Animal Physiology
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Module - 01
Lecture – 17

Welcome back to the lectures in Animal Physiology in NPTEL. So, we are into the last lecture of section 5, which is the 10 th lecture and in this lecture, we will be talking about autonomic nervous system, what really is autonomic nervous system, to start off with let us do some situation or aspect which may help you to appreciate it better. So, think of it you are walking in a lonely or walking in a dark street in the night or you are sitting in your room and studying late hour of the night all of a sudden, you hear a loud noise or you hear like it is stormy night, and you hear that breakage of the window panes or outside you hear some cracker or something.

You all of sudden gets scared and subsequent set of event which take place, like you know you just try to escape or you feel sacred and all of a sudden the blood flow enhances in your body and you lose the sensation of thirst or urination or anything.

And all over there is some kind of panic over sacred, what is that reaction, what kind of circuits regulates that kind of situation, this falls under something called autonomic nerves system. In day to day life if you think about, so how many times we really use conscious thought process, well you are studying of course, uses it you are crossing the roads you have to ensure the buses are not coming on the motor vehicles are not coming.

So, or you are at same distance from them then you have to cross the road, other than that most of the time we do not even know that we are being controlled by our own system you know autonomous manner in an automatic manner, something like you know we do not decide that we are going to get urination. We do not even command to tell our digestive system that you digest our food, we do not tell the heart that you beat and we do not decide the secretion of the hormones.

They all happen in their own course in a kind of as if within this whole system of powers, they are in built circuit, intrinsic circuits which ensures that all our day to day events takes place without even we giving any command. They are in voluntary, I mean

we have no command or control on all those kind of things, so this is exceptionally essential for you people to understand and will talk about that how the nerves system really deal with this kind of actions.

Let us take another situation, which will help you to appreciate it much better, some time we here this some bodies brain dead. In other word somebody is lying in the hospital and who is responding to any signal or anything and yet doctors are unable to declare this person dead and there is always kind of debate or controversy over this. Shall, we give this person some kind of injections, so that this person dies or like you know there is lot of debate over it.

And, is it euthanasia allowed in this kind of situation or not, though this person is brain dead, he or she is not at all responding to any stimuli, but yet his heart is beating and the defecation is taking place, urination is taking place and all these events are taking place, then what is that coordination, so this is the zone of autonomic nervous system.

So, now let us get into the way, we will talk about it is that, we will talk about the circuits involved in it, the autonomic circuits and will compare with it with the other circuits, which does not follow the autonomic system. Then, we will talk about the classification of autonomic nerves system, which falls under parasympathetic and sympathetic systems and we will talk about some of the situations. And I promised you that the cardio vascular control and all these things and we will talk about the neuro transmitters which are involved in it and how that circuit functions in this section.

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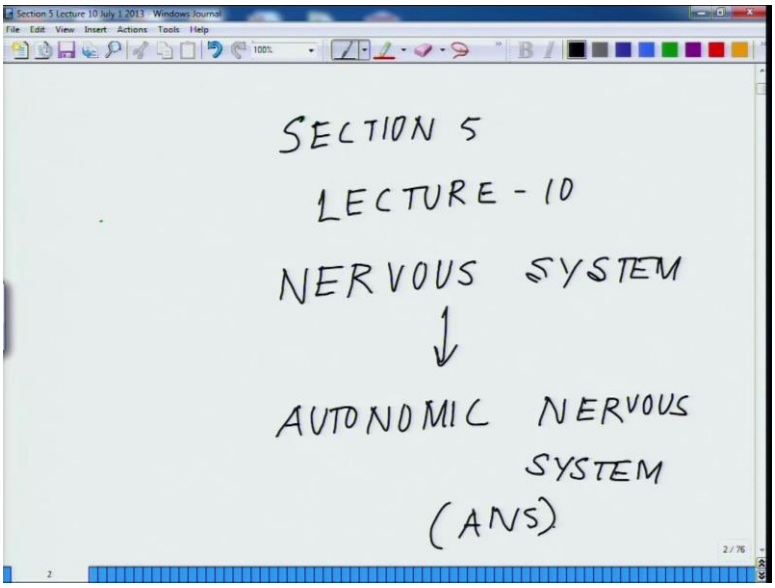

So, let us starts with the our section 5 and lecture 10 and this is nervous system and within nervous system. Today, we are dealing with autonomic nervous system auto autonomic nervous system; this is what we are going to deal with.

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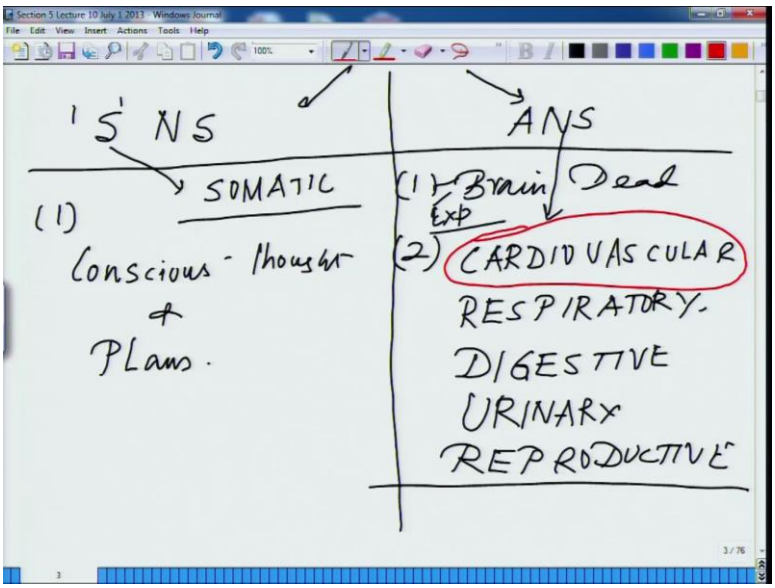

When in the autonomic nervous system, your first thing we will do if kind of draw out a classification of all of the nervous system, what we have already talked about, which I is termed as technically somatic nervous system and ANS as Autonomic Nervous System,

next going back, so this is also called ANS. So, whenever I have drawn the circuit of autonomic nervous system, so this is basically S stands for Somatic nervous system.

So, this falls under conscious thoughts and plans, well is in this section, I talked about person with brain dead, it is the example of that I talked about other function, so let us, what all ANS is controlling is this, just an example. Portentous controlling essentially is cardiovascular system, respiratory system, digestive system, urinary system and reproductive system.

