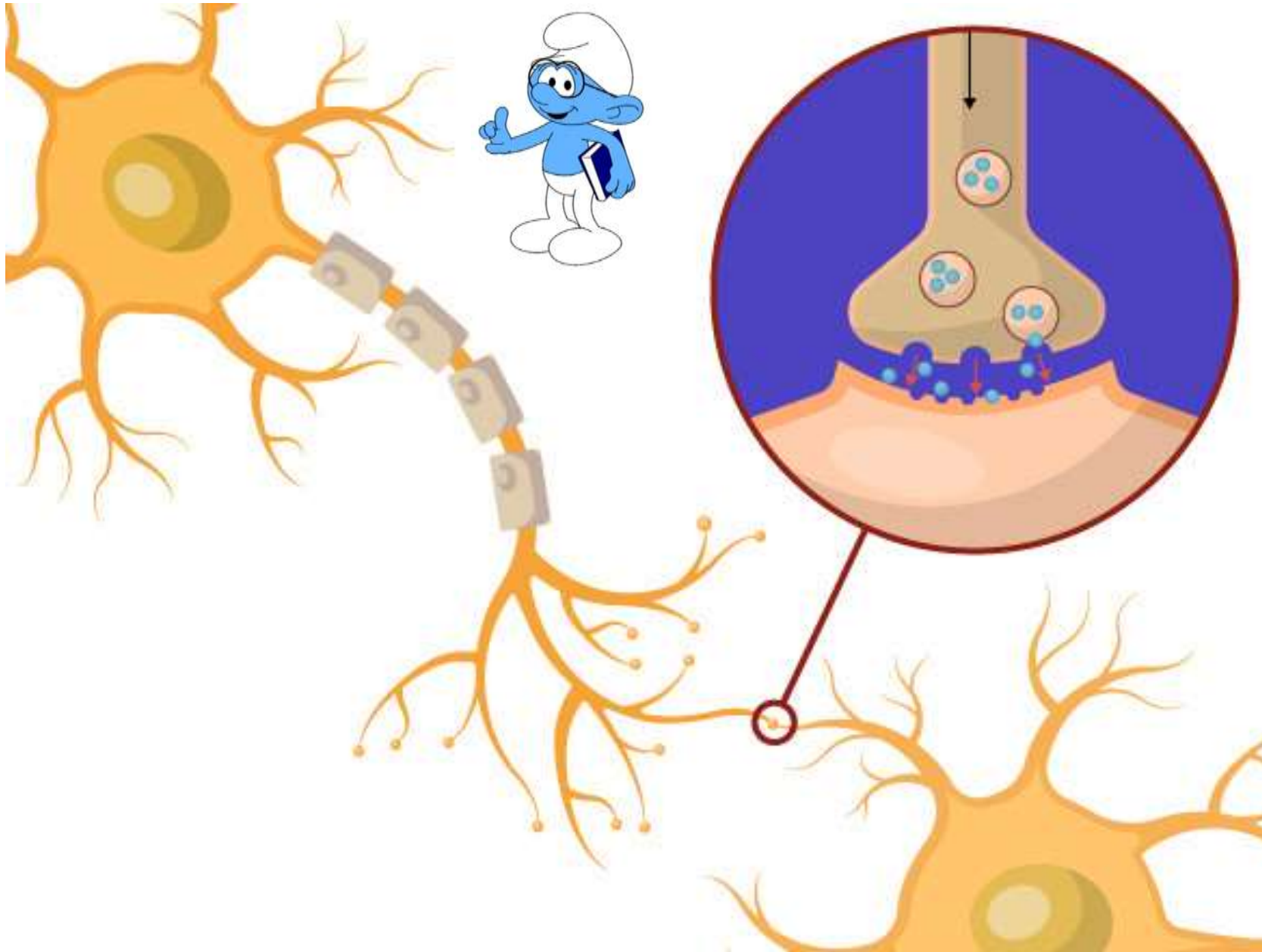
- The synapse is a region where communication occurs between two neurons or between a neuron and an effector cell (muscle cell or glandular cell).

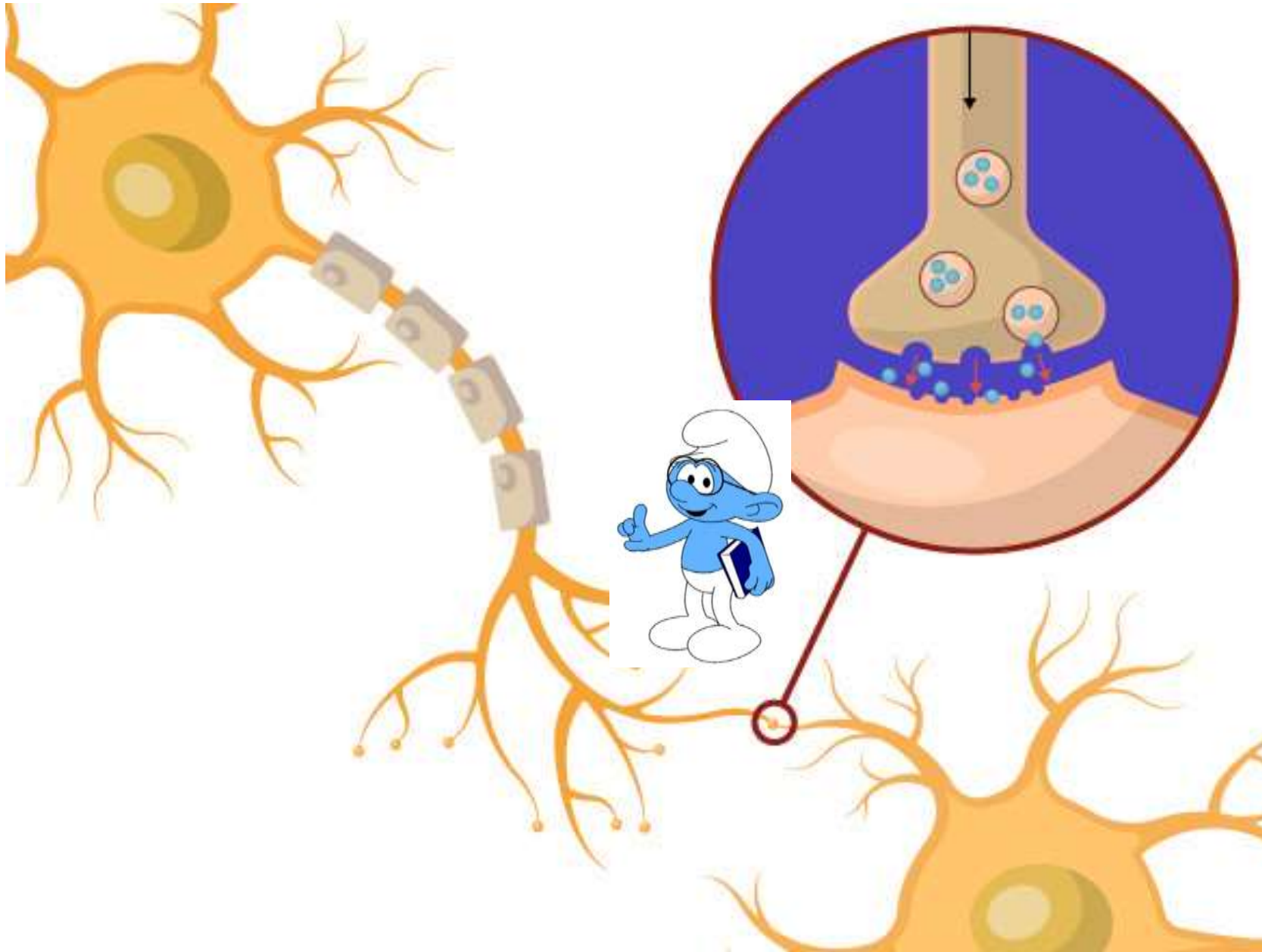
# Synaptic functions of neurons

Information is transmitted in the nervous system mainly in the form of nerve action potentials, called nerve impulses, through a succession of neurons, one after another.

