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لجان الرُفَعَات



تفريخ فسيولوجي

موضوع المحاضرة: Nervous system

رقم المحاضرة: 6

إعداد الصيدلانية: إسلام





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LECTURE 5- PARTS (1) & (2)

Objectives

1. Discuss **signal transmission** at **synapses**.
2. Distinguish **spatial and temporal summation of postsynaptic potentials**.

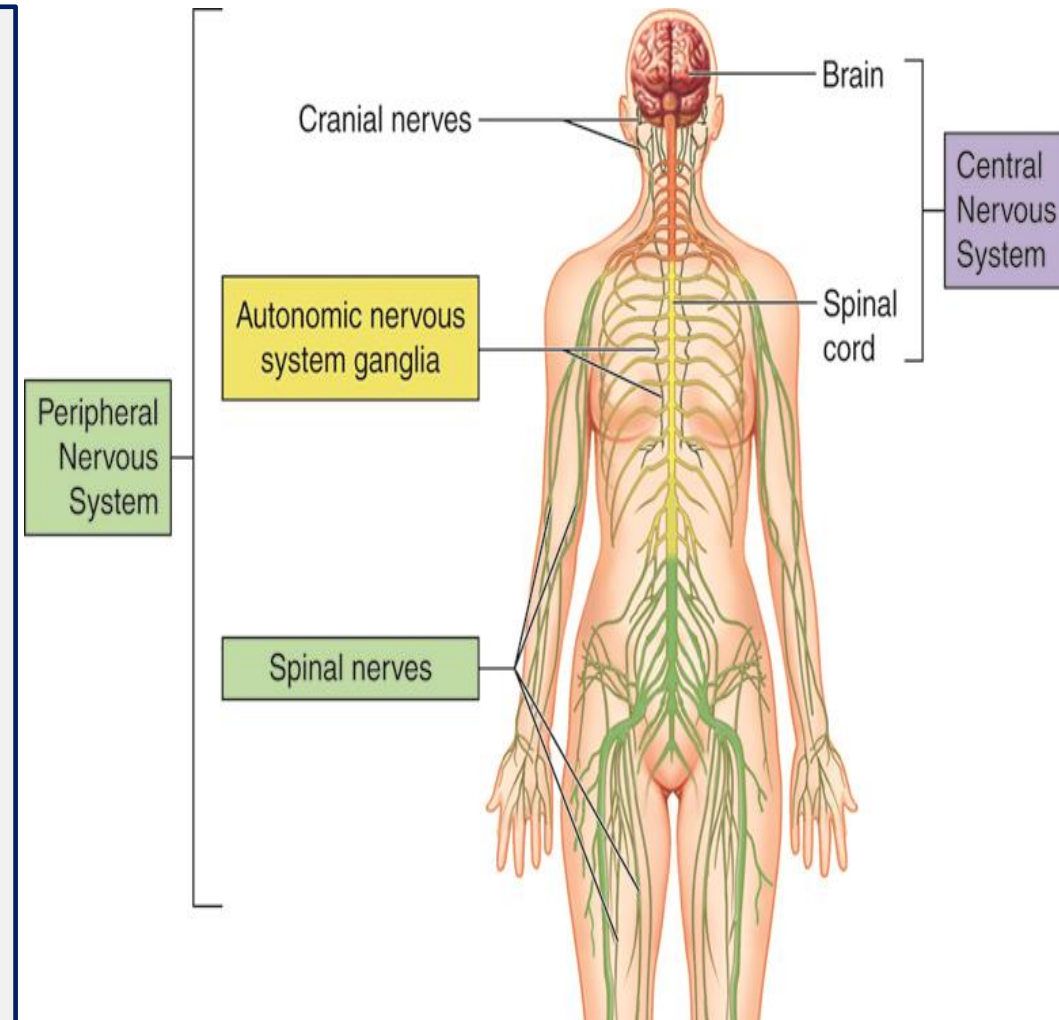
(Pages 424-436 of the reference).

General Overview



NERVOUS SYSTEM

- It consists of **central nervous system (CNS)** and **peripheral nervous system (PNS)**.
- The **CNS** consists of brain (85 billion neurons) and spinal cord (100 million neurons.).
- The **PNS** consists of all nervous tissue outside the CNS, which include nerves, ganglia, enteric plexuses, and sensory receptors.



SIGNAL TRANSMISSION AT SYNAPSES

- ✓ Recall from lecture 3 that **a synapse** is a region where communication occurs between two neurons or between a neuron and an effector cell.
- ✓ The term **presynaptic neuron** refers to a nerve cell that carries a nerve impulse toward a synapse (sends a signal).

ال neuron الذي ياتي قبل ال synapse

SIGNAL TRANSMISSION AT SYNAPSES

وال neuron يلي بعد ال synapse

- ✓ A **postsynaptic cell** is the cell that receives a signal. It may be a nerve cell called a **postsynaptic neuron** that carries a nerve impulse away from a synapse or an **effector cell** that responds to the impulse at the synapse.

SYNAPSES BETWEEN NEURONS

- Synapses may be **electrical or chemical** and they differ both structurally and functionally.

ELECTRICAL SYNAPSES

- At an electrical synapse, **action potentials (impulses)** **conduct directly** between the plasma membranes of adjacent neurons through structures called **gap junctions**.
- Each gap junction contains a **hundred or so tubular connexons**, which act like tunnels to connect the cytosol of the two cells directly.

انابيپ داخل ال gap junctions

ELECTRICAL SYNAPSES

وبعض انواع ال electrical impulses في

سؤال مهم : اهم الاعضاء او. ال effector يلي بتعمل electrical synapse ؟ اهم مثالين ال brain وال cardiac muscle

■ Gap junctions are common in visceral smooth muscle, cardiac muscle, and the developing embryo. They also occur in the brain.

مش دائماً عمليه انتقال ال action potential من neuron الى اخر شرط تتضمن خروج الناقل العصبي من الاول ويرتبط بالثاني بعض الاحيان تكون ال cell body لل neuron بيناتهم روابط هذه الروابط تسمى ال gap junctions تربط ال cell body الاول بالثاني فينتقل ال action potential الموجود في ال cell body للعصب الاول ينتقل مباشره للثاني للثالث للرابع .