And here, I wish to highlight that during 1960's, if a person would have been suffering from gets an heart attack most unlikely was that you could really either recover this person or the life acceptance use to reduce very sharply. But today almost 50 years down a line these are not a big deal, when after 100 act a couple of heart attacks peoples arrive.

Because, now we have reach to a point, where we can intercept the control circuits of the nervous system or another word we could intercept the autonomic nervous circuits, which regulates the cardiovascular movement. The blood flow, the blood pressure and the cardigan exactions, and all these things are slowly under the pharmacological intervention.

So, there are series of drugs which could bring down your blood pressure, essentially what they do is that, they target the autonomic nervous systems. And, especially they target the receptor for the neuro transmitters which regulates your blood pressure or under unusual situation there is increase in blood pressure and how to bring that down. So, these are and this particular system of autonomic system is of extreme important from pharmacological prospective.

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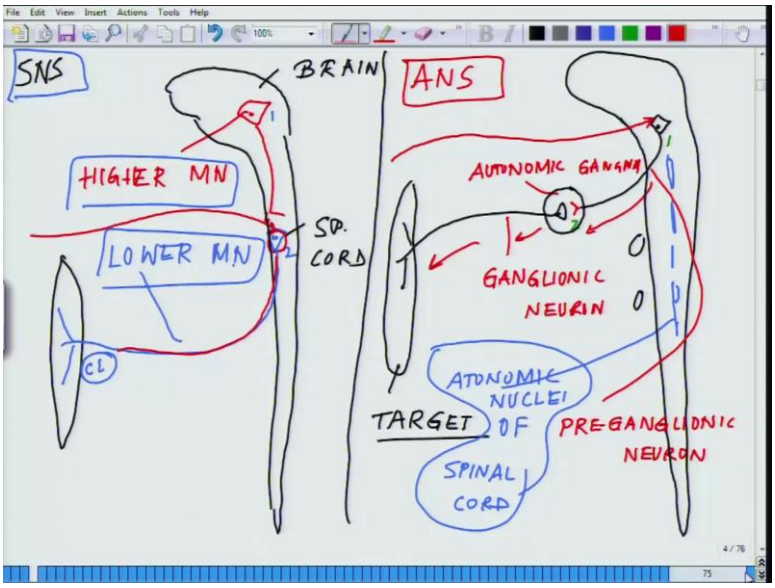

Now, what we will do in the next slide, we will compare the autonomic nervous, the structure of the autonomic nervous system and the structure of the somatic nervous system. So, whenever I drew it, so this side from my left this is basically somatic nervous system, so this is the side view of the brain and the spinal cord. So, I have drawn like this is this is the brain and here is the spinal cord and here is imagine this is the target tissue.

So, I always mention that you may have two possibilities in a higher motor neuron which is synopsizing on the second series motor neuron which are lower motor neurons and they are synopsizing on the target tissue. And, this is how circuits works, this is the basically a very simple way of defecting it, so these are the higher MN motor neuron, these are lower or somatic motor neuron MN, we have talked about it.

So, now what about the autonomic nervous system, again the same drawing the spinal cord of the brain, so there are two options here, what happens is say for example, so it in a specific neurons which are sitting out here. This send out signal and out here they have in the ganglion, I should told you that they are ganglions around it. So, in the ganglion there is another set of neurons which take the message to the target, so this is the target.

And, in other word, so basically what you have, if you compare these two, so here what you see is from level 1, level 2 and this is the control level CL. Here, essentially what is happening, one this is the level 1, which is getting of course a signal from the brain even

higher centers from the brain, this is level 2, there is another bicarnation which is outside the system.

So, possibilities are there, say for example, if you look at it, if it is a reflex circuit, then it will be like this, a signal reaching here. So, it is just like one level of processing the signals comes back, here the processing is not at one level, there are two level of processing. Another word, this essentially this signal will go like, this from here, it will come back to one level of this thing.

And, this is a second level of it and this second neuron which is involved is called ganglion neuron and the message is coming like this ganglionic neuron and the first neuron which is giving the ganglionic neuron, a message is called pre ganglionic neuron. And this particular ganglion is called autonomic ganglia. Ganglia are basically series of neuron switch gathered to gather at one spot autonomic ganglion.

And, there are within the ventral horn there are spots, there are zones which are called autonomic nuclei of a spinal cord or autonomic control centers which are mostly regulated by phase maker cells of the nervous system, autonomic nuclei of spinal cord. So, this is the basic geometry of the somatic nervous system and here we have ANS autonomic nerves.

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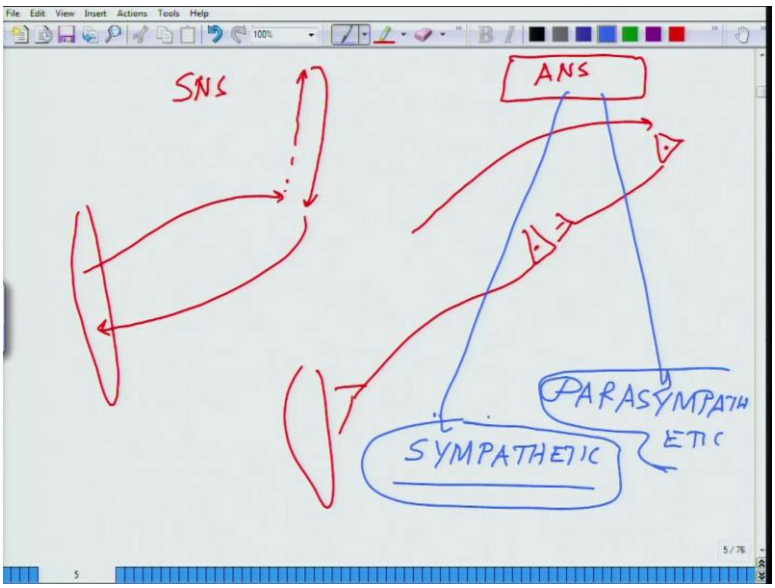

So, if you look at it in a simple way, so in case of somatic nervous system here is the target tissue, a signal reaches a processing signal comes back, there is a possibility that this part of the signal may go up to the brain and comes back. And in the case of ANS, it is slightly different, I will show you the complete circuit signal reaches hit upon a center from their signal comes to the ganglia, from the ganglia another set of neurons bring the signal back to the target, this slightly mode the longer route out here. So, now this ANS is further sub divided into two parts, I come in depth, but before that I will draw the circuit 1 is called sympathetic, then the other is called parasympathetic, these are the two classes of autonomic nervous system.

