Pre-lab homework Lab 5: Circulation

Lab Section: ____________  Name: ____________

1. In humans the circulatory system is closed but in other organisms, like insects, the circulatory system is open. What is the difference between an open and a closed circulatory system?

2. When you go to the doctor and they measure you blood pressure they will actually measure two numbers, systolic and diastolic. Why do they need to measure two numbers and what is a common reading for these numbers? (hint: read the lab and look at fig. 28-5 (Audesirk) or read p.442 (Cain) in your text)

3. In plants water travels through a large number of structures before it gets to the leaves. Briefly define each of these structures:
   
   Root Cortex:

   Endodermis:

   Vascular Cylinder:
Lab 5: Circulation

Lab section__________________ Name: ______________________

Objectives: Upon completion of this activity, you should be able to:

• Describe the pattern of blood flow through the mammalian heart and body.
• Explain the differences in hearts found in organisms with backbones.
• Compare open and closed circulatory systems and give examples.
• Describe fluid flow in plants including both the xylem and phloem systems.

Introduction:

Multicellular organisms that reach a certain size and complexity end up with cells that are too far removed from sources of nutrition and gas exchange to allow diffusion to take care of their nutritional and waste removal needs. These organisms need specialized systems to move waste and nutrients from sites where they are in excess to sites where they can be used or gotten rid of. These circulatory systems come in a variety of types and complexities. From the relatively simple circulatory open circulatory systems of insects and most mollusks to the more complex closed systems of mammals to the dual track system of plants that circulate water and nutrients in separate tubes from sugar filled fluids used as energy sources these circulatory systems move fluid throughout multicellular organisms in often-extraordinary ways.

During the lab this week we will focus on the circulatory systems of humans and will then compare our system to the system used by other organisms ranging from fish to amphibians, from insects to plants.

Exercise 1: Human Circulation: The human circulatory system consists of a network of interconnected veins and arteries that form continuous loops throughout the body. Powered by pressure generated in the heart the fluid of this system is pumped in prescribed tracks to every part of your body. We will examine three aspects of this system today: first we will look at the power generated by your heart by using a simple blood pressure cuff to measure blood pressure, next we will examine the heart and its chambers and track the flow of blood through your body, we will then look at the vessels that move blood in your body examining both artery and vein structure.

• Measuring blood pressure: Blood pressure is actually measured at two different times, first at the peak of contraction of the heart (called systole) and then when the heart is fully relaxed (called diastole). These numbers are usually reported as systole/diastole and in most 20 year olds is about 120/70 give or take a few points. As the vessels of the circulatory system stiffen
either due to age, smoking, or cardiovascular disease, the heart must generate more pressure to overcome the resistance of these vessel walls. In addition excess fat tissue needs excess blood supply so overweight people have a larger number of capillary beds causing further increases in blood pressure. High blood pressure is both a symptom and a cause of the cardiovascular disease that kills more people in America over the age of 25 than any other factor. In this part of the lab each person in the lab-group will attempt to measure the blood pressure of one other group member. You will need a blood pressure cuff and a stethoscope to complete this activity. These cuffs work by increasing the pressure until it is higher than the pressure of the blood – at this point the artery under the cuff pinches off and blood flow is stopped (detected by an absence of sound in the artery below the cuff) as you slowly release pressure the point where blood flow is first heard represents the systolic pressure. As the pressure of the cuff continues to block blood flow during some of the hearts contraction cycle you will continue to hear blood flow but once the pressure in the cuff is lower than the lowest blood pressure generated by the heart this sound will stop. So as you continue to release pressure the sound will gradually disappear, at the point where the sound of blood flow completely stops again you will record the diastolic pressure

**Procedure:**

1. Wrap the cuff around the upper arm of the subject. Try to use the left arm, as it is slightly closer to the heart, and try to place the cuff on a bare arm if possible.
2. Once the cuff is wrapped around the arm place your stethoscope on the inside of the elbow just below the cuff and repeatedly squeeze the bulb to increase the cuff’s pressure. Listen for the sound of blood flowing through the arm with your stethoscope.
3. As the pressure increases the sound will disappear (blood flow is blocked), now slowly release the pressure and record the systolic pressure when the sound of blood flow returns.
4. Continue releasing pressure until the sound of blood flow completely disappears; at this point record the diastolic blood pressure.
5. Record your blood pressure here:

   \[
   \begin{align*}
   \text{Systole} & = \underline{\text{mmHg}} \\
   \text{Diastole} & = \underline{\text{mmHg}}
   \end{align*}
   \]
• **Tracing blood flow:** Blood flow in mammals and birds follows a double circuit, from the heart to the lungs then back to the heart then from the heart to the body and back to the heart. This blood flow pattern is made possible by the four chambered heart found in these organisms. Each side of the heart has two chambers a relatively thin walled atrium where blood first enters the heart and a thick walled ventricle where muscle contraction generates the force needed to move blood throughout your body.

Place the number that corresponds to each structure on the diagram to the left.

1. Right atrium  
2. Right ventricle  
3. Pulmonary artery  
4. **Lungs**  
5. Pulmonary veins  
6. Left atrium  
7. Left ventricle  
8. Aorta  
9. **Body capillaries**  
10. Inferior vena cava  
11. Superior vena cava

*not on diagram – place # at arrow
**Blood flow in a real heart:** At the back of the room there are several pre-dissected pig hearts for you to examine. You should wear gloves when handling the hearts and use only blunt probes to examine them. These hearts can last us many years if you are careful with them so please be gentle when handling. As you look at these hearts notice the size of the walls of each chamber (if apparent) and the structure of the valves that prevent blood from going in the wrong direction. While working with the hearts think about the following questions.

