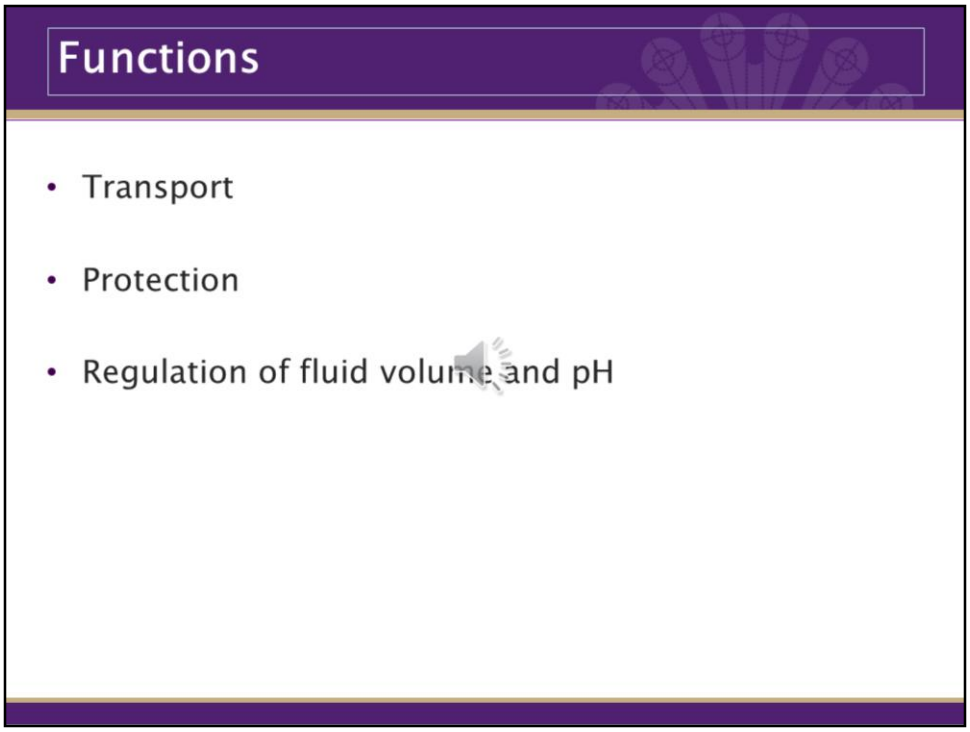
ST. CATHERINE UNIVERSITY

Blood

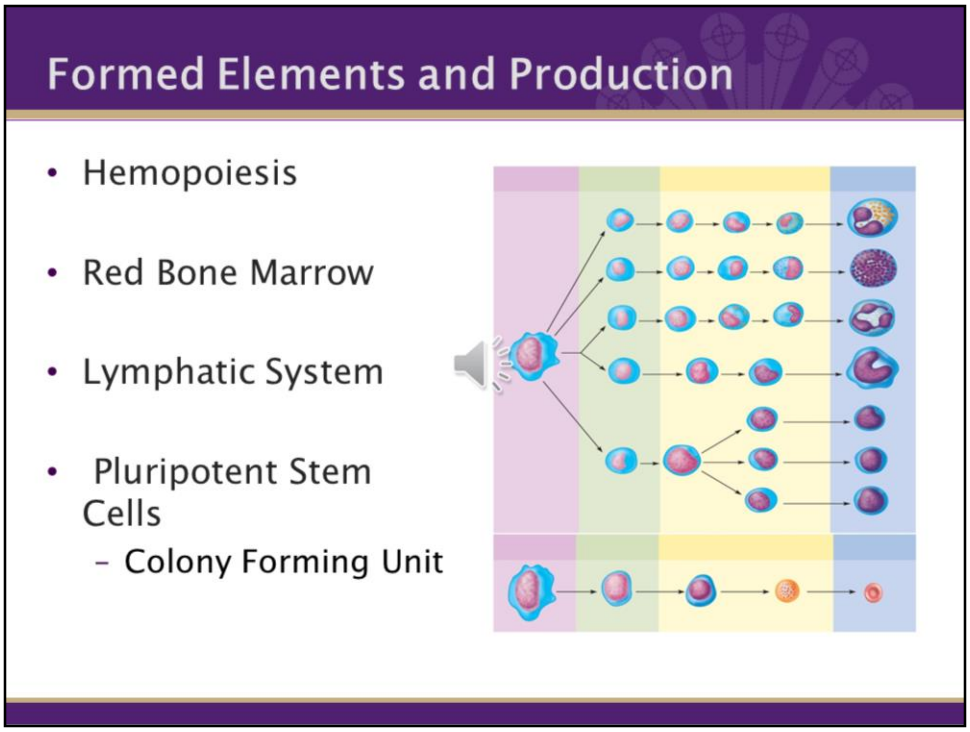


Blood has multiple functions:

