Circulatory System

Objectives:

Be able to identify red and white blood cells.
Know the heart anatomy of humans.
Know the names of the major vessels.
Know the direction of blood circulation throughout the body.

The circulatory system in mammals consists of the heart and vessels and the blood inside them. The **arteries** are vessels that carry blood away from the heart, whether oxygenated or not, while **veins** carry blood toward the heart. Connecting the arteries and veins are the smallest of vessels, the thin-walled **capillaries**, where exchange of materials between the blood and other tissues occurs. The average adult has 100,000 kilometers (61,000 miles) of vessels, the vast majority of the length contained in the 40 billion capillaries. The capillaries come very close to every metabolizing cell of the body. Because of the vast number of capillaries in the skin, muscles, and other organs of the body, these organs are said to contain **capillary beds**. Blood transports oxygen, nutrients, and hormones to the cells and carries nitrogen waste products and carbon dioxide from cells to organs that expel these from the body. Blood is also involved in defense against foreign substances. To carry out these functions the blood must have various components -- a liquid plasma (55% of blood volume) and a variety of cells (45% of blood volume) -- as well as an effective means of controlling the distribution of the blood. The average human has 5 to 6 liters of blood.

BLOOD

Use a Prepared slide labeled "blood smear, Wright's stain"

Examine the slide under HIGH power. The most abundant circular cells are **erythrocytes** (red blood cells). There are 5 million per cubic ml of blood, about 30 trillion total RBCs in the body. Note that these mammalian erythrocytes lack nuclei. The lighter circular area in the center of each cell is thinner than the outer portion of the cell. Even though erythrocytes lack nuclei, they are alive. Their function is the transport of oxygen by using a red pigmented protein called hemoglobin.

The relatively uncommon cells within the blood smear that have darkly-stained nuclei, are the **leucocytes** (white blood cells). There are 7-10,000 per cubic ml. Note that there are different types of leucocytes, distinguished from one another by their nuclear configuration. The leucocytes are important in immune responses and protection against disease. All blood cells are carried through your body by the liquid part of the blood, the plasma.

DRAW a single erythrocyte and a representative leucocyte as they appear at HIGH power. Make the drawings large and draw the two types of cells in the same **relative** size they appear on the slide.

Anatomy of the Heart (sheep or beef)

On the surface of the heart, the boundary between the two ventricles is marked by a small **coronary artery**, which runs diagonally over the ventral surface of the heart. Coronary arteries supply the heart muscle itself with blood. Parallel to the coronary artery is a **coronary vein** that returns blood to the heart chambers. Two darker-colored structures, the **right atrium** and the **left atrium** (plural = atria) are above the ventricles on humans. Leading diagonally out of the right ventricle and lying between the atria is a large, whitish vessel, the **pulmonary trunk** artery, which carries oxygen-poor blood to the lungs.

Internal Anatomy of the Heart

Dissected beef or sheep heart.

Examine a beef or sheep heart that has already been partially dissected. First finding the two thin, flap-like **atria** and position these away from you and the pointed end of the heart toward you. Look inside the two ventricles. The thicker-walled ventricle is the **left ventricle.** The thinner-walled ventricle is the **right ventricle**. Now orient the heart the way it would be if the animal was laying on its back in front of you. The side facing you would should have a large whitish vessel, the pulmonary trunk, running diagonally between the atria. Verify your identification of the pulmonary trunk by inserting either your finger or a dull probe into the upper medial corner of the right ventricle and see if it goes to the pulmonary trunk. Note that the atria are both very thin-walled compared to the ventricles. Use the dull probe or finger in the right atrium to find where the 2 **vena cavas** enter. Observe the thin, tough flaps, the **atrioventricular valves**, attached at the junction of each atrium and its corresponding ventricle and projecting into the ventricle. The free end of each flap is held in place by many tough "strings", the **chordae tendineae**. The right atrioventricular valve has three flaps or cusps, so this valve is often called the **tricuspid valve.** (You can remember this with the mnemonic "Try it, you'll get it right." Try = tri) The left atrioventricular valve has two cusps which reminded someone of a bishop's cap or miter, so this valve is called the **bicuspid** (or mitral) **valve**. These are one-way valves that allow blood to enter the ventricles, but when the ventricles contract, blood pressure forces the cusps together and prevents backflow into the atria. Verify that there are also valves at the bases of the aorta and the pulmonary trunk, the **semilunar valves,** which are so-named because they are shaped like half moons**.** What will the semilunar valves do when the blood is forced out of the ventricle?

What will the semilunar valves do when the ventricles relax and blood flows back toward the ventricles?