ال electrical synapse اسرع من ال chemical لان ال action potential ينتقل مباشره للثاني والثالث والرابع .

ELECTRICAL SYNAPSES HAVE TWO MAIN ADVANTAGES:

Faster communication (At an electrical synapse, the action potential passes directly from the presynaptic cell to the postsynaptic cell. The events that occur at a chemical synapse take some time and delay communication slightly).

* ينتقل بسرعة من ال neuron
الاول الى ال neuron الثاني

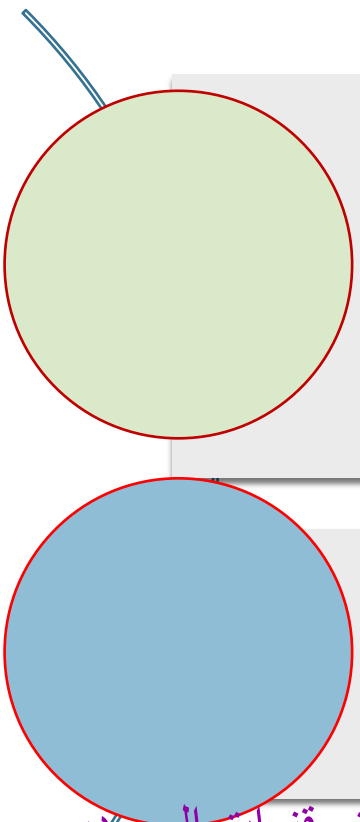
Synchronization (large number of neurons or muscle fibers can produce action potentials in unison if they are connected by gap junctions).

من سرعه نقل ال data من عصب لآخر ال data تبقى على العصبين

نشعر بأن ال action potential على كل ال neurons

CHEMICAL SYNAPSES

نحتاج فيه الى ناقلات عصبية

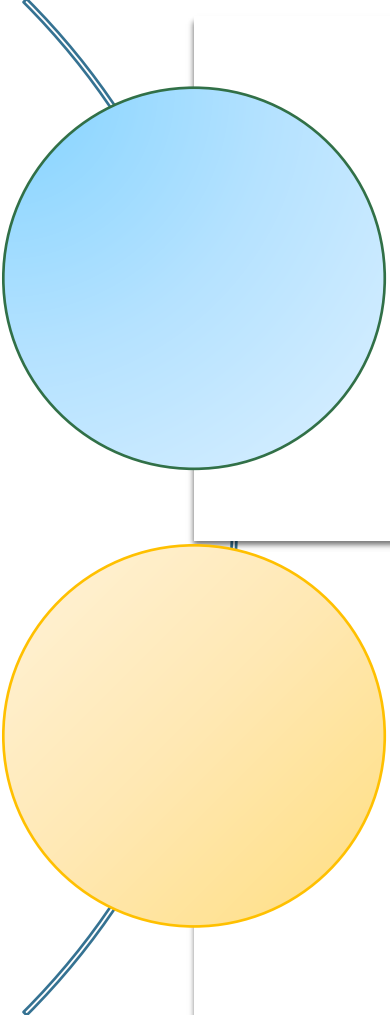


The **plasma membranes of presynaptic and postsynaptic neurons** in a chemical synapse are separated by the **synaptic cleft**, a space of 20–50 nm that is filled with interstitial fluid.

Nerve impulses cannot conduct across the synaptic cleft (**indirect form of communication**).

انتاج ال action potential عن طريق الخلية : عن طريق ال channels تفتح واحده من هذه القنوات الاربعه تفتح قنوات الصوديوم يدخل الى الخلية يصل الى ال threshold ثم depolarization يخرج prepolarization يتحرك ال action potential عن طريق ال axon تخرج النواقل العصبية وتذهب الى synaptic cleft of synapse لل neuron الثاني وترتبط مع المستقبل هذا ال synapse يسمى chemical synapse (فنحن بحاجة الى جزئيات كيميائية وهي الناقلات العصبية)

CHEMICAL SYNAPSES

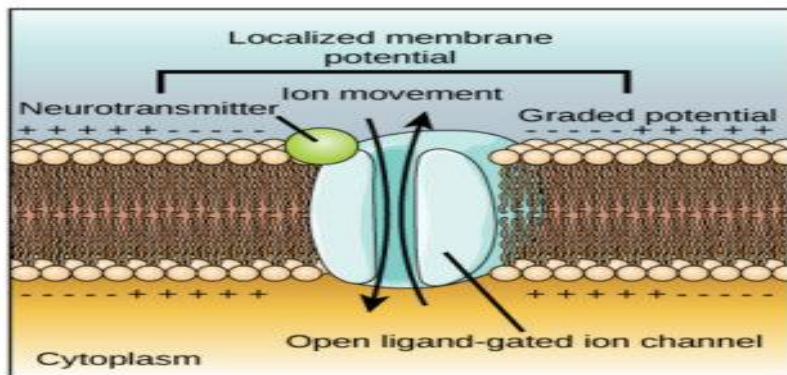
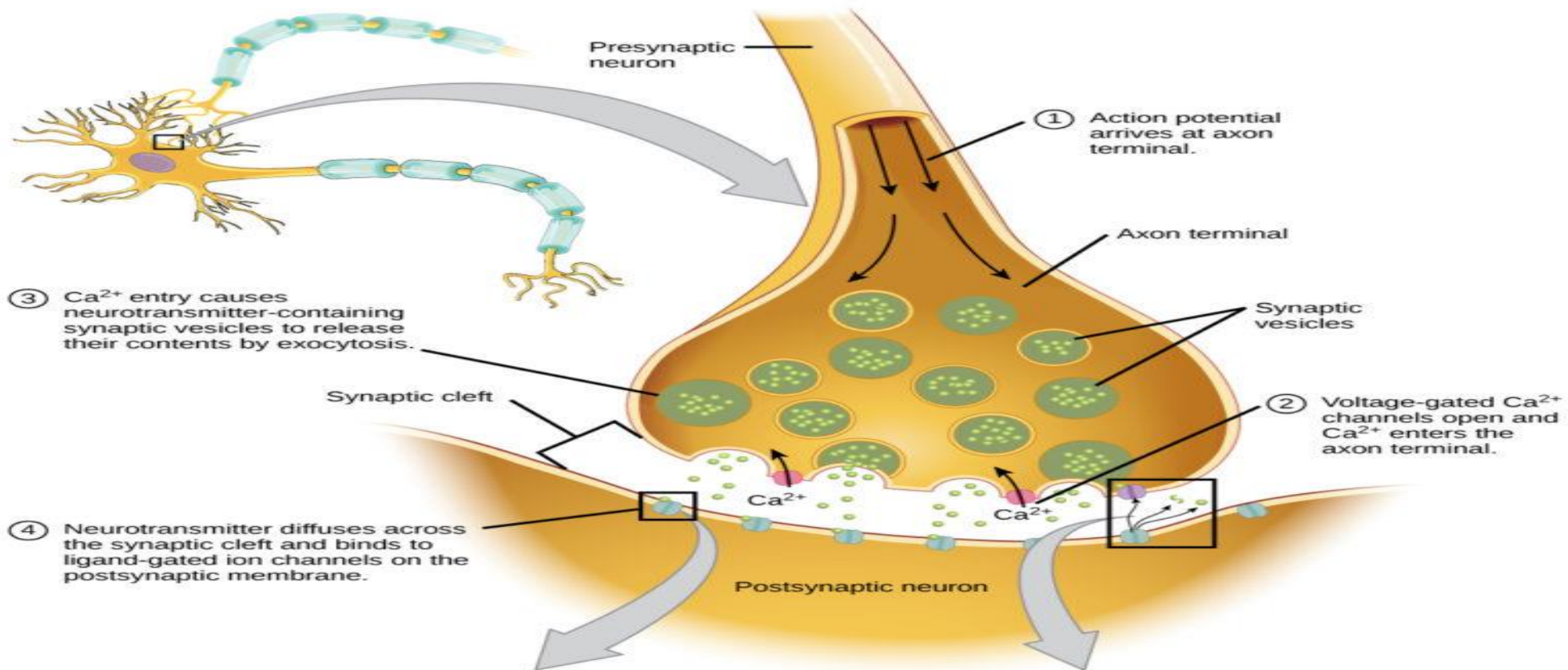


