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Blood

This consists chiefly of a liquid called plasma, which is made up mostly of water, but also contains proteins, glucose, amino acids, salts, hormones, and antibodies. Floating in the plasma are three kinds of solid particles: red blood cells, white blood cells, and platelets. The **red blood cells** are formed in bone marrow - mainly in the ribs, vertebrae, and limbs; they contain haemoglobin and carry oxygen and carbon dioxide throughout the body. The red blood cells, which have no nucleus, have a relatively short life of about four months. **White blood cells** are also made in the bone marrow, as well as in the lymph nodes. They do have a nucleus, often quite large, and they are able to move around and pass through the walls of capillaries into all parts of the body. Their main function is to fight infection and help protect the body from disease. This is done by the production of antibodies which counteract the effects of invading bacteria or viruses. **Platelets** are small fragments of cells with no nucleus. They too are produced in the bone marrow and their function is to release substances which enable blood to clot. Thus they help to prevent the loss of blood from damaged vessels.

Functions of the system

The circulatory system plays an important role in many of the body's processes including respiration, nutrition, and the removal of wastes and poisons. In respiration it delivers oxygen to the body's cells and removes carbon dioxide from them. In nutrition, it carries digested food substances to the cells. Nutrients from food enter the bloodstream by passing through the walls of the small intestine into the capillaries. The blood then carries most of the nutrients to the liver, where some of these are extracted and stored for release back into the blood as and when the body needs them. Other nutrients are converted by the liver into substances which are required in the production of energy, enzymes, and new building materials for the body. Hormones, which affect or control the activities of various organs and tissues, are produced by the endocrine glands - including the thyroid, pituitary, adrenal, and sex glands - and they too are transported by the blood through the body.

Waste disposal

In addition to feeding and nourishing the body, the circulatory system also helps to dispose of waste products and poisons which would prove harmful if

allowed to accumulate. Carbon dioxide, produced by the body's cells as they respire, diffuses through the walls of the capillaries into the blood. The blood containing carbon dioxide is returned via the heart to the lungs and passed out of the body on expiration. In processing food, the liver removes ammonia and other wastes, together with various poisons that enter the body through the digestive system. These are converted into water-soluble substances, which are carried by the blood to the kidneys. The kidneys then filter out these wastes and expel them from the body in urine.

Temperature control

As well as the heat produced generally by cells during respiration, some parts of the body, such as the liver and muscles, produce heat in the course of their activities. This heat is transported by the blood to warm other parts of the body. As the temperature of the body rises, the flow of blood into vessels in the skin increases as a result of small arteries expanding, and excess heat is conveyed to the surface where it is lost. When the temperature of the body drops the flow of blood to the skin is restricted. Thus, the circulatory system acts as a natural thermostat allowing the body to maintain an optimum and stable temperature.

Disease and disorders

One of the most common diseases of the circulatory system is arteriosclerosis, a slow deterioration of arteries that results from the accumulation of fatty deposits in the arteries. If it affects the arteries supplying blood to the walls of the heart, it is called heart disease. The deposits thicken the walls of the arteries and reduce their elasticity, thus restricting the flow of blood. If a blood clot then develops in the affected vessels (thrombosis), this can further inhibit the circulation and lead to a heart attack or, if it affects the brain, a stroke - where the brain does not receive enough blood. Arteriosclerosis can also lead to increased blood pressure, or hypertension, as the heart is forced to work harder to force the blood through the arteries. This too can result in a heart attack or stroke, or in kidney failure.
There are other disorders which can result from damage or defects in the heart or blood vessels. For example, bacteria may harm or destroy the valves that control the flow of blood through the heart. Incomplete development of the heart or its blood vessels before birth may produce congenital heart disorders. Many cases of damage or defects can be corrected by surgery or alleviated with the use of drugs. Vasoconstrictors are agents which cause narrowing of the blood vessels, thus decreasing blood flow. These can be used to raise blood pressure in circulatory disorders, shock, or severe bleeding, or help to stabilize it during surgery. Vasodilators are drugs that

