

The Human Heart

1. The pumping of the heart keeps the blood moving in arteries.
2. Skeletal muscle contraction is responsible for the blood movement in veins.
3. The **heart** is a cone-shaped, muscular organ about the size of a fist.
4. It is located between the lungs directly behind the sternum and is tilted so that the apex is oriented to the left.
5. The myocardium is a major portion of the heart consisting mostly of cardiac muscle; its muscle fibers are branched and tightly joined together.
6. The heart lies within the pericardium, a sac that secretes a lubricating fluid.
7. The endocardium lines the inner surface of the heart; it consists of connective tissue and endothelial tissue.
8. An internal wall called the **septum** separates the heart into right and left halves.
9. The heart has two upper, thin-walled **atria** and two lower, thick-walled **ventricles**.
10. Heart valves direct the flow of blood and prevent any backward movement.
 - a. Valves are supported by strong fibrous tendons (chordae tendineae) which support the valves and prevent them from inverting when the heart contracts.
 - b. **Atrioventricular valves** between the atria and ventricles prevent any back flow from the ventricle to the atrium.
 - c. The right atrioventricular (tricuspid) valve on right side of the heart consists of three cusps or flaps.
 - d. The left atrioventricular (bicuspid or mitral) valve on left side consists of two cusps or flaps.
 - e. **Semilunar valves** are located between the ventricles and their attached vessels.
 - 1) The pulmonary semilunar valve lies between the right ventricle and the pulmonary trunk.
 - 2) The aortic semilunar valve lies between the left ventricle and the aorta.

Path of Blood Through the Heart

1. The route of blood through the heart is as follows:
 - a. Oxygen-poor blood enters the right atrium from both the superior vena cava and the inferior vena cava.
 - b. The right atrium sends blood through the right atrioventricular (tricuspid) valve to the right ventricle.
 - c. The right ventricle sends blood through the pulmonary semilunar valve into the pulmonary trunk and arteries to the lungs.
 - d. Oxygen-rich blood returns from the lungs through pulmonary veins and is delivered to the left atrium.
 - e. The left atrium sends blood through the left atrioventricular (bicuspid or mitral) valve to the left ventricle.
 - f. The left ventricle sends blood through the aortic semilunar valve into the aorta and on to the body proper.
2. The heart is therefore a double pump serving the lungs and body circulations simultaneously; O₂-poor blood and O₂-rich blood never mix.
3. Since the left ventricle has the harder job of pumping blood throughout the body, its walls are thicker; accordingly, blood pressure is greatest in the aorta.
4. Blood pressure decreases as the cross-sectional area of the arteries and arterioles increases.

The Heartbeat

1. The human heart contracts (beats) about 70 times a minute (2.5 billion times in a lifetime); each heartbeat lasts about 0.85 seconds.
2. The heartbeat or **cardiac cycle** consists of phases.
3. The atria contract first while the ventricles relax (0.15 sec.), then the ventricles contract while atria relax (0.30 sec.), and then all chambers rest (0.40 sec.).
4. **Systole** refers to the contraction of heart chambers and **diastole** refers to the relaxation of the heart chambers.
5. The heart is in diastole about 50% of the time.
6. The short systole of the atria is needed only to send blood into the ventricles.
7. When the term “systole” is used alone, it refers to the left ventricle systole; the volume of blood that the left ventricle pumps per minute into the systemic circuit is called the **cardiac output**.
8. When the heart beats, the familiar *lub-dub* sound is heard as the valves of the heart close.
 - a. *Lub* is caused by the vibrations of the heart when the atrioventricular valves close.
 - b. *Dub* is heard when the vibrations occur due to the closing of semilunar valves.
9. The **pulse** is a wave effect that passes down the walls of arterial blood vessels when the aorta expands and then recoils following ventricular systole.
10. Since there is one arterial pulse per ventricular systole, the arterial pulse rate can be used to determine the heart rate.
11. Rhythmic contraction of the heart is due to the **cardiac conduction system**.
 - a. The sinoatrial (SA) node is the “pacemaker” found in the upper dorsal wall of the right atrium; it initiates the heartbeat by sending out an excitatory impulse every 0.85 seconds to cause the atria to contract.
 - b. The atrioventricular (AV) node is found in the base of the right atrium very near the septum; when stimulated by impulses from the SA node, it sends out impulses through the septum to cause the ventricles to contract.
 - c. Although the beat of the heart is intrinsic, it is regulated by the nervous system which can increase or decrease the heartbeat rate.
 - d. The SA node is called the **cardiac pacemaker** because it usually keeps the heartbeat regular.
 - e. The hormones epinephrine and norepinephrine also stimulate the heart.
12. An **electrocardiogram (ECG)** is a recording of the electrical changes that occur in the myocardium during a cardiac cycle; it is used as a diagnostic tool to identify abnormal cardiac function.
13. Normal Cardiac Cycle
 - a. The P wave represents excitation and occurs just before atrial contraction.
 - b. The QRS complex signals that the ventricles are about to contract.
 - c. The electrical changes that occur as the ventricular muscle fibers recover produce the T wave.
14. Ventricular fibrillation is uncoordinated contraction of the ventricles; with the application of a strong electric current, the SA node may reestablish a coordinated beat.

