Basics of Biology
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Lecture – 39
Circulatory System Part - I

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 basic properties of the living organism. And in this context so, far we have discussed about the many aspects of the living organisms. And in the couple of previous module we are discussing about the human physiology.

And in the human physiology so, far what we have discussed? We have discussed about the digestion and then we have once you have the digestion you are actually going to generate different types of nutrients. And once you have the different types of nutrient, these nutrients has to be supplied to the different parts of the body. So, this is going to be the function of the circulatory system. So, circulatory system is required for distributing the nutrients for different parts of the body. So, in today's lecture, we are going to start discussing about the circulatory system.

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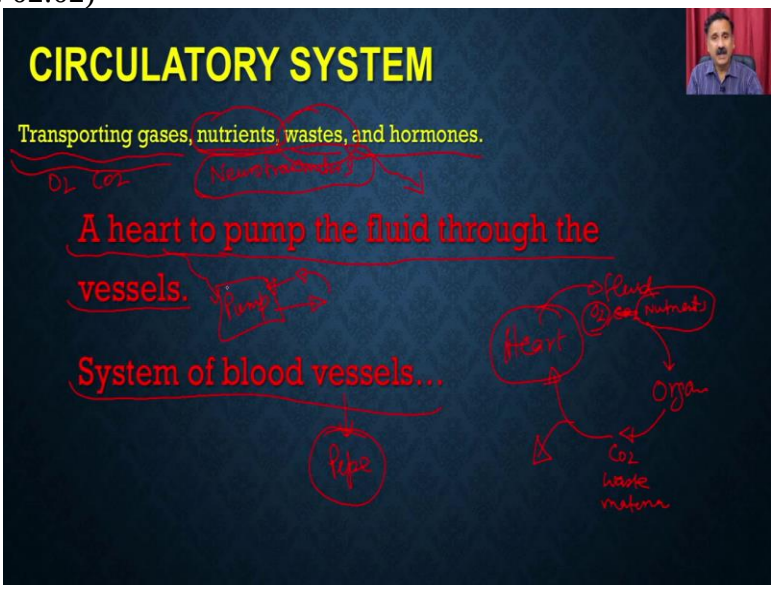

So, as we discussed circulatory system is actually going to be required for transporting the gases, nutrients, it is going to collect a waste from the different cells and it is also going to distribute the hormones. Apart from that the circulatory system is also going to transport the neurotransmitters,

which is actually going to transmit the signal from the one part of the body to another part. So, if you want to perform these functions, you require a system so that you can be able to circulate the liquid within the body and then you also required the tubes.

So, remember that when you are actually want to do this in your home, for example, if you want to circulate the water into the home. So, what you do is you are actually going to take up the water and then you are pumping that water into the water tank. Similar to that, in the human body also you require a pump. So, you require a heart which is actually a pump, so that you can be able to circulate the fluid throughout the body.

And then you also require a system of blood vessels. So, blood vessels are actually going to mimic the pipe through which you are actually going to throw the water in your home. And the heart is actually going to function as the pump. So, pump is actually going to take up the water or take up the blood from the one part of the body and it is actually going to throw into the other part and that is how it is actually going to keep circulating the fluid throughout the body.

And while it is circulating the fluid, it will actually going to do many functions. For example, the heart is actually going to circulate the fluid to different parts. So, when this fluid will go this fluid is going to carry the different types of gases like the co2, carbon dioxide and all that. And it is going to circulate the, it is going to have the nutrients. So, once it is about reaches to a particular organ, this organ is actually going to take up the carbon dioxide, oxygen and nutrients.

And in return, the organ is actually going to give the different types of gases like the metabolic byproducts, so it is actually going to give the carbon dioxide and it is going to give the waste material. And that waste material is actually going to, heart is actually going to carry that waste material and then it is actually going to give the waste material to different other types of organ. And ultimately it is going to again, bring the liquid back to the heart.

And that, that cycle will continue. And that is how the heart is actually going to circulate the fluid throughout the body. And that is how it is actually going to make the exchange of the different types of material, whether it is the gases like the oxygen and the carbon dioxide or whether these are the nutrients like the different types of nutrients, carbohydrates, proteins, and lipids, nucleic acids or they are mono medic constituents is actually going to be circulated.

And along with that, it is actually going to start collecting the waste from the different parts of the body and these waste are actually going to be excreted out through the kidney and that also we are going to discuss when we are going to discuss about the homeostasis. So, if you want to do this, you can actually have the two ways of doing it.

You can have the open system or you can have the closed system. And that is how the circulatory system in the different organisms what we have discussed so, far could be of two different types.

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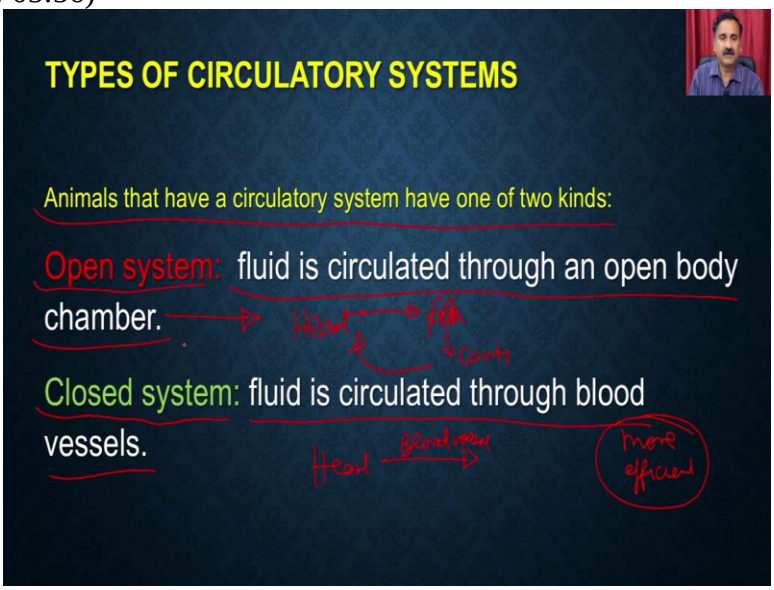

It could be an open system like the so, animals do have a circulatory system of two different kinds. You can have the open system, the fluid is circulated through an open body chamber. In this the heart is actually going to pump the liquid or the fluid and that fluid will go into a cavity and from the cavity the fluid will return back to this. So, this is called as the open system. Whereas, we can have the closed system where the fluid is circulated through the blood vessel.

