Educator's Guide and Script For
Human Body:
The Cardiovascular System

Table of Contents **Page**

INTRODUCTION

The goal of this program is to present an upper level high school or introductory pre-med or pre-nursing school overview of the anatomy and physiology of the cardiovascular system. Using the latest in 3-D graphics, medical imaging and for the first time detailed cadaver dissection, this program is designed to maximize student learning. The program begins with a brief look at the miracle of the human heart. Next, it gives an in depth examination of the blood vessels, how the blood circulates from the heart throughout the rest of the body, and the two circuits of the cardiovascular system – the pulmonary circuit and the systemic circuit. Next, the program looks at how the heart works. The chapter on blood discusses what blood is made of – plasma, water, white and red blood cells. Finally, the last chapter employs a cadaver dissection to show the amazing anatomy of the heart.

ADVANCED VOCABULARY DEFINITIONS

- **Aorta**: The large trunk artery that carries blood from the left ventricle of the heart to branch arteries
- **Aortic valve**: One of the four valves in the heart, this valve is situated at the exit of the left lower chamber of the heart where the aorta begins
- **Arteries**: Arteries are blood vessels that carry blood away from the heart
- **Atria**: The upper heart chambers, also known as auricles, the atria act as a temporary reservoir for blood before sending it to the lower heart chambers
- **Blood pressure**: The pressure of blood on arterial walls, it is produced by heart contractions and depends on the elasticity of the arterial walls and the volume of blood
- **Blood vessels**: The part of the circulatory system that transports blood throughout the body, it includes the arteries, capillaries and veins
- **Capillaries**: Blood vessels which enable the exchange of water and chemicals between the blood and the tissues
- **Cardiovascular system**: The heart and the whole of the circulatory system, which is divided into the systemic (arteries and veins of the body) and pulmonary (arteries and veins of the lungs)
- **EKG**: electrocardiogram: a graphical recording of the cardiac cycle produced by an electrocardiograph:
- **Heart chamber**: A general term used to refer to any of the four chambers of the heart

- **Heart valves**: Valves that regulate blood flow into and out of the heart chambers
- **Hemoglobin**: The iron-containing substance in red blood cells that transports oxygen from the lungs to the rest of the body
- **Iliac vessels**: The arteries and veins that carry blood to and from the pelvic organs
- **Kidneys**: Paired organs, which have the production of urine as their primary function
- **Left Ventricle**: The chamber on the left side of the heart that receives arterial blood from the left atrium and pumps it into the aorta
- **Pericardial sac**: A double walled sac that surrounds the heart
- **Plasma**: The colorless watery fluid of the blood
- **Platelets**: Special blood cells that plug up damaged blood vessels and help clot blood to stop bleeding
- **Pulmonary artery:** The artery that carries venous blood, rich in carbon dioxide and poor in oxygen, from the heart to the lungs
- **Pulmonary circuit**: The portion of the cardiovascular system which carries oxygen-depleted blood away from the heart, to the lungs
- **Red blood cells**: Blood cells that transport oxygen to all the tissues in the body
- **Right ventricle**: The chamber on the right side of the heart that receives venous blood from the right atrium and pumps it into the pulmonary trunk
- **Stethoscope**: An instrument used to listen to the heart and other sounds in the body
- **Systemic circuit**: The loop of the circulatory system that carries blood through the body and back to the heart
- **Tachycardic**: A heart rate that exceeds the normal range for a resting heartrate
- **Veins**: Blood vessels that carry blood from the capillaries back toward the heart
- **Ventricle**: A chamber of the heart that receives blood from an atrium and pumps it to the arteries
- **White blood cells**: Cells found in the blood that act as an immune system in the blood

SCRIPT

HUMAN BODY: THE CARDIOVASCUALR SYSTEM

The miracle of all miracles on this planet is the human body. Now see it in a way never revealed before.

