LECTURE 1: BLOOD

INTRODUCTION
Cardiovascular system- consists of circulating fluid (Blood), a pump (heart) and a medium through which the blood travels (blood vessels). In this lecture we will discuss the blood and our next lecture will cover the heart and blood vessels.

Recall from your anatomy and physiology I lecture that blood is a fluid connective tissue i.e. blood is a population of cells (the RBCs, WBCs and Platelets) scattered within a cellular matrix (the plasma). However there are differences between blood and the other connective tissues: The cells are not formed within the connective tissue (in other word blood cells are formed in bone marrow not within blood), and the matrix is not produced by the blood cells but by many other cells (in other word fluid diffuses into the blood vessels from form other cells and interstitial fluid. Blood cells are produced in bone marrow from a single stem cell. Stem cells first commit to become either myeloid or lymphoid cells. Myeloid cells then choose among four main lines of differentiation (RBCs, megakaryocytes (develop platelets), granulocytes, monocytes), while lymphoid cells mature to lymphocytes. Blood plasma contains plasma proteins, electrolytes, organic molecules (e.g. glucoses, amino acids), waste substances (e.g. urea, creatinin). The plasma proteins play the main role of providing the “colloid” osmotic pressure that sucks fluid back into capillaries from the interstitial space. Inadequate levels, due to liver disease or malnourishment, result in ascites, accumulation of fluid in the peritoneal cavity.

Mature erythrocytes (RBC) are enucleated (without nucleus i.e. RBC have no nucleus) and are shaped like a cookie with a thumb indentation on both sides (shaped like a donut with a hole that doesn't go all the way through). Without a nucleus, the red blood cell has one major function: to deliver oxygen to the tissues. Their size is approximately equivalent to the diameter of the smallest capillaries; hence, erythrocytes must pass through the capillaries. A typical RBC has a life span of about 120 days. Mature erythrocytes are enucleated and are.

The erythrocytes (WBC) defend the host (human body) are like honeybees defending the hive. Both die in the process but the host (hive) lives on i.e. honeybees are WBC that defend the hives (human body) against any invasion, and in the process of defending the hives honeybees (WBC) and attackers (Pathogen, Bacteria) dies. A moderate elevation of WBCs (leukocytosis) is often a sign of infection. Very high counts may indicate leukaemia.

Platelets and plasma protein fibrinogen, Calcium, Vitamin K play major role in blood clotting. Some drugs like aspirin are anticoagulant (blood thinners). Individuals suffering from alcoholism often have coagulation (blood clotting) problems due to liver injury that reduces the levels of coagulation proteins (fibrinogen) made by the liver. Vitamin deficiencies from poor nutrition also contribute to clotting pathologies.

The bloodstream is like a river flowing past a city. The people in the city (the cells) pull out of the river what they need (oxygen, nutrients) and dump into it their wastes (carbon dioxide, urea) for downstream processing by the lungs and kidneys. In Adult Circulating blood provide nutrient, oxygen, chemical instruction to roughly 75 trillion cells.

Among blood’s many functions, transport of oxygen to the tissues is the most important. In order for cells to run aerobic metabolism, they require oxygen. Without oxygen, the tissues begin to break down. Blood is also needed in trauma situations.

