



◉Sheet ○Slides

Number

11

Done by:

Razi Kittaneh & Leen Osama

Corrected by:

Marah Bitar

Doctor

Mohammad Khatatbeh

## Notes on the previous lecture

- **Spatial summation:** input (postsynaptic potentials) from multiple presynaptic neurons. These postsynaptic potentials are below the threshold. When 2 potentials reach one point at the same time they add up and an action potential will be created if the threshold is exceeded.
- **Temporal summation:** one presynaptic source(usually) generates **high frequency** of action potentials that elicits postsynaptic potentials. Which summate with each other and generate an action potential. The postsynaptic potential will summate with the next one as soon as the next postsynaptic potential begins. The duration of a postsynaptic potential is longer than the duration between action potentials. (the postsynaptic potentials are subthreshold)
- In our body **both** summations take place. Sometimes spatial summation and temporal summation occur together at the same time to produce an action potential.
- The summation process can be between:
  - EPSPs→increases probability of generating an action potential
  - EPSP and IPSP→ they cancel each other
  - IPSPs→ prevent the cell from achieving an action potential

- The main function of **dendrites**: provide a large surface area to receive as much neurotrophic factors as possible for the cell.
- **Motor neurons** send impulses to effectors **e.g.** muscles, glands. While sensory neurons generate impulses at receptors and send them to CNS.
- **Receptors** are small functional structures linked to the terminals that can generate action potentials.

## Synaptic organization (neural network structure) :

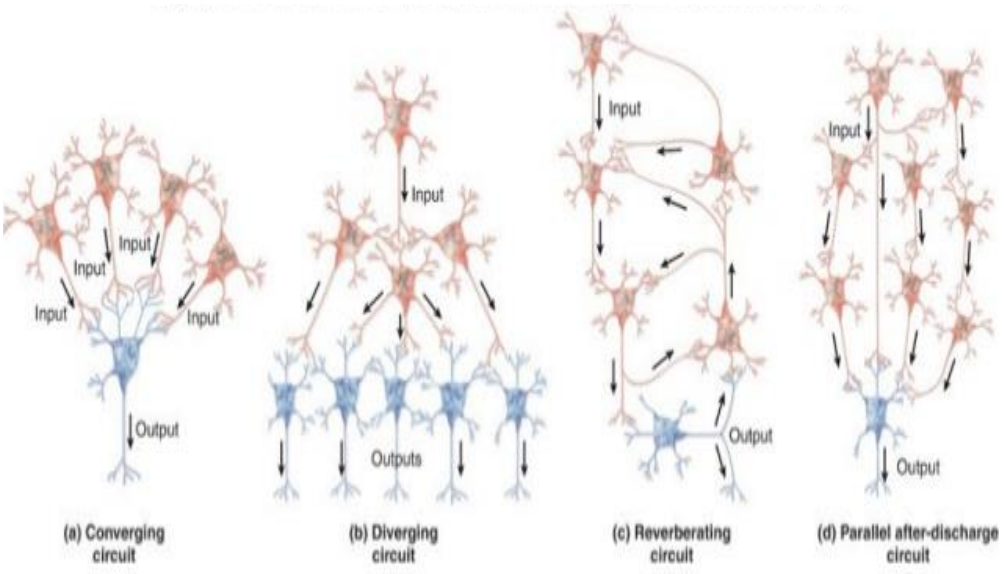
a) Diverging circuit

b) Converging circuit

c) Reverberating circuits

d) Parallel after-discharge circuit

## Divergence and convergence of signals

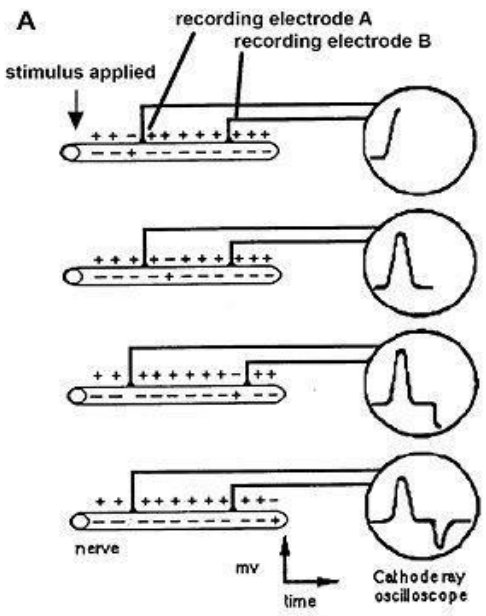



**Convergence:** means signals from multiple inputs uniting to excite a single neuron. Action potentials converging on the neuron from multiple terminals provide enough spatial summation to bring the neuron to its threshold.

