Basics of Biology
Professor Vishal Trivedi
Department of Biosciences and Bioengineering
Indian Institute of Technology, Guwahati
Lecture – 45
Nervous System – Part 3

Hello everyone, this is Doctor Vishal Trivedi from Department of Biosciences and Bioengineering IIT Guwahati. And what we were discussing? We were discussing about the living organisms.

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And so far what we have discussed, so, in this course is that we have discussed about the classifications, evolutions, understanding the prokaryotic and the eukaryotic cells, then we have discussed about the different types of biomolecules, cellular processes, and in the previous few modules, we are discussing about the human physiology. So, in this context in the previous lecture, we discussed about the, we discussed about the nervous system. So, within the nervous system what we have discussed? We have discussed about the machinery.

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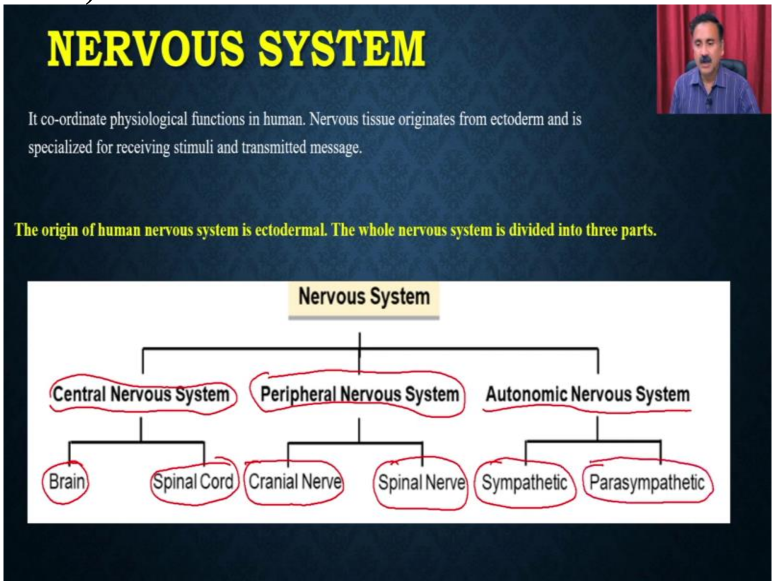

So, as you can see that what we have done is we have discussed about the nervous system and the nervous system can be divided into three different components. It could be a central nervous system, it could be peripheral nervous system, and it could be autonomous nervous system. In the, in the central nervous system, we have the two organs, we have the brain and the spinal cord. And whereas, in the peripheral nervous system, we have the different types of nerves, whether it is the cranial nerves or the spinal nerves.

And then in the autonomous nervous system, we have the sympathetic system as well as the parasympathetic nervous system. So, in the previous lecture, if you recall, we have discussed in detail about the anatomy as well as the structures and the function of the brain and as well as we have discussed about the spinal cord. And what we have also discussed is that there, the different types of nerves are actually originating either from the brain or the spinal cord.

And that is how they are actually regulating and monitoring the different types of functions. So, in today’s lecture, we are mostly going to discuss more about the nerves and how the nerves, the messages are actually going to transmit from the brain to the site and as well as from the site how the stimulus is being recorded.

So, in a basic phenomena of the nervous system is that the brain is actually going to receive the stimulus, brain or the spinal cord is going to receive the stimulus from the peripheral body and then it is actually going to give the signal for the executions. So, in today's lecture, we are going to discuss about the nerves, different types of nerves.

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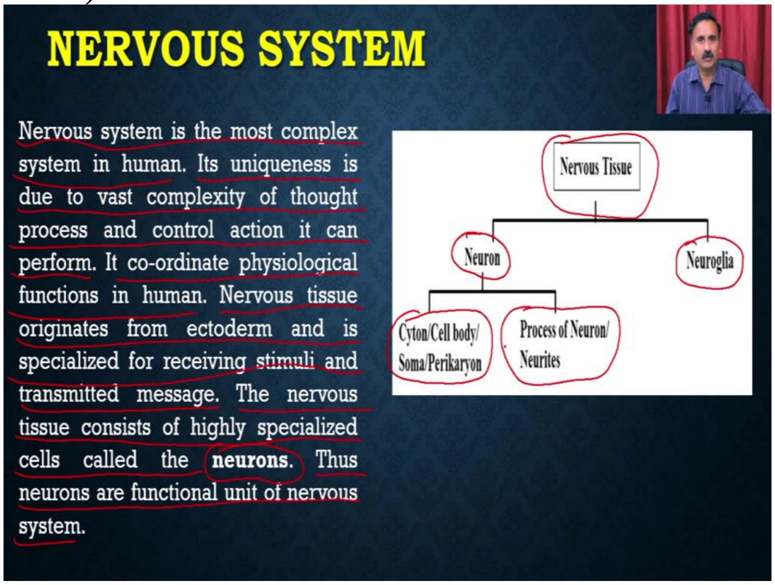

So, nervous system is the most complicated system in the humans. It is uniqueness is due to the vast complexity of the thought process and the control action it can perform. It coordinates the physiological functions in the humans. Nervous tissue originates from the ectoderm and is specialized for receiving the stimuli and the transmitted messages. The nervous system, nervous tissues consists of highly specialized cells which are called as the neurons.

Thus, the neurons are the functional unit of the nervous system. And what you see here is that the nervous tissue is actually composed of the two components, one it is actually going to have the neurons and then it also going to have the neuroglia. Within the neuron, the neuron is structure or neuron is the, is the basic cell which is responsible for the structure of the nervous tissue is can be decided can be divided into the two parts one is called as the cyton or the cell body.