Embryos do not need CVS in early stages because diffusion across their exposed surface provide oxygen and remove waste product. Diffusion becomes inadequate when embryo reaches few millimeters because Oxygen and Nutrients consumption increases thus diffusion cannot keep up with the amount of oxygen and nutrients consumed. Therefore CVS is the first system to become fully operational (heart starts beating end of week 3).
OVERVIEW
1. Blood is a type of connective tissue whose cells are suspended in a liquid extracellular matrix, called plasma.
2. Blood volume varies with body size, fluid and electrolyte balance, and adipose content.
   a. Average blood volume (70 kg male) is 5 liters.
3. Components
   a. Blood can be separated into two major components: Formed elements and Plasma
      i. Blood cells or "formed elements" (about 45% of blood), which is composed mainly of red blood cells (RBC) i.e. 99% of blood cells are RBC and the other 1% is white blood cells (WBC) and platelets. NOTE: because 99% of formed elements are RBC, usually the percentage of formed elements determine percentage of RBC
         1. Quantitative analysis of this portion of blood represents the hematocrit (HCT) reading or packed cell volume (PCV).
      ii. Plasma (about 55% of blood), liquid portion that contains water, plasma proteins (fibrinogen, albumin, globulin), organic molecules (amino acids, carbohydrates, lipids, ATP), vitamins, hormones, electrolytes, and cellular wastes (urea, uric acid, creatinin, bilirubin).
4. Physical Characteristics and Volume
   a. Blood is a slightly basic (pH = 7.35–7.45) fluid that has a higher density and viscosity than water, due to the presence of formed elements.
   b. Normal blood volume in males is 5–6 liters, and 4–5 liters for females.
5. Functions
   a. Blood transports substances between body cells and the external environment and helps maintain a stable internal environment i.e. blood is the medium for delivery of oxygen and nutrients, removal of metabolic wastes to elimination sites, and distribution of hormones.
   b. Blood aids in regulating body temperature, body fluid pH, and fluid volume within fluid compartments.
   c. Blood protects against excessive blood loss through the clotting mechanism, and from infection through the immune system.

BLOOD COMPOSITION
Whole blood is composed of Plasma (55%) and Formed elements (also called blood cells) (45%)

Formed element is composed of three types of cells, including erythrocytes (red blood cells) make up 99.9% of blood cells, leukocytes (white blood cells), and thrombocytes (platelets). White blood cells include: Neutrophils; Eosinophils; Basophils; Monocytes; and Lymphocytes
Plasma makes up about 46-63% of blood volume. Blood plasma consists of mostly water (92%) and solutes about 1% (including nutrients, gases, hormones, wastes, ions), and proteins (7%).
BLOOD CELLS
Blood is composed of **three types** of cells, including erythrocytes (red blood cells), leukocytes (white blood cells), and thrombocytes (platelets).

1. **The Origin of Blood Cells**
   b. Hemopoiesis first appear in the yolk sac of the 2-week embryo i.e. yolk sac is primary site of blood formation for the first 8 week. After 8 weeks ((2nd month to 5th month) the liver, and spleen are primary sites of blood formation. In adult all the various types of blood cells are produced in the red bone marrow, and all types of blood cells arise from a single type of cell stem cell called Hemocytoblast.
   a. The type of cells produced is regulated by: The need for the type of blood cell (for example during infection more of WBC will be produced, during bleeding more of platelets will be produced)
      i. Specific types of hematopoietic growth factors produce differentiation resulting in specific types of cells.
         1. Myeloid stem cells
         2. Lymphoid stem cells

ERYTHROCYTES (RED BLOOD CELLS)
**Overview:** Erythrocytes, or red blood cells, are small cells that are biconcave in shape. They lack nuclei and most organelles, and contain mostly hemoglobin. Hemoglobin is an oxygen-binding pigment that is responsible for the transport of most of the oxygen in the blood. Hemoglobin is made up of the protein globin bound to the red heme pigment. Hematopoiesis, or blood cell formation, occurs in the red bone marrow. Erythropoiesis, is the formation of erythrocytes, begins when a myeloid stem cell is transformed to a proerythroblast, which develops into mature erythrocytes. Erythrocyte production is controlled by the hormone erythropoietin. Dietary requirements for erythrocyte formation include iron, vitamin B₁₂, and folic acid, as well as proteins, lipids, and carbohydrates. Blood cells have a short life span due to the lack of nuclei and organelles; destruction of dead or dying blood cells is accomplished by macrophages. Erythrocyte Disorders include anemia which are characterized by a deficiency in RBCs, and polycythemia which is characterized by an abnormal excess of RBCs.

