CARDIOVASCULAR SYSTEM

Introduction:

We will be observing the cells and tissues of the cardiovascular system, as well as, performing physiological experiments measuring student blood pressure and heart rates in this exercise.

Activity 1: Microscopic Observation of the Blood Smear Slide

We observed the blood smear slide in the Histology or Human Body Tissues lab exercise. As a connective tissue, blood is composed of a fluid or liquid matrix called plasma. Plasma is responsible for the transport of small molecules throughout the body including ions (salts), nutrients, respiratory gases, hormones, blood clotting factors (proteins), and antibodies. The formed elements (cells and cellular components) include erythrocytes, leukocytes and thrombocytes. Each of these formed elements carry out their own unique function—erythrocytes transport oxygen, leukocytes carry out immune function and thrombocytes play a role in blood clotting.
**Procedure:** Observe the Blood Smear Slide using your High Power or Oil Immersion Lens, as directed by your lab instructor.

1) **Before Lab,** confirm that your histology atlas contains drawings of erythrocytes, neutrophils, lymphocytes and thrombocytes. Add labels to include the following bold-faced anatomical features of each of these formed elements in your histology atlas that are included below.

2) As you observe the red blood cells microscopically, record the following information in your lab notebook:

   a) Note the relative number of erythrocytes as compared to the relative number of leukocytes in a single field of view by counting the number of red blood cells you see.

   b) The shape of a typical red blood cell is a distinguishing characteristic of the cell. Describe the shape of the red blood cells.

   c) Calculate the average cell size (diameter) of a red blood cell. Show work in your lab notebook.

   d) Is there a nucleus present? Describe/explain.

3) You may need to scan the slide in order to find a Wright stained leukocyte. The Wright stain is used to stain the nucleus so that the cells are easier to see microscopically. Leukocytes are identified by their size (diameter) and the shape of their nucleus. Record all of your observations in your lab notebook.

   a) Note the relative number by counting the number of leukocytes as compared to the relative number of erythrocytes in a single field of view.

   b) Describe the shape of the white blood cells.

   c) Is there a nucleus present? Describe/explain.

3) Leukocytes can be divided into two general categories: Granulocytes and Agranulocytes. Record all of your observations in your lab notebook.

   a) **Granulocytes** are a type of white blood cell which have cytoplasmic granules, storage areas, which stain different colors based on the molecules stored in these granules. The most common granulocyte is the neutrophil (polymorphonuclear leukocyte). These cells have a multilobed nucleus.

      1. Describe the shape and distinguishing characteristics of the neutrophil.
      2. Calculate the average cell size (diameter) of a neutrophil. Show work in your lab notebook.
      3. Is there a nucleus present? Describe/explain.

   b) **Agranulocytes** lack granules. One type of agranulocyte is the lymphocyte. It is slightly larger than erythrocytes and has a large nucleus surrounded by a thin layer of cytoplasm.

      1. Describe the shape and distinguishing characteristics of the lymphocyte.
      2. Calculate the average cell size (diameter) of a lymphocyte. Show work in your lab notebook.
      3. Is there a nucleus present? Describe/explain.

4) **Thrombocytes** are cellular fragments. You may need to adjust the light (condenser height or iris diaphragm lever) in order to view these. Record all of your observations in your lab notebook.

   a) Describe the shape and distinguishing characteristics of the thrombocytes.

   b) Calculate the average cell size (diameter) of a thrombocyte. Show work in your lab notebook.

   c) Is there a nucleus present? Describe/explain.
Activity 2: Observation of the Human Heart Model

Practice identifying both external and internal structures on the model of the human heart.

The human heart is often referred to as a double pump because the right side of the heart is responsible for pumping blood to the lungs (pulmonary circulation) while the left side of the heart is responsible for pumping blood to the body (systemic circulation). Each side of the heart consists of two chambers, an atrium and a ventricle—a total of 4 chambers. The atria receive incoming blood while the ventricles pump the blood out of the heart.

Attached to each heart chamber, are blood vessels—veins returning blood to the atria and arteries carrying blood to the body organs.

