Blood

Blood is the fluid of life, transporting oxygen from the lungs to body tissue and carbon dioxide from body tissue to the lungs. Blood is the fluid of growth, transporting nourishment from digestion and hormones from glands throughout the body. Blood is the fluid of health, transporting disease-fighting substances to the tissue and waste to the kidneys. Because it contains living cells, blood is alive. Red blood cells and white blood cells are responsible for nourishing and cleansing the body.Without blood, the human body would stop working.

Blood is one of the most important components of life. Almost any animal that possesses a circulatory system has blood. From an evolutionary perspective, blood was speculated to have risen from a type of cell that was responsible for phagocytosis and nutrition. Billions of years later, blood and the circulatory system have drastically helped the evolution of more complex lifeforms.

Blood is a fluid connective tissue that consists of plasma, blood cells and platelets. It circulates throughout our body delivering oxygen and nutrients to various cells and tissues. It makes up 8% of our body weight. An average adult possesses around 5-6 litres of blood.

Types of Blood Cells

We have seen blood consist of cells known as formed elements of blood. These cells have their own functions and roles to play in the body. The blood cells which circulate all around the body are as follows:

Red blood cells (Erythrocytes)

RBCs are biconcave cells without nucleus in humans; also known as erythrocytes. RBCs contain the iron-rich protein called haemoglobin; give blood its red colour. RBCs are the most copious blood cells produced in bone marrows. Their main function is to transport oxygen from and to various tissues and organs.

White blood cells (Leucocytes)

Leucocytes are colourless blood cells. They are colourless because it is devoid of haemoglobin. They are further classified as granulocytes and agranulocytes. WBCs mainly contribute to immunity and defence mechanism.

Types of White Blood Cells

There are five different types of White blood cells and are classified mainly based on the presence and absence of granules.

- Granulocytes
- Agranulocytes

Granulocytes

They are leukocytes, with the presence of granules in their cytoplasm. The granulated cells include- eosinophil, basophil, and neutrophil.

Eosinophils

- They are the cells of leukocytes, which are present in the immune system.
- These cells are responsible for combating infections in parasites of vertebrates and for controlling mechanisms associated with allergy and asthma.
- Eosinophil cells are small granulocyte, which are produced in the bone marrow and makes 2 to 3 per cent of whole WBCs. These cells are present in high concentrations in the digestive tract.

Basophils

- They are the least common of the granulocytes, ranging from 0.5 to 1 per cent of WBCs.
- They contain large cytoplasmic granules, which play a vital role in mounting a non-specific immune response to pathogens, and allergic reactions by releasing histamine and dilating the blood vessels.
- These white blood cells have the ability to be stained when exposed to basic dyes, hence referred to as basophil.
- These cells are best known for their role in asthma and their result in inflammation and bronchoconstriction in the airways.
- They secrete serotonin, histamine and heparin.

Neutrophils

- They are normally found in the bloodstream.
- They are predominant cells, which are present in pus.

- Around 60 to 65 per cent of WBCs are neutrophils with a diameter of 10 to 12 micrometres.
- The nucleus is 2 to 5 lobed and the cytoplasm has very fine granules.
- Neutrophil helps in the destruction of bacteria with lysosomes, and it acts as a strong oxidant.
- Neutrophils are stained only using neutral dyes. Hence, they are called so.
- Neutrophils are also the first cells of the immune system to respond to an invader such as a bacteria or a virus.
- The lifespan of these WBCs extends for up to eight hours and is produced every day in the bone marrow.

Agranulocytes

They are leukocytes, with the absence of granules in their cytoplasm. Agranulocytes are further classified into monocytes and lymphocytes.

Monocytes

- These cells usually have a large bilobed nucleus, with a diameter of 12 to 20 micrometres.
- The nucleus is generally half-moon shaped or kidney-shaped and it occupies 6 to 8 per cent of WBCs.
- They are the garbage trucks of the immune system.
- The most important functions of monocytes are to migrate into tissues and clean up dead cells, protect against bloodborne pathogens and move very quickly to the sites of infections in the tissues.
- These white blood cells have a single bean-shaped nucleus, hence referred to as Monocytes.

Lymphocytes

- They play a vital role in producing antibodies.
- Their size ranges from 8 to 10 micrometres.
- They are commonly known as natural killer cells.
- They play an important role in body defence.

- These white blood cells are colourless cells formed in lymphoid tissue, hence referred to as lymphocytes.
- There are two main types of lymphocytes – B lymphocytes and T lymphocytes.
- These cells are very important in the immune systems and are responsible for humoral and cell-mediated immunity.

Platelets (Thrombocytes)

- Thrombocytes are specialized blood cells produced from bone marrow.
- Platelets come into play when there is bleeding or haemorrhage.
- They help in clotting and coagulation of blood. Platelets help in coagulation during a cut or wound.

Components Of Blood

There are many cellular structures in the composition of blood. When a sample of blood is spun in a centrifuge machine, they separate into the following constituents: Plasma, buffy coat and erythrocytes. Thus blood contains RBC, WBC, platelets and plasma.

