

Laboratory Investigation 25

Chapter 25: The Circulatory System

Human Anatomy & Physiology: Circulatory System

You may refer to pages 403-419
in your textbook for a general
discussion of the circulatory system.

Background Material

Getting nutrients and oxygen to the body's tissues is called **circulation**. Circulation, like digestion, involves not only taking in materials that the body needs but also excreting waste products that result from metabolism—the chemical activity that takes place inside living cells.

One-celled organisms absorb nutrients directly from their environment. This is also true of simple animals, such as sponges and coelenterates. The cells of most animals, however, are not exposed to the outside environment and are not able to get nutrients directly from it. Most animals have a circulatory system, composed of specialized tissues and organs, that concentrates nutrients and brings them to body cells. The circulatory system also carries away cellular wastes to sites in the body where they can be excreted.

The circulatory systems of animals usually have a network of blood vessels. The blood is pumped through the blood vessels by a muscular organ called the heart. In **open circulatory systems**, the blood vessels empty the blood into spaces called sinuses. In a **closed circulatory system**, the blood does not leave the blood vessels, but circulates over and over again.

Most mollusks have an open circulatory system. Blood is pumped from the heart to sinuses, where it is poured over the body tissues. Nutrients and oxygen dissolved in the blood diffuse into body cells. Wastes, including carbon dioxide, diffuse out into the blood.

Annelids have a closed circulatory system. Earthworms, for example, have two main blood vessels. One runs near their back and another runs along their belly. Muscular vessels called **aortic arches** connect these vessels and act like hearts to push the blood through the circulatory system.

Arthropods have open circulatory systems. The heart pumps blood into sinuses that bathe the body tissues. This blood then empties into another sinus around the heart. The sinus has small holes. Blood passes through the holes into the heart. Insects' circulatory systems do not carry much oxygen. Insects have another system that delivers oxygen to their body cells.

Vertebrates have a closed circulatory system. The heart pumps blood into large vessels called arteries. The blood then enters very small vessels called capillaries, which pass through the body tissues. Nutrients and oxygen diffuse out of the capillaries into the body tissues. Wastes produced by the body tissues diffuse into the capillaries to be carried away. Blood from the capillaries enters large blood vessels called **veins**, which carry the blood back to the heart. The veins contain valves that prevent blood from flowing backwards.

The hearts of vertebrates are divided into chambers to help increase the amount of oxygen that goes to the blood. Fishes' hearts are two-chambered. The hearts of amphibians and most reptiles are three-chambered. The hearts of crocodiles, birds, and mammals are four-chambered. In animals with three- and four-chambered hearts a separate circulation carries blood between the heart and lungs. Since a body system that involves lungs is called a pulmonary system, the separate circulation is called **pulmonary circulation**.

Part 1 - Blood Typing

Background

Your blood type is determined by the alleles you inherited from your parents. It is possible to inherit three different

types of alleles—A, B, or O. These three alleles make up four different blood types—A, B, O, and AB. By using a blood-typing serum, you can determine the type of a human blood sample. The serum works by reacting with certain antibodies in the blood. The Rh factor, a kind of protein found in the blood, is also genetically determined. If a blood sample has this protein, it is called Rh positive. If it does not, it is Rh negative.

Materials Part 1

Materials: blood test cards, blood, toothpicks, anti-A anti-B and anti-D human blood sera

Procedures Part 1

1. Obtain a Blood Test Card and 3 toothpicks. Place a drop of Anti-A serum (blue) in the circle labeled “Anti-A.” Replace the cap on the Anti-A vial. Always replace the cap on one vial before opening the next vial to prevent cross contamination.
2. Place a drop of Anti-B serum (yellow) in the circle labeled “Anti-B” and then replace the cap.
3. Place a drop of Anti-D serum (clear) in the circle labeled “Anti-D.” Replace the cap on the Anti-D vial.
4. Place a drop of blood in each “blood” circle. Give the number located on the bottle of blood you used for your sample:
5. Mix each drop of blood with the anti-serum adjoining it. Carefully spread the blood and serum mixture with a toothpick until both connecting circles are covered by the mixture. Then discard the toothpick. Use a separate toothpick for each mixture (Anti-A, Anti-B, and Anti-D). **Note:** be careful not to cross-contaminate the samples, because the slightest mixing will ruin your test results.
6. Gently rock the test card back and forth for 1 minute. Be careful to keep each mixture within its circle.
7. Tilt the Blood Test Card, allowing the blood and serum mixtures to drain to the side but not out of the circles. Compare the appearance of the thin blood films. If a film remains uniform in appearance, there is no agglutination. If a film appears granular, agglutination has occurred. **Note:** Positive Rh reactions take longer than A or B reactions. Five minutes may be required to obtain an accurate Rh reading.
8. Record the blood type of the Blood Test Card here:

Letter of blood sample: _____

Blood type found: _____

9. Did the blood agglutinate? _____
10. What types of blood could safely receive the blood you tested? _____
11. What types of blood could safely be given to the person you tested? _____
12. Why is it necessary to stir the drop of blood? _____

Observations and Conclusions Part 1

Blood Types

Before a transfusion can be given, the blood must be accurately typed. If the wrong type is donated, the recipient’s blood may agglutinate, causing death. Blood is usually typed by testing it with sera as you will do in this section. The educational grade of sera used for this exercise is neither pure enough nor fresh enough to give accurate blood tests. Do not decide that your blood is a particular type on the basis of the tests run in class. Only a licensed laboratory technician can accurately run sufficient tests to correctly type blood for clinical purposes.

