Animal Physiology
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Module - 1
Lecture - 23

So, welcome back to NPTEL lecture series on animal physiology. So, we are in the section of the respiratory physiology. So, we are done with first two parts of this section. So, today ((Refer Time: 00:27)) we will be exactly dealing with exchange of the gases in the alveoli. What is the partial pressure of the gas, inside the alveoli. What is the partial pressure of the gas outside. And then we will be talking about some of the centers, in the vein stem which controls the respiration. So, before I get into the lecture, let us talk about the basic mechanism or basic outline; what is governing the process. So, what is essentially happening is that, when the blood is saturated with oxygen, which is being pumped from the heart to the rest of the body. It travels and down loads the oxygen, in the various cells and tissues. And while it is downloading the oxygen, the blood itself picks the carbon dioxide. So, while blood is travelling which is loaded with oxygen, to all the different tissues. It down loads the oxygen which is consumed by mitochondria for production of a t p and cellular respiration.

And during that process, it fix of the carbon dioxide, and this carbon dioxide, is then brought back to the heart through the venous vessels, and then it is being sent, to the lungs, for down loading the carbon dioxide, and again engage the blood with oxygen . So, what essentially happens, if you look at the concentration, if you see the first lecture where I started. The concentration of carbon dioxide in the air is very low. whereas, the blood which comes back to the heart, from all over the body, through the venous vessel, and which is sent to the lungs, is fairly rich in carbon dioxide, and the partial pressure of carbon dioxide, inside the blood vessels is very high, as compared to the environment. So, automatically by this simple logic of partial pressure; one which has partial pressure, will flow down the gradient. So, if outside it is less, then the carbon dioxide will be ejected out from the system, that is what it exactly happens. Carbon dioxide is being ejected out from the system. Whereas, in the case of oxygen what happens.

Since this blood, which is coming, is devoid of oxygen. So, level of oxygen in the blood vessel at that point of time while it is going to the lungs is really low, and oxygen partial pressure in the environment is high. So, automatically down the gradient what will happen, the oxygen which is outside, will be pulled inside the system. And that is how it works; the oxygen comes in, and then again this blood becomes laden with oxygen, filled with oxygen, or oxygenated blood comes to the heart, and from there it is being pumped from all over the body.

This is essentially what is happening in the whole process of respiration, and this is how the whole respiration system works. It is the simple partial pressure shift, and the other gases, which are in environment do not really matters, because they do not do any important physiological function. So, they are binding or not binding does not really affect our whole process. So, what I will do now, what I have explained now. I will just diagrammatically put it, so that kind of (( )) engraved into your understanding, and will help you to analyze this case much better.

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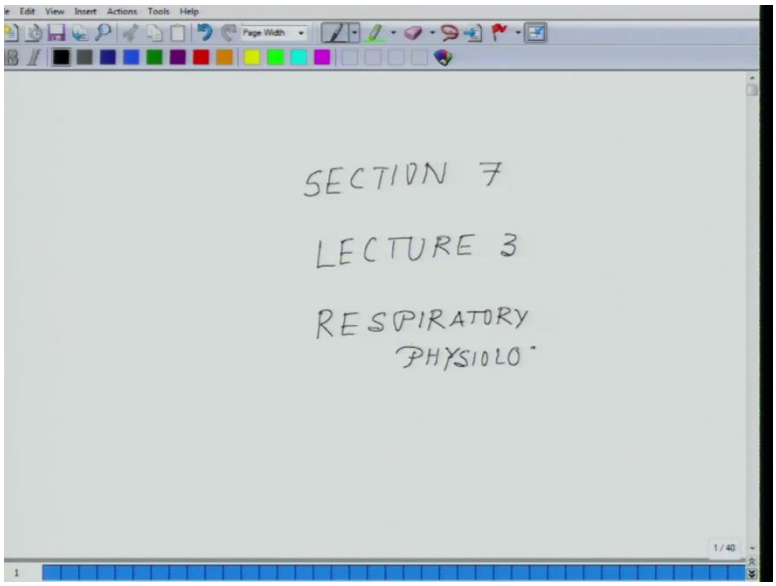

So, let us come back. So, we are in section seven, lecture three, respiratory physiology.

