The Functioning Brain

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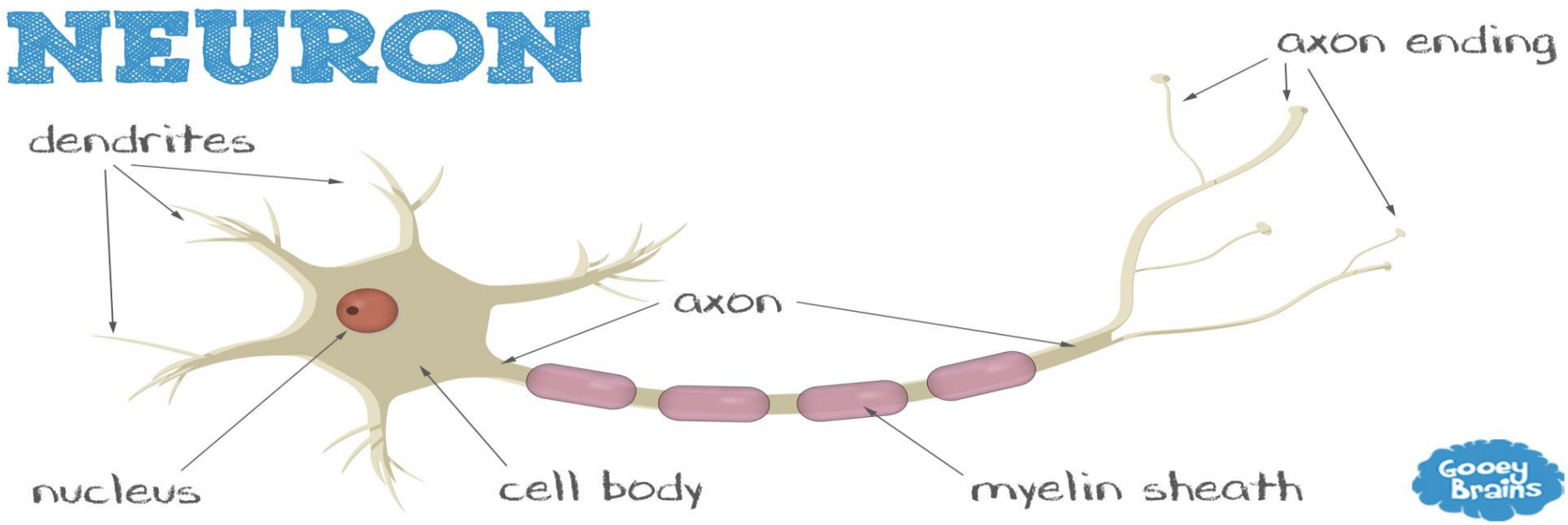
Structure and Functions of Neurons