Plasma

The liquid state of blood can be contributed to plasma as it makes up ~55% of blood. It is pale yellow in colour and when separated. Blood plasma consists of salts, nutrients, water and enzymes. Blood plasma also contains important proteins and other components necessary for overall health. Hence, blood plasma transfusions are given to patients with liver failure and life-threatening injuries.

Components of Blood Plasma

Blood plasma has several protein components. Proteins in blood plasma are:

- Serum globulin
- Serum albumin
- Fibrinogen

The serum contains only globulin and albumin. Fibrinogen is absent in serum because it is converted into fibrin during blood clotting.

Hemostasis

Hemostasis is your body's natural reaction to an injury that stops bleeding and repairs the damage. Hemostasis is your body's normal reaction to an injury that causes bleeding. This reaction stops bleeding and allows your body to start repairs on the injury. This capability is essential to keep you alive, particularly with significant injuries. However, in uncommon cases, the processes that control hemostasis can malfunction, causing potentially serious — or even dangerous — problems with bleeding or clotting.

Hemostasis combines the terms "hemo" (meaning "blood") and "stasis" (meaning "standing still"). In this context, it's the term for how your body stops bleeding. Rather than being just a single process, hemostasis is actually a collection of several processes. Though they look like separate processes, these all happen at the same time when your body forms a blood clot.

Primary hemostasis (platelet clotting)

Primary hemostasis is when your body forms a temporary plug to seal an injury. To accomplish that, platelets that circulate in your blood stick to the damaged tissue and activate. That activation means they can "recruit" more platelets to form a platelet "plug" to stop blood loss from the damaged area. That clot works much like a cork or bottle stopper, keeping blood in and debris or germs out. Primary hemostasis may also involve constriction (narrowing) of the damaged blood vessel, which can happen because of substances that activated platelets release.

Secondary hemostasis (coagulation cascade)

The platelet plug is the first step to stop bleeding, but it isn't stable enough to stay in place without help. The next step, which stabilizes the plug, is secondary hemostasis. This step, sometimes called coagulation, involves molecules in your blood called "coagulation factors." Those factors activate in sequence, the "coagulation cascade," which amplifies clotting effects as the sequence continues. Ultimately, the coagulation cascade forms a substance called fibrin. During this step, the platelet plug acts like bricks and the fibrin acts like mortar. Together, they form a solid, stable clot.

Fibrin clot remodeling

The last stage of hemostasis is when your body remodels the existing clot into a fibrin clot. Your body does that because blood clots are a temporary patch, not a permanent solution. That removal involves a process called fibrinolysis. During fibrinolysis, your body remodels the clot into the same kind of tissue that was there before the injury.

What causes hemostasis?

Your body naturally monitors itself for injuries, and when it detects one, it reacts quickly to take control of the situation. Without normal hemostasis, even minor injuries could cause dangerous blood loss. An example of this is hemophilia, a condition where hemostasis doesn't work properly and blood can't clot effectively. Any break in your skin is also a risk for germs to enter your body. Clots help reduce that risk by sealing the injury.

Hemostasis refers to normal blood clotting in response to an injury. However, your body can also have too much clotting, known as hypercoagulability. That can cause many blood clots to form spontaneously and block normal blood flow. When blood clots form inside your blood vessels, this is known as thrombosis. When you have thrombosis that happens repeatedly, that’s a condition called thrombophilia.

Thrombophilia (hypercoagulability or too much clotting)

Hypercoagulability is when your blood clots too much or too easily. This is dangerous because those clots can develop or get stuck in different places in your body and cause severe, life-threatening problems. Examples of these problems include:

- Stroke.
- Deep vein thrombosis (DVT), which can then cause a pulmonary embolism.
- Heart attack.

Many types of cancer can cause hypercoagulability, and some rare conditions that cause hypercoagulability are also genetic. That means they are either inherited from your parents or happen because of a random mutation in your DNA. People with these conditions have thrombophilia. A few examples of conditions like this include:

- Protein C deficiency.
- Prothrombin gene mutation.
- Factor 5 Leiden mutation.

Inherited disorders that cause thrombophilia aren’t as common as “acquired” conditions, which you usually develop later in life. Examples of acquired conditions include:

- Antiphospholipid syndrome.
- Inflammatory bowel disease.
- Severe reactions to infections, such as sepsis.

Most medications that treat thrombophilia make it harder for your blood to clot in some way. Examples of these include antiplatelet, anticoagulant and fibrinolytic (fibrin-breaking or clot-busting) drugs.

Hypocoagulability (not enough clotting)

When your blood doesn't clot well, any injury becomes a much more dangerous event. Without proper clotting, even minor injuries can cause you to lose a lot of blood. It also means you're at greater risk for injuries to organs and blood vessels inside your body, which can then cause internal bleeding.

Certain types of cancer like leukemia can cause you to bleed too easily. That's because they often involve a lack of platelets in your body or anti-clotting activity. Conditions that keep your blood from clotting are often genetic, also. Some examples of genetic conditions include:

- Hemophilia.
- Von Willebrand disease.
- Inherited thrombocytopenia (low platelet count).