Blood-typing serum is made from blood plasma; therefore it contains only antibodies. Anti-A serum, then, contains anti-A antibodies, and thus causes blood containing A antigens to agglutinate.

I. Answer the following questions regarding blood-typing sera, antigens, and antibodies.

13. What antigens would be found in anti-B serum? _____
14. What antibodies would be found in anti-B serum? _____
15. If the red blood cells agglutinate when anti-A serum is placed on the blood, what type(s) of blood may the person have?

16. If the red blood cells agglutinate when anti-B serum is placed on the blood, what type(s) of blood may the person have?

17. If the red blood cells agglutinate when anti-A serum is placed on the blood and also when anti-B serum is placed on the blood, what type(s) of blood may the person have?

18. If the red blood cells do not agglutinate when anti-A or anti-B serum is placed on the blood, what type(s) of blood may the person have?

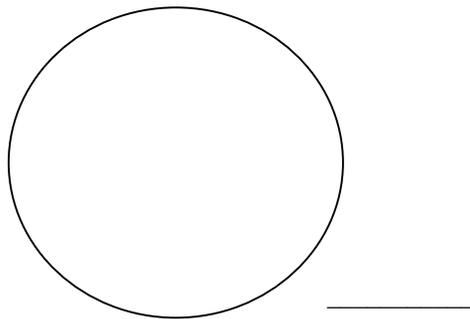
Part 2 – Observing blood Cells

Materials Part 2

Compound light microscope; prepared stained slides of human blood

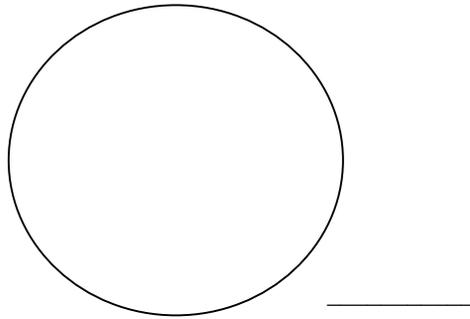
Procedures Part 2

19. Place a prepared slide of human blood on the stage of a compound light microscope. Focus on high power. Locate the numerous disk-shaped cells in your field of view. These cells are red blood cells.
20. Sketch a red blood cell as it appears in your field of view

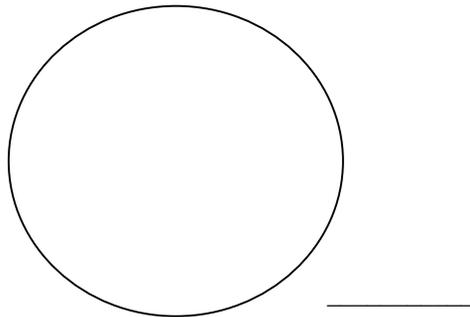


21. Move the slide around on the stage until you find one or more white blood cells. They are larger than red blood cells and will likely appear blue or purple due to the staining process used in the slide's preparation. Each white blood cell will probably have more than one round or horseshoe-shaped nucleus, and the nuclei will be dark blue or purple in appearance. You may also notice bits of matter that appear as red or blue dots within the cell itself.

22. Sketch a white blood cell as it appears in your field of view



23. Locate the very small blue dots that are on your slide. These dots are bits of cytoplasm called platelets.
24. Sketch a platelet as it appears in your field of view



Analyses and Conclusions

25. Is there a nucleus visible in a red blood cell? Why or why not?

26. List the structures you examined in order from the most numerous to the least numerous.

27. What medical problems might you expect to find in a person whose blood does not contain enough red blood cells? Explain why you would expect to find the problems.

28. Complete this table that compares the different cells of your blood.

	 Red Blood Cells	 White Blood Cells	 Platelets
Appearance			
Functions			
Where Produced			

Part 3 – Circulation in Vertebrates

Background Material

Blood flows through the body in a complicated system of vessels. Arteries are the vessels which take the blood away from the heart, and veins carry the blood back to the heart. The heart functions as a pump to push the blood through the vessels. The heart is a large muscle which “pumps” each time it beats or contracts. Arteries are connected to the veins by very tiny blood vessels called capillaries.

In addition to connecting arteries and veins, capillaries make the many exchanges between the bloodstream and the body’s cells. Oxygen and food molecules pass to the cells from the blood; waste and carbon dioxide molecules pass to the bloodstream from the cells. The capillaries are often so tiny that red blood cells must pass through them in single file.