Which means, the from the heart the fluid is circulated through the blood vessels. And because of that, the closed system is going to be more efficient compared to the open system. And that is why the all the higher organisms are actually having the closed systems. So, let us discuss about these different types of system what is present in the different types of organisms.

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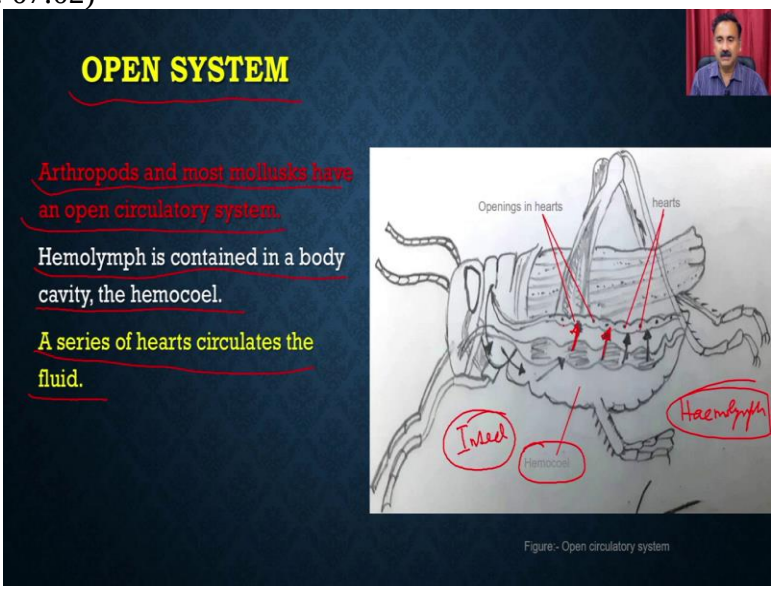

When we talk about the open system, the arthropoda and most of the molluskas have the open circulatory system. So, this is what you see here is arthropoda, you have this is what you see here is the insect. And in the insect what you see here is a body cavity which is called as the hemocoel and the liquid what is present in this is called as the hemolymph. And so, and then it also has the different types of it has the heart rate.

So, what you see here is actually the pumping system, which is not the real heart what we discussed or what we are going to discuss, but it is going, these are the muscular chambers, which are actually going to have the ability to pump the liquid. And once the liquid comes out from the heart, it actually falls into this cavity which is called as the hemocoel. And then from the hemocoel, the liquid enters into the heart again.

So, these are the actually going to have the, the heart which are actually going to have the opening. So, the hemolymph is contained in a body cavity which is called as the hemocoel. And then it has a series of heart which circulates the fluid. But, as I said it is actually going to have the less efficient because the collection of the fluid from the cavity and then the leakage of the fluid from the heart is actually going to be less efficient compared to the closed system.

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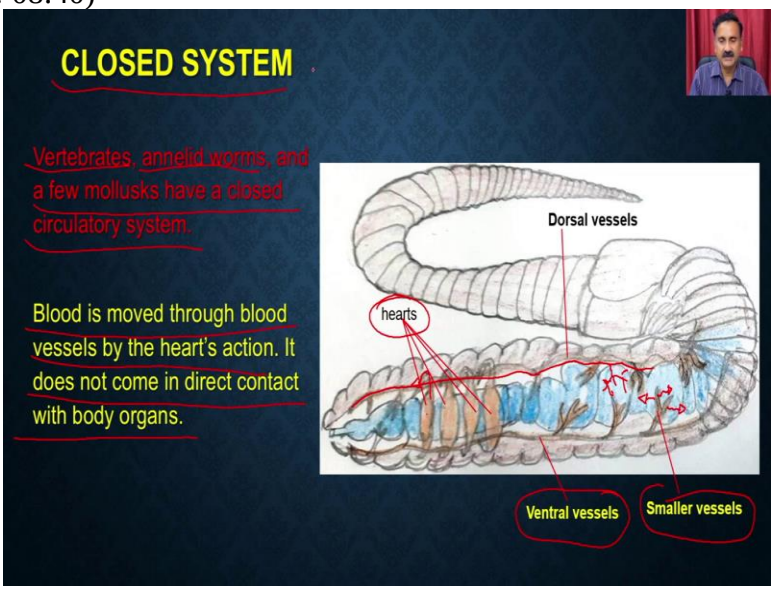

Whereas in the closed system, closed system is present in most of the vertebrates, anelids and the few mollusk also have the closed circulatory system. In a closed circulatory system blood is moved through the blood vessel by the hearts action. And it does not come in direct contact with the body organs. So, what you see here is the different types of heart. So, you see the 1 2 3 4 hearts.

And once the heart is pumping the liquid, it is going through into the blood vessels and that is how the blood vessels are actually transporting the heart, the blood or the fluid throughout the body. And then ultimately, they are actually, transmitting this liquid into the different organs without having the direct contact. Which means at the end the blood capillaries or the blood vessels are actually going to form the blood capillaries.

And the blood capillaries, the nutrients or the gases are actually going to diffuse and reach to the final destinations. So, what you see here is it has the blood vessels like the ventral vessels or the dorsal vessels. It has the different types of hearts and then it also has the smaller vessels or the capillaries. And these smaller vessels and capillaries are actually going to diffuse out the nutrients or the gases to the final organs.

So, the closed system is more efficient compared to the open system because of the same reason that blood is going to move through the blood vessels. And that is how there will be no loss of pressure there will be no loss of liquid.