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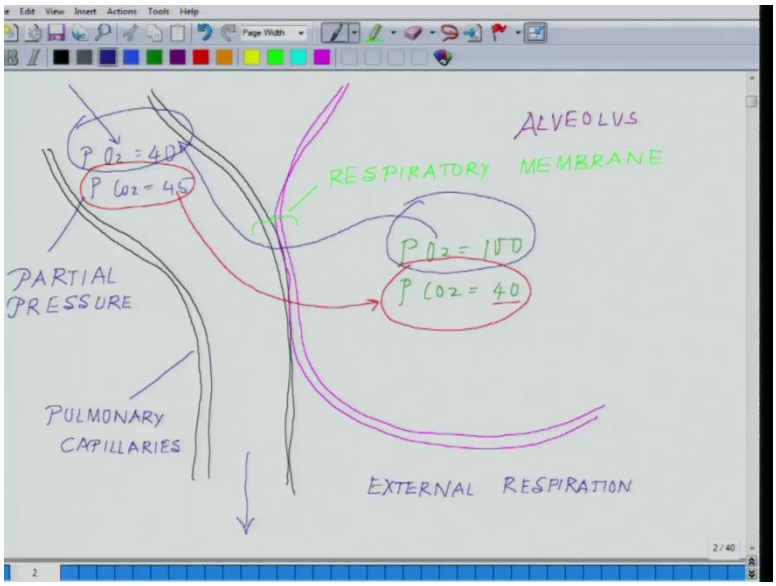

So, the blood which is coming in the pulmonary capillaries. So, this is what I am representing at; the pulmonary capillaries. I will use another different color to show you the alveolus. This is in close conjunction with the pulmonary capillaries. So what is happening. Here is a venous blood, which is coming, with partial oxygen pressure P 02, is around 40. Whereas, P C 02 is around 45; P is the partial pressure. These are the pulmonary capillaries. Now within the pulmonary capillaries, here you have the alveolus, and this part, which I am highlighting in green, is called the respiratory membrane. Now, what is essentially happening on this side; your P 02 is 100. Partial pressure of oxygen is 100, and partial pressure of C 02 is 40. So, if you now compare these values. Now here I am comparing P C 02 out here and P C 02 here. So, by the gradient, carbon dioxide will move to this side, because there partial pressure of carbon dioxide in alveolus is 40, and partial pressure here is 45. And by the same token, other side what will happen. Here you see partial pressure of oxygen is 40 inside the capillaries, and partial pressure of oxygen in alveolus is 100, so automatically this oxygen is moved into the capillaries. So, this is how the external respiratory is taking place.

So, there are two level of respiration; this is the external respiration. So, this is one part, I have not introduced, so let me come back. So, whenever we use the word called respiration, it immediately comes in mind, that this is the exchange of gases which is taking place, but there are two level of respiration. This is an external respiration where you are taking the gross gas into your body, and you are throwing out the gas, which is

undesirable for the metabolism or functioning of the body. but there is another level of respiration; that is called cellular respiration or internal respiration; that is the zone where this vary gas, which your picking up from outside, is being picked up by the different cells. So, at that zone. So, this is basically what is happening. This first stage of external respiration is through the pulmonary circuit, in that situation it is the venous blood, which reach reaches the heart, and from there it is being sent to the lungs for purification. And this is what I just now drew, for you people that is essentially the external respiration, but now what I will draw, with respect to the partial oxygen pressure and partial pressure of carbon dioxide in the cellular respiration.