Materials

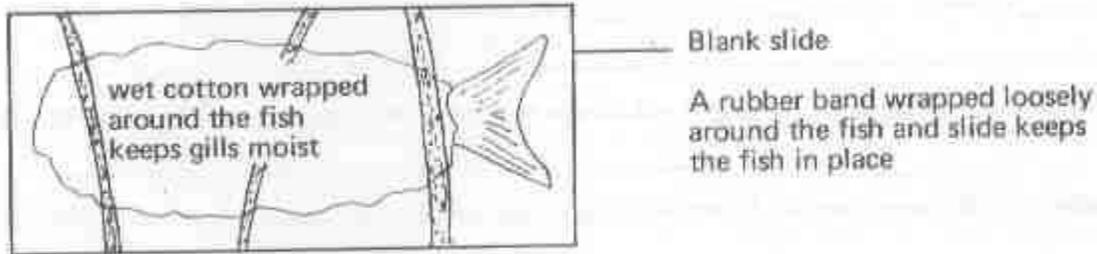
Aquarium, Well-oxygenated aquarium water, Goldfish, Dip net, Petri dish, Absorbent cotton, Microscope slides (2), Compound light microscope, Watch or clock with second hand, Transparent tape, Aquarium water, Eyedropper, Rubber band

Procedure

29. Using dip net, carefully remove a goldfish from the aquarium, and place it in a Petri dish. Cover the fish’s body with cotton that has been soaked in aquarium water. Be certain to cover the fish’s gills with the wet cotton, but take care to Leave its mouth and tail exposed. At regular intervals throughout the investigation, remoisten the cotton with aquarium water.

30. Use one of these two methods to secure the fish:

- A. Spread the fish's tail and place it between 2 slides. Secure both ends of the slides with transparent tape.
- B. Using a rubber band, attach the goldfish loosely to a blank slide as shown. To keep the fish's tail from flopping, place a drop of water on it and press it to the slide.



31. Set the microscope on low power and examine the fish's tail fin.

Observations

- 32. Notice the structure of the tail. It is made of a series of jointed rods.
- 33. Carefully examine the tail and look for any parasites which may be on it. Examine the scales.
- 34. Look for movement of a liquid between the rods. When you find the flowing liquid, you will be watching the fish's blood as it moves through its body. You should see many blood vessels of varying size.
- 35. Locate and observe blood vessels in which the blood is moving in regular pulses. These are the arteries carrying nutrient-rich blood to the cells of the fish's body.
- 36. Count the number of times the blood surges in an artery for one minute. *How many surges did you count?* _____
- 37. Locate and observe blood vessels in which the blood is moving in a steady flow. These are the veins transporting deoxygenated blood back to the heart.
- 38. Locate the capillaries that connect the arteries and veins. The blood moves through the capillaries in an irregular stop and go motion. While the blood is in the capillaries, the cells exchange their waste material for the nutrients carried by the red blood cells.
Do you see the red blood cells? _____
- 39. If the blood slows down, what is a safe assumption to make? _____
- 40. What would be the most prudent thing to do with the goldfish under such circumstances?
_____ Do it!
- 41. Carefully remove the slides and the cotton wrap from the fish. Place the goldfish into the dip net and return it to the aquarium.

Analyses and Conclusions

- 42. How does the size of the capillaries compare to that of the arteries and veins?

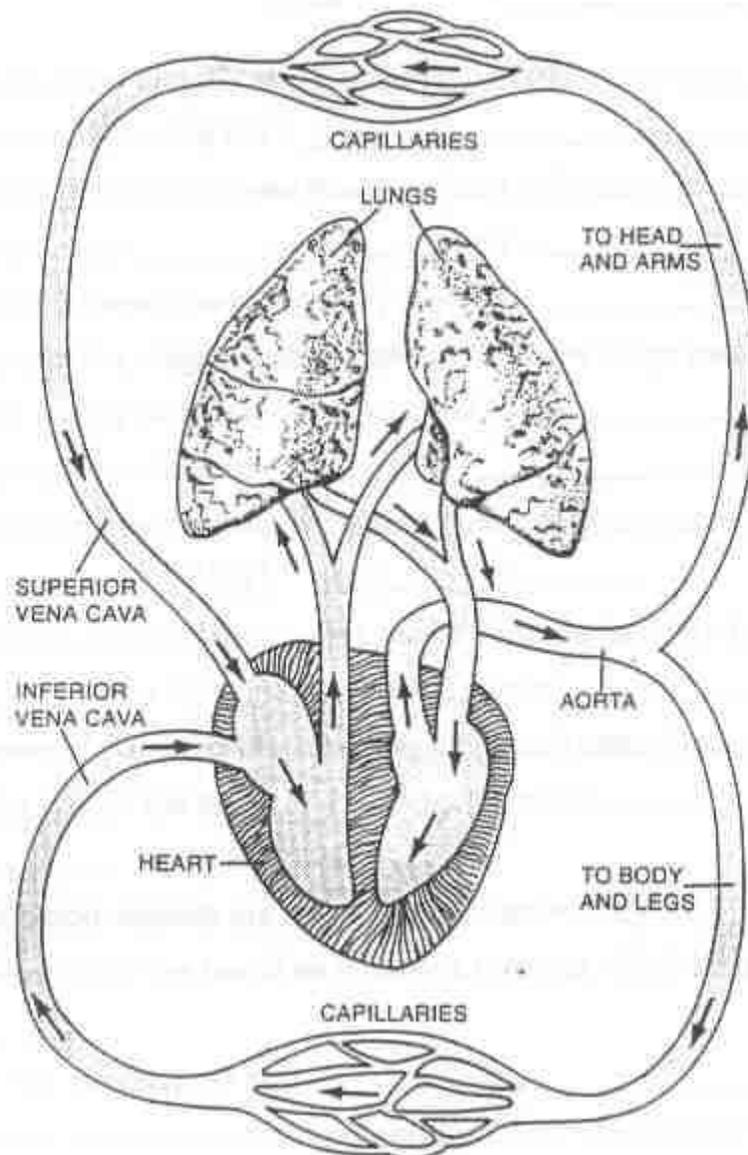
- 43. What causes the blood in the arteries to move in regular pulses?

