

Blood: The body's vital defense force

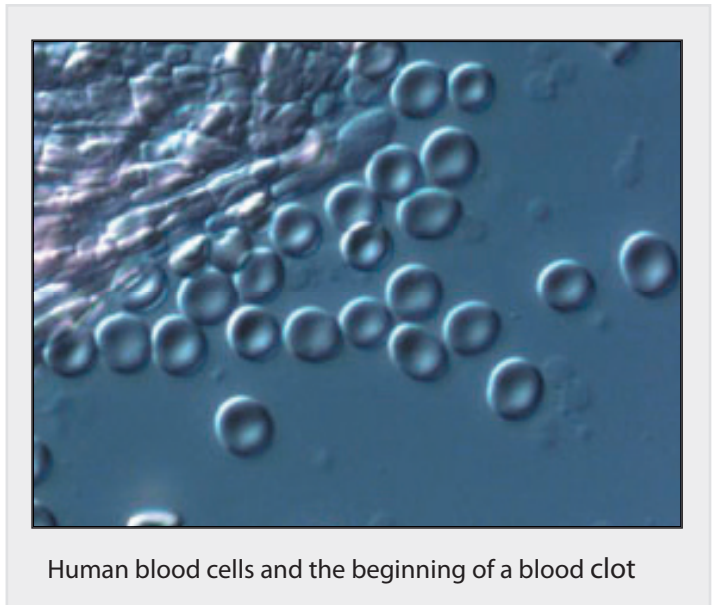
Ouch—you've cut your finger! A familiar red substance oozes out. As you reach for a bandage, take a moment to ponder the vital role this remarkable fluid performs. Blood feeds your cells, kills off invaders, and will soon begin healing up that wound. It carries every substance on the move within your body—oxygen, vitamins, drugs, hormones, water, and nutrients from your last meal. What's in your blood varies from hour to hour, and its components can be read like a report card, offering volumes of information on how your body is functioning.

What is blood?

In many cultures, blood is a powerful symbol or talisman, capable of giving life, purifying objects, and placating the gods. Shared blood is considered the strongest of bonds between people, and shedding blood is the ultimate sacrifice. Blood is certainly central to our survival, an organ we can't do without. It's the second most common tissue in the body (skin being the first), and comprises about 7% of a human's body weight.

When you think of blood, you probably think "red." Red blood cells (RBCs) are by far the most common cells in your blood, but they are only one of over ten types of blood cell. RBCs carry oxygen from your lungs to your tissues, using a protein called hemoglobin. Hemoglobin, which binds oxygen, contains iron, the element that gives blood its familiar crimson shade.

All animals use blood cells to transport oxygen, but not all animals' RBCs are the same.



Human blood cells and the beginning of a blood clot

Humans make RBCs in their bone marrow. Before the cells enter the bloodstream to do their job, they lose their nuclei, which keeps them from dividing. When your body needs more RBCs—they wear out and die after about 120 days—your bone marrow must produce them. Birds, on the other hand, have hollow bones without marrow. Their RBCs retain their nuclei, and therefore can reproduce by dividing.

The shapes of RBC differ between animals as well. Human RBCs are doughnut shaped, while those of some other animals, like camels and penguins, have a more oval appearance. Whichever shape they take, an important characteristic of RBCs is their flexibility: their shapes make them pliable enough to squeeze through the tiny capillaries where oxygen is exchanged for carbon dioxide.

But blood contains other types of cells as well. About one percent of the cells in your blood are white blood cells. These make up the most important part of your immune system. Unlike RBCs, WBCs can leave your circulatory system and move out into other types of tissues to fend off invading bacteria and viruses. They rush to the site of an injury (remember that cut on your finger?), seek out foreign cells and particles, and engulf them. There are many different types of white cells; some live less than a day, others stay with you for much of your life.

It's worth marveling at the scope of your white blood cells' effectiveness: every day, you're exposed to thousands of germs—bacteria and viruses—but the vast majority never succeed in infecting you. An invading cell does slip through just about every other day. But thanks to the quick response of your immune system, you actually get a cold or flu far less often than that. When you do get a cold, you usually get over it in

Blood samples

What does blood do for you?

- carries oxygen to all your tissues
- protects you from viral and bacterial invaders
- heals wounds

What's blood made of?

- Red blood cells, doughnut-shaped oxygen carriers
- Numerous kinds of white blood cells, such as granulocytes, T cells, and macrophages, important components of your immune system
- Platelets, tiny cells that help heal wounds
- Complement, proteins that assist in fighting infections
- Plasma, the watery substance that carries nutrients

- The average adult has 5-6 quarts of blood.
- blood makes up about 7% of your body's weight
- In one day, your blood travels nearly 12,000 miles.
- About half of your blood volume is water.
- There is no known medical substitute for human blood
- one teaspoon of blood contains about 25 million red blood cells

The cells in your blood have a variety of lifespans.

