Chapter 7
Circulation and Blood

Try This Activity (page 241)

(a) The pulse in the carotid artery feels stronger because it is closer to the heart.

(b) The heart rate after exercise is greater.

(c) The resting heart rate of an athlete will be lower than that of an average individual. An athlete will also be able to sustain a higher heart rate for longer periods of time than the average individual. However, the heart rate of the athlete while at peak exertion will be lower than that of the average individual because the athlete's heart is stronger and has a higher capacity than that of a typical individual.

Reflect On Your Learning (page 241)

1. Active tissues need increased oxygen. To deliver the oxygen, blood flow must increase. Because the heart muscle is weak, heart rate increases dramatically to increase oxygen delivery.
2. Athletes have a lower heart rate. Because they have a stronger heart which pumps more blood per beat, it has to beat less often.
   Students are not expected to know the answer, but many will be aware that a lower heart rate is a sign of fitness. A weaker heart must pump more often to pump enough blood to meet the demands of the cells of the body. A great cyclist, Michel Indurian from Spain, two-time winner of the Tour de France, had a resting heart rate of 28 beats/minute. The average for an adult is approximately 70 beats/minute.
3. If cells are taken from a genetically different donor, the body may reject the cells or organ. If the heart problem is linked to a genetic defect, growing cells with the same DNA might just perpetuate the problem.
4. Arteries deliver oxygenated blood to the heart muscle cells. Veins carry deoxygenated blood and wastes away from these cells. Blood vessels are necessary to provide oxygen and carry away wastes from the cells of the heart muscle.
   It is important for students to recognize that all cells require nutrients and produce wastes.

7.1 Practice (page 243)

1. The circulatory system brings oxygen and nutrients to cells, takes wastes away from cells, relays chemical messages throughout the body, and helps maintain acceptable levels of fluid. The circulatory system is also important in the body's immune system and permits the transport of immune cells throughout the body.
2. In an open circulatory system, blood carrying oxygen and nutrients is pumped into body cavities where it bathes the cells directly; there is no distinction between blood and the interstitial fluid. Open circulatory systems are commonly found in snails, insects and crustaceans.
   In a closed circulatory system blood is always contained within blood vessels; closed circulatory systems are commonly found in earthworms, squids, octopuses and vertebrates.
3. One advantage of an open circulatory system is that blood loss due to injury is reduced because low blood pressure is maintained. One disadvantage of an open circulatory system is that there is limited ability to divert blood to needed tissues.

4. Sponges do not have a circulatory system. Water flows over the cells, bringing in nutrients and carrying away wastes. The snail has an open circulatory system that moves blood through sinuses. The earthworm has five heart-like vessels that pump blood through three major blood vessels. The larger blood vessels branch into smaller vessels that supply blood to the various tissues.
5. Multicellular animals need a circulatory system because they have several layers of cells; cells in the inner layers cannot rely on diffusion to bring in nutrients and expel wastes.

7.2 Practice (page 246)

1. Like all tissues, blood is composed a group of similarly shaped cells which carry out a similar function.
2. The two major components of blood are plasma and cellular components.
3. Three plasma proteins are albumins, globulins and fibrinogens. Albumins maintain osmotic pressure in capillaries, globulins produce antibodies to provide protection against invading microbes and parasites, and fibrinogens are important in blood clotting.
4. The main function of hemoglobin is to carry oxygen.
5. Red blood cell production will be initiated by any factor that lowers oxygen levels in the blood, e.g., exercise, moving to high altitudes, hemorrhage.
6. Anemia is a condition which results in the reduction of blood oxygen levels; usually it is associated with reduced red blood cell production or lower levels of hemoglobin. Anemia may also be associated with a dietary deficiency of iron, an important component of hemoglobin.
7. Pus is produced when a white blood cell releases enzymes that digest an invading microbe and the white blood cell itself. Pus is fragments of protein that remain after this digestion has occurred.
8 Platelets initiate blood clotting reactions.

7.3 Practice (page 248)

1. Antigens are markers on cell membranes that white blood cells can recognize and classify as self or invader. They are usually proteins and they stimulate the formation of antibodies. Antibodies are proteins formed within the blood to counter invading antigens.
2. Rh+ blood contains an antigen for the rhesus factor; Rh– blood does not.
3. Artificial blood is a synthetic substance that performs some of the functions of real blood. For example, Fluosol performs the functions of hemoglobin (it carries both oxygen and carbon dioxide) but does not function in blood clotting and immunity. It requires no blood matching, and when frozen, can be stored for long periods of time.