Hello, my name is Dr. Mark Reisman, and I will be your guide for a fantastic adventure through the cardiovascular system, a system whose center is the heart. Imagine that you had to exercise 24 hours a day, 7 days a week. That's what the heart is doing, working all the time to provide blood flow through your entire body as you sleep, walk, or run.

It's a beautiful sunny day and Keith is about to go on his early morning run. His heart is about to undergo a huge change. After a few minutes into his run, he begins to hear and feel the pounding of his heart. What's happening? His heart is pumping large volumes of

blood and at a much faster rate.

This elite athlete is well trained. He's able to run without stopping for many, many miles. This endurance doesn't happen overnight. He's trained both his muscles and his heart to work together, so that his heart can meet the demands of his muscles, and the muscles can meet his desire to perform as a peak athlete.

Michelle is a gymnast. She can flip into the air. She can even walk on her hands. That's quite remarkable, because, think about it, the heart is now upside down and still has to pump blood throughout her body, even to her legs. Imagine, not only just pumping the blood to all parts of the body, but pumping it against gravity. The heart is truly a miraculous organ that's able to function continuously and meet the demands of our body, regardless of the position or the amount of energy that is required.

Dan is working in the kitchen, and is chopping vegetables. Unfortunately, he cuts his finger slightly. At first, blood oozes out. But quickly he realizes that the bleeding will stop. That's due to very important cells that are present in the blood supply. They're called platelets. Platelets are like little cells of glue, which, in a most remarkable way, stop the bleeding. And then, after putting on a small Band-Aid, Dan can now go back to chopping vegetables.

Arteries and Veins

What we have just witnessed is a spectacular demonstration of the cardiovascular system. Our next step will be a journey through the arteries and veins of the system to understand how blood flows to the various parts of the body.

Those arteries and veins, the blood vessels, are spread throughout the whole body. Placed end to end, incredibly, they would extend for over 50,000 miles.

Lets picture the heart and the cardiovascular system as a huge highway, carrying oxygen rich blood from the lungs to all the organs of the body. For a runner, who needs all the oxygen he possibly can have going to his muscles, the pace and volume of delivery needs to increase. How does the cardiovascular system do this? The heart beats stronger and faster. Once the oxygen is all used in the muscles, the deoxygenated blood flows back to the heart and is ready for the return trip to the lungs.

Here's one trip down that highway – from the heart to the hand, and back. The roads on this highway, the red colored arteries and the blue colored veins, are quite different in size and structure.

The blood vessels of the body come in two varieties. The arterial side, which you see here, is very thick-walled and very, very strong. They have to maintain all the pressure that's delivered by the heart muscle. The veins, which are the other blood vessels of the body, return the blood to the heart, and they're very, very elastic and very thin-walled, and in fact, very floppy as you can see here. Very soft.

Arteries originate at the heart, and as we have just seen, they are like rubber tubes. And if we go inside one, we can observe that they divide, split into two tubes.

Arteries are very easy to think about - like trees and the branches of those trees, So initially, when the arteries come out of the heart, they're very large and very thick. But as they go further away from the heart, they become smaller and smaller as they begin to nourish the various tissues and muscles and organs of your body. So you can see here, as this large artery comes out of the heart, it's very large, and even its initial branches, you can see how small they ultimately get. And over time, as they course to the various organs, they get smaller and smaller.

So let's look a little more closely at arteries, the blood vessels that carry the oxygen rich blood away from the heart. The largest artery in the body is the aorta, measuring about an inch across, it connects to the left side of your heart, sort of near the top. Once it moves beyond the heart, it branches into some other well known arteries. Running down the leg is the femoral artery. We've all heard of the carotid artery, that takes blood to the head and brain. The organs need blood too, so there is a branch to the kidneys called the renal artery. The celiac and mesenteric arteries bring blood to the digestive system, the stomach and intestines, and many more arterial branches to all parts of the body. It's an incredible piece of biological engineering, equal to any modern mass transit system in the world.