And the other one is called as the neurites or the process of the neurons. So, if you see the structure of typical neuron it is actually going to be distributed or it is going to have the ability to receive the signal from the peripheral system and then it also can be able to communicate to the different types of other tissue system.

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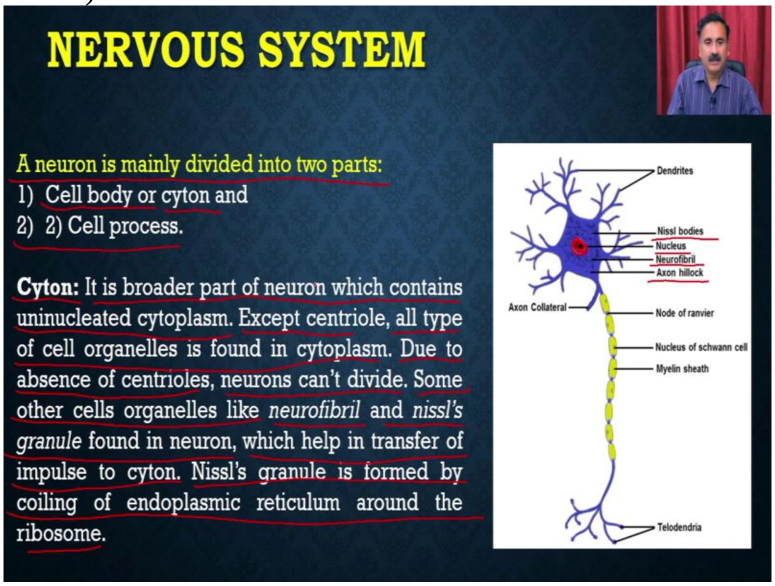

So, a neuron is mainly been consists of the two parts, it is having a cell body or the Cyton. So, this is the cell body or the cyton what you are going to see. And then it also going to have the cellular process, cell processes. So, cyton, cyton it is the broader part of the neuron which contains the uninucleated cytoplasm. So, this is the cyton where you have the uninucleated nucleus. Except centrioles, all types of cell organelle is found into the cytoplasm.

So, it actually has the nucleus it has the neurofibrils, axon, it has initial bodies, and then it also has the dendrites and all that. But it does not contain the centrioles and because it does not contain the centriole, the neurons cannot be able to divide and cannot be replicated. Due to the absence of centrioles the neurons cannot divide, and some other cells organelles like the neurofibrils, and the Nissl's granules are found in the neuron which helps in the transfer of impulse to the cyton.

Nissl’s granule is formed by the coiling of the endoplasmic reticulum around the ribosomes. So, the cyton is actually the cell body and that cell body is very much like a any other cell what is present in the, in the human body, but it does not contain the centrioles. And it also has a specialized cellular body, like the Nissl’s body and other kinds of neurofibrils. And that is how they are actually been able to communicate with the brain as well as it can be able to transmit the messages to the other parts of the body. Then the second part is the cellular processes.

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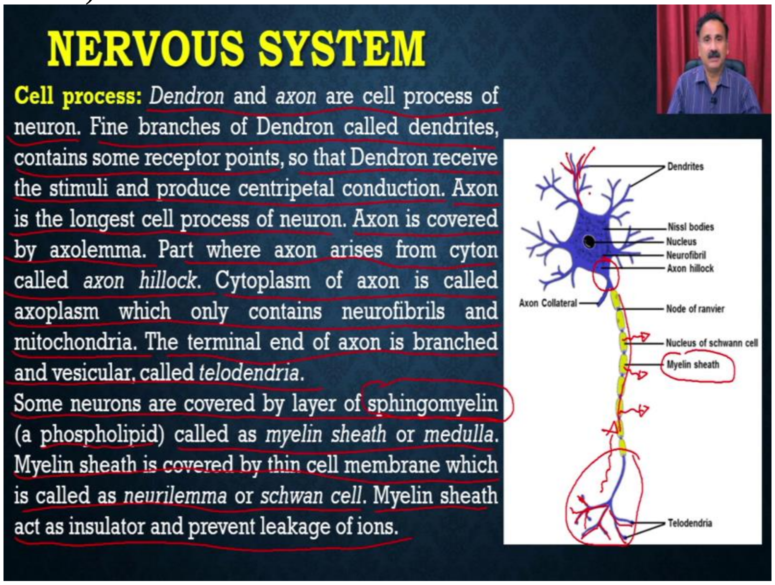

So, cellular processes are actually going to, going to be by this the dendrones. So, the dendron and the axons are cellular processes of the neuron. The fine branches of the dendron are called as the dendrites. So, these are the dendrites, what you see here is the branch structure. So, these branched structures are actually spreading over the different organs and that is how, they are actually able to communicate.

So, dendrites which contains the receptor points so that the dendrones receive the stimuli and produce the centripetal action conductions. The axon is the longest cell process of the neuron, the axon is covered by the axolemma. And part where the axon arises from cyton is called as the axon hillock. So, this is what you see here. So, from the here you are actually going to see the axon and this portion is called as the axon hillock.

The cytoplasm of the axon is called as the axoplasm which only contains the neurofibrils and the mitochondria. So, this is the portion which is going to be called as the neurofibrils and they are actually been contains the neurofibrils and the mitochondria. The terminal end of the axon is branch and it is vesicular and it is called as a telodendria. So, this is a terminal portion of the axon, and it is branched, and it is called as a telodendria.