Sections 7.2–7.3 Questions (page 249)

1. Erythrocytes are red blood cells. They carry oxygen and carbon dioxide.
2. Oxygen diffuses from the air into the plasma, but the plasma can carry only about 3 mL of oxygen per 1 L of blood. Red blood cells contain hemoglobin molecules, which are composed of heme, the iron-containing pigment, and globin, the protein structure. Four iron molecules attach to the protein structure and bind to oxygen molecules. Hemoglobin increases the capacity of the blood to carry oxygen to about 200 mL of oxygen per 1 L of blood, a 70-fold increase.
3. Mature red blood cells are not true cells because they do not contain a nucleus.

4. Physical injury, internal bleeding (e.g., caused by ulcers), or hemorrhage in the lungs (associated with tuberculosis) can cause anemia. Anemia is a reduction in blood oxygen due to low hemoglobin or red blood cell production.
5. White blood cells contain a nucleus, are capable of some independent movement, and function in disease defense.
6. The major functions of leukocytes are the production of antibodies and phagocytosis.
7. Type O blood carries no A or B antigens and thus will not cause clumping when infused into an individual with any other blood type. An individual with type AB blood can receive any blood type because that person has both A and B antigens and thus antibodies will not be produced.
8. Artificial blood will not cause an immune reaction, does not have to be screened for AIDS and other blood diseases, and requires no donor. However, artificial blood is not very efficient at carrying oxygen, is not useful for other functions such as clotting and immunity, and can only be used for short periods of time.
9. Subject B might be suffering from leukemia; this subject has increased white blood cell numbers compared to the normal amount.
10. Many other diseases, such as bacterial or viral infections, can cause white blood cell numbers to increase.
11. Subject C might have head poisoning, indicated by low red blood cell numbers. Red blood cells are produced in the bone marrow.
12. Subject A might live at high altitude. This subject's red blood cell numbers are unusually high, indicating compensation for low oxygen content in the air at high altitudes.
13. Because blood is removed, the body begins producing more red blood cells to replace the loss. When the removed red blood cells are returned to the body, oxygen-carrying capacity will be elevated. However, some problems may result. The greater number of red blood cells means that the fluid-to-cell ratio of the blood will be lower, and therefore it will be more difficult to pump. The increased viscosity will place added strain on the heart. The red blood cells also present a problem when they begin to break down, because the heme component of the hemoglobin is toxic.

7.4 Practice (page 253)

1. Arteries carry blood from the heart to the body; veins carry blood from the body to the heart. Arteries tend to have more elastic tissue and are able to withstand greater pressure. Lower pressure veins have a thinner middle layer. Venous blood moves with the help of valves and skeletal muscles.
2. A pulse is caused by a change in the diameter of the arteries following heart contraction. A pulse can be felt in places where the artery is close to the outer surface of the body.
3. Vasodilation is the widening of the diameter of the blood vessel. Vasoconstriction is the narrowing of the blood vessel.
4. Diffusion of gases and nutrients between the blood and surrounding cells occurs in the capillaries.

Try This Activity (page 255)

(a) Veins are close to the surface of the skin, have no pulse and appear bluish in color.

Section 7.4 Questions (page 255)