1. Transportation of nutrients, gases, wastes, hormones, and stem cells.

2. Protection. Inflammation is used to limit the spread of infection. White Blood Cells are used to fight infections and produce antibodies. Blood proteins also assist in neutralizing toxins. Clotting is another important protection function of blood, it keeps us from loosing 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.



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

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.

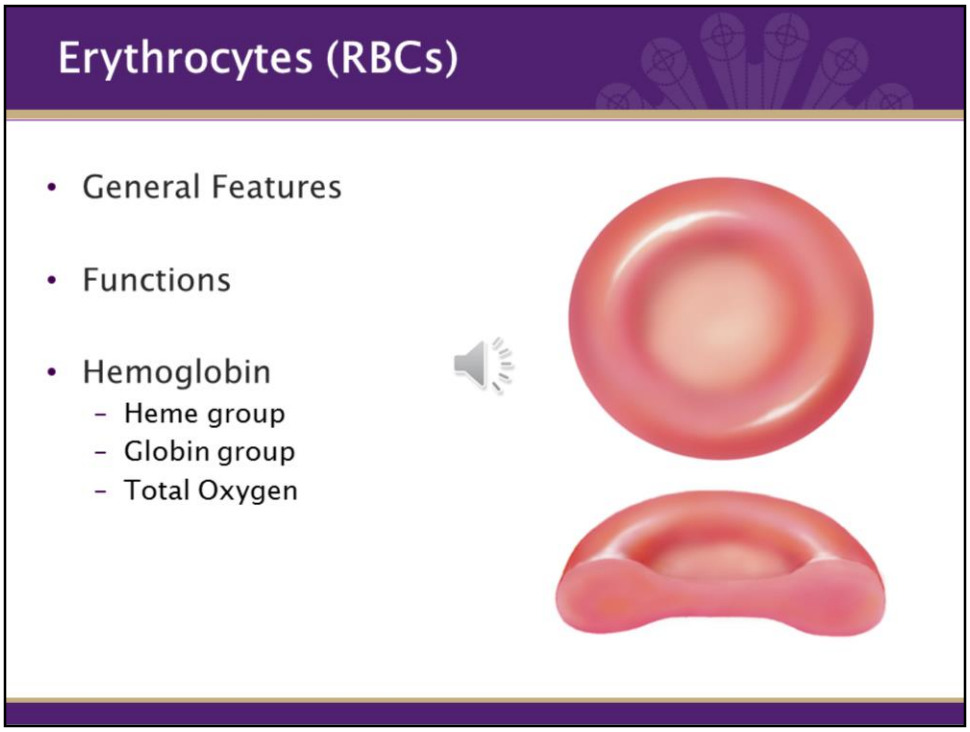
Some WBC types (lymphocytes) are produced by the lymphatic system.

WBCs and RBCs originate from a bone marrow stem cell called pluripotent stem cell (have potential to develop into multiple cell types). These then become a colony forming unit which is a more specialized stem cell. The colony forming units will then differentiate into their respective blood cell types.

Remember, in children, red bone marrow is found in nearly all marrow cavities, in adults it is limited to specific areas. With all the growing kids are doing, they need a large supply of blood for their little bodies.

