Synapse and synaptic transmission

Synapse	A junction where the axon or some other portion of one cell (presynaptic cell) terminates on the dendrites, soma, or axon of another neuron (post synaptic cell).

Anatomical Types

Axodendritic	Axosomatic	Axoaxonic	Dendrodendritic	Dendrosomatic

Functional types of synapses in CNS

Chemical synapses	Electrical Synapses	Conjoint synapses
- **Neurotransmitters**, excitatory or inhibitory. - Almost **ALL** synapses in CNS.	- Membranes come **close together** → gap junction → no membrane borders which allow passage of ions. - Are important in the CNS in: - **Mental** attention - Emotions and **memory** - **Arousal** from sleep	**Both** electrical and chemical. Examples: Neurons in **lateral vestibular nucleus**.

Synapses outside CNS

1- Neuromuscular junction	2- Contact between **autonomic neurons** and smooth, cardiac muscles, and other effector.

Synaptic structures

Synaptic knob " terminal boutons"	Synaptic cleft	Postsynaptic
Presynaptic terminal	Space between the **axon terminal** and **sarcolemma**. It has a width of 200-300 angstroms.	-

Postsynaptic receptors components

1- Binding site facing the cleft to bind **NT**	2- **Ionophore**: passes all the way through the membrane to the interior.

Ionophore types

A- **Ion channels**	1- cation channel: Na^+, K^+, Ca^{2+}. 2- Anion channel: Cl^- (mainly)
B- 2nd messenger system in the **post-synaptic** membrane. (Metabotropic R)	

Fate of NT

- Diffusion	out of synaptic cleft into surrounding fluid.
- Enzymatic destruction	e.g. **Ach esterase** for Ach.
- Active transport	Back into **pre**-synaptic terminal itself e.g. NE

Electrical events in post-synaptic neurons

1- RMP of neuronal soma	- ~ -65 mV. - If voltage is less, neuron is more excitable.
2- Excitatory post-synaptic potential [EPSPs]	- When **excitatory NT** binds to its receptor on postsynaptic membrane → partial depolarization = ↑ Na^+ influx of postsynaptic cell membrane immediately under presynaptic ending, i.e. **EPSPs** - If this potential rises enough to threshold level, **AP** will develop and **excite** the neuron.

3- Inhibitory post-synaptic potentials (IPSPs):	- When an **inhibitory NT** binds receptor on postsynaptic membrane → hyperpolarization of the postsynaptic membrane → ↑ membrane permeability to Cl^- of post-synaptic memb. (produced by inhibitory NT) → ↓ excitability and m. potential (more negative)
Synaptic properties	
1- One-way conduction	i.e. from pre-synaptic to post-synaptic neuron.
2- Synaptic delay	The minimum time required for transmission across the synapse. It is 0.5 ms for transmission across one synapse. This time is taken by: - **Discharge** of transmitter substance by pre-synaptic terminal. - **Diffusion** of transmitter to post-synaptic membrane. - Action of transmitter on its **receptor**. - Action of transmitter **to** ↑ **membrane** permeability. - ↑ diffusion of Na^+ to ↑ post-synaptic potential.
3- Synaptic inhibition	Types: A- **Direct** inhibition B- **Indirect** inhibition C- **Reciprocal** inhibition D- **Inhibitory interneuron**
4- Summation	A- Spatial summation: When EPSP occurs in more than one synaptic knob **at the same time**
	B- Temporal summation: If EPSPs in a pre-synaptic knob are successively repeated without significant delay so the effect of the previous stimulus is summated to the next.
5- Convergence and divergence	A- Convergence: When **many** pre-synaptic neurons converge on any single post- synaptic neuron.
	B- Divergence: Axons of pre-synaptic neurons divide into many branches that diverge to end on many post-synaptic neurons.
6- Fatigue	- Due to **exhaustion of neurotransmitter**. - If the pre-synaptic neurons are continuously stimulated there may be an exhaustion of the NT → stoppage of synaptic transmission.
Synaptic inhibition types	
A- Direct inhibition	when an inhibitory neuron (releasing inhibitory substance) acts on a postsynaptic neuron directly → hyperpolarization due to influx of Cl^- [IPSPs] and/or outflux of K^+. e.g. **Glycine** at the level of the spinal cord to **block pain impulses**.
B- Indirect Inhibition	Inhibitory synaptic knob lies directly on the termination of a **pre**-synaptic excitatory fiber.

= Presynaptic inhibition	The inhibitory synaptic knob releases a transmitter which **inhibits** the release of excitatory transmitter from the **pre**-synaptic fiber. e.g. **GABA** (Pain modification)
C- Reciprocal inhibition	Impulses pass directly to the motor neurons supplying the same muscle and via branches to inhibitory interneurones that end on motor neurones of **antagonist** muscle.
D- Inhibitory interneuron (Renshaw cells)	Negative feedback inhibitory interneuron of a spinal motor neuron.
Factors affecting synaptic transmission	
Alkalosis	- ↑ **neuronal excitability**. - Causes cerebral epileptic seizures (Increased excitability cerebral neurons) - e.g. over-breathing in person with epilepsy. The over breathing blows off carbon dioxide and therefore elevates the pH of the blood momentarily.
Acidosis	- ↓ **neuronal activity**; pH around 7.0 usually causes a coma (e.g. severe diabetic or uremic acidosis)
Drugs	Caffeine found in coffee, tea: ↑ neuronal excitability, by ↓ the **threshold** for excitation of neurons. عشان كذا نحس بالنشاط والحيوية بعد ما نشرب قهوة.
Hypoxia	Depression of neurons. لأن الدم ما وصلها فبتتعطل الوظيفة.

Resource:
- Prof. Laila Ayadhi slides. L1, 2016

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