In **response to a nerve impulse**, the presynaptic neuron releases a **neurotransmitter** that diffuses through the fluid in the synaptic cleft and binds to receptors in the plasma membrane of the postsynaptic neuron.

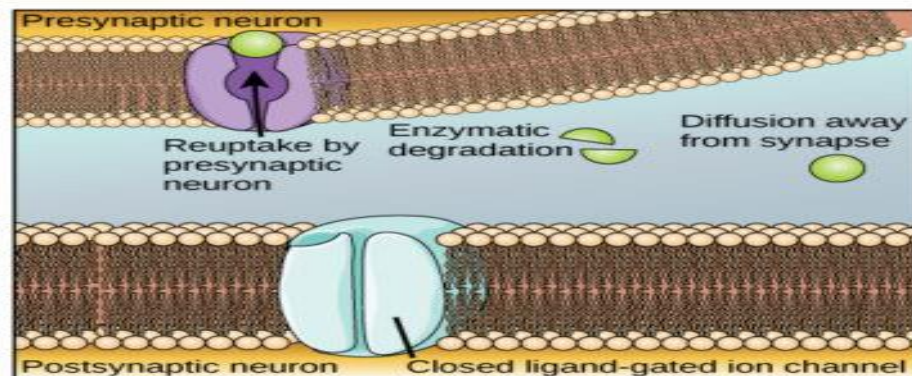
The **postsynaptic neuron** receives the chemical signal and in turn produces a **postsynaptic potential**, a type of **graded potential**.

CHEMICAL SYNAPSES

- Thus, the presynaptic neuron converts an electrical signal (nerve impulse) into a chemical signal (released neurotransmitter).
- The time required for these processes at a chemical synapse, a synaptic delay of about 0.5 msec, is the reason that chemical synapses relay signals more slowly than electrical synapses.