**Questions:**

1. Which of the chambers has the largest/thickest wall? Why do you think this is?

2. Trace the flow of blood through the heart. When the heart contracts tremendous pressure is generated yet blood flows out only one of the two openings in any chamber because valves prevent backflow of the blood. How are the valves anchored to prevent being turned inside out by the pressure? (you may want to draw a picture)

3. Think about your own heart – What do you think is similar between your heart and the pig hearts? What is different?

- **Blood vessels:** Because arteries experience blood right after it has left the heart arteries are subjected to large pressure swings, remember the pressure values you measured were actually
the pressures experienced by an artery in your left arm! Veins, on the other hand, have capillary beds between them and the pressure generated in the heart. Since pressure dies off as it passes through these beds the veins experience only low blood pressures. So veins and arteries have very different structures. The wall of an artery is much thicker with more smooth muscle and more connective tissue than a vein. In the boxes below sketch an artery and a vein.

Cross section an artery 400x

Cross section of a vein 400x

Exercise 2: Circulation in other animals

- **Open vs. Closed circulation:** The following diagrams show an open (on the left) and a closed circulatory system. Use them to answer the questions on the next page.
Questions:

1. In your own words describe the difference between an open and a closed circulatory system?

2. All organisms with a backbone have the same type of system, what is it?

- **Vertebrate systems:** The following diagram shows the three different types of circulatory systems used by vertebrates. Use them to answer the questions on the next page.
Questions:

1. How many chambers do fish hearts have? How is their circulation different from mammals?

2. What seems to be the main difference between amphibian and mammal hearts?

3. If capillary beds are the main things that reduce blood pressure then which type of organism will have the greatest difficulty maintaining blood pressure in their systems? Why?

4. Circulation in mammals is more efficient at delivering oxygen to the body then circulation in amphibians. Why do you think this is and why would this help an organism?
Exercise 3: Plant circulation: Circulation in plants is very different from animals in several ways. Most notably plants have two distinct types of vascular tissue, xylem for water transport and phloem for transporting sugars.

- **Xylem and water transport in the root:** Water enters a plant at the roots where it is primarily drawn in through the root hairs. Water then passes through the cortex and moves to the **vascular cylinder**. This cylinder is surrounded by a ring of specialized cells called the **endodermis**. The cells of the endodermis have a waxy barrier embedded in their cell walls that prevents water from passing through the cell wall into the vascular cylinder. This waxy layer (called the casparian strip) forces all liquid to flow across the plasma membrane of the endodermal cells, giving the plant a chance to selectively filter all the liquid it absorbs. The interior of the vascular cylinder is made up of several types of cells. Notice the large diameter cells (often stained red) that make up an X shape through the center of the cylinder. These cells are specialized for transporting water and are called **xylem** (these are the same cells you saw making up the majority of the woody part of a tree trunk in the lab on plant support systems). Xylem tissue is dead at maturity and has a secondary cell wall that is very rigid which allows it to help support the plant and to withstand the pressure needed to transport water up the stem. In the axis of the X made by the xylem cells are bundles of sugar transporting **phloem** cells.
• **Leaf anatomy, xylem transport and transpiration:** Water in the vascular cylinder of the root is pulled upward by negative pressure (similar to how fluid is drawn up a straw). The pressure that pulls water up the plant is generated by transpiration, the evaporation of water out of the leaf. Plants can control the rate of transpiration by controlling the opening and closing of leaf *stomata*, pores in the epidermis of the leaf. These pores are controlled by a pair of cells on either side called *guard cells* surrounded by the *epidermal cells* of the leaf. Using a prepared slide and the leaf model make a sketch that shows stomata, guard cells and epidermal cells.

![Stomata, guard cells and epidermis of a leaf 100x](image)

• **Phloem and sugar transport:** Xylem moves water from the roots to the shoots of a plant but plants have an entirely separate system for transporting sugars from regions of high concentration to regions of low. This transport system, called phloem, works because of high pressure generated in the cells near a source of sugar. In a stem cells of the xylem and phloem are found together in structures called vascular bundles. In these bundles the xylem is always on the inside (toward the center of the stem) and the phloem is always on the outside. As these bundles bend out into a leaf the xylem ends up on top and the phloem on the bottom of the veins of a leaf (this is easiest to see in the leaf model and leaf section slide).

![stem vascular bundle 400x label xylem and phloem](image) ![Leaf vein 400x – label xylem and phloem](image)
**Transpiration:** In plants the transport of water from roots to stem and from stem to leaves is driven by the evaporation of water from the surface of the leaves. This process, called transpiration, is controlled by plants by controlling the opening and closing of pores in the surface of leaves called stomata. Under different conditions plants can dramatically alter their rates of transpiration. We will examine several setups that allow us to track transpiration rates in plants under varying conditions.

<table>
<thead>
<tr>
<th>Transpiration</th>
<th>At start</th>
<th>After 10 min</th>
<th>After 20 min</th>
<th>After 30 min</th>
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<tr>
<td>Baseline measure</td>
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<tr>
<td>Change in water level</td>
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<tr>
<td>With Fan</td>
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<tr>
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<tr>
<td>With Light</td>
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<tr>
<td>Change in water level</td>
<td>0</td>
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</tbody>
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1. Which conditions allowed for the most transpiration? Why do you think that is?

2. Which conditions allowed the least transpiration? How could this help a plant?