2. **Characteristics of Red Blood Cells (RBC) = Erythrocytes**
   a. RBC has biconcave disc like shape that increases its surface area
   b. RBC are the most abundant blood cells (99.9% of formed element) i.e. 99.9% of blood cells are RBC
   c. RBC count is done as the number of RBC/ml of whole blood. In adult 1ml whole blood contain:
      i. In male there are 4.5-6.3 million RBC per milliliter of blood
      ii. In female there are 4.2-5.5 million RBC per milliliter of blood
   d. RBC contains **hemoglobin**, which is loosely bound to oxygen.
   e. Hemoglobin is a globulin protein + heme and iron
   f. Hemoglobin consists of 4 polypeptides each chain holds a Heme group containing on Iron atom.
      i. Oxymemoglobin (when hemoglobin is bound to oxygen) = bright red
      ii. Deoxymemoglobin (when hemoglobin is not bound to oxygen) = darker red
   g. Mature RBC **lack nuclei** (i.e. RBC are anucleate) and organelles such as mitochondria, leaving more room for hemoglobin and oxygen. NOTE: recall from your Anatomy and Physiology I that Mitochondria are an organelle that uses oxygen to generate energy. The function of RBC is to deliver oxygen. If RBC had mitochondria it would use the oxygen instead of delivering it to the cells. It would like if a pizza delivery guy, eats the pizza and by the time he get to the destination, the pizza is finished.

3. **Red Blood Cell Production and Its Control**
   a. Production (Erythropoiesis)
i. In fetuses = yolk sac, liver, spleen
ii. In adults = red bone marrow

b. Control of Production
i. RBC number remains relatively stable.
ii. Negative feedback mechanism involving the hormone erythropoietin, which is produced and secreted by the special cells in the kidney and liver.
   1. Erythropoietin is released from kidney and liver into circulation.
   2. Erythropoietin targets red bone marrow (in epiphyses of long bones and spongy bone of flat bones), stimulating erythropoiesis.

4. Dietary Factors Affecting RBC Production
a. B12, folic acid, and iron are all needed for RBC production. Thus deficiency in any one of them will disrupt RBC production.

5. Lifespan
a. Average life-span = 120 days
b. After 120 days about 10% hemolysis (rupture) and 90% are engulfed by phagocytes.
c. Phagocytic cells recognize damaged RBC and engulf them before hemolysis, and recycle their AA (Amino Acid) and Iron i.e. liver and spleen macrophages destroy worn RBCs, and then hemoglobin is broken into globin and heme. Iron in Hb is recycled i.e. Fe2+ from heme is either stored in phagocyte or released into blood. If released in the blood, then Fe2+ binds to transferrin (a protein that transports iron), and transported to bone marrow, liver and spleen for reuse (so it could be recycled to make new RBC). Heme is broken into biliverdin and then biliverdin is converted into bilirubin and then bilirubin is excreted with bile. Note: Liver damage e.g. blockage of bile ducts leads to increase level of bilirubin in blood. As the level of bilirubin increases it diffuses from the blood to tissues and give them yellow color (Recall from you’re A&P I that diffusion is movement of molecules from area of high concentration to an area of low concentration).

LEUKOCYTES (WHITE BLOOD CELLS)
Overview: Leukocytes, or white blood cells, are the only formed elements that are complete cells and make up less than 1% of total blood volume. Leukocytes are critical to our defense against disease and removal of cellular debris i.e. it is our WBC that defend us against pathogens (disease causing bacteria) and they remove toxins, waste material and abnormal cells (for example we discussed how worn out RBC are removed and recycled by Macrophages). WBC are classified into Granulocytes and Agranulocytes. Granulocytes are a main group of leukocytes characterized as large cells with lobed nuclei and visibly staining granules; all are
phagocytic. Granulocytes include: **Neutrophils** which are the most numerous type of leukocyte and they are active phagocytes; **Eosinophils** which are relatively uncommon and attack parasitic worms; and **Basophils** which are the least numerous leukocyte and release histamine to promote inflammation. Agranulocytes are a main group of lymphocytes that lack visibly staining granules. Agranulocytes include: Lymphocytes; and Monocytes which become macrophages and activate T lymphocytes.