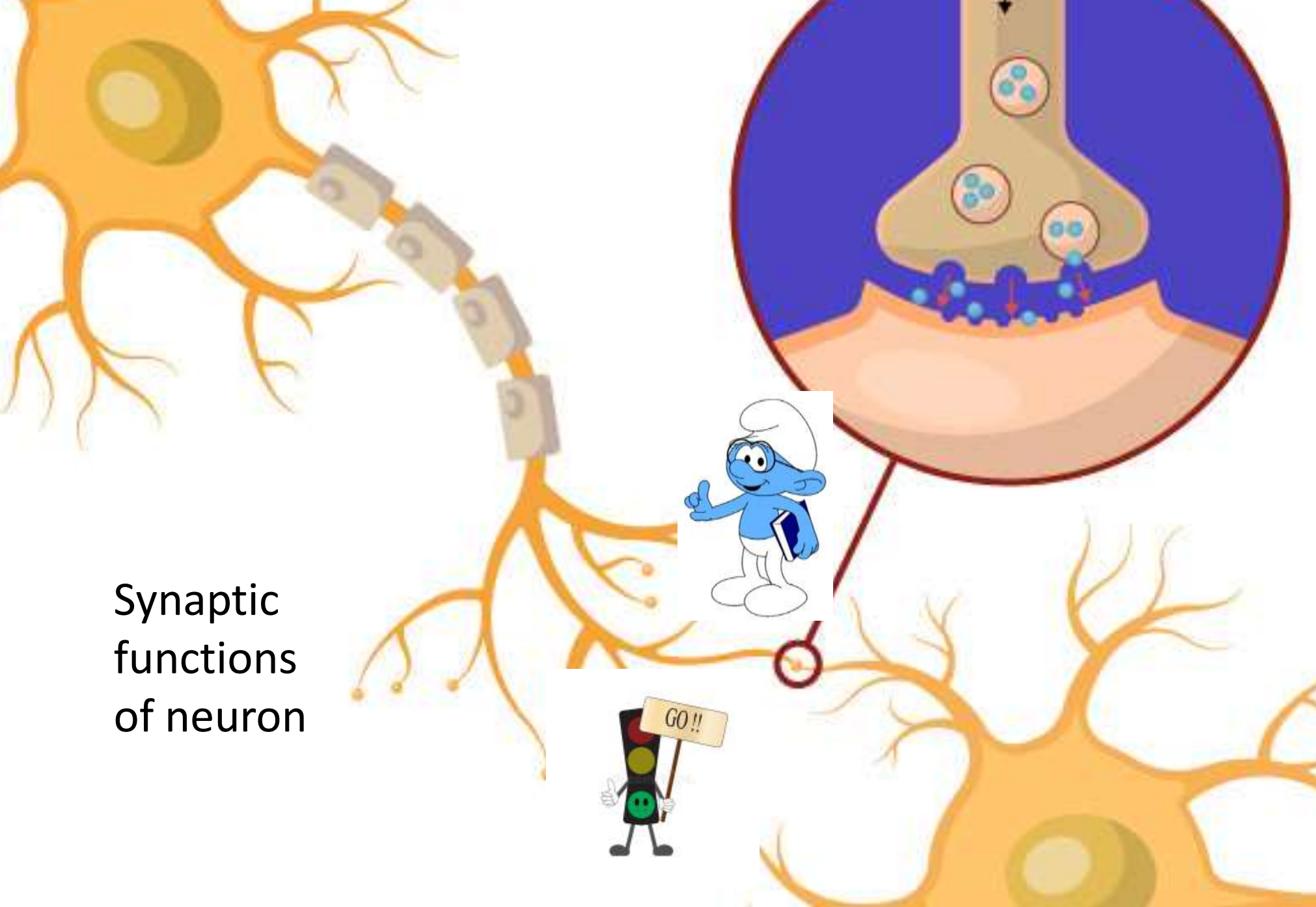
However, this impulse may be blocked, changed into repetitive impulses, or integrated with other impulses.

These functions are called **synaptic functions of neurons**.

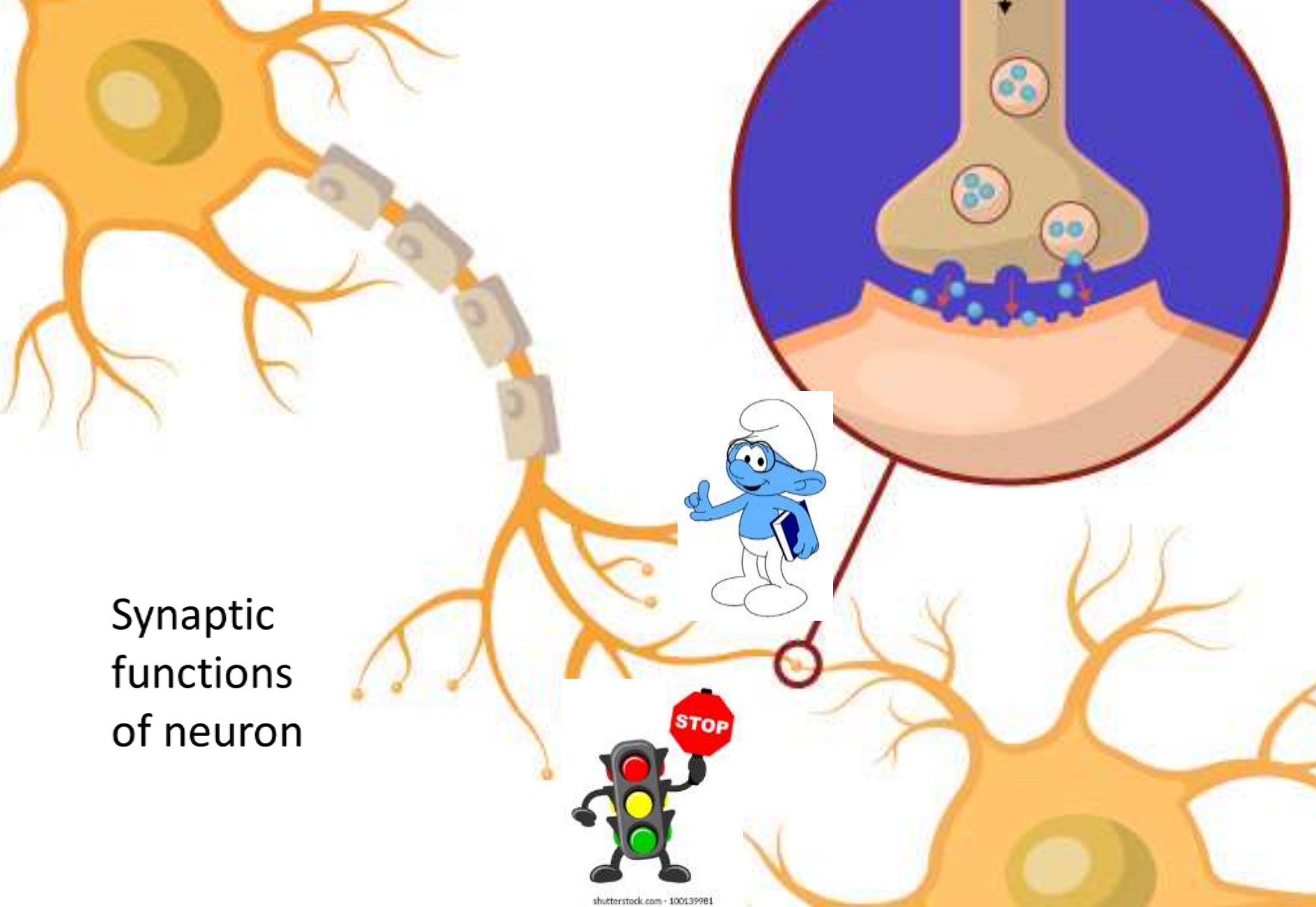




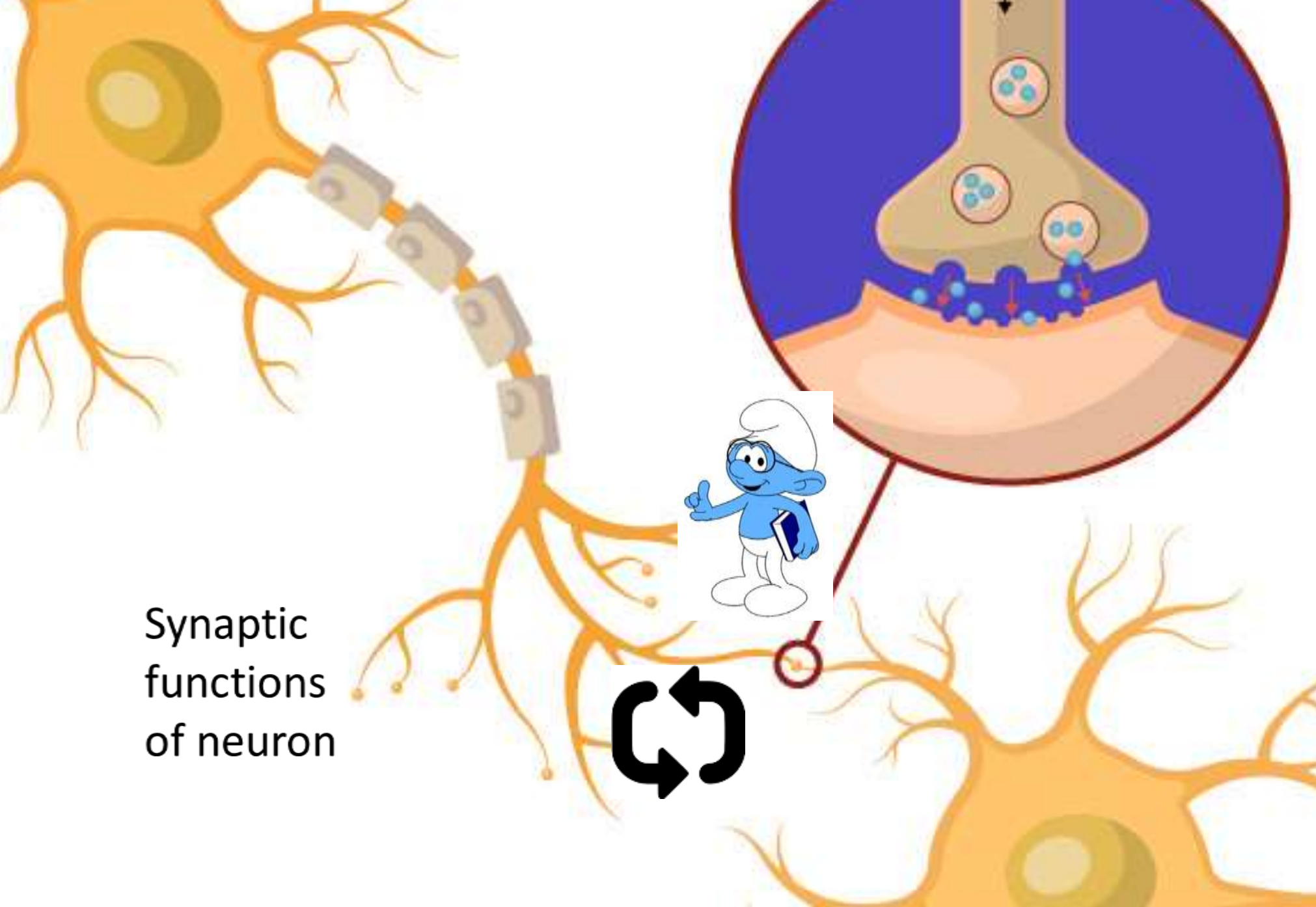
# Synaptic functions of neuron



# Synaptic functions of neuron



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Synaptic  
functions  
of neuron