Now review what you've learned. Fill in the blanks bel Identify these structures as you follow the path of blood through the heart.

Deoxygenated blood in the superior and inferior vena cavas empties into the right atrium of the heart, and when the ventricles relax the blood moves through the tricuspid valve into

the _____. When the ventricles contract, the pressure of the blood closes the tricuspid valve, so blood is pushed through the semilunar valves in the pulmonary trunk artery and then to the _____ (organs). Oxygenated blood returning from the lungs enters the left atrium and passes through the _____ valve into the _____ when the ventricles relax. When the ventricles contract again, blood is then forced through the _____ valves in the base of the _____ (name the vessel), which begins the distribution of blood to the rest of the body. Blood returns to the heart through veins that ultimately empty into the _____ (vessels) and into the _____ of the heart.

On the heart below, label the right ventricle, left ventricle, chordate tendinae, semilunar valves, aortic arch, pulmonary trunk, superior vena cava, inferior vena cava.

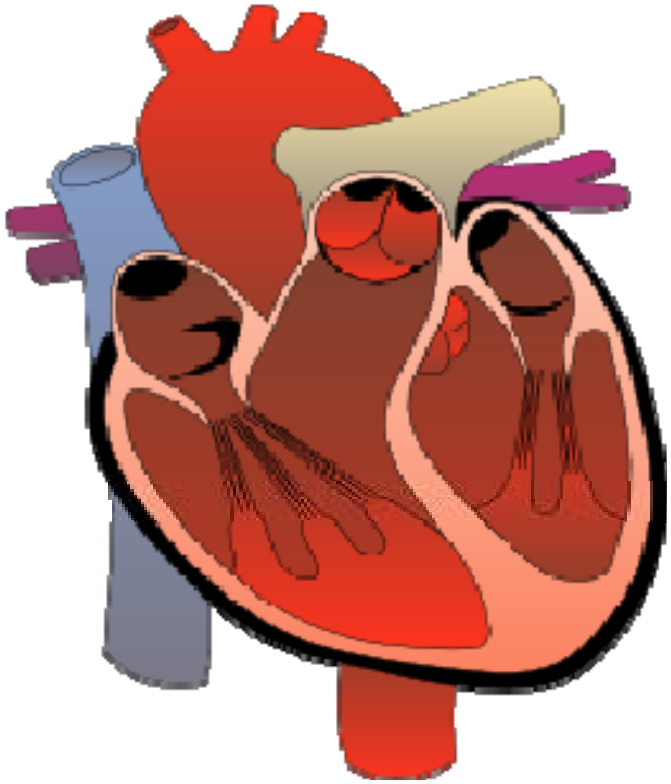

Figure 1

Venous System

Remember that the veins have been painted blue on the human torso model. Find the following veins on the human torso and LABEL them in Figure 2. The blood returning from the upper part of the body enters the right atrium of the heart from the **superior vena cava**. Blood flows into the superior vena cava from 3 pairs of major veins: 1) the **subclavian veins** (sub = under, clavian = clavicle) from the forearm and shoulder; 2) the **external jugular veins** located laterally in the neck and draining the face and neck; and 3) the **internal**

jugular veins which run parallel to the trachea, medial to the external jugular veins, and drain the brain and deep regions of the head.

Blood from the lower part of the body enters the right atrium via the **inferior vena cava**. Look under the right lung to see that the inferior vena cava penetrates the diaphragm to return blood to the heart. Remove the intestines to follow the inferior vena cava through the abdominal cavity and note that the vena cava receives branches from each of the abdominal organs. Note particularly the large **renal veins** (renal = kidney) from the kidneys, which are the large bean-shaped bulges pressed against the back wall of the abdomen. The renal veins carry blood from the kidneys to the inferior vena cava. The inferior vena cava is formed near the pelvic girdle by two branches, the **iliac veins**, which drain blood from the legs.

