BLOOD

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The Blood

◘ The Primary Function of Blood:

- to supply oxygen and nutrients as well as constitutional elements to tissues and to remove waste products.
- Blood also enables hormones and other substances to be transported between tissues and organs.
- Problems with blood composition or circulation can lead to downstream tissue malfunction.
- Blood is also involved in maintaining homeostasis by acting as a medium for transferring heat to the skin and by acting as a buffer system for bodily pH.

◘ Gas exchange

◆ Oxygen (O_2)

- **O_2** is the most immediate need of every cell and is carried throughout the body by the blood circulation.
- Oxygen is used at the cellular level as the final electron acceptor in the electron transport chain (the primary method of generating ATP for cellular reactions).
- Oxygen is carried in the blood bound to hemoglobin molecules within red blood cells.
- Hemoglobin binds oxygen when passing through the alveoli of the lungs and releases oxygen in the warmer, more acidic environment of bodily tissues, via simple diffusion.

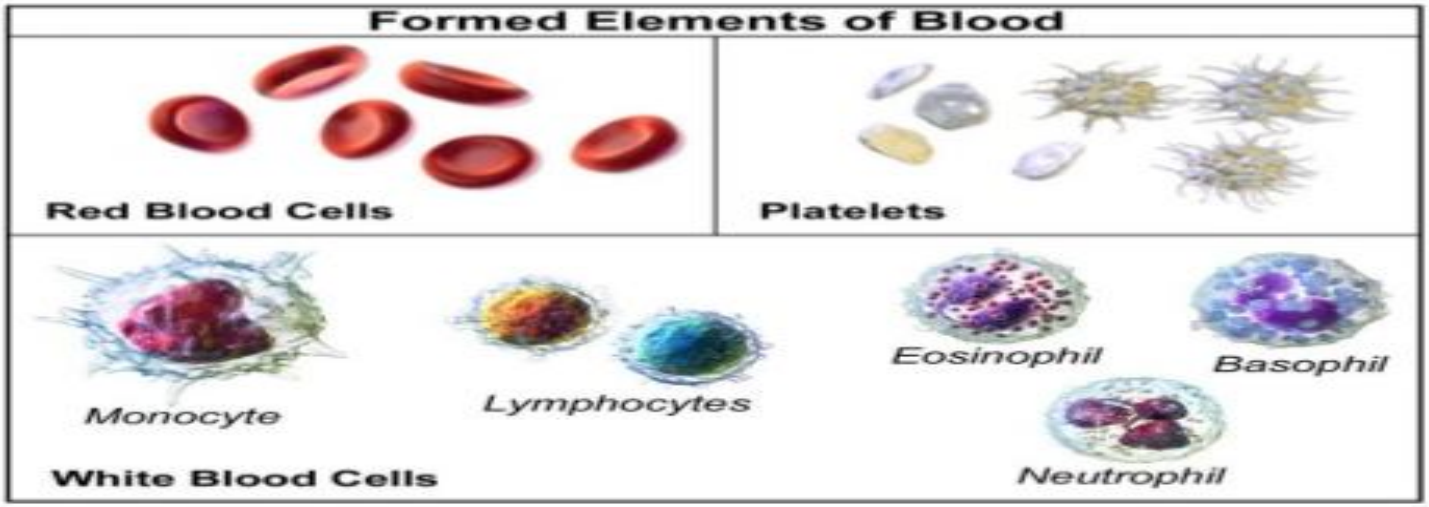
- **Carbon dioxide (CO_2)**
  - **CO_2** is removed from tissues by blood and released into the air via the lungs.
  - Carbon dioxide is produced by cells as they undergo the processes of cellular respiration.
  - Most of the carbon dioxide combines with water and is carried in the plasma as bicarbonate ions.
  - An excess of carbon dioxide (through exercise, or from holding ones breath) quickly shifts the blood pH to being more acidic (acidosis).
  - Chemoreceptors in the brain and major blood vessels detect this shift and stimulate the breathing center of the brain.
  - Hence, as CO_2 levels build up and the blood becomes more acidic, we involuntarily breathe faster, thus lowering CO_2 levels and stabilizing blood pH.
  - In contrast, a person who is hyperventilating (such as during a panic attack) will expire more CO_2 than being produced in the body and the blood will become too alkaline (alkalosis).

