Synaptic transmission (cc4, unit7)

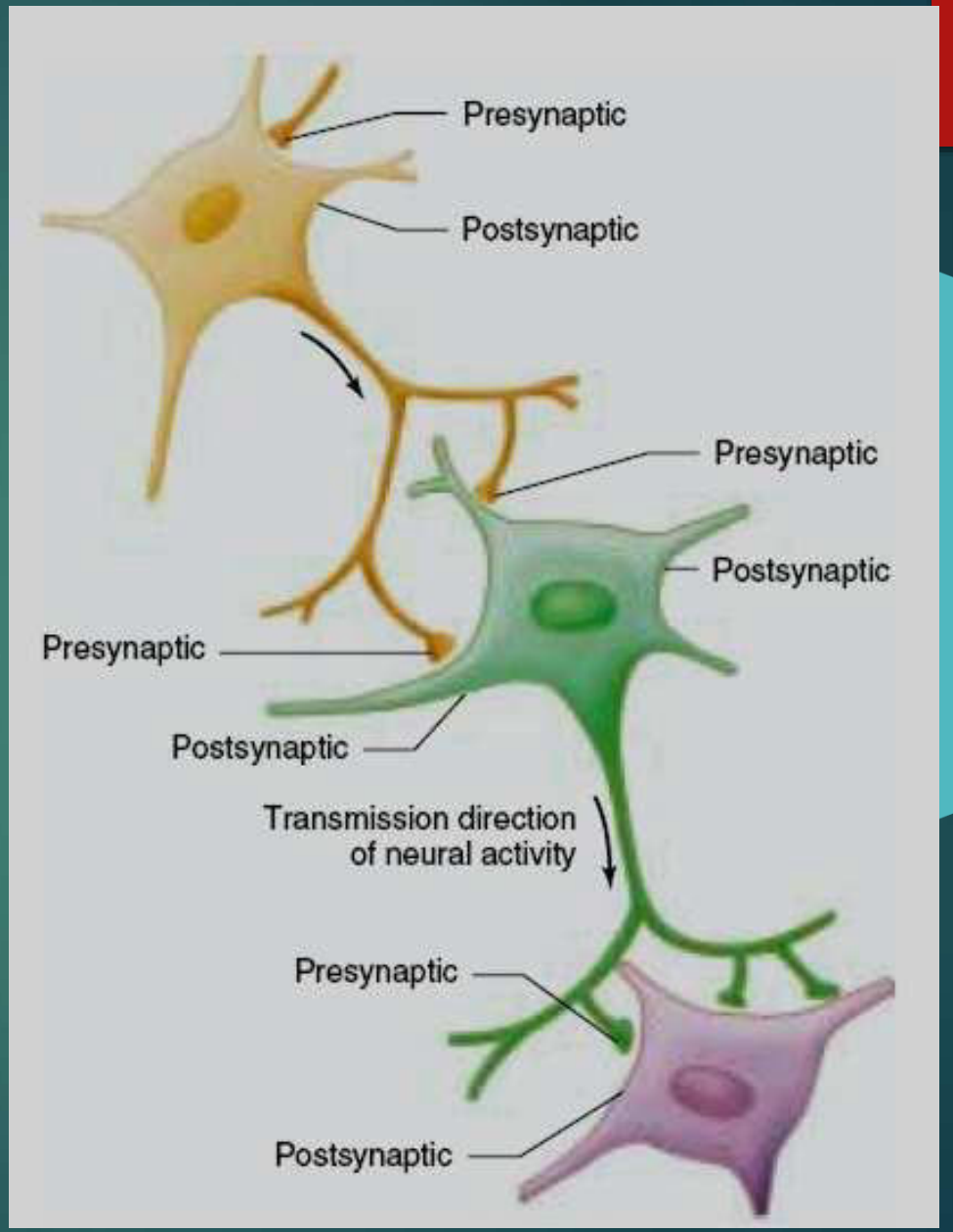
By Sriparna Ray, Bidhan Chandra College

Topics

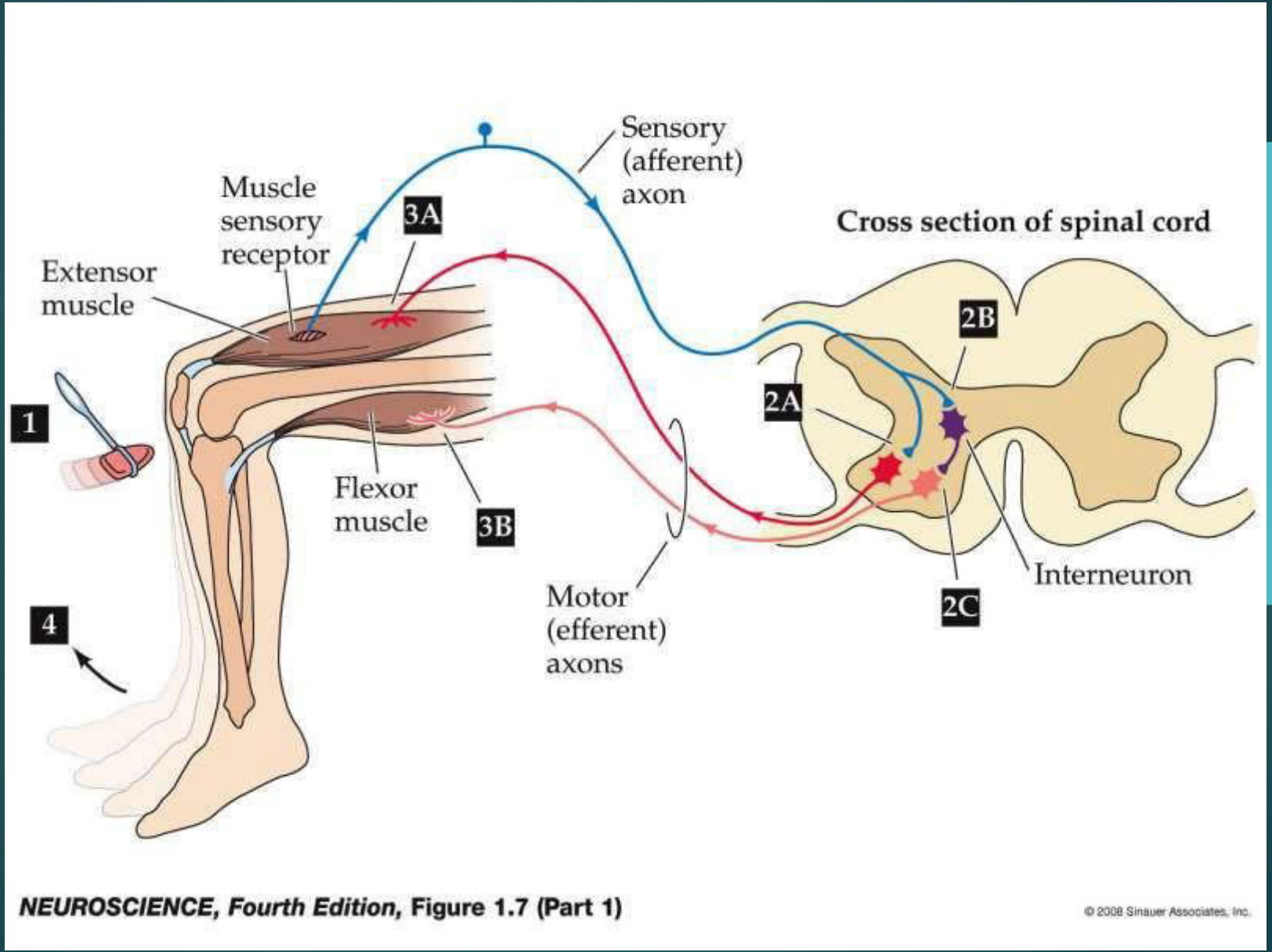
1) What is synapse and synaptic transmission?
2) Types
3) Structures that form the synapse
4) Process of synaptic transmission
5) Properties