Between the atria and the ventricle is an atrioventricular valve. A valve is a specialized structure which only allows the blood to travel in one direction. The atrioventricular valves are anchored to the internal heart muscle wall by connective tissue heartstrings called chordae tendineae. The right atrioventricular valve includes three cusps so it is also called the tricuspid valve. The left atrioventricular valve includes two cusps so it is also referred to as the bicuspid valve or mitral valve.

Between the ventricles and the arteries are the semilunar valves. These valves also ensure blood flow is in one direction as the blood leaves the heart. The semilunar valves are modifications of the lining of the pulmonary trunk and aorta; similar to pockets. These semilunar valves (pockets) fill with blood and form a barrier to prevent the back flow of blood after it has left the heart.

The heart muscle, myocardium, requires oxygen and nutrients to pump the blood. On the surface of the heart are the coronary arteries and coronary veins which support the cardiac muscle cells. These are most easily viewed on the anterior surface dividing the heart into its right and left side, as well as, within the atrioventricular sulcus (groove) between the atria and ventricles.

PreLab Activity:

1) In your lab notebook, draw and label a diagram of the external structures of the heart using your textbook and/or lecture notes to help you in your drawing.

2) In your lab notebook, draw and label a diagram of the internal structures of the heart using your textbook and/or lecture notes to help you in your drawing.
Activity 3: Adult Circulation versus Fetal Circulation

As a double pump in an adult, the heart pumps blood in two circuits; the pulmonary circuit and the systemic circuit. The ventricles pump the blood into arteries. All arteries carry blood away from the heart. As the arteries move away from the heart, they branch into smaller diameter blood vessels called arterioles. Arterioles continue to branch into the smallest of the blood vessels, capillaries. Exchange always occurs within capillaries. As the blood passes through capillaries, these blood vessels begin to merge into slightly larger diameter venules and veins. All veins always bring blood back to the atria. The largest artery of the body is the aorta, while the largest veins are the Vena Cava.

The pulmonary circuit is responsible for circulating the blood from the heart to the lungs. The right ventricle begins the circulation carrying the blood through the pulmonary arteries. Once the blood enters the capillaries of the lungs, carbon dioxide diffuses out of the blood while, oxygen enters the blood by diffusion.

After gas exchange has occurred the oxygenated blood passes through the pulmonary veins to enter the left atria completing the pulmonary circuit.

Oxygenated blood is now ready to enter the systemic circuit. The systemic circuit is responsible for routing blood to most other body organs. It begins with the left ventricle which pumps the blood through the largest artery of the body, the aorta. From the aorta, it branches into smaller diameter arteries to feed individual organs (hepatic artery, renal artery, mesentery artery, gondal arteries, etc.). As arteries enter into organs, they continue to branch into arterioles and finally capillaries where exchange occurs by diffusion—oxygen diffuses into active body tissues and carbon dioxide diffuses into the blood.

Blood moves back to the heart from the capillaries, as they merge into larger diameter venules, exit out of organs as veins and continue to merge into the superior and inferior vena cava to complete the systemic circuit when the blood enters into the right atria.
As you observe the diagram, note the oxygenated blood is represented by the red blood vessels and the deoxygenated blood is represented by the blue blood vessels. As you review the pulmonary circuit, keep in mind where the blood has been and where it is going and you can identify the blood within the blood vessel as oxygenated or deoxygenated. The definition of artery is a blood vessel that carries blood away from the heart, the definition of an artery does not describe the oxygenation status of the blood passing through the vessel. However, as you identify a specific artery (or vein) then you can identify the oxygenation status of the specific vessel.

There are distinct differences between the circulation pathways between an adult and a fetus.

1) The blood bypasses the lungs in the fetus because the respiratory system is nonfunctional in a fetus—the exchange of respiratory gases, occurs through umbilical blood vessels of the placenta (an organ that develops on the inner wall of the uterus).

2) Blood moves from the right atria directly to the left atria through a hole within the interatrial septum called the foramen ovale.