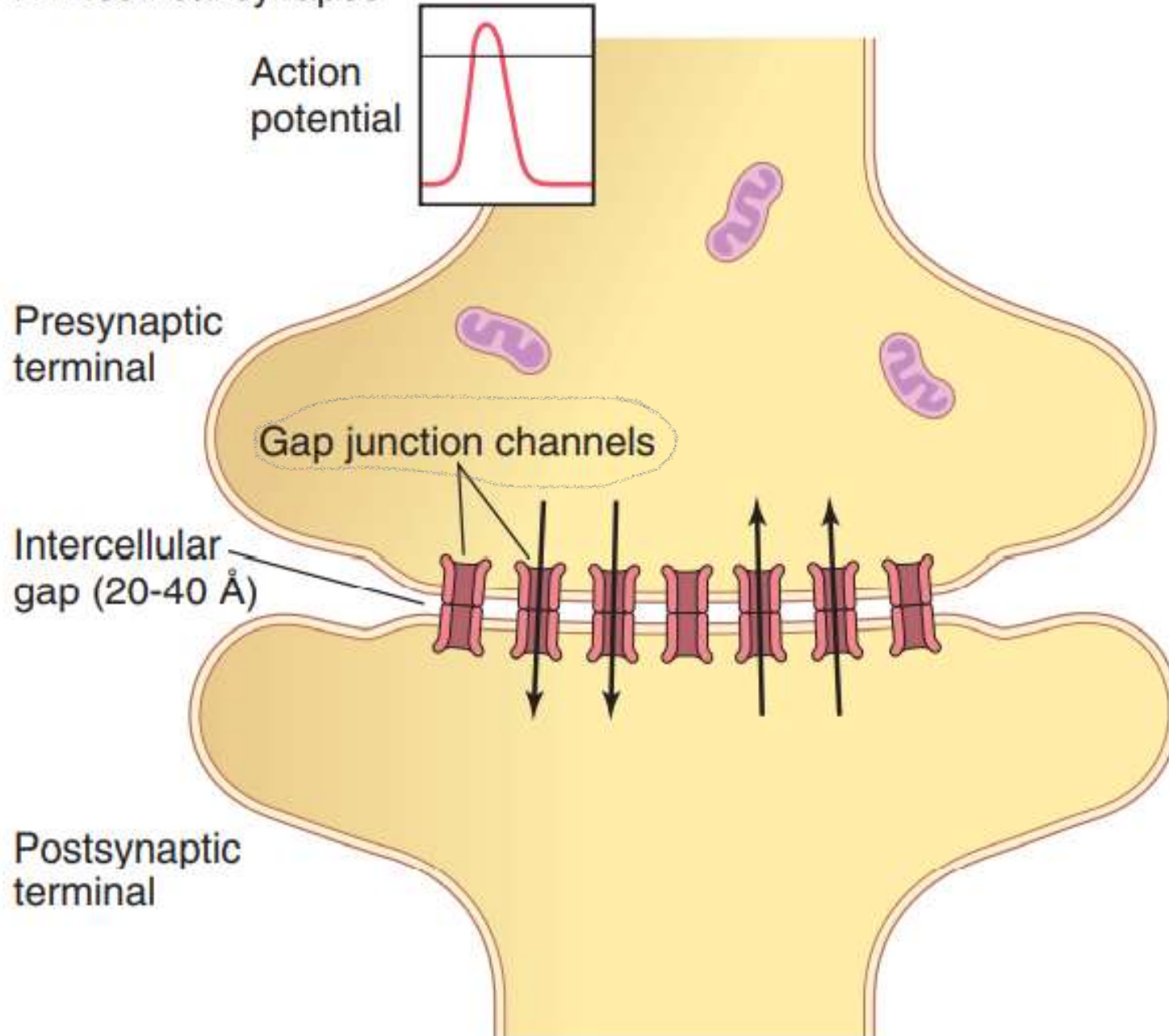
# Types of Synapses

- Chemical synapses.

- Electrical synapses.



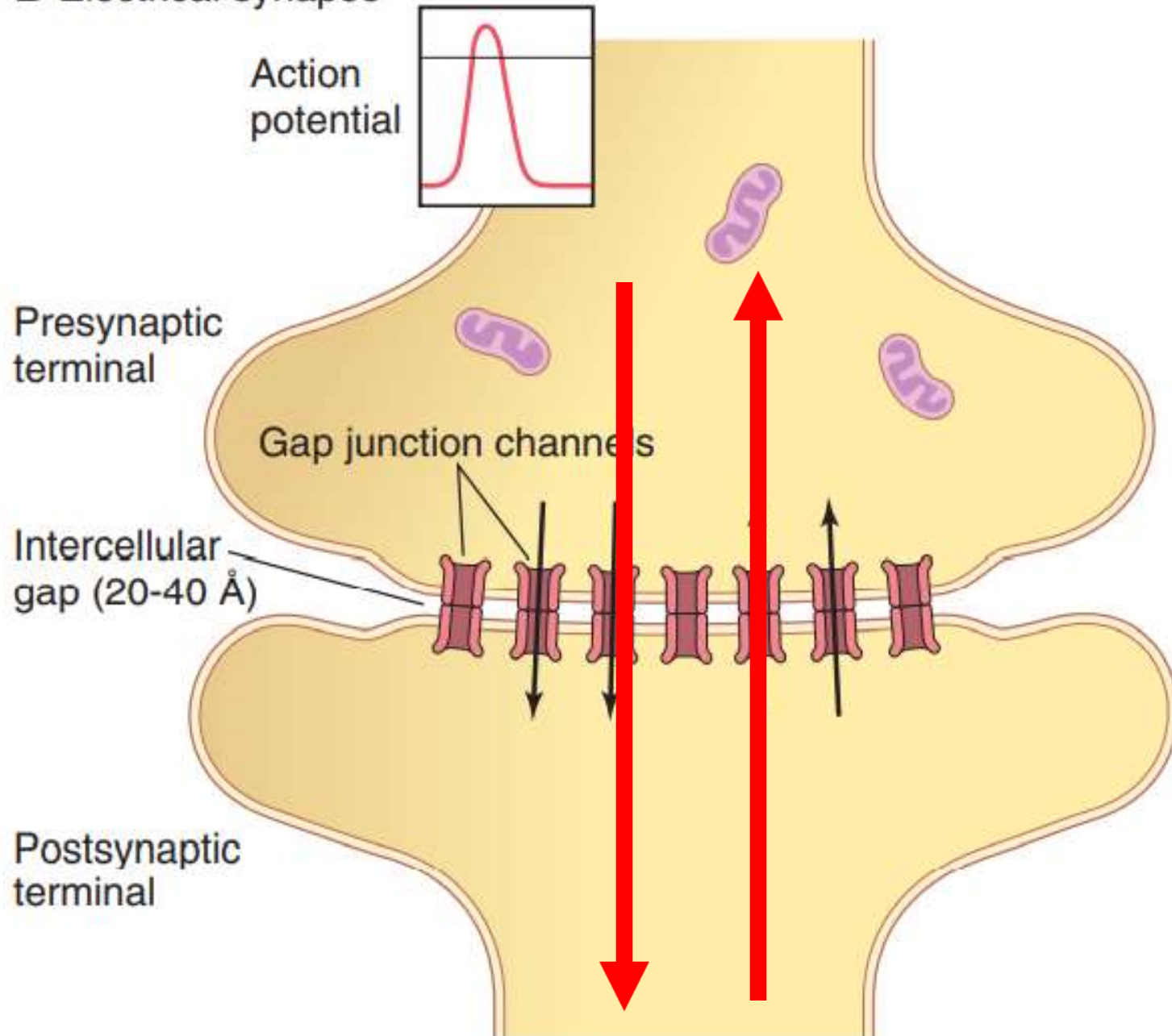
## B Electrical synapse



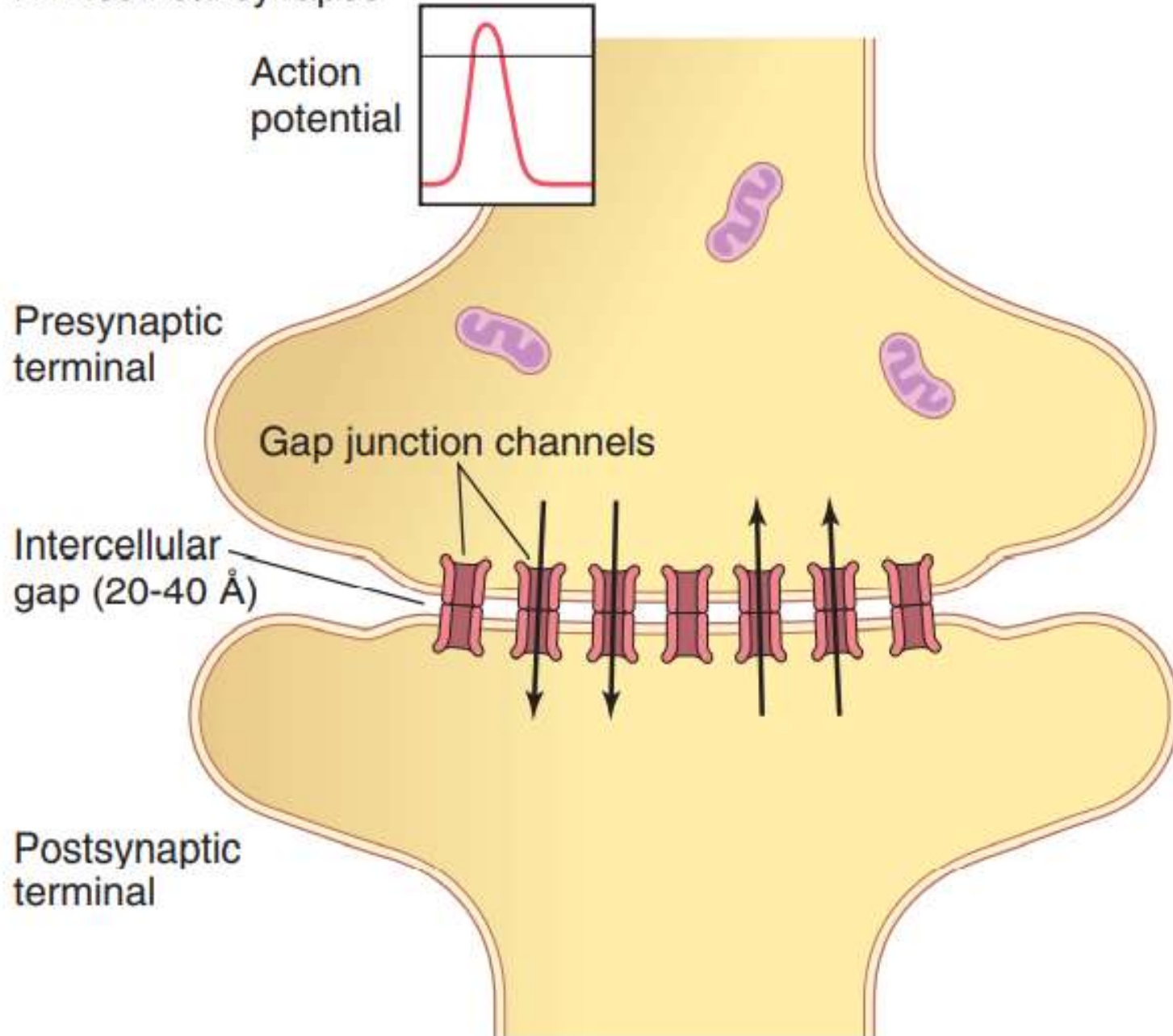
Cytoplasms are directly connected by gap junctions