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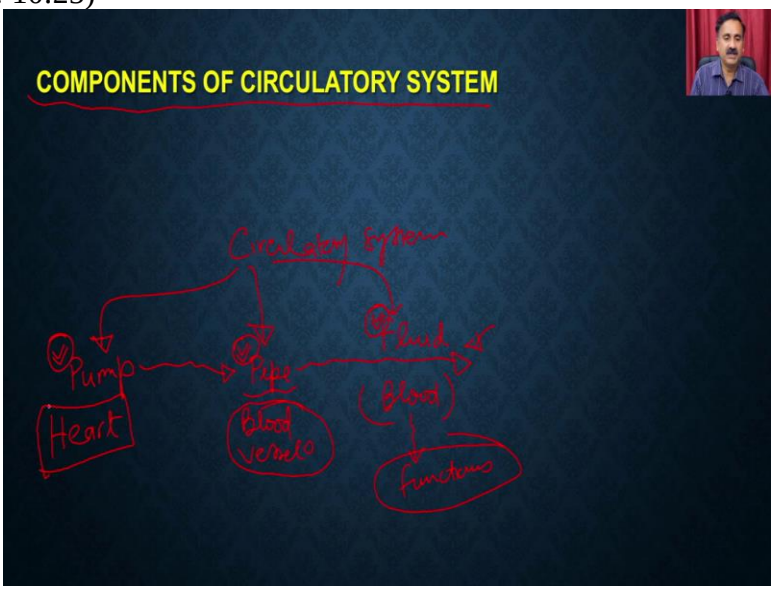

So, what are the different components of a circulatory system? So, when we talk about the circulatory system, circulatory system as I said circulatory system should have the three components. One you can actually have a pump. So, the pump is in this case it is heart, which is actually going to be required for circulating the liquid. And how it is going to circulate a liquid? It is actually should also have the pipe.

So, pipe is actually the blood vessels and, and the blood vessels also could be of different types. So, you require a pump, you require a pipe and then the third component is that you also require a fluid which is actually going to transport within this pipe. So, fluid is in this case is the blood. So, blood is actually the major fluid which is going to be circulated throughout the body and that is how the fluid is actually going to carry all the material.

So, this fluid is should be compatible with the all the different types of material like it should be able to carry the gases, it should be able to carry the waste. And so, what we are going to discuss? We are going to first discuss about the structure of the pump, which means the structure of the heart. Then we are going to discuss about the structure of the pipe, which means that we are going to discuss about the different types of blood vessels.

And then we are also going to discuss about the fluid like the blood and how, what are the different functions of the blood and as well as the function of the different organs. So, let us first start the discussing about the machinery, that is the pump as well as the pipe.

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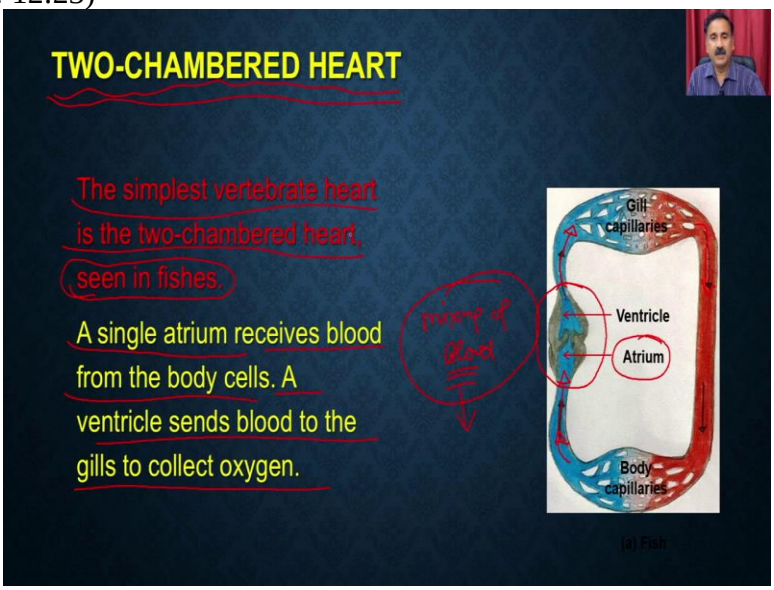

Now, when we talk about the pump, the pump could be of different types. I am sure when you go to the any electrical shops, you always have the different variety of the water pumps. You can also have the, same way in the heart also. You can actually have the different types of pumps and all these pumps are been evolving because the you know, the different types of organisms. I am sure we have discussed when we were discussing about the classification that we have the two chamber heart, we have three chambered heart, we have the four chamber heart.

So, the simplest is the two chambered heart. So, the simplest vertebrate heart is the two chambered heart, which is mostly been found in the fishes. So, in a two chambered heart we have the single atrium, which received the blood from the body cells. And then we actually have the single ventricles, which sends the blood to the gills to collect the oxygen. So, this is what the single two chambered heart.

Where you have the single atrium which is going to send the blood to the different parts of the body or which is actually going to receive the blood from the different parts of the body. And then we also have the single ventricle which is actually going to throw the liquid or throw the blood to the gill capillary. So, that the blood whatever you have collected is actually going to have the deoxygenated, the blood is going to be get oxygenated.

Then this oxygenated blood will enter into the capillaries and then it is actually going to reach to the different parts of the body. So, what is the disadvantage? When you have the single two chambered heart there will be always a mixing of the blood. Remember that we have the two

different types of blood, the blood what we are receiving from the body is actually a dirty blood and the blood what you are throwing into the gill capillaries are the oxygenated blood.

So, because of this, there will be a mixing of the blood and that is a major issue with the two chambered heart. So, to avoid that the organisms have evolved and that is how they are actually started having the three chambered heart.

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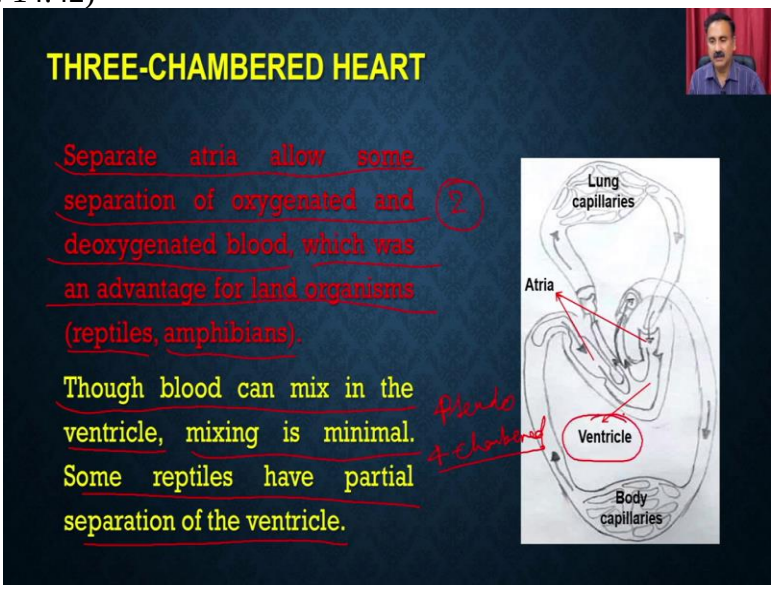

So, in a three chambered heart we have the separate artria which allows the some separation of the oxygenated and deoxygenated blood, which was an advantage for the land organisms. For example, the reptiles and amphibians. So, you have the two atria chambers, two chambers in the atria and you actually have the single ventricle. So, though the blood can mix in the ventricles, the mixing is minimized.