1. **Types and Function of WBCs**
   a. There are five types of leukocytes that **function to control disease**.
   b. Leukocytes are divided into granulocytes and agranulocytes:
      i. **Granulocytes include:**
         1. **Neutrophils:**
            a. Most abundant WBC = 54%-62%; **Phagocytosis of** foreign particles (disease organisms & debris); **Increased in acute bacterial infections**
         2. **Eosinophils:**
            a. 1-3% of total WBC; Kill parasites and are responsible for **allergic reactions**; increased during parasitic infections (tapeworm, hookworm); **Release histamine during allergic reactions**
      3. **Basophils:**
         a. <1% of total WBC; **Release heparin** which inhibits blood clotting; **Release histamine**, a vasodilator that serve as helpful inflammatory responses (for example increases blood flow to damaged tissue); **May leave bloodstream and develop into mast cells** (antibodies attach and cause mast cell to burst, releasing allergy mediators.
      ii. **Agranulocytes include:**
         1. **Monocytes:**
            a. 3-9% of total WBC; **phagocytosis (monocytes are phagocytic cells)**; they are the largest WBC; when monocytes leave the blood and enter tissues they become macrophage; increased during typhoid fever, malaria, and mononucleosis
         2. **Lymphocytes:**
            a. 5-33% of total WBC; live for several months to years (only leukocyte that lives more than a few days); smallest WBC; function in immunity

2. **WBC Counts**
   a. Average WBC count (WCC) = **5000-10,000 WBC’s / mm³ blood**
   b. Number of WBC’s increases during infections
   c. **Differential white blood cell count (DIFF)** indicates % of each particular leukocyte.
   d. **Leukemia** = abnormal (uncontrolled) production of specific types of immature leukocytes.

**THROMBOCYTES (BLOOD PLATELETS)**

**Overview:** Platelets are not complete cells, but fragments of large cells called megakaryocytes. Platelets are critical to the clotting process, forming the temporary seal when a blood vessel breaks. Formation of platelets involves repeated mitoses of megakaryocytes without cytokinesis.

1. **Fragments of giant cells called megakaryocytes**
2. **Normal count = 130,000-360000 platelets/ mm³ blood.**
3. **Function** = **blood clotting** (will be discussed in more detail later).
BLOOD PLASMA

Blood plasma is clear, yellow liquid, composed of water, proteins, nutrients, gases, electrolytes and many more substances.

1. Water:
   a. 92% of plasma is water; water functions as solvent, enables transportation of nutrients and other material, temperature regulation, and serves as site of metabolic reactions.

2. Proteins
   a. Plasma Proteins include: Albumin; Globulin; Fibrinogen and other plasma proteins.
      i. Albumins: makes up about 60% of plasma proteins. Albumin controls osmotic pressure of plasma, transport FA(fatty Acid), thyroid hormones
      ii. Globulins: makes up about 35% of plasma proteins. Example of these proteins are: Antibodies/Immunoglobulin- Attack foreign protein and pathogen i.e. their function is defense of the body against pathogens. Transport Globulin- bind small ions, hormones and compounds and transport them e.g. Thyroid-binding globulin- transport thyroid hormones; Metalloproteins- Transport Metal Ions; Apoloproteins - Carry triglycerides and other lipids; Steroid Binding Proteins - Transport steroids
      iii. Fibrinogen – Form insoluble strands of fibrin leads to blood clotting i.e. they play role in blood clotting
      iv. Other Plasma Proteins: Prolactin; Thyroid Stimulating Hormones (THS)

3. Summary Plasma Proteins:
   a. 7% of plasma volume
   b. all produced in the liver
   c. Three types:
      i. Albumin: maintains osmotic pressure of cells, transports fatty acids
      ii. Globulins: play role in defense e.g. antibodies = immunoglobulin
      iii. Fibrinogen: blood clotting

4. Plasma Gases:
   a. Oxygen (needed for cellular respiration) – RBC deliver oxygen from the lung to the cells throughout the body.
   b. Carbon dioxide (produced by cell respiration) – RBC collect CO₂ from the cells and deliver them to the lungs for elimination.