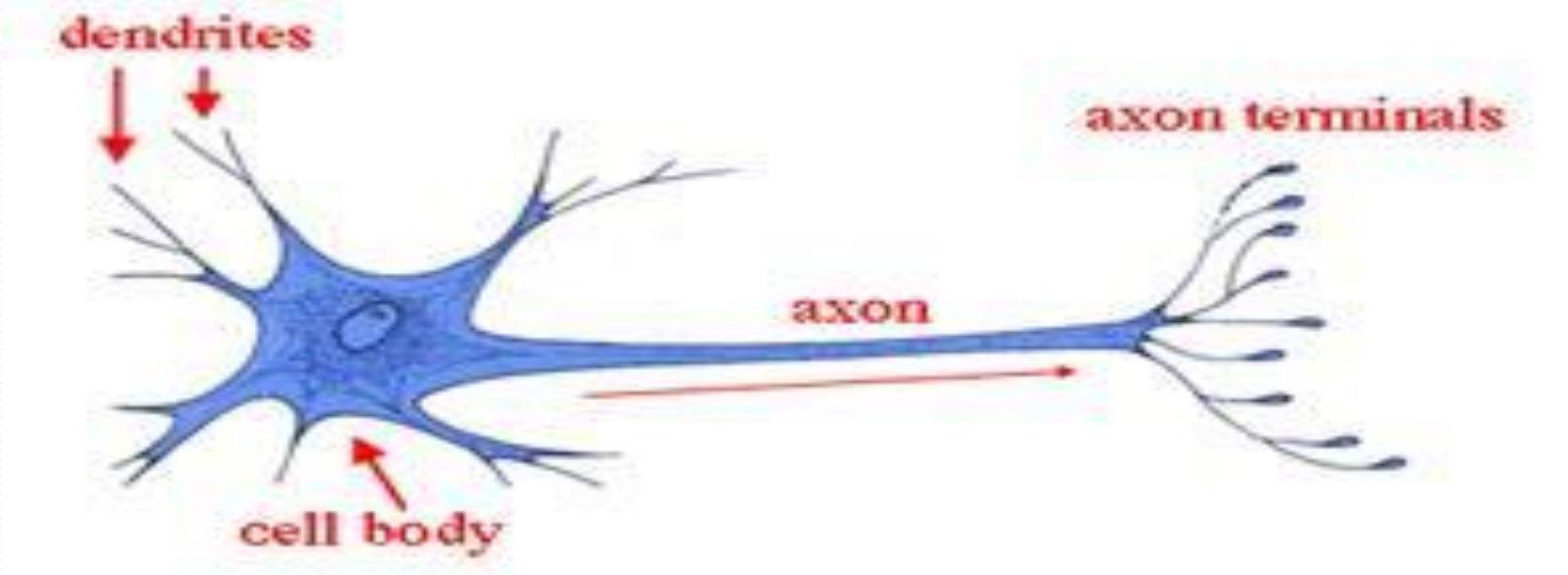
Neuron

The basic unit of the nervous system



- Neuron is the smallest structure/the building block of the nervous system. All our thoughts, feeling and behavior can ultimately be traced to the activity of neurons which are the specialized cells that conduct impulse though the nervous system. Most experts estimate that there may be as many as 100 billion neurons in the brain itself (Swanson, 1995). In the recent research it has been found that there are 86 billion or more than these neurons are found in the brain.

- Despite the difference in the neurons of the nervous system they share in common three fundamental components –the Cell body or Soma, the Dendrites and the Axon.



- **Neurons are having two important functions or things:**

    1. **They generate electricity**
    2. **They release chemicals**

Nerve conduction is thus, an electro-chemical process.

- **There are two aspects of conduction of neural impulse which are-**

    1. Transmission of neural impulse within the neuron, and

    2. Synaptic transmission.

1. **Transmission of neural impulse within the neuron**

The development of extremely thin electrodes, less than one micron in diameter, had made it possible to insert the electrode tip into the cell body itself and make recording of the electrical difference between the inside and outside of the neuron at rest.