## B Electrical synapse



B Electrical synapse



**FAST**

**Synchronization**



# Electrical Synapses

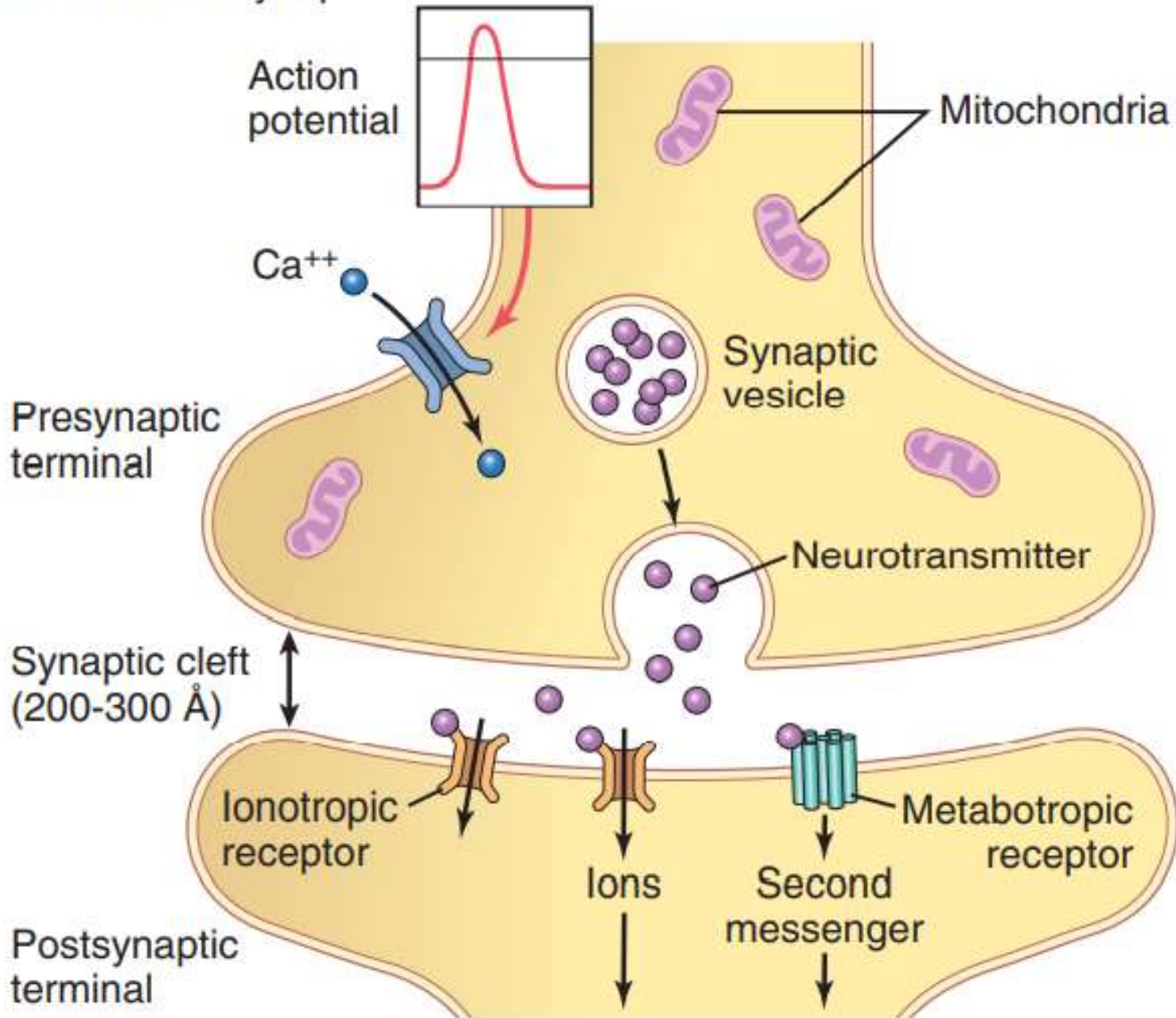
- The **cytoplasms of adjacent cells are directly connected by gap junctions** that allow free movement of ions between cells.
- Similar to the ones in smooth muscles and cardiac muscles.

# Bidirectional transmission of electrical synapses

Two main advantages:

- **1. Faster communication.** Because action potentials conduct directly through gap junctions, electrical synapses are faster than chemical synapses.
- **2. Synchronization.** Electrical synapses can synchronize (coordinate) the activity of a group of neurons or muscle fibers. As well as increasing neuronal sensitivity of connected neurons.