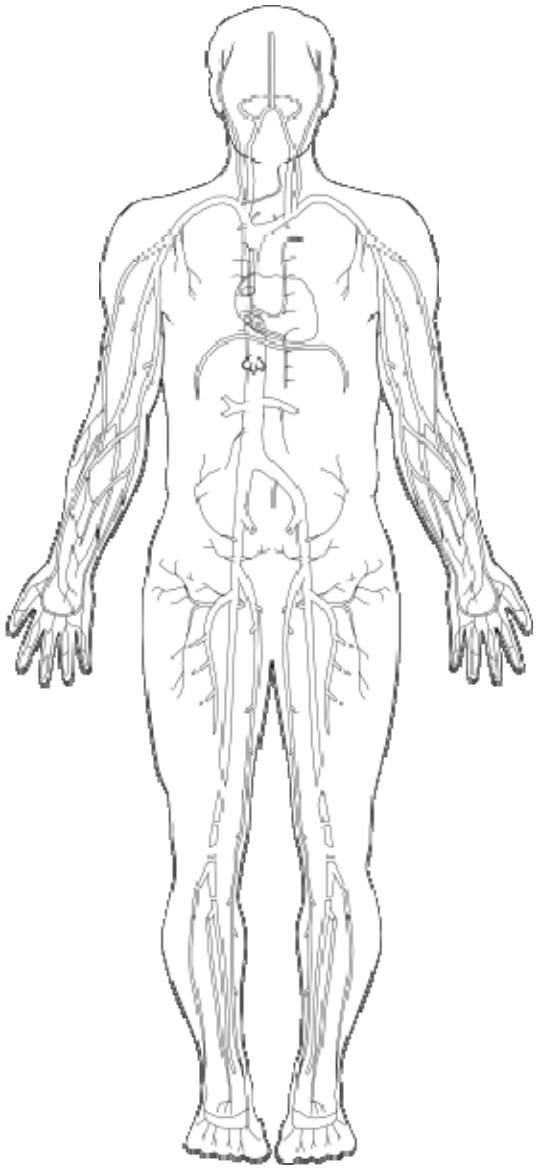

Figure 2 - veins

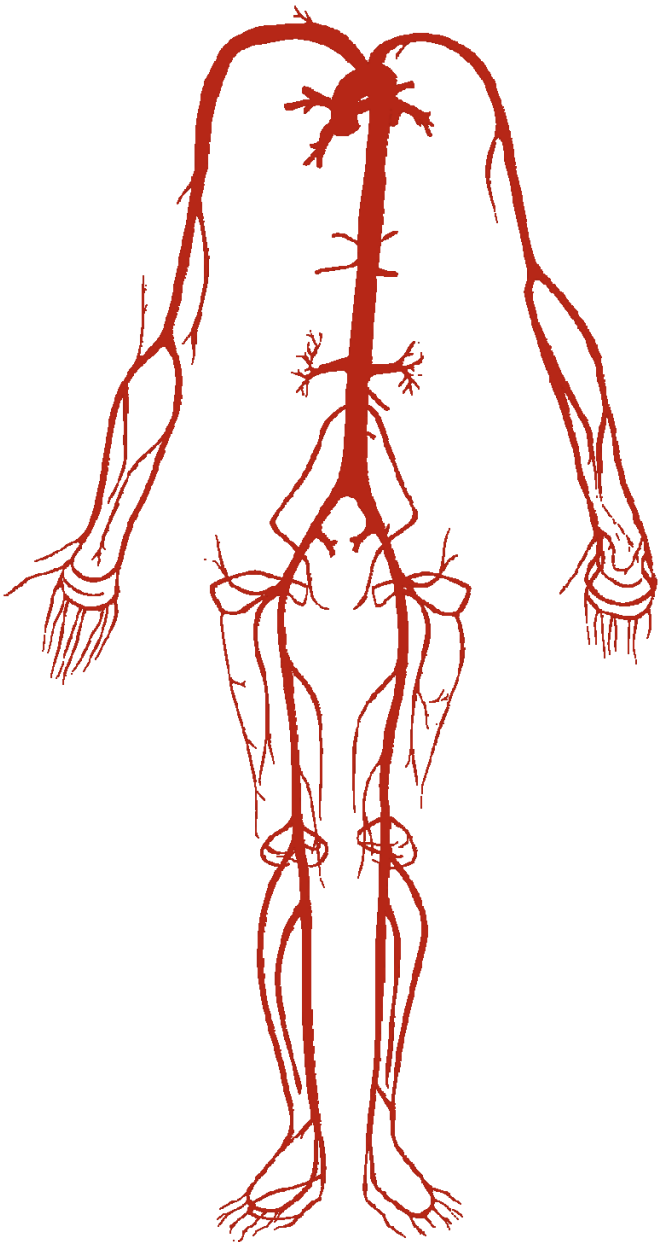

Figure 3 -- arteries

Arterial System

Remember that the arteries have been painted red on the human torso model. Find the following arteries on the human torso and LABEL them in Figure 3. Exiting the heart just dorsal to the **pulmonary trunk** artery is the largest artery, the **aorta.** The aorta exits the heart on its upper end, and makes a 180° turn; this bend is called the **aortic arch.**

Note the three large arteries leaving the aorta at the top of the arch. The large one on the right (the torso's right) is the **brachiocephalic artery or brachiocephalic trunk.** (brachio = arm, cephalic = head). It is divided into two branches: the right subclavian, feeding the shoulder and arm, and the right common carotid, carrying blood to the head and neck. In the middle is the left common carotid artery which contains blood traveling to the

head and neck, as well. The large artery on the left, the **left subclavian artery**, supplies the left arm.