44. What are some of the factors that can influence the rate at which blood flows through your vascular system?

Diagram of the path of a red blood cell

On the diagram of the circulatory system, use colored pencils or markers to trace the path of a red blood cell in each situation below. Use a red pencil for oxygenated blood (blood that is rich in oxygen) and a blue pencil to represent blood that is deoxygenated (blood that is high in carbon dioxide).

- From the right ventricle to the left ventricle.
- From the body and the legs to the left atrium.
- From the right atrium to the cells of the heart.
- From the lungs to the head and arms.
- From the head and the arms to the left ventricle.



Part 4 – Counting Your Pulse and Listening to Your Heart

An irregular heartbeat is an indication of disease, disorder, or emotional trauma. One of the first things a doctor wants to know about a patient is his pulse rate. Another part of almost every physical examination is listening to sounds of the heart. In this exercise you will count your partner's pulse rate and he will count his own heart rate while he engages in various activities. Afterwards you will compare the different rates.

Materials Part 4

stopwatch or a clock with a second hand, stethoscope, alcohol, tissue

Procedures Part 4

I. Taking a pulse rate

- Have your partner sit quietly for about four minutes (□while working on his lab). While your partner is seated, find his radial pulse. Place your fingertips (□not your thumb) over the place where the radial artery passes over the radius.
- Using a stopwatch or a clock with a second hand, count the number of pulses that take place in fifteen seconds.
 - > Record the number on scrap paper. Multiply by four to get the rate per minute.
 - > Repeat the procedure twice more.
 - > Average the results and record your answer in the proper space on the following page.

