Basics of Biology
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Lecture – 44
Nervous System – Part 2

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 different properties of the living organism. And in this context, what we have discussed we have discussed about the classification of the living organisms, we have discussed about the evolutions and we have also discussed about the different aspects of the living organisms.

So, in this context, in this particular series of modules, we were discussing about the physiology of the living organisms and in that, so far what we have discussed? We have discussed about the digestions and then subsequent to that we have discussed about the circulatory system. And then we have also discussed about the muscular system. So, in the previous module, we have also discuss about the circulatory system as well as muscular system.

And in the today's lecture, we are going to start discussing about the nervous system. So, nervous system is the, is the system which actually controls the different types of activities. So, so far what we have discussed, we have discussed about the digestion, circulation, muscular even in the subsequent to that, we are also going to discuss about the endocrine system as well as the (())(02:23) system.

But in that all these different types of activities has to be done under the coordination to each other. And these coordination is always being maintained by the nervous system, because nervous system is going to respond to the different types of stimuli or the different types of responses from the different sources. And that is how they are actually going to act on. So, the nervous system as the name suggests, is going to, is a organ system which is actually going to respond to the different types of responses.

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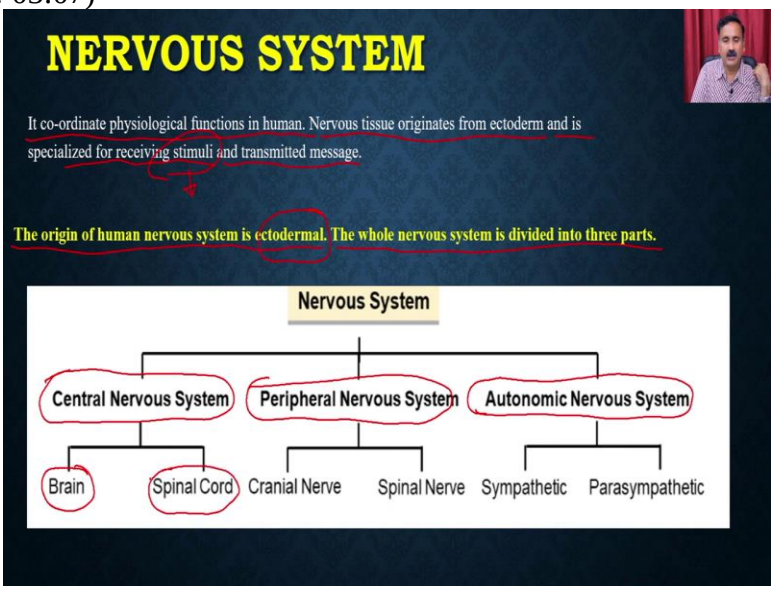

So, the nervous system, it is what is the physiological function is that it coordinates the physiological function in the humans, which means it is actually going to control the different types of activities. It is going to coordinate when the, there will be a secretion of the gastric juices, when there will be a secretion of the different types of hormones, when there will be a secretion of the sweat, when there will be a secretion of the different types of other signaling molecules. So, that the person is going to be respond accordingly.

So, the nervous system is originated from the ectoderm and it is a specialized for receiving the stimuli and the, it is going to transmit the message. So, depending on the stimuli, it is actually going to transmit to the message to the particular organ. For example, if there will be a stimuli that there will be a danger, so then that is actually going to transmit to the hormonal systems, it is going to transmit to the muscular system.

So, if there will be a danger, what you are going to do is you are going to secrete the different types of hormones. And then, in addition to that, you are also going to activate the particular type of muscular system like for example, if you have to run then the muscular muscles of the legs are going to be activated and that is how they are, you are going to start running. In other conditions, if there is a danger signal, but that danger signal is can be managed, then it is actually going to secrete a particular type of hormone.

And then you are going to use your hands or other kinds of defense mechanisms to overcome that particular type of danger. So, the origin of the human nervous system is ectodermal which

means it this is actually going to be generated from the ectodermies, you know that we have the three germ layers, ectodermies, endodermies and the misodermies. The whole nervous system can be divided into the three parts.

So, the nervous system what is there in the human body can be controlled or can be divided into the three parts depending on the its functions. So, the nervous system can be divided into three parts, you can have the central nervous system, you can have the peripheral nervous system and then you can also have the automatic nervous system. And the function of these three components are very well defined.

The central nervous system is going to be comprised of the brain and the spinal cord, and they are actually going to respond to some of the executory functions. So, they are actually going to respond to the stimuli and accordingly they are going to give the functions, they are going to give the instructions to the particular organ or the organ system, and that is how they are going to function.

So, all the spinal reflexes are actually the reflexes where you already have the pre decided, pre programmed decision powers. So, already decisions are already been made, if you touch the warm surfaces, you should withdraw the hands. Then this is all about the central nervous system and then let us move on to the peripheral nervous system.

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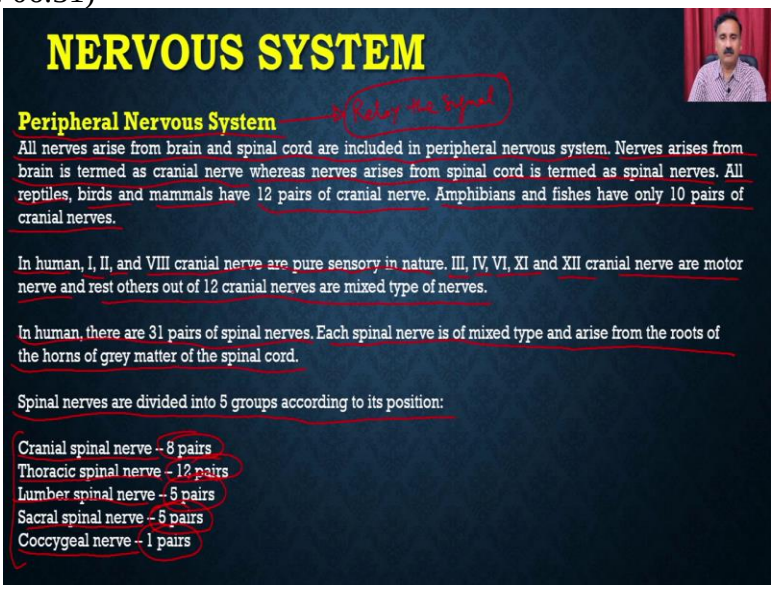

So, the peripheral nervous system is actually going to relay the signal what you are going to get the from the central nervous system. So, it is going to have the relays of the signal, so it is going to have the network of the different types of nerves, which are actually going to relay the signal and then they are also go into perceive the messages as well. So, all nerves arises from the brain and the spinal cord are included into the peripheral nervous system.