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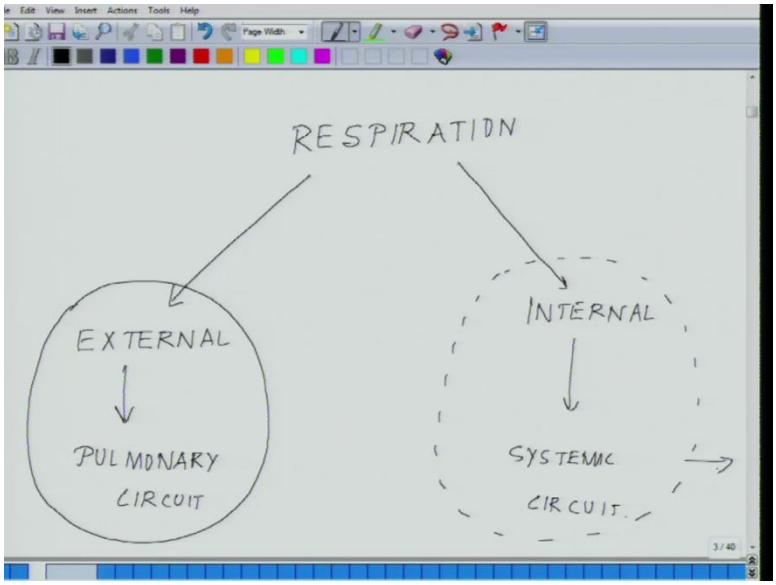

So, just for your little bit more. So, basically what we are talking about now is, we are dividing respiration into two parts. This is the external respiration in the pulmonary circuit; external, and this involves pulmonary circuit, and then there is an internal, which is in the systemic circuit. These are the two classification of respiration. So, we have already done with this part. We have talked about this aspect. Now what I will do, I will talk about, the internal systemic circulation, what is exactly happening in the next slide.

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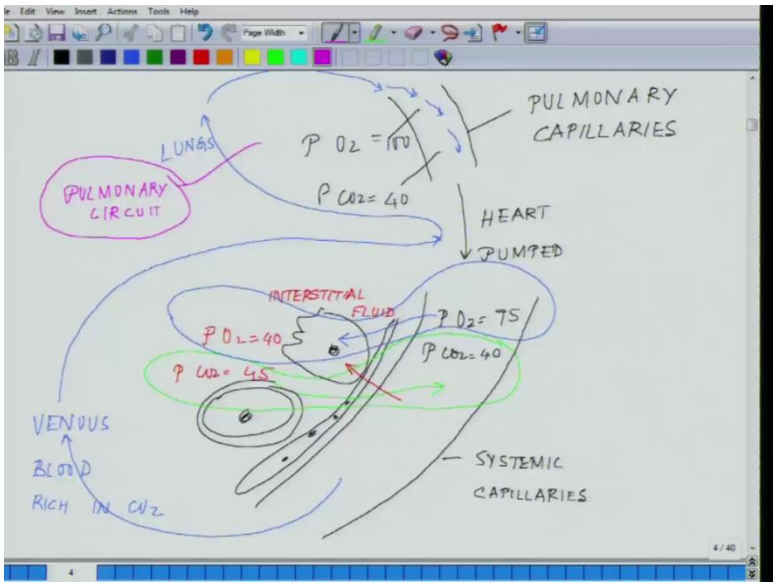

We will move on to the next slide. So, the blood which upon in the pulmonary capillaries, so that blood has partial oxygen pressure of P 02 which is equal to 100, and P C 02 is equal to 40 pulmonary capillaries. Now from here, this is moving into the systemic capillaries. Now this is the zone from where, it came to heart, and from there it is pumped. Now it is travelling in the systemic capillaries, so these are the systemic capillaries. in the systemic capillaries in the partial pressure of oxygen is, around 95, and partial pressure of C 02 is 40. Now here is the situation where, this blood which is travelling in the systemic capillaries, has to be downloaded, into the different tissues, which are different cells and tissues which are present. These are different cells and tissues, in surrounding (( )) talking about. And now these cells and tissues will be needing oxygen. The partial pressure of oxygen in the interstitial fluid, so this is we are in the interstitial fluid. So, partial pressure of oxygen here is 40, and partial pressure of C 02 is 45. This is just the reverse situation. So, what will essentially happen.