3) In addition to the foramen ovale, another fetal blood vessel directly connects the pulmonary trunk with the aorta, the ductus arteriosus.

Both the foramen ovale and the ductus arteriosus close soon after birth. The foramen ovale becomes the fossa ovalis which may be viewed on the dorsal wall of the interatrial septum (the wall between the right and left atria). The ductus arteriosus, closes and becomes the ligamentum arteriosum and can be felt as a connective tissue cord between the aorta and pulmonary trunk.

Procedure:

1) Before Lab, answer as many questions in your lab notebook as you can.

2) During lab, observe the model of the human heart and review the structures of the human heart associated with the pulmonary circuit, the systemic circuit and fetal circulation (fossa ovalis and the ligamentum arteriosum).
Activity 4: Microscopic Observation of Blood Vessels

Blood is moved through arteries by the pumping of the heart creating blood pressure. As you look at the blood vessel slides you will notice that arteries and veins lie parallel to each other bringing blood to body tissues and then returning blood to the heart. However, the size of the walls of the blood vessel varies, as well as, the diameter of the lumen. At the same time, both veins and arterial walls are composed of the same three tissue layers or *tunicas* in differing amounts.

Arteries carry blood away from the heart and the blood is moving at a higher pressure within the blood vessels, therefore, the arterial wall is thick to accommodate for the pressure during the expansion when blood is pumped through them by the heart. The *tunica intima*, innermost layer of all blood vessels that lines the lumen, is *simple squamous epithelial tissue*. The *tunica media* (middle layer) is composed of a thick layer of *smooth muscle* and elastic tissue. The *tunica externa* is a *connective tissue* covering of collagen and elastic fibers. Arteries are identified by the thick wall, smaller diameter and circular shape of the lumen.

Veins carry blood away from the heart at lower pressures than arteries. Blood movement is maintained, in part, by skeletal muscle contractions, and valves within their lumens. As skeletal muscles contract, the lumen of the vein changes shape so veins often appear *flat* microscopically. Vein walls also have the same three tunicas as arteries, however, the tunica media is thinner.

**Procedure:**

1) **Before Lab**, update your histology atlas in your lab notebook by (pencil) drawing a sketch of an Artery & Vein slide. Clearly label the following observable features: identify the artery and the vein, identify each of the three tunicas, and identify the tissue that makes up each tunica.

2) **During Lab**, observe the Artery and Vein slide using your high power objective lens.

3) Answer the related questions in your lab notebook.
Activity 5: Heart Beat

As the heart beats, the contraction begins with the atria followed by the ventricles. Using a stethoscope, you can hear two heart sounds with each complete heart beat. The first sound, ‘lub’ is low and dull lasting longer than the second. ‘Lub’ is caused by the closure of the atrioventricular valves following atrial contraction. The second sound, ‘dub’ follows after a brief cause and is higher pitched, shorter in duration, caused the snapping shut of the semilunar valves following ventricular contraction.

In the following procedures we will use two different methods to determine heartbeat at rest: (1) A stethoscope to listen directly to the heart beat and (2) determination of heart rate by detecting pulse.

Pulse is caused by the expansion of the arterial blood vessels following each contraction of the heart. At rest, average pulse rates are 70-76 beats per minute. The alternating expansions of arteries are easily felt on any superficial artery when the artery is compressed over bone or other firm tissue.

Procedure-Heart Rate:

1) Obtain a stethoscope and use the alcohol wipes provided to clean the ear pieces.

2) Check the diaphragm or bell to see if it has an on/off switch and if applicable, turn it on (see photograph on left).

3) Position the earpieces pointing anteriorly to insert properly. Place the bell on the left side of your partner’s thorax between the fourth and fifth ribs. This is where the apex of the heart is closest to the ventral body wall.

4) Count the number of heartbeats for 15 seconds, multiply by 4 in order to determine the number of heartbeats per minute. Record this number in your lab notebook and label it beats per minute.

5) Repeat the procedure step #4 to report your lab partner’s heartbeats per minute.

6) Use your first 2-3 fingers of one hand and press on the lateral aspect of your partner’s wrist. See figure.