5. Plasma Nutrients (Organic molecules found in plasma):
   a. Organic nutrients are used for ATP (energy) production, growth,
   b. Organic nutrients include: Amino acids; Monosaccharaides (i.e. glucose); fatty acids

   a. Urea (by product of amino acid metabolism i.e. when cell breaks down amino acids urea is
produced as by product/waste product),
b. Uric acid (nucleotide metabolism)
c. Creatinin (creatin metabolism)
d. Bilirubin (hemoglobin metabolism)

7. Plasma Electrolytes:
   a. Includes sodium, potassium, calcium, magnesium, chloride, bicarbonate, phosphate, and sulfate
   b. Maintain osmotic pressure, resting membrane potential, and pH.

8. Regulatory Substances:
   a. Enzymes – speed up chemical reaction by lowering the activation energy
   b. Hormones – are chemical messengers produced by glands.

HEMOSTASIS
Definition: Hemostasis = stoppage of bleeding from a blood vessel. 3 steps involved in hemostasis i.e. hemostasis consists of three phases: Vascular phase (Blood Vessel Spasm); Platelet phase (plug formation); Coagulation phase

1. Blood Vessel Spasm (vessel walls constrict)
   a. Vasospasm i.e. a cut or damage to the endothelial cells of blood vessel triggers vascular spasm. Vasospasm reduces blood flow due to narrowing of the blood vessel diameter. The vascular phase of hemostasis lasts for roughly 30 minutes after the injury occurs.
   b. The endothelial cells contract and release endothelins which stimulate smooth muscle contraction and endothelial division. The endothelial cells become “sticky” and adhere to platelets and each other.

2. Platelet Plug Formation
   a. The platelet phase of hemostasis begins with the attachment of platelets to sticky endothelial surfaces, to the basement membrane, to exposed collagen fibers, and to each other. As they become activated, platelets release a variety of chemicals that promote aggregation, vascular spasm, clotting, and vessel repair.
   b. Platelets become sticky and adhere to one another.
   c. Platelets also release the hormone serotonin, which causes further vasoconstriction of the vessel.

3. Blood Coagulation = formation of a blood clot
   a. complex cascade of events (positive feedback mechanism)
   b. Requires calcium ions (Calcium is needed for activation of clotting factors). Also vitamin K is needed (Vitamin K is essential for the functioning of several proteins involved in blood).
   c. Chain reactions of enzymes and proenzymes via two pathways (Extrinsic and Intrinsic) convert circulating fibrinogen into insoluble fibrin i.e. Coagulation, or blood clotting, involves a complex sequence of steps leading to the conversion of circulating fibrinogen into the insoluble protein fibrin. As the fibrin network grows (like spider web), blood cells and additional platelets are trapped in the fibrous tangle, forming a blood clot that seals off the damaged portion of the vessel.

   i. Extrinsic Clotting Mechanism
      1. Starts when platelet contacts damaged tissue or tissue outside of blood vessel (hence, extrinsic)
      2. Cascade leads to prothrombin activator (PA) release by platelets
      3. PA and Ca$^{2+}$ cause prothrombin to convert to thrombin
      4. Thrombin catalyzes the final step i.e. conversion of fibrinogen to fibrin.
         a. Fibrin threads make up meshwork of clot.

   ii. Intrinsic Clotting Mechanism (all factors normally found in blood)
      1. Starts when blood contacts a foreign substance
2. Cascade again leads to same final steps as above.
   a. Final step = fibrinogen → fibrin.

4. Fate of Blood Clots
   a. A formed clot retracts and pulls the edges of a broken blood vessel together.
   b. A thrombus is an abnormal blood clot in a vessel.
   c. An embolus is a clot or fragment of a clot that moves in a vessel.
   d. Heparin is an anticoagulant
      i. Heparin prevents blood clotting by inhibiting the formation of prothrombin activator and the action of thrombin on fibrinogen. So if there is no prothrombin, then there will be no thrombin, and if there is no thrombin, then there will be no fibrin, because thrombin converts fibrinogen to fibrin.

