The Wonders of Blood

Right now, without any effort or awareness on your part, blood is circling your entire body in about twenty seconds. It is feeding your brain, fighting off infections, sealing tiny wounds, and carrying away waste — all while you're reading or listening to this talk.

This most miraculous fluid has fascinated scientists, physicians, and storytellers for thousands of years, and it still has surprises to offer. What follows is a collection of the less commonly known facts about blood — the strange, the remarkable, and the occasionally unsettling.

Here are a few to give you a taste:

Studies suggest that mosquitos tend to prefer people with Type O blood, landing on them significantly more often than on those with Type A.[1]

The US President travels with a supply of his own blood type in his vehicle, particularly in the presidential limousine known as "The Beast."[2]

The cornea is one of the few parts of the human body that contains no blood vessels; it gets oxygen directly from the air. (Cartilage is another avascular tissue.)[3]

Human blood contains trace amounts of gold.[4]

What Blood Is

Blood is the most important transport medium in the human body, carrying oxygen from the lungs and nutrients from the gut to tissues where chemical reactions occur. It then picks up carbon dioxide and other wastes and transports them to the lungs, kidneys and liver for removal.[5]

When mixed with an anticoagulant such as a citrate or heparin, and left to settle, blood separates into three distinct layers: a red blood cell portion at the bottom of the tube, a narrow whiteish layer of white blood cells and platelets, and a straw-colored layer of plasma at the top.

Red Blood Cells

Red blood cells make up 40–45% of whole blood.[6]

By about the 32nd week of pregnancy, a woman's blood volume increases by 50%.[7]

Most RBCs in adults are produced in the bone marrow of the vertebrae, ribs, sternum, pelvis and the ends of long bones in a process called erythropoiesis. This production is stimulated by

erythropoietin, a hormone made mainly by the kidneys.

As they mature and are released into the bloodstream, red blood cells lose their nucleus. This gives them more space for their primary job, carrying hemoglobin. Each red blood cell carries roughly 270 million hemoglobin molecules.[8]

RBCs live about 120 days. Roughly 2 million RBCs are produced per second to replace the 1 percent daily loss of the body's approximately 25 trillion RBCs.[8-1]

After about 120 days, RBCs wear out. They lose their elasticity and become less flexible. They are then recycled in the spleen, liver and bone marrow. Old, damaged cells are eaten by specialized immune cells called macrophages. The iron is recycled for new RBCs and other waste products are expelled.[8-2]

Both chlorophyll and hemoglobin are built on almost the same "molecular scaffold": The metal ion bound at the center in hemoglobin is iron, while in chlorophyll it is magnesium.[9]

White Blood Cells

White blood cells are the body's first responders, rapidly migrating to infection sites. They engulf microbes, releasing antimicrobial proteins and forming traps that ensnare bacteria.

Each type of white blood cell protects against different threats, whether it's parasites, bacteria, viruses, fungi or helminths like roundworms or hookworms.

Platelets

Platelets (thrombocytes) are tiny colorless cell fragments in the blood that play a central role in stopping bleeding and forming blood clots. They gather at sites of blood-vessel injury, stick to the damaged wall, clump together to form a temporary plug, and release chemical signals that activate the coagulation cascade.[10]

Other Colors of Blood

While red blood cells are red because of the iron in the hemoglobin molecule, not every living thing has red blood.