So, you can imagine that they will actually going to, sit on to the different types of tissues and that is how they can be able to receive the signal. And that is how they can be able to transmit the signal through the dendrites. Some neurons are covered by a layer of sphingomyelin. So, remember that when we were talking about the biomolecules, we discuss about the sphingomyelin, which is actually a phospholipid. And the sphingomyelin, how the absence of the sphingomyelins or there will be a mutations into the sphingomyelins or the modification into a sphingomyelin is responsible for the different types of genetic diseases.

So, the neurons are covered with a sheath of sphingomyelin and these sheaths are called as the myelin sheath or the medulla. So, this is the myelin sheath, which is actually going to be present outside the axon. And the myelin sheath is covered by the thin cell membrane which is also called as the neurilemma or the schwan cells. So, this is the neurilemma or the schwan cells. And the myelin sheath is act as an insulator and it prevents the leakage of the ions.

So, actually the myelin sheath is going to act as a insulator. So, there it is, that is how it is actually not going to leakage of the signal. So, it is going to, say if the signal is going to be received by the dendrites from this side or the axon from this side, it is actually going to transmit on to this side. Or if the telodendria are actually going to receive the signal, then it is not going to sneak out from the other part of the axon and it is going to be communicated to the dendrites. Now, based on the different types of modifications and the anatomy, the neurons can be of the different types.

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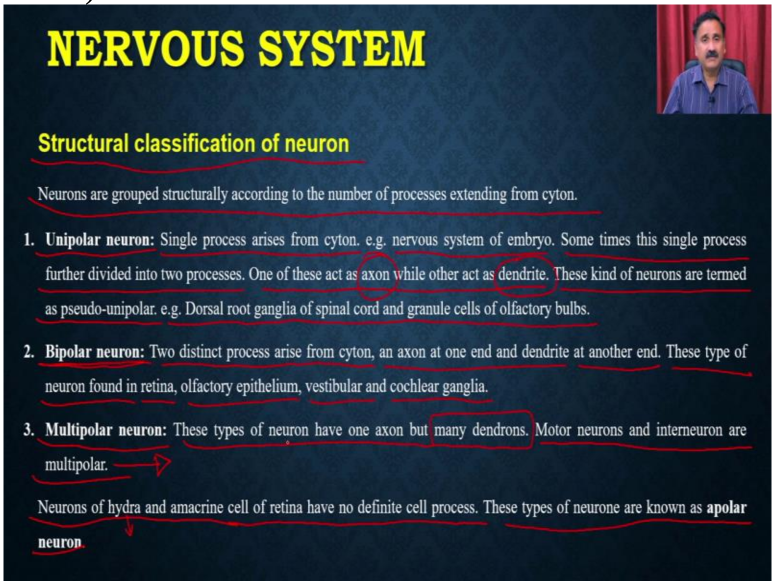

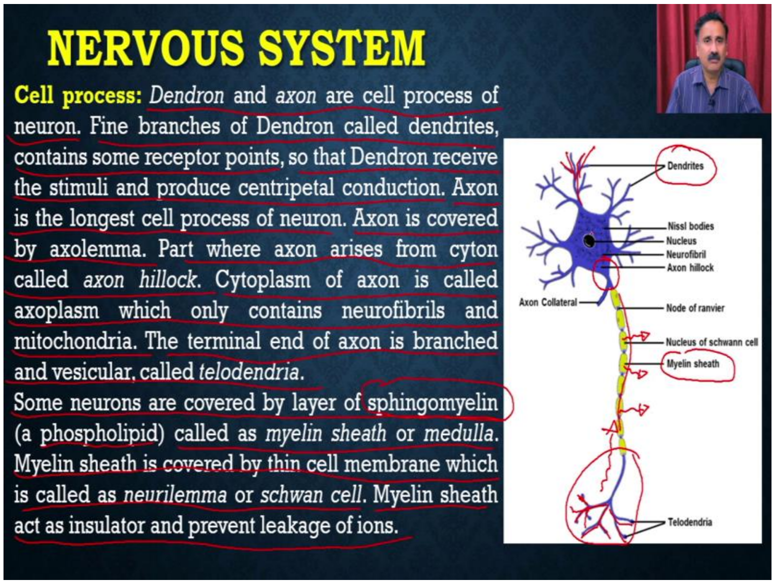

The structural classifications of the neurons. So, neurons are grouped structurally according to the number of processes extending from the cyton. So, what you see here is a simple neuron cells and it actually has the cyton and the, the axon part and that cyton is actually going to have the dendrites as well as the telodendria. And based on the these kind of modifications, the neurons can be of different types.

Because they are actually going to have different types of structural modifications and that is going to be well suited for the particular function. So, the neurons are grouped structurally according to the number of processes extended from the cytron. You can have the unipolar neurons, you can have the bipolar neurons, you can have the multipolar neurons. And so, unipolar neurons, single processes arises from the cyton.

For example, the nervous tissue of the embryo. Sometime this single process is further divided into the two processes. One of these act as the axon, while the other is act as a dendrite. These kind of neurons are termed as the pseudo unipolar. So, in a unipolar neuron, you are going to have a single process which is going to be arises from the cyton. Classical example is the nervous system of the embryo.

Sometimes the single process further divided into two processes and one of these act as a axon, whereas, the other one act as a dendrite. But it is kind of neurons where you have the single processes divided into the two processes are going to be called as the pseudo unipolar neurons.

Classical example is the dorsal root ganglion of the spinal cord and the granule cells of the olfactory bulbs.

