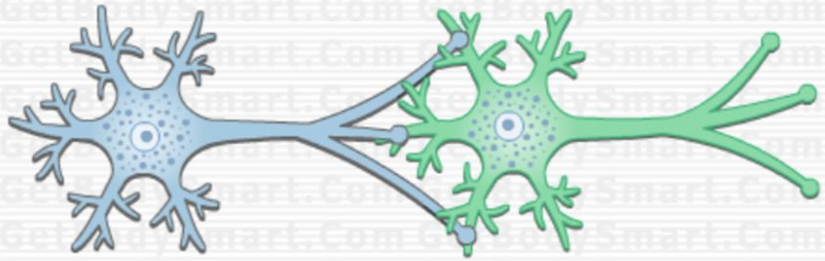
Features of synaptic transfer

http://www.mind.ilstu.edu/curriculum/neurons_intro/neurons_intro.php

Plan

- Types of synapses ,their structure
- Functions of membranes of synapses
- Mechanism of excitement distribution in a synapse
- Generation of postsynaptic potentials
- Properties of synapses



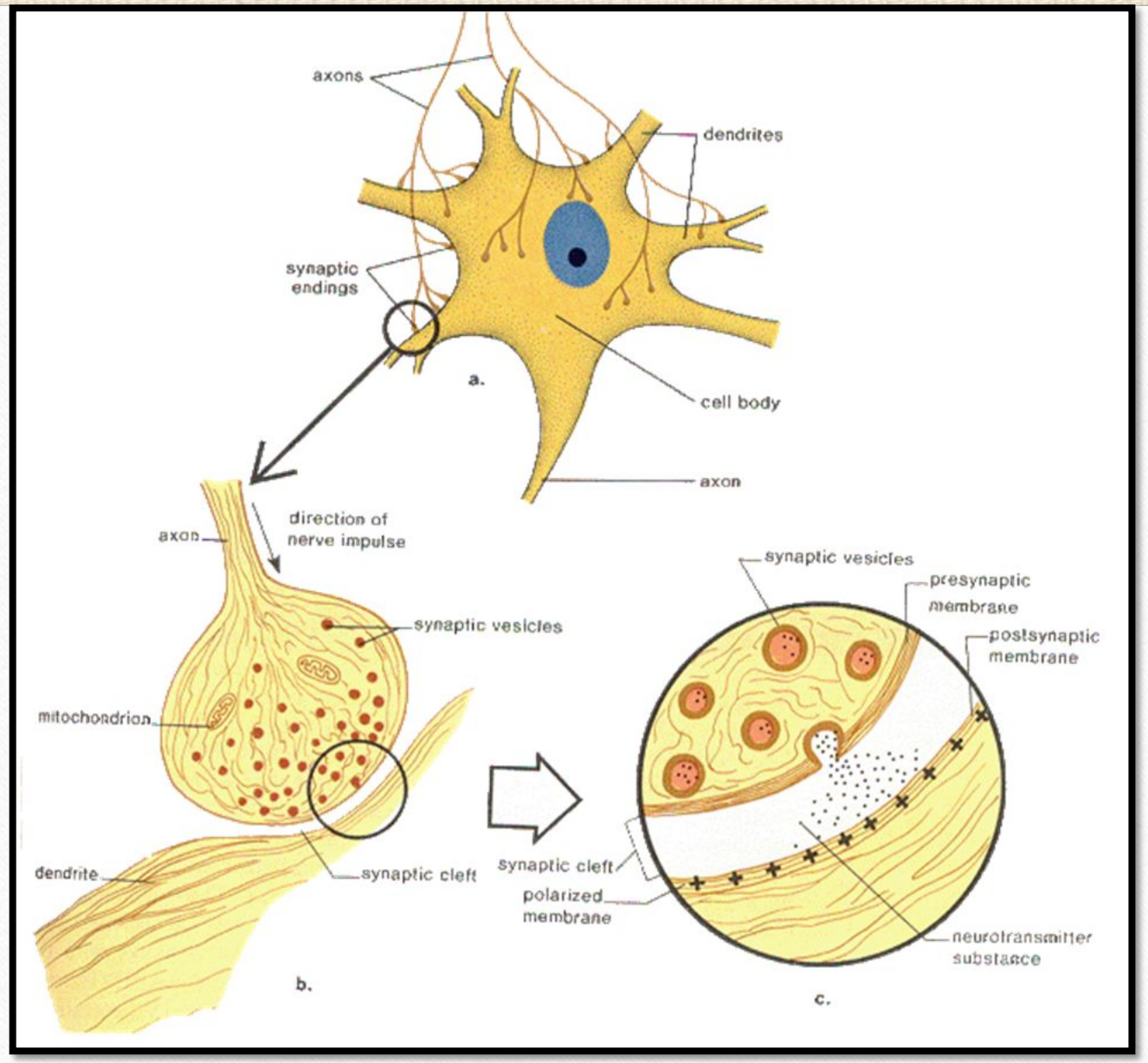
Definition

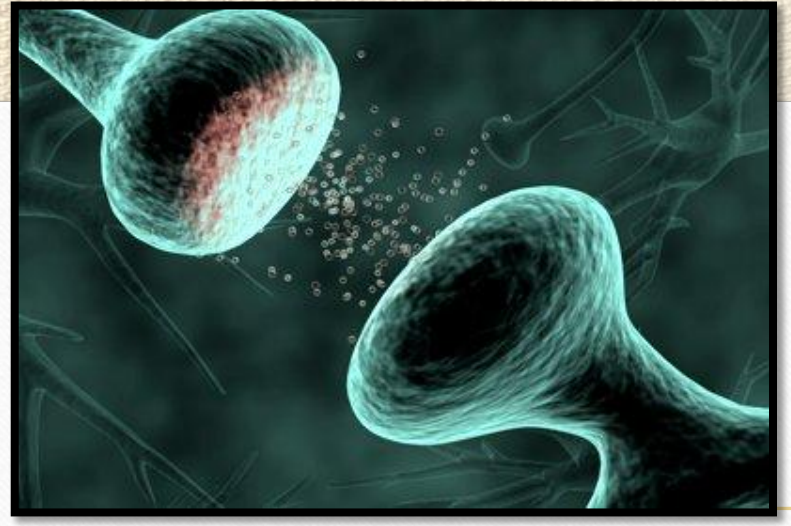
- The junction between two neurons is called a synapse.
- It is a specialized junction where transmission of information takes place between a nerve fibre and another nerve, muscle or gland cell.
- It is not the anatomical continuation. But, it is only a physiological continuity between two nerve cells.

Structure

The synapse consists of:

1. A **presynaptic ending** that contains neurotransmitters, mitochondria and other cell organelles.
2. A **postsynaptic ending** that contains receptor sites for neurotransmitters.
3. A **synaptic cleft** or space between the presynaptic and postsynaptic endings. It is about 20nm wide.


axons
dendrites
synaptic endings
a.
cell body
axon
direction of nerve impulse
axon
synaptic vesicles
mitochondrion
dendrite
synaptic cleft
b.
synaptic vesicles
presynaptic membrane
postsynaptic membrane
synaptic cleft
polarized membrane
neurotransmitter substance
c.



Function

- The main function of the synapse is to transmit the impulses, i.e. action potential from one neuron to another.
- They allow integration, e.g. an impulse travelling down a neuron may reach a synapse which has several post synaptic neurons, all going to different locations. The impulse can thus be dispersed. This can also work in reverse, where several impulses can converge at a synapse