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

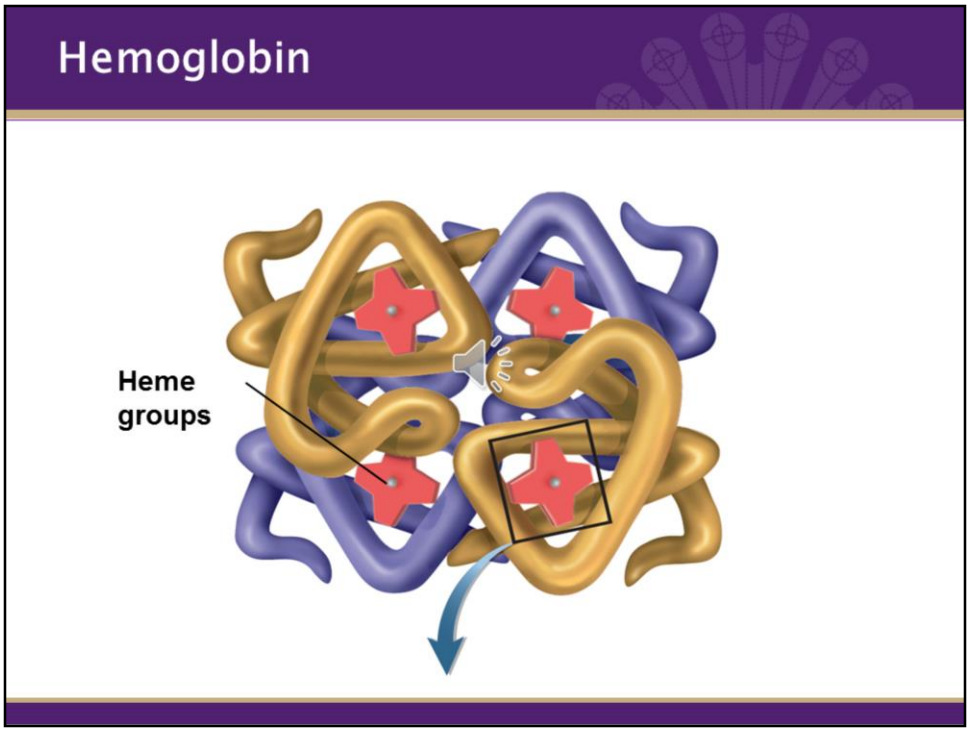
Erythropoiesis, leukopoiesis, and thrombopoeisis is the development of RBC, WBC, and platelets, respectively.



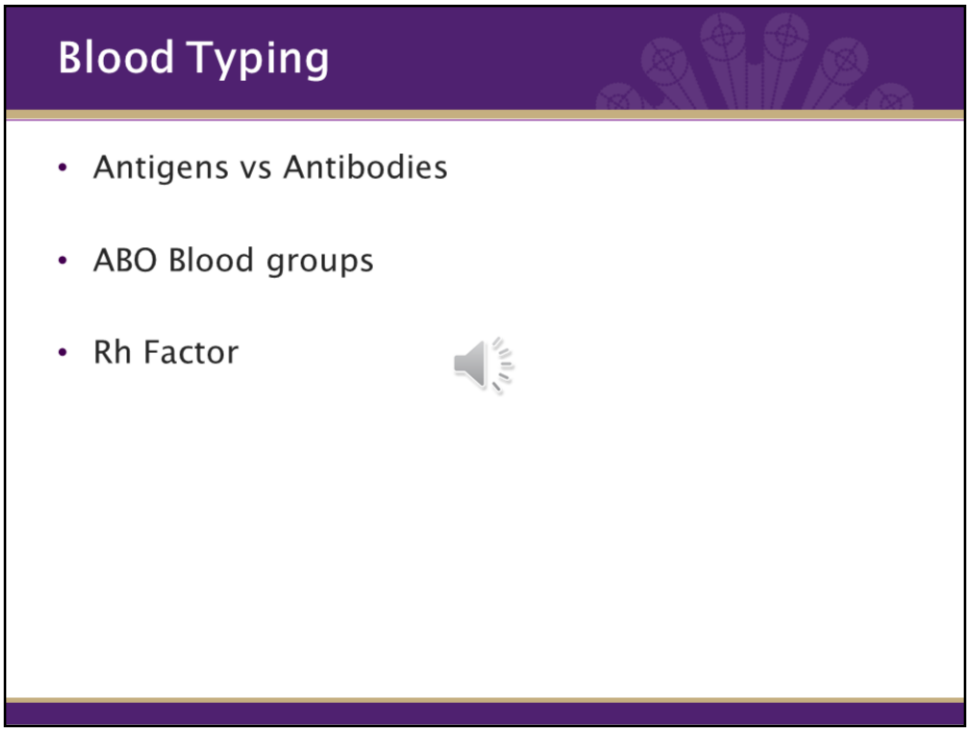
RBC's are also called Erythrocytes

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 O_2 from lungs throughout the body and pick up CO_2 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 O_2 and 1 globin chain carries 1 CO_2 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 (hypoxia is the lack of O_2).