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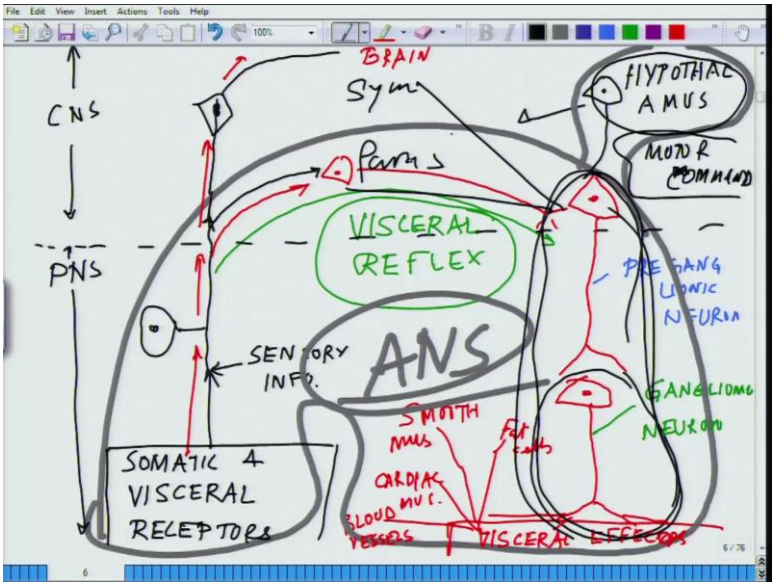

From here what I will do, I will draw the complete circuit, so that will kind of work help you to appreciate the whole process, so let us start like here these are somatic sensors. So, somatic and visceral receptors, the receptors present in the digestive system within the visceral of the body, these receptors are sensing some kind of change and these are transmitted higher.

The sensory information's are send via sensory neurons, these are the sensory neurons and this is the sensory information's, sensory information these are all part of the peripheral nervous system. There is a classification here and this is the part of the central nervous system, this dotted line separates the central nervous system and peripheral nervous.

So, this is the schematic stu, which you have to understand from here the possibilities of the sensory information is still either it moves to reflex circuit like this or it goes directly to the higher centers of the brain. Fire the ascending pathway, if guys remember I thought, you the ascending pathway all the way, so the signal is moving like this from here sensations moving like this moving like this one option to the brain, the other option is that it by passes, it does not go to the brain.

All the signal reaches here, which is mostly in the case of the reflex circuit, from here the signal is being transmitted to something called a pre ganglia neuron, why are inter neuron or may be some other neuron. Now, this pre ganglionic neuron, now synapse on a ganglionic neuron, this ganglionic motor neuron, these are also called motor neurons.

Technically, speaking they reaches the target which is on the visceral effectors, you have I will draw the blood vessels cardiac muscle, smooth muscle which is part of the digestive system and then you have the edible sites of the fat cells. So, this one is your pre ganglionic neuron and the second one is the ganglionic neuron and this is the circuit of the ANS and there are major reflex which it control is falls under visceral reflex.

We have talked about the stress reflex arch, this is another form of reflex which is called as visceral reflex, essentially this is the one which regulates of the food are getting digested and everything. And, these neurons which are pre ganglionic neurons are under the tone of another set of neuron from the higher center, especially from the hypothalamus which will be touching in the endocrine system.

It is, I will just show you where exactly its hypothalamus, this is basically the higher centers which are controlling the motor commands, they issue the motor commands and set the tone or set the phase for this. So, this is essentially is I have to kind of highlight this hypothalamus, this is essentially is the tertiary of the autonomic nervous system with a command from the higher centers. And even some time these commands from the hypothalamus come without envying getting any sensory, you there their information's. So, this is all falls under ANS or autonomic nervous system.

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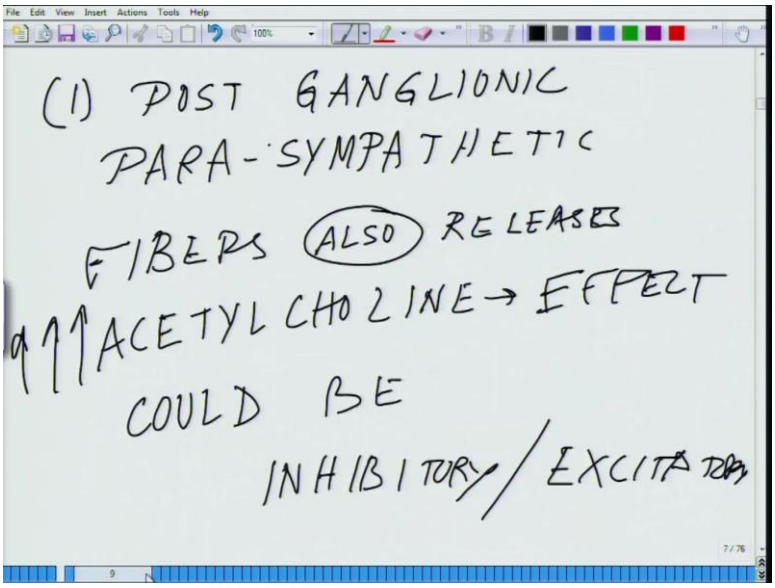

Now, we will talk about here a couple of things which is worth mentioning is that, please remember the post ganglionic parasympathetic system. So, this could be sympathetic or parasympathetic and I will come to just for it, just gather this information parasympathetic fibers. So, let us going back, so this is essentially is the sympathetic and parasympathetic control out here, these this circuit falls under two categories sympathetic and parasympathetic, so post ganglionic parasympathetic fibers also releases.

So, the neuro transmitter involved is as still acetyl choline, there are few, it mention it also because of a reason the major neuron transmitter is acetyl choline and it effect could be inhibitory or effect could be inhibitory or excitatory, this is first thing in you have to realize here.