Types

1. Synapse with another neuron

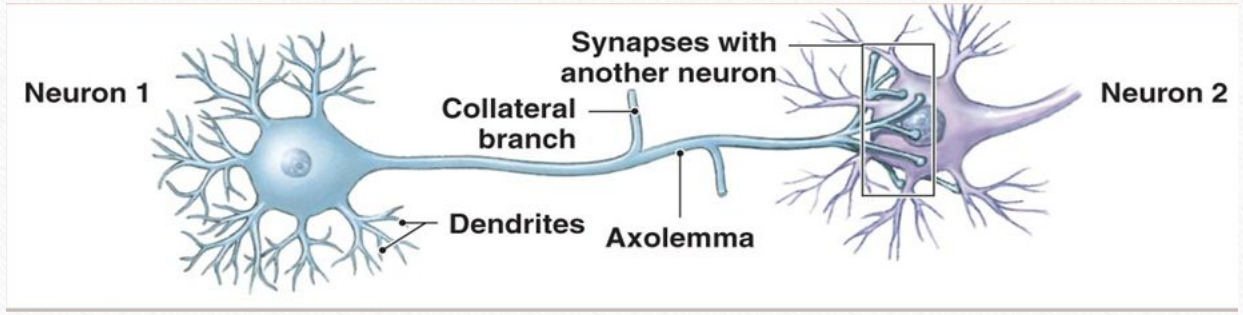
It is the junction between two nerve cells. They are of 3 types; axodendritic, axosomatic & axoaxonic

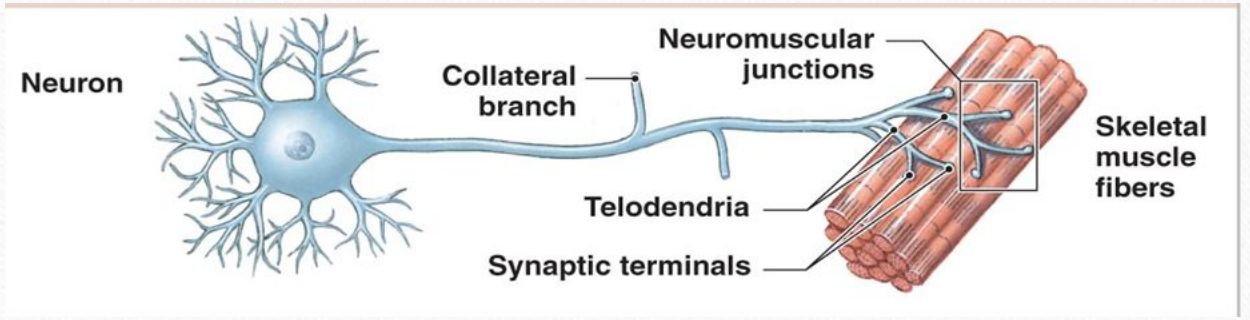
2. Neuromuscular

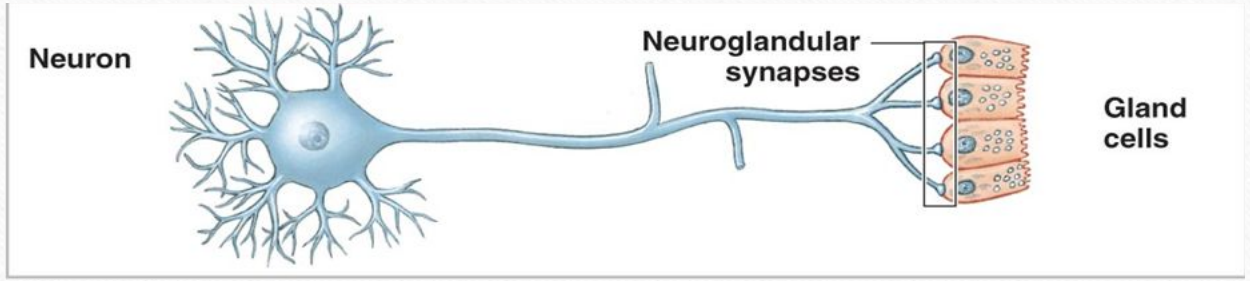
It is the synapse pf a motor neuron and a muscle