Some reptiles have the partial separation of the ventricle. So, in some of the reptiles, we still can have the four chambered or we can say that the pseudo four chambered heart. Because there the ventricle is also been partially been separated from each other. So, you have the two ventric oracles and one ventricles. So, this is what you see here is we have the two oracles and the single ventricle. So, still there is a mixing of the blood when it is going to enter into the ventricles, but still it is going to be minimized.

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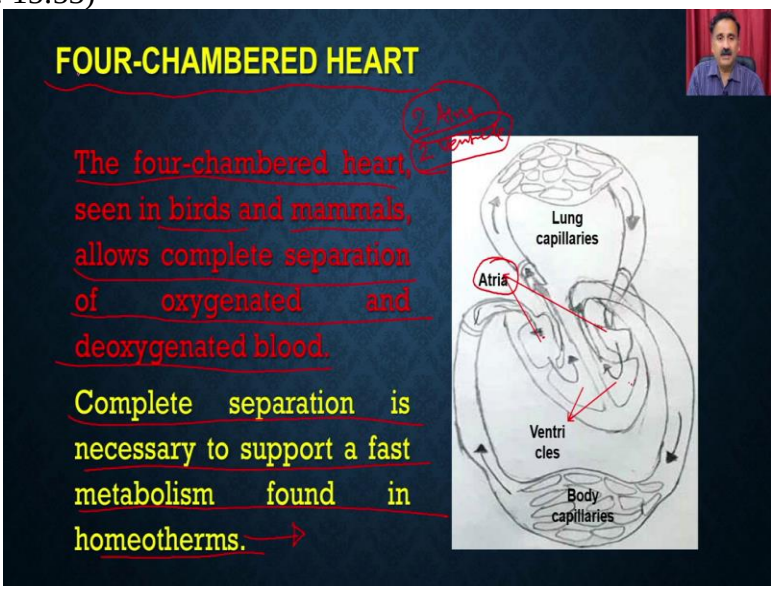

Then we enters into the another which is called as a four chambered heart. So, the four chambered heart is the most developed heart and that is present into the higher vertebrates such as the birds and the mammals. And it allows the complete separation of the oxygenated as well as the deoxygenated blood, because it has the two oracles or atria and the two ventricles. So, because of that, it will not have any kind of mixing of the oxygenated as well as the deoxygenated blood.

So, you have the two atria like this one and this one, and then you also have the two ventricles on this and that. So, the complete separation is necessary to support a fast metabolism, which is found in the homeotherms. So, most of these organism which actually have the four chambered heart are the homeotherm or the warm blood animals. Now, what is the advantage of the four chambered heart?

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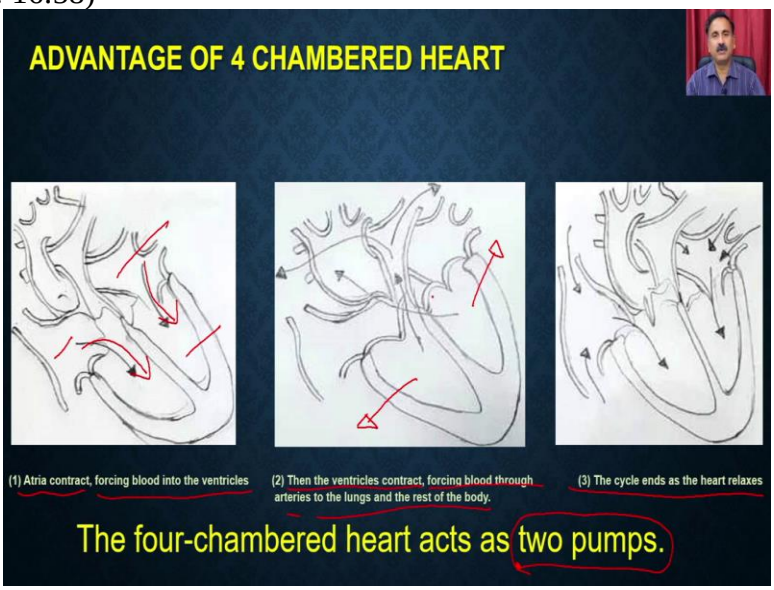

The major advantage of a four chambered heart is that it four chambered heart is actually act as the two pumps. So, it is not a single pump, it is actually can be further divided into the two pumps. So, for example, you can have the atria, when the atria is going to contract, it force the liquid or the blood into the ventricle. So, this is going to enter into the ventricles. So, this is the ventricle, this is the atria.

Then when the atria contract, it holds the blood through the arteries to the lungs and the rest of the body. So, when the atria is going to contract, it is either going to throw the blood into the rest of the body, or it will also going to throw the blood into the lungs for the purification. And then again, the cycle will continue. Then the cycle and as the heart relaxes, so that time it is actually going to start filling the liquid from the rest of the body or from the lungs.

So, that is how you can actually will say that in the four chambered heart, you have actually made the two different pumps. You have made a pump, which is related to the atria. So, where you can have the flexibility of making a contraction, as well as the relaxation of the atria or you can also have the pump where you can have the contraction and the relaxation of the ventricle. And that us how a four chambered heart is a two pumps. So, that is how you can actually be able to, coordinate the both the functions like the filling of the liquid, and as well as the releasing of the liquid can be separated from each other.