II. Listening to your heart

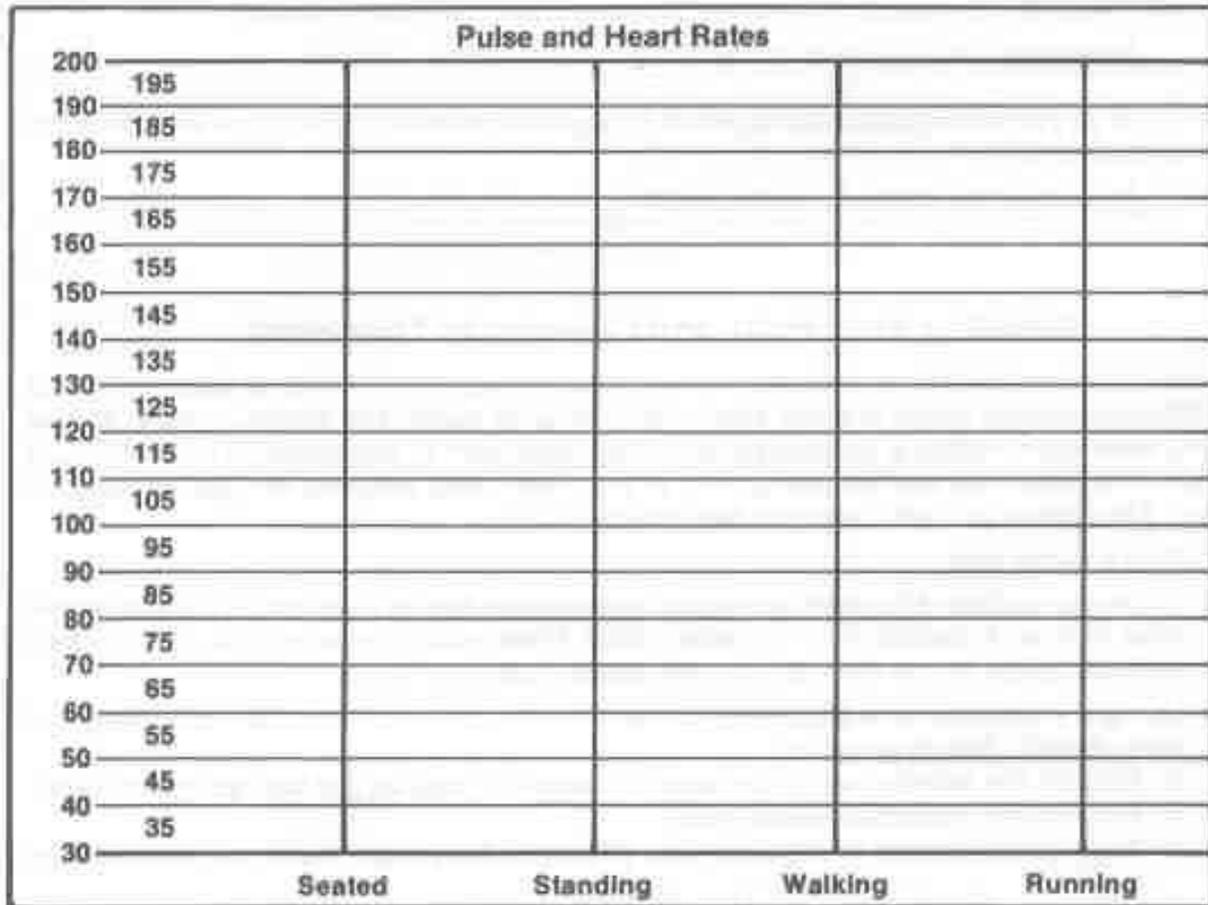
- While you are seated, listen to your own heart, following these instructions.
 - > Using a tissue, clean the earplugs of a stethoscope.
 - > Place the stethoscope in your ears, allowing the tubes to hang freely.
 - > Place the diaphragm of the stethoscope just below your third rib, slightly to the right of the sternum.
- Using a stopwatch or a clock with a second hand, count the number of beats that take place in fifteen seconds.
 - > Note: A “lubb-dupp” sound counts for **one beat**, not two.
 - > Record this number on scrap paper. Multiply by four to get the rate per minute.
 - > Repeat the procedure twice more.
 - > Average the results and record your answer.

III. Pulse and heart rates during activity

- Have your partner stand quietly for four minutes (□while working on his lab). Then, at the same time, your partner will listen to his own heart and you will count his pulse rate. Record your results below.
- Have your partner walk a prescribed distance (□your instructor will set up a course for your class to use). As soon as your partner returns, you will take his pulse rate and he will listen to his heart at the same time. Record your results below.
- Have your partner run the prescribed distance. As soon as he returns, you will take his pulse rate and he will listen to his heart at the same time. Record your results below.

	Seated	Standing	Walking	Running
Pulse Rate	_____	_____	_____	_____
Heart Rate	_____	_____	_____	_____

- Plot the preceding information on the graph below, using one color for the pulse rate and another for the heart rate.
 color for pulse rate _____ color for heart rate _____



Observations and Conclusions Part 4

45. Is there a significant difference between the rate of the heartbeat and the pulse rate? _____
46. Why would you expect to find little difference between the two rates? _____
47. Was there a major difference between the two rates during any of the above experiments? _____
48. What do you think might account for this difference (or lack of difference)? _____
49. Is there a major increase in the rate between any of these exercises? _____
50. What do you think this increase in rate would indicate? _____

51. If you were to take your own pulse rate and listen to your heart at the same time, would you expect the pulse and heartbeat to occur at the same time? _____