Vascular Pathways

- The human cardiovascular system has two major circular pathways.
1. The Pulmonary Circuit

- a. The **pulmonary circuit** circulates blood to the lungs.
 - b. Oxygen-poor blood from the body collects in the right ventricle, which pumps it to **pulmonary trunk**.
 - c. The pulmonary trunk divides into right and left pulmonary arteries to carry blood to each lung.
 - d. In the lungs, carbon dioxide (CO₂) is unloaded and O₂ is picked up by blood.
 - e. Oxygen-rich blood from the lungs is returned through pulmonary veins to the left atrium.
2. The Systemic Circuit
 - a. The **aorta** and **vena cavae** are main pathways for blood in the **systemic circuit**.
 - b. Transport of oxygenated blood moves from the left ventricle through the aorta out to all tissues.
 - c. Deoxygenated blood returns from all tissues via the vena cavae.
 - d. In a systemic circuit, arteries contain bright red oxygen-rich blood; the veins contain dull red oxygen-poor blood that appears blue when viewed through the skin.
 3. The coronary arteries serve the heart muscle itself.
 - a. Coronary arteries originate from the base of the aorta just above the aortic semilunar valve.
 - b. Coronary arteries lie on the external surface of the heart; they branch into arterioles and capillaries.
 - c. Capillary beds enter the venules that join to form the cardiac veins.
 - d. Coronary veins collect oxygen-poor blood from the capillaries and empty it into the right atrium.
 4. The **portal system** is a pathway of blood flow that begins and ends in capillaries.
 - a. The **hepatic portal vein** transports blood from capillaries in the small intestinal villi to capillaries in the liver.
 - b. The hepatic vein leaves the liver and enters the inferior vena cava.
 - c. In the liver, substances absorbed by the intestine are modified, toxins and bacteria are removed, and the normal composition of blood is monitored.
 5. Tracing the Path of Blood
 - a. Branches from the aorta go to the organs and major body regions.
 - b. Generally, the artery and the vein that serve the same region are

given the same name.

- c. One blood goes through the artery, it travels to the arterioles, then into branching capillaries where gas exchange occurs, and then venules join to form the vein that enters a vena cava.

Blood Pressure

1. Systolic pressure results from blood being forced into the arteries during ventricular systole.
2. Diastolic pressure is the pressure in arteries during ventricular diastole.
3. Human **blood pressure** is measured as the force pushing against the wall of the brachial artery of the upper arm.
 - a. Blood pressure is measured by a **sphygmomanometer**, which has a pressure cuff.
 - b. Clinical blood pressure measures pressures produced by contraction and relaxation of the left ventricle.
 - c. Blood pressure is stated in millimeters of mercury (e.g., 120/80 mm Hg) for

- systolic/diastolic.
4. As blood flows from the aorta into arteries and arterioles, the blood pressure falls.
 5. The difference in pressure between systolic and diastolic pressures gradually diminishes.
 6. Capillaries have a slow, even blood flow due to the high total cross-sectional area.
 7. Blood pressure in the veins is low and cannot move blood back to heart, especially from the limbs.
 8. Venous return is dependent on these factors:
 - a. Skeletal muscle contraction on the walls of veins with valves, preventing backflow of blood, is responsible for the flow of blood in veins.
 - b. Varicose veins are abnormal dilations that develop when the valves become weak and ineffective.
 - c. A respiratory pump helps blood flow from the higher pressure (when we exhale) to lower pressure (when we inhale).