Anemia can also cause edema (blood in the extracellular spaces) and heart complications (heart beating too fast). So, it is essential that we get enough iron in our diet.

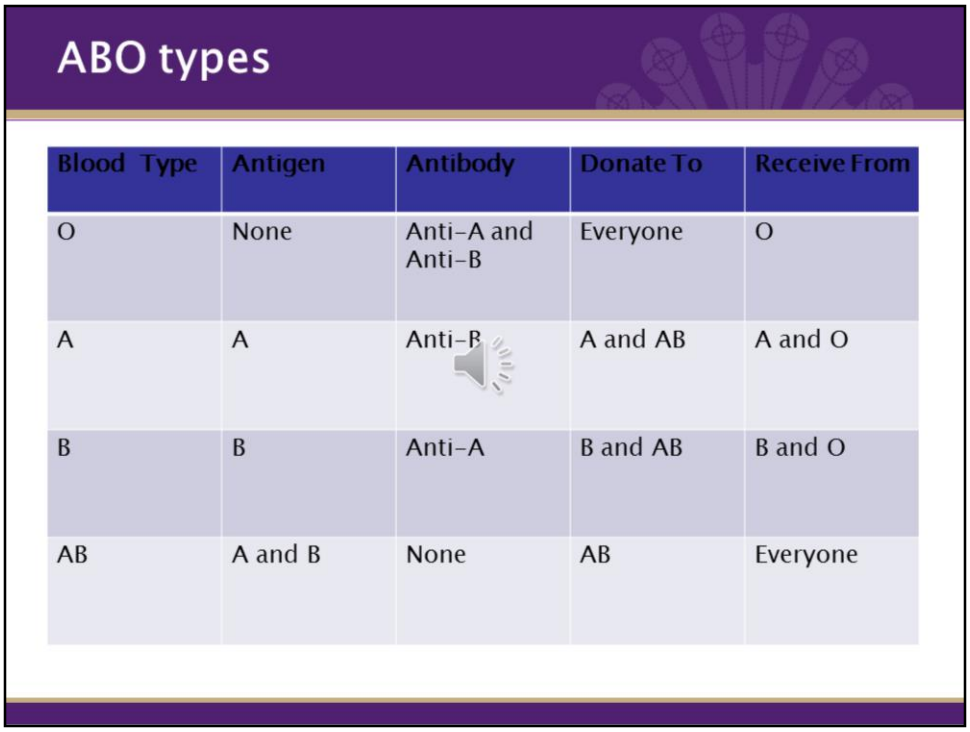


Here is our hemoglobin. The star x-shaped red structures are the heme groups and the gold and purple squiggles are the globin chains. There are 280 million hemoglobin PER RBC!!!!!!!!!!!!!!!!!!!!!



Our blood type is determined by antigens, or protein molecules, found on the surface of the red blood cell. There are a lot of different types of antigens on the RBC, but there are a couple that can cause problems during blood transfusions due to their reactions with antibodies. Antibodies are particles in the blood plasma that identify cells that do not belong in our body. They do this by a lock-and-key type mechanism. Each antibody corresponds to a particular type of antigen. When our antibodies recognize its type of antigen they bind to it. This is our bodies way of identifying foreign cells. This antibody-antigen reaction will cause blood to start to clump. So, the antibodies that are found in our blood cannot match the antigens on our RBCs, otherwise, our body would attack its own cells.

There are two antigen groups that are very important when it comes to considering antigen-antibody reactions. They are the ABO blood groups and the Rh Factor.