A number of neurons are involved in the transmission of nerve impulse from its origin to destination.

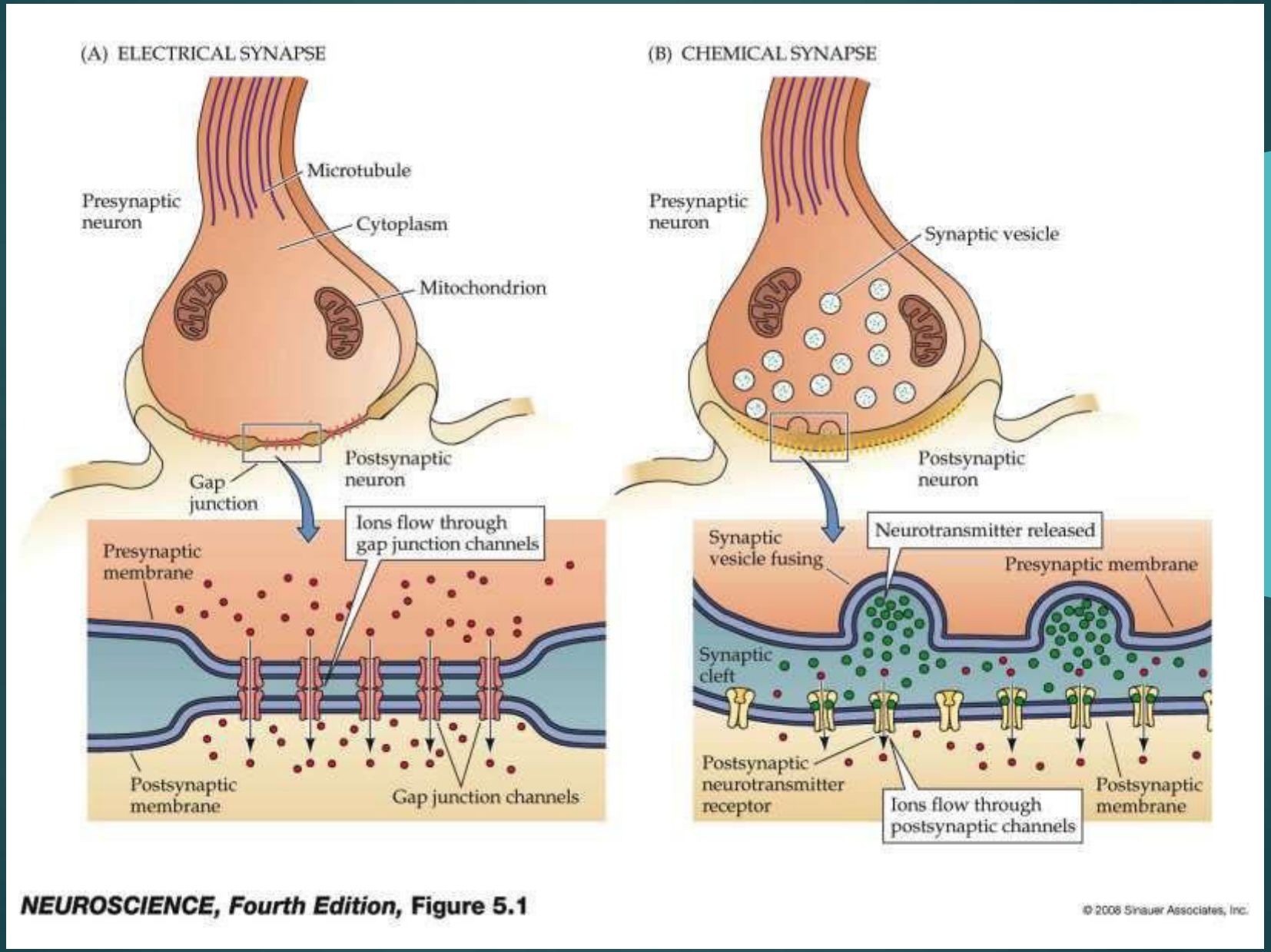
Synapses are the junctions between two neurons.