**Divergence:** one presynaptic neuron (one axon) that has terminals synapsing with many postsynaptic neurons.

## Measuring action potential

For **biphasic action potential** recording, both the recording electrodes can be placed either in extracellular fluid or intracellular fluid. (we can do this because this action potential has both positive and negative deflections)



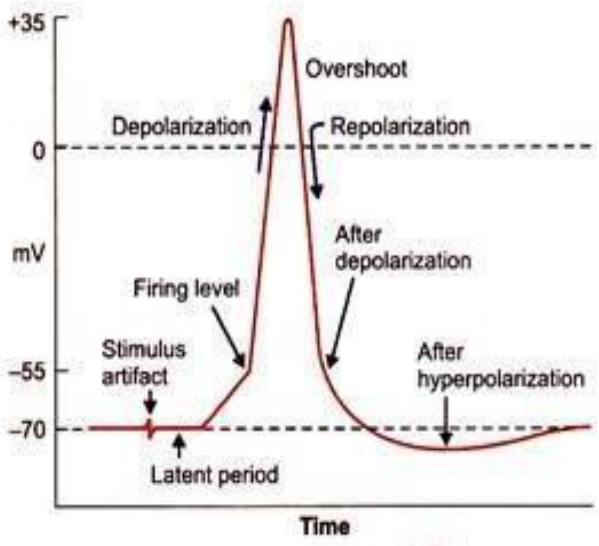

1-In the Y axis when there is no stimulation of the nerve fiber, there is no potential difference between the two recording electrodes and hence the horizontal line is recorded (resting membrane potential)

2- The recording will have two peaks and one will be the mirror image of the other.

*The first wave represents depolarization, the second wave represents repolarization*

3- The duration of the horizontal line between the mirror images will depend on the distance between the two recording electrodes and is directly related. If the electrodes are closer the horizontal line (0 mV) will take a longer time

- Switching the electrodes will result in a mirror image of the graph
- The first wave is always called depolarization wave even if we switched the electrodes.

