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Blood has multiple functions:

1. Transportation of nutrients, gases, wastes, hormones, and antibodies.

2. Protection. White Blood Cells are used to fight infections and produce antibodies. Clotting is another important protection function of blood, it keeps us from losing too much blood via injury.

3. Regulation of fluid volume and pH levels. Blood stabilizes fluid distribution throughout the body, buffers acids and bases to stabilize pH, and regulates body temperature by shifting blood flow.

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Blood is composed of formed elements and plasma. The formed elements are: red blood cells (RBC), white blood cells (WBC), and platelets.

To find the relative concentrations of the formed elements and plasma we spin a tube of blood to separate the various substances.

RBCs go to the bottom of the tube and make up about 45% of volume.

The little white strip on top of the RBCs is the Buffy coat which is made of platelets and WBCs and comprises 1% of blood.

The top portion of the tube is Plasma. Plasma, the liquid or fluid portion, is 55% of the total blood volume.

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Plasma composition can be placed into 2 groups: proteins and non-proteins.

There are three primary proteins:

1. Fibrinogen is a sticky protein that is the precursor to fibrin which functions in coagulation or clotting.

2. Albumin is the most abundant plasma protein. It can influence blood pressure, volume, and flow (thickness or stickiness of blood) by maintaining osmotic pressure. It helps transport various blood solutes (things that are dissolved into blood) by maintaining the H_2O concentration gradient. It also maintains blood pH.

3. Globulin has 3 classes of protein (alpha, beta, and gamma) and functions in blood clotting and protection as antibodies.

Plasma also has non-protein components:

1. Water makes up 92% of plasma.

2. Other components are electrolytes, glucose, Nitrogenous wastes such as urea, hormones, and dissolved gases such as oxygen, carbon dioxide, and nitrogen.

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Hemopoiesis is the production of any formed element. Adults generally produce 200 billion RBCs and 10 billion WBCs a day!

Red bone marrow produces the majority of formed elements.

Some WBC types (lymphocytes) are produced by the lymphatic system.

WBCs and RBCs originate from a bone marrow stem cell called hemopoietic cells. These cells will go through a series of steps and differentiate into their respective blood cell types.

Platelets are formed in a slightly different manner. They are cytoplasmic fragments of a large marrow cell called megakaryocyte.

Erythropoiesis, leukopoiesis, and thrombopoeisis is the development of RBC, WBC, and platelets, respectively.

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RBC's are also called Erythrocytes

They are biconcave and discoid. They have no DNA, mitochondria, or nucleus. So technically, they are not true cells since they can't reproduce themselves. They live about 120 days and are the most abundant formed element in blood. They function to carry O2 from lungs throughout the body and pick up CO2 in various parts of the body and bring it to the lungs to be expelled. They do this with the use of hemoglobin. Hemoglobin is a molecule that consists of 4 protein chains called globin. It also contains 4 heme groups, 1 heme group is associated with 1 globin chain. 1 heme group carries 1 molecule of O2 and 1 globin chain carries 1 CO2 molecule. Iron is essential to the formation of hemoglobin. It is the center element in the heme group, which everything else is built around. Anemia, or iron deficiency, can have large impacts on blood cell formation and the transportation of gases.

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Here is our hemoglobin. The star x-shaped red structures are the heme groups and the gold and purple squiggles are the globin chains. There are 280 million hemoglobin PER RBC!!!!!!!!!!!!!!!!!!!!

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RBCs have a life cycle of 120 days. Towards the end of its life cycle, their membranes begin to deteriorate. The cells are broken down by the liver and spleen, a process called hemolysis. While the membrane fragments can be dealt with easily, hemoglobin presents a challenge. If it is not properly broken down, hemoglobin will block the tubules in the kidney and lead to renal failure. Therefore, the hemoglobin must be broken down into its components, heme and globin. Globin can be further broken down into amino acids and then recycled. Heme is more complicated. The iron must first be removed from heme and put into blood where it can ultimately be reused. The remainder of the heme molecule is converted into a bile pigment by the liver and excreted in feces.

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WBCs are also called Leukocytes. They are the least abundant of the formed elements and actually only spend a few hours in blood and then migrate to live in connective tissues. They also retain their organelles throughout their lifetime and are larger than RBCs. They mainly function in immune defense and protect us from toxins, pathogens, and other foreign elements.

WBCs are classified into two categories: granulocytes and agranulocytes.

Granulocytes contain cytoplasmic granules, organelles with membranes that store products of cell metabolism. There are 3 types of granulocytes.

1. Neutrophils are the most abundant WBC type, they phagocytize bacteria, and release antimicrobial chemicals to fight bacteria. Even though they are the most abundant, they are short-lived. Their numbers are particularly high during bacterial infections.

2. Eosinophils have counts that fluctuate daily and seasonally, they fight allergens, parasites and worms. Eosinophils release anti-inflammatory chemicals to fight off allergies. They are also phagocytic.

3. Basophils are rarest of WBCs, they release histamine (vasodilator) to increase flow to tissues and heparin (an anticoagulant or anticlotting molecule) which allows other WBCs to move by preventing clotting, they help heal damaged tissue, and they also release factors that attract neutrophils and eosinophils for further immune response. In contrast to the previous 2, Basophils are not phagocytic.

Agranulocytes do not have cytoplasmic granules and there are two types.

1. Lymphocytes are very abundant and the smallest in size. They destroy cancer cells, cells infected with viruses and foreign cells. They are important for immune memory, secret antibodies, and coordination of other immune cells.

2. Monocytes are the largest in size of the WBCs. They phagocytize pathogens, dead neutrophils, and cellular debris. Their numbers are high when fighting viral infections. They will leave the bloodstream and differentiate into macrophages within the various tissues.

Granulocytes typically live for 4-5 days. Lymphocytes live for a few weeks to decades. And, macrophages can live for years.

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Platelets, also called thrombocytes, are not true cells, they do not have a nucleus but do retain their lysosomes and mitochondria. They are actually cytoplasmic fragments of megakaryocytes and are second in abundance after RBC. They are also very small. Their primary function is hemostasis, or cessation of bleeding. To do this they secrete vasoconstrictors (chemicals that clamp down the blood vessels) to prevent further bleeding and clotting factors which promote blood clotting. They also help to limit blood lose by sticking to collagen fibers.

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For size comparison, you can see the red blood cells, white blood cells and platelets. Notice the platelets as the small purple particles. Also notice how much larger the WBCs are in comparison to the RBCs.