cause widening of the blood vessels, thus increasing blood flow. These are used to lower blood pressure - for example, in hypertension.
Disorders of the blood itself, such as anaemia, can occur when the quantity of haemoglobin - the oxygen-carrying pigment in the blood - is insufficient and the blood cannot carry enough oxygen. This can lead to excessive fatigue, breathlessness, and reduced immunity to infections. Iron-deficiency anaemia results from lack of iron necessary for the production of haemoglobin. Conditions such as sickle-cell anaemia and thalassaemia are associated with abnormal forms of haemoglobin. Impaired production of red blood cells in the bone marrow can result in pernicious anaemia or leukaemia, while problems affecting the production of white blood cells can impair the body's immune system.

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Human Circulatory System

The human circulatory system functions to transport blood and oxygen from the lungs to the various tissues of the body. The heart pumps the blood throughout the body. The lymphatic system is an extension of the human circulatory system that includes cell-mediated and antibody-mediated immune systems. The components of the human circulatory system include the heart, blood, red and white blood cells, platelets, and the lymphatic system.

Heart

The human heart is about the size of a clenched fist. It contains four chambers: two atria and two ventricles. Oxygen-poor blood enters the **right atrium** through a major vein called the **vena cava.** The blood passes through the **tricuspid valve** into the **right ventricle.** Next, the blood is pumped through the **pulmonary artery** to the lungs for gas exchange. Oxygen-rich blood returns to the **left atrium** via the **pulmonary vein.** The oxygen-rich blood flows through the **bicuspid (mitral) valve** into the **left ventricle**, from which it is pumped through a major artery, the **aorta.** Two valves called **semilunar valves** are found in the pulmonary artery and aorta.

The ventricles contract about 70 times per minute, which represents a person's pulse rate. Blood pressure, in contrast, is the pressure exerted against the walls of the arteries. Blood pressure is measured by noting the height to which a column of mercury can be pushed by the blood pressing against the arterial walls. A normal blood pressure is a height of 120 millimeters of mercury during heart contraction (*systole*), and a height of 80 millimeters of mercury during heart relaxation (*diastole*). Normal blood pressure is usually expressed as “120 over 80.”

Coronary arteries supply the heart muscle with blood. The heart is controlled by nerves that originate on the right side in the upper region of the atrium at the sinoatrial node. This node is called the *pacemaker*. It generates nerve impulses that spread to the atrioventricular node where the impulses are amplified and spread to other regions of the heart by nerves called **Purkinje fibers.**

Blood

Blood is the medium of transport in the body. The fluid portion of the blood, the **plasma**, is a straw-colored liquid composed primarily of water. All the important nutrients, the hormones, and the clotting proteins as well as the waste products are transported in the plasma. Red blood cells and white blood cells are also suspended in the plasma. Plasma from which the clotting proteins have been removed is **serum.**

Red blood cells

Red blood cells are **erythrocytes.** These are disk-shaped cells produced in the bone marrow. Red blood cells have no nucleus, and their cytoplasm is filled with hemoglobin.

Hemoglobin is a red-pigmented protein that binds loosely to oxygen atoms and carbon dioxide molecules. It is the mechanism of transport of these substances. (Much carbon dioxide is also transported as bicarbonate ions.) Hemoglobin also binds to carbon monoxide. Unfortunately, this binding is irreversible, so it often leads to carbon-monoxide poisoning.

A red blood cell circulates for about 120 days and is then destroyed in the spleen, an organ located near the stomach and composed primarily of lymph node tissue. When the red blood cell is destroyed, its iron

component is preserved for reuse in the liver. The remainder of the hemoglobin converts to bilirubin. This amber substance is the chief pigment in human bile, which is produced in the liver.