Sitting on top of the heart again. This time on the right side of your heart is a very special artery - the pulmonary artery. It immediately splits into two. Unlike the earlier arteries which carry oxygen rich blood, the pulmonary artery carries carbon dioxide rich/oxygen poor blood to the lungs. There is one more important group of arteries. Look at this beating heart. Remarkably, the heart supplies blood, nutrition, and oxygen to itself. This group of rather small arteries, seen here, are the coronary arteries. Their failure is the cause of most heart attacks.

Now that we've seen how arteries take blood away from the heart, the blood has to return to the heart. And running parallel to those arteries, but in the opposite direction, back to the heart, are the veins. They don't need to be as thick and strong, because after going through all the muscles and tissues, they don't have that high pressure forced upon their walls. And as you can see, they're much thinner than the arteries of the heart.

Like the arteries, there are some well known veins, bringing the de-oxygenated blood back to the heart, the right side of your heart. The jugular vein, brings blood from the head. Others are the femoral vein from the legs, and the many organ veins. They all converge back at the heart and flow into the heart through the Vena Cavae: the superior on the top, and the inferior below.

And again there are pulmonary veins that arrive from the lungs, this time converging into the left side of the heart. In addition to the content of the blood, veins differ from arteries in another important way: they use skeletal muscles to help propel the blood back to the

heart, and one way valves that prevent blood from flowing backwards. All very miraculous and ingenious.

Remember Michelle, the Gymnast? We now have a better idea of how the miracle of the cardiovascular system allows her to walk on her hands.

So when Michelle went upside down, this did not happen. And that's because of the power of the pumping of the heart, as well as these valves that are in the blood vessels that don't allow blood to back up.

In addition to the veins and arteries, there is a third branch of the highway system that carries blood throughout the body. They are like the surface streets that deliver people and goods to homes and businesses. In the cardiovascular system they are called capillaries.

Capillaries are the smallest blood vessels. They're actually the final exit of the blood before they reach the organs and the muscles and the tissue. As you can see here, in the heart, these are the blood vessels – these very large tubes. And then finally, this small mesh of vessels represent the capillaries. This is where the blood finally is deposited into the muscle of the heart. The capillaries serve a similar function throughout the body.

Have you ever seen capillaries? Take a look. They are the little red lines in the whites of your eyes, blood shot eyes. Capillaries are where the arteries and veins meet up, as seen here, meet up in what are called capillary beds, beds that are in every tissue, every organ. In one sense, they do all the important work, delivering the nutrients to, and removing the waste from the body's cells.

Amazingly, at any given time, 5% of your blood is in the capillaries, 20% is in the arteries, and a full 75% of your blood is in the veins.

Doctors have known for a very long time that there are two circuits in the cardiovascular system. One circuit is called the systemic system, and that brings blood to the various organs of the body. Except for one. And that one is the lungs. That is managed by the pulmonary circuit.

It all starts with the heart. Your right side is the side that sends all of the blood to the lungs. As the blood circulates through the lungs, it picks up oxygen molecules. Once the blood picks up this oxygen, it is then transported to the left side of your heart, and ultimately to the remainder of the body. Once the oxygen is extracted from the bloodstream by cells in muscles and organs, the blood is returned without oxygen to your right side, and the oxygen again is put back into the blood by the lungs.

Now that part of the cardiovascular system, the part that carries blood from the heart to the other organs, tissues and cells and back to the heart, is called the systemic circuit.

This brilliantly designed marvel of engineering takes approximately 60 seconds to

complete one cycle, performing flawlessly throughout the entire life of a human being. At the center of this engineering wonder is the heart itself, a powerful muscle.

The heart is an organ, a muscle centrally located in the body. Not only is it located in the physical center, but it is also the center of the body's functioning, its power source.