So, C 02 here, if we compare these two values. So, C 02 from here will start moving into the systemic capillaries. Whereas if you look the other side of it, which is partial pressure of oxygen, and partial pressure of oxygen in the interstitial fluid. So, oxygen will be downloaded out here. So, the moment of oxygen will be from the systemic capillaries, to the tissues, and the moment of carbon dioxide will be from the interstitial fluid, to the systemic capillaries. And eventually this is the venous blood which is rich in C 02, comes back to the heart again. From here it is being pumped to the lungs, and there it is

getting purify, and this is what you see is now tripling down. So, this is how the whole circulation continues, and this is the part of the pulmonary circuit. So, this is what you can say; over view of the respiratory process and partial pressure, during respiration. So, this is one of the key thing which I wished to discuss with you people, and from here what I will do, I will move on to the control of respiration. So, we are done with the partial pressure and everything, the certain areas which… If you are interested you may cover the respiratory mechanics, when we are in hailing and exhaling, what are the different diaphragm movements, which are taking place, which I am not covering out here. But your most welcome to go through A C guidance book or some other standard text book in physiology, which will give much in depth of this, but this is the basic fundamental understanding of respiratory physiology, what I expect you people to understand.

So, from here what we will do, we will move on to the different control centers of respiration. So, most of these processes are very tightly controlled by the brain system and the higher centers of the brain; otherwise it becomes really challenging, because we have to attach to different type of situations. Sometime we are in a situation is a fairly you know sufficient oxygen, and we can do a lot of you know a gas exchanges really smooth, yet there are situations when we reach the place, where oxygen is deficient, carbon dioxide is rich, or in a very damp place.

So, we have to continuously regulate our respiration process, and the body has to continuously adjust to this, because if it fails to adjust then what will happen is this; the buffering of the body will be compromised, oxygen carrying capacity will be compromised, and cellular metabolism will be compromised, and essentially what will happen, there will be a shift of homeostasis in that whole process. So, that is why these things are extremely essential to, you know has to be controlled in a very tightly regulated factors. So, what we will do now, is that I will talk about some of these control mechanisms, which will help to you know understand how exactly this local regulation are taking place in the respiration.

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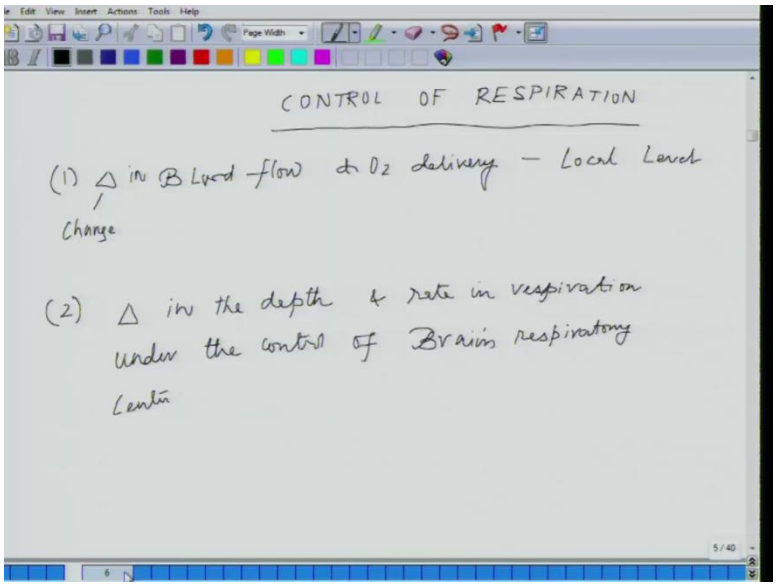

So, let us move to control of respiration. So, the respiration control. So on the major. See what involves is that. So, the peripheral cells are continuously absorbing oxygen, that we have already discussed, from the interstitial fluid to the carbon dioxide. On a normal conditions this cellular rate of absorption and generation, are matched by capillary rates of delivery and removal. So, these rates are identical to those of oxygen absorption and carbon dioxide excretion at the lungs. So, what essentially is happening is change in the blood flow, and the oxygen delivery that is regulated at the local level. So, essentially what is happening is that, change in blood flow, and oxygen delivery, that are regulated at the local level and second is change in the depth, and rate in respiration, under the control of the brain respiratory centers.