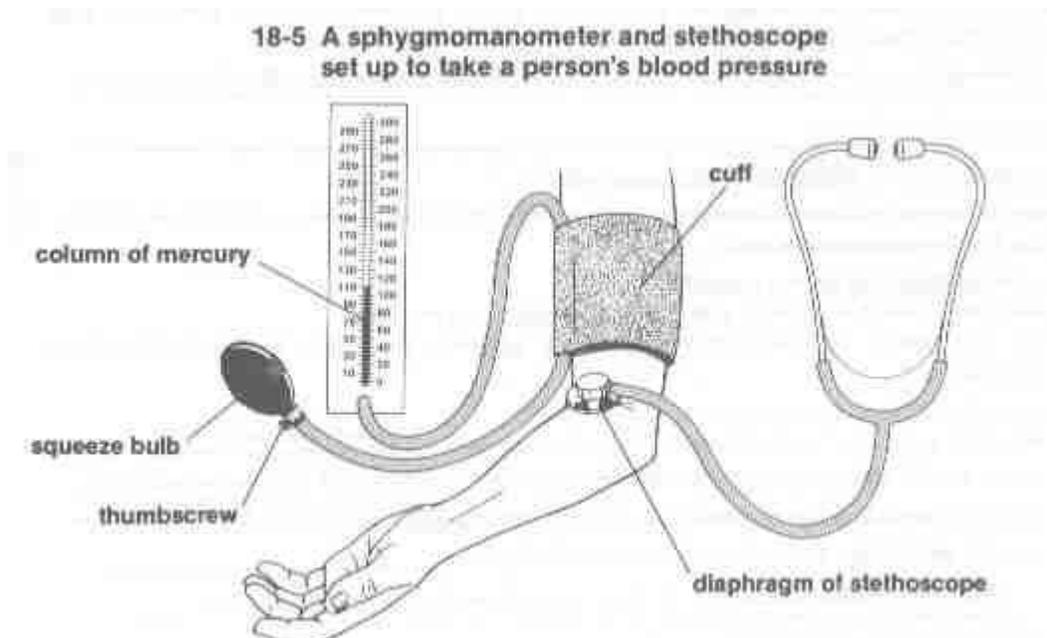
Why or why not? _____

Part 5 - Measuring Your Systolic Blood Pressure

Blood pressure is the pressure of the blood against the walls of the blood vessels. Although professionals take blood pressure readings quickly and easily, the process is not as easy as it looks. Nurses in training often spend long hours learning the proper techniques.

Materials Part 5

sphygmomanometer, stethoscope, alcohol, tissue



Procedures Part 5

- I. Set up the sphygmomanometer.
 - Place the cuff tightly around your lab partner's arm, in the area of the belly of the biceps brachii.
 - Turn the thumbscrew near the squeeze bulb until the valve is closed.
 - Have your lab partner bend his arm and place it on a table.
 - Place the stethoscope earpieces in your ears. Be careful not to hit the diaphragm against any object.
 - Find your partner's radial pulse with your fingers.
- II. Take the systolic blood pressure of your partner.
 - While feeling your partner's radial pulse, squeeze the bulb repeatedly until you can no longer feel a pulse in the radial artery.

The remainder of the exercise must be done in thirty seconds. If you are unable to complete it in thirty seconds, you must release the pressure on the arm and permit the blood to flow freely into the arm for a minute before you try again. Do not cut off the circulation in the arm for more than thirty seconds. Also, do not flex the arm muscles while the cuff is tight. Such movement causes the mercury to rise and can destroy the sphygmomanometer.

- > Keep your eye on the mercury column. The pulse should stop near 140.

- > As soon as the pulse cuts off and you have let the mercury rise about twenty points higher on the scale, stop squeezing the bulb.
- Place the diaphragm of the stethoscope in the cubital fossa (pit in the bend of the arm).
- Partially release the thumbscrew. You will hear the air hiss out and see the column of mercury drop.
 - > Listen for the sound of the first spurt of blood as it passes through the partially closed artery.
 - > When you first hear the sound, note what number the mercury is on. (The mercury should take a quick little jump just as the sound starts.)
- Immediately release the thumbscrew completely.

Note: If you must repeat the procedure more than three times in order to do it right, switch the cuff to the other arm.

Observations and Conclusions Part 5

52. What was the partner's systolic blood pressure? _____
53. Normal systolic blood pressure for adults is about 120; for young people it should be slightly lower. What would you know about a person whose pressure was higher than that?

- IV. Take your partner's diastolic blood pressure.
- After taking the systolic blood pressure, instead of releasing the thumbscrew rapidly, allow the air to escape slowly.
 - Continue listening to the sounds.
 - > At one point the sounds will become softer and muffled.
 - > At this point, the level of the mercury column indicates the diastolic blood pressure.
 - Answer the following questions.
54. What was your partner's diastolic blood pressure? _____

Part 6 – Observing a Heart

Background Material

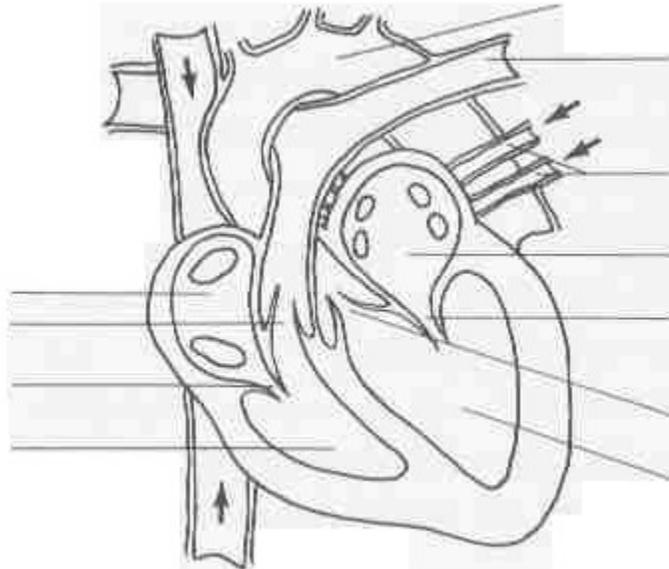
A person's heart is about the size of his or her fist. In fact, a child's fist and heart grow at about the same rate. An adult human heart is about 13 cm long, 9 cm wide, and 6.4 cm thick. A man's heart weighs about 312 g while a woman's heart weighs about 260 g.