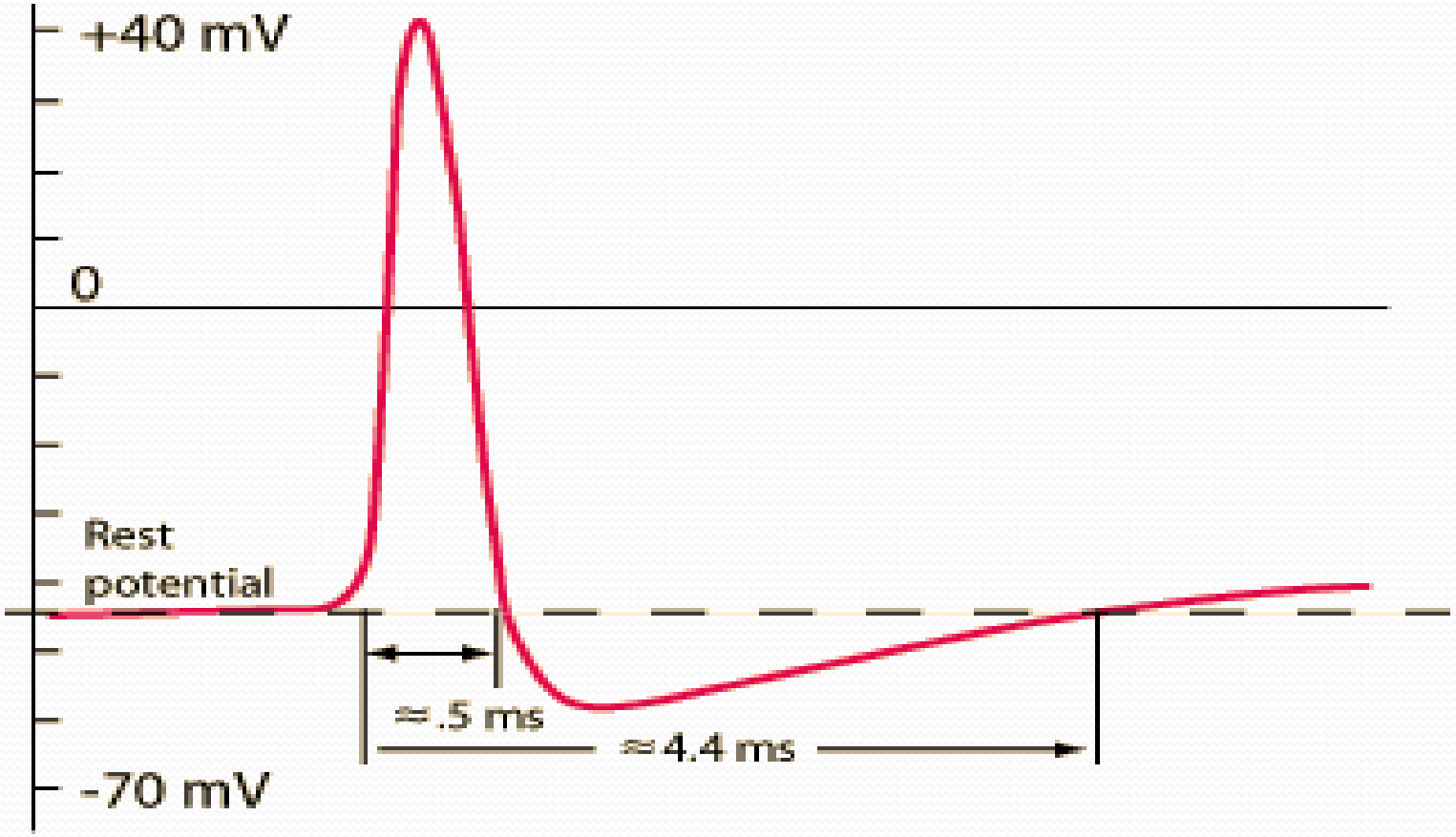
- **Body fuels contain ions (electrically charged atoms or molecules) some with positive charges and others with negative charges. Inside the neurons membrane is a more negative than positive ions.**
- **What actually moves through the axon is a change is the permeability of the cell membrane. This process allows ions to move into an out of the axon through the ion channels in the membrane.**

- When a neuron is at rest (undisturbed) the axon membrane carries a negative electrical potential of about 70mv. This is referred to as resting potential. Since, the potential is assumed to be the difference as measured inside related to outside, this figure is expressed as - 70 mv. When in this resting state the neuron is said to be polarized.

- Fluctuation of the resting membrane, potential can cause a change in the – 70mv level towards a less negative value, a process called de-polarization since the new value is closer to zero or, it can be toward more negative values, called hyper – polarization.

- If the change is small equilibrium back to -70 mv is soon re-gained but if de-polarization of around 20 mv occurs and the potential nerve is -50 mv, a dramatic series of events is triggered of. The potential rapidly reverses its polarity to +40mv where it remains for about 1milli second (ms), later to recover and return within 10ms to its resting level of -70mv. The brief change in potential is called the action potential or nerve impulse or spike potential or firing.

Figure: Process of Action Potential



- When the dendrites or the cell body of a neuron is directly stimulated by external physical environment or from chemical messages from adjacent neurons, a graded potential is produced. Their magnitude varies in proportion to the size of the stimulation.

- Unlike graded potential within a graded cell all action potentials are approximately equal in size and shape (amplitude) under normal circumstances. This is the all or none law i.e. the size and shape of the action potential are independent of the intensity of the stimulus that initiate it. Action potential either occur or do not occur and there is no in between condition.

- Immediately after a neuron fires it enters a refractory period during which it cannot fire again for 1-2 millisecond but the rest period is often very short as when stimulated neurons can fire up to 1000 times per secs.