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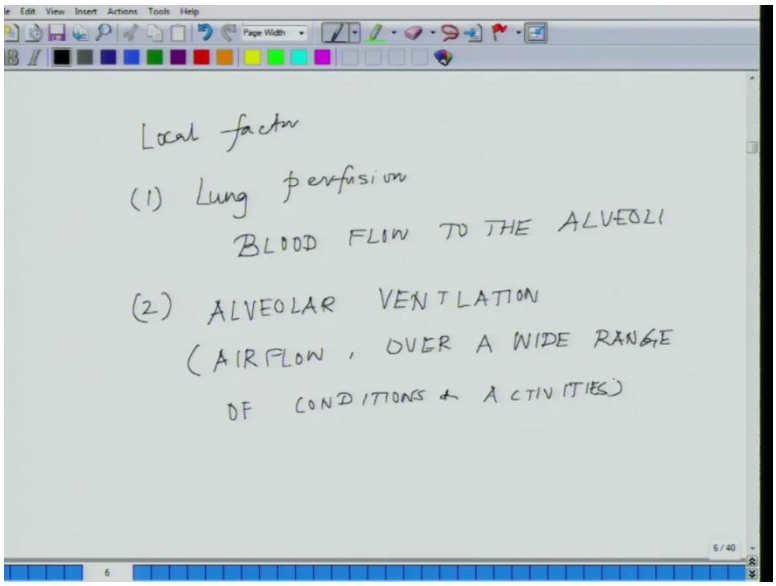

So, talking about the local factors which are involved in it; one of them includes, the local factors includes lung perfusion or in other word this also be called blood flow to the alveoli. This is one of the factor, the second factor, which is involved in that is, alveolar ventilation, which is basically the airflow, over a wide range of conditions and activities. What does this essentially means. So, this essentially means is the; suppose we are in a situation when there is lack of oxygen, in the environment, and we need to take more oxygen. So, the first thing what is needed here, we should have more and more blood flows to the lungs.

So, that is what I meant by lung perfusion, the more blood goes whatever oxygen in the environment; you can pick it up, because you are exposing your system to more and more oxygen exposure. The second thing, what is alveolar ventilation I told. So, if there is less oxygen. So, we always take a deep breath. So, essentially what you are doing, you are taking lot of air in to the system. So, whatever oxygen is available you should able to pick it up, vice versa in the reverse situation there is you know excess air you do not to bother. So, you kind of you know, your slow, you do not have to bother. .Like I am in a room, which is proper oxygenated and everything. So, you do not have to bother, but if I am in a situation say high altitude. So, in the classic situation is high altitude situation, why in a high altitude. Let us talk about what is happening in a high altitude situation.

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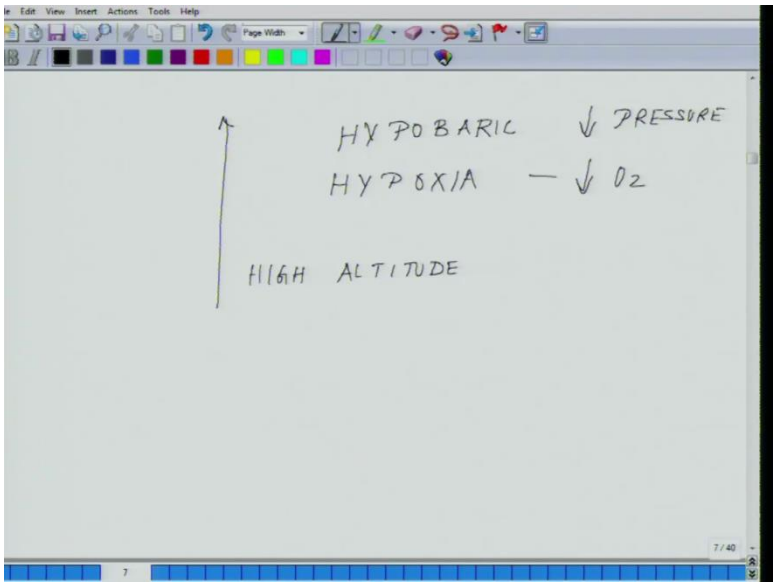