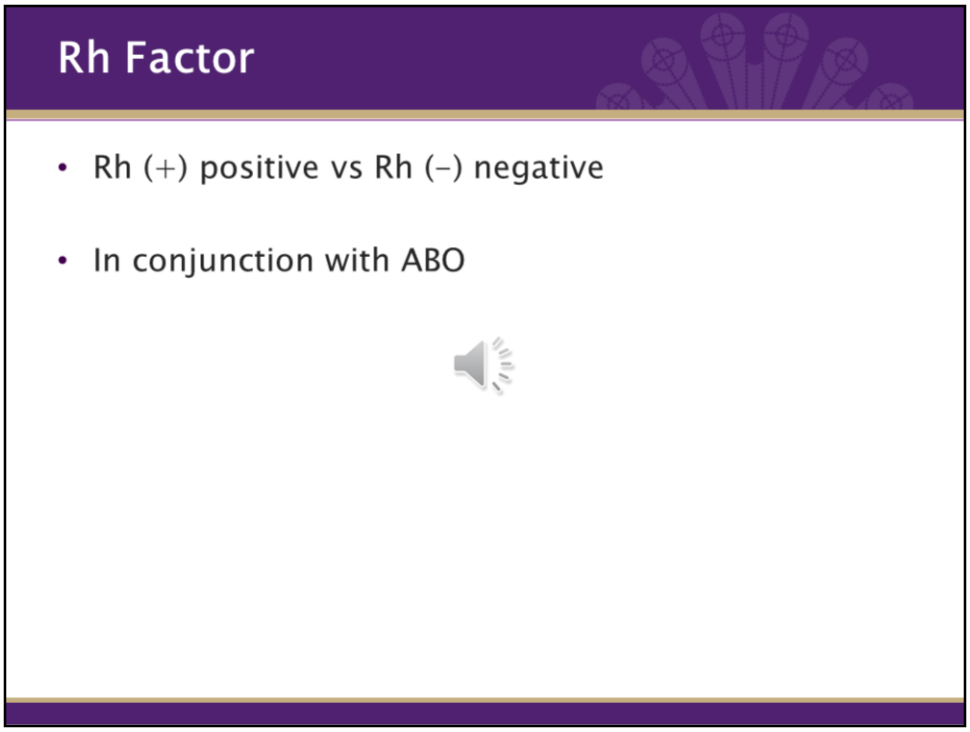
I think it is easier to understand blood typing if we can put it all in a chart. There are 4 blood types in the ABO grouping. The first type is O. O has a small, non-functional antigen like structure. But, since it doesn't work like an antigen, we say that there is not an antigen on O. O also makes both types of antibodies, Anti-A and Anti-B. Since O doesn't have any antigens that other blood types would recognize, it can be donated to everyone. But, since O does make both types of antibodies, it can only receive blood from other people who are O.

Type A has A antigens and anti-B antibodies. They can donate to types A and AB and can receive blood from types A and O. They cannot receive from either B or AB because both of those types have antigens that would be recognized by Type A's antibodies.

Type B has B antigens and anti-A antibodies. They can donate to types B and AB and can receive blood from types B and O. They cannot receive from either A or AB because both of those types have antigens that would be recognized by Type B's antibodies.

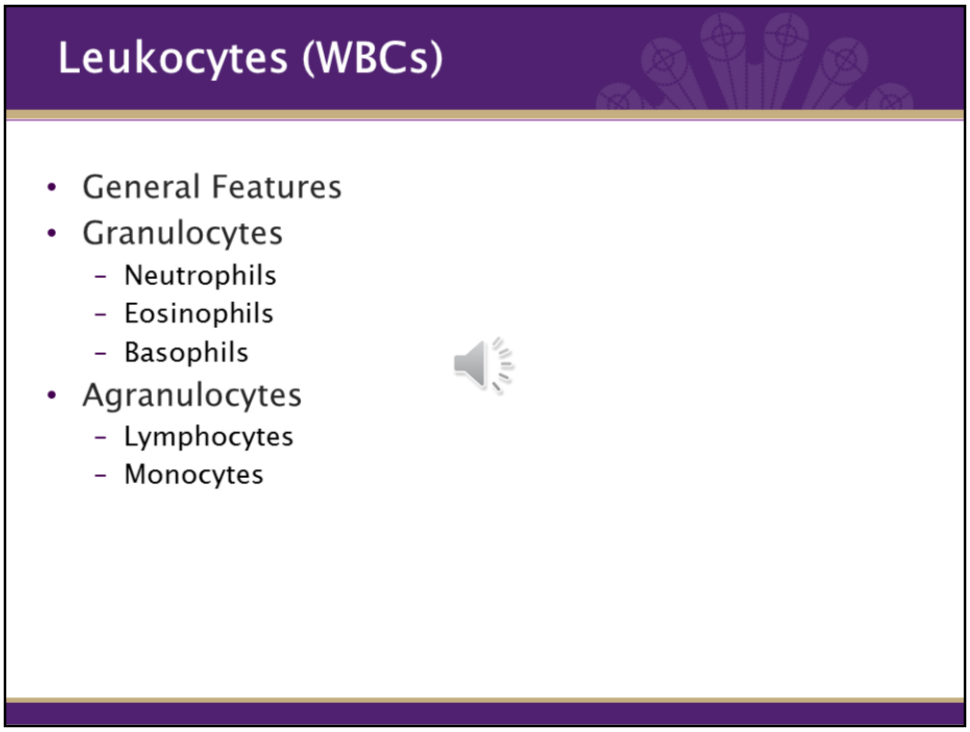
Type AB has BOTH A and B antigens. It does not make any antibodies. If it did, the antibodies would always find a type of antigen they could bind to and the body would