5 Binding of neurotransmitter opens ligand-gated ion channels, resulting in graded potentials.

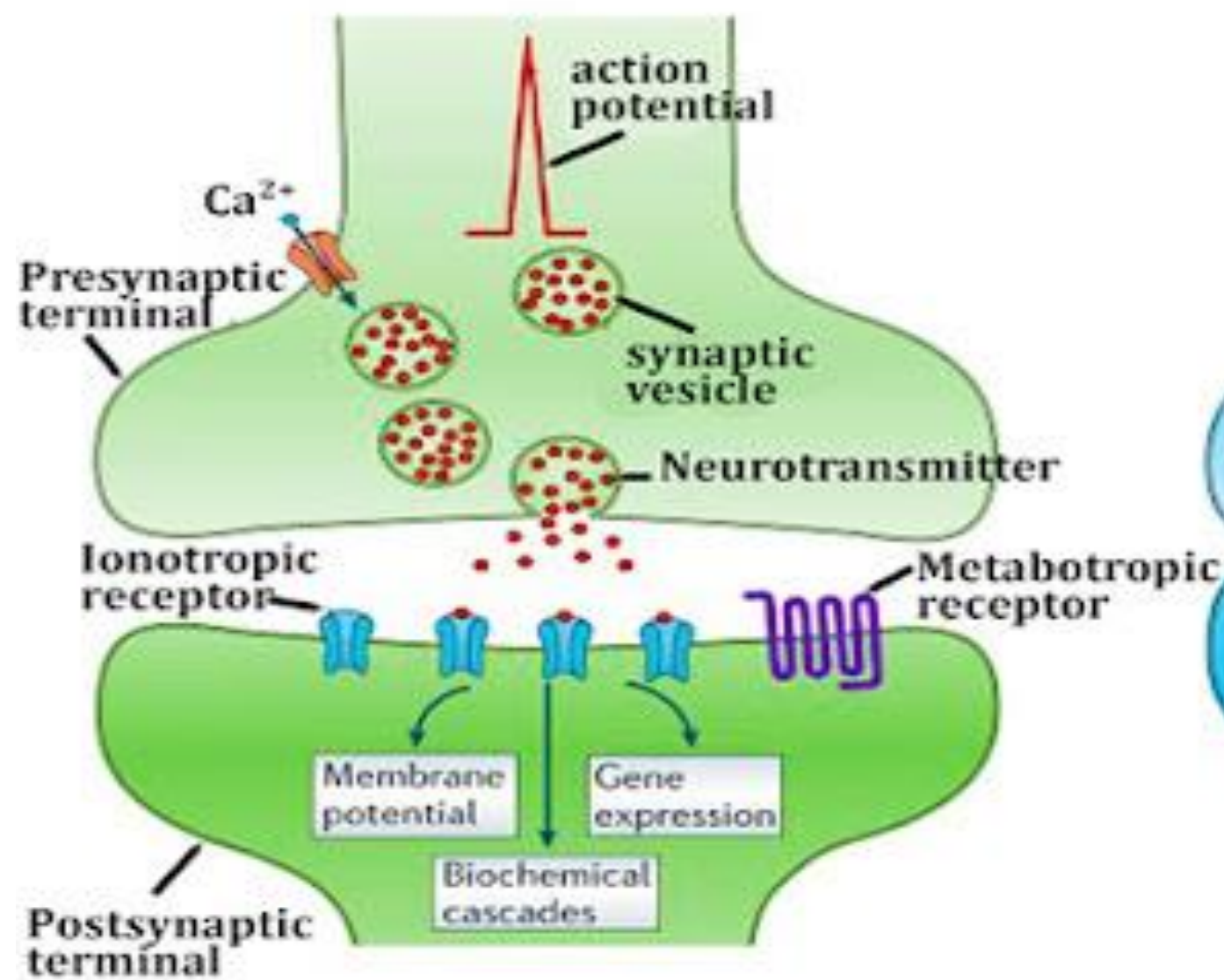


6 Reuptake by the presynaptic neuron, enzymatic degradation and diffusion reduce neurotransmitter levels, terminating the signal.

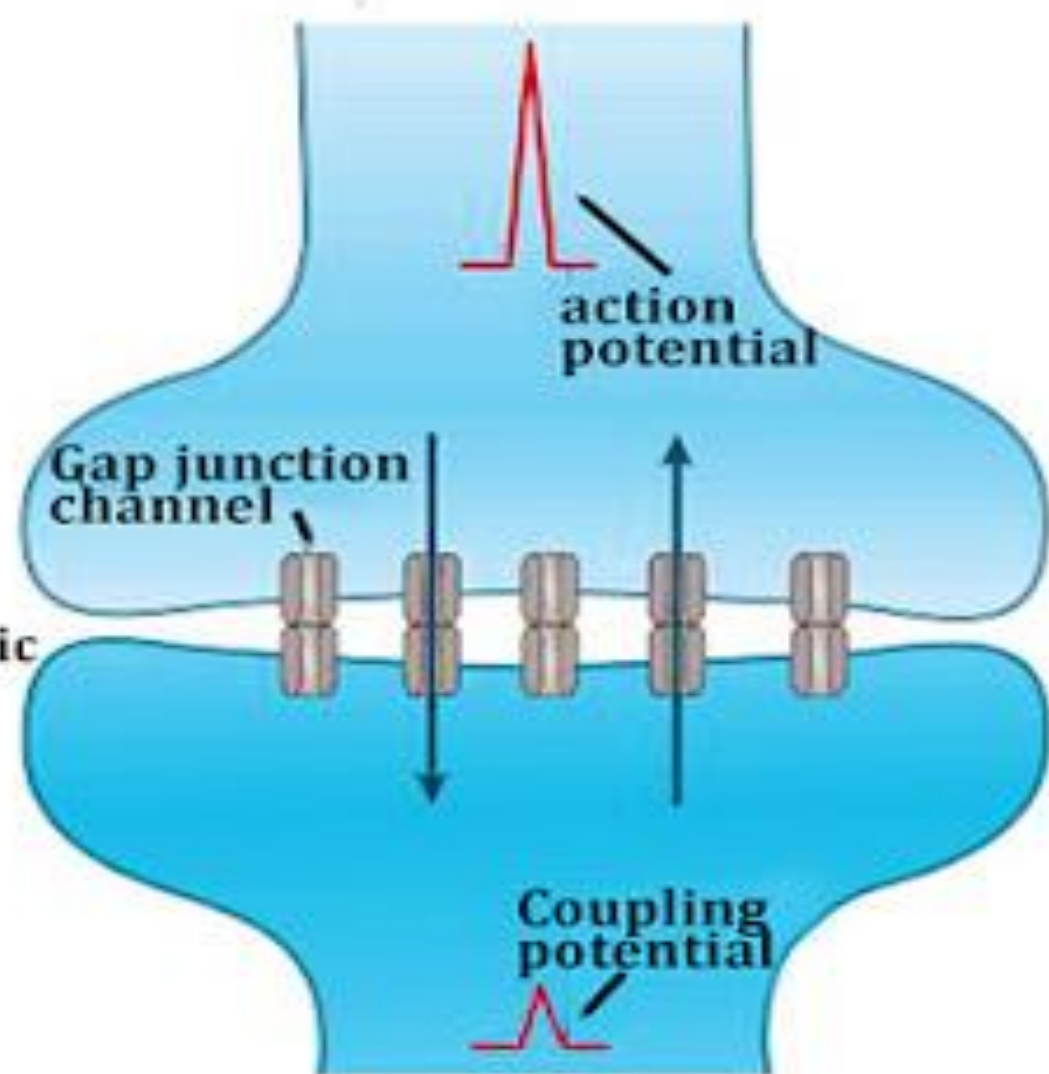
Postsynaptic potential

- Opening of Na^+ ions channels allows inflow of Na^+ ions, which causes depolarization.
- However, opening of Cl^- or K^+ ions channels causes hyperpolarization.
- When a depolarizing postsynaptic potential reaches threshold, it triggers an action potential in the axon of the postsynaptic neuron.