The Heart

Could you imagine that this little organ is able to produce enough energy to supply blood to an entire body? And look! It's not plugged into anything! This organ has to work independently without any power source other than the nutrition that you give it. It beats thousands of times a day and billions of times a year.

The beating of the heart is complex, not one simple beat at all. It is a movement that can be separated into distinct parts, parts that can be heard through a stethoscope.

What I'm about to do is listen to this patient's heart. What I'm listening to over here is the aortic valve, and the blood moving through it, and the valve closing. As I move my stethoscope over here, I'm listening to the mitral-valve and the valve opening and closing, as well as the blood moving through it. Doctors listen to various positions on the chest to hear various parts of the heart and the movement of the valves as they open and close. And as the blood flows through them.

So the heart, this beating marvel of efficiency, this pump, has structure - valves and chambers. The lower two chambers are called ventricles and have powerful muscles that can squeeze blood out through the arteries. The two upper chambers, atria, have thinner walls and act as passive reservoirs that hold the blood oozing in from the veins.

So let's look at a heartbeat. Remember there are two circuits. The right side chambers connect to the pulmonary circuit. The left side of your heart connects to the systemic circuit.

Now back to the heartbeat. During the first phase, the diastolic, the heart chambers fill with blood from the veins until the lower chambers, the ventricles, are about 80% full. Then the second phase, the systolic, begins. The muscles of the ventricles contract forcing the blood into the arteries. During this phase, valves between the upper and lower chambers lock preventing blood from flowing into the atria. So this is the heartbeat, and it takes less than a second.

Two other valves are extremely important in the beating of a heart, the pulmonary and aortic valves, such as this aortic valve, that is forced open by the pressure produced by the ventricle's squeezing of the blood, and then closes when the heart relaxes.

So when Keith stopped and heard his heart beat, what he was hearing were the valves of his heart opening and closing. What he is checking now is the rate at which his heart is beating, much faster now than when he started his run. That raises a question. So people

will often ask why does the heart beat faster in certain circumstances. Well, when you're doing exercise the reason is because the muscles demand more blood, and by virtue of those signals, the heart will beat faster and pump out more blood to the muscles. Also, when someone gets excited or nervous, we often feel our heart pounding. This time it's the nervous system that is able to send out these messages to the heart that there is something awry and it responds in a way of beating faster.

This multi-level functioning of the heart and its overall health can be checked in two simple ways. The first is by performing an EKG, or Electro-Cardio-Gram. Here, Tisa is placing electrical sensors at key points on the body of the patient. The heart, besides being a powerful muscle, also puts out electrical signals.

Often people are interested to know why we do electrocardiograms on patients. And this patient just underwent an electrocardiogram, and the idea is to figure out what the rhythm of the heart is, the beat of the heart, and also whether or not there is any damage to the heart muscle. So Tisa, what do we have here?

Dr. Mark Reisman and Tisa examine the EKG
So when I first hooked the patient up to the EKG, he was a little tachycardic, but he's now in a normal sinus rhythm. I think he may have been nervous when I first hooked him up to the machine.
So when you say tachycardic, you mean that he had a very fast heart rhythm.
His beat was going very fast.
Was it a regular beat, when you first took it? Regular.
Okay, so there were no arrhythmias.
No, not at all.
And did he complain of anything when you first hooked him up? No. Okay, perfect. So it doesn't sound like he was having any low blood flow to his heart muscle.
Not at all.

And now let's look it over. It looks like the rhythm is normal. All the segments are normal, indicating he's probably had no damage to his heart in the past or anything going on presently, which obviously is good news for our patient. And I think also, it looks like he's got a very, very healthy heart. So that's a lot of information we can obtain just from a simple tracing of the electrical rhythm of his heart.

We doctors are always checking a patient's blood pressure, the second way of looking at the overall health of the heart and the flow of blood through the arteries.