Nerves arising from the brain is termed as a cranial nerves, whereas the nerves arises from the spinal cord is called as the spinal nerves. All reptiles, birds and mammals, they have the 12 pairs of the cranial nerves. Amphibians and fishes only have the 10 pair of the cranial nerves. So, apart from the humans, the brain is also being well developed in the other animals like the reptiles, birds and mammals, and as well as the amphibians and the fishes.

But there is a difference in terms of the number of veins and that always been in accordance to the size of that organ or the development of that particular brain. In human, we have the 1, 2 and 8 cranial nerves are pure sensory in nature, whereas the cranial nerves of 3, 4, 6, 11 and 12 are motor nerves and the rest other out of 12 are mixed type of nerves. So, you can actually have the nerves which are actually either the sensory nerves or the motor nerves.

In humans, there are 31 pairs of the spinal nerves, each spinal nerve is of a mixed type and arrives from the root of the horn of the gray matter of the spinal cord. Spinal nerves are divided into five groups according to the positions. You have the cranial spinal nerves, which is 8 pairs, you have the thoracic spinal nerves, which is 12 pairs, then you have the lumbar spinal nerve which is 5 pairs then you have the sacral spinal nerves which are 5 pairs and then you have the coccygeal nerves which is 1 pair.

So, these are the different if you see very carefully these are the different areas of these spinal cord through which these nerves are coming out and that is how they are being grouped into different groups. The function of these spinal nerves is or the in general the peripheral nervous system is to relate the signal from the brain or the spinal cord and as well as to bring the messages from the other parts of the body. So, let us see what different types of nerves, what are the function of these nerves.

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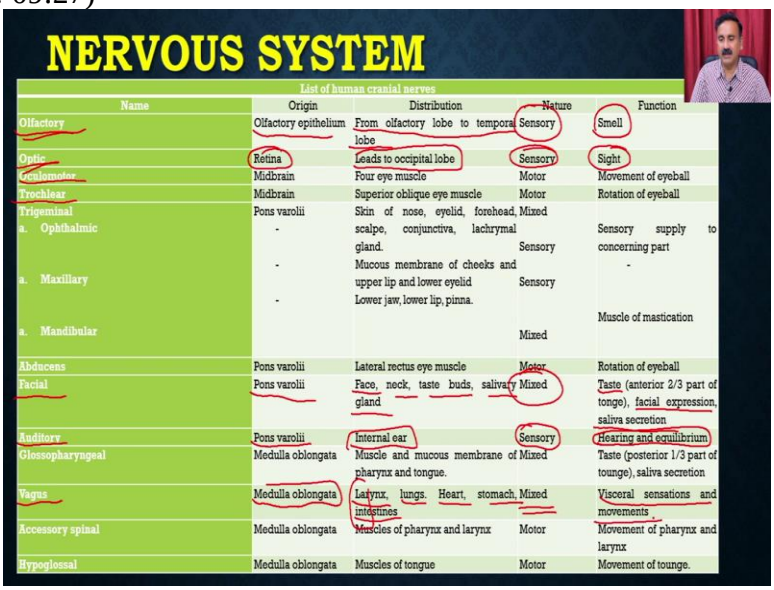

Name	Origin	Distribution	Nature	Function
Olfactory	Olfactory epithelium	From olfactory lobe to temporal lobe	Sensory	Smell
Optic	Retina	Leads to occipital lobe	Sensory	Sight
Oculomotor	Midbrain	Four eye muscle	Motor	Movement of eyeball
Trochlear	Midbrain	Superior oblique eye muscle	Motor	Rotation of eyeball
Trigeminal	Pons varolii	Skin of nose, eyelid, forehead, scalpe, conjunctiva, lachrymal gland.	Mixed	
a. Ophthalmic	-		Sensory	Sensory supply to concerning part
a. Maxillary	-	Mucous membrane of cheeks and upper lip and lower eyelid	Sensory	-
a. Mandibular	-	Lower jaw, lower lip, pinna.	Mixed	Muscle of mastication
Abducens	Pons varolii	Lateral rectus eye muscle	Motor	Rotation of eyeball
Facial	Pons varolii	Face, neck, taste buds, salivary gland	Mixed	Taste (anterior 2/3 part of tongo), facial expression, saliva secretion
Auditory	Pons varolii	Internal ear	Sensory	Hearing and equilibrium
Glossopharyngeal	Medulla oblongata	Muscle and mucous membrane of pharynx and tongue.	Mixed	Taste (posterior 1/3 part of tounge), saliva secretion
Vagus	Medulla oblongata	Larynx, lungs. Heart, stomach, intestines	Mixed	Viscoral sensations and movements
Accessory spinal	Medulla oblongata	Muscles of pharynx and larynx	Motor	Movement of pharynx and larynx
Hypoglossal	Medulla oblongata	Muscles of tongue	Motor	Movement of tounge.

So, you have the different types of nerves, you can have the olfactory nerves, you have the optic nerves, you have oculomotor nerve, you have trochlear nerves and so on. And their function is already been given. So, origin is like for example, for the olfactory nerves, you are going to have the origin from the olfactory epithelium. And what is the distribution? It is going to be distributed from the olfactory lobe to the temporal lobes.

And it is going to be a sensory neuron. And what is the function? Its function is that it will going to help in terms of smell, so it is actually going to bring the sense of the smell. Similarly, you have the optic nerves, optic nerve is going to start from the retina, and it is going to lead to the occipital lobe. And it is going to be sensory in nature and it is going to bring the light vision or the vision informations.

Similarly, you have the other kinds of brains, you can have the facial nerves, the facial nerves are going to be start from the pons varolli and they are actually going to have the distribution into the face, neck, taste buds, salivary glands and so on and they are actually going to be of mixed type which means they are going to have the sensory as well as the motor neurons and they are actually going to function in terms of the taste, facial expression as well as the saliva secretion.