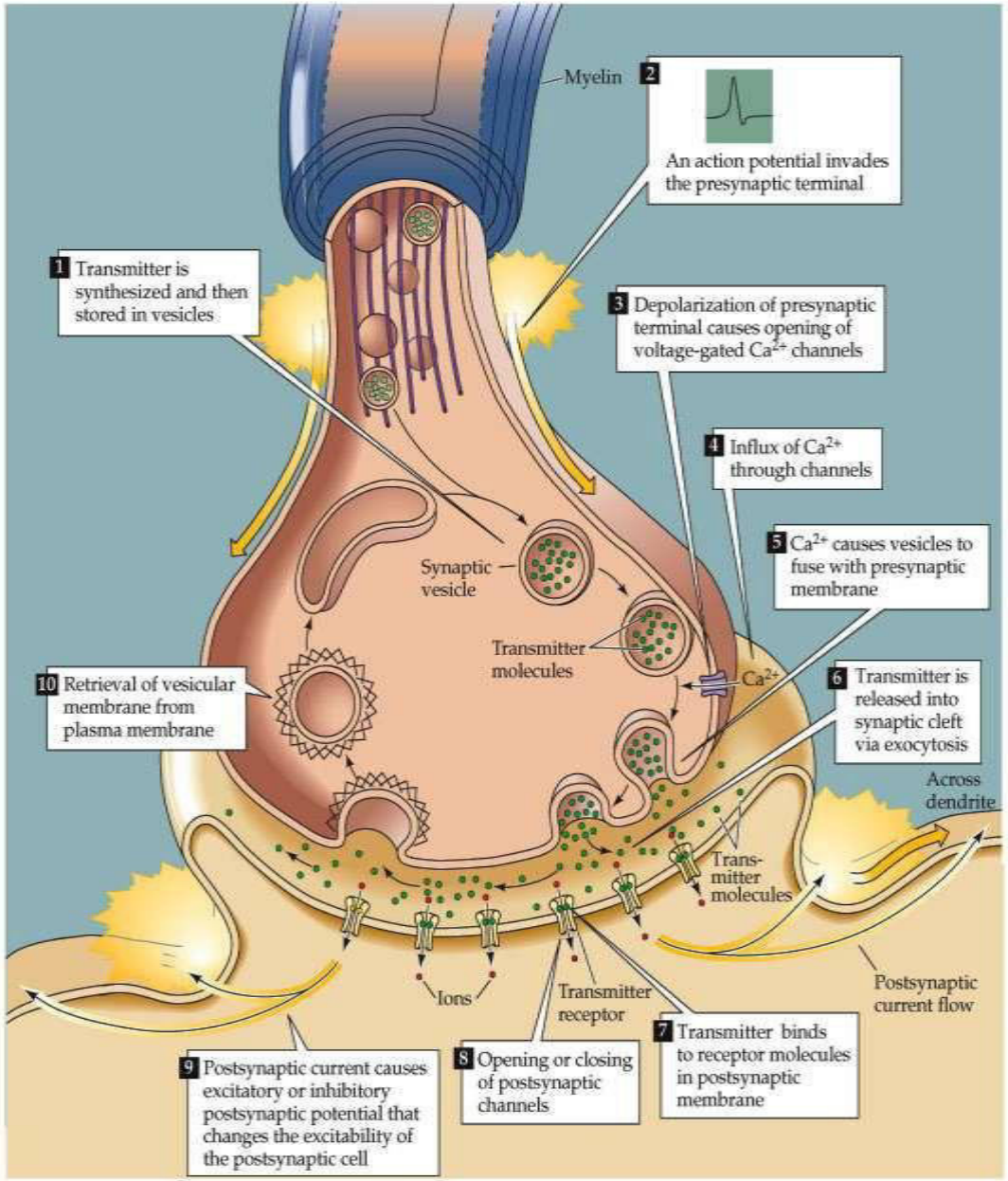
Synaptic transmission: communication between neurons



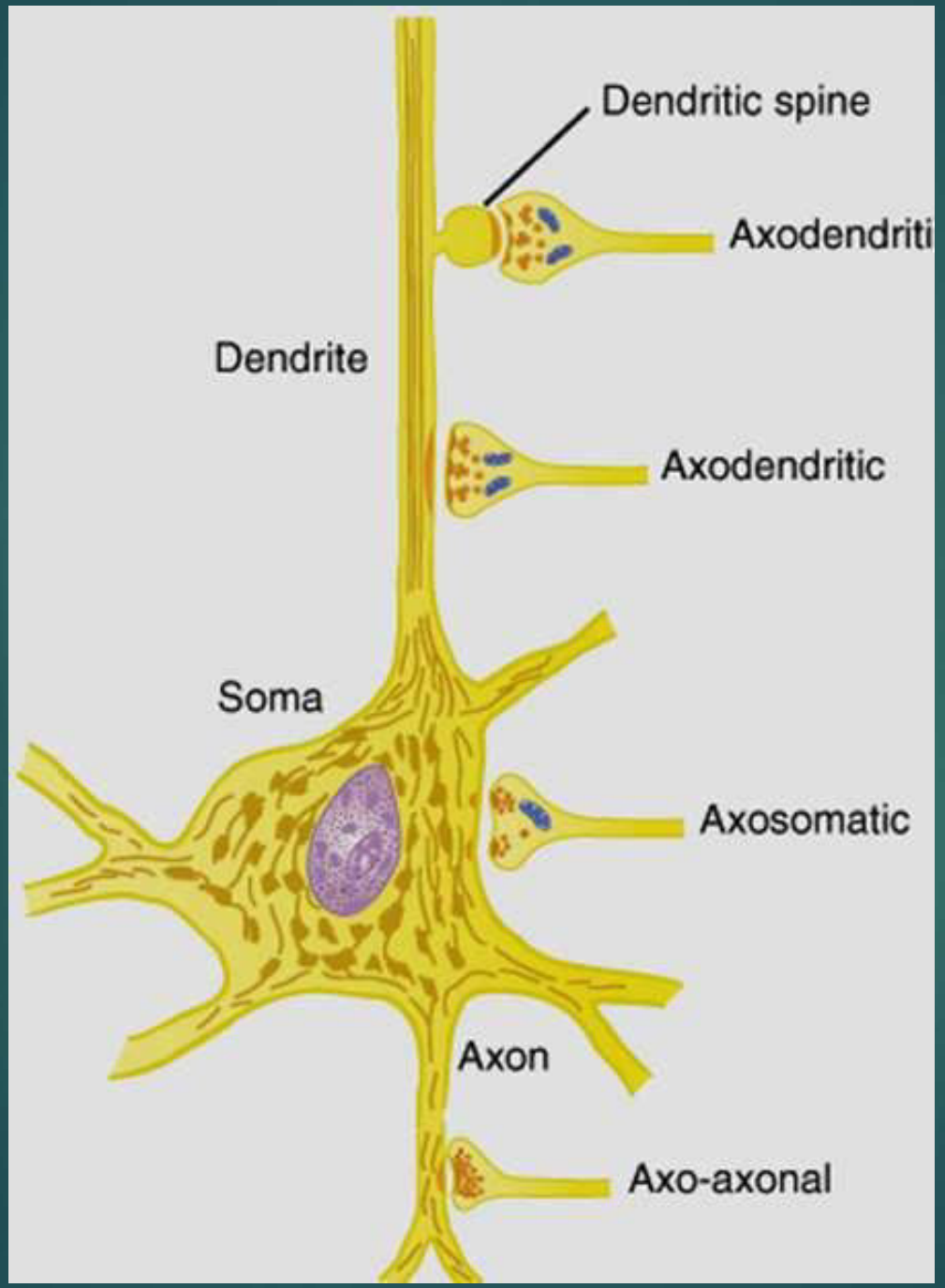
Two principal kinds of synapses: electrical and chemical