Your heart is attached to about 160,000 km of blood vessels that carry blood throughout your body. These blood vessels carry blood to all parts of your body, including your brain, lungs, kidneys, the heart itself, and other vital organs.

Your heart beats about 70 times per minute, 60 minutes an hour, 24 hours a day, and 365 days a year for an average of 72 years. Each minute that your heart beats, it pumps 4.7 liters of blood through its chambers.

Materials

dissected hearts, dissecting pans

Label the Heart

Obtain a specimen from your teacher and rinse it off with cold water to remove excess preservative. Before you begin dissecting, review the rules of safety that you have learned. Always direct a scalpel or razor blade away from your body, hand, or fingers to avoid a possible injury.

The heart is covered with a very thin layer of cells called the visceral pericardium. With a scalpel try to peel away a small piece of this membrane. Now position the heart so that it is in the same position as your own. To determine right and left sides, feel the thickness of the walls. The right wall will be thinner, since it pumps blood only through the lungs. The left wall is much thicker, because it pumps blood throughout the body. If you have properly determined right from left and are holding it as it would be in your body, you are looking at the back side of the heart. Embedded in the fat toward the top should be four thin-walled pulmonary veins coming from the lungs to the left atrium.

Now, turn the heart around. This should be the front side. Look for the fat-covered division between the right and left ventricles. In this division, embedded in fat, lie important coronary arteries and cardiac veins that send blood to and from the heart muscle itself. On the top of the heart lie the atria. They are thin-walled chambers that are probably shriveled up and looking like chunks of cauliflower. They expand greatly when filled with blood. Identify the right atrium and note the large superior vena cava which empties into it. Locate the aorta, which is the large, thick-walled vessel next to the right atrium. You may need to clean off much of the fat that usually covers this area. Locate the pulmonary artery, a large vessel between the aorta and the left atrium. It may be long enough for you to see it divide into the left and right pulmonary arteries.

Check off the structures as you find them. Use the diagrams on the next pages.

External Anatomy

- | | | | |
|---|---|--|---|
| <input type="checkbox"/> pericardium | <input type="checkbox"/> pulmonary vein | <input type="checkbox"/> right ventricle | <input type="checkbox"/> left ventricle |
| <input type="checkbox"/> coronary artery | <input type="checkbox"/> aorta | <input type="checkbox"/> right atrium | <input type="checkbox"/> left atrium |
| <input type="checkbox"/> superior vena cava | <input type="checkbox"/> pulmonary artery | | |

Internal Anatomy

- | | | | |
|---|--|---------------------------------------|--------------------------------------|
| <input type="checkbox"/> right ventricle | <input type="checkbox"/> left ventricle | <input type="checkbox"/> right atrium | <input type="checkbox"/> left atrium |
| <input type="checkbox"/> septum | <input type="checkbox"/> tricuspid valve | <input type="checkbox"/> mitral valve | <input type="checkbox"/> bicuspid |
| <input type="checkbox"/> semilunar valves | | | |