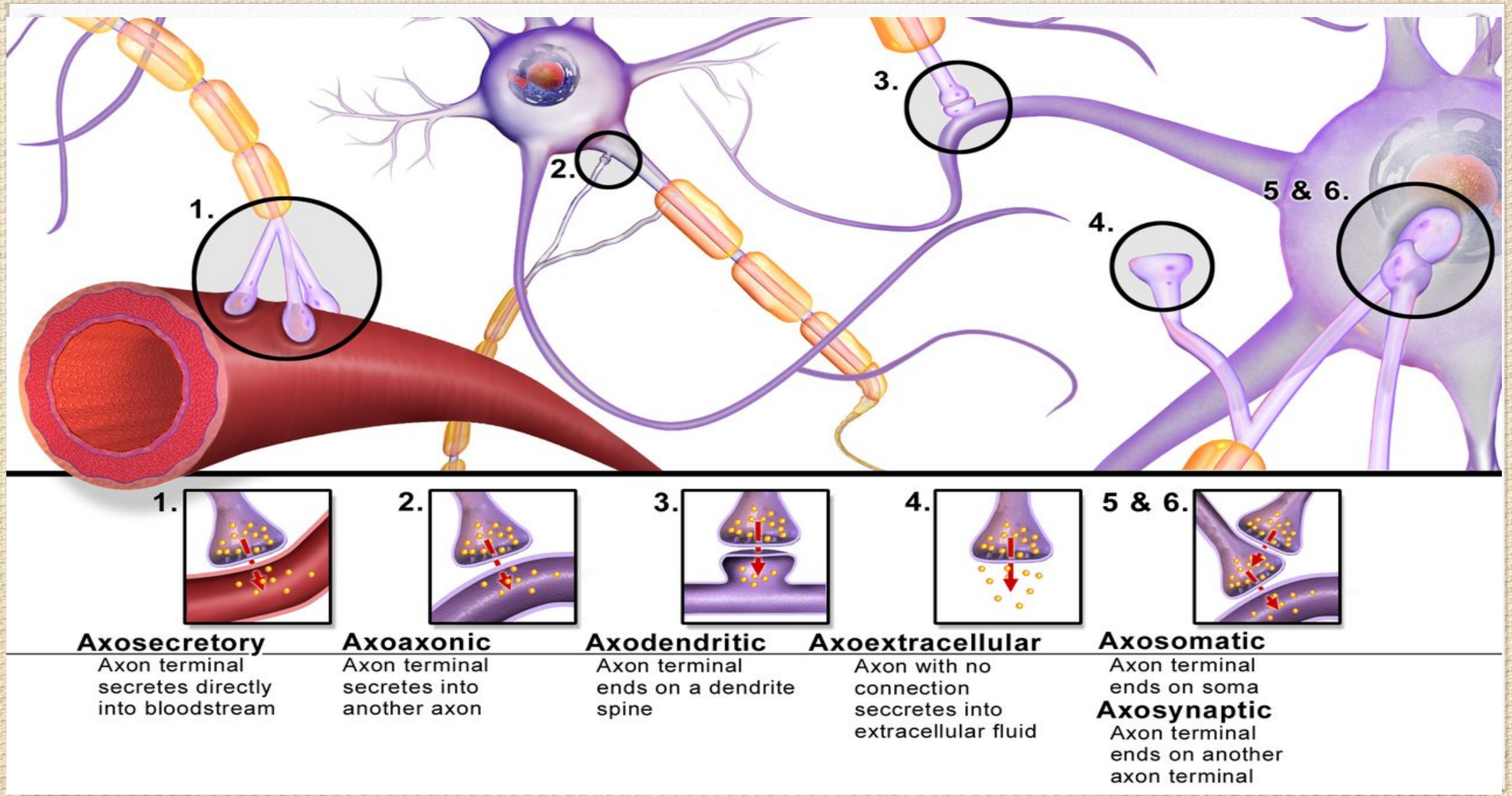
3. Neuroglandular

It is the synapse of a neuron and a endo/exocrine gland.


Neuron 1
Synapses with another neuron
Collateral branch
Neuron 2
Dendrites
Axolemma


Neuron
Collateral branch
Neuromuscular junctions
Skeletal muscle fibers
Telodendria
Synaptic terminals


Neuron
Neuroglandular synapses
Gland cells


1.
2.
3.
4.
5 & 6.
1.
2.
3.
4.
5 & 6.
Axosecretory
Axon terminal secretes directly into bloodstream
Axoaxonic
Axon terminal secretes into another axon
Axodendritic
Axon terminal ends on a dendrite spine
Axoextracellular
Axon with no connection seccretes into extracellular fluid
Axosomatic
Axon terminal ends on soma
Axosynaptic
Axon terminal ends on another axon terminal

5. Synaptic Transmission

- It is the process which nerve cells communicate among themselves or with muscles and glands.
- The synapse is the anatomic site where this communication occurs.
- It can be of 2 types:

A. Electrical transmission

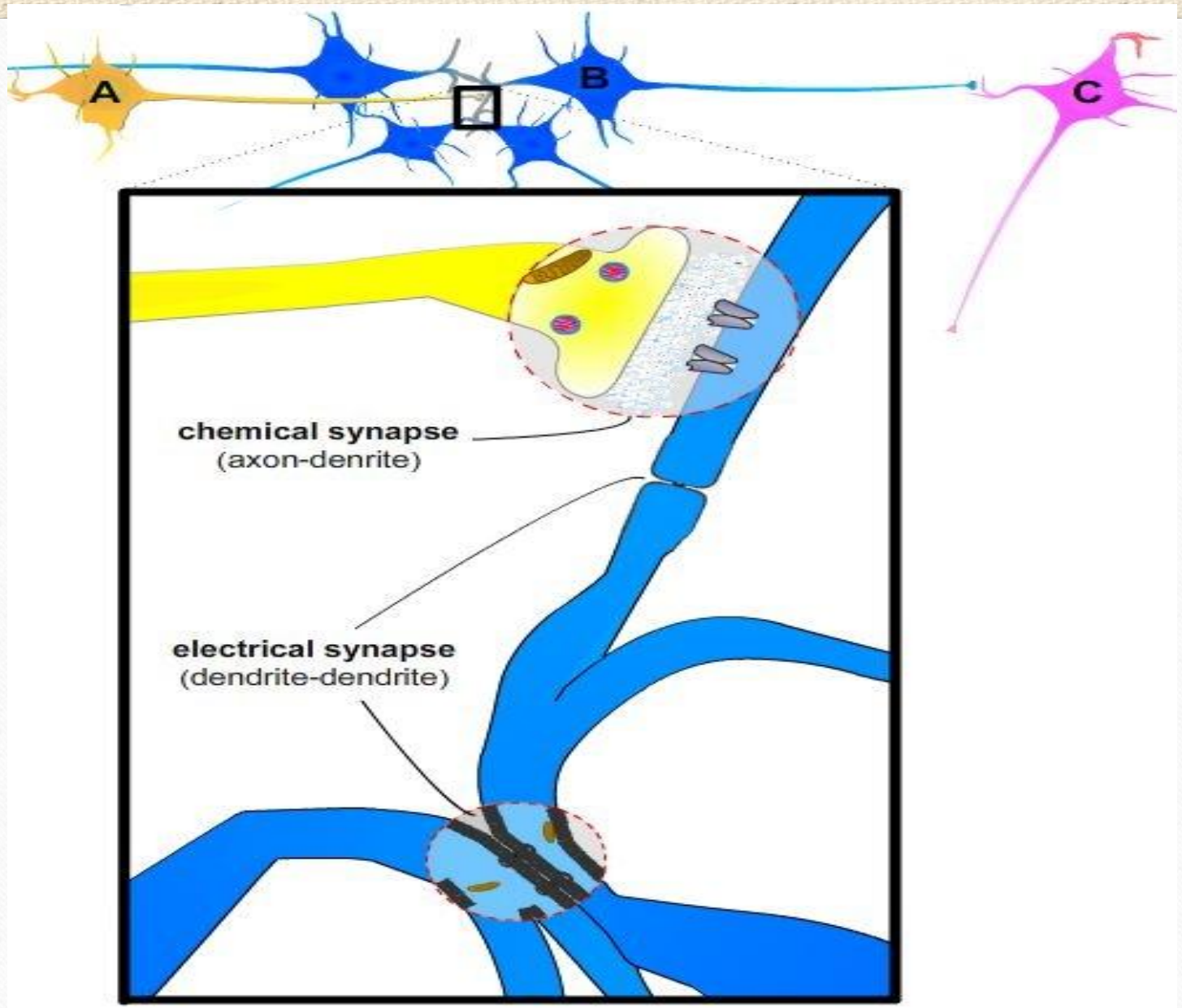
B. Chemical transmission

Electrical transmission

In these synapses the membranes of the two cells actually touch, and they share proteins. This allows the action potential to pass directly from one membrane to the next. They are very fast, but are quite rare, found only in the heart and the eye.