- Spiders, lobsters and snails have blue blood.
- Some worms have green or violet blood.
- Insects such as beetles and butterflies have colorless or pale-yellowish blood.
- The color of blood is determined by the molecule that carries oxygen — iron in hemoglobin, in the case of human blood.[11]

How Blood Moves

The idea of a circulatory system for blood flow evolved through centuries of observations. William Harvey's 1628 publication marked the modern understanding of how blood travels through the body. We call this the cardiovascular system.[5-1]

This challenged beliefs of the time that blood in the body was consumed by tissues and was renewed by the food we eat.[12]

In this closed loop system, blood is pumped away from the heart through arteries, carrying oxygen-rich blood. It travels through smaller and smaller vessels, releasing oxygen and nutrients, until it reaches the tiny capillaries. Capillaries are found throughout the body, including in the extremities — hands, feet, fingers, and toes. Here the RBC's biconcave-disc shape provides a thin central region and flexible membrane that allows the red blood cell to elongate, fold, and squeeze through these tight spaces, single file, without rupturing. During capillary confinement, the cell temporarily shifts to a bullet-like form, maximizing contact with vessel walls for oxygen unloading while minimizing resistance. It then springs back to its original shape once past the capillary constriction.[13]

Then, the RBCs begin their return trip to the heart and lungs, full of carbon dioxide and other waste products to repeat the cycle again. While the heart drives blood through arteries, peripheral venous return depends largely on muscle contractions, one-way valves, and breathing to propel blood against gravity back toward the heart.[13-1] (Notice in the diagram that the lower chamber of the heart on the arterial side is thicker than the venous side, because the heart, a muscle, has to work harder to pump the blood through the circulatory system to the capillaries)

The 'thump thump' or 'lub dub' sound of the heartbeat we hear is produced by the closing of the heart valves during the cardiac cycle.

“Arteries deliver blood to capillaries, veins carry it away, but capillaries are where the real business of exchange with tissues happens.”[14]

Arterial blood carrying oxygen is bright red. Venous blood, carrying carbon dioxide and waste products, is a dull red. Most of the blood you have drawn during venipuncture is the dull red color of carbon dioxide-laden venous blood. Veins are closer to the surface than arteries and are therefore easier to access than arteries.

Blood travels the entire body in about 20 seconds through about 60,000 miles of vessels, mostly capillaries.[15]

Blood Types

The four major blood types were discovered by Karl Landsteiner in 1901. He noticed that mixing blood sera from different people caused clumping in some cases but not others. He named his blood types A, B and C, (C was later renamed O.) Landsteiner's students found the AB group two years later, in 1902.[16]

Red blood cells differ one type from another by having different antigens on the surface of the cell. Antigens are molecules — proteins, carbohydrates, or other substances — that trigger an immune response by being recognized as foreign by the body's immune system. They prompt the production of antibodies and activation of immune cells like T-cells. They are essentially "antibody generators." The ABO blood group antigens are carbohydrates on the RBC surface.[6-1]

- Type A blood has A antigens on the surface of the RBC.
- Type B blood has B antigens on the RBC surface.
- Type AB blood has both A and B antigens on the surface.
- Type O blood has no antigens on the blood cell surface.

RBCs float in the plasma of the blood. The *plasma* of each blood type contains antibodies:

- Type A blood contains B antibodies.
- Type B blood contains A antibodies.
- Type AB blood contains no antibodies.
- Type O blood contains both A and B antibodies.

All live in harmony in the body unless you mix the same type antigen with its antibodies. When that happens, agglutination occurs: the RBCs clump together.

The Rh Factor

The Rh blood factor, or Rhesus factor, was not discovered until 1940. This factor is a protein on the surface of red blood cells that determines if a person is Rh positive (has the protein), or Rh negative (lacks the protein).

In 1961, a new blood type was discovered in an Australian woman. It is called *'golden blood',* or Rh-null blood — not because of its color, but due to the complete absence of all 61 known Rh antigens on the red blood cell, and due to its extreme scarcity. It occurs in fewer than 50 known individuals worldwide with only about nine active donors.