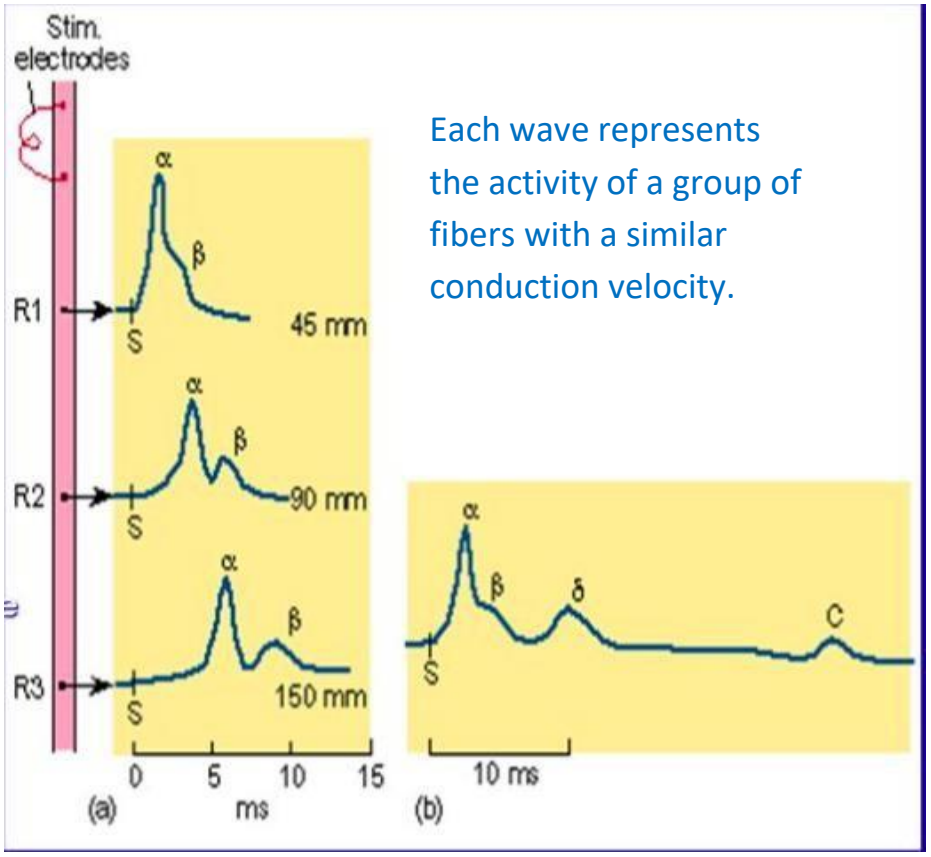



To record a **monophasic action potential**, one of the recording electrodes should be in ECF and the other in ICF.

**For clinical use**, a similar but not the same method is used to record a compound action potential.

In a mixed nerve, action potential appears with multiple peaks and is known as a **compound action potential**. This action potential results from the summation of action potentials of all fibers in the nerve. Its shape is due to the fact that a mixed nerve is made up of different fibers with varying speed of conduction (fibers with larger diameters have less resistance, thus they show greater velocities). Therefore, when all fibers are stimulated, the activity in fast conducting fibers arrives at the recording electrode sooner than the activity in slower fibers. The number and size of the peaks vary with the type of fibers in the particular nerve being studied.

When compound action potentials are recorded; one point on the nerve is stimulated. Then an electrode is placed on the skin near that point, the other electrode is connected to a high resistance (Because we are measuring the change according to the zero voltage). This allows us to get some information about the integrity and functionality of neurons and axons of the nerve fiber (to know if there is any problem in the nerve, fibers or in the conduction).




Each wave represents the activity of a group of fibers with a similar conduction velocity.

As we place the electrode further from the stimulation point, more waves will be recorded due to different velocities of conduction. The first wave represents the bigger nerve fibers because they have the highest velocity. The next wave represents slower fibers, and so on…

**Note:** action potentials cannot be summed when recording for one axon. BUT the sensitivity of recording the activity of group of axons is different, that's why we can see the action potential summing with each other.

### Nice to know

This principle of recording a Biphasic action potential is used to analyze the electrical activities in our body e.g. cardiogram, electroencephalography. When recording such events, very sensitive devices are needed in addition to a quiet environment (reduced breathing, no movement of muscles, no talking) to reduce interferences from other electrical physiological processes.

**Electrocardiograms:** at the heart, some parts are depolarized, and others are polarized. By placing an electrode at the apex and another at the base, we can measure the potential difference between them which reflects what is happening at the level of the heart.

# Autonomic nervous system

→ It adapts our body to the internal and external changes.
→ It has two divisions; sympathetic, and parasympathetic. They both supply the same organs but have opposite effects on them.
→ each system is formed by 2 neurons.

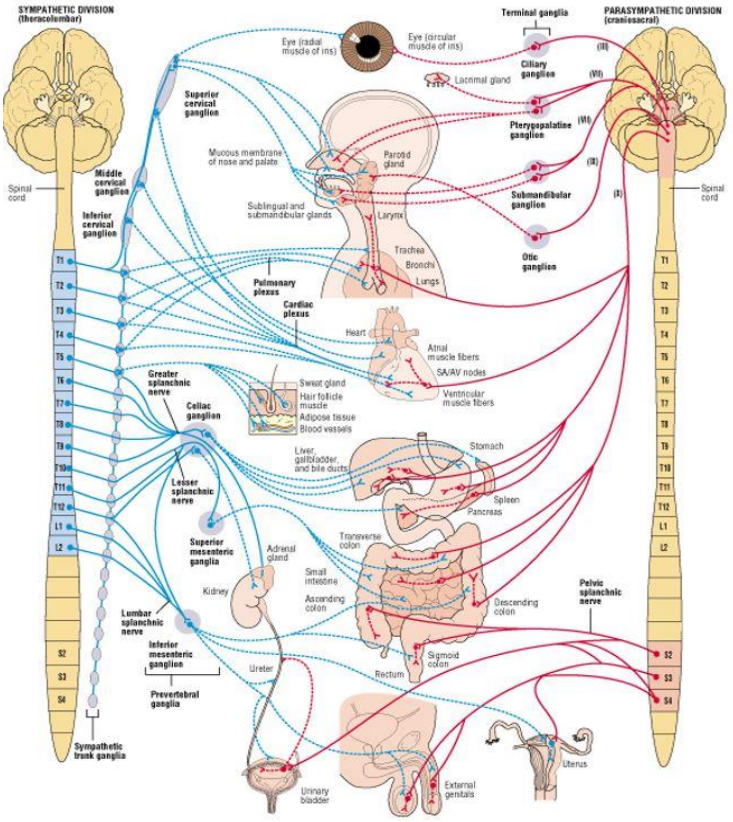
## Important terminology:

**Ganglia**: a structure containing a number of nerve cell bodies, typically linked by synapses. A ganglion is where preganglionic and postganglionic fibers synapse. The preganglionic axon leaves the spinal cord towards the ganglia. In the ganglia are the cell bodies of postganglionic neurons. The terminals of the preganglionic neurons synapse with the with postganglionic neurons.

**Presynaptic fiber**: called the first neuron, a neuron from the axon terminal of which an electrical impulse is transmitted to the cell body or one or more dendrites of a postsynaptic neuron by the release of a chemical neurotransmitter.

**Postsynaptic fiber**: called the second neuron, the neuron than receives the neurotransmitters from the presynaptic fiber.

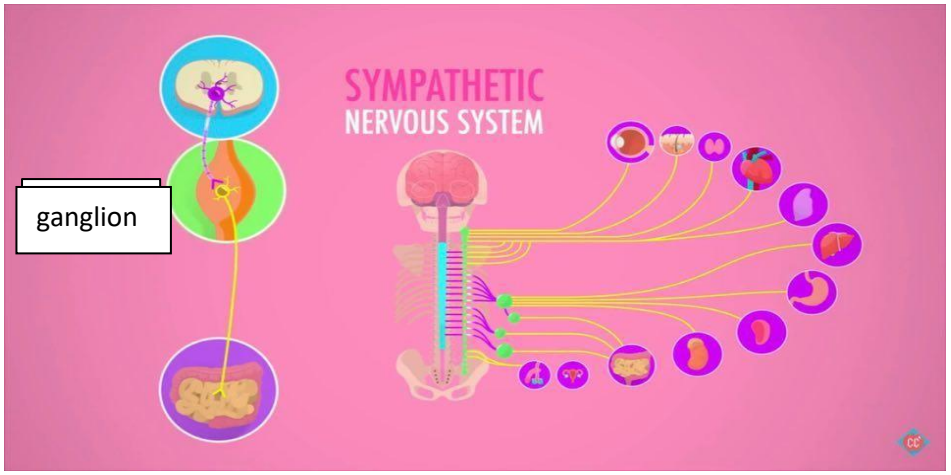
- the presynaptic fiber is located in the central nervous system (in the brain and the spinal cord).
- the postsynaptic fiber is located outside the central nervous system, in the human body.