- Depending on the neuron most impulses travel at speed ranging from 2 miles an hour to 200 miles an hour. The larger longer axon, those that reach from the brain through the spinal cord and from the spinal cord to remote parts of the body send impulses at a faster speed than do neuron with smaller, shorter axon

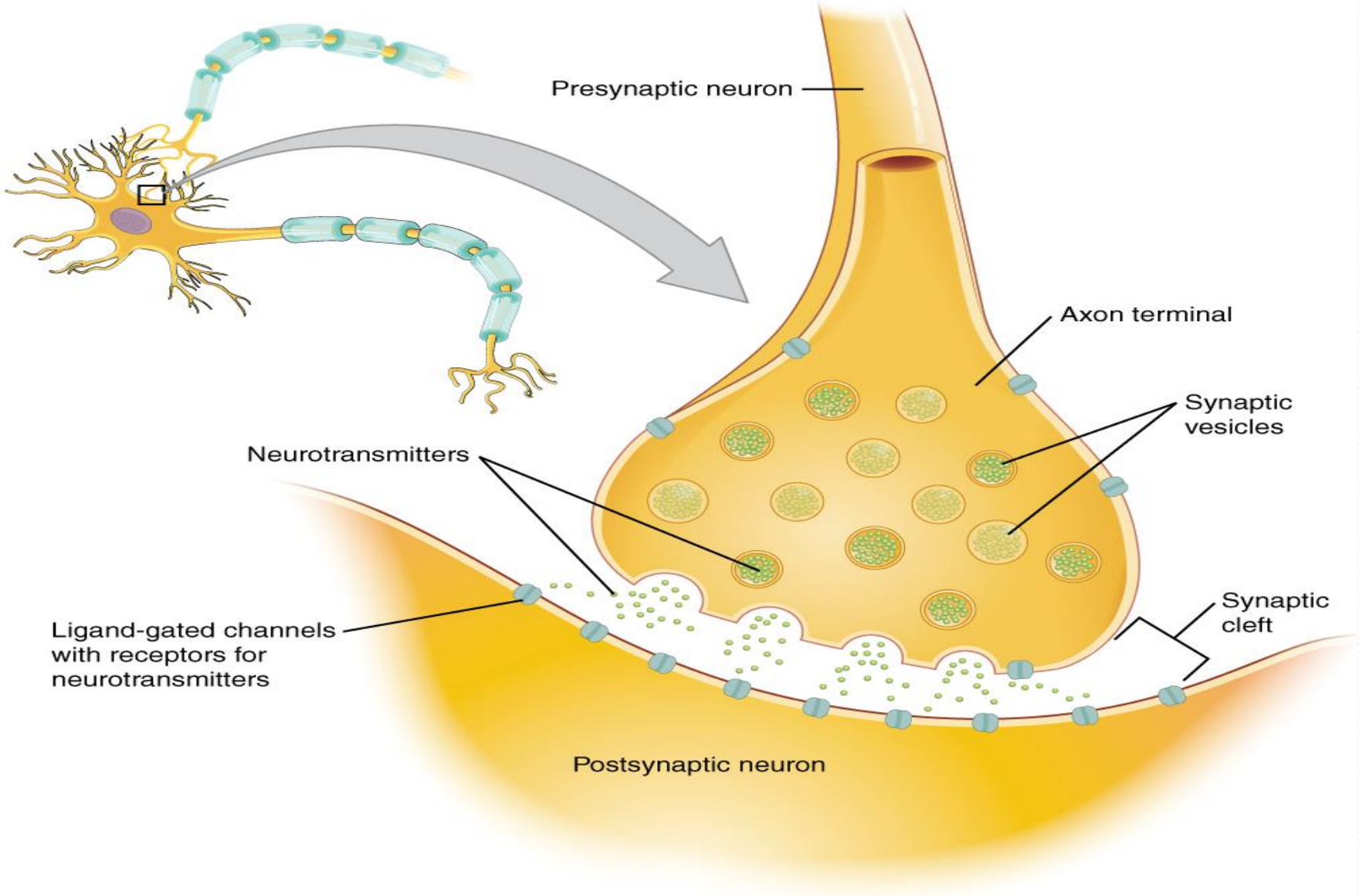
- The insulation provided by myelin sheath allows the nerve impulse to jump from one node of Ranvier to the next. This is called as **Saltatory Conductions** which comes from the Latin word **“Saltair”** meaning **“to jump”.**