Rh null individuals can only receive Rh-null blood, making transfusions extremely difficult and reliant on a global donor network.[17]

Rh-negative women face specific risks during pregnancy if the fetus they are carrying is Rh-positive, primarily due to potential blood type incompatibility. This can lead to the mother's

immune system producing antibodies that attack the fetus's red blood cells. Incompatibility often doesn't affect the first pregnancy significantly, as the mother hasn't yet developed strong antibodies. However, in subsequent pregnancies with an Rh-positive fetus, these antibodies that formed due to the previous pregnancy can cross the placenta, causing hemolytic disease of the fetus and newborn which may result in fetal anemia, jaundice, low birth weight, or even heart failure or stillbirth.[18]

Today, unsensitized Rh negative women receive RhoGAM injections at 28 weeks of pregnancy and within 72 hours after delivery of an Rh positive baby. RhoGAM provides passive antibodies that clear fetal Rh-positive cells from the mother's blood before her body can form its own antibodies. Before the 1960s, when RhoGAM was developed, this condition occurred in 15–20% of such pregnancies. Today, the occurrence is less than 1%.[19]

Blood Through History

For over 2,000 years, the practice of bloodletting played a central role in Western medicine. Thankfully, this is now largely obsolete.

Hippocrates (c. 460–370 BCE) posited four life forces or humors: blood, phlegm, yellow bile and black bile. Ancient civilizations like Egyptians and Mesopotamians practiced bloodletting to balance these bodily fluids, viewing blood as one of the life forces. When these humors were out of balance, illness occurred. To correct this imbalance, they practiced bloodletting.[20]

In bloodletting, a cut was made in a vein, usually the arm, and excess blood was drained from the body. The amount of blood was a bit of a guess. This supposedly rebalanced the humors in conditions ranging from fever and inflammation to epilepsy and even childbirth. George Washington, on the day of his death, is reported to have been bled five times, during which roughly 40% of his blood volume was removed within about 12 hours. This almost certainly hastened his death. It also hastened the death of countless others.[20-1]

Leeches

Leeches have been used for at least 3,000 years to suck blood from the body, a practice that transitioned from ancient "balancing of humors." Leech saliva contains an anticoagulant and anti-platelet agent that works to prevent blood clots and reduce the amount of congested blood in the tissues. Other chemicals in leech saliva keep the blood flowing in the damaged area, even after the leech is detached, allowing time for new veins to grow and the existing ones to widen and accommodate more blood flow. As a bonus, the treatment is painless – when a leech bites, it releases a naturally occurring anesthetic that numbs the area. Leeches are still used in medicine in cases such as tissue reattachment.[21]

Under the Microscope

With the development of the microscope in the mid-1600s, Antonie van Leeuwenhoek was able to see tiny red globules suspended in a pale yellow fluid in blood samples. He estimated the size of these globules, concluding they were roughly 1/25,000 the size of a fine grain of sand, which is remarkably close to modern measurements.[22]

About seventy years later, in the 1740s, red blood cells were shown to contain iron. The red color of blood was linked to the iron in hemoglobin in the red blood cells. Because of this iron, blood has a metallic taste as well as a metallic smell.

In the 1770s, about 100 years after red blood cells were observed in blood samples, and using more advanced microscopes, colorless white blood cells were identified in the blood. Platelets were identified later, in 1842, by Alfred Donné.

When a drop of blood was spread out thinly on a glass slide, colored with specialized stains, and observed under the new more powerful microscopes, white blood cells were able to be differentiated one from the other because granules and other differences in the different types of cells stain differently. Some white blood cells, when stained, had blue granules, some red granules, others segmented portions. Differentiating different types of white blood cells became possible.

During WW II, especially in South-East Asian theaters like Ceylon and Sumatra, medics successfully used coconut water as an emergency short-term substitute for IV fluid when medical supplies were scarce.[23]

Blood Banking

Transfusing bleeding victims has been attempted for centuries. Early efforts to transfuse blood directly from animals to people were almost always fatal because antibodies in, say, a calf or pig, are not compatible with humans and agglutination occurred.

During WW I and more especially during WW II, where wounded soldiers were often far from an immediate source of whole blood, searches were made to find better ways of preserving blood and forming ways to transport it to locations such as the battlefield.[24]

With the use of anticoagulants, whole blood could be stored for several days, but RBCs are fragile and can't be handled roughly. More improvements were needed.