1. Blood rushes into the capillary as the pre-capillary sphincter relaxes. This reaction serves to release some of the excess heat that is produced when an individual is nervous.
2. Capillaries open when the surrounding cells require oxygen. If all capillaries were open all the time, blood rushing into the capillaries would cause a dramatic drop in blood pressure.
3. The advantage of capillaries being composed of a single cell layer is that there is a small distance for diffusion of gases and nutrients; one disadvantage is that they can easily be destroyed.
4. Prior to Harvey's time many scientists did not identify the heart as a circulating pump. Harvey's explanation provided a way of looking at the heart and blood within a system, the circulatory system.
5. An aneurysm is a weakening in the wall of a blood vessel. If pressure is increased the aneurysm may rupture, causing hemorrhage. This will reduce the delivery of oxygen to the tissues.
6. Blood vessels can narrow because of the fat deposits. This restricts blood flow to an organ.
7. Skeletal muscles massage blood back to the heart. Body movements such as stretching help the massaging action. In addition, the veins have a series of one-way valves which prevent the back flow of blood in veins.
8. Varicose veins are caused by the pooling of blood, which can damage the valves in the veins and lead to further pooling. Surface veins gradually become larger and begin to bulge. Lifestyle changes to prevent varicose veins include avoiding standing for prolonged periods and avoiding compression of the superficial veins in the legs.
9. (a) Atherosclerosis occurs when lipids clump together in an artery; calcium and other minerals form plaque that adheres to the lipid, slowly closing off the blood vessel.
   (b) The buildup of fat and plaque restricts the blood flow to organs, and can lead to high blood pressure.
   (c) Some treatments for atherosclerosis involve medications that reduce blood fat and cholesterol. One treatment involves a technique called balloon angioplasty, which uses a balloon-tipped catheter to flatten plaque in an artery. More serious surgery involves a bypass graft; a normal artery is used to bridge the region experiencing the blockage.

7.5 Practice (page 258)

1. The pulmonary circulatory system carries deoxygenated blood to the lungs and oxygenated blood back to the heart. The systemic circulatory system carries oxygenated blood to the tissues of the body and deoxygenated blood back to the heart.
2. The AV valves and semilunar valves ensure one-way movement of blood through the heart. The AV valves prevent the backflow of blood from the ventricles into the atria. The semilunar valves prevent the backflow of blood from the arteries into the ventricles.
3. Angina is chest pain caused by too little oxygen reaching the heart due to narrowing of the coronary arteries.
4. Coronary bypass operations divert blood around an area of blockage to maintain adequate circulation for the heart muscle.

7.6 Practice (page 261)

1. Myogenic muscle is muscle that contracts without external nerve stimulation.
2. The sympathetic nervous system prepares the body for stress; heart rate and blood flow to tissues increases, enabling the body to meet increased energy demands. The parasympathetic nervous system returns the body to normal resting levels. The two systems form the autonomic nervous system, which controls the motor nerves that regulate homeostasis. Autonomic nerves are not under conscious control.

Try This Activity (page 262)

(a) The diagram should indicate that the clearest sound is heard slightly left of the centre of the chest.

(b) Exercise increased the heart sounds. The valves close with greater force as more blood surges through the heart.

7.7 Practice (page 263)

1. Diastole refers to the relaxation of the heart, during with the cavities of the heart fill with blood. Systole refers to the contraction of the heart, during which blood is pushed out of the heart.
2. Heart sounds are caused by the closing of the heart valves. The first sound (the "lubb" sound) is caused by the closing of the AV valves, while the second sound (the "dubb" sound) is caused by the closing of the semilunar valves.
3. Heart murmurs are caused by faulty heart valves which permit the backflow of blood into one of the chambers of the heart.

Sections 7.5–7.7 Questions (pages 263–264)

1. The atria are thin-walled chambers of the heart that receive blood from veins. Ventricles are muscular, thick-walled chambers of the heart that deliver blood to the arteries
2. Deoxygenated blood enters the right atrium. Blood from the right atrium is pumped to the right ventricle, which, in turn, pumps it to the lungs. Oxygenated blood moves from the lungs to the left atrium. Blood from the left atrium is pumped to the left ventricle, which, in turn, pumps it to the cells of the body. The atrioventricular (AV) valves separate the atria from the ventricles and prevent blood from flowing from the ventricles back to the atria. The semilunar valves separate the ventricles from the arteries and prevent blood that has entered the arteries from flowing back into the ventricles.
3.
4. Cardiac catheterization enables doctors to see where a problem is prior to performing surgery. A catheter is inserted into a leg vein and dye is then injected into the catheter. As the blood and dye move through the blood vessel, an X-ray movie can be made. An area of restricted blood flow pinpoints the region of blockage. Blood samples can also be taken with the catheter to determine how much oxygen is in the blood in the different chambers. This tells the physician how well the blood is being oxygenated in the lungs. The catheter can even be used to monitor pressures in each of the heart chambers.
5. The pulse is stronger in the carotid artery because it is closer to the heart.
6. Heart rate increases in an attempt to provide more blood and oxygen for the tissues.