Similarly, you have the auditory nerves and they are also going to start of the pons varolli and they are going to be distributed within the internal ear and then you have the, they are sensory in nature and they are going to help in the hearing as well as the balancing. And apart from that you have the vagus nerves. So, vagus nerve is going to start from the medulla oblongata. And the

medulla oblongata is it is going to have the distribution between the larynx, lungs, heart, stomach and the intestines.

So, all these are actually the internal organs, they are going to be of mixed type and they are actually going to function as the visceral sensations and as well as the movements. Then we also have the other kinds of nerves.

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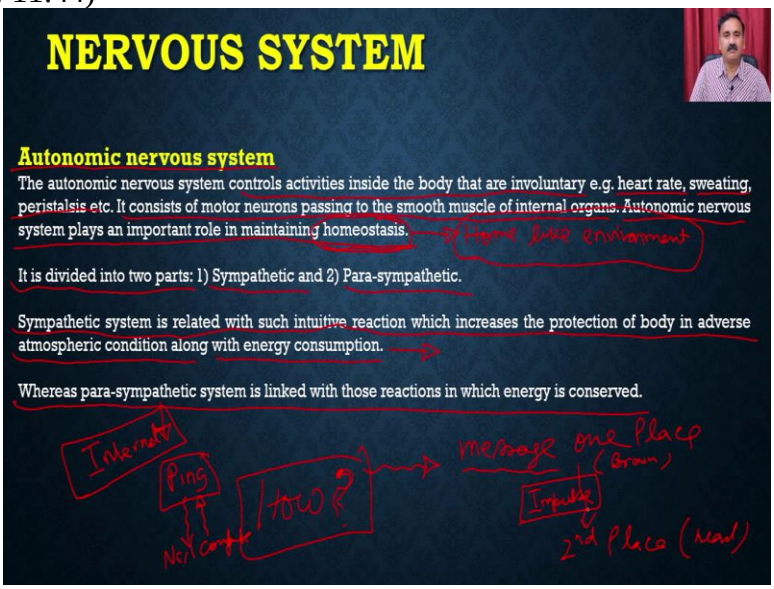

Then we have the autonomic nervous system. So, autonomic nervous system is actually going to control the activities inside the body that are involuntary. For example, the regulation of the heart rate, sweating, peristalsis, and it consists of the motor neuron passing to the smooth muscles of the internal organs, autonomic nervous system plays an important role in maintaining the homeostasis.

So, after this module, when we are going to discuss about the homeostasis, we will understand how the autonomic nervous system is actually going control in maintaining the homeostasis which means it, how it is actually going to help in terms of the maintaining the good internal environment. So what is homeostasis means is home like environment. And you know that the home like environment is always been good for you.

So, homelike environment which means it is going to maintain the different types of parameter, what could be the pH of the blood, what could be the temperature of the body and so on. Autonomic nervous system can be divided into two parts, it could be a sympathetic nervous

system or the parasympathetic nervous system. So, sympathetic nervous system is related with the such intuitive reaction which increases the protection of the body in adverse atmospheric conditions along with the energy consumptions.

Like so, sympathetic nervous system is the system where actually going to function to follow danger conditions. So, it is actually going to function in terms of the protection of the body under the adverse atmospheric conditions. Whereas the parasympathetic nervous system is linked with those reaction in which the energy is conserved. So, parasympathetic nervous system is going to having the all the activities where the energy is going to be conserved.

Now, the question is, how do you know that the nervous system is actually working? How you know that the nervous system is actually going to working? So, one thing what you can do is the nervous system what is the function of the nervous system is that it is actually going to send the message from the one place to another place, second place. For example, it can be from the brain to the heart, it can actually be a signal from the brain to the heart.

So, if you want to know whether the message is, nervous system is working or not, you can actually be able to measure whether the messages are going or not. And the messages in terms of the nervous system is actually going to go in terms of the impulse. So, that you can be able to measure, and that is how you can be able to measure whether the messages are going from one place to another place.

I am sure you might, you might have daily routine activities. For example, how do you know that the internet in your computer is working or not? How do you know that the internet is working? What you do is you always use the ping command and that is how you are actually going to send a message to the to the neighboring computer.

So, if you send it to the next computer, and if the next computer is going to send you the message back that means that internet is working. So, same way we can actually be able to measure and follow whether the messages are going between the two different parts of the body, which are connected through the nerves or not.

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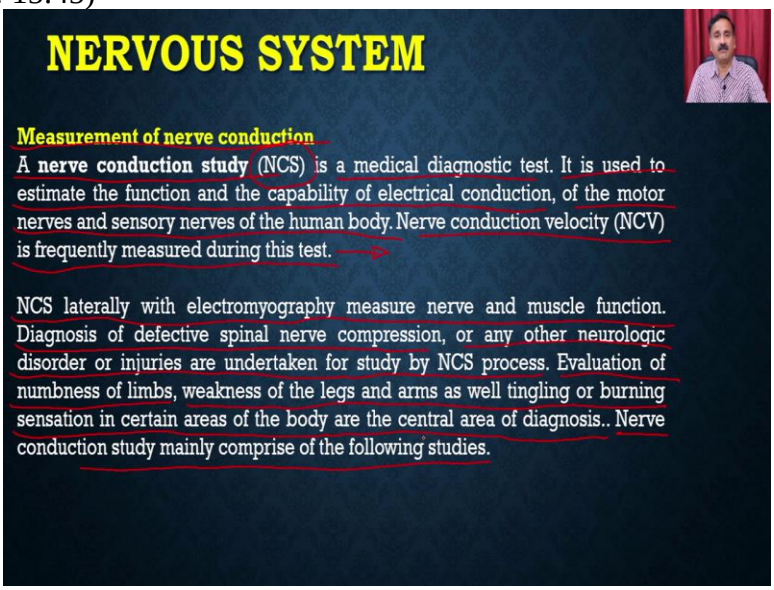

So, what is the measurement of the nerves conductions? A nerve conduction study or the NCS is a medical diagnostic test. It is used to estimate the function and the capability of the electrical conductions of the motor nerves as well as the sensory nerves of the human body. Nerve conduction velocity, NCV is a frequently measured during this test. So, the nerves conduction study is going to be performed to see whether the nervous system is working or not.