So, and then we have the bipolar neurons, so, two distinct processes rise from the cyton and axon at one end and dendrite at the other end. These type of neurons are found in the retina, olfactory epithelium, vestibulars and the cochlea ganglia. So, these are the bipolar neurons where you on one side you are going to have the axon and the other side you are going to have the dendrites. Then we have the multipolar neurons.

So, these types of neurons have the one axon but they are going to have the many dendrones. And the motor neurons and the inter neurons are the multipolar neurons. Neurons of the hydra, the (())(13:40) and the amacrine cell of the retina have no definite cell processes, these type of neurons are called as the apolar neurons. So, whatever we discussed is based on the different types of processes what has been present onto the neural cells.

So, it can be unipolar, bipolar, multipolar and these are the examples where they are not going to have the any type of processes and these neurons are called as the apolar neurons. And these neurons are present in the retina of the cells. Then based on the different types of functions, remember that when we were discussing about the different types of nerves, which said that the nerves could be cranial nerves or the spinal nerves, but here the function is different. So, whether the different types of neurons are going to have the different types of functions which are actually going to be a part of the different types of nerve cells.

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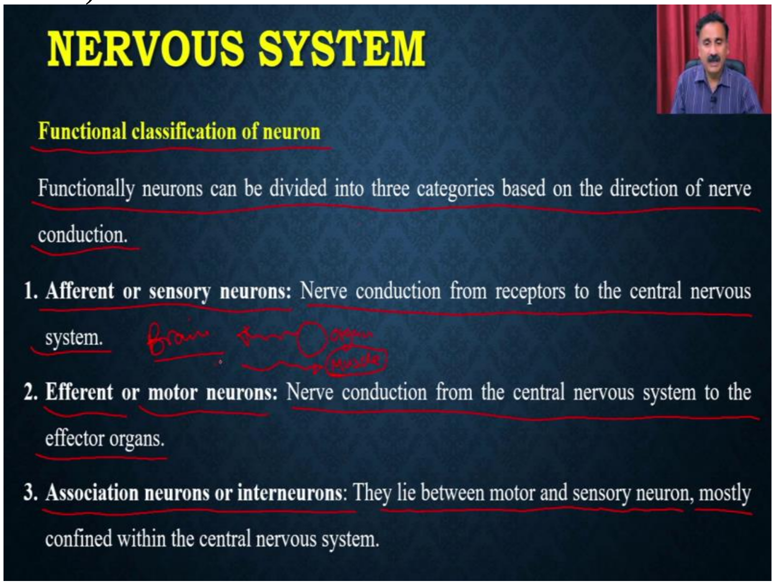

So, based on the functions, the neurons can be divided into the multiple functions. So functionally, neurons can be divided into the three categories based on the direction of the nerve conductions. So, you can have the afferent neurons. So. the nerve conduction from the receptor to the central, central nervous system that is going to be called as the afferent or the sensory neurons. Then we have the efferent or the motor neurons.

So, the nerve conduction from the central nervous system to the effector function which means the afferent or the sensory neurons are actually going to receive or going to actually carry forward the stimuli from the organs, organ to the brain. So, that the brain will know what is happening in this particular organ. Whereas the efferent or the motor neurons are actually going to take up the messages from the brain and they are actually going to give it to the executory organs.

So, these are the nerves which are actually going to conduct the messages from the central nervous system to the effector organs. So, for example, when you are going to hit the hot objects like or suppose you are going to put your finger into the fire. So, the first the fire when you put the finger into the fire, the afferent neurons are actually going to collect that information and they will give it either to the brain or the spinal cord.

And then from the brain or the spinal cord, they are actually going to carry the message through the afferent neurons. And that is how it will say that, you remove your finger. So, it is actually going to give the signal to the nearby muscles, muscular system and that is how the muscles will say that you can actually pull out your fingers.

Then we have the association neuron or the interneurons, they will so, these are the neurons which lies between the motor and the sensory neurons and they are mostly confined within the central nervous system. So, you are actually also going to have the neurons which are actually going to make the communication between the sensory neuron as well as the motor neurons. Now, the question comes, how actually the neurons are actually relaying the signals?

Whatever we discuss that whether these are the sensory neurons or the motor neurons, they are actually going to take up the message from the organ to the brain or the message from the brain to the organ. But the question comes, how these different types of neurons are carrying the messages from the affector organs to the brain or from the brain to the affector organs.

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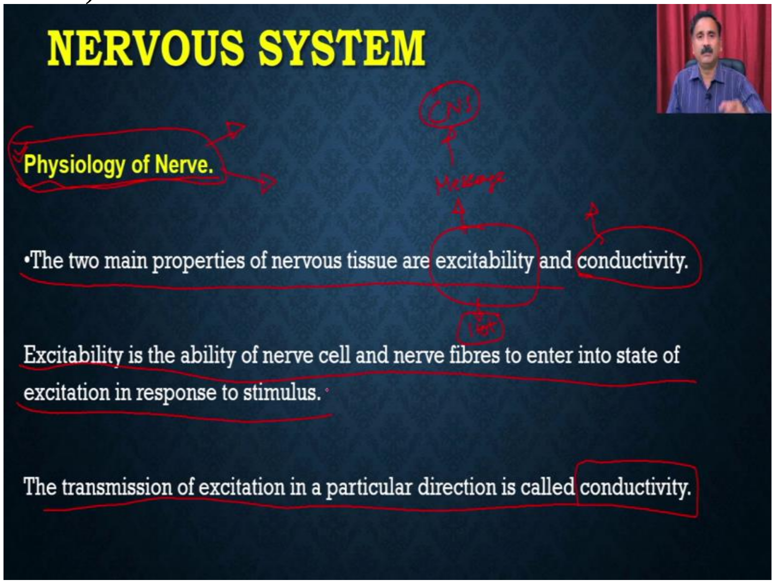

So, what is the physiology of the nerve conductions? So, there are two main properties of the nervous tissues, one is called as the excitability, the other one is called as the conductivity. Excitability means then when you are actually going to touch the fire it is actually going to excite the receptors and that is how, it is actually going to send the message to the central nervous system. So, it is going to send the message to the CNS.