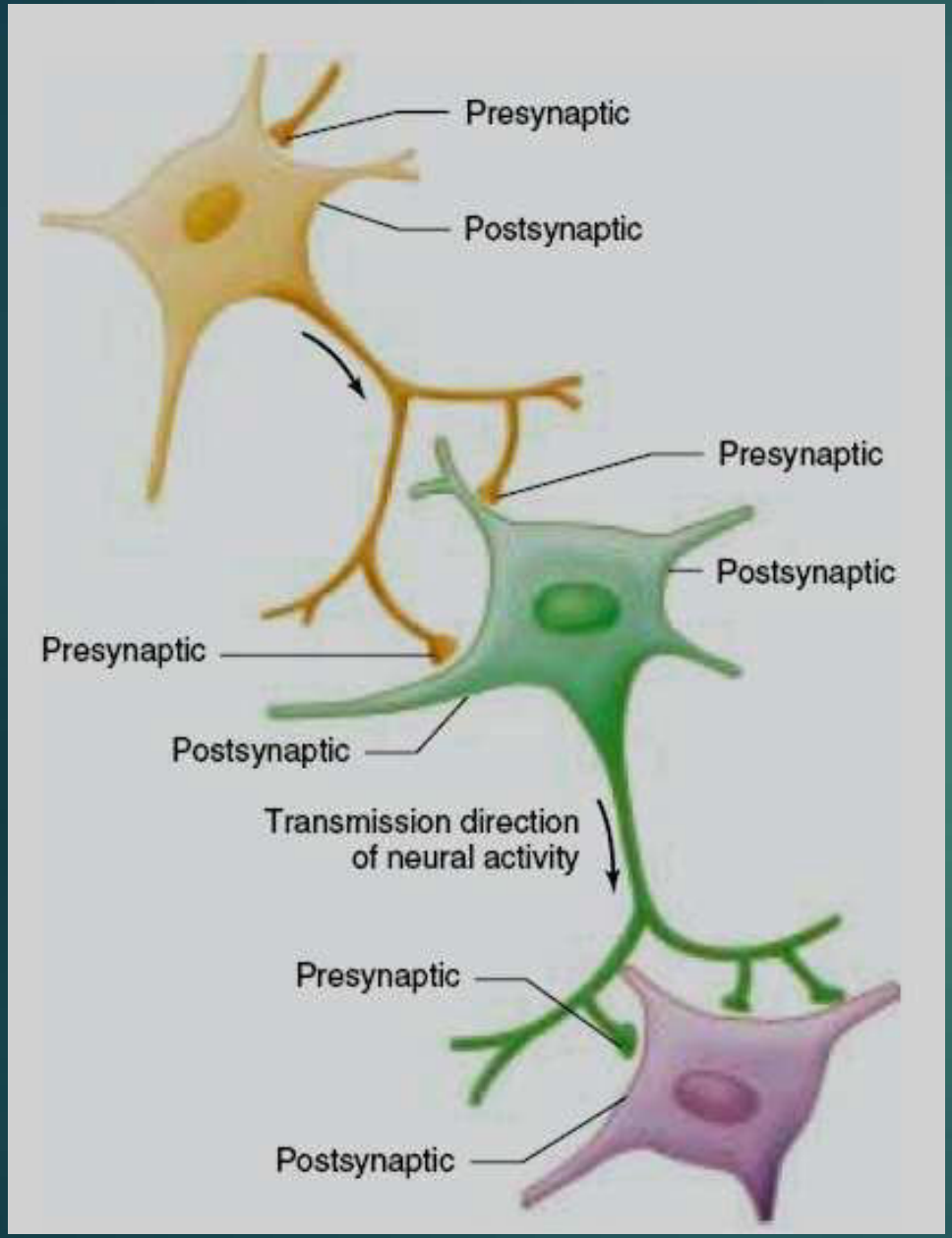


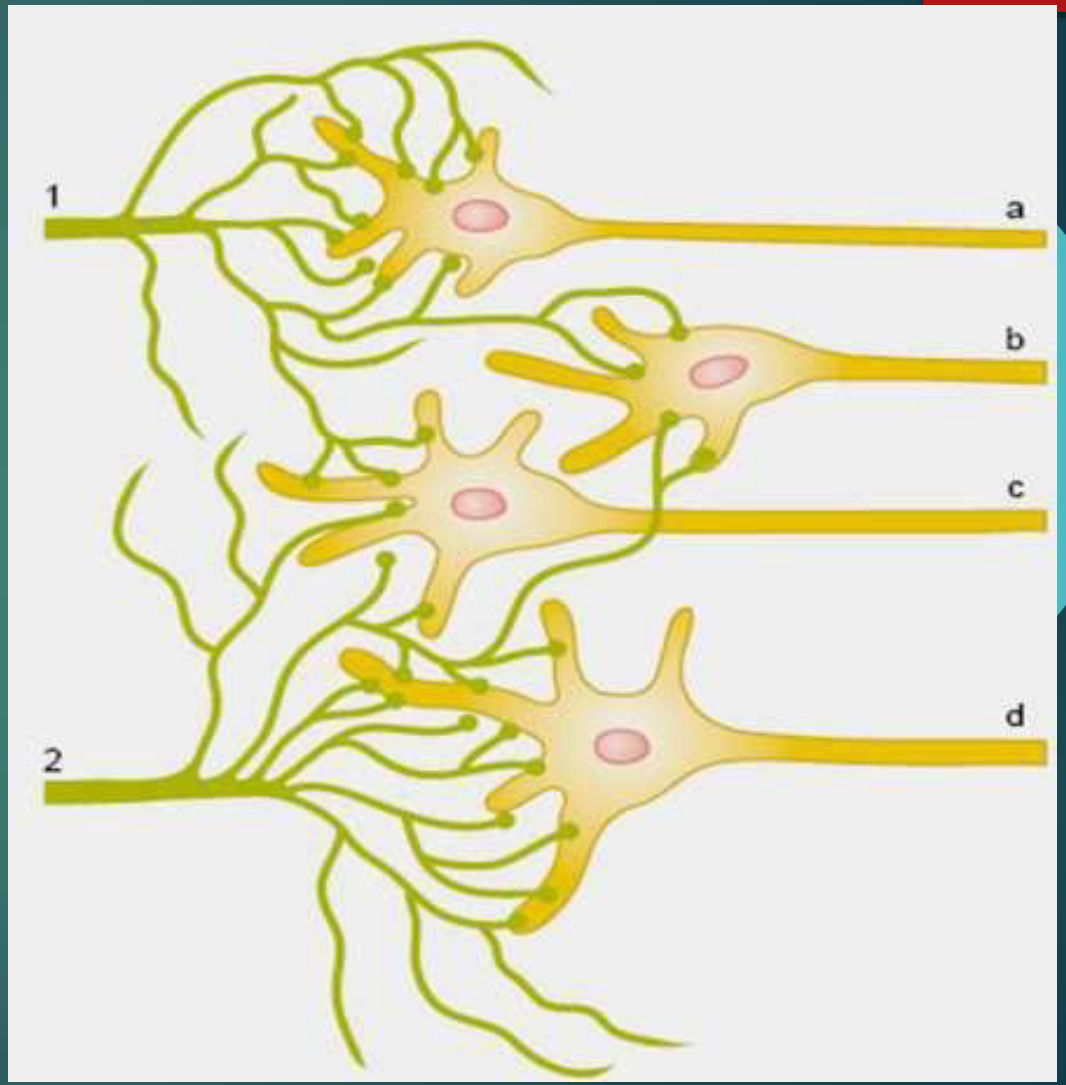
Chemical synapses: the predominant means of communication between neurons



NEUROSCIENCE, Fourth Edition, Figure 5.3


Dendritic spine
Axodendriti
Dendrite
Axodendritic
Soma
Axosomatic
Axon
Axo-axonal


Presynaptic
Postsynaptic
Presynaptic
Postsynaptic
Presynaptic
Postsynaptic
Transmission direction
of neural activity
Presynaptic