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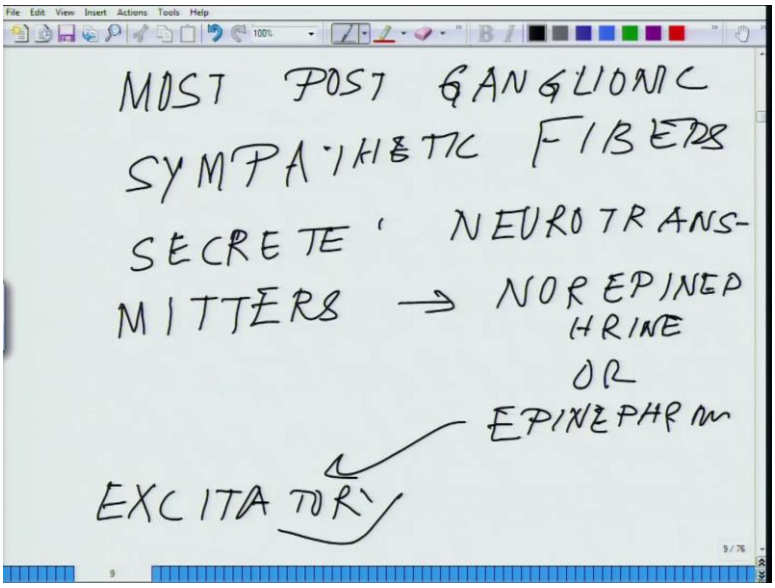

Second thing is that most post ganglionic sympathetic fiber secrete, so we talked about parasympathetic that they secrete acetyl chorine, one most post synaptic sympathetic fiber secretes neuro transmitter. So, now you might realize that, how important are these neuro transmitter, they are the ones which offers the functionality to the nervous system nor epinephrine or epinephrine and the effect could be effect is mostly excitatory.

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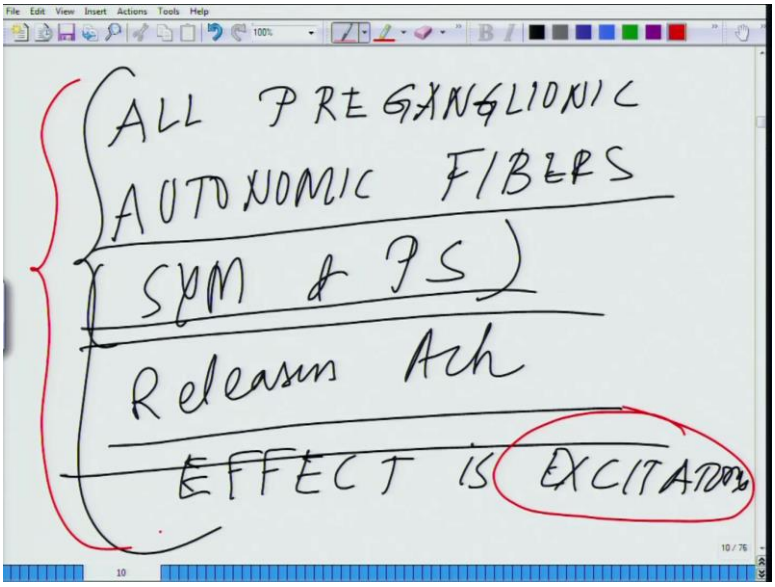

Now, one more piece of information which from that circuit, we obtain all pre ganglionic autonomic fibers which includes sympathetic and parasympathetic releases acetyl

choline. Always remember this, if I go back to the circuit out here, this pre ganglionic fiber this is one of interest, whether it is sympathetic or parasympathetic, this exclusively releases acetyl choline. Just remember this, it is the change is after this, irrespective of this pre ganglionic fiber will always release sympathetic or parasympathetic into the circuit. All pre ganglionic autonomic fibers sympathetic or parasympathetic releases acetyl choline and the effect is excitatory, this is very, very important effect is excitatory, I exclusively on whenever you draw the circuit just keep this in mind this is very important.

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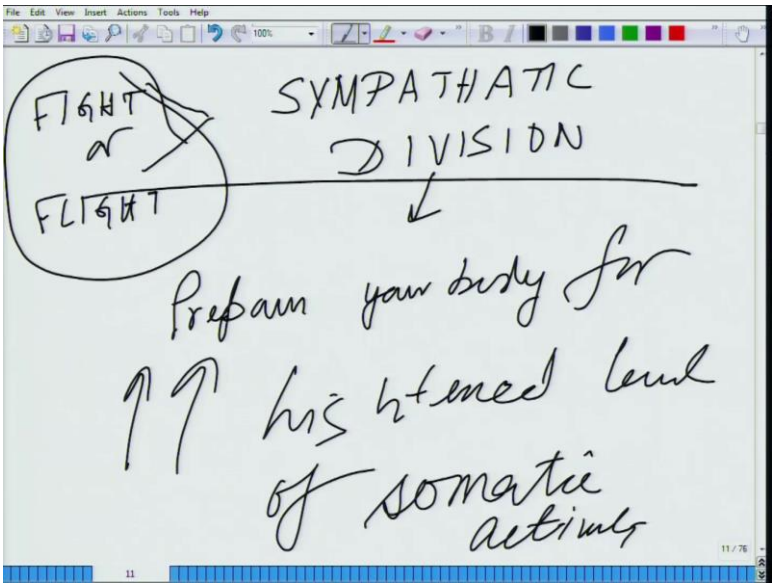

So, with this we will move on to the sympathetic division, what the sympathetic division means, so sympathetic division sometime is also called fight or flight system. Generally, the sympathetic system, prepares your body for heighten level of somatic activity. So this is a situation, when say for example, I give you this example in the beginning, that suppose you are sitting in dark room, you are just a studying late hour of the night, all of a sudden you here a window panes have broken, you just get scared.

All of a sudden, your mental alertness start, it its goes up like there is something wrong, you are feeling like you wanted to go to urinate, all of a sudden, the urination stopped, you really do not feel that, you just forget. Even if you are feeling that, you are hungry, you just forget as if all of a sudden everything all part of your body is kind of almost frozen, your metabolism goes up, you started prospering, you are as if lot of sweating is

taking place. And you are sweat gland as if got completely activated and you are energetically very high, if in a really very active state.