attack itself. AB can only donate to other AB's. Everyone else makes a type of antibody that would recognize at least one antigen on AB's RBCs. Because AB doesn't make any antibodies, they can receive from everyone.



The second antigen group we want to talk about is the Rhesus antigen or Rh Factor. We refer to these types as either positive or negative. Rh positive individuals have the antigen, but do not make the antibodies. They can receive from both types but can only donate to other Rh+ individuals. Rh negative do not have the antigen and have the capability of making antibodies. Unlike with the ABO antibodies, Rh- individuals only make the antibodies after they have been exposed to positive blood. They can donate to both positive and negative individuals, but can only receive from Rh-.

When we consider a person's blood type in a medical situation, we identify their blood based on both the ABO and Rh antigens. For example, we would say a person is A+, meaning they have type A and type Rh+ antigens on their RBC surface. When we talk about a blood transfusion, we are not normally talking about whole blood, but rather packed red blood cells. Plasma and platelets are separated out. You can receive whole blood, but you need to be a little more cautious because the donor's antibodies will be in the plasma and that can cause some reactions. Also, you can donate just plasma and platelets. They have a special machine that separates the plasma or platelets and puts your RBC back into your body.



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.

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.

2. Eosinophils have counts that fluctuate daily and seasonally, they fight allergens, parasites and worms.

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.

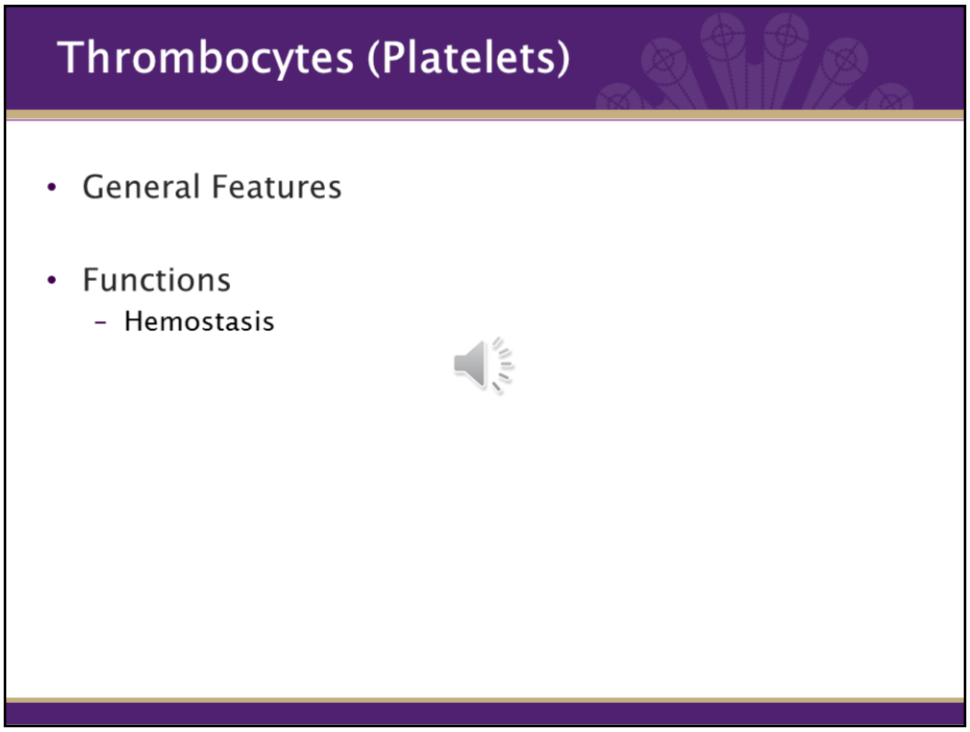
Agranulocytes do not have cytoplasmic granules and there are two types.