Whereas the conductivity means how fast it is actually going to send these signals. So, excitability is the ability of the nerve cells and the nerve fibers to enter into the excitation in response to a stimuli. So, how fast how much you are actually going to get excited when you are actually going to touch. For example, if you touch a hot pan or fire actually, so, how you are going to get excited.

The conductivity is the transmission of the excitation in a particular direction is called as the conductivity. So, when we want to understand the physiology of the nerve, we have to understand the two processes one, the excitability, how quickly the particular nerve cell is going to be give the message and how quickly that message is going to be conveyed from the sight of the damage or sight of the stimulus to the central nervous system.

So, if you want to do this, you are actually going to, you have, we have to understand the physiology of the nerve cells and how the nerve cells are conducting the signal from one part of the body to the other part.

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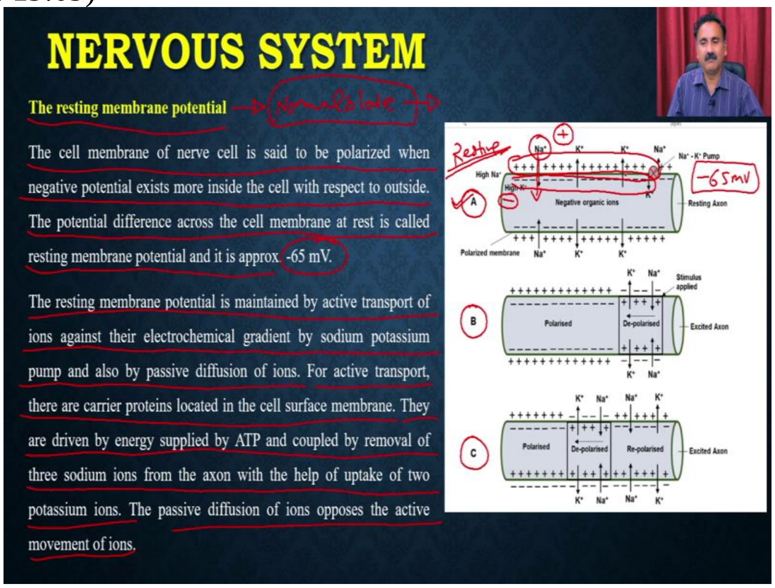

And this is actually been a submission of the three different types of activities. So, the nerve cells actually can remain into the three different state. It can have the resting state, it can have the excited state and then it also can then return back to the resting state or this is called as the repolarization state. So, when you have the resting state, resting state is the normal state in which the, in which the nerve cells are actually going to be present in normal state.

But they are actually going to be ready to receive the stimulus. So, the cell membrane, or the nerve cell is to be polarized when the negative potential exists more inside the cell with respect to the inside. So, this is the resting cells or resting neurons in the A. So, the in the A you have the resting neurons where the more number of negative ions are going to be present inside and more number of positive ions are going to be present outside.

Which means there will be a polarization of the ions along the length of the neurons. And the potential difference across the cell membrane at rest is called as the resting potential and it is approximately minus 65 millivolts. So, at minus 65 milli volts, you are actually going to have the resting potential. And how the different types of pumps what are present, so which are actually going to maintain the resting potential.

The resting potential is maintained by the active transport of ions against their electro chemical gradient by the sodium potassium pump and also by the passive diffusion of the ions. For active transport, there are carrier protein located in the cell surface membranes. They are driven by the energy supplied by the ATP and coupled by the removal of three sodium ions from the axon with the help of uptake of two potassium ions.

The passive diffusion of the ion oppose the active movement of the ions. So, how you are going to maintain the resting potential of minus 65 milli volts that you are actually going to use many of the active membrane transporters. And what they will do is one other transporter is sodium potassium transporter, and that what they are going to do is they are actually going to transmit or they are going to transfer the different types of protons or different types of ions.

So, in a particular activity, since you want to maintain the minus inside and the positive outside, what you are going to do is you are going to pull the three ions of sodium inside and you are going to throw the two ions of the potassium. And because of the sodium potassium pump and some of the other passive pumps, you are actually going to maintain the negative inside and the positive outside.