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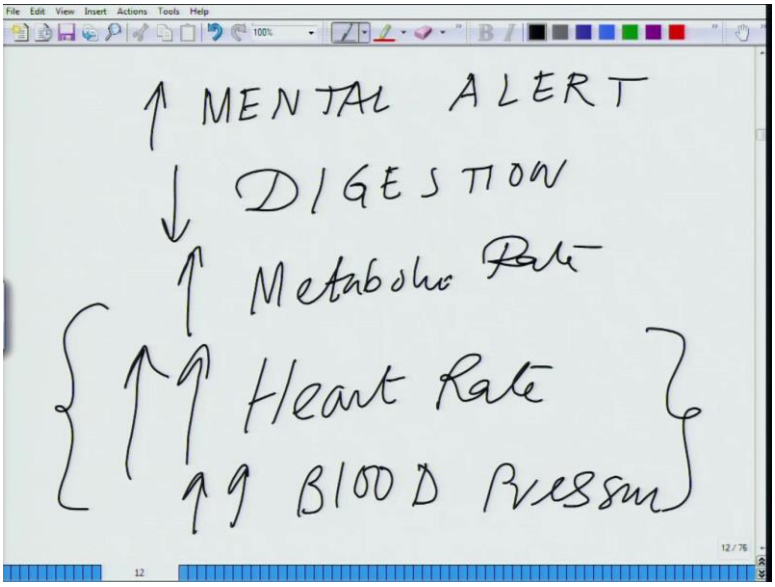

So, if I put them all together, in terms of like or you have to understand, so the first thing increase is mental alertness, you are become very alert at that point, then there is a the digestion goes down your metabolic rate goes up your heart rate goes up. So, here comes the control system, your heart rate goes very, very up, so when your blood pressure goes up, now these are the control systems of the heart rate.

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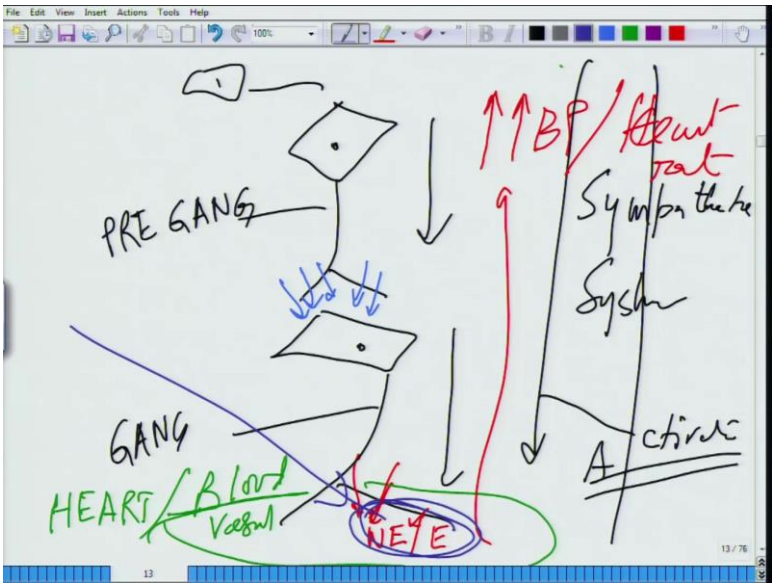

So, in other word what is happening, we are talking about sympathetic system which is secreting, in other word if I again go back to the circuit, if this is the pre ganglionic neuron and here you have the ganglionic neuron. And, the signal is coming like this and with the higher centers setting the tone for it, so this is the pre ganglionic and this is ganglionic and we are talking about the sympathetic system.

So, now when we know that this only secrets acetyl choline with the irrespective of sympathetic or parasympathetic and this one the ganglionic has option to secrete nor epinephrine or epinephrine. So, now and this is the target tissues say in all situation, let is imagine target tissue is cardiac heart or cardiovascular or blood vessels. So, essentially what is happening, when this sympathetic circuit is activated out here, this is all like activated, this is all activated, when this circuit is activated.

So, automatically the secretion of this nor epinephrine or epinephrine by these neurons release leads to the increase in the blood pressure and cardiac output or heart rate. Now, if you have drug, which could target this some more you could block the secretion of nor epinephrine or epinephrine, essentially you can control that control your heart rate as well as your metabolic rate as well as your blood pressure.

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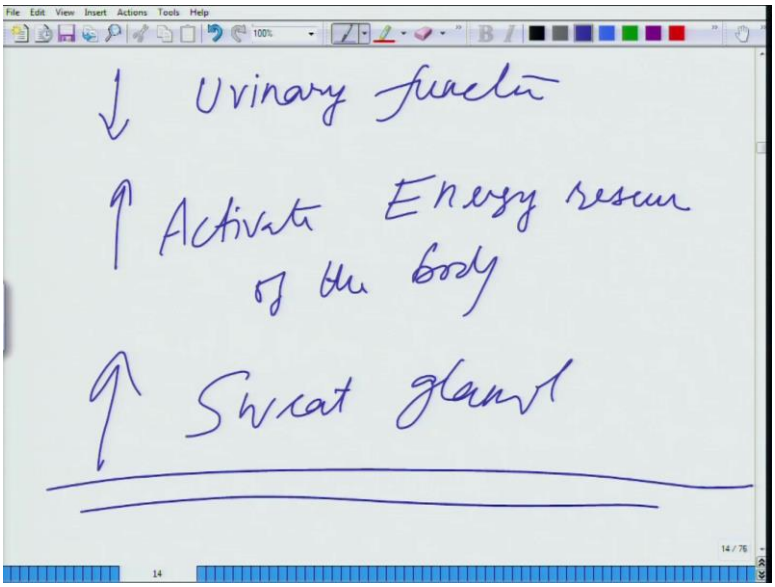

So, blood pressure goes up urinary function is compromised, it goes down, your activate energy results of your body and activate the sweat gland. If on your day to day life, you try to correlate this situation, you will find exactly that is what happens, when you get

scared or you are concentrating heavily on something. This is exactly, how the sympathetic system comes into play, heart rate increases, you respire really fast, energy results of body starts getting activated likewise. Now, simultaneously so I told you this is called fight or flight situation.