Postsynaptic

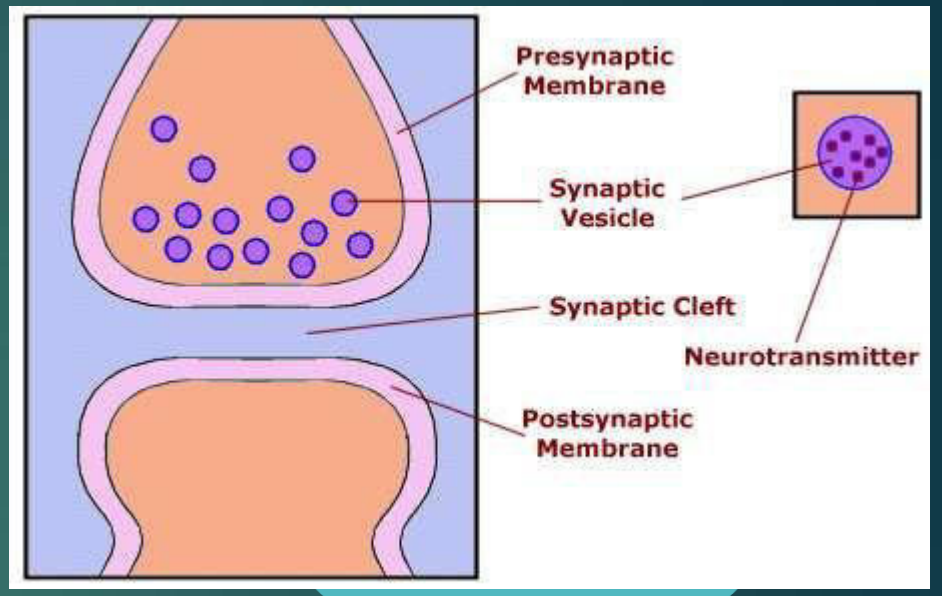

1
2
a
b
c
d

Synapse Structure

- The part of the synapse that belongs to the initiating neuron is called the *presynaptic membrane.*

- The part of the synapse that belongs to the receiving neuron is called the *postsynaptic membrane.*

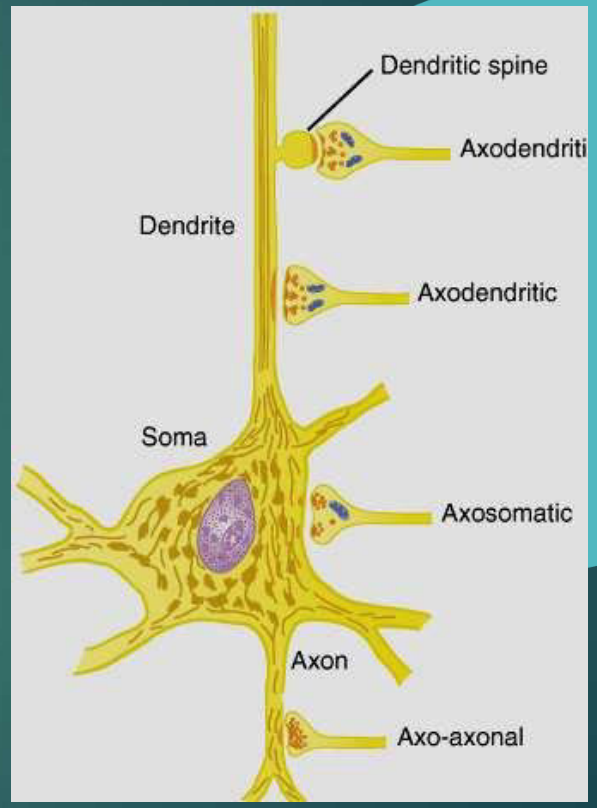
- The space between the two is called the *synaptic cleft.* It is approx 20-50 nm wide.