Chemical synapse



Electrical synapse



EXCITATORY AND INHIBITORY POSTSYNAPTIC POTENTIALS

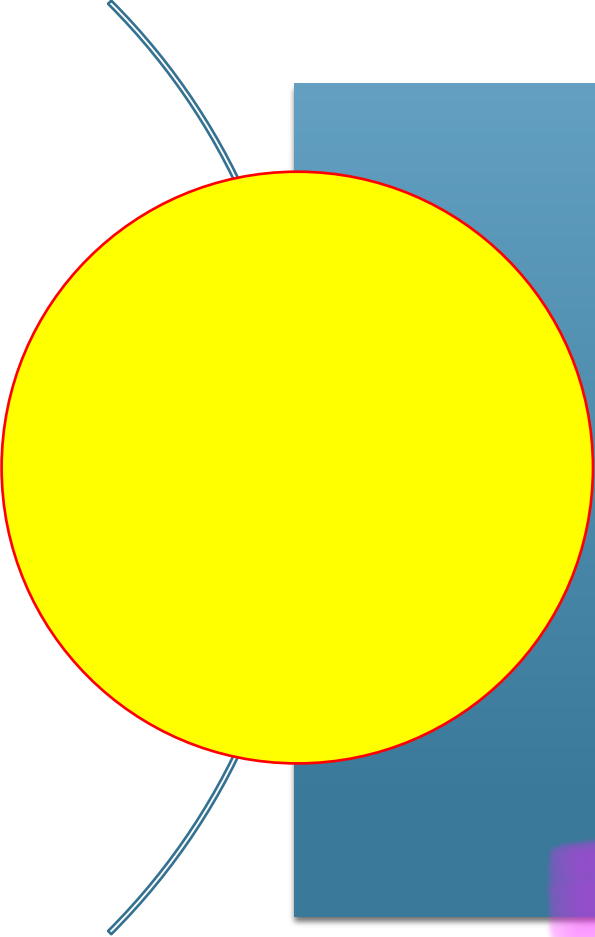
activation/excitation

Depolarization of the postsynaptic membrane is excitatory because it brings the membrane closer to threshold. A **depolarizing postsynaptic potential** is called an **excitatory postsynaptic potential (EPSP)**.

يعني لو وصل action potential على ال post synaptic neuron هذا ال potential رح يعمل activation
للخلية بكون اسمه depolarization post synaptic potential وبديل كلمه depolarization بنحط excitatory

EXCITATORY AND INHIBITORY POSTSYNAPTIC POTENTIALS

inhibition



During **hyperpolarization**, generation of an action potential is more difficult than usual because the membrane potential becomes inside more negative and thus even farther from threshold than in its resting state. A **hyperpolarizing postsynaptic potential** is termed an **inhibitory postsynaptic potential (IPSP)**.

إذا عملنا inactivation لل parasympathetic بصير اسمه inhibitory post synaptic potential

STRUCTURE OF NEUROTRANSMITTER RECEPTORS

Neurotransmitter receptors are classified as either **ionotropic receptors** or **metabotropic receptors** based on whether the neurotransmitter binding site and the ion channel are components of the same protein or are components of different proteins.

المستقبل الذي يرتبط مع Ach و adrenaline وال noradrenaline موجود على ال dendrite .

ال channels مش دائما بتكون جنب المستقبل أحيانا تكون بعيدة عن المستقبل .

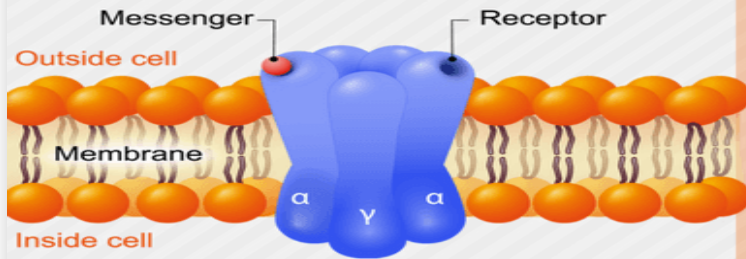
IONOTROPIC vs METABOTROPIC RECEPTORS

WWW.INTERACTIVE-BIOLOGY.COM

IONOTROPIC RECEPTORS

both are ligand-gated transmembrane proteins

Acts quickly.



Ionotropic receptors change shape when they are bound by a ligand. This change in shape creates a channel that allows ions to flow through.

METABOTROPIC RECEPTORS

Takes a little longer depending on the number of steps required to produce a response.

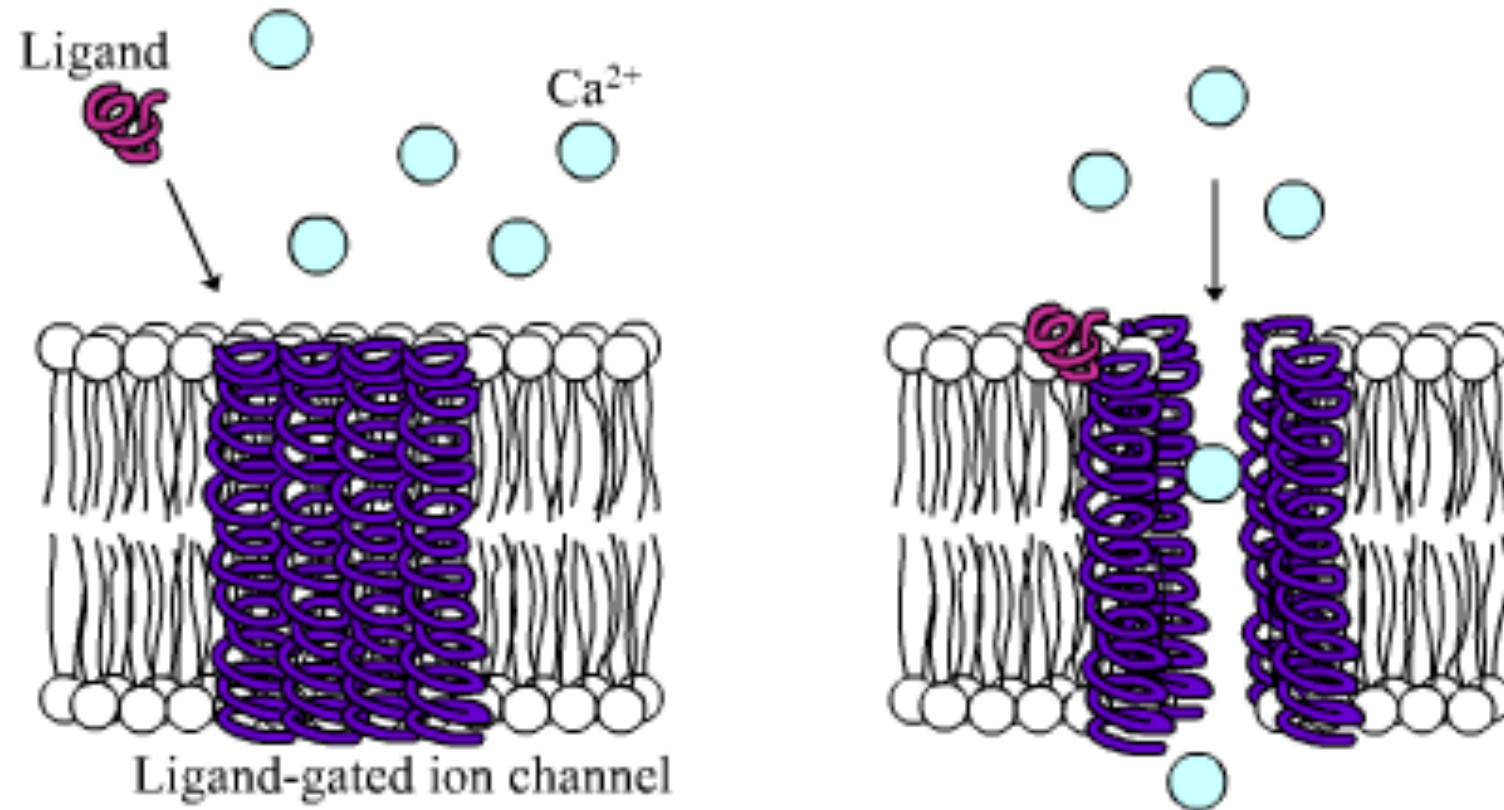
Metabotropic receptors do not have channels.