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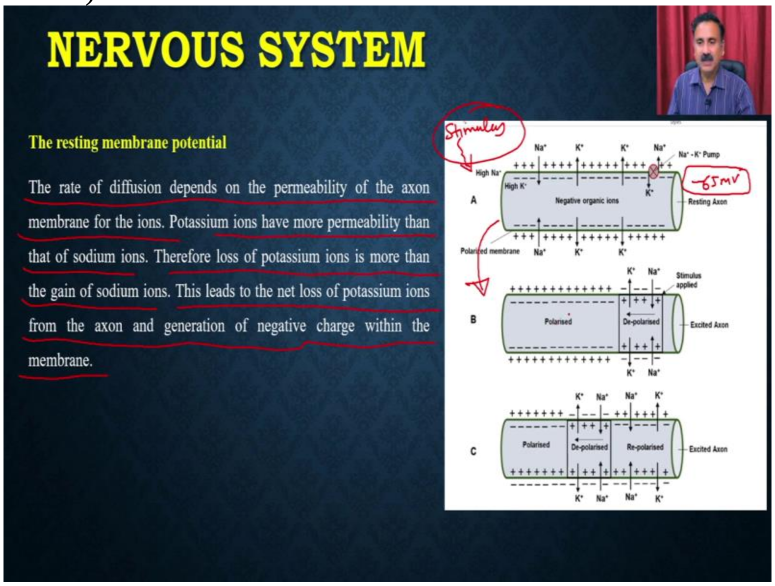

Now, once the neuron is actually going to receive the signal, the resting potential is actually going to be changed into the action potential. So, the rate of the diffusion depends on the permeability of the axon membrane for the ions. So, potassium ion have more permeability then of the sodium, therefore, loss of potassium ion is more than the gain of sodium potassium. This lead to the net loss of potassium ions from the axon and the generation of the negative charge within the membrane.

So, this is the mechanism through which the resting potential is going to be maintained as the minus 65 millivolts into the resting ions or resting neurons. Then we have the once the resting potential are, resting neurons are going to receive the stimulus, they are actually going to enter into the next phase. And they are actually going to enter into the active potentials or the exciting states.

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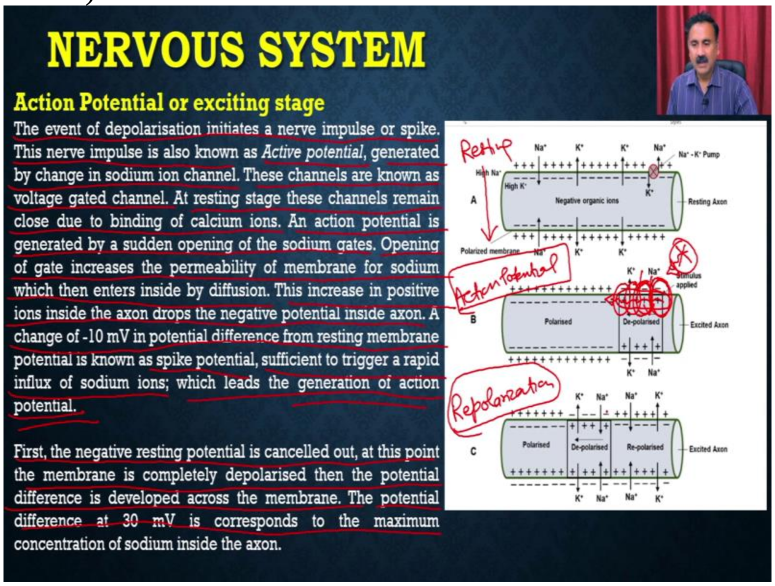

So, when they enter into the exciting state, so, this is the resting neurons and then they will enter into the exciting state. So, the, and in that what is going to happen? It is actually going to change the potential. So, what will happen? The event of the depolarization initiate the nerve impulse or the spike. This nerve impulse is also known as the active potential generated by the change in the sodium ion channel.

These channels are known as the voltage gated channel. So, at resting stage, these channels remain closed due to the binding of calcium ions. And action potential is generated by the sudden opening of the sodium gates. Opening of the gate increases the permeability of the membrane for the sodium which then enter inside by the diffuser, this increase in positive ion inside the axon drop the negative potential axon inside the axon.

A change of the minus 10 millivolts in the potential difference from the resting membrane potential is known as the potential spike and that is sufficient to trigger the rapid influx of the sodium ions which leads a generation of the action potential. So, what happened here is that when there will be a stimulus, the resting potential is actually going to be changed. So, it is actually going to be deporalized.

And in the deporalization, it is actually going to happen because there will be a voltage gated sodium channels. So, these voltage gated sodium channels are actually going to start pushing the more amount of sodium inside. And because of that, there will be a positive charge which is going to be generated and that positive charge is actually going to be generated at in a, in a rhythmic or in a wavy, wavy fashion.

So, because of that, it is actually going to generate the waves. So, first for example, the sodium is going to be enter into this portion of the neurons, then sodium is going to enter into this portion of the neuron and that is how it is actually going to start changing the negative ions one after the other. And that is actually going to lead the generation of the action potential. First the negative resting potential is canceled out at this point the membrane is completely depolarized then the potential difference is developed across the membrane.

The potential difference at 30 milli volts is corresponds to the maximum concentration of the sodium inside the ions. So, this is actually going to be the action potential what is going to be and once it received the action potential, it is actually going to do the depolarization and that is how the neurons are actually going to relay the signal from the one end to the other end.

Now, once this action potential is over, like the stimulus is actually going to be not present, then there will be the third event and third event is called as the repolarization. So, repolarization is actually going to revert all the changes what is going to happen.