Presynaptic terminals contain numerous synaptic vesicles
Synaptic vesicles contain *Neurotransmitters*, chemical substances which ultimately cause postsynaptic changes in the receiving neuron, is contained within the synaptic vesicles. Common neurotransmitters include : Acetylcholine, Dopamine, Norepinephrine (a.k.a., noradrenaline), Serotonin

Functional Anatomy of chemical synapses

- Presynaptic neuron on an average divides into 2000 synaptic endings. Each endings enlarge to form terminal buttons (synaptic knobs).
- Synaptic knobs are in close proximity to post synaptic neuron (dendrites, dendritic spines, soma of the post synaptic cell, or axon of the post synaptic neurons).
- Most of the synapses are on dendrites.



Steps of Synaptic Transmission

Action potential signal arrives at the presynaptic axon terminal

↓

Opening of voltage gated Ca channels

↓

Ca enters into the presynaptic terminal

↓

Ca mediated exocytosis of neurotransmitter

↓

Neurotransmitter binds to the receptors at post synaptic membrane

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Opeining of ion channels

↓

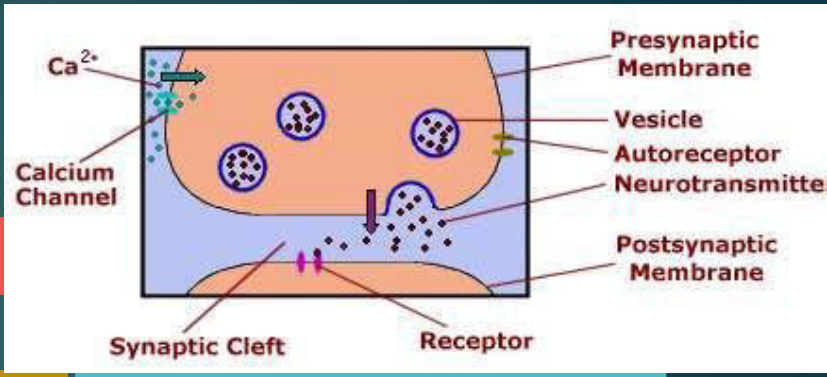
Movement of ions through the post synaptic membrane