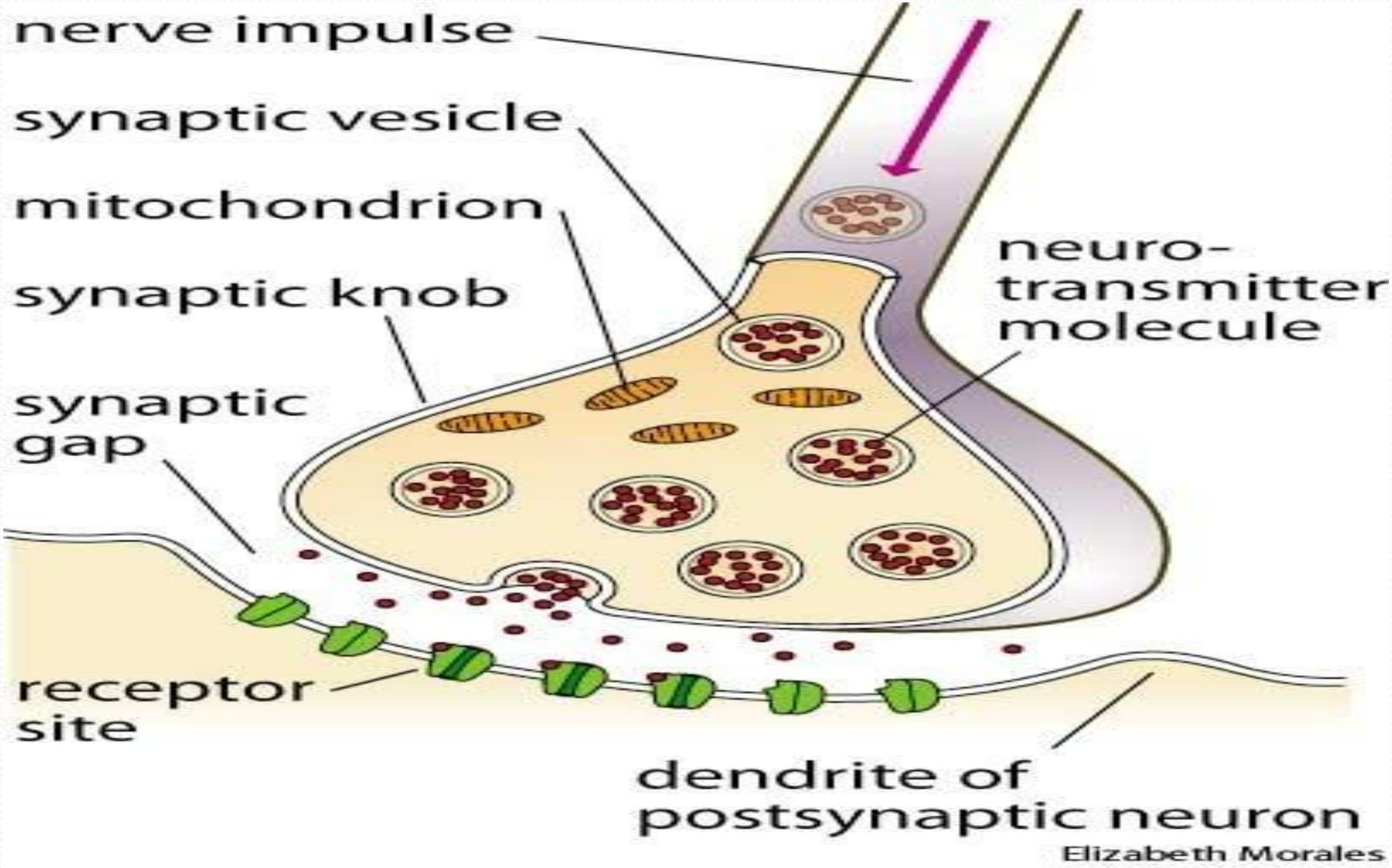
- Saltatory conduction is an extremely effective way of speeding the impulse because a small myelinated axon can conduct an impulse as rapidly as on myelinated axon 30 times as large. The presence of myelin also conserves energy.

- The principle of electrical signaling (the resting potential or nerve impulse i.e. action potential) has been developed by Hodgkin, Huxley and their Colleagues.

2. Synaptic Transmission

- The synapses, the junction between two neurons were founded by Charles Scott Sherington (1906). These are the primary venue for neurons to communicate with one another. Messages are transmitted between neurons by one and more of a large group of chemical substances known as neuro-transmitters. These are released by the terminals of the neurons.