So, as you go up, you meet a situation something like hypobaric, hypoxia. So, essentially; that means, these are less in a oxygen, and the pressure is low, air pressure is low, because any way as your going up, into a mountain or something places like (( )) in Peru or Mexico city or places Laddak and Leh. So, this is a situation when you are exposed to a low oxygen intention. So, the oxygen as you are going up, and atmosphere is becoming rarer and rarer, as it is the gas thing is reducing, and you are expose to a low oxygen, automatically the carbon dioxide is also getting reduced, so you are in a low oxygen situation. So, what we will do essentially, the best thing what we do is, we have to inhale slowly first. In that process, your increasing the ventilation, and in the mean time what brain will do the (( )) centers of brain. They will ensure that there is more and more circulation of the blood in to the lungs. So, you are picking in as much as oxygen possible. So, these fall under the local control. Now what we will do, after talking about the local control, I will move on to the respiratory centers of the brain.

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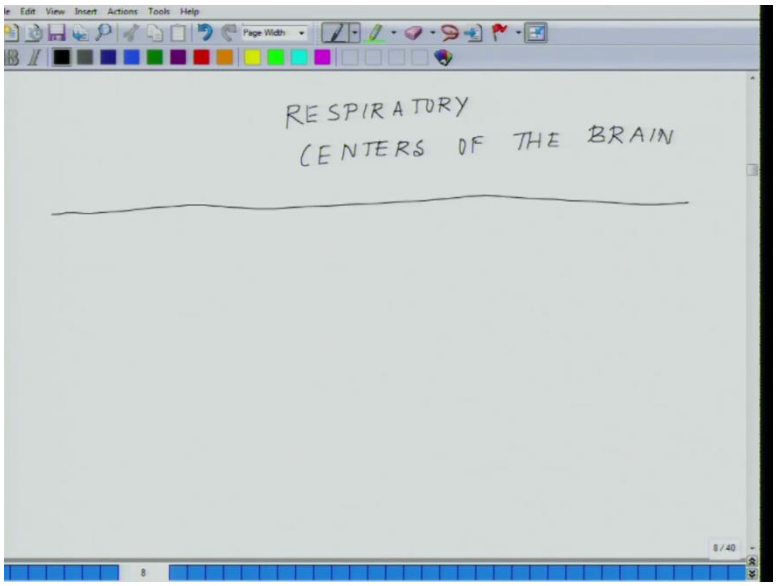

So, moving back to the respiratory centers of the brain. So, among the respiratory center of the brain, what is essentially happening is this.

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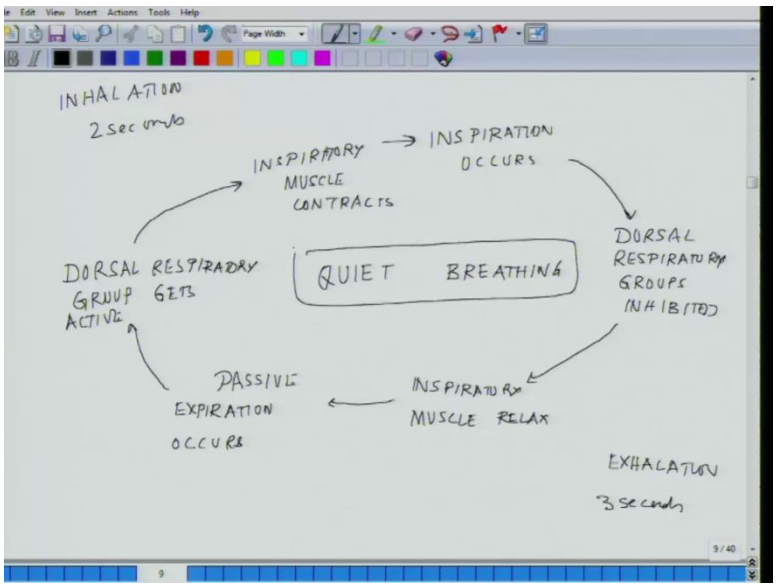

So, think of the situation where. So, for example, this is a quite breathing situation. Let us take two cases of studies that will help you. So, here there is a quite breathing. So, during, quiet breathing. So, starts from somewhere, inspiration you are taking in air, inspiration occurs. This is followed by dorsal respiratory group inhibited, inspiratory muscle relax. Then next thing which is happening is the, passive expiration occurs,

followed by dorsal group dorsal respiratory groups. So, gets activated, and gets active inspiratory muscle contracts, and the inspiration take place. So, this is what happening in inhalation, which last for around 2 seconds, and exhalation, which will last for around 3 seconds.