Dr. Charles Drew is best known for his innovations in blood preservation and the creation of blood banks. During World War II, he developed advanced techniques for processing and storing blood plasma, making it possible to collect and transport life-saving blood donations to soldiers on the battlefield. His work laid the foundation for the American Red Cross Blood Bank, a system that continues to provide critical transfusions worldwide.[24-1]

Plastic bags replaced glass bottles in the 1950s for easier, safer storage, and the separation of blood into components allowed plasma to be collected. Storage time is significantly longer for plasma, up to a year when frozen. And there are no fragile cells to protect.

In 1972, aphaeresis was introduced, allowing specific components of the blood to be collected while returning the rest of the blood to the donor.

A single donation can now treat up to three people using specific components like platelets for cancer patients.[24-2]

Blood donations are now screened for Hepatitis C, West Nile virus, HIV, and other transmissible diseases before being given.

Diseases of the Blood

Sickle Cell Anemia

Sickle cell anemia is more often found in people from parts of Africa, the Middle East, and India, or their descendants — parts of the world where malaria is present.

These people have red blood cells that deform to sickle cell shapes under low-oxygen conditions. This leads to blocked blood vessels, severe pain, anemia and organ damage. Normal RBCs last around 120 days. Sickle cells survive only 10–20 days, about 1/10 as long, leading to chronic anemia.[25]

Human red blood cells are part of the life cycle of the malaria parasite, *Plasmodium falciparum*. When red blood cells are deformed as in Sickle Cell Anemia, these parasites cannot complete their life cycle. As a result, fewer parasites complete their life cycle, and malaria cases decrease.[26]

The Sickle Cell trait is an evolutionary adaptation that protects against severe malaria. People who are born with sickle cell trait are better able to survive malaria and pass this trait on to their children.[26-1]

Hemophilia

Hemophilia is a rare genetic disorder, primarily affecting males, where blood does not clot properly due to a deficiency in one of the clotting factors — Factor VIII in hemophilia A, or Factor IX in hemophilia B. Common signs include easy bruising, prolonged bleeding from cuts, and risks like internal hemorrhage in muscles.

Well-known cases of hemophilia include the Romanov family in Russia.

Tsarevich Alexei Romanov, the only son of Tsar Nicholas II, suffered from hemophilia B (Factor IX deficiency), inherited from his great-grandmother Queen Victoria. Queen Victoria was a carrier. She also passed the X-linked gene to other descendants, including her son Prince Leopold. Ryan White was a hemophiliac who contracted AIDS from contaminated blood products used to treat his condition.[27]

Blood Frontiers

Elizabeth Holmes famously promised a way to run hundreds of blood tests on a single drop of blood. The company, Theranos, was founded in 2003 and raised more than 700 million dollars, reaching a peak valuation of about 9 billion dollars. It secured partnerships with Walgreens, Safeway, and well-known personalities, despite never having robust peer-reviewed validation of its core technology. Investigative reporting beginning in 2015 revealed the fraudulent scheme. Holmes was convicted in 2022 on charges of wire fraud and conspiracy and is now serving an 11-year prison sentence.[28]

Researchers are working on developing artificial blood. The focus is on transporting oxygen and carbon dioxide throughout the body, not full replacements for all blood functions. Unfortunately, no truly safe and effective artificial blood is currently marketed.[29]

Luminol tests are a forensic, chemiluminescent technique used to detect trace, or invisible, bloodstains by spraying a reagent (luminol) that reacts with iron in hemoglobin, causing a blue glow in darkness. It is highly sensitive, capable of detecting blood diluted up to 10 million times, and does not destroy DNA.[30]

About 25 billion red blood cells fit in a single teaspoon of blood. And right now, every one of them is at work — circling, delivering, defending, repairing — in you, and in everyone around you. Blood never stops. Neither has our fascination with it.

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