- **Blood composition**
  - **Blood** is a circulating tissue **composed of** fluid plasma and cells (red blood cells, white blood cells, platelets).
  - Anatomically, blood is considered a connective tissue, due to its origin in the bones and its function.
  - Blood is the means and **transport system of the body** used in carrying elements (e.g. nutrition, waste, heat) from one location in the body to another, by way of blood vessels.

- Blood is **made of** two parts:

1. Plasma which makes up 55% of blood volume.

2. Formed cellular elements (red and white blood cells, and platelets) which combine to make the remaining 45% of blood volume.



◆ **Plasma make up of**

- 90% water
- 7-8% soluble proteins (albumin maintains bloods osmotic integrity, others clot, etc)
- 1% electrolytes
- 1% elements
- 1% is salt, which helps with the pH of the blood.

◘ Plasma Proteins

◆ Albumins

- are the most common group of proteins in plasma and consist of nearly two-thirds of them (60-80%).
- They are produced in the liver.
- The main function of albumins is to maintain the osmotic balance between the blood and tissue fluids and is called colloid osmotic pressure.
- In addition, albumins assist in transport of different materials, such as vitamins and certain molecules and drugs (e.g. bilirubin, fatty acids, and penicillin).

◆ Globulins

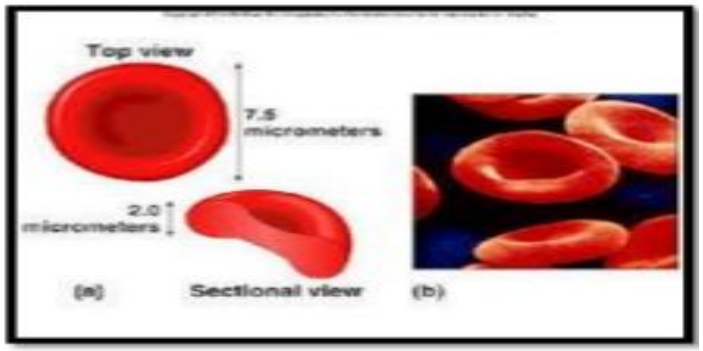
- are a diverse group of proteins, designated into three groups: gamma, alpha, and beta.
- Their main function is to transport various substances in the blood.
- Gamma globulins assist the body's immune system in defense against infections and illness.

◆ Clotting proteins

- are mainly produced in the liver as well.
- There are at least 12 substances, known as "clotting factors" that participate in the clotting process.
- One important clotting protein that is part of this group is **fibrinogen,** one of the main components in the formation of blood clots.

- In response to tissue damage, fibrinogen makes fibrin threads, which serve as adhesive in binding platelets, red blood cells, and other molecules together, to stop the blood flow.
- Plasma also carries **Respiratory gases**; CO_2 in large amounts (about 97%) and O_2 in small amounts (about 3%), various nutrients (glucose, fats), wastes of metabolic exchange (urea, ammonia), hormones, and vitamins.

Red blood cell (erythrocyte)



- also known as "RBC's, erythrocytes".
- RBC's are formed in the **myeloid tissue** or most commonly known as **red bone marrow**, although when the body is under severe conditions the yellow bone marrow, which is also in the fatty places of the marrow in the body will also make RBC's.
- The formation of RBC's is called **erythropoiesis** (erythro/ red; poiesis / formation).
- Red blood cells lose nuclei upon maturation, and take on a biconcave, dimpled, shape.
- They are about 7-8 mm in diameter, a thickness of 2.5 mm at the thickest point and 1 mm or less in the center.
- There are about 1000x more red blood cells than white blood cells.
- RBC's live about 120 days and do not self repair.
- RBC's contain hemoglobin which transports oxygen from the lungs to the rest of the body, such as to the muscles, where it releases the oxygen load.
- The hemoglobin gets it's red color from their respiratory pigments.