And the nerve conduction study latterly with electromyography measure the nerves as well as the muscles functions and diagnosis of the defective signal spinal nerves compression or any other neurological disorder or injuries are undertaken for a study by the NCS process. The evaluation of the numbness of the limbs, weakness of the legs and arm as well as the tingling or the burning sensation in the central area of certain areas of the body are the central area of diagnosis.

So, you have the different types of conditions where you know that the nerves, nervous system is probably be involved. So, it is not working properly. For example, in numbness of the limbs, weakness of the legs, arms, tingling or the burning sensation all these are associated with the malfunctioning of the nervous system.

And you if you do the nervous conduction study, you can be able to know the, you can be able to know the cause and you can be able to rectify the problems. So, the nerves conduction study mainly composed of the following studies, you can actually be able to do the different types of nerve conduction studies.

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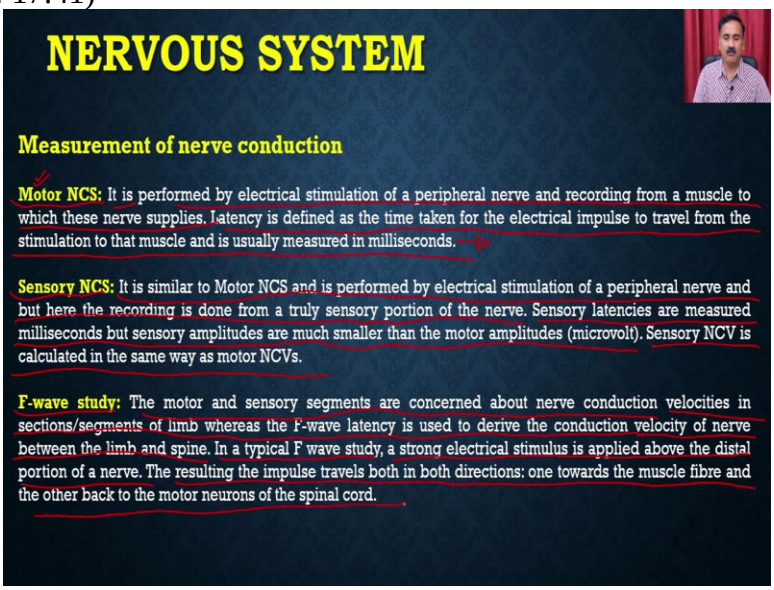

You can actually do the motor nerve conduction studies, you can do the sensory nerve conduction studies, you can have the F wave study. So, it is so, in the motor nerves study, it is performed by the electrical stimulus of a peripheral nerve and the recording from a muscles through which these nerve supplies. Latency is defined as the time taken for the electrical impulse to travel from the stimulation to the muscles, and it is usually measured in milliseconds.

So, in the motor nerves conduction study you are going to send the message or you are going to send the impulse and then you are going to measure how long it takes for the muscles or the impulse to return back to the origin. Then you have the sensory nerve conduction study, it is similar to the nerves and it is performed by the electrical stimulation of the peripheral nerves and but here the recording is done from the truly sensory portion of the nerves.

So, the sensory latencies are measured milliseconds but sensory amplitudes are much smaller than the motor amplitudes. Sensory nerve conduction study is calculated in the same way as the motor nerve conduction study. Then we have the F wave study. So, you have different types of pattern in the nerve conduction and that also can be measured. The motor and the sensory segments are concerned about the nerve conduction velocities in the section or the segment of the limb, where the F wave latency is used to derive the conditions.

Condition velocity of the nerve between the limb and the spine. In a typical F wave study, a strong stimulus is being applied above the distal portion of a nerve, resulting in the impulse

travel both in both the direction and one towards the muscle fiber and the other back to the motor neuron of the spinal cord.

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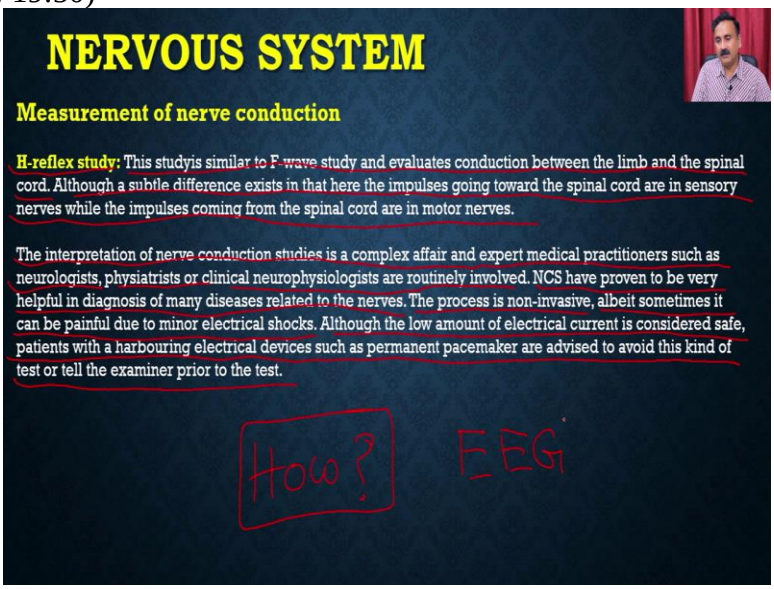

Then we have the H-reflex study. This study is similar to the F wave study and evaluates the conduction between the limb and the spinal cord. Although a subtle difference exists and here the impulse going towards the spinal cords are in the sensory nerves, while the impulse coming from the nerves cord, spinal cords are in the motor nerves.

So, once you do these kinds of nerve conduction studies, the interpretation of the nerve conduction study is a complex affair and expert medical practitioners such as the neurologist, psychotics or the clinical neurophysiologist are routinely been involved in interpreting the backend, interpreting the different types of waves and all that. So, nuclear conduction study have proven to be very helpful in the diagnosis of many diseases related to the nerves.

The process is non invasive. So, you can actually be able to do the different, these kind of measurements and it is non invasive, means you are not going to insert a probe into the body. Albeit some time, it can be painful due to the minor electrical shocks. Some, because you are going to send the shocks, you are going to do electrical impulse. So, that may actually cause a minor electrical shocks.