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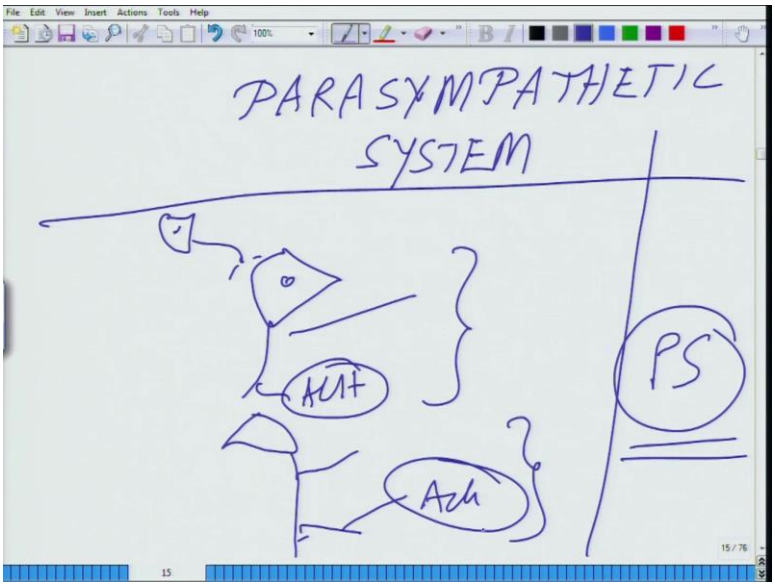

The next thing is let us talk about the parasympathetic system, let us again redraw the circuit, so if you redraw the circuit. So, these are the higher centers of the brain which are controlling, here is the circuit, so this is secreting a acetyl choline ACH and this is the pre ganglionic neuron and this is the ganglionic neuron which also secretes. In the case of parasympathetic only PS, I am just showing, it is PS also secreting acetyl choline.

So, this is one comparison, you have to realize in the case of sympathetic system, it was epinephrine or nor epinephrine. If you go back couple of slides back, so this was nor epinephrine or epinephrine and in this situation at both the level, it is acetyl choline where is in the other situation at this level of course pre ganglionic, it was acetyl choline, but at this level it was epinephrine or no nor epinephrine.

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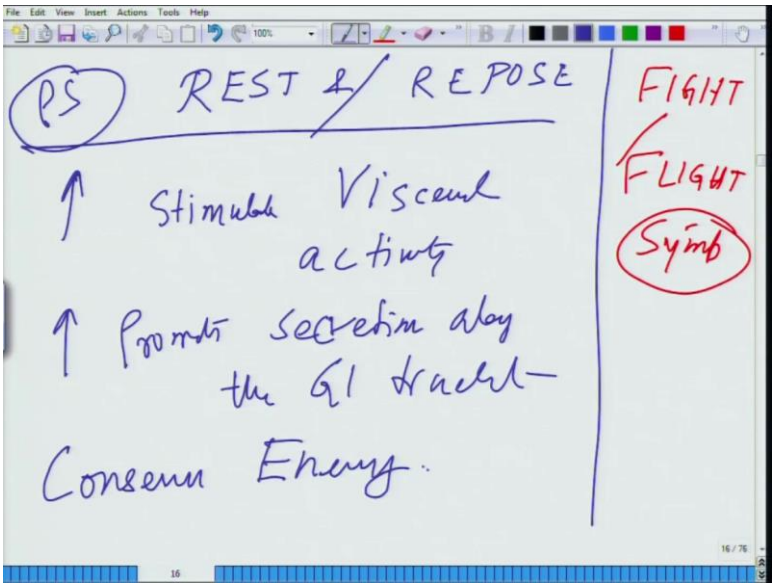

So, what essentially is this, this is also called a rest and repose, if you remember as against fight or flight which was sympathetic and here we are talking about the parasympathetic system which is PS, what all happens first of all, it stimulates visceral activity. In other word your digestion increases, promotes secretion along the secretion, along the GI track or gastro intestinal track, this conserves energy.

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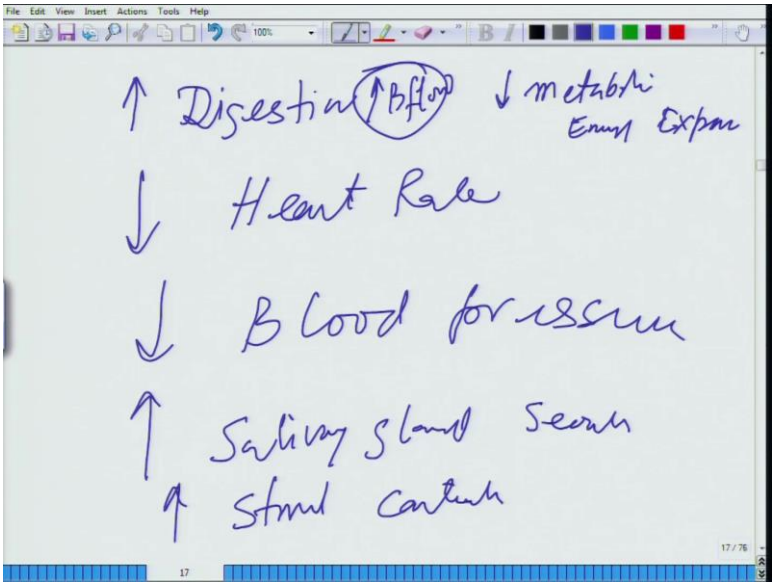

Then, it enhances digestion brings down, heart rate brigs down, blood pressure, just the opposite of what happens in the sympathetic system and it increases the salivary gland

secretion and increases stomach contraction. And metabolic rate goes down, metabolic energy expenditure goes down and blood flow to the digestive track increases that you can figure out in the digestion in terms, blood flow increases out here and blood flow increases and it stimulates urination and defecation.