Chemical transmission

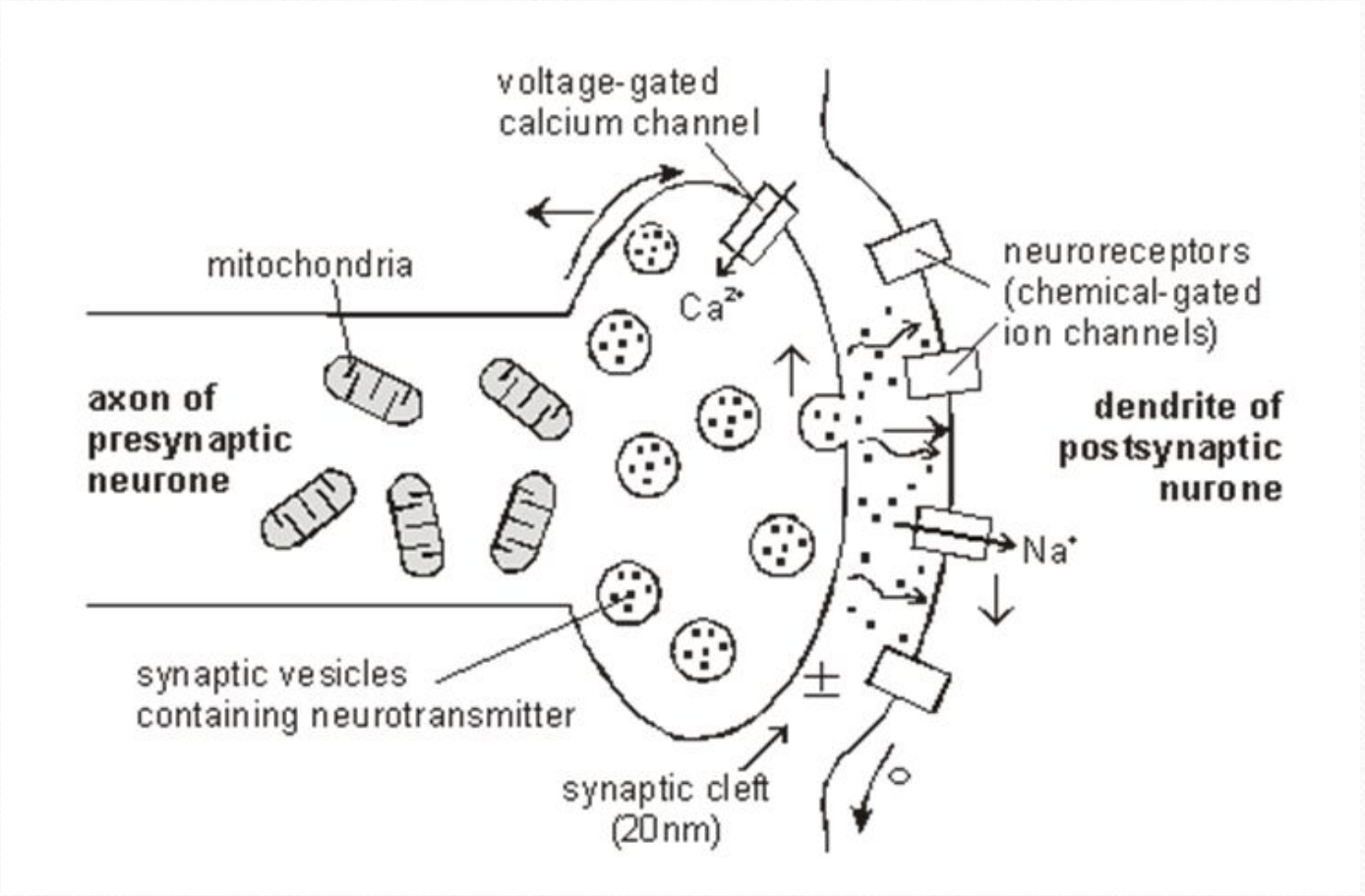
In a chemical synapse, electrical activity in the presynaptic neuron is converted into the release of a chemical called a neurotransmitter that binds to receptors located in the plasma membrane of the postsynaptic cell.