Although the low amount of electrical current is considered safe, patients with a harboring electrical devices such as permanent pacemakers are advised to avoid this kind of test or tell the examiner prior to the test. So, nerve conduction studies are actually being done only to understand how the nervous system is functioning or not.

Now, the question is how you are actually going to do the nerve conduction studies and what will be the setup for the nerve conduction studies. So, the nerve conduction study is always being done with a setup which is called as the elliptical encephalographs.

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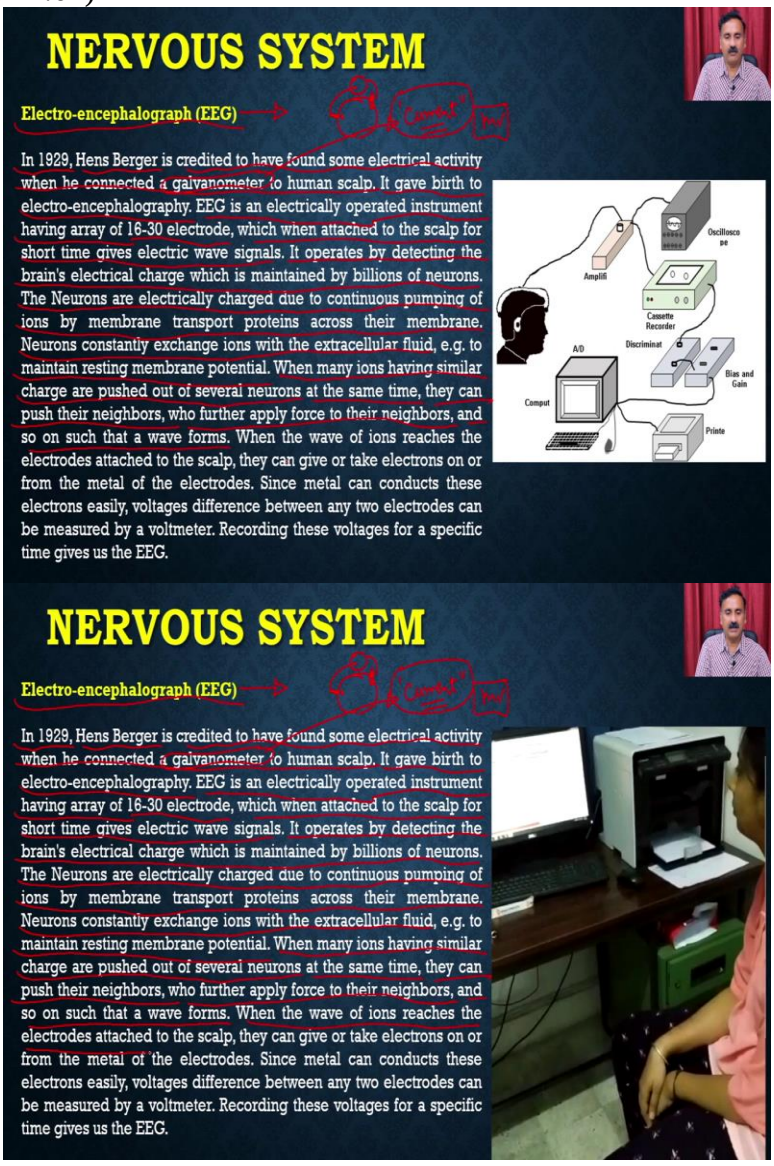

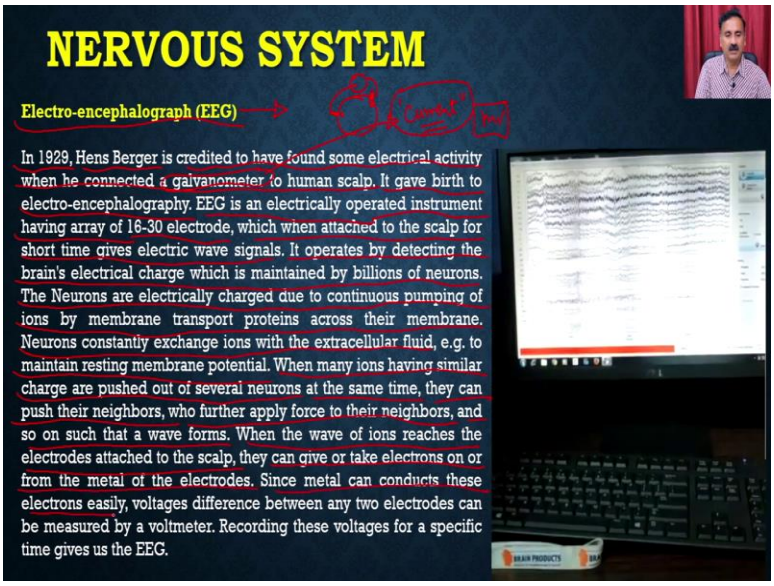

So, electro-encephalograph or the EEG is a technique which is actually been developed in 1923 by a scientist named as the Hens Berger and it is credited to have found some electrical activity when it is connected a galvanometer to the human skull. So, what you are going to do is if you take the different types of probes, and if you use the galvanometer if, I am not sure if you all aware of what is mean by the galvanometer.

Galvanometer is a instrument which measure the current. So, if you can measure the current and let us suppose you connect the two wires onto the two part of the brain, so, here you have the neuron, here you have the neuron and that you can be able to if you connect the galvanometer in between these two neurons, you can be able to measure the current. These currents are going to be in the millivolt range and there you require a very, very highly sensitive galvanometer to measure this intensity.

It gave birth to a electro-encephalography. EEG is a electrically operated instrument having an array of 16 to 30 electrodes, which when attached to the skull for the short time gives the electrical wave signal. It operates by detecting the brain's electrical charge which is maintained by the millions of the neurons. The neurons are electrically charged due to continuous pumping of the ions by the membrane transport protein across their membrane.

And the neuron constantly exchanging ion with the extracellular fluid. For example, to maintain the resting membrane potential, when many ions having the similar charge are pushed out of the

several neuron at the same time, they can push their neighbors who further apply force to the near neighbor and so on such a wave form.