Treating conditions that keep your blood from clotting usually involves medications that slow down or block your body's anti-clotting processes, that boost your body's ability to make platelets or that add more of certain clotting factors to your blood. You can also receive transfusions of platelets to add more if your body needs them.

Functions of Blood

Blood is responsible for the following body functions:

Fluid Connective Tissue

Blood is a fluid connective tissue composed of 55% plasma and 45% formed elements including WBCs, RBCs, and platelets. Since these living cells are suspended in plasma, blood is known as a fluid connective tissue and not just fluid.

Provides oxygen to the cells

Blood absorbs oxygen from the lungs and transports it to different cells of the body. The waste carbon dioxide moves from the blood to the lungs and is exhaled.

Transports Hormones and Nutrients

The digested nutrients such as glucose, vitamins, minerals, and proteins are absorbed into the blood through the capillaries in the villi lining the small intestine.

The hormones secreted by the endocrine glands are also transported by the blood to different organs and tissues.

Homeostasis

Blood helps to maintain the internal body temperature by absorbing or releasing heat.

Blood Clotting at Site of Injury

The platelets help in the clotting of blood at the site of injury. Platelets along with the fibrin form clot at the wound site

Transport of waste to the Kidney and Liver

Blood enters the kidney where it is filtered to remove nitrogenous waste out of the blood plasma. The toxins from the blood are also removed by the liver.

Protection of the body against pathogens

The White Blood Cells fight against infections. They multiply rapidly during infections.

Blood groups

There are 4 main blood groups (types of blood) – A, B, AB and O. Your blood group is determined by the genes you inherit from your parents.

Each group can be either RhD positive or RhD negative, which means in total there are 8 blood groups.

Antibodies and antigens

Blood is made up of red blood cells, white blood cells and platelets in a liquid called plasma. Your blood group is identified by antibodies and antigens in the blood.

Antibodies are proteins found in plasma. They're part of your body's natural defences. They recognise foreign substances, such as germs, and alert your immune system, which destroys them.

Antigens are protein molecules found on the surface of red blood cells.

The ABO system

There are 4 main blood groups defined by the ABO system:

- **blood group A** – has A antigens on the red blood cells with anti-B antibodies in the plasma
- **blood group B** – has B antigens with anti-A antibodies in the plasma
- **blood group O** – has no antigens, but both anti-A and anti-B antibodies in the plasma
- **blood group AB** – has both A and B antigens, but no antibodies

Blood group O is the most common blood group. Almost half of the UK population (around 48%) has blood group O.

Receiving blood from the wrong ABO group can be life-threatening. For example, if someone with group B blood is given group A blood, their anti-A antibodies will attack the group A cells.

This is why group A blood must never be given to someone who has group B blood and vice versa.

As group O red blood cells do not have any A or B antigens, it can safely be given to any other group.

The Rh system

Red blood cells sometimes have another antigen, a protein known as the RhD antigen. If this is present, your blood group is RhD positive. If it's absent, your blood group is RhD negative.

This means you can be 1 of 8 blood groups:

A RhD positive (A+)

A RhD negative (A-)

B RhD positive (B+)

B RhD negative (B-)

O RhD positive (O+)

O RhD negative (O-)

AB RhD positive (AB+)

AB RhD negative (AB-)

About 85% of the UK population is RhD positive (35% of the population has O+, the most common type).

In most cases, O RhD negative blood (O-) can safely be given to anyone. It's often used in medical emergencies when the blood type is not immediately known.

It's safe for most recipients because it does not have any A, B or RhD antigens on the surface of the cells, and is compatible with every other ABO and RhD blood group.

Blood group test

To work out your blood group, your red blood cells are mixed with different antibody solutions. If, for example, the solution contains anti-B antibodies and you have B antigens on your cells (you're blood group B), it will clump together.

If the blood does not react to any of the anti-A or anti-B antibodies, it's blood group O. A series of tests with different types of antibody can be used to identify your blood group.

If you have a blood transfusion (where blood is taken from one person and given to another) your blood will be tested against a sample of donor cells that contain ABO and RhD antigens. If there's no reaction, donor blood with the same ABO and RhD type can be used. Pregnant women are always given a blood group test. This is because if the mother is RhD negative but the child has inherited RhD-positive blood from the father, it could cause complications if left untreated. RhD-negative women of child-bearing age should always only receive RhD-negative blood.

Universal donor

Blood type O negative (O-) is the universal donor. This means that a person with any other blood type can safely receive your blood. It doesn’t contain any antigen markers that other blood types recognize as not belonging. Providers use type O negative blood the most in emergencies when someone needs blood fast.

Providers look at different markers to determine blood type compatibility for donating plasma. Plasma is the liquid part of blood. The universal plasma donor is type AB.

Universal recipient

Blood type AB positive (AB+) is the universal recipient. You can safely receive blood from any other blood type. Your blood recognizes all potential antigens as safe, so your immune system doesn’t launch an attack.