One of the most important characteristics of the cardiovascular system is the blood pressure. And the only way to know about blood pressure is to actually do an examination and check it. So what we do, is we listen for the blood flow. The first thing I do is pump up the cuff, just above the level of the pressure, so I can't hear anything. So we pump it up, and we look carefully at the wall and look at the pressure. As I let the cuff release, I start hearing her pressure, which now is about 140. And I can hear her heart pumping through her artery, and now it's stopped. And that's about 60. So at this point, I

report to the patient that her blood pressure is 140/60. And I would say that's a little elevated for you. But generally I expect this woman to have a very healthy blood pressure which would be under 120/80.

Blood

Coursing through the veins, arteries and capillaries, filling and emptying in the heart ventricles is one of the most marvelous liquids on the planet: blood.

Blood represents 8% of the weight of the body, or about 1.4 gallons.

Blood is mostly plasma and plasma is mostly water. Here at a blood bank, blood has been separated into red blood cells, on the right, and plasma, on the left. Plasma, which is yellow in color because of the many dissolved minerals and nutrients, minerals and nutrients carried to and from the cells that make up the body.

Plasma makes up 55% of the blood volume. The remainder are red blood cells. Red blood cells get their characteristic color from the hemoglobin inside the cell. It is that hemoglobin that's responsible for carrying the oxygen which then allows these red blood cells to deliver the oxygen to the various organs in the body. White blood cells also travel in the blood with the red blood cells. The white blood cells are important for fighting infection. Both the red and the white blood cells are produced in the bone marrow.

Also originating in the bone marrow are platelets, special cell fragments that come to the rescue when blood vessels are damaged, and bleeding occurs.

Almost immediately through a sequence of chemical reactions, platelets produce clotting. As seen here, a fiber mesh is formed, trapping platelets, creating a sort of plug that stops the bleeding in just a few minutes.

Let's review the components of blood. Clear liquid plasma transports nutrients and clotting platelets throughout the body. Red blood cells, the most abundant cell the body produces, 25 trillion of them, carry oxygen, and a variety of white blood cells are part of the body's mechanism for fighting off infection and disease. Now, let's take one last look at the cardiovascular system, in a rather unique way.

Cardiovascular Anatomy

We have here this amazing specimen of the human body, a cadaver, that we are looking at in order to better understand the cardio vascular system. As I had mentioned earlier, we have the heart which sits in a sac called the pericardial sac here, and around the heart we have two lungs that inflate when the patient breathes. Well we did that little bit of a trick by putting air into the lungs but as you can see that's how oxygen would enter and carbon dioxide would exit the lungs when a person would be breathing. We also see here coming very nicely, we see the aorta, which leaves the heart, which we could see down here, which I am going to open up, this pericardial sac, in order to better demonstrate the

overall heart. The front of the heart, as you can see, has a little bit of what we call fat on top of it here, and underneath it is predominately the right side or right ventricle of the heart, and that is the ventricle that ultimately pumps the blood to the lungs to get the oxygen. On the left side we can see here the highway out of the left ventricle or to the systemic system or circuit. This is the large aorta. This aorta will pump blood throughout the entire body with the exception of the lungs. It will pump blood, as you can see, by these large vessels up to the brain and to the head and also, as you can follow it down - if you were able to from behind - into the stomach cavity, which you see here. And ultimately it comes in what we call the descending aorta, or descending systemic blood supply that feeds all of the organs of the stomach and abdomen - as you can see here the two kidneys, this is the left kidney and the right kidney - and here are the remaining parts of the aorta, which basically divide into what are called the common iliac vessels. These are the blood vessels that ultimately will feed blood to those moving legs as you do more exercise.

In this program we've been looking at the cardiovascular system as an isolated system. But we've also seen that it connects to many of the other body systems: The nervous, which sends signals regulating the heartbeat, the skeletal, where blood cells are produced, and the muscular system, which can send signals to the heart to beat faster. It's all part of the miracle of the human body.

I appreciate your watching. I'm Doctor Mark Reisman.

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