BLOOD GROUPS AND TRANSFUSIONS
1. Antigens and Antibodies
   a. Antigens (Ag) are substances that trigger immune response
   b. Most Ag are proteins recall from you’re A&P I that plasma membrane consist of bilayer of phospholipids and proteins are embedded in the membrane. Membrane proteins can be receptor proteins, channel proteins or recognition proteins. So some of the plasma proteins are used by our WBC to distinguish self (its own cells) from foreign (cells that are none self i.e. bacterial cells and cells of other individuals). So cell membrane proteins can be considered as surface Ag i.e. Ag are proteins found on the surface of cells.
   c. Antibodies are also proteins produced by B lymphocytes (also called B Cells) against an Ag i.e. if a membrane protein is recognized as foreign by WBC, then Ab against that protein will be produced by B lymphocytes. NOTE: antibodies that are produced against non-self antigens circulate in our plasma.

2. Blood type is determined by the presence or absence of specific surface Ag on the surface of RBC membrane
   a. Three important Ag (proteins) on the surface of RBC membrane are: A, B, and Rh (D). Two of the Ag (Ag A and Ag B) determine blood type, and one of the Ag (Ag D) determine Rh of the blood. NOTE: Antigen = agglutinogens, and Antibodies = agglutinins
      i. If there is Ag A on the surface of RBC, then the person would have blood type A- (blood type A Rh minus)
      ii. If there is Ag A and Ag D on the surface of RBC, then the person would have blood type A+ (blood type A Rh plus)
      iii. If there is Ag B on the surface of RBC, then the person would have blood type B minus (blood type B Rh minus)
      iv. If there is Ag B and Ag D on the surface of RBC, then the person would have blood type B+ (blood type B Rh plus)
      v. If there is Ag B and Ag A on the surface of RBC, then the person would have blood type AB minus (blood type AB Rh minus)
      vi. If there is Ag A and Ag B and Ag D on the surface of RBC, then the person would have blood type AB+ (blood type AB Rh plus)
      vii. If there are no Ag A, no Ag B and no Ag D on the surface of RBC, then person would have O- (blood type O Rh minus)
      viii. If there are no Ag A, no Ag B on the surface of RBC but there is Ag D on the surface of RBC, then person would have O- (blood type O Rh minus)
   b. Any Ag (protein) that is missing from the surface of RBC, the person will have Abs against it. For example if a person has blood type A+, then it means he/she has Ag A and Ag D on the surface of their RBC, and Ag B is missing. Thus this person will have Ab against Ag B. So any RBC that has Ag B on their surface will be attacked by the Ab found in the plasma of this
person. Therefore this person cannot receive blood type AB- or B- or B+ or AB+, because they all contain Ag B in their surface.

3. **Summary of Blood type**
   a. Type A blood = antigen A on RBC
   b. Type B blood = antigen B on RBC
   c. Type AB blood = both antigen A & B on RBC
   d. Type O = neither A or B antigen on RBC
   e. Antigen D present on RBC = Rh positive;
   f. Lack of antigen D on RBC = Rh negative
   g. A person with **type O** blood is considered the **universal donor**.
   h. A person with **type AB** blood is considered the **universal recipient**.

![Blood Type Diagram](image)

If you have Type A blood, your plasma contains anti-B antibodies, which will attack Type B surface antigens. If you have Type B blood, your plasma contains anti-A antibodies, which will attack Type A surface antigens.