Cardiovascular Disease

- Cardiovascular disease (CVD) is the leading cause of untimely death in Western countries.
- The risk of CVD can be reduced by following guidelines for a heart-healthy life-style.
 1. Hypertension
 - a. An estimated 20% of Americans suffer from hypertension (high blood pressure).
 - b. Under the age of 45, a reading above 130/90 is hypertensive.
 - c. Beyond the age of 45, a reading above 140/95 is hypertensive.
 - d. The diastolic pressure is what is emphasized when medical treatment is considered.
 2. Atherosclerosis
 - a. Hypertension is seen in individuals with atherosclerosis (formerly called arteriosclerosis).
 - b. Soft masses of fatty materials, mostly cholesterol, accumulate beneath the inner linings of arteries.
 - c. As this plaque accumulates, it protrudes into the vessel and interferes with blood flow.
 - d. Atherosclerosis develops in early adulthood but the symptoms may not appear until age 50 or older.
 - e. Plaque can cause a blood clot to form on irregular arterial walls.
 - f. As long as a clot remains stationary, it is a thrombus.
 - g. If a clot dislodges, it is an embolus, a blood clot that moves in the blood.
 - h. In some families, atherosclerosis is inherited as familial hypercholesterolemia.
 3. Stroke and Heart Attack
 - a. Stroke, heart attack, and aneurysm are associated with hypertension and atherosclerosis.
 - b. A **stroke** can result in paralysis or death; a small cranial arteriole bursts or is blocked by an embolus.
 - 1) A stroke is also called a cardiovascular accident (CVA).
 - 2) Whether paralysis or death occurs depends on the extent of the portion of the brain that lacks O₂.
 - 3) Warning symptoms that foretell stroke include: numbness in hands or face,

- difficulty speaking, blindness in one eye, etc.
- c. A myocardial infarction (MI) is also called **heart attack**.
 - 1) This occurs when a portion of heart muscle dies due to a lack of O₂; this may be caused by a thromboembolism blocking a coronary artery.
 - 2) A partially blocked coronary artery causes **angina pectoris** causing pains or a flash of burning.
 - 3) Nitroglycerin and related drugs dilate the blood vessels and relieve pain.

Prevention of Cardiovascular Disease

- 1. The Don'ts
 - a. Smoking
 - 1) Smoking contributes to hypertension.
 - 2) When a person smokes, nicotine enters the bloodstream, causing arterioles to constrict and blood pressure to rise.
 - 3) Restricted bloodflow and cold hands are associated with smoking.
 - 4) The heart then must pump harder to send the blood through the lungs at the time when oxygen-carrying capacity of the blood is reduced.
 - b. Drug Abuse
 - 1) Drugs, particularly stimulants, can lead to heart attacks and strokes.
 - 2) Drinking two to four drinks a week for men and one to three drinks for women may actually lower the risk of heart disease.
 - c. Weight Gain
 - 1) People who are more than 20% above their recommended weight have a higher risk of hypertension.
 - 2) In overweight people, more tissue needs servicing, and the heart sends the extra blood out under greater pressure.
- 2. The Do's
 - a. Healthy Diet
 - 1) Eating food with monounsaturated and polyunsaturated fats may lower LDL cholesterol.
 - 2) A diet high in antioxidants may prevent cardiovascular disease.
 - b. Cholesterol Profile
 - 1) An LDL level above 160 mg/100 ml and an HDL level below 40 mg/100 ml are matters of concern.
 - 2) An LDL level of below 100 mg/100 ml is recommended.
 - 3) Medications may be prescribed for individuals who do not meet these minimum guidelines.
 - c. Exercise
 - 1) Exercise may reduce the risk of cardiovascular disease.
 - 2) Exercise helps keep weight under control, may help minimize stress, and reduce hypertension