

TRANSPORT WITHIN THE BODY— THE CIRCULATORY SYSTEM

The circulatory system is designed to move stuff around the body. It transports oxygen, carbon dioxide, glucose, hormones, waste products, lipids, etc. Essentially, the circulatory system consists of a pump (the heart), a network of tubing (the blood vessels), and a fluid (the blood). Let's start by talking about the blood.

THE BLOOD

Any organism with a closed circulatory system has blood. A closed circulatory system just means that the blood is carried in vessels. But some organisms do not have a closed system; their blood (called **hemolymph** in these organisms) is not carried in vessels; it simply bathes the organs in their body cavities. Examples of organisms with open circulatory systems are the arthropods (insects, crustaceans etc.).

Blood consists of two main things: (1) fluid and (2) cells that float around in the fluid. The fluid is called plasma, and the cells that float around are red blood cells, white blood cells, and platelets.

Plasma is mostly water. It has a lot of stuff dissolved in it, such as glucose, hormones, ions, and gases. The glucose makes it sticky. It also has a lot of protein in it, like albumin (the most abundant protein in blood), fibrinogen, and lipoproteins. All the blood proteins are made by the liver, and plasma makes up about 50% of the blood volume.

Most of the cells in the plasma are **red blood cells**. In fact, red blood cells make up about 45% of the total blood volume. Red blood cells are shaped like biconcave disks, which look sort of like disks that have been squashed in the center, on both sides. Red blood cells are filled with a protein called **hemoglobin**. There is so much hemoglobin in red blood cells that there is no room for organelles or a nucleus. Red blood cells are the only cells in the body that do not have a nucleus.

Hemoglobin can bind oxygen. Because red blood cells contain hemoglobin, and hemoglobin carries oxygen, we say that *red blood cells carry oxygen and deliver it to cells all over the body*. Really, though, it's the hemoglobin that carries the oxygen.

Hemoglobin is made partly of iron. That means that if you don't get enough iron in your diet, you can't produce enough hemoglobin. Your red blood cells can't bind enough oxygen, and your body's cells get shortchanged. They don't receive all the oxygen they need to carry out cellular respiration to make energy (ATP). When that happens, you have **anemia**. One of the most obvious symptoms of anemia is fatigue. It makes sense—if you can't use cellular respiration to make ATP, you don't have enough energy and you're easily fatigued.

The remaining 5% of the blood volume is made up of white blood cells and platelets. **White blood cells** are very important in fighting off disease. Most of the white blood cells are phagocytes, which means they are very good at phagocytosis (eating stuff). What do they eat? Well, viruses, bacteria, parasites, dead cells, and sick cells, to name a few—anything that's potentially

harmful to your body. Some of the white blood cells are **lymphocytes**, which participate in very specific disease defense called immunity. Lymphocytes come in two forms: B-cells and T-cells.

B-cells make antibodies. Antibodies are just markers that can bind to foreign things in the body and mark them for destruction (like by phagocytosis). For example, if you get infected with the chickenpox virus, some of the B-cells in your blood will make antibodies that can bind to the chickenpox virus and mark it for destruction. Because there are millions of different viruses, bacteria, parasites, and other potentially harmful things, you have millions of different B-cells that can make antibodies that are specific for each of the million different potentially harmful things. After B-cells fight off an infection some of them stick around as a militia and the second time you get infected with that pathogen your body responds strongly and swiftly.

T-cells have two jobs. First, they help the B-cells and other T-cells divide and proliferate. T-cells that do this are called **helper T-cells**. The second type of T-cell kills any cells that have been infected by viruses. Because viruses are not complete cells, they cannot reproduce without some help. So they act as parasites, living *inside* our cells and essentially turning them into virus factories. The easiest way to kill the virus, then, is to kill the cell it has infected. That's what this type of T-cell does, and they are called **killer T-cells**.

Here's another thing to know: AIDS is a disease caused by a virus called **HIV** (Human Immunodeficiency Virus). HIV infects and lives in helper T-cells, killing the helper T-cells in the process. The helper T-cells are super important to B-cells and killer T-cells, and without the helper T-cells, the other two cell types can't reproduce and fight infection. As a consequence, many, many infections spring up. Patients with AIDS often die of these infections.

Platelets are very, very small structures that are important in blood clotting. If a person is deficient in platelets, the blood does not clot. Platelets secrete a substance that activates a chain of events that ultimately converts a soluble blood protein—fibrinogen—into insoluble threads called fibrin. The fibrin threads form "nets" that trap blood cells and more platelets to form a clot. The process requires calcium, vitamin K, and many other chemicals.

Finally, all blood cells—red, white, and platelets—are made in the bone marrow inside bones.

Blood Cells: A Quick Review

- All blood cells are made in the bone marrow.
- Blood cells include red cells, white cells, and platelets.
- Red blood cells contain hemoglobin (which contains iron), and hemoglobin binds oxygen and carries it around the body.
- Some white blood cells help to fight infection by phagocytizing harmful things.
- B-cells are a type of white blood cell that makes antibodies against very specific foreign things. Some stick around as a militia.
- Helper T-cells help B-cells and other T-cells reproduce, and killer T-cells kill cells that have been infected by a virus.
- AIDS is caused by a virus (HIV) that infects and kills helper T-cells. Without helper T-cells, the body cannot fight infection.
- Platelets are necessary for blood clotting.