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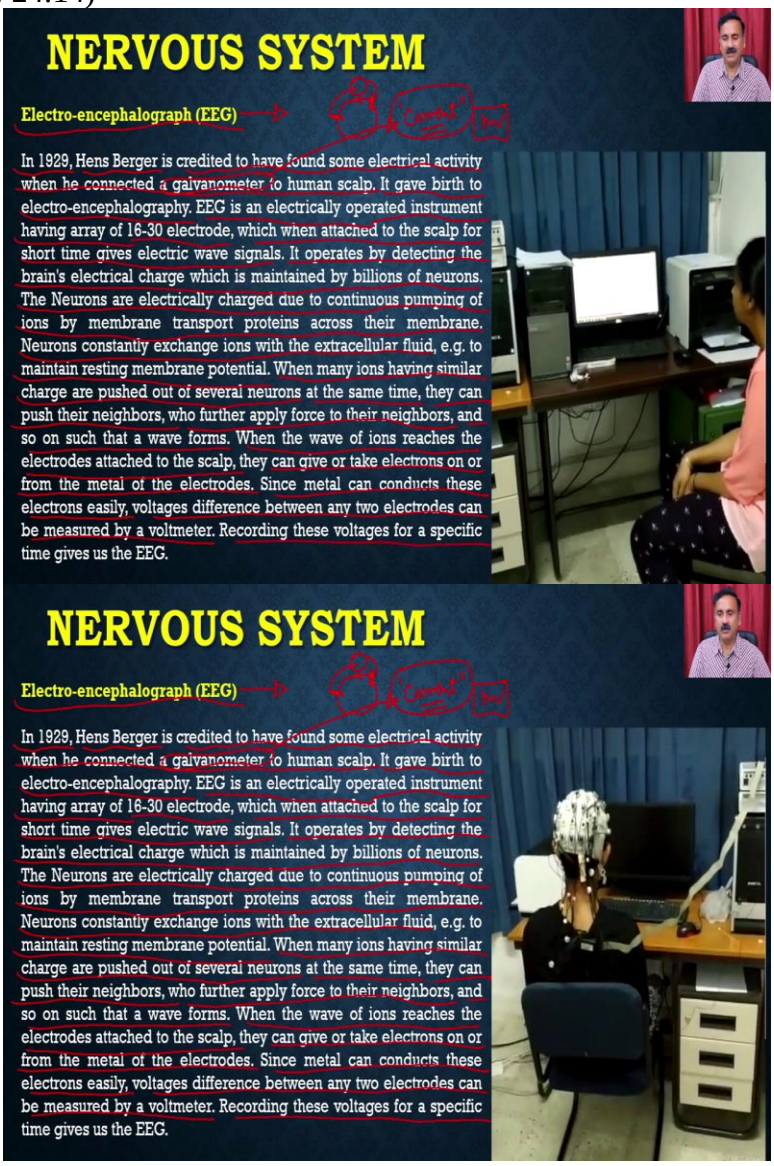

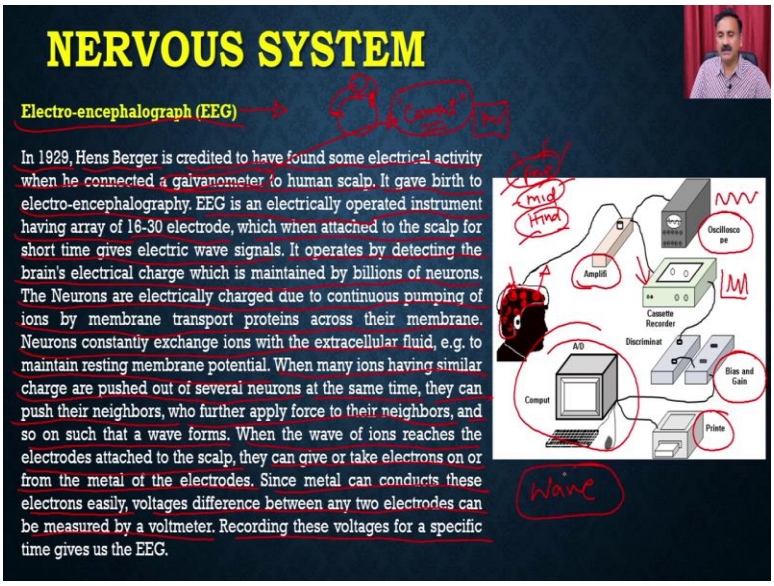

So, when the wave ions, reaches the electrode attached to the skull, they can give or take electron on or from the metals of the electrode. Since metal can conduct these electrical electrons easily voltage difference between the two electrode can be measured by a voltmeter. And recording these voltages for a specific time give us EEG. So, this is what you are going to see, this is the electrical setup where a person is actually going to provide a cap, so it is going to provide a cap.

On this cap you are going to see that it has the different types of holes. And on these holes, they are going to put the electrodes so they are going to put the electrode and these holes are according to the different zone within the brain. You know that the brain has the midbrain, you have the forebrain, you have the midbrain, you have the hind brain.

So, and all these forebrains, mid brain, hind brains, the different types of cranial nerves, different types of other kinds of nerves whether how they are distributed into the forebrain, midbrain and hindbrain are already being known. And what are the circuits which are actually going to be formed within the brain is also known.

So, you can actually be able to put the different types of probes into different areas, and then what you can do is you can just give the impulse into one of the probes, and then you can collect from the other probe and that is how you can be able to measure or you can be able to follow the connections, whether there is a continuous connection or not. So, once you connect the electrode, then you are actually going to have the amplifiers that is going to amplify the signal.

So, it is going to amplify the current what you are going to get when there will be a connection of (())(26:04) there will be a flow of current. And then it is actually going to go into the oscillograph. So, oscilloscope is actually going to give you a pattern of the electrical impulse and that can also be gone into the cassette recorder. So, cassette recorder is actually going to give you the recording of that.

So, it is going to give you a graph. And apart from that, you can also be having the gain and you are going to have the printers and you are also going to have the computer so that you can be able to monitor all these activities on the real time. And gain and bias is actually going to help in terms of increasing or the decreasing the signal versus noise ratios. So, this is what the setup is and how the different, what could be the pattern? You are going to have the different types of waves, what is going to come out after the EEG.