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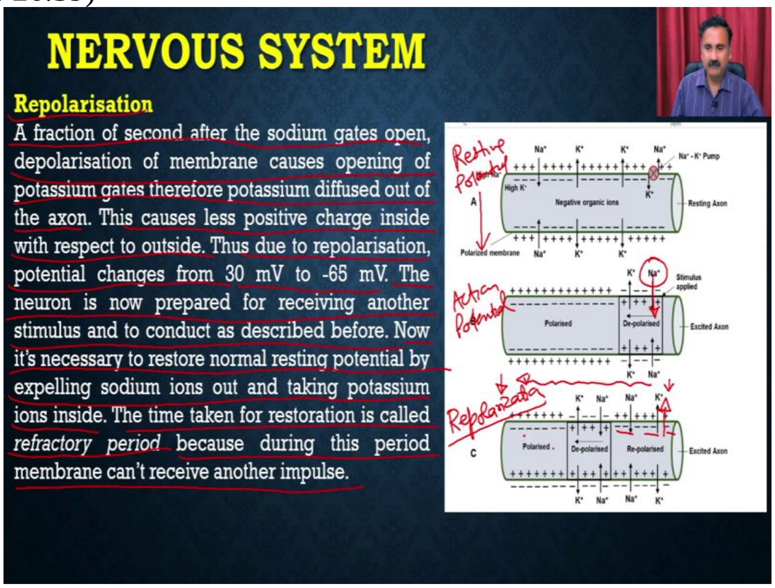

So, what is the repolarizations? A fraction of the second after the sodium gates open the repolarization of the membrane causes the opening of the potassium gates, therefore, the potassium diffuses out of the axon, this causes the less positive charge inside with respect to the outside and thus leads to the repolarization or the potential difference changes from the 30 millivolts to the minus 65 millivolts.

The neuron is now prepared for receiving the another stimuli and to conduct as described above. Now, it is necessary to restore the normal resting potential by expelling the sodium ions out and taking the potassium ion inside. The time taken for the restoration is called as the refractory period, because during this period, the membrane cannot receive another impulse. So, this is what is actually happening, you have the resting neurons or the resting potential.

Then you have the action potential, so you have the action potential. And during the action potential, there will be a voltage gated sodium channels, which are actually going to insert the sodium more sodium inside and because of that, it is actually going to cause positive ions. And once it happens, it is actually going to initiate a process of the repolarisation. And when it is going to have the repolarization, what will happen is that it is actually going to start pushing the more amount of potassium outside.

And because of that, the whatever the positive charge it is been generated during the action potential is actually going to reverse and because of that, it is again regaining the negative inside and the positive outside. And this repolarization and the repolarization and the action potentially is going to be keep happening throughout this and that is how the signal what is being generated here is actually going to carry forward up to the end of this particular neuron.

But once it reaches to the end of this neuron, it will enter into the state where it is actually going to restore the resting potential and during this period it was not actually going to respond to the external stimuli. So, this is what it is going to happen, into the nervous system.

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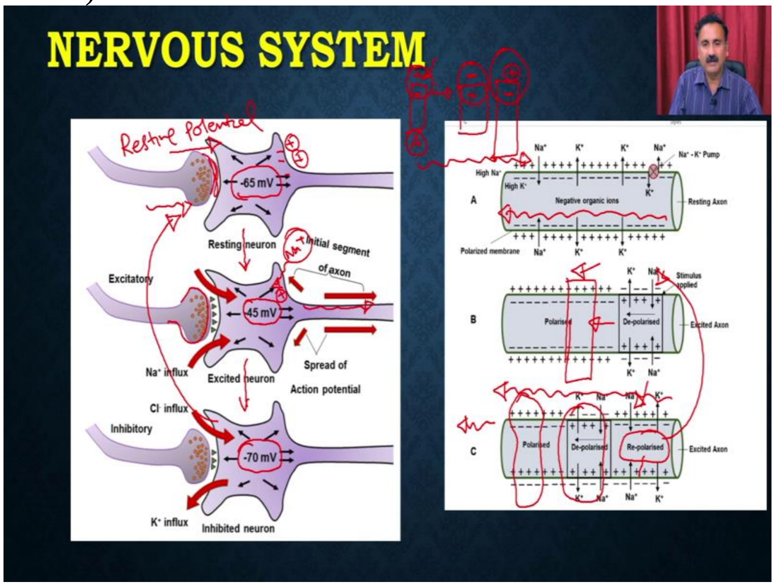

What you see here is that this is the resting potential. So, this is the resting potential. So, once the signal comes, once the signal comes, it is actually going to generate a minus 65 millivolts resting potential and because of that, it is going to have the negative inside and the positive outside. But after this resting neuron, once they receive the signal for example, they are actually going to receive the signal from the synapse the resting potential is going to be change through the minus 45 millivolts.

Once it there will be a change in the potential that is actually going to open the sodium gated or the voltage gated sodium channels. And because of that, the some of the negative ions are actually going to be get converted into the positive ions. And once that happens it is actually going to start relaying the signal. But after this, it is again going to reenter into the repolarization step and repolarization is again going to generate the action potential, the potential of the minus 70 millivolts.

Once it, the and that is actually going to relay the signal from this site to the further down into the axon. Once that happens, then the, the neurons are again going to enter into the state of the resting potential and they will be ready to receive the second round of the signal. So, this is the mechanism through which the nerves are actually conducting the signal. So, you can imagine that at this site, for example, you have the positive outside and negative inside.

And this is the site A, so once you receive the signal, it is actually going to be get converted like this, it is going to be that negative is going to be get converted positive, and this is going to be negative. But after that, it is going to have the repolarization. And again, there will be a negative and positive outside. And this rhythmic event like this, this is the resting potential, this is action potential. And this is the repolarization will continue from every point.

So, that is how the signal is actually going to relay from this part of the neuron to this part of the neuron. And this will continue until you are actually going to keep receiving the stimuli, because you can imagine that first of all the, you got the stimuli, so this portion got repolarized. And that is how you have generated more amount of positive inside and negative outside after that, this depolarization event is actually going to be transferred from this side to this side.