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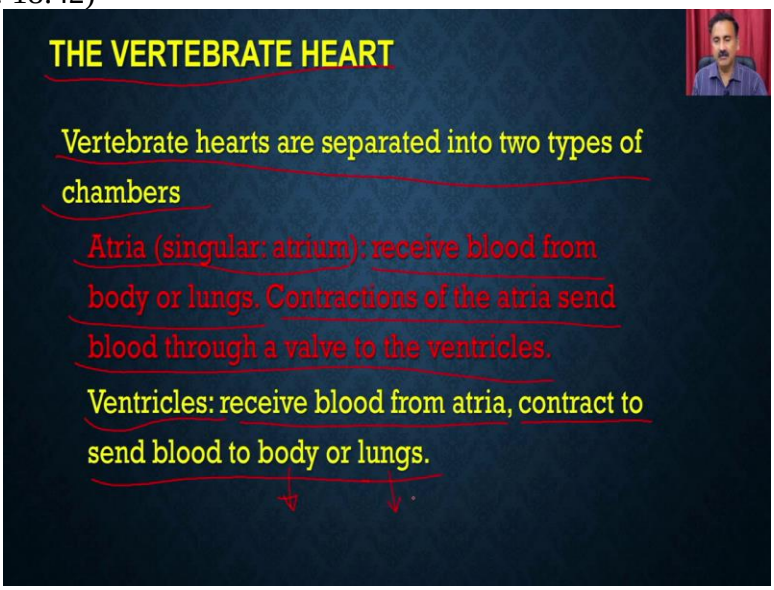

Now, when we talk about the vertebrate heart, the vertebrate heart has separated into the two different types of chambers. We can have the atria, or the atrium, which is a singular form, which receives the blood from the body or the lungs. And the contraction of the artria send the blood through a wall into the ventricles. Then we have the ventricles, which receives the blood from the atria.

And contraction to the ventricles are going to send to the body, send the blood to the body. So, that it can actually will going to give the oxygenated blood into the body or it is actually going to give the blood into the lungs. Because that blood is going to be deoxygenated.

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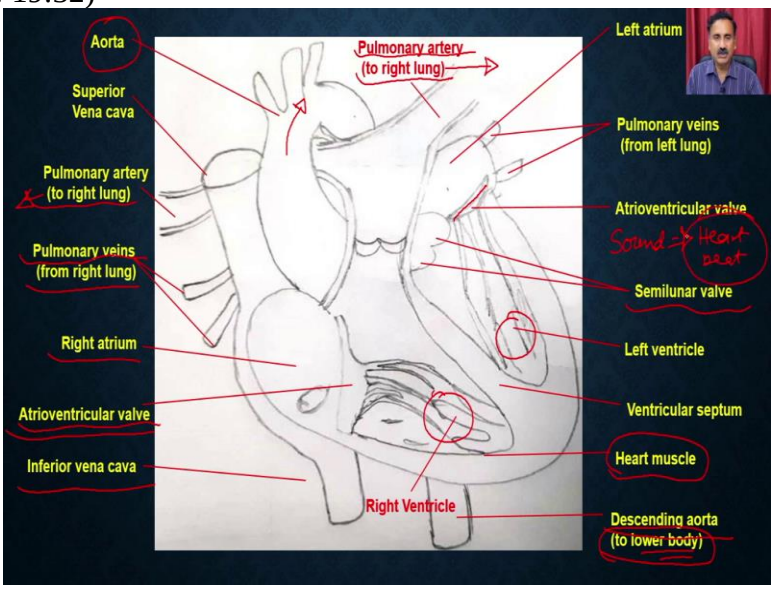

So, what you see here is the complete structure of the heart, where you have the aorta. So, all the thick blood vessels are called as the Aorta. So, we have the aorta which is actually being connected into the heart and that is going to supply the blood to the different parts of the body. So, initially you require a wide pump, wide tubing. And then you can also have the different types of arteries.

You can have different pulmonary artery which is going to supply the blood to the right lungs, and then you also have the pulmonary artery, which is going to supply the blood to the, to the left or right lungs. And then you are also going to have the pulmonary veins, which are actually going to carry deoxygenated blood, then we have the right atrium. So, we have seen, we have the right atrium, and you also have the right ventricles and as well as the left ventricle.

So, these are the two chambers. And then you also have the descending aorta. So, that descending aorta is actually going to be connected into the ventricles and that is going to supply the blood to the lower part of the body and then the heart is going to be made up off of the heart muscles. And remember that the heart muscles are going to contract and relax. And they are very, very hard muscles.

So, they are actually going to be very efficient, then we also have the inferior vena cava and the, we also have the valve which is actually going to regulate the entry of the blood from the artria to the ventricles. And that will, that wall is called as the atrioventricular valves. So, what you see here is that we have the atrioventricular valve here, we also have the atrioventricular valve here. So, that is actually going to regulate the supply or the regulation of the blood into the, into the ventricles.

And apart from that, we also have the semilunar valves and all that. Now, when the heart is going to contract and relax, it is actually going to make the sound and that sound is called as the heartbeat. So, when you are actually going to have the one round of contraction and the one round of relaxation that is going to constitute for the one heartbeat.

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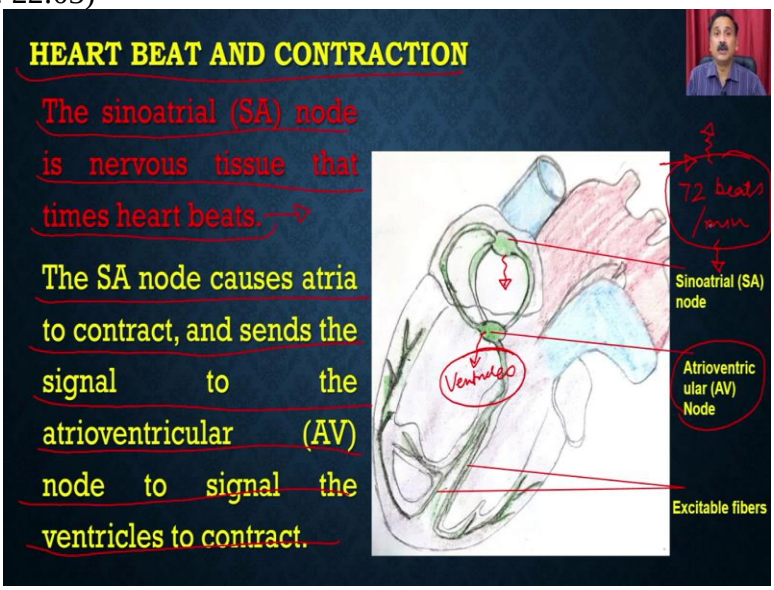

So, heartbeat and the contraction. So, you are actually going to have the different types of the neuro, neuromuscular junctions, and these neuromuscular junctions are going to give the signal to the different parts of the heart muscles. And that is how they are actually going to have the contractions. So, the sinoatrial node, which is a nervous tissue, it is the nervous tissue that regulates the heartbeat, and that is actually going to give the signal to the heart for the beating.