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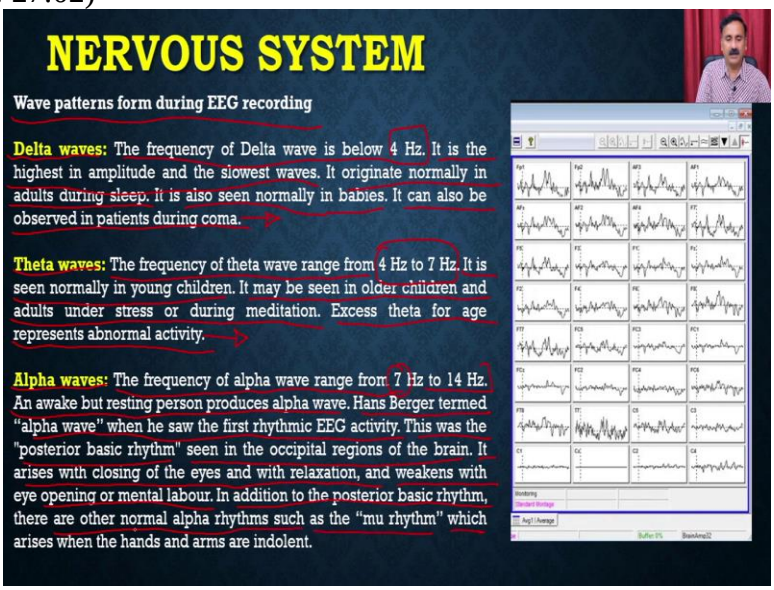

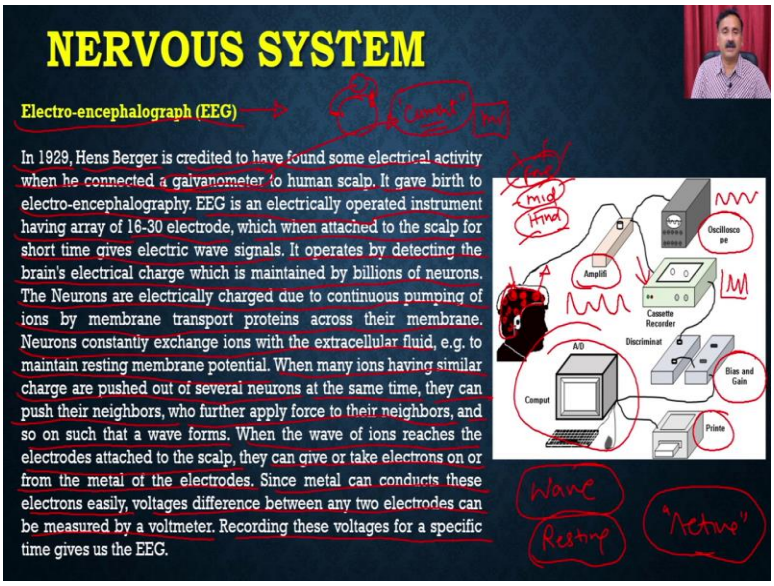

So what information you will get after the EEG. So, the wave pattern during the EEG recording. So, these are the what you are going to see from the system, you are going to see the different types of wavy pattern and these waves are actually going to be regulated to the different types of probes what you have put. Remember that we have put the probes into the cap and these probes are actually going, every probe is actually going to give you a electrical impulse.

So, it is going to give you a pattern, how the current is flowing between the these two electrodes. Because you can ask the person to do different types of activities for example, you can ask him to read the (())(27:39). So, you can actually be able to do the EEG under the resting state or you can be able to do the EEG under the active state. In the active state probably you can actually ask the person to read a book for example, or you can actually ask him to watch the TV or something like that. So, accordingly the other different parts of the brain are actually going to participate into different types of activities. And that is how you will going to have the pattern.

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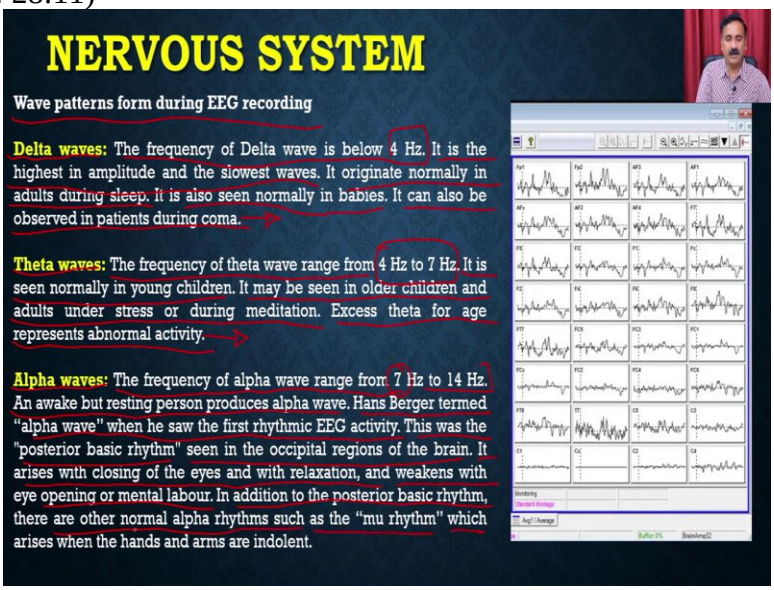

So, after the EEG you are going to have the different types of waves. For example, you can have the delta waves, you can have the theta waves, you can have the alpha waves and all these waves are actually going to have its own significance in terms of interpretation of the information. The frequency of the delta waves is going to be around 4 hertz. And it is the highest in the amplitude and the slowest waves.

It originates normally in the adult during the sleep and it also been seen normally in babies, it can also be observed in the patient during the coma. So, this is actually a delta wave which is associated with the sleep. Then we have the theta waves, the frequency of the theta waves ranges from the 4 hertz to the 7 hertz. And it is seen normally in the young children, it can be seen in the older children and adults under stress or during the meditations. Excess theta for age represents the abnormal activities. So, that is going to be not normal.