Presynaptic neuron
Axon terminal
Synaptic vesicles
Neurotransmitters
Ligand-gated channels with receptors for neurotransmitters
Synaptic cleft
Postsynaptic neuron


nerve impulse
synaptic vesicle
mitochondrion
synaptic knob
synaptic gap
neuro-transmitter molecule
receptor site
dendrite of postsynaptic neuron
Elizabeth Morales

- The terminal is separated from other neuron by a very small space called the Synaptic – cleft. If the receiving membrane is part of the cell body the synapse is refer to axosomatic; if it is the part of the dendrite, then axodendritic and if the receiving membrane is a part of the axon then it is known as axoaxomic. The membrane of the terminal (ends) is called the pre-synaptic membrane and the membrane it synapses with is called post-synaptic membrane.

- Penetrating the terminal from the axon are microtribules which may transport “Pre-cursor chemicals” for the manufacture of neurotransmitters into the terminal. There are also mitochondria in a terminal which provide energy for metabolic processes.

- In addition, there are two types of vesicles in the terminals –

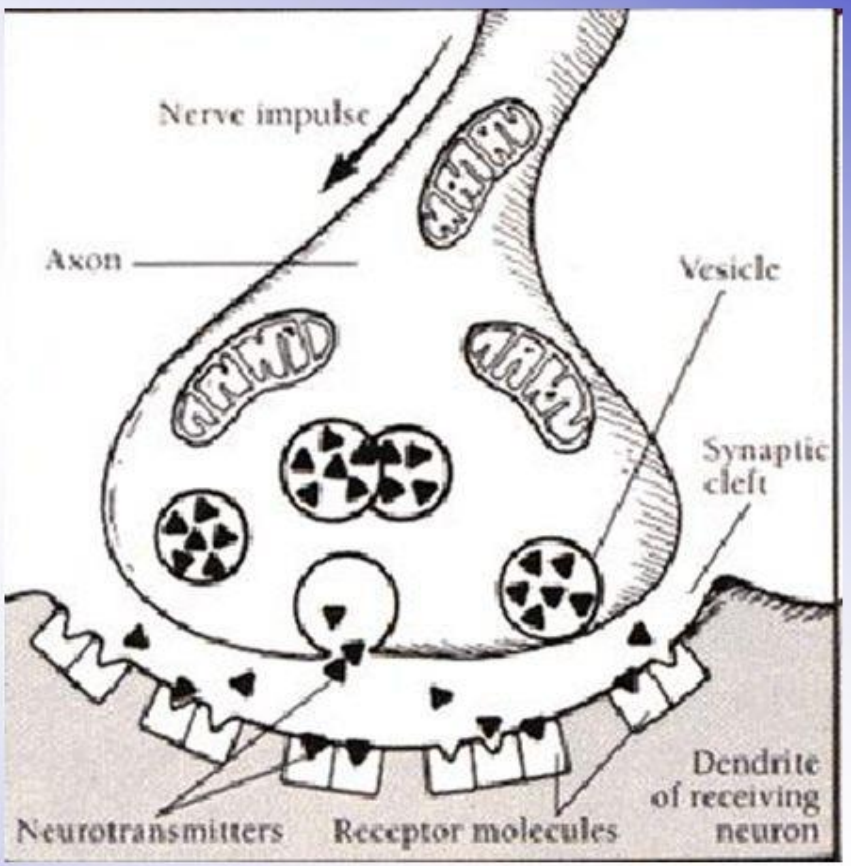
1. Storage granules which are presumed to be long term storage site for neuro-transmitter.

2. Synaptic vesicles which hold neuro-transmitters for immediate use.

- On the post synaptic membrane there are specialized proteins that act as a receptor for the neuro – transmitters. The synaptic function is carried out in a following way: When a neuron fires some synaptic vesicles release their neuro-transmitter chemicals into the synaptic space. The neuro-transmitter binds quickly to the receptors on the post synaptic membrane after which it is either quickly washed away by the extra cellular fluid, destroyed or taken back into the pre-synaptic membrane for re-uses. The process called **Reuptake.**

THE REUPTAKE PROCESS

- A process in which neurotransmitters are sponged up from the synaptic cleft by the presynaptic membrane



- Depolarization of post – synaptic potential increases the probability of the neuron firing, which are called **Excitatory post-synaptic potential or (EPSP)** and hyper-polarizing potential decrease the probability of the neuron firing which are called **Inhibitory post – synaptic potential or (IPSPs).**

Thus, we can see that conduction of neural impulse in the axon is electrochemical, while the nature of synaptic transmission is chemical.

References

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