Beating means it is going to contract and relax. The sinoatrial node causes the artria to contract and send the signal to the atroventricular node to the signal the ventricular to contract. So, you are actually apart from the sinoatrial node, you also going to have the atrioventricular node and atrioventricular node is going to send the, give the signal to the ventricles. And that is how there will be a contract, there will be a coordination between the sinoatrial node and as well as the atrioventricular node.

So, that there will be a contraction of the articles and that there will be a contraction of the ventricles in a coordination. And because of that, the heart is going to beat and you know that heart is going to beat. In a normal human being you are actually going to have the 72 beats per minute.

Which means that is the number of times the heart is going to contract and relax in a normal human being. It actually can go up or it actually also can go down under the unusual circumstances. And thus are responsible for the different types of diseases into the human being.

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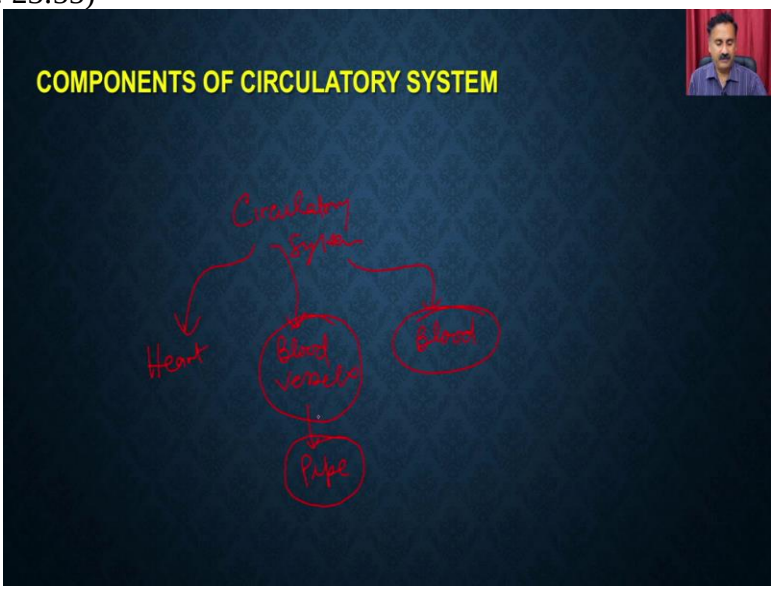

Now, so, we have discussed about the circulatory system, we are in a circulatory system, we are discussing about the heart. So, so, far we have discussed about the heart. Now, we are going to start discussing about the pipe or the blood vessels and the third component is the blood or the fluid. So, let us discuss about, discussing about the blood vessels. Blood vessels which are going to serve the purpose of the pipe.

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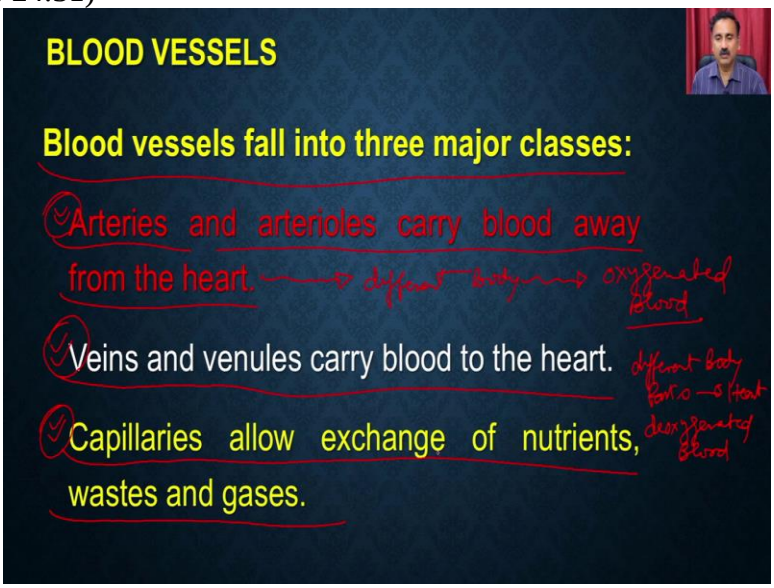

So, the blood vessels, the blood vessels are fall into the three major classes, arteries, or and the arterioles carry the blood away from the heart. Then we have the veins and the venules which carry the blood to the heart. And capillaries which are allowing the exchange of the nutrients

waste and the gases. So, heart, arteries and the arterioles are actually going to carry the blood from the heart to the different parts of the body and different parts of the body.

And they are actually going to carry the oxygenated blood. There are exceptions, so, that we will discuss later on, anyway. Then we have the weights and the venules which are actually going to carry the blood from the different parts of the body to the heart. So, to the heart, and they are actually mostly be going to carry the deoxygenated blood. Which means, the veins are actually going to carry the deoxygenated blood, the arteries are going to carry the oxygenated blood.

And since the arteries and the arterioles carry the blood away from the heart, they are more deeper into the body compared to the veins and the venules which are actually going to be present closer to the blood vessels. For example of the artery what you for example, the blood vessels what you see here, which actually normally the doctors are used to count the pulse is actually not artery, it is actually a vein what you see.

So, the pulse rate when you go to the clinics and the doctor is trying to see the pulse, that pulse or the veins what they use is actually a veins actually, they are not the artery. So, arteries are mostly been deeper into the body compared to the veins. And the capillaries, the capillaries are actually going to be the thin walled under narrow diameter blood vessels which are actually going to be responsible for the exchange of the nutrients waste and as well as the gases of the different parts of the body.