Then we have the alpha waves, the frequency of the alpha waves range from the 7 Hertz to the 14 hertz. An awake but resting produces alpha waves, hence Berger termed the alpha waves when he saw the first rhythmic EEG activity. This was the posterior basic rhythm seen in the occipital region of the brain.

It is arises from the closing of the eyelid and with the relaxation and the weakens with the eye opening or the mental labor. In addition to the posterior basic rhythm there are other abnormal alpha rhythms such as the mu rhythm which arises from the hand and the arm are indolent.

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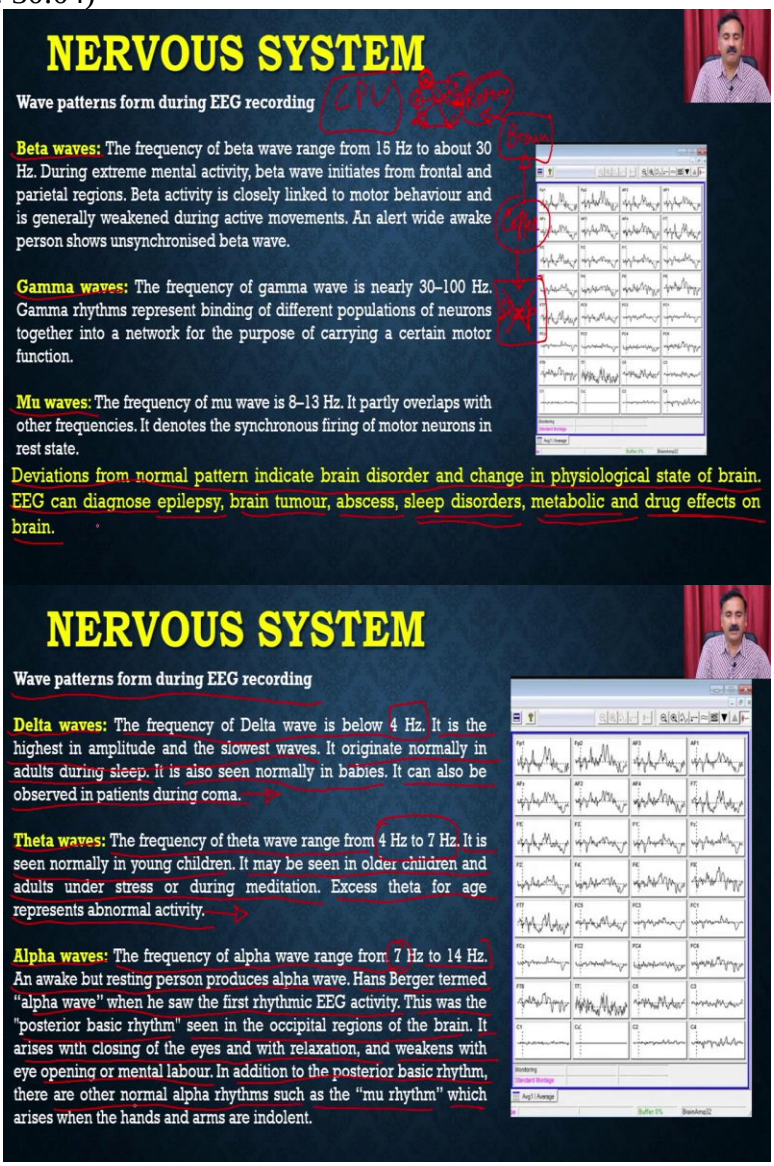

Then we have the beta waves, and we have the gamma waves, we have the mu waves. And what is the purpose of the EEG recording? The EEG recording is actually going to tell you how the circuit is actually working. So, brain is nothing brain is like a computer. And within the computer, you know that you have the different types of circuits like you have the processor, you have the RAM, you have the all of the components.

So, if your computer is not working, what you are going to do is you are going to fix, you are going to see whether the current is flowing between all these components or not. And these are actually going to give you the different types of waves, which are actually going to respond when you have the connection between this and this, or when you have a connection between

this and this or when you are going to have the connection between this and this. So, depending on the neurons, you are going to see the different types of waves.

And deviation from the normal pattern indicate the brain disorder and changes in the physiological state of the brain. You are actually going to have the normal state and then the brain is actually going to give you the abnormal pattern like abnormal waves, and these abnormal waves are actually going to say that there is a disorder associated with the brain activity.

So, EEG can be used to diagnose the epilepsy, brain tumors, abscess, sleep disorders, metabolic and drug effects on the brain. So, you know that epilepsy, brain tumor for example, if there will be a person is developing the brain tumor, then the tumor is actually going to affect the internal structure of the brain. And it is actually going to, may interfere even the conduction of the waves also.

And that is actually also can be interpreted by using the EEG. Then we can have the sleep disorder, you know that we have said just now. That the alpha waves are, the theta waves are actually going to function when they are actually going to have they sleep actually. So, (())(32:17) sleep.

So, if you have a sleep disorder, for example, if you do not get a very good sleep, that sleep is actually being controlled by the brain, when your brain is going to sleep or it will go into the resting state, then only you can be able to sleep. So, that also can be diagnosed with the help of the EEG. Then we have the some kind of metabolic and as well as the drug affects.

For example, if you take the simple coffee, if you take a coffee, the first effect happen is that you are going to have the no sleep. Why it is so because the coffee is actually going to affect the brain's activity, it is not going to allow the brain to go into the resting stage and that is how it is actually going to disturb your sleep cycle. So, that also can be interpreted by the EEG. So, this is all about the nervous system, what we have discussed.

So, what we have discussed so far? We have discussed about the different components of the nervous system. So we have the central nervous system, we have the peripheral nervous system and we have the autonomic nervous system. Then in the central nervous system, we have the two

different organs, we have the brain and the spinal cord. Whereas in the peripheral nervous system, we have the different types of nerves.

So, we have the cranial nerves and we have a spinal nerves and in the automatic nervous system, we have the parasympathetic nervous system and as well as the sympathetic nervous system. In turn, we have discussed in detail about the anatomy and structure of the different region of the brain. And then we also discuss about the spinal cords.

So, we have discussed many nerves and how the nerves are controlling the different types of activities. So, with this, I would like to conclude today's lecture. In a subsequent lecture, we are also going to discuss about the some more aspects related to the nervous system. Thank you.