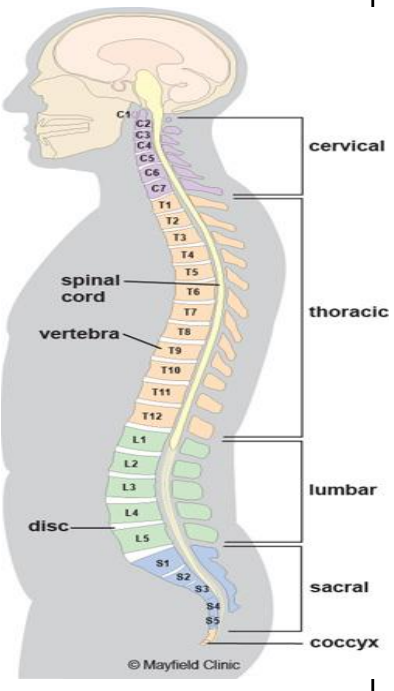


## Comparing sympathetic and parasympathetic systems

| | sympathetic | parasympathetic |
|---|---|---|
| **Similarities:** | 1) From the origin until the effectors each has 2 neurons synapsing with each other.<br>2) The 1st neuron is inside the CNS (brain or spinal cord)<br>3) The 2nd neuron is outside the CNS | |
| **Anatomical differences:**<br>**1-** Origin | Thoracolumbar origin (thorax + lower part of the back) | Craniosacral origin (base of brain + sacrum) |
| **2-** 2nd neuron position | Paravertebral Ganglion, Closer to the spinal cord | Near or inside effector organs (Prevertebral) Like abdominal cavity ganglia celiac ganglia, superior mesenteric ganglia and inferior mesenteric ganglia. |
| **3-** Preganglionic fiber length | Short, ganglia are near the spinal cord | Long, ganglia are far away from the spinal cord |
| **4-** Postganglionic fiber length | Long | short |

Also, in the sympathetic system, some fibers may not synapse neither at the paravertebral nor the prevertebral ganglia. Heading to the suprarenal gland instead, synapsing with endocrine cells. These cells release epinephrine hormone (another name for adrenaline).



## Fight and flight reactions

### The sympathetic system is the one responsible for these reactions.

For example, if someone is in the jungle and they face a predator, the person will have 2 options; either to **fight or flight** away. After seeing the dangerous creature, the sympathetic nervous system forces the muscles to function optimally. A lot of reactions and changes occur in their body including:

- The heart's rate and force of contraction increases, to increase blood supply to other organs and muscles.
- Widely dilated pupils, to improve the person's vision.
- Pallor, (pale skin) which happens because more blood is supplied to muscles instead of skin. So, blood vessels near the skin constrict. Also, other systems activity is reduced during this time, like the urinary system.
- goose pimples (the bumps on a person's skin at the base of body hairs), goose bumps are created when tiny muscles at the base of each hair, known as *arrector pili muscles* contract and pull the hair erect.
- Cold sweat, blood flow heats the sweat in normal conditions. Since the flow is reduced the sweat won't be heated.
- Dry mouth. Because saliva secretion is reduced.

## Paravertebral and Prevertebral ganglia

**Paravertebral ganglia**: *(para means occurring besides)* are ganglia corresponding to the vertebrae along the length of the sympathetic trunks, they exist at both sides of the body.

- The first neuron's axon leaves the spinal cord towards the ganglia, in the paravertebral ganglia the cell bodies of the second neuron are present, the axon terminal of the first neuron synapses with the second neuron
- an axon has many terminals and each of these terminals can synapse with a different neuron cell, so a single cell might influence many other cells (this is called **Divergence**)

- also, some axon terminals may not synapse at this level, leaving the paravertebral ganglia and going to the abdominal cavity, there we can find 3 more ganglia, which are the **prevertebral ganglia**, they are solitary ganglia, existing only in one side of the body. Those 3 ganglia are: **celiac ganglia**, **superior mesenteric ganglia** and i**nferior mesenteric ganglia**.

**Prevertebral ganglia**: sympathetic ganglia which lie between the Paravertebral ganglia and the target organ.

- Also, some fibers may not synapse neither at the **para** nor at the **pre**vertebral ganglia, heading to the suprarenal gland, synapsing with endocrine cells there, these cells release **epinephrine** hormone (a new name for adrenaline).

**Notes:**

- To summarize the previous events, we have 3 levels of synapses, the first is at the paravertebral ganglia, the second is at the prevertebral ganglia and the third is in the suprarenal gland. the first neurons reach the ganglia and the suprarenal gland in the previous levels.
- in sympathetic system there are many convergences and many divergences, this makes the effect of this system generalized rather than localized like the effect of parasympathetic system.
- **the presence of convergence and divergence** helps the sympathetic system to show these mentioned effects at the same time. The absence of convergence and divergence in the parasympathetic system makes its effect localized. If a signal was sent to the stomach to start digesting, the heart rate will not be affected…

## Useful video:

https://www.youtube.com/watch?v=71pCilo8k4M

## Good luck