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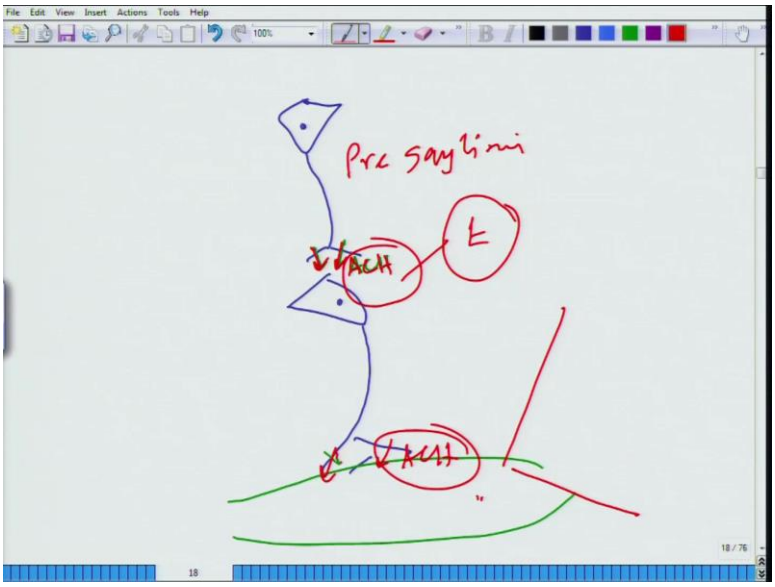

Now, what is essential here to understand is this, so how it modulates is signal, this is the pre ganglionic neuron and this is the ganglionic neuron and this is the target tissue and in both the situation, so it is secreting acetyl choline. Here also it is secreting, let us put it red, it will be easy for me to explain acetyl choline, here also it is secreting acetyl choline, but essentially there is something very interesting about this acetyl choline, what happens to this, this acetyl choline which is secreted here and I told this is all the time.

The pre ganglionic one is excitatory, but for this acetyl choline which is secreted on the target tissue there are two receptors, where acetyl choline, so here is a situation you have to this is something new, which I have discussed before this. So, for one neuro transmitter, there may be multiple receptors, that does not mean, that if I have acetyl choline out here, the receptor will be always same. There could be varied kind of receptor based on the receptor type and based on the binding kinetics; the output result will be different.

So, in the case of acetyl choline, there are two major receptors, one of them is called nicotinic receptor, the other one is called muscarinic receptor. So, nicotinic receptor got

it is name, because on that hand, so just for your understanding, as I just introduce this thing.

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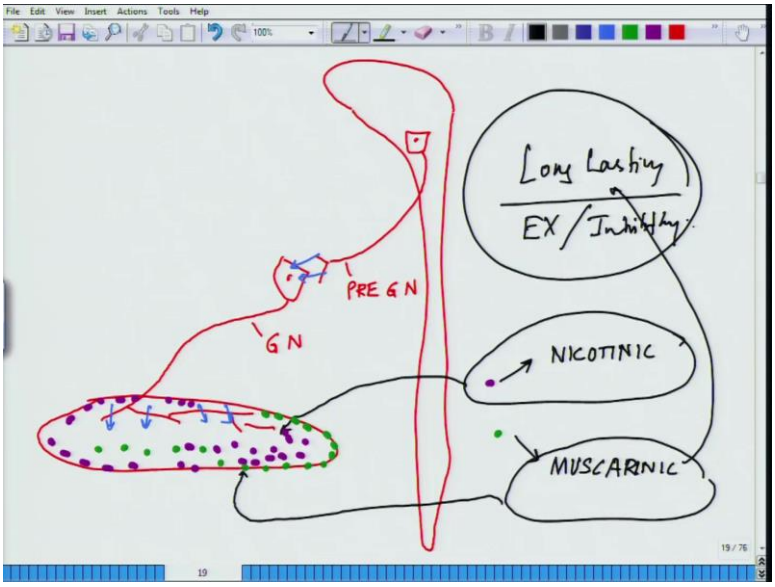

So, the receptors are likewise, so if I blow up this MH, it will be something like, so let us redraw this, for better understanding sake, so here is the target tissue and here you have the ganglionic system and this is the parasympathetic system out here. So, this is the ganglionic one, ganglionic neuron and this is the pre ganglionic neuron and at this level it is secreting acetyl choline showing by green, here also it is secreting acetyl choline, but the differences lies here.

There are two kind of receptor like this these are the receptor on the surface and it need disperse with another kind of receptor. So, now I call that has nicotinic receptor and this one is muscarinic receptor, how they got this name muscarinic and nicotinic, muscarinic receptor, because nicotinic which is on a several source nicotinic binds to these nicotinic acetyl, these receptors and muscarinic. It is from one of the poisonous mushrooms muscarinic, that particular compound binds to them, based on that, they got their name muscarinic and nicotinic acetyl receptors. So, the secretion of this acetyl choline binds to either to the muscarinic or nicotinic acid receptor and based on that, there rest of the activities take place.

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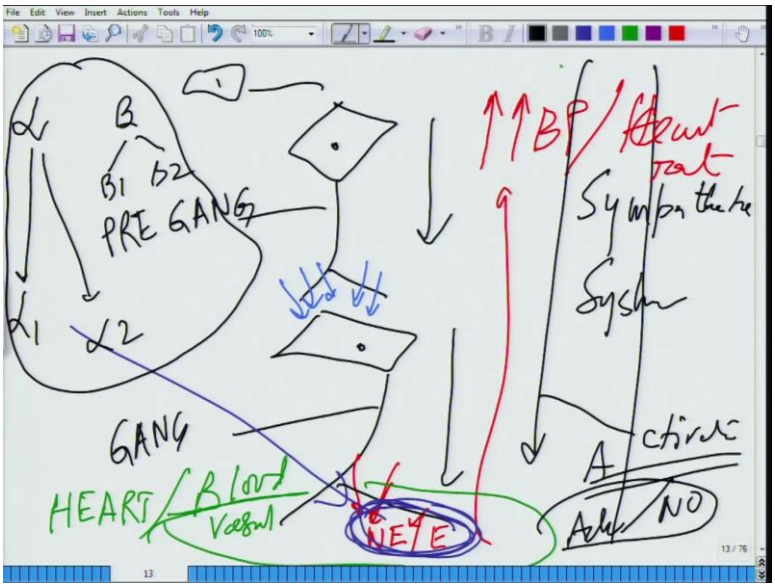

Similarly, which I have not mention is I just kind of slipped out from my mind, well talking about the sympathetic system out here, listen this epinephrine or nor epinephrine I talked about the receptor for sympathetic system includes alpha receptor and beta receptors and within beta. Here, beta 1, beta 2 and few more are there; and alpha 1, and alpha 2 and few more are there; these are the receptors for the nor epinephrine which is secreted as a part of the sympathetic system.

Where as in the case of and one more thing will add, apart from epinephrine or nor epinephrine, sometimes some of the sympathetic system verse with acetyl choline as well as nitric oxide NO and acetyl choline. Sometimes, but those are very, very rear even when they act with these those kind of receptors.