- red blood cells – 120 days
- granulocytes – 6 hours
- some macrophages and some T cells – decades

a few days. That's your immune system at work, too. (Without it, you'd constantly have a runny nose!) Just as there are different types of WBCs, there are also many different types of invading bacteria and viruses. But your white cells form an agile and adaptive swarm keeping this ever-changing set of microscopic trespassers at bay.

What is immunity?

The protection from bacterial and viral infections conferred by your white cells is called immunity. Your immune system has two primary methods of protecting you, innate and acquired immunity, and they involve different kinds of white blood cells.

Most of us are born with a set of cells already prepared to fight off viruses and bacteria, giving us a built-in system of innate immunity. These cells include the granulocytes and the macrophages, both of which stop potential invaders by engulfing and digesting them. Cells like these are "preprogrammed" to recognize a huge number of pathogens, and are able to discern invaders from cells that belong to the body. Both granulocytes and macrophages rush to the site of infection or injury, ready to defend the home front. The swelling you find around a wound (or, when you're sick, in your lymph nodes) is this army of white blood cells on the scene.

Granulocytes get their name from tiny granules within them that hold the potent chemicals used to destroy the microorganisms they've consumed. Like RBCs, granulocytes are produced in bone marrow—but they have a much shorter lifespan, usually around 6 hours. Granulocytes can eat one or several bacteria, but then die after releasing their toxic granules.

Macrophages, in contrast, can live for decades. These are large, malleable cells that can stretch themselves out within tissues as they look for marauders, and can eat many microorganisms. Not only do they kill the bugs, they also recycle their components (such as DNA and proteins), and parts of dead cells (like spent granulocytes).

The innate immune system protects us from many potential pathogens, but babies and children still get sick. In fact, they get sick more often than middle-aged adults. That's because we also gain acquired or adaptive immunity as we get older. Some white cells, called T cells, have a kind of cellular memory for invaders they've encountered before. They can help spot a previously troublesome microorganism and jumpstart an immune response to it.

There are several kinds of T cells: some signal that an invader is present, others can sidle up to a foreign microorganism and kill it. Still others regulate the immune response

to keep it from getting out of control. Vaccines work by invoking acquired immunity: a person receives a small amount of a virus that has been weakened in the laboratory. As they fight the weakened virus, some of the T cells “learn” the characteristics of the invader and so can fend it off, should it invade again. In many cases, these “memory” T cells remain with a person their entire life. A person who’s had mumps or chicken pox, for example, develops a strong acquired immunity, and is protected from getting the disease again.

When the immune system goes awry

For most of us, and for most of our lives, the immune system does its job to perfection. Occasionally, however, an overzealous immune system is the cause of a condition or disease. Allergies, for example, are actually the out-of-control responses of our own T cells. An allergy is caused when your body perceives some chemical— from a bee, a poison oak leaf, or some type of food—as a foreign substance. The T cells responsible for going after the substance mount a prolific response. But the allergy sufferer either has too few regulator T cells to control the response, or the response is so strong that it overrides regulation. In either case, the result can be a rash, stuffy head, or inflammation.

Overactive macrophages can also cause debilitating inflammation. Arthritis is painful swelling in the joints that happens when the body has triggered an inappropriate immune response. Macrophages move into the scene, and their presence encourages blood flow. The excess white cells and whole blood cause tissues to swell. Because the system started acting up without a real cause, the swelling cycle may also stop as randomly as it started. There is also evidence that macrophages play a role in other conditions, such as psoriasis and atherosclerosis.

Telling good cells from bad

Most of the time, your white blood cells recognize the other types of cells that make up your body and don’t attack them. But there are times when you want your WBCs to attack your own cells. T cells have a way of recognizing cells from your body that are misbehaving—in other words, cells that are threatening to divide uncontrollably and cause cancerous tumors. T cells often turn their attacks on precancerous cells. In fact, some researchers believe this is actually one of their primary functions.

When a person receives an organ transplant, of course, they’re getting someone else’s cells. The natural response of the recipient’s T cells would be to attack those foreign cells, even though they were transplanted to save the person’s life. That’s why doctors

have to try to prevent the recipient's immune system from seeing the new organ as an invader to be destroyed. Drugs like cyclosporine are used to hinder the body's immune response to transplanted tissues—but they're used with caution, because they may also affect immune responses to other invaders. A similar situation arises with blood transfusions—which is why doctors have to make sure that blood donors and recipients have compatible blood types.

The symbolic power of blood in many cultures is not surprising, especially when you consider the emotional impact of seeing it flow from an injury. It's one of the few internal tissues that we occasionally get a glimpse of—and when we do, it usually means something bad has happened. But even when it's out of sight, blood is working behind the scenes, ferrying oxygen and nutrients and providing a vital defense force for your body.