- **Shape**
  - RBC'S have a shape of a disk that appears to be "caved in" or almost flattened in the middle; this is called bi-concave.
  - This bi-concave shape allows the RBC to carry oxygen and pass through even the smallest capillaries in the lungs.
  - This shape also allows RBCs to stack like dinner plates and bend as they flow smoothly through the narrow blood vessels in the body.
  - RBC's lack a nucleus (no DNA) and no organelles, meaning that these cells cannot divide or replicate themselves like the cells in our skin and muscles.
  - RBC's have a short life span of about 120 days, however, as long as our myeloid tissue is working correctly, we will produce about 2-3 million RBC's per second.
  - That is about 200 billion a day! This allows us to have more to replace the ones we lose.
- **Concentration Of Red Blood Cells In The Blood**
  - In normal men, the average number of red blood cells per cubic millimeter is 5,200,000 (±300,000);
  - in normal women, it is 4,700,000 (±300,000).
  - Persons living at high altitudes have greater numbers of red blood cells.

♦ Quantity Of Hemoglobin In The Cells

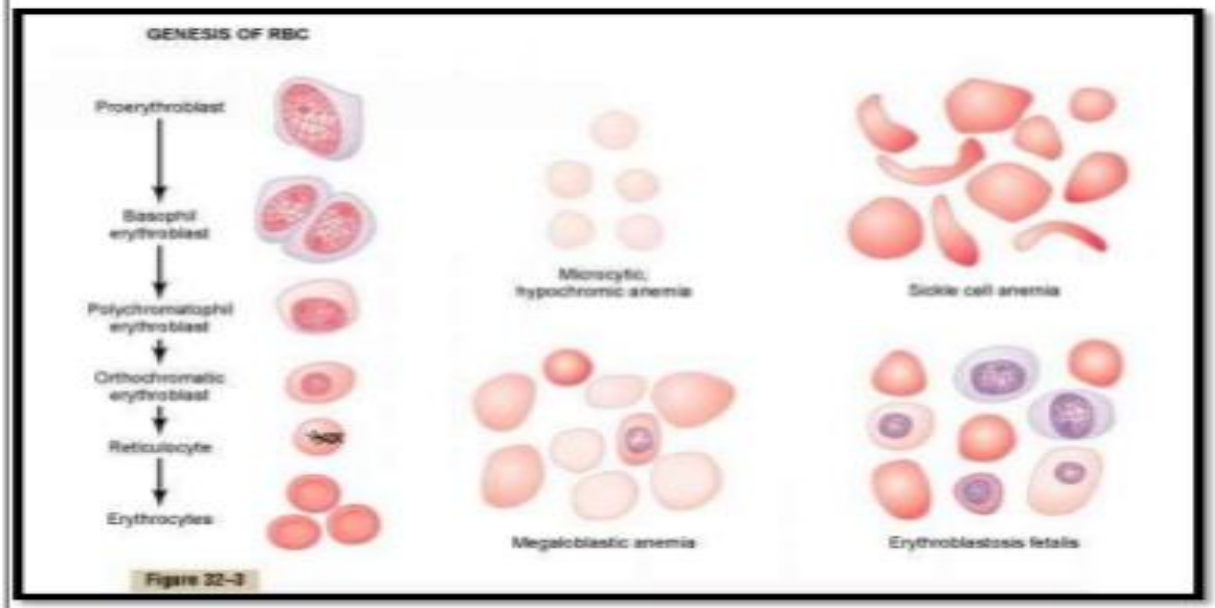
- Red blood cells have the ability to concentrate hemoglobin in the cell fluid up to about 34 grams in each 100 milliliters of cells.
- The concentration does not rise above this value, because this is the metabolic limit of the cell's hemoglobin-forming mechanism.
- Furthermore, in normal people, the percentage of hemoglobin is almost always near the maximum in each cell.
- However, when hemoglobin formation is deficient, the percentage of hemoglobin in the cells may fall considerably below this value, and the volume of the red cell may also decrease because of diminished hemoglobin to fill the cell.