Look below the heart and follow the path of the aorta down through the thorax by removing the lungs and heart. What is the name of the blue vessel that that runs beside the dorsal aorta ? _____

Just after the aorta penetrates the diaphragm (the muscle that forms a partition just below the lungs and above the stomach), the **coeliac artery** leaves the aorta medially and proceeds to the stomach, spleen, and liver. Slightly below the coeliac artery, the **anterior mesenteric artery** arises and supplies the small intestine and pancreas. Next, a pair of **renal arteries** exit the aorta laterally and go to the kidneys. At the inferior end of the aorta are two large arteries. The lateral pair going into the legs are the **common iliac arteries**. Femoral arteries branch off of them and feed the femur and many of the muscles of the thigh.

REVIEW

Blood flowing to the thigh flows from the aorta to the _____.

Blood flowing to the kidney flows from the left ventricle, into the _____ and then to the _____ artery.

Blood flowing to the head must flow through the aorta and then the _____.

Blood draining from the head back to the heart flows through the _____.

Blood draining from the head and shoulders travels through the _____ and into the right atrium of the heart.

Blood draining from the iliac vein drains into the _____ which carries it into the right atrium of the heart .

Review the circulation of blood throughout the body by tracing the path of a red blood cell from one place to another, giving in order all vessels and chambers it passes through (that you've studied).

1. Brain to kidneys in an adult. _____
_____
_____
_____
_____

2. Kidneys back to brain in an adult _____
_____
_____
_____
_____

The circulation in a fetus is similar to that of an adult or a newborn infant, but it is not exactly the same. A nine-month-old fetus has to have a system that works inside the mother's uterus one moment, and outside of the body a moment later. There are two major

differences between fetal circulation and non-fetal circulation and both of them are altered at birth.

Difference #1: The fetus has a placenta; the placenta is an organ of the fetal mammal; it is not part of the mother's body. The placenta is another organ within the systemic circulation, so once you have learned the systemic circulation, it is easy to understand the flow of blood to and through and back from the placenta. Umbilical arteries branch off the iliac arteries and allow blood to travel to the placenta. The placenta is rich with capillaries, and exchange of nutrients and toxins takes place with the mother's body. An umbilical vein drains the placenta and allows blood to flow back to the inferior vena cava.
When the umbilical cord is cut, so are the umbilical arteries and veins.

In its role as an organ of molecular exchange, the placenta does the work of several organs: lungs, small intestine, and kidneys. Fetal blood and maternal blood come in close proximity at the placenta, where the placenta is pressed against the wall of the mother's uterus. Carbon dioxide diffuses from the fetal part of the placenta to the maternal part, while oxygen and nutrients diffuse from the maternal part to the fetal part. The fetal digestive system is not ingesting anything, and nutrients from the mother's blood also diffuse into the fetal blood at the placenta. The fetus cannot urinate into its uterine environment, and gets rid of wastes like urea when they diffuse into the mother's bloodstream at the placenta. Then the mother's kidney makes urine which contains the urea produced by both herself and the fetus.

Difference #2: Since the fetus is living inside a sac of fluid (the amnion) in the uterus, the fetal lungs are not functioning. Most of the blood in the fetus bypasses the pulmonary circulation. There are a couple of fetal shunts (i.e.., detours or shortcuts) that allow the circulation through the lungs to be bypassed. For instance, some blood in the right atrium passes through a hole in its wall into the left atrium, thus bypassing the right ventricle. Also, the blood that does enter the right ventricle enters the pulmonary artery, but then goes though a fetal shunt into the aorta. This shunt is called the **ductus arteriosus**, a small tube that connects the pulmonary trunk to the aorta, thus most of the blood entering the pulmonary artery does not go to the lungs. At birth, as air enters the lungs and blood flow to the lungs is less constrained both of these shunts collapse and mostly seal off at birth,

Review the fetal circulation

Review the circulation of blood through the body by tracing the path of a red blood cell from one place to another, giving in order all vessels and heart chambers it passes through (that you've studied).

1. Placenta to heart in a fetus. _____

2. Left leg to placenta in a fetus _____

Human Anatomy