# A Chemical synapse



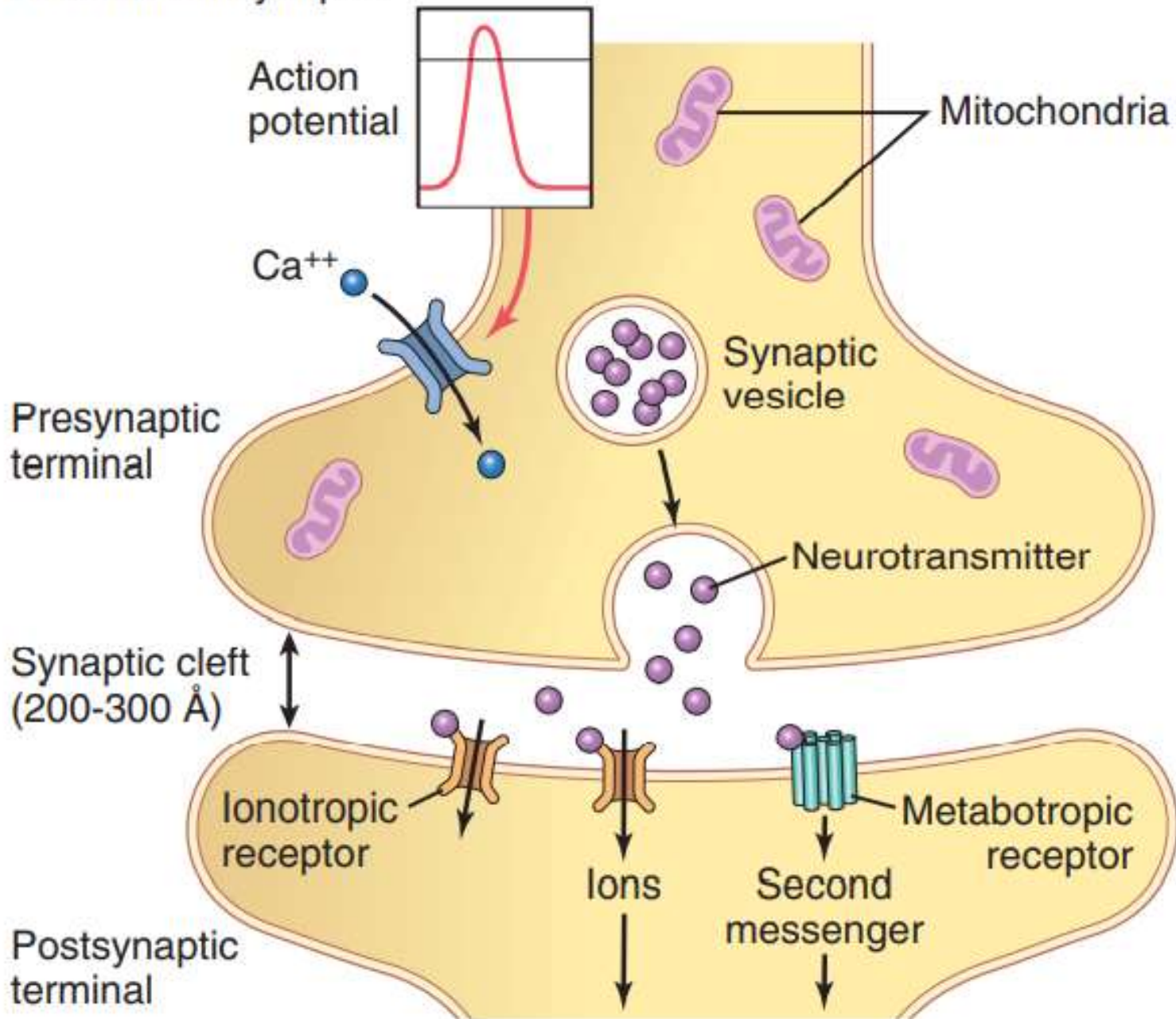
More common



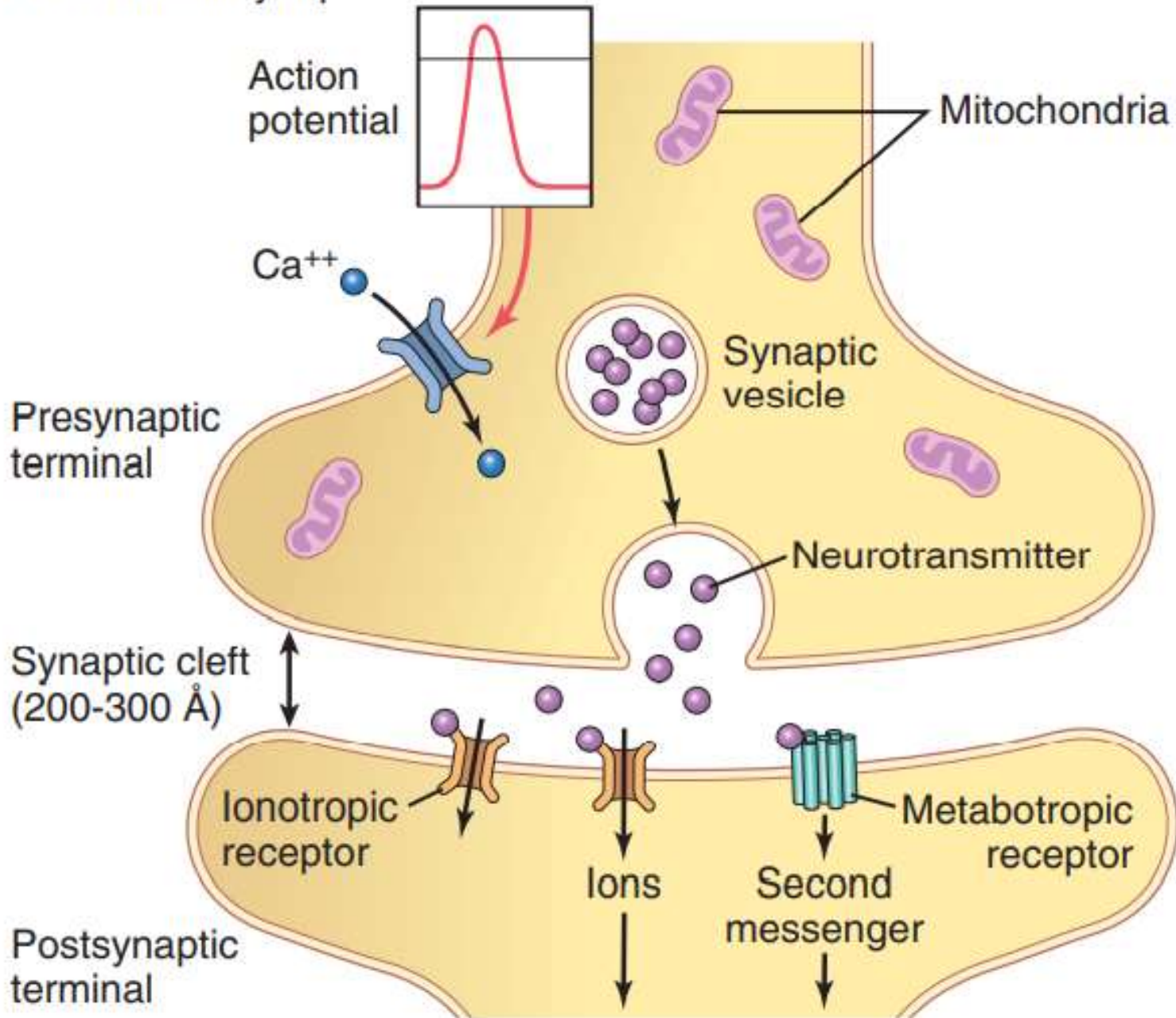
# Chemical synapses

- **Most of the synapses** in the CNS are chemical synapses.
- The first neuron secretes at its nerve ending synapse a chemical substance called a **neurotransmitter**.
- Neurotransmitter acts on receptor proteins in the membrane of the next neuron **to excite the neuron, inhibit it, or modify its sensitivity in some other way**.