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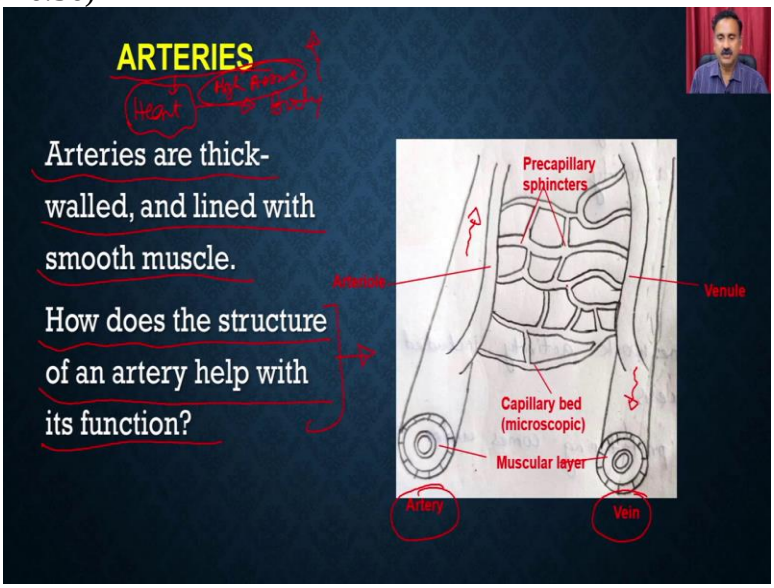

Now, the arteries are the tick walled and they are lined with the smooth muscles. So, remember that arteries are actually going to carry the blood from the heart to the different parts of the body. And because of that, the blood is actually going to carry at a very high pressure, because the heart is pumping the blood into the arteries. And because of that the, the pressure is going to be very very high in the arteries.

And because of that the arteries walls are very thick and they are lined with the smooth muscles. And this is what is going to explain that how the structure of the artery is actually explaining its function. So, these are the different types of arteries, you have the arteries and the veins which are communicating with each other by the capillary bed. So, what you see here is that oxygenated blood is actually traveling into the arteries.

And the deoxygenated blood is carrying into the blood vessels. And then you are actually going to have the network of capillaries which are actually going to, take away the deoxygenated blood or take, going to give the oxygenated blood all the nutrients to the different parts of the body.

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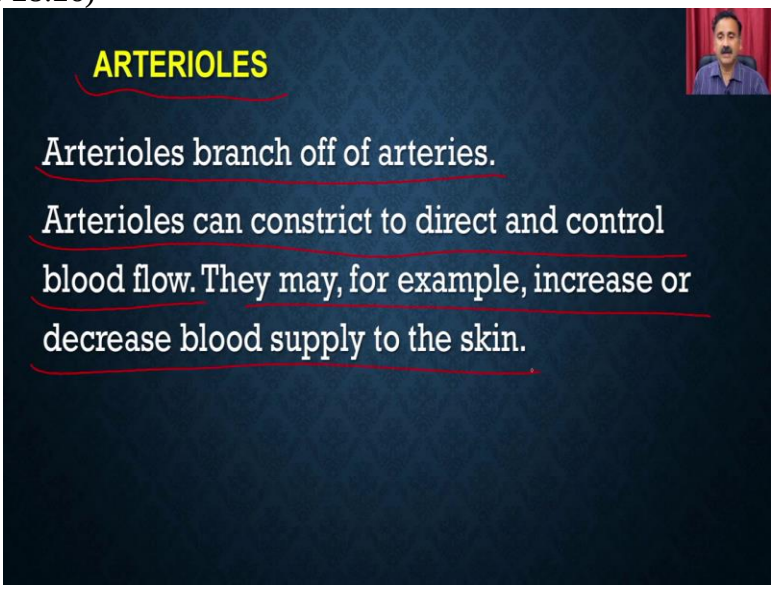

Then we have the arterioles so arterioles are branch off to the arteries. And arterioles can constrict to direct and control the blood flow. They may be, for example, increase or decrease the blood supply to the skin.

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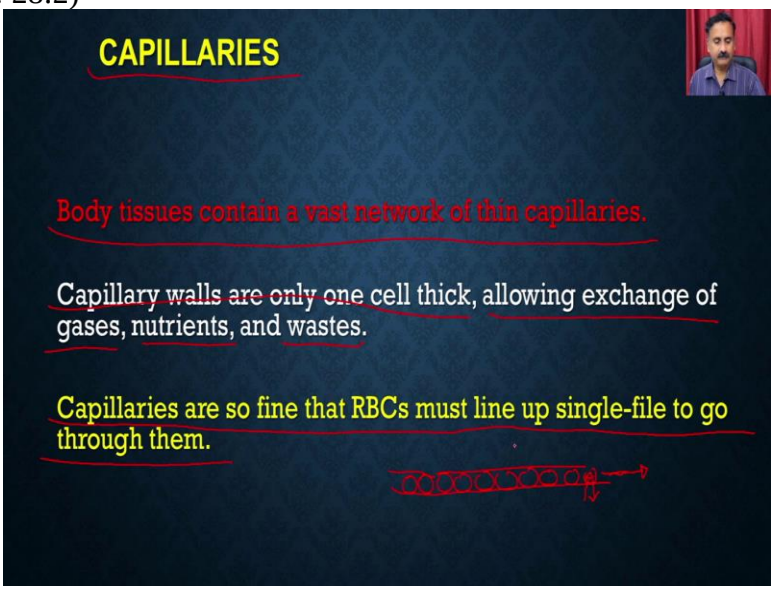

Then we have the another part which is called as the capillaries. So, the body tissue contains a vast network of the thin capillaries and these thin capacities are responsible for the exchange of the nutrients and as well as the exchange of gases. Capillary walls are only one cell thick and they allow the exchange of the gases nutrient and as well as the waste material. And the capillaries are so fine that the RBC must line up the single file to go through them.

So, capillaries are actually very thin and because of that the capillary the blood vessels like the RBCs has to travel like a single line, then only they can be able to reach to the last part of the capillaries and that is how they can be able to give away the oxygen and they can actually be able to take up the carbon dioxide.