So, coming back where we come back, the nicotinic and muscarinic receptors, so muscarinic effect of muscarinic is fairly long lasting as compare to the nicotinic receptor. They are shortening effect and muscarinic effect could be either excitatory, as well as inhibitory depending on the context inhibitory, this is completely context dependent situation.

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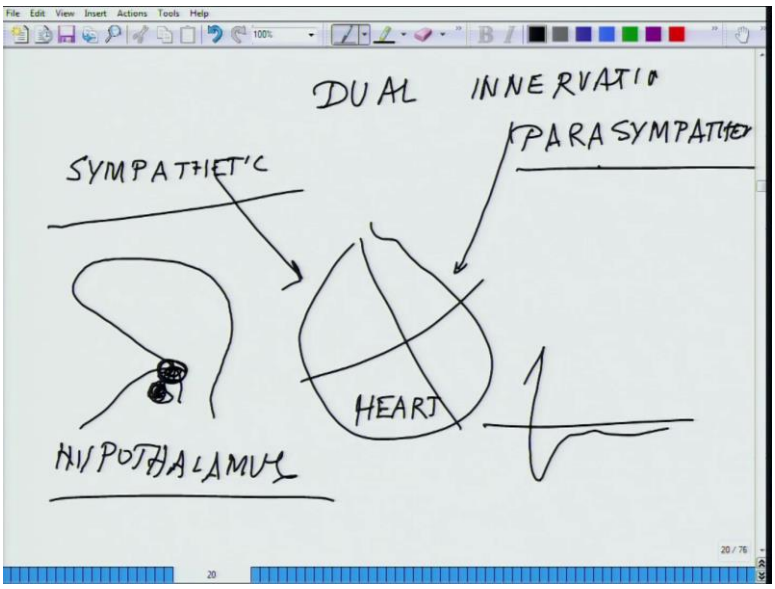

Apart from it, always there is one thing, which you people has to appreciate that, most of these organs are innervated, it is a dual innervations. In other word say for example, this is your heart again coming back, so this is under both sympathetic and parasympathetic control, sympathetic this is that and parasympathetic. So, you have a balance between the parasympathetic system and the sympathetic system which ensures the proper functioning of the heart all the time.

So, this something all over our body, all the organs are most of them having the dual innervations of sympathetic and parasympathetic which dictates how the signals are being transmitted. So, with this I will close in with the autonomic nervous system to summaries the autonomic nervous system, autonomics nervous system is the one which ensures the autonomous functioning of our system which are not in our voluntary control.

They are involuntary your heart beat movement of the bolus movement of the food across the digestive system; you do not say that now digest or secrete this acid. That,

acid or that compound to ensure the food get digested, your urinary system, reproductive system and other secretaries systems, they are purely under the autonomic control which does not need your conscious thinking or does not need a decision making.

This is all completely controlled by a certain group of phase makers, which are setting are very specific area of the brain called hypothalamus. I told you that, I will show you where hypothalamus is situated, if this is the side 3 of the brain, it is somewhere out here is a hypothalamus and underneath, there is something called pituitary. And, you come to this entire thing, so out here somewhere hypothalamus is situated.

So, this is a master neuro endocrine gland, this master neuro endocrine gland essentially regulates the tone or offers the tone to the autonomic nervous system and from hypothalamus, it controls the autonomic centers along the ventral horn of the central nervous system. So, whenever a signal comes a sensory input comes and if it is in autonomic sensory input, it needs an autonomic control and then sensory input enters into the ventral horn.

But, instead of going to other centers, it hits upon the autonomic center and from their there is a pre ganglionic neuron which comes out and reaches the ganglion from the ganglion, it transmit the signal to another set of sympathetic ganglia sympathetic neurons or parasympathetic neuron which carries the message to the target. So, there is a breakage of information and this is all done to ensure that this is separated out from the somatic nervous system.

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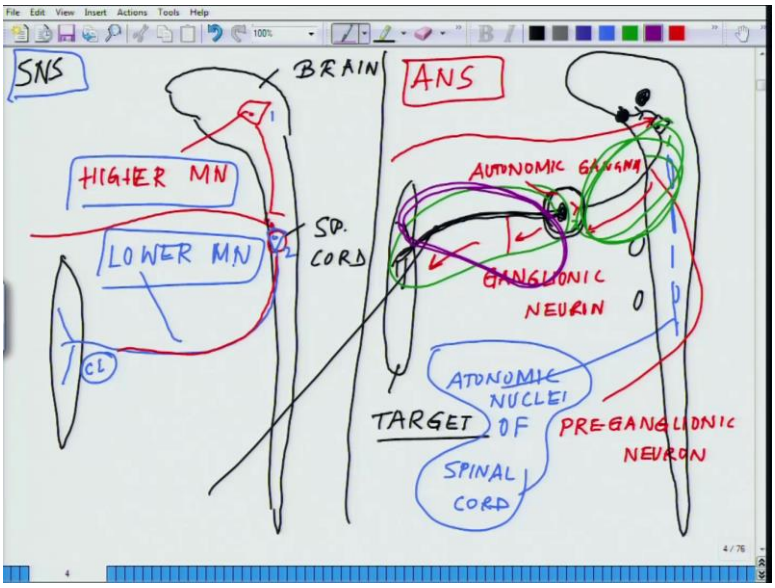

And, if you go back and see the first slide where I started, one slide back, if you look at it, so these are the centers which are regulating, which is in the hypothalamus, which is regulating or which is setting the tone out here. And, now from here the signal reaches here, so it is all ganglionic zone from here it is motor, so this circuit, the nature of the circuit and the kind of neuro transmitter involve decides, whether it is sympathetic or parasympathetic.

And parasympathetic is the one, where at both the level, at this level at secretion of neuro transmitter, at this level both time, it is acetyl choline which regulates it in the case of sympathetic. At this level, it is of course, acetyl choline, but at the second level out here, it is nor epinephrine or epinephrine. Apart, from nitric oxide and other things sympathetic is the one which is also called fight or flight and parasympathetic is a one which is called rest or repose, it is kind of bring down much of your it is.

So, sympathetic on one hand, make your system very excited, parasympathetic on the other hand, being sit down and it is the interplay of balancing act between the sympathetic and parasympathetic system, which ensures our normal functioning of the body. So, with this and with the control, what I highlighted about this sympathetic and parasympathetic control of the heart, I am closing on the nervous system. So, next we will start with the new section.

Thanks for your attention.