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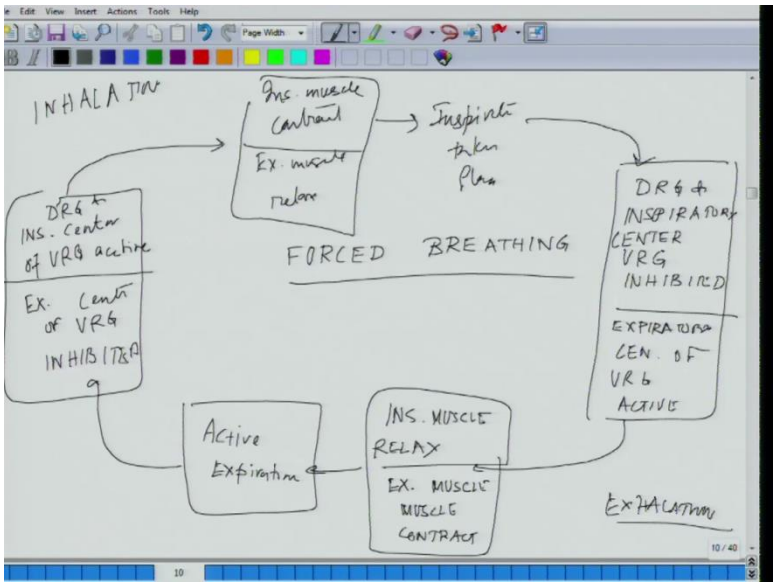

So, this is the pattern are there in quiet breathing now what is happening in force breathing. Now, when I am doing like this. So, this is a situation I am taking in a lot of air. So, during force breathing, the whole mechanism takes a slightly difference route. Let us talk about what is happening during forced breathing. So, during forced breathing, basically your DRG dorsal respiratory group, and inspiratory centers of VRG. VRG stands for ventor expiratory groups are inhibited, and essentially happens, this is there; expiratory centers of venture respiratory groups are active. So, now, venture respiratory now comes into play. Now, inspiratory muscle relax, and expiratory muscle. This is ex is respiratory, ins is inpiratory muscle contract, and this leads to active expiration. So, there is an active expiration followed by. Again the reverse events now will takes place, as I was drawing in other side. So, DRG and inspiratory centers of VRG are active.

Whereas expiratory centers of VRG are inhibited, followed by your inspiratory muscle contract, and expiratory muscle relax. This is where inspiration takes place, again followed by secrets. So, this is situation of inhalation, and here you have the situation of exhalation. So, this is a case of force breathing and regular breathing, and this whole

process is regulated both at the local, and at the high centers of the brain. Now we will go, and I will give you the outline or diagrammatic presentation of brain stem; the centers, respiratory centers, which are controlling, or coordinating the whole process, so that our homeostatis is being maintained. Let us talk about the vein stem centers. So, this is what essentially looks like.