Metabotropic receptors activate a G-protein that in turn activates a secondary messenger, that in turn will activate something else.

Metabotropic receptor activation may or may not result in the opening of ion channels somewhere else on the membrane.

More on this at www.interactive-biology.com

IONOTROPIC RECEPTORS



IONOTROPIC RECEPTORS

- is a type of **neurotransmitter receptor** that contains a neurotransmitter binding site and an ion channel (i.e neurotransmitter binding site and the ion channel are components of the same protein).

IONOTROPIC RECEPTORS

- *When the correct neurotransmitter binds to the ionotropic receptor, the ion channel opens, and an EPSP or IPSP occurs in the postsynaptic cell.*

METABOTROPIC RECEPTORS

is a type of neurotransmitter receptor that contains a **neurotransmitter binding** site but **lacks an ion channel** as part of its structure. However, a metabotropic receptor is **coupled to a separate ion channel** by a type of membrane protein called a **G protein**.

METABOTROPIC RECEPTORS

- When a neurotransmitter binds to a metabotropic receptor, the **G protein either directly** opens (or closes) the ion channel or it may act **indirectly** by activating another molecule, a **“second messenger,”** in the cytosol, which in turn opens (or closes) the ion channel.
- Thus, a metabotropic receptor differs from an ionotropic receptor in that the neurotransmitter binding site and the ion channel are components of **different proteins.**

REMOVAL OF NEUROTRANSMITTER

- is essential for **normal synaptic function**. If a neurotransmitter could linger in the synaptic cleft, it would influence the postsynaptic neuron, muscle fiber, or gland cell indefinitely.

REMOVAL OF NEUROTRANSMITTER

1. *Diffusion*: Neurotransmitters diffuse away from the synaptic cleft.
2. *Enzymatic degradation*: Certain neurotransmitters are inactivated through enzymatic degradation.
3. *Uptake by cells*: Many neurotransmitters are actively transported back into the neuron that released them (reuptake). Others are transported into neighboring neuroglia (uptake).

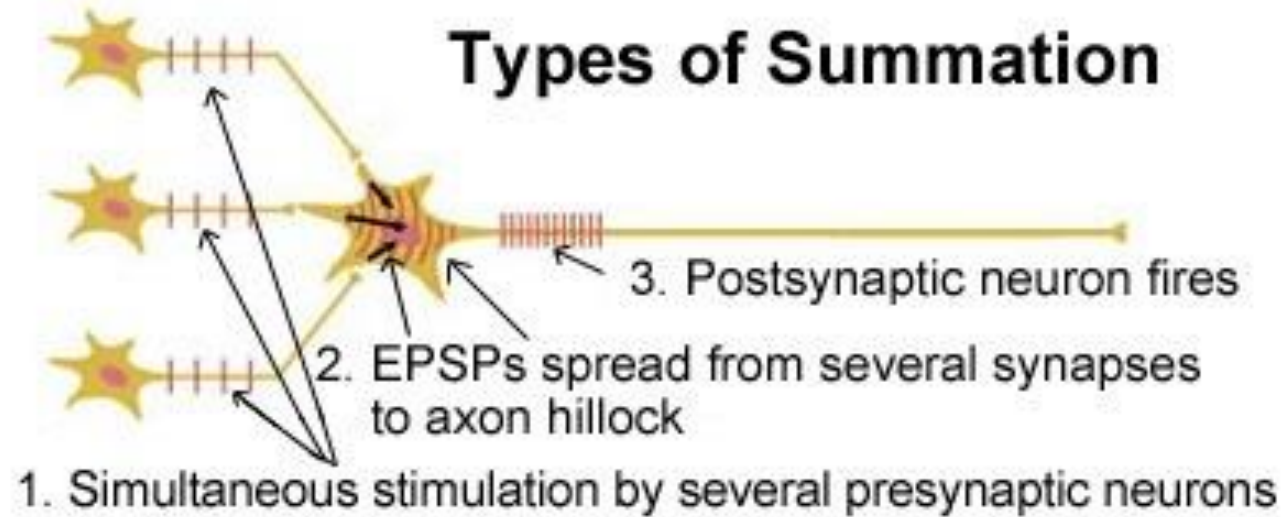
SPATIAL AND TEMPORAL SUMMATION OF POSTSYNAPTIC POTENTIALS

- A typical neuron in the CNS receives input from 1000 to 10,000 synapses.
- Integration of these inputs involves summation of the postsynaptic potentials that form in the postsynaptic neuron. Recall that summation is the process by which graded potentials add together.