The radial pulse is felt on the wrist, just below the thumb

7) Count the pulse rate for 15 seconds and multiply by 4. Record the pulse rate for yourself and your lab partner in your notebook.

8) Repeat procedure step #7 and calculate your pulse rate for yourself and your lab partner after exercise. (Exercise may be described by your instructor—may include running up and down the stairs, jumping on each foot 20 times, etc.). Record your calculations and measurements in your lab notebook.
Activity 6: Blood Pressure

The beating of the heart creates blood pressure as it presses against blood vessel walls. **Blood pressure** is generally measured in the arteries and is used as an indication of cardiovascular health. The heart alternates between contraction and relaxation so blood pressure rises with contractions of the heart and decreases with heart relaxation. We will be taking two blood pressure measurements: Systolic Pressure and Diastolic Pressure.

**Systolic pressure** is the pressure of the blood within arteries during the peak of ventricular ejection, while **diastolic pressure** reflects the pressure of the blood within arteries during ventricular relaxation. Blood pressure is reported as millimeters of Mercury (mm Hg). Normal blood pressure, 120/80, translates to 120 mm Hg as systolic pressure and 80 mm Hg for diastolic pressure.

We will be measuring arterial blood pressure using a **sphygmomanometer**, or blood pressure cuff. It includes an inflatable cuff with an attached pressure gauge. When the cuff is placed around the brachium (upper arm) and inflated, the cuff prevents blood flow through the **brachial artery**. The cuff pressure is released while the examiner listens, with a stethoscope, for the resumption of blood flow into the antebrachium. The pressure, first soft tapping sounds, is recorded as the systolic pressure. As the cuff pressure decreases, blood flow increases—becoming more turbulent and louder. When the artery is no longer compressed, blood flows freely without turbulence and this is recorded as diastolic pressure.

**Procedure-Blood Pressure determinations:**

Note: **Blood pressure is recorded as the pressure gauge reading when the pulsing sound first appears and diastolic pressure is recorded as the pressure gauge reading when the pulsing sound disappears.**

1) Obtain a blood pressure cuff and stethoscope. Use the alcohol wipes provided to clean the ear pieces.

2) Place the inflatable cuff of the sphygmomanometer around the subject's brachium so it is above the joint of the elbow. Secure it with the Velcro attachments. Some cuffs will have an arrow indicating where the cuff should be placed over the brachial artery.

3) The head of the stethoscope is placed over the artery below the pressure cuff at the antecubital. It may be placed slightly underneath the cuff, if necessary.

4) Prepare to listen with the stethoscope by placing the clean earpieces in your ears.

5) Close the valve on the tubing and pump the bulb until pressure completely collapses the brachial artery. This should be monitored with the pressure gauge which measures in mm of Hg (millimeters of Mercury). Do NOT inflate the cuff above 200 mm of Hg. The cuff may be uncomfortable when inflated.

6) Loosen the valve slightly so that it slowly lets air out of the cuff while simultaneously listening for heart sounds and watching the pressure gauge. You may need to hold your breath in order to hear the sounds. As the pressure in the cuff falls, blood will re-enter the artery. At first, it will only enter at the peak systolic pressure. The stethoscope will pick up the sound of blood pulsing through the artery. In the stethoscope, it will sound similar to a thumping sound. The needle on the pressure gauge may jump slightly as well. Note the pressure as this happens—it is systolic pressure.

7) As the pressure continues to fall, the sound changes because the artery remains open for longer periods of time. When the cuff pressure falls below diastolic pressure, blood flow becomes continuous and the pulsing sound in the stethoscope disappears.

Note: **Blood pressure is recorded as the pressure gauge reading when the pulsing sound first appears and diastolic pressure is recorded as the pressure gauge reading when the pulsing sound disappears.**

8) Record the BP measurements systolic pressure and diastolic pressure at rest in your lab notebook.

9) Run in place for one minute and repeat the above procedure to determine BP after exercise. Report your measurement in your lab notebook.

Complete the questions and write a conclusion in your lab notebook.