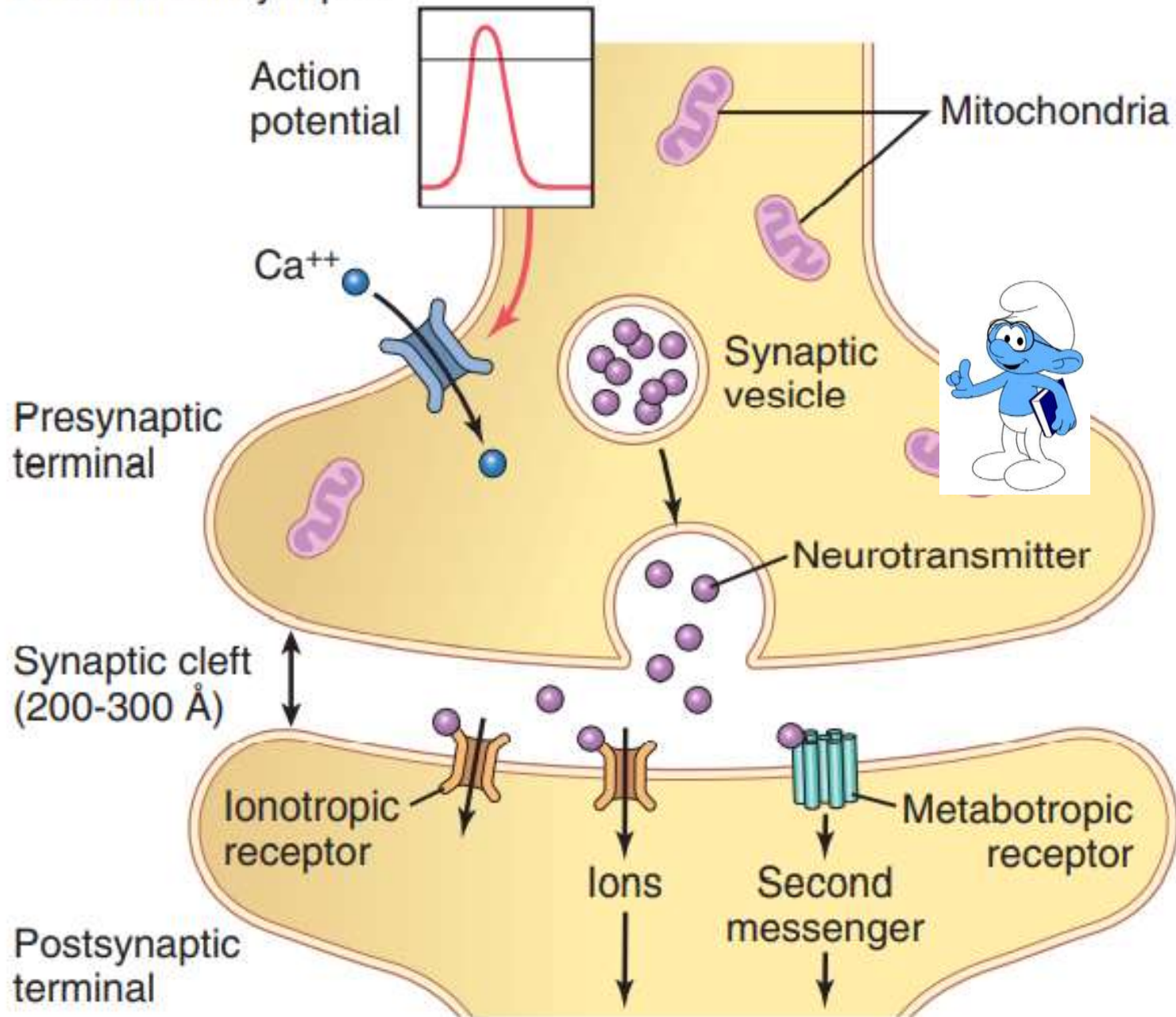
# A Chemical synapse



# A Chemical synapse

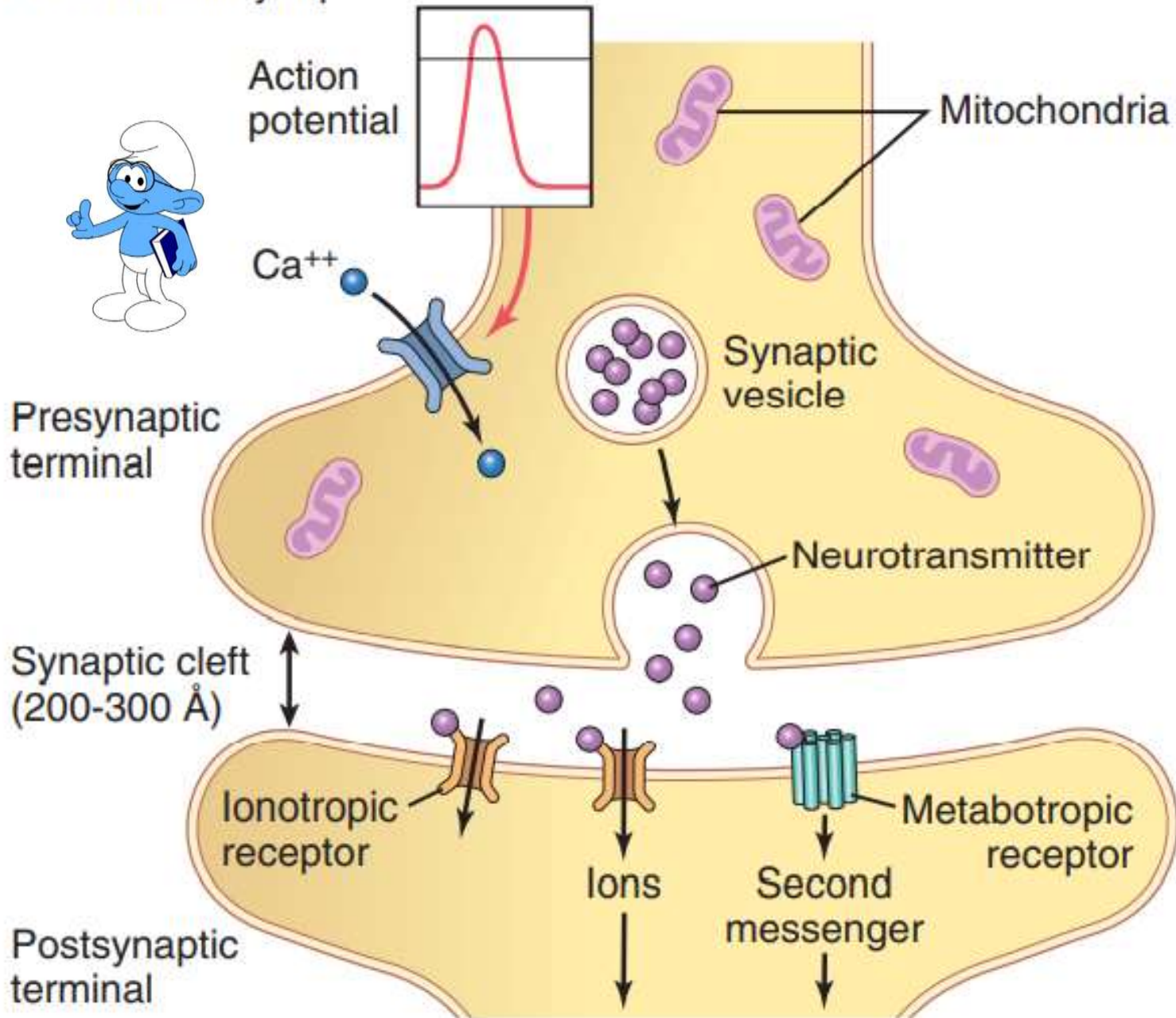


# A Chemical synapse



# A Chemical synapse

More Ca<sup>++</sup>  
More NT



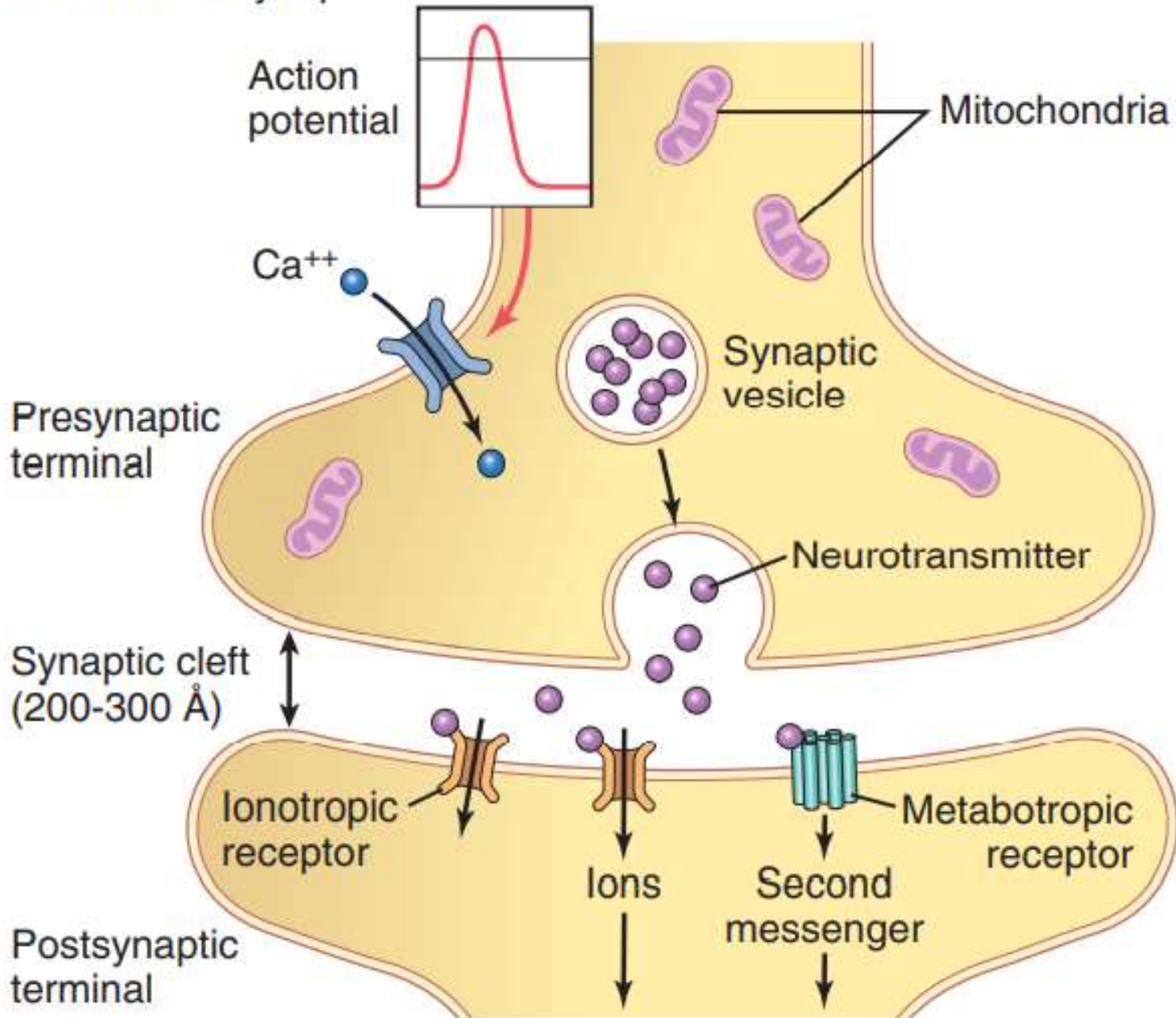
# Presynaptic terminals

- The terminal has two important internal structures:
- The transmitter vesicles contain the neurotransmitter that, when released into the synaptic cleft, either excites or inhibits the postsynaptic neuron.
- The mitochondria provide adenosine triphosphate (ATP), which in turn supplies the energy for synthesizing new transmitter substance.

# Presynaptic terminals

- The presynaptic membrane contains large numbers of **voltage-gated calcium channels**.
- When an action potential depolarizes the presynaptic membrane, these calcium channels open.
- The quantity of neurotransmitter that is released is directly related to the number of calcium ions that enter.

# A Chemical synapse

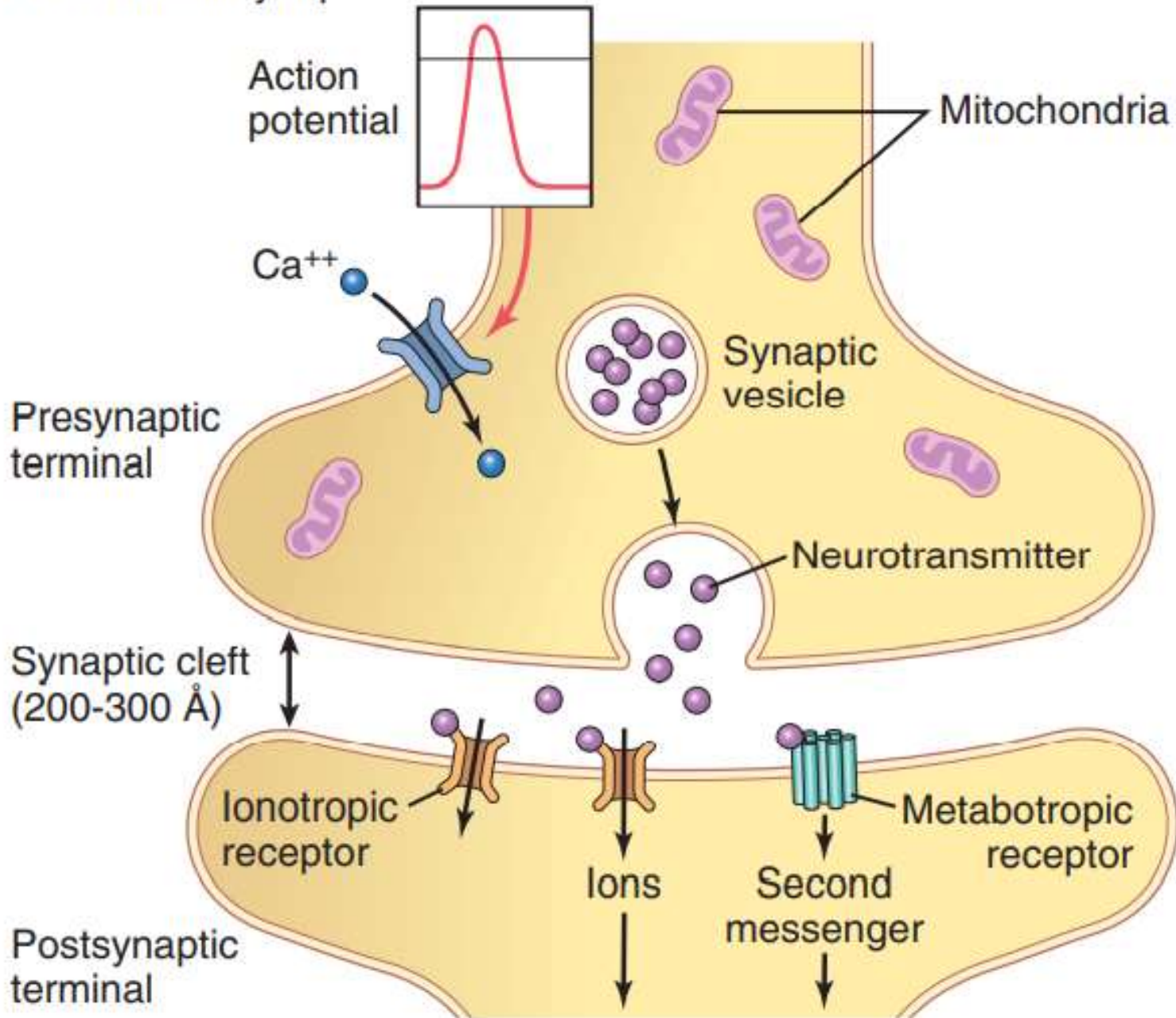


Cation and anion channels

Excitation ( $Na^{+}$ ) or inhibition ( $Cl^{-}$ )