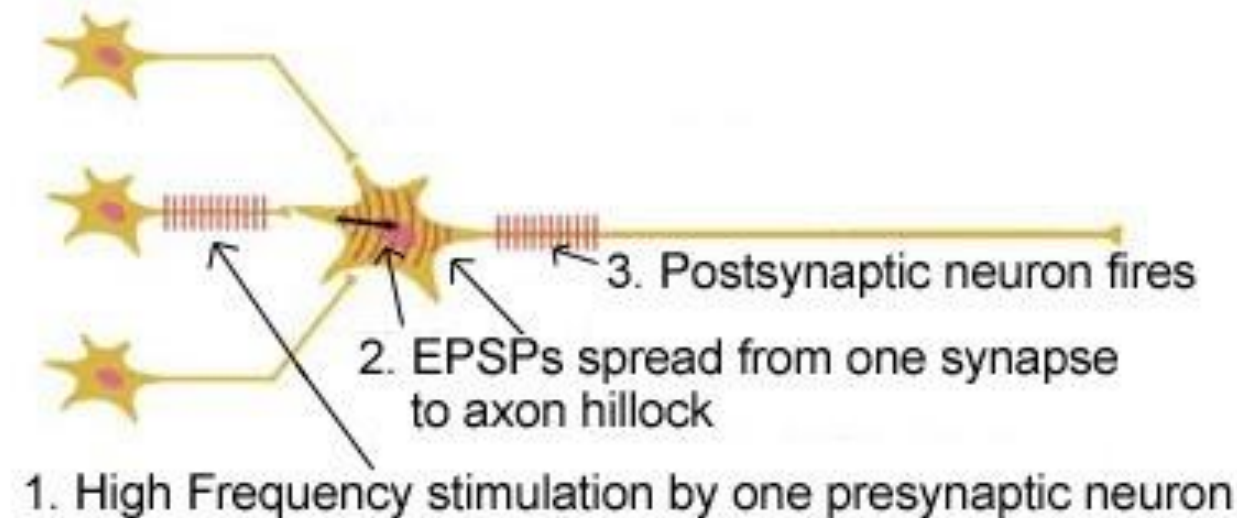
SPATIAL AND TEMPORAL SUMMATION OF POSTSYNAPTIC POTENTIALS

- The greater the summation of EPSPs, the greater the chance that threshold will be reached. At threshold, one or more nerve impulses **(action potentials)** arise.

Types of Summation



Spatial summation



Temporal summation

SPATIAL AND TEMPORAL SUMMATION OF POSTSYNAPTIC POTENTIALS

- There are two types of summation: **spatial summation and temporal summation.**
- **Spatial summation** is summation of postsynaptic potentials in response to stimuli that occur at **different locations in the membrane of a postsynaptic cell at the same time.**

SPATIAL AND TEMPORAL SUMMATION OF POSTSYNAPTIC POTENTIALS

- **Temporal summation** is summation of postsynaptic potentials in response to stimuli that occur at the **same location in the membrane of the postsynaptic cell but at different times.**

SMALL-MOLECULE NEUROTRANSMITTERS

■ Acetylcholine (ACh)

- Released by many PNS neurons & some CNS neurons.
- Excitatory neurotransmitter on neuromuscular junction (NMJ) but inhibitory neurotransmitter at others.
- Inactivated by acetylcholinesterase.

■ Amino Acids

- المطلوب فقط ■ Glutamate released by nearly all excitatory neurons in the brain - inactivated by glutamate specific transporters
- تعداد في الامتحان ■ Gamma-aminobutyric acid (GABA) is inhibitory neurotransmitter (blocking brain signals) for 1/3 of all brain synapses (Antianxiety drugs such as diazepam (Valium) is a GABA agonist -- enhancing GABA's inhibitory effect).

SMALL-MOLECULE NEUROTRANSMITTERS

■ Biogenic Amines

على ال amino acid عملنا
decarboxylation فنتج

- Certain amino acids are modified and decarboxylated (carboxyl group removed) to produce biogenic amines .
- They are prevalent in the nervous system include norepinephrine, epinephrine, dopamine, histamine and serotonin.
- Biogenic amines may cause either excitation or inhibition, depending on the type of metabotropic receptor at the synapse.

نواقل عصبية اخرى سندرسها لاحقا :
dopamine, histamine , serotonin
بعض الاماكن تعمل excitation وبعض
الاماكن تعمل inhibition

NEURAL CIRCUITS

- The CNS contains **billions of neurons organized into complicated networks** called **neural circuits**, functional groups of neurons that process specific types of information.
- In a **simple series circuit**, a **presynaptic neuron stimulates a single postsynaptic neuron**. The second neuron then stimulates another, and so on.
- The **divergence**, permits one presynaptic neuron to **influence several postsynaptic neurons** (or several muscle fibers or gland cells) at the same time.

NEURAL CIRCUITS

- **Convergence**, several **presynaptic neurons synapse with a single postsynaptic neuron**.
- Stimulation of the presynaptic cell causes the postsynaptic cell to transmit a series of nerve impulses. One such circuit is called a **reverberating circuit**. **This arrangement sends impulses back through the circuit again and again.**
- Fourth type of circuit is the **parallel after-discharge circuit**. In this circuit, a **single presynaptic cell stimulates a group of neurons, each of which synapses with a common postsynaptic cell**. A differing number of synapses between the first and last neurons imposes varying synaptic.