And that is how you will see the depolarization is happening now here. And after some time, depolarization is going to happen here, and so on. And just after depolarization, there will be another round of repolarization and that is actually going to keep changing the positive to negative. And that is how it is actually keep continuing the signal up to the end once it reaches to the end and it is actually going to deliver to the next neuron through the synapses.

Then the signal is going to be, there will be no signal and that's how the repolarized neurons are actually going to be get converted into the resting neurons. Now, this is the mechanism to how the signal is actually going to be traveled throughout the neurons, neuron cells. But how the signal is actually going from these within the synapses like from the one neuron to the another neuron, you are actually going to have a synapses. At this side, the signal is actually crossing and reaching to the neurons. So, how the signal is also operating at the synapses?

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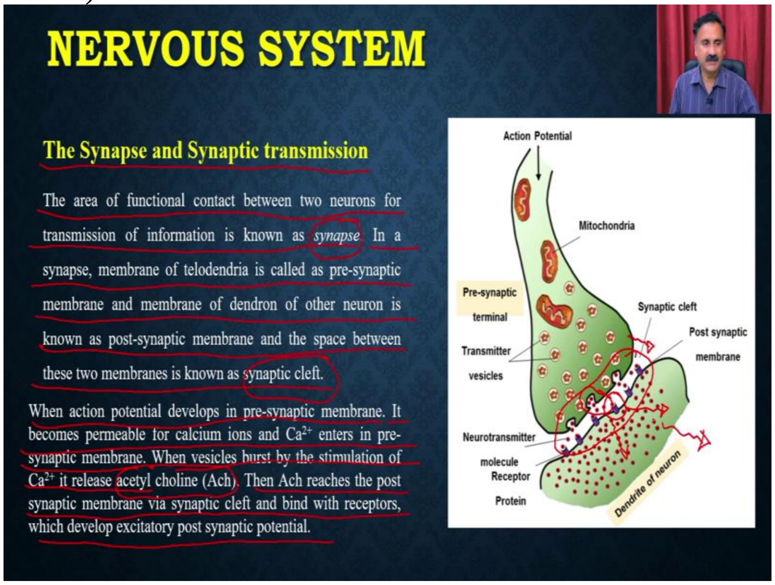

So, at the synapse, the synapse at the synapse transmissions, the area of the functional contact between the two neuron for the transmission of information is known as a synapses. So, synapse is the junction at which the information in one neuron is going to be transmitted into another neuron. So, in a synapse the membrane of the telodendria is called as the presynaptic membrane and the membrane of the dendron of the other neuron is known as the post synaptic membrane.

And the space between the two membrane is known as the synaptic cleft. So, this is the synaptic cleft between the two. When the action potential develop in the pre synaptic membrane, it becomes permeable for the calcium and the calcium enters in presynaptic membrane. And the vesicle burst by the action of the calcium it releases the neurotransmitter that is the acetyl choline.

And then the acetyl choline reaches to the post synaptic membrane via the synaptic cleft and bind with the receptor which develop the excitatory post synaptic potential. So, this is what happened, when you have the signal. So, when the neurons are into the action potential, they actually releases the calcium and then these calcium are actually going to interact with the membranes what is present on to the receiving neurons.

And that is how and they are actually going to release the acetylcholine. And these acetyl choline are then going to be received by the acetyl choline receptor on to the present onto the dendrite of the next two neurons. And that is actually going to relay the signal and that is how this event of the repolarization, action potential and as well as the resting potential is going to be transmitted into the next neuron and then it will continue the same way as we have discussed.

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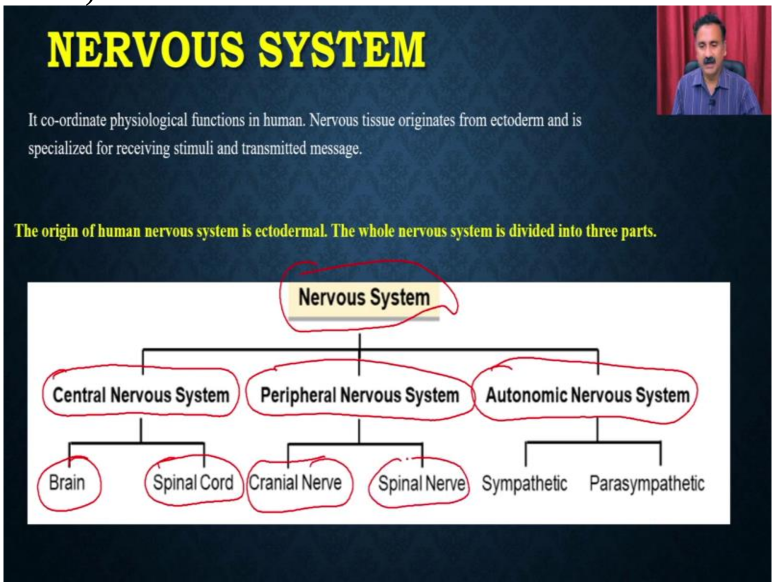

So, so, far what we have discussed is we have discussed about the nervous system, and we have discussed about the three branches or the part of the nervous system, central nervous system, peripheral nervous system and as well as the autonomic nervous system. And in the central nervous system, we discuss about the brain as well as the spinal cord, whereas the peripheral nervous system we have discussed about the cranial nerves as well as the spinal nerves.

And in the today's lecture, we have discussed about how the nerves are actually conducting the messages from the one part of the neuron to the another part of neuron and what could be the different steps which are involved. So, with this I would like to conclude my lecture here and in subsequent lecture we are going to discuss some more aspects related to the living organism. Thank you.