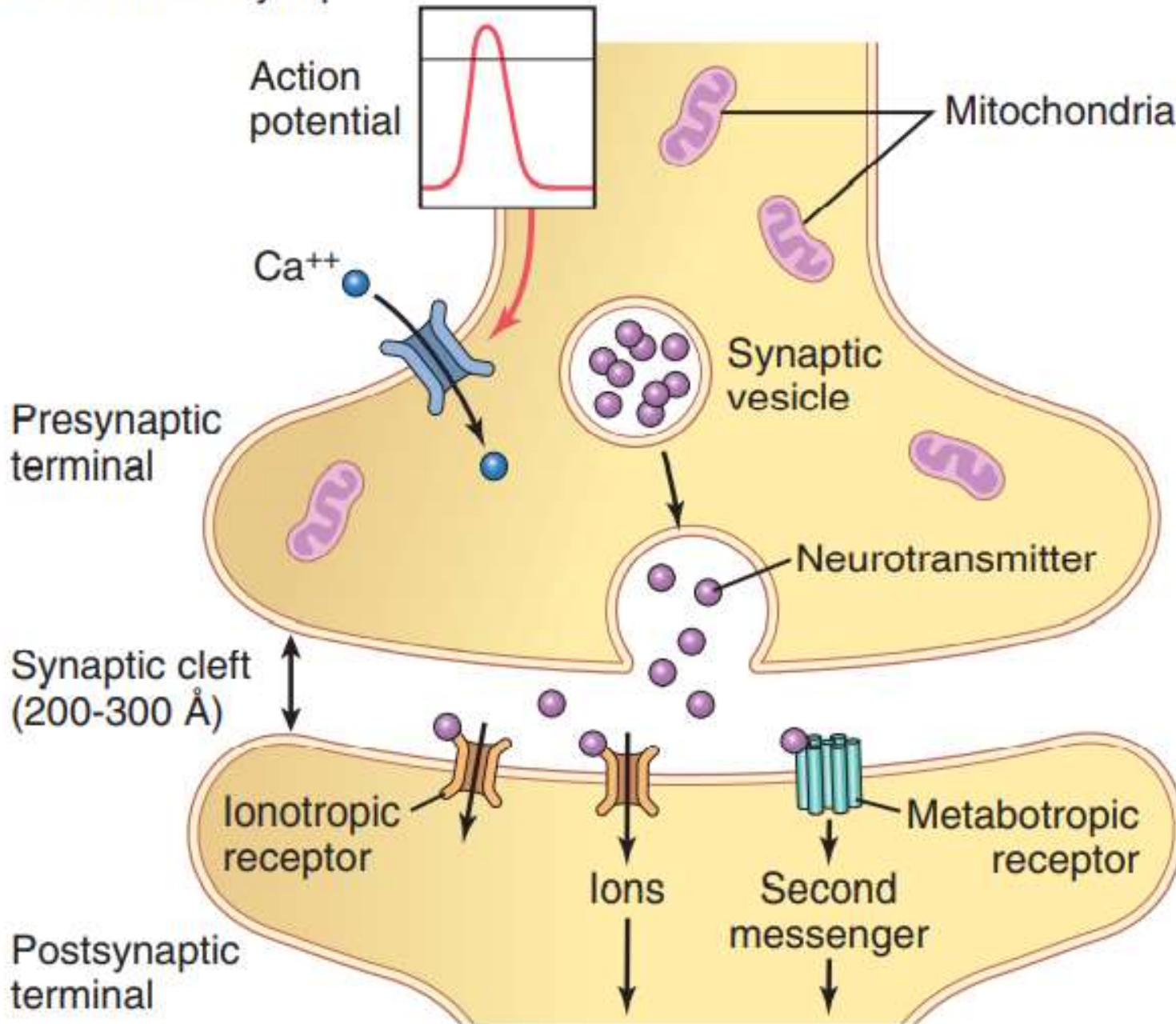
# A Chemical synapse



Prolonged  
action  
e.g.  
memory



# A Chemical synapse



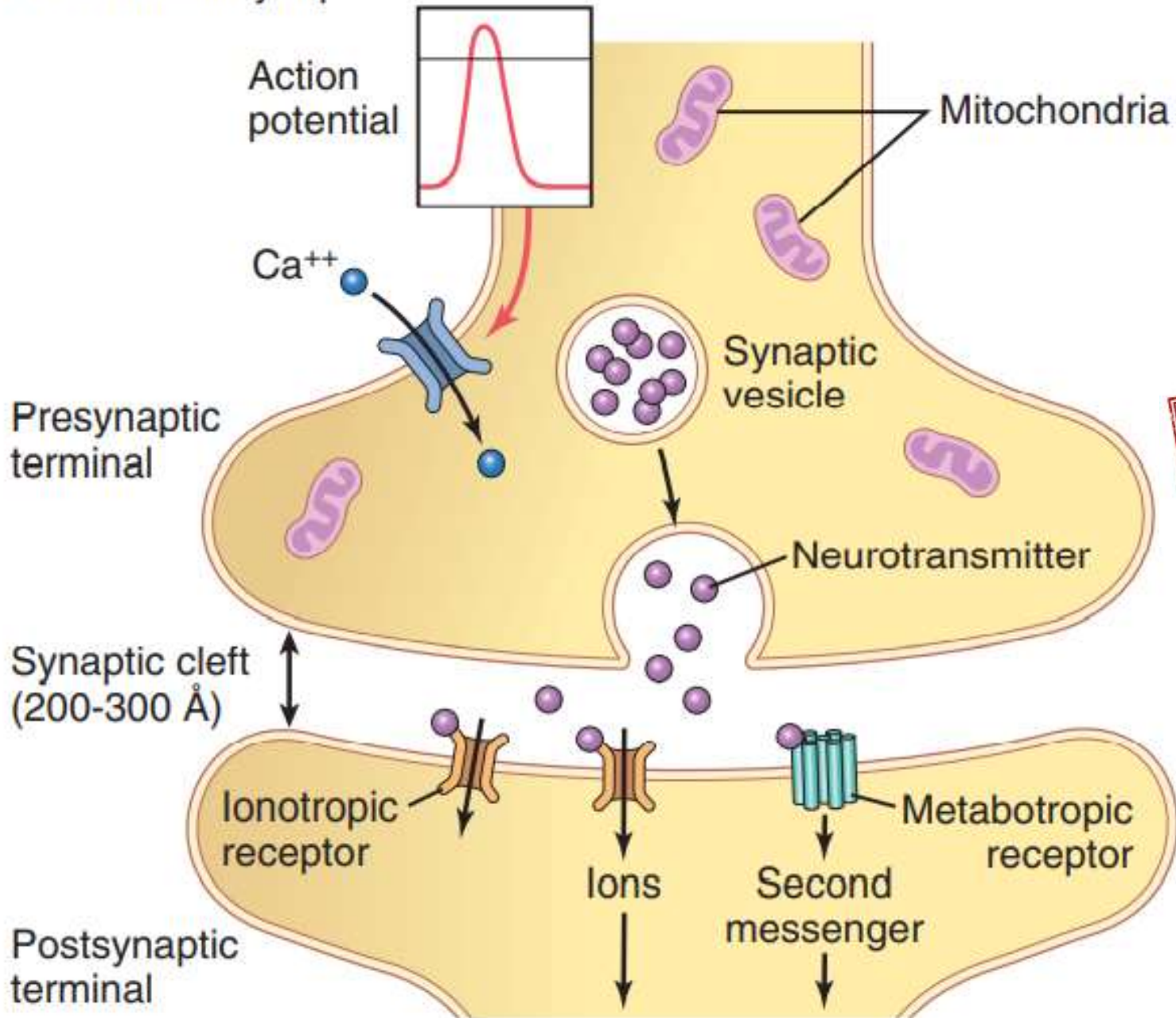
**Principle of one-way conduction at chemical synapse**



# Principle of one-way conduction at chemical synapses

- **Always transmit the signals in one direction:** from the presynaptic neuron to the postsynaptic neuron.
- Allows signals to be directed toward specific goals and perform specific nervous functions.