Red blood cells commonly have immune-stimulating polysaccharides called **antigens** on the surface of their cells. Individuals having the A antigen have blood type A (as well as anti-B antibodies); individuals having the B antigen have blood type B (as well as anti-A antibodies); individuals having the A and B antigens have blood type AB (but no anti-A or anti-B antibodies); and individuals having no antigens have blood type O (as well as anti-A and anti-B antibodies).

White blood cells

White blood cells are referred to as **leukocytes.** They are generally larger than red blood cells and have clearly defined nuclei. They are also produced in the bone marrow and have various functions in the body. Certain white blood cells called **lymphocytes** are essential components of the immune system. Other cells called **neutrophils** and **monocytes** function primarily as **phagocytes;** that is, they attack and engulf invading microorganisms. About 30 percent of the white blood cells are lymphocytes, about 60 percent are neutrophils, and about 8 percent are monocytes. The remaining white blood cells are **eosinophils** and **basophils.** Their functions are uncertain; however, basophils are believed to function in allergic responses.

Platelets

Platelets are small disk-shaped blood fragments produced in the bone marrow. They lack nuclei and are much smaller than erythrocytes. Also known technically as **thrombocytes**, they serve as the starting material for **blood clotting.** The platelets adhere to damaged blood vessel walls, and thromboplastin is liberated from the injured tissue. Thromboplastin, in turn, activates other clotting factors in the blood. Along with calcium ions and other factors, thromboplastin converts the blood protein prothrombin into thrombin. Thrombin then catalyzes the conversion of its blood protein fibrinogen into a protein called *fibrin*, which forms a patchwork mesh at the injury site. As blood cells are trapped in the mesh, a blood clot forms.

Lymphatic system

The lymphatic system is an extension of the circulatory system consisting of a fluid known as lymph, capillaries called lymphatic vessels, and structures called lymph nodes. **Lymph** is a watery fluid derived from plasma that has seeped out of the blood system capillaries and mingled with the cells. Rather than returning to the heart through the blood veins, this lymph enters a series of one-way **lymphatic vessels** that return the fluid to the circulatory system. Along the way, the ducts pass through hundreds of tiny, capsulelike bodies called **lymph nodes.** Located in the neck, armpits, and groin, the lymph nodes contain cells that filter the lymph and phagocytize foreign particles.

The **spleen** is composed primarily of lymph node tissue. Lying close to the stomach, the spleen is also the site where red blood cells are destroyed. The spleen serves as a reserve blood supply for the body.

The lymph nodes are also the primary sites of the white blood cells called lymphocytes. The body has two kinds of lymphocytes: **B-lymphocytes** and **T-lymphocytes.** Both of these cells can be stimulated by microorganisms or other foreign materials called **antigens** in the blood. Antigens are picked up by phagocytes and lymph and delivered to the lymph nodes. Here, the lymphocytes are stimulated through a process called the **immune response.**

Certain antigens, primarily those of fungi and protozoa, stimulate the T-lymphocytes. After stimulation, these lymphocytes leave the lymph nodes, enter the circulation, and proceed to the site where the antigens of microorganisms were detected. The T-lymphocytes interact with the microorganisms cell to cell and destroy them. This process is called **cell-mediated immunity.**

B-lymphocytes are stimulated primarily by bacteria, viruses, and dissolved materials. On stimulation, the B-lymphocytes revert to large antibody-producing cells called **plasma cells.** The plasma cells synthesize proteins called **antibodies**, which are released into the circulation. The antibodies flow to the antigen site and destroy the microorganisms by chemically reacting with them in a highly specific manner. The reaction encourages phagocytosis, neutralizes many microbial toxins, eliminates the ability of microorganisms to move, and causes them to bind together in large masses. This process is called **antibody-mediated immunity.** After the

microorganisms have been removed, the antibodies remain in the bloodstream and provide lifelong protection to the body. Thus, the body becomes immune to specific disease microorganisms.