المحفز يؤثر

على

sensory

neuron واحد

(يعني يوجد)

input واحد

هذا input

يؤثر على 2

sensory

neurons هذا

ال sensory

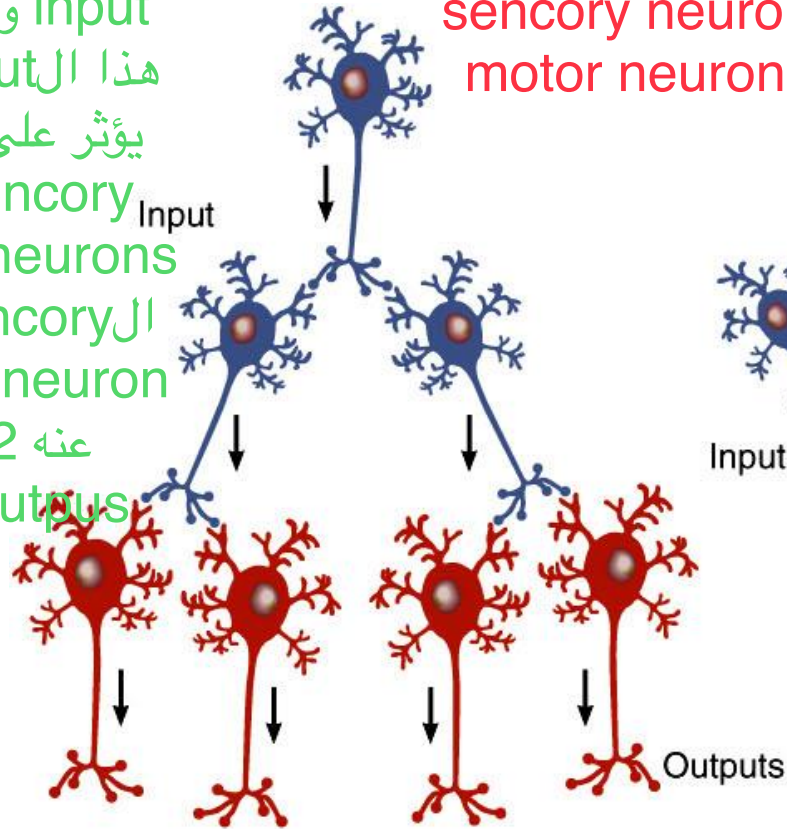
neuron ينتج

عنه 2

(outputs)

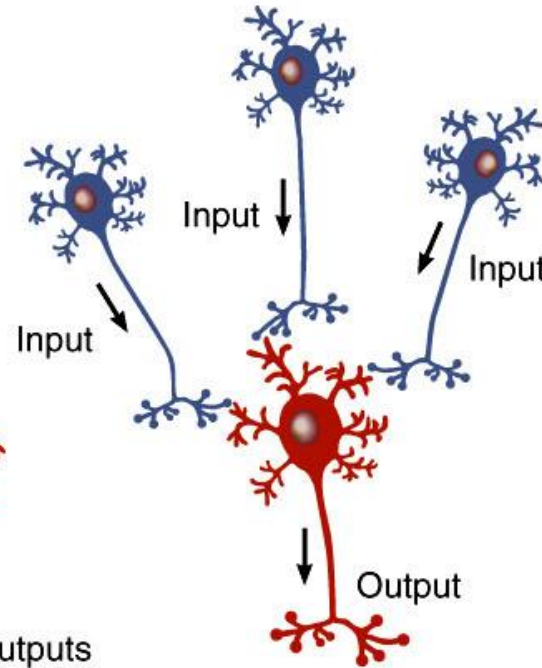
NEURAL CIRCUITS

اللون الازرق sensory neuron
اللون الاحمر motor neuron

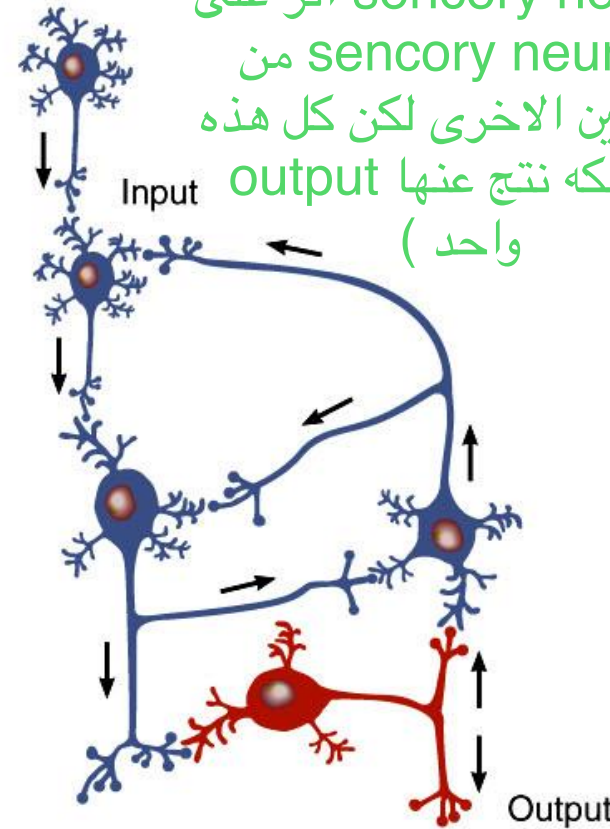


(a) Diverging circuit

تضاعف / دمج

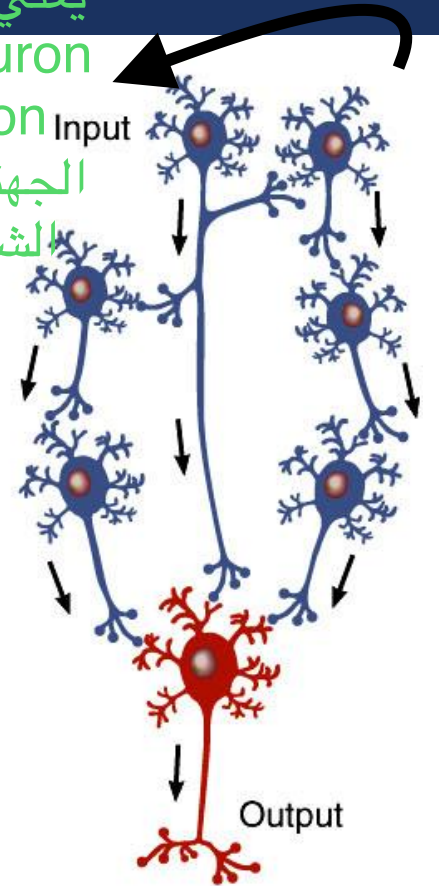


(b) Converging circuit



(c) Reverberating circuit

مستمره لا تتوقف



(d) Parallel after-discharge circuit

متوازي

يعني على الجهتين (1 input)
sensory neuron اثر على
sensory neuron من
الجهتين الاخرى لكن كل هذه
الشبكة نتج عنها output
(واحد)



THANK YOU

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