Neural network. "Information" flows between the blue neurons through **electrical synapses**. "Information" flows from yellow neuron **A**, through blue neuron **B**, to pink neuron **C** via **chemical synapses**.

6. Transmission of Neurotransmitters

- At the end of the pre-synaptic neuron there are voltage-gated calcium channels. When an action potential reaches the synapse these channels open, causing calcium ions to flow into the cell.
- These calcium ions cause the synaptic vesicles to fuse with the cell membrane, releasing their contents (the neurotransmitter chemicals) by exocytosis.
- The neurotransmitters diffuse across the synaptic cleft.
- The neurotransmitter binds to the neuroreceptors in the post-synaptic membrane, causing the channels to open.


voltage-gated
calcium channel
mitochondria
Ca^{2+}
neuroreceptors
(chemical-gated
ion channels)
axon of
presynaptic
neurone
dendrite of
postsynaptic
nurone
Na^{+}
synaptic vesicles
containing neurotransmitter
synaptic cleft
(20nm)

Chemical Synaptic Transmission.

- Definition: Communication between cells which involves the rapid release and diffusion of a substance to another cell where it binds to a receptor (at a localized site) resulting in a change in the postsynaptic cells properties.

Chemical synapse types.

- Axosomatic, axoaxonic, axodendritic, and dendrodendritic.
- Excitatory (type I) and inhibitory (type II) synapses have different structure in CNS neurons.
- CNS synapses usually have one or small number of release sites while nerve muscle synapses have up to 300 active zones.

Principles of Chemical Synaptic Transmission

Mechanisms

- Process of exocytosis stimulated by release of intracellular calcium, [Ca^{2+}]
- Proteins alter conformation - activated
- Vesicle membrane incorporated into presynaptic membrane
- Neurotransmitter released
- Vesicle membrane recovered by endocytosis

Electrical Synapses

- Gap junction-type communication important for rapidly synchronizing syncytia of cells as is observed in astrocytes, heart, and developing brains. Present in some invertebrates to promote rapid defensive secretions.
- Problems with electrical: difficult to modulate gating of channels (exceptions exist cAMP, pH).
- Can't change sign, i.e. charge always flows "down hill."
- Electrical synaptic transmission requires that the presynaptic cell or terminal be larger than the postsynaptic cell for it to inject considerable charge, no real amplification mechanism.

Electrical Synapses

- Symmetrical morphology.
- Bidirectional transfer of information, but can be unidirectional.

- *Pre-* and *post*synaptic cell membranes are in close apposition to each other (~ 3.5 *vs*. ~ 20 nm in other cells), separated only by regions of cytoplasmic continuity, called *gap junctions*.

  - Ions can flow through these gap junctions, providing low-resistance pathway for ion flow between cells without leakage to the extracellular space: signal transmission = electrotonic transmission.

  - Instantaneous, fast transfer from 1 cell to the next (< 0.3 msec), unlike the delay seen with chemical synapses.

Generation of postsynaptic potentials

- **Postsynaptic potentials** are changes in the membrane potential of the postsynaptic terminal of a chemical synapse. Postsynaptic potentials are graded potentials, and should not be confused with action potentials although their function is to initiate or inhibit action potentials. They are caused by the presynaptic neuron releasing neurotransmitters from the terminal bouton at the end of an axon into the synaptic cleft. The neurotransmitters bind to receptors on the postsynaptic terminal, which may be a neuron or a muscle cell in the case of a neuromuscular junction. These are collectively referred to as postsynaptic receptors, since they are on the membrane of the postsynaptic cell. . .

Properties of synapse

- **Neurotransmitter receptor complex**
- **One-way conduction**
- **Summation in Neurons**
- **Facilitation of Neurons**
- **Fatigue of Synaptic Transmission**
- Effect of **Acidosis or Alkalosis** on Synaptic Transmission
- Effect of **Hypoxia** & **Drugs**
- **Synaptic delay**
- **Convergence & Divergence**

Properties

One Way Conduction

(Bell-Magendie Law)

According to Bell-Magendie law, the impulses are transmitted only in one direction in synapse, i.e. from presynaptic neuron to postsynaptic neuron.