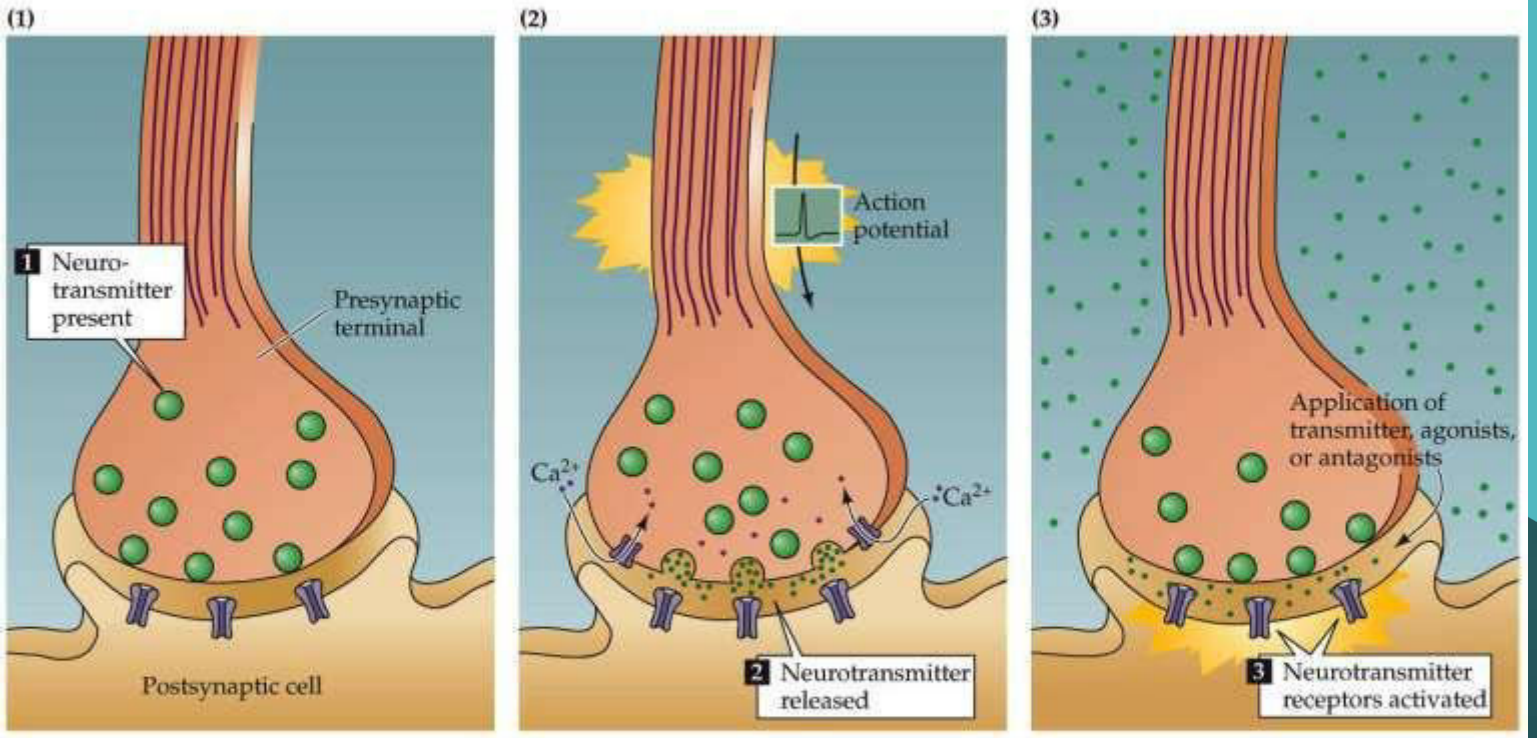
↓

Change in membrane potential in post synaptic membrane

↓

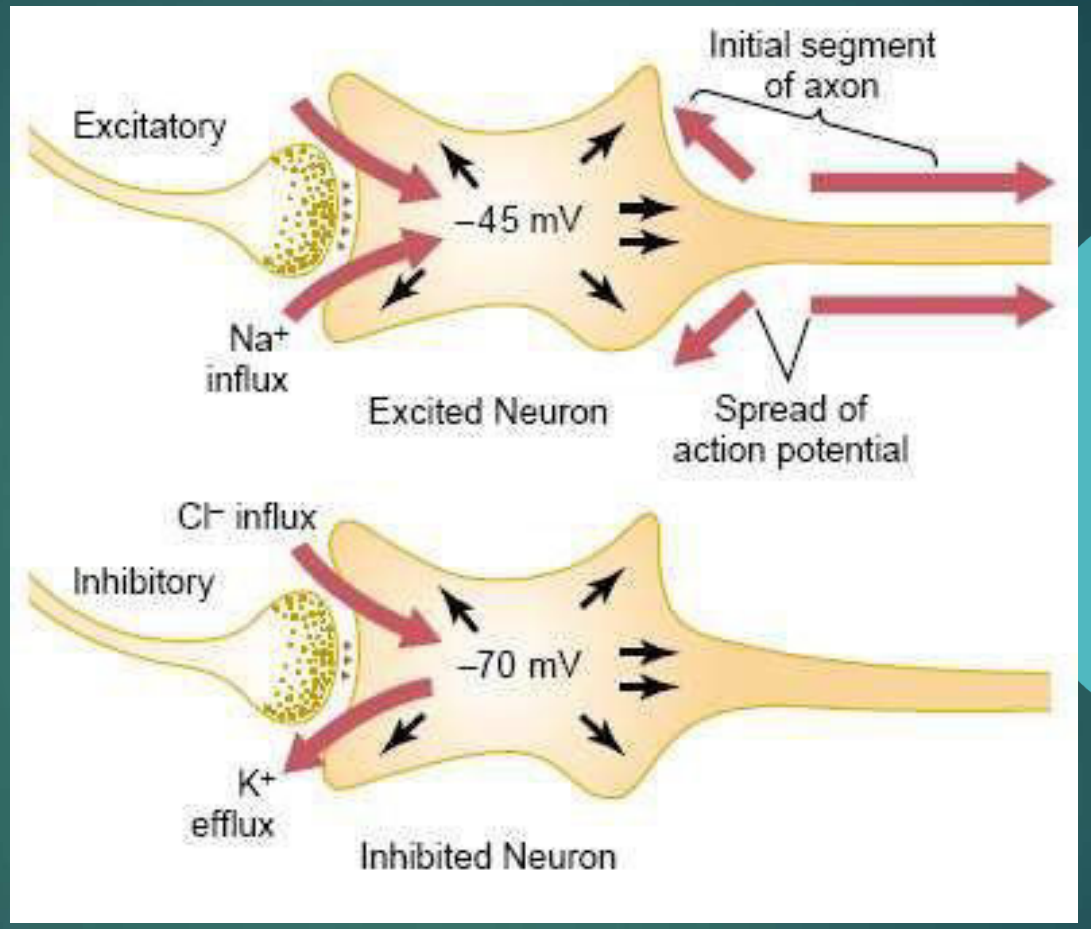
Synaptic potential generated





NEUROSCIENCE, Fourth Edition, Box 5A

Synaptic Potential



EPSP

IPSP

Electrical Synapse	Chemical Synapse
1) EPSP short latency	1) Long latency
2) Transmission is bidirectional	2) Unidirectional
3) Signal is not magnified	3) Magnified/modified
4) Less time consuming for impulse to travel	4) Time consuming

Fate of the neurotransmitter discharged in the synaptic cleft

Degradation: Enzymes located in the synaptic cleft break down the neurotransmitter into a substance which has no effect on the receptor channel

Reuptake: The neurotransmitter can reenter the presynaptic cell through channels in the membrane.