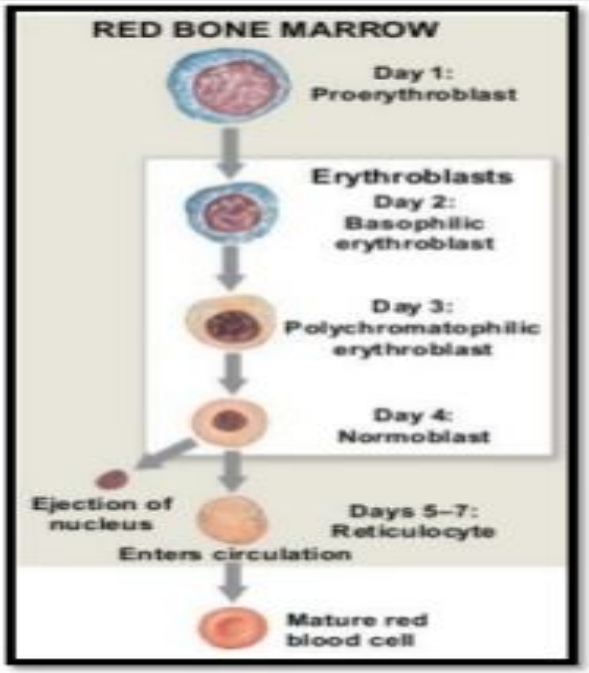
◘ Production Of Red Blood Cells

♣ Areas of the Body That Produce Red Blood Cells.

- In the **early weeks of embryonic life**, primitive, nucleated red blood cells are produced in the **yolk sac**.
- During **the middle trimester of gestation**, the **liver** is the main organ for production of red blood cells, but reasonable numbers are also produced in the **spleen** and **lymph nodes**.
- Then, **during the last month** or so of **gestation** and **after birth**, red blood cells are produced exclusively in the **bone marrow**.

◘ Stages of Differentiation of RBCs



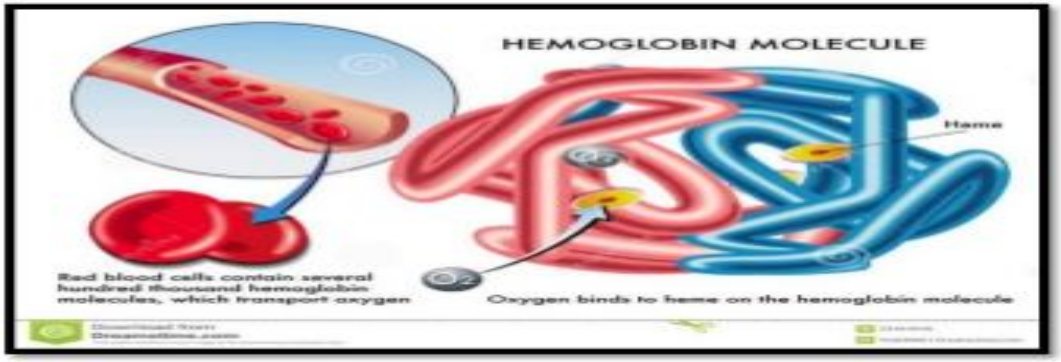


♣ Erythropoietin Stimulates Red Cell Production, and Its Formation Increases In Response To Hypoxia

- The principal stimulus for red blood cell production in low oxygen states is a circulating hormone called erythropoietin, a glycoprotein with a molecular weight of about 34,000.
- In the absence of erythropoietin, hypoxia has little or no effect in stimulating red blood cell production.
- But when the erythropoietin system is functional, hypoxia causes a marked increase in erythropoietin production, and the erythropoietin in turn enhances red blood cell production until the hypoxia is relieved.

◘ Main Component of RBCs

- The main component of the RBC is **hemoglobin** protein which is about 250 million per cell.
- The word hemoglobin comes from **hemo** meaning blood and **globin** meaning protein.
- This is the protein substance of four different proteins: polypeptide globin chains that contain anywhere from 141 to 146 amino acids
- Hemoglobin also is responsible for the cell's ability to transport oxygen and carbon dioxide.
- This hemoglobin + iron + oxygen interact with each other forming the RBC's bright red color.
- You can call this interaction by product **oxyhemoglobin**.

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