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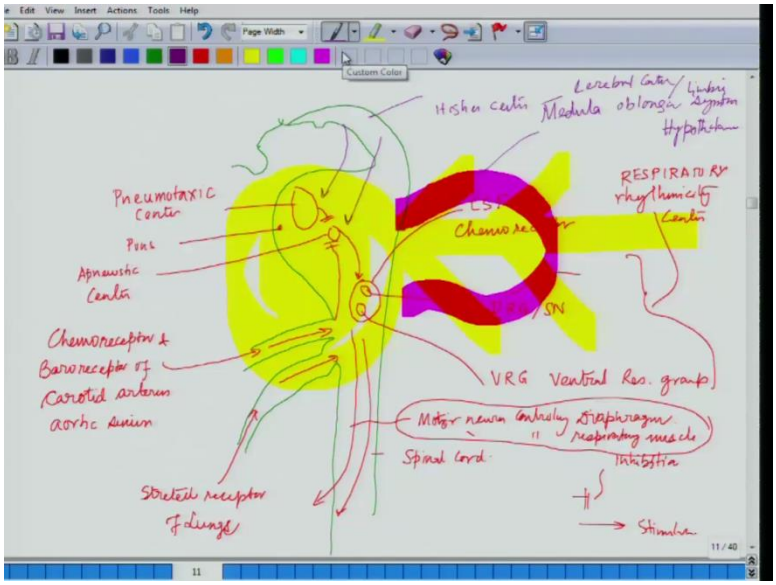

So, this is the brain stem we are talking about. This is a pituitary. Chemoreceptors coming in. These are the stretch sectors coming in. So, these are the chemoreceptor and baroreceptor carotid arteries. Chemoreceptor and baroreceptor of carotid arteries and aortic sinuses. So, these are the stretched receptors of lungs, which helps the lungs to expands out, and this is your spinal cord. And here you have your different centers, which includes pneumtaxic center. These are the centers which are regulating under the influence of higher centers of the brain; pneumotaxic center.

So, this is the brain stem where I am putting; the pneumotaxic center. Here you have the pons, apneustic centers. So, what I do, just now to show that inhibitory and supporting circuit, apneustic centers, and these signals which are coming in, are either inhibiting the pons, or regulating the pons, regulating the apneustic centers, and here you have something called C S F chemoreceptor. There are two nuclear here; one nuclear is called dorsal root of ganglion, or sensory neurons, which we talked about. The other group is called ventral respiratory group, or VRG ventral. So, these are the ones which I just now

talked in the previous slide, and these are also called under the heading; respiratory rhythmicity center, and what you saw this sign I am putting; that is basically for inhibition, and whenever I m putting an arrow this mean stimulation.

So, these are the motor neurons which are coming through the ventral route, which are motor neuron controlling diaphragm, one of the things the motor neuron controlling respiratory muscle. There are multiple jobs this motor neuron have. And apart from it the motor neuron. So, there are higher centers, so this is what basically the brain stem we were talking about behind the brain stem out here. So, out here what you see is the medulla oblongata; the highlighted part what I drew just now, and from higher centers of the brain are being controlled. So, these are the cerebrum, and these are the higher centers of cerebral cortex, limbic system, which in puts hippocampus, limbic system and hypothalamus.

So, these are the different centers which are regulating the whole process out there. So, this is a complex circuit which brings. You should call it as something like pacemaker kind of thing. The setting of the pace of the system, and these although, when I was drawing the respiratory rhythmicity center, is basically what that means. You are setting the phase of the system, whenever the lungs have to stretch, those can control. Whenever the lungs have to be in a normal condition, they can control. So, it is totally another control of the very higher centers of the brain, including the limbic system, which includes the hippocampus and the surrounding part of the brain.

We are controlling the hypothalamus, and from hypothalamus it is these signals are being sent to the brain stem just behind the medulla oblongata. So, essentially that why it has being said that on the back part of the brain, you can actually make somebody unconscious, or you know you can hit somebody badly here, a person may die. They may die, because if I hit something like if you think of it. Say for example, a situation like this; say for example, a person is getting a hit out here, somewhere a hit like this. So, essentially what your happening, this hit is influencing the whole region, and that is why what is was telling you, that I hit like that could lead to a death of a person, or somebody become unconscious because of that hit. So, it is just out here, in the back side of the brain, where the brain stem is sitting, which is controlling by the, control by the higher center of the cell. So, this is pretty much what, I expect that you guys go through. So, (( )) as given a fairly good. (( )) book has given a fairly good description of it, and that will

be big help to go through it, but this is the overall out line of different centers of the brain which are controlling the pons and pneumotaxic centers, and apneustic centers, in the brain stem control by the higher centers. So, that is pretty much wind up our respiratory physiology section.

Thanks a lot.