Diffusion

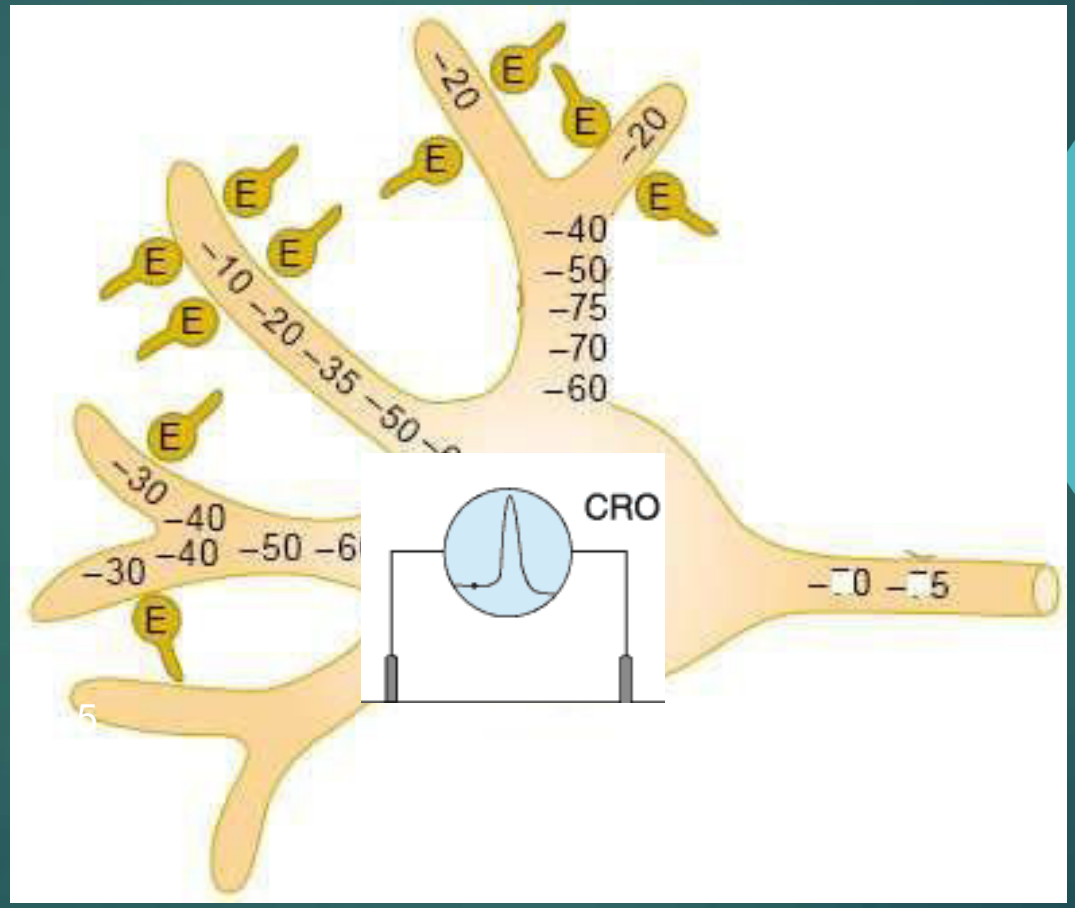
Properties of synaptic transmission

1. Synaptic delay: All the events involved in synaptic transmission need some time usually between 0.5 &1 ms

2. Law of forward conduction: impulse always travels from presynaptic to postsynaptic neuron

Properties of synaptic transmission

3a. Spatial summation: If a number of fibers converging on a single neuron are stimulating simultaneously with sub-threshold stimuli, the postsynaptic neuron may fire action potential.

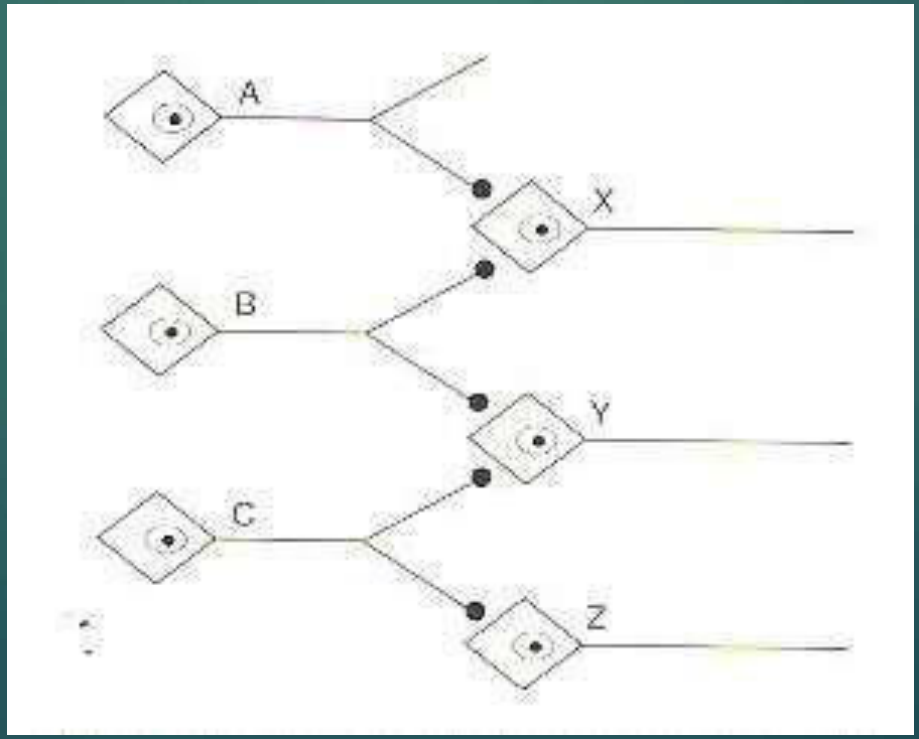


3b. Temporal summation: If a sub-threshold stimulus is repeated several times in quick succession, the postsynaptic neuron may fire.

Properties of synaptic transmission

4a. Facilitation: The effect of stimulating two nerve fibres may turn out to be greater than the sum of stimulating either of them separately.

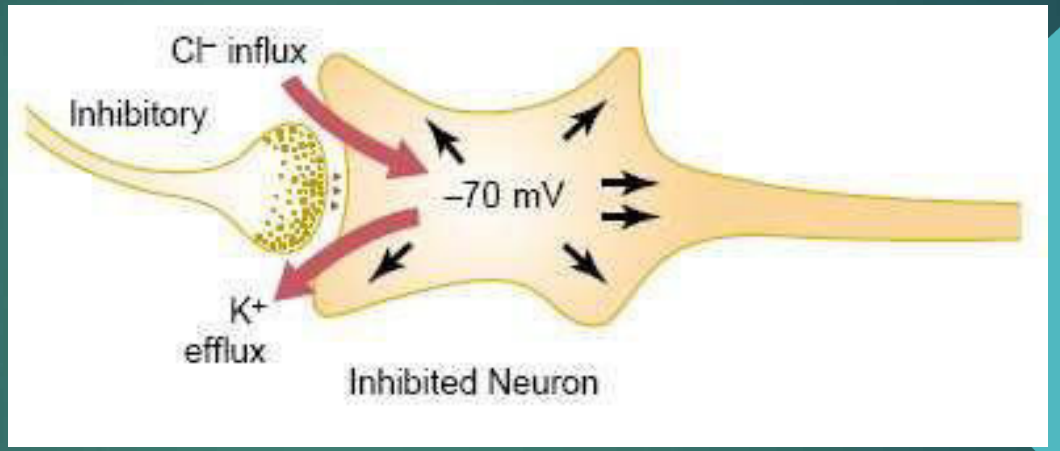
4b. Occlusion: with stronger stimuli, the effect of stimulating two nerve fibres may turn out to be less than the sum of stimulating either of them separately.



Properties of synaptic transmission

5. Inhibition: Inhibitory pre-synaptic neuron – release of Inhibitory NT

IPSP



6. Fatigue: Repeated stimulation of a synapse leads to gradual diminution and finally disappearance of the postsynaptic response.

Plasticity of synaptic transmission

1. Habituation: When a stimulus is repeated over and over, the response to the stimulus gradually disappears.

2. Sensitization: When a stimulus accompanied by painful/unpleasant sensation, the response increase is more and more.

3. Posttetanic potentiation: If rapidly repeated stimulation (tetanic stimulation) is followed by a brief pause, the response to subsequent stimulation is frequently enhanced lasts up to 60 seconds.

4. Long-term potentiation: Persistent enhancement of the postsynaptic potential response to presynaptic stimulation after a brief period of rapidly repeated stimulation of the presynaptic neurons.

5. Long-term depression: It is opposite to the LTP. It is characterized by a decrease in synaptic strength.