# A Chemical synapse



**DELAYED**



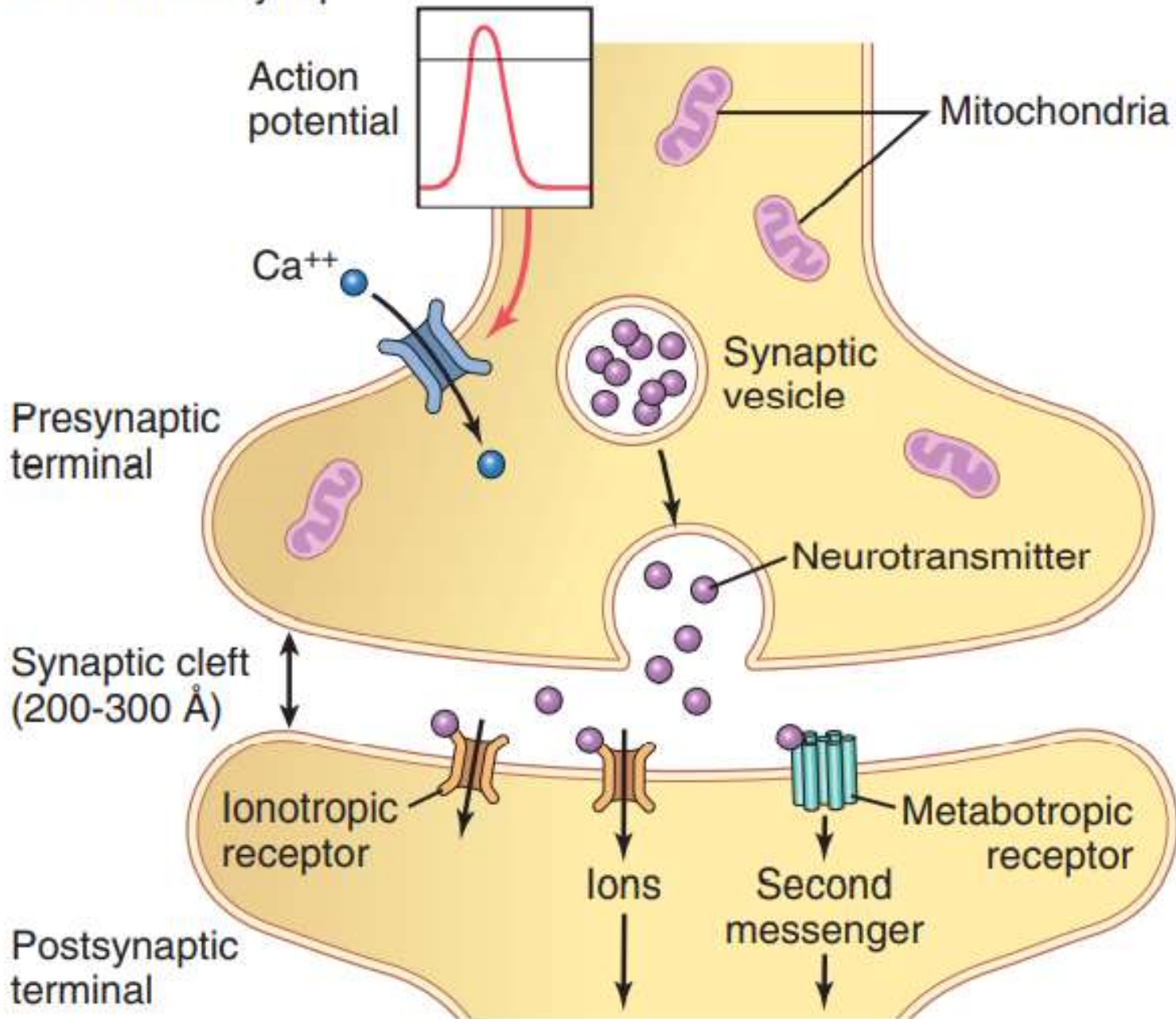
# Synaptic delay

- During transmission of a neuronal signal from a presynaptic neuron to a postsynaptic neuron, a certain amount of time (0.5 msec) is consumed in the process of
  - (1) discharge of the transmitter substance by the presynaptic terminal,
  - (2) diffusion of the transmitter to the postsynaptic neuronal membrane,

# Synaptic delay

- (3) action of the transmitter on the membrane receptor,
- (4) action of the receptor to increase the membrane permeability,
- (5) inward diffusion of sodium to raise the EPSP to a high enough level to elicit an action potential.

# A Chemical synapse



# Postsynaptic neurons

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

(1) by gating ion channels directly (Ionotropic receptors).

(2) by activating a second messenger (metabotropic receptors).

# Excitation of postsynaptic neuron

- Opening of sodium channels.
- Changes in the internal metabolism of the postsynaptic neuron to excite cell activity or to increase the number of excitatory membrane receptors or decrease the number of inhibitory membrane receptors.

# Inhibition of postsynaptic neuron

- Opening of chloride ion channels through the postsynaptic neuronal membrane.
- Increase in conductance of potassium ions out of the neuron.
- Activation of receptor enzymes that inhibit cellular metabolic functions or that increase the number of inhibitory synaptic receptors or decrease the number of excitatory receptors.

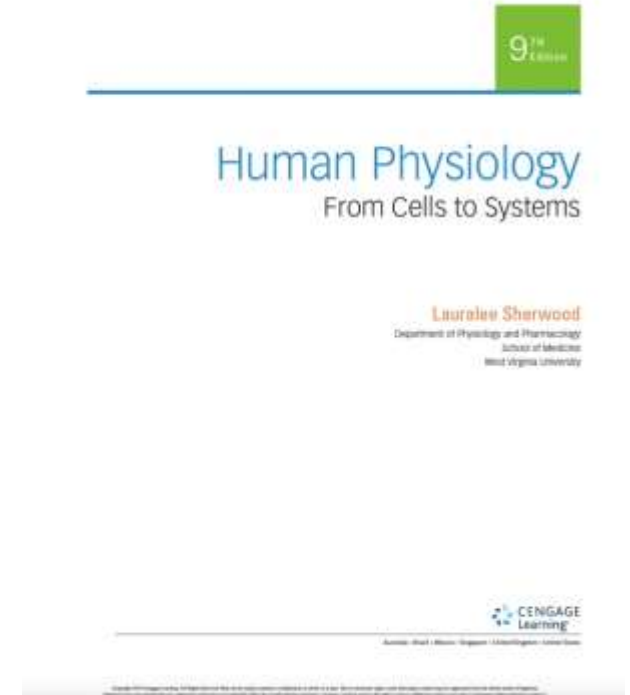
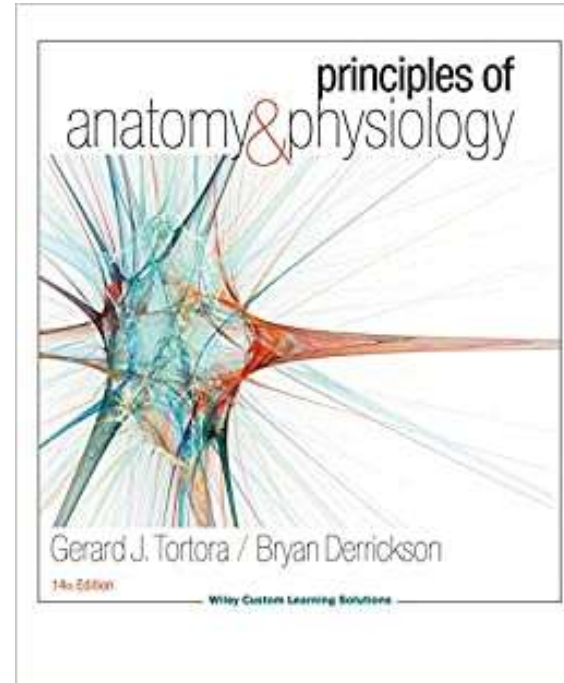
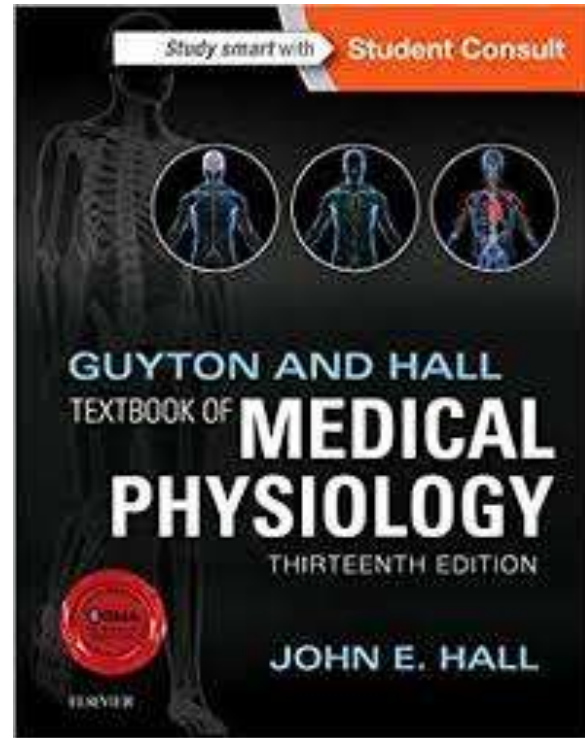
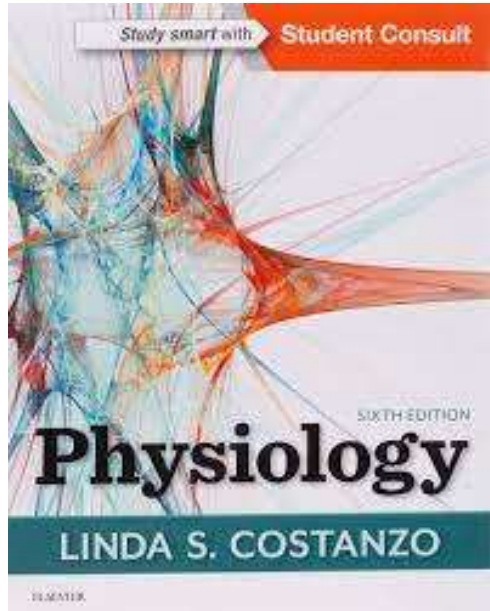
# Second-messenger system

- Many functions of the nervous system—for instance, the process of memory—require prolonged changes in neurons for seconds to months after the initial transmitter substance is gone.
- The ion channels are not suitable for causing prolonged postsynaptic neuronal changes because these channels close within milliseconds after the transmitter substance is no longer present.

# Second-messenger system

- However, in many instances, **prolonged** postsynaptic neuronal excitation or inhibition is achieved by activating a “second messenger” chemical system inside the postsynaptic neuronal cell itself, and then it is the second messenger that causes the prolonged effect.

# References





Questions? Feedback?

Thank you