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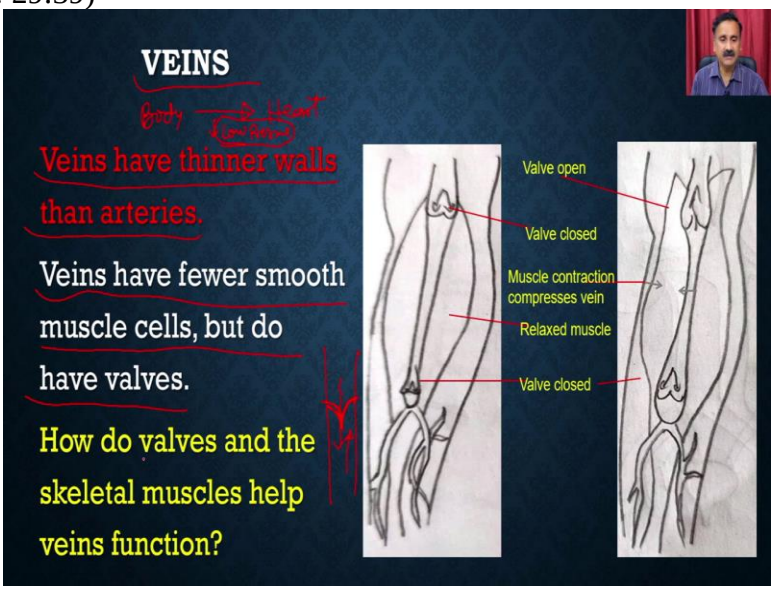

Now apart from this, we also have the veins. So, veins have the thinner wall than the arteries. And the reason is that the vein is actually going to carry the blood from the body to the heart. So, when the heart is actually going through the relaxation mode, it is actually going to collect the blood from the heart. And because of that, it is actually going to operate on a low pressure. So, when it is operating at a low pressure it does not require up very very sturdy blood vessels.

And because of that the veins are actually of thin walls and because it is thin walled that is how the doctors are using this particular vein for detecting or counting the heartbeat, because it is easy to do that. Veins have the smoother, fewer smooth muscle cells, but they do have the valves. So, the flow of the blood into the arteries or the veins are always been regulated by the valves. And these valves, the function what is the function of the valves?

That they are actually going to be present like this. So, when the blood is entering, it is going to allow the unidirectional motion. So, it should not allow the reversal of the blood. So, because if there will be a reversal these, these valves will come together and that is how they are actually going to close. And these valves and when sometimes these valves or the defect in the walls are actually been responsible for the different types of diseases.

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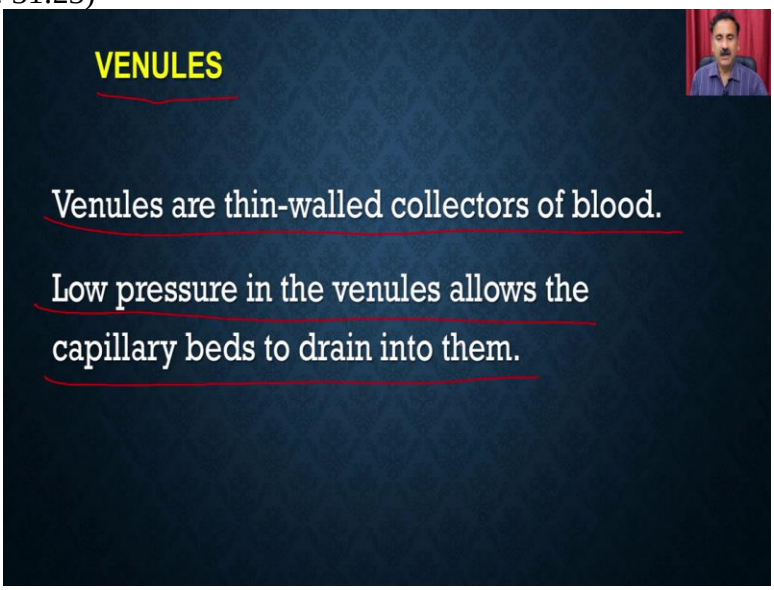

Then we have the venules. So, venules are the thin walled collectors of the blood, low pressure in the venules allow the capillary bed to the drain into them.

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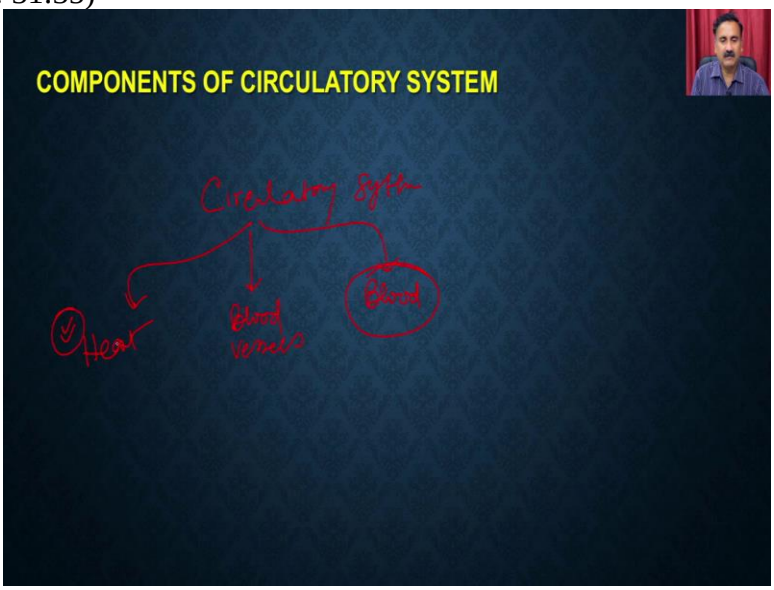

So, what we have discussed so far? We have discussed about the different components of the circulatory system. We have discussed about the heart, we have discussed about the blood vessels or and we have now left with discussing with the fluid like the blood. So, what we have discussed in today's lecture is that we have discussed about the structure and the function of the heart.

So, within the heart, we have discussed that we have the two chambered heart, we have the three chambered heart, we have the four chambered heart, what is the disadvantage and what is the advantage of the different types of heart. And how these four chamber heart is advantageous for the different types of, for the vertebrates, especially the birds and as well as the higher mammals.

And how the different components are present into the four chambered heart. So, we have the two oracles and two ventricles and how these oracle and ventricles are being present and what are different types of valves are present. And then we also discuss about how the nervous system is actually regulating the contraction in the relaxation of the heart and how it is actually regulating the heartbeat.

Apart from that, we also discuss about the different types of blood vessels. So, we discuss about the arteries, we have discussed about the vessels or the veins, we have discussed about the capillaries and the different properties of these blood vessels and what are their functions. And now in our subsequent lecture, we are going to discuss about the blood and its component and what are the different functions of these components.

So, with this, I would like to conclude my lecture here. In our subsequent lecture, we are going to discuss about the blood and its components and how they are actually going to function into the how they are actually performing the different types of functions. Thank you.