4. **Antibodies** in plasma:
   a. Shortly after birth, we spontaneously develop antibodies against RBC antigens that are not our own (i.e. non-self).
   b. Antibodies formed include:
      i. Persons with Type A blood, develop Anti-B antibodies
      ii. Persons with Type B blood, develop Anti-A antibodies
      iii. Persons with Type AB blood, do not develop either Anti-A or Anti-B antibodies
      iv. Persons with Type O blood, develop both Anti-A and Anti-B antibodies.
### Major Blood Cell Summary Table

<table>
<thead>
<tr>
<th>Major Blood Cell Type</th>
<th>Red Blood Cell</th>
<th>White Blood Cell</th>
<th>Platelet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Name</td>
<td>Erythrocyte</td>
<td>Leukocyte</td>
<td>Thrombocyte</td>
</tr>
<tr>
<td>Circulating Concentration/mm³ blood</td>
<td>4-6 million/mm³ blood</td>
<td>5-10,000/mm³ blood</td>
<td>130,000-360,000/mm³ blood</td>
</tr>
<tr>
<td>General Function</td>
<td>Transportation of oxygen</td>
<td>fight infection/ control disease</td>
<td>blood clotting</td>
</tr>
<tr>
<td>Key Characteristic</td>
<td>Has no nucleus and organelles such as mitochondria; more than 95% of proteins in RBC is hemoglobin</td>
<td>Has nucleus, some are phagocytic (e.g. monocytes, neutrophils), B-Cells produce Antibody</td>
<td>are fragments of giant megakaryocyte i.e. they are formed from cells in the bone marrow called megakaryocyte, has no nucleus; release serotonin</td>
</tr>
</tbody>
</table>

### White Blood Cell Summary Table

<table>
<thead>
<tr>
<th>Specific WBC</th>
<th>Function/ Event of Increase?</th>
<th>Differential %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutrophil</td>
<td>general phagocytosis (most active as phagocytes); acute bacterial infections</td>
<td>54%-62% (The most numerous white blood cells in peripheral circulation)</td>
</tr>
<tr>
<td>Eosinophil</td>
<td>kills parasites involved in inflammation and allergic reactions</td>
<td>1%-3%</td>
</tr>
<tr>
<td>Basophil</td>
<td>Inflammatory reactions: releases heparin (natural anticoagulant) and histamine (inflammation)</td>
<td>less than 1%</td>
</tr>
<tr>
<td>Monocyte</td>
<td>phagocytosis of large particles typhoid, malaria, mononucleosis</td>
<td>3%-9%</td>
</tr>
<tr>
<td>Lymphocyte</td>
<td>produce antibodies/immunity viral infections, tissue rejection, tumors, whooping cough</td>
<td>25%-33%</td>
</tr>
</tbody>
</table>

### Summary of Plasma Proteins

<table>
<thead>
<tr>
<th>Plasma Protein</th>
<th>Their Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Globulin</td>
<td>Defense (e.g. Immunoglobulin = Antibodies) and Transportation</td>
</tr>
<tr>
<td>Albumin</td>
<td>Osmotic Pressure, the most abundant plasma protein</td>
</tr>
<tr>
<td>Fibrinogen</td>
<td>Blood clotting</td>
</tr>
</tbody>
</table>

### Summary of Blood, Plasma, Serum and Interstitial Fluid

Whole Blood = Plasma + formed elements
Plasma = Proteins + electrolytes (bicarbonate, magnesium, chloride, and potassium ions) + organic nutrients (glucose, amino acids, fatty acids) + water + waste (urea, uric acid, creatinin)
Serum = the same as plasma but without fibrinogen
Intestinal Fluid = fluid found in between the cells i.e. fluid outside the blood vessels. The chief difference between plasma and interstitial fluid involves the concentration of dissolved oxygen and proteins.

### Summary of ABO Interactions

<table>
<thead>
<tr>
<th>BLOOD TYPE</th>
<th>A</th>
<th>B</th>
<th>AB</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antigen on RBC</td>
<td>A</td>
<td>B</td>
<td>A and B</td>
<td>Neither A or B</td>
</tr>
<tr>
<td>Antibodies in plasma</td>
<td>B</td>
<td>A</td>
<td>Neither A or B</td>
<td>Both A and B</td>
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<tr>
<td>Compatible donors</td>
<td>A, O</td>
<td>B, O</td>
<td>AB, A, B, O</td>
<td>O</td>
</tr>
<tr>
<td>Incompatible donors</td>
<td>B, AB</td>
<td>A, AB</td>
<td>NONE</td>
<td>A, B, AB</td>
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