1. Lymphocytes are very abundant and the smallest in size. They

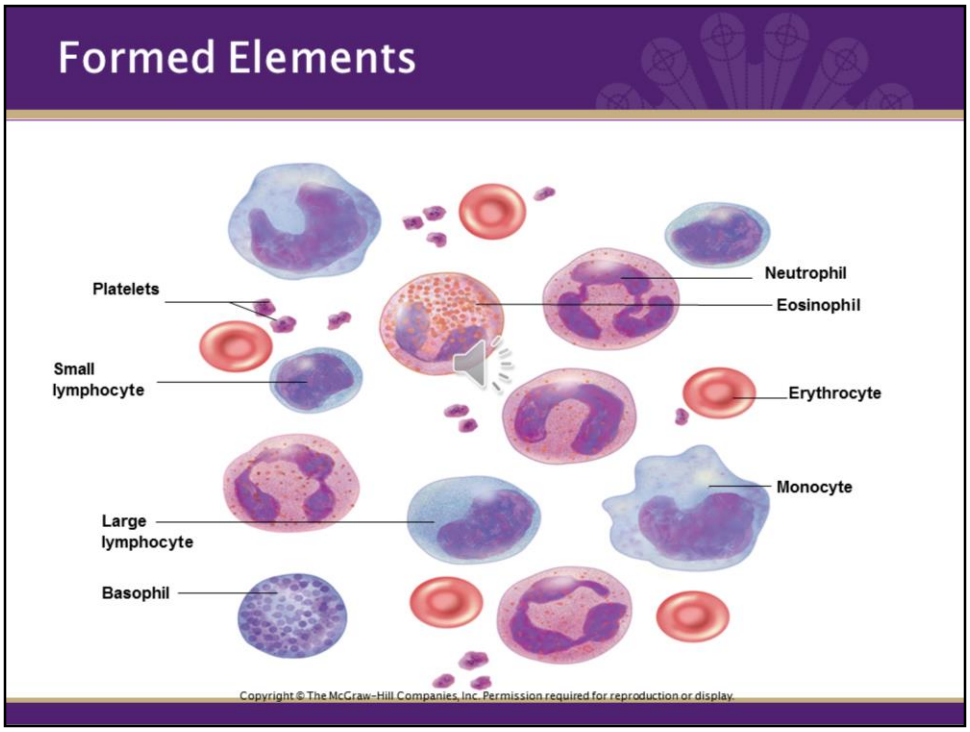
destroy cancer cells, cells infected with viruses and foreign cells. They are important for immune memory, secret antibodies, and coordinate immune cells.

2. Monocytes are the largest in size of the WBCs. They phagocytize pathogens, dead neutrophils, and debris in dead cells. They activate the immune system and differentiate into macrophages. A macrophage is any cell of the body that is specialized for phagocytosis.

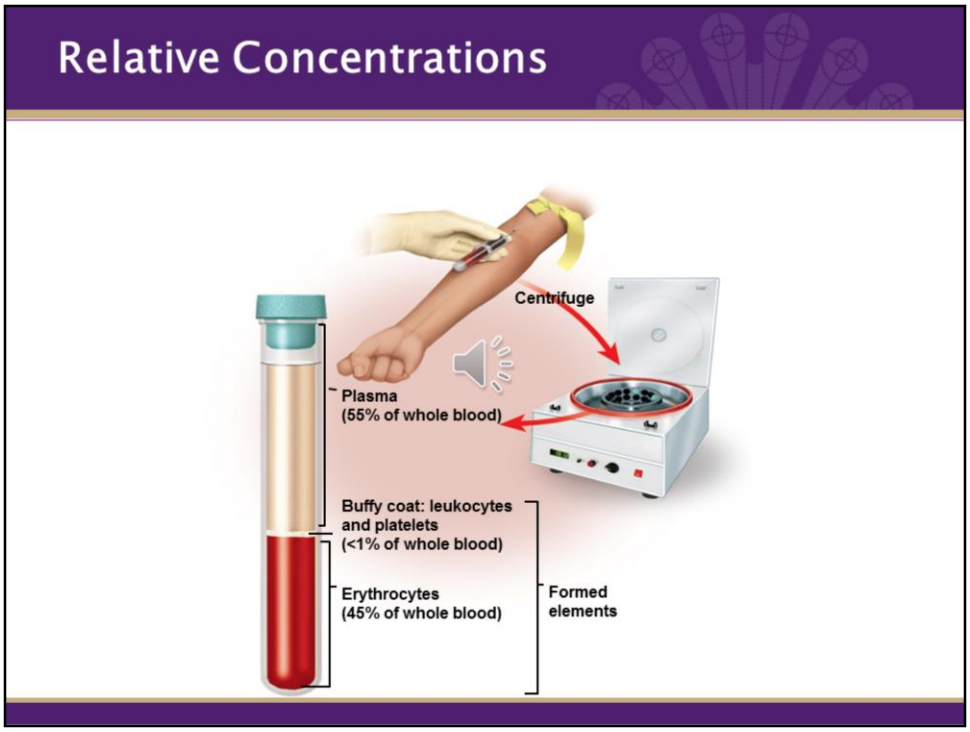
Granulocytes typically live for 4-5 days. Lymphocytes live for a few weeks to decades. And, macrophages can live for years.