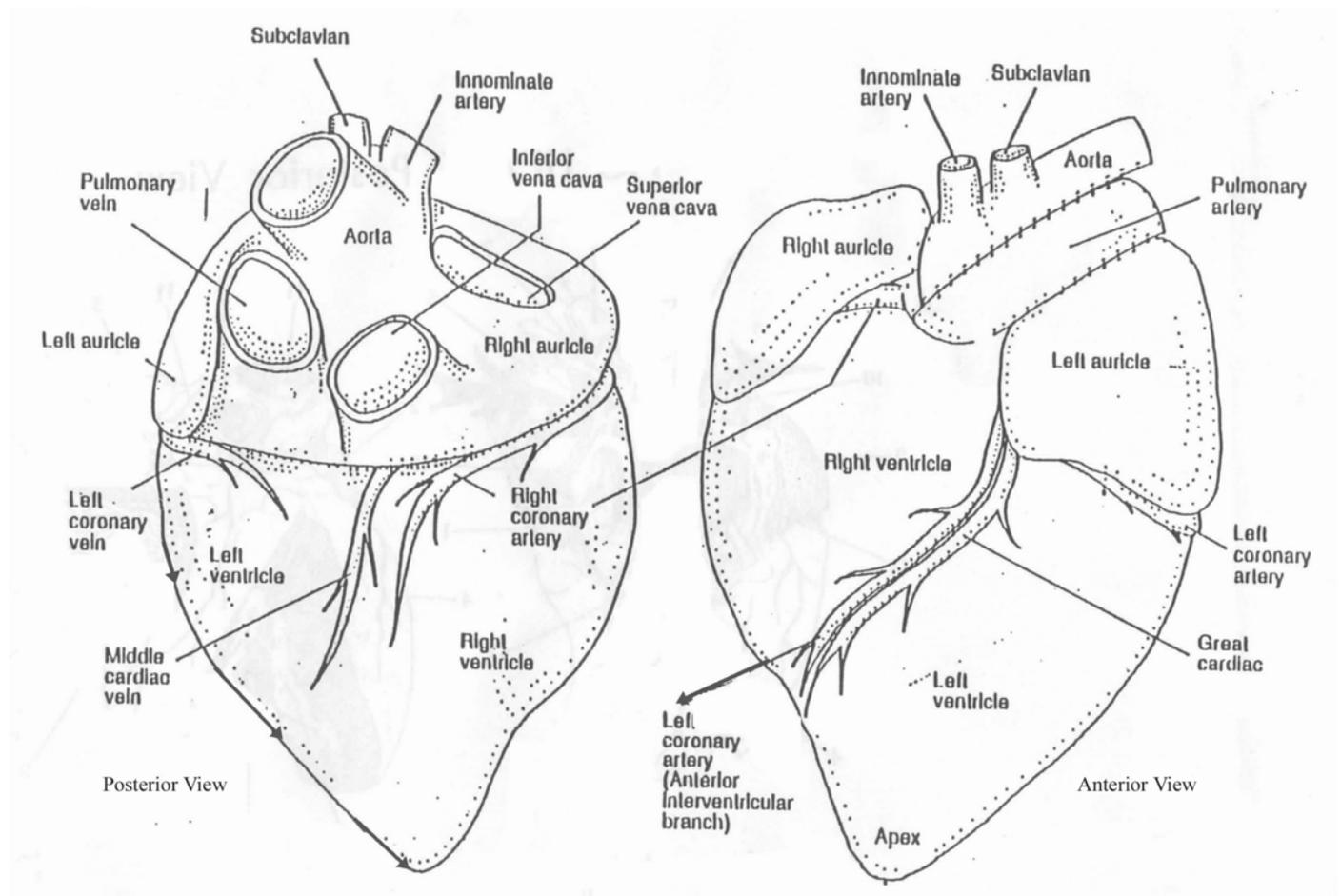
Observations and Conclusions Part 5

55. What is the function of the pericardium?

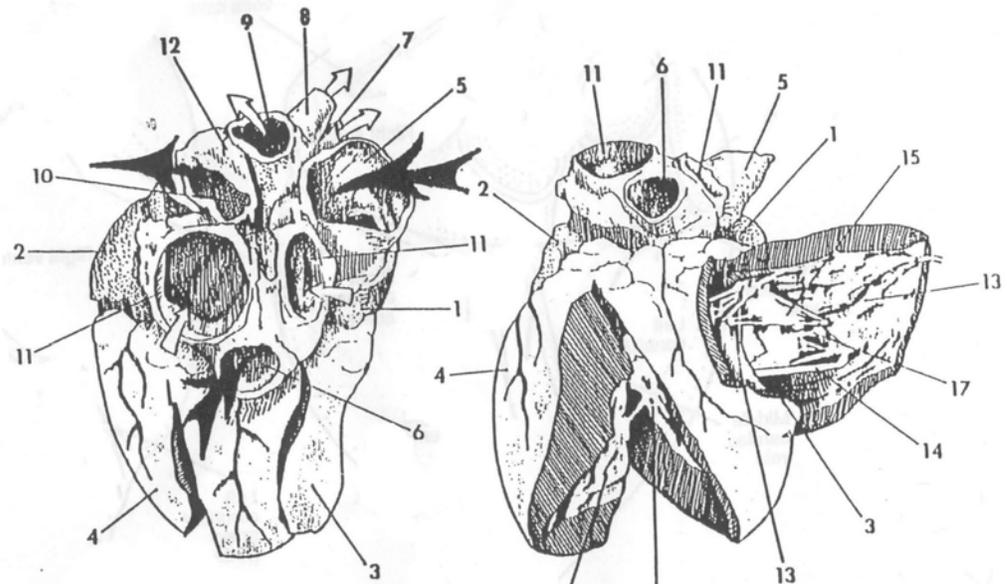
56. Why is there a difference in the size of the ventricle walls?

57. Why is the aorta thick-walled and tough?

58. Why are the atria so thin-walled?

Pig Heart Exterior View

PIG HEART, Posterior View



 Oxygenated blood
 Unoxygenated blood

- | | | | |
|--------------------|---------------------------|-----------------------------------|-----------------------|
| 1. Right auricle | 5. Superior vena cava | 9. Aorta to arteries | 13. Papillary muscles |
| 2. Left auricle | 6. Inferior vena cava | 10. Pulmonary artery to lung | 14. Moderator band |
| 3. Right ventricle | 7. Innominate artery | 11. Pulmonary vein from lungs | 15. Tricuspid valve |
| 4. Left ventricle | 8. Left subclavian artery | 12. Remnants of ductus arteriosus | 16. Bicuspid valve |
| | | | 17. Chordae tendineae |