Platelets, also called thrombocytes, are not true cells, they do not have a nucleus but do retain their lysosomes and mitochondria. They are actually 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. They also help to limit blood lose by sticking to collagen fibers. Additionally, they remove old and useless blood clots and they attract neutrophils and monocytes to sites of inflammation and stimulate other tissues for blood vessel repair.



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.

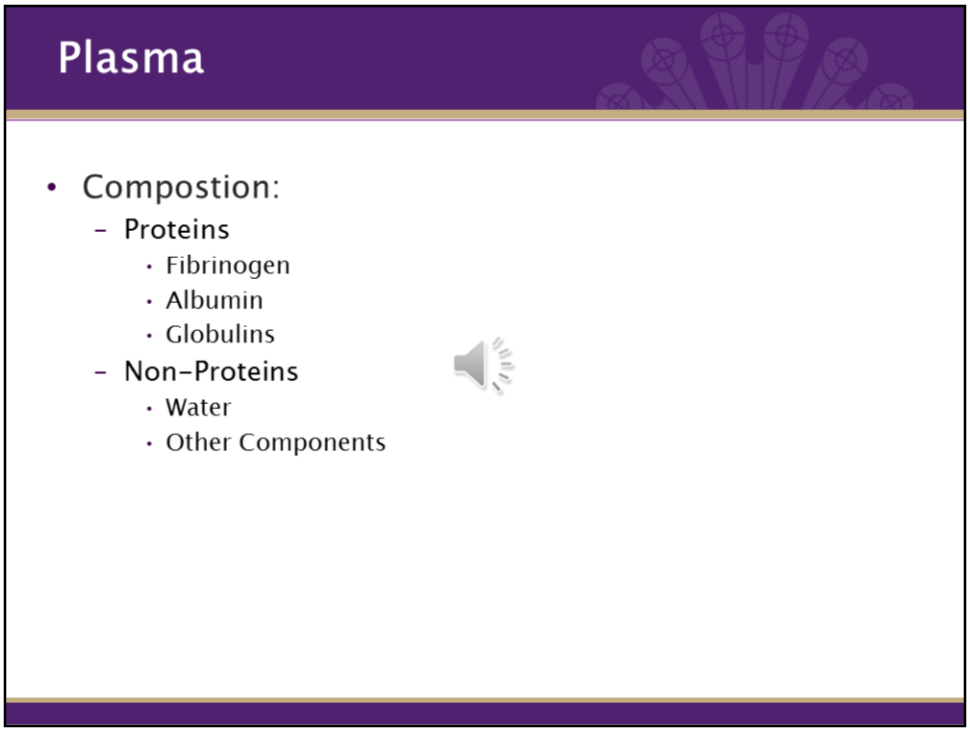


To find the relative concentrations of the formed elements and plasma we spin a tube of blood to separate the various substances.

RBCs go to the bottom of the tube and make up about 45% of volume (packed cell volume or hematocrit level).

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

The top portion of the tube is Plasma. Plasma is 55% of the total blood volume.



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

There are three primary proteins:

1. Fibrinogen is a sticky protein that forms the framework of a blood clot.

2. Albumin is the most abundant plasma protein. It can influence blood pressure, volume, and flow (thickness or stickiness of blood). 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 also aids in the transportation of solutes, blood clotting and immunity

Plasma also has non-protein components:

1. Water makes up 92% of plasma.

2. Other components are electrolytes, nutrients, urea, hormones, gases