HEMATOLOGY
&LYMPH SYSTEM

physiology sheet

Number	1
Done BY	Abdullah Nimer
Correction	Ghufran Touma
Doctor	Saleem

Introduction

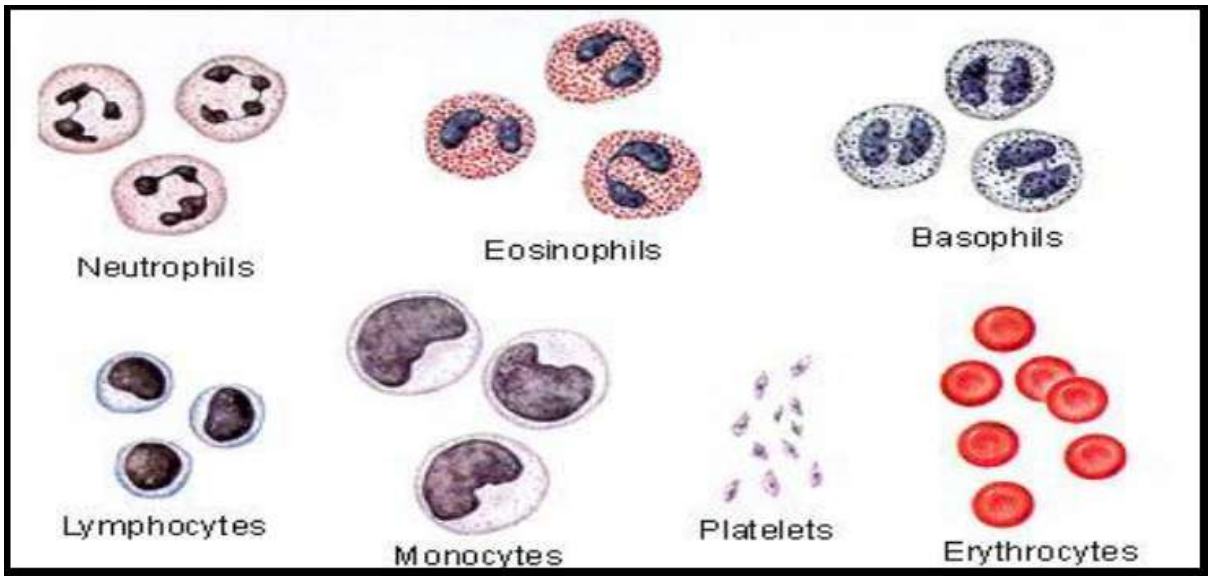
●Haematology and lymph system (MLS):

It is a branch of medicine concerned with the study, diagnosis, prevention and treatment of blood and lymph disorders. In MLS physiology, we are concerned about body fluids and the concept of the blood. We will talk about each type of blood cells as well as haematopoiesis. We will study also gas transport and homeostasis.

- What is blood?
  Blood is a specialized type of connective tissue. In the average 70-Kg man, the total body water is about **60%** of the body weight or about 45 litres of fluid, **5 litres of these fluids are blood.**
  -Blood is composed of:
  1- Blood plasma: %55.
  2- Blood cells (also called formed elements): %45.

  *If we take a tube full of uncoagulated blood (doesn't clot) and we centrifuge it for (5-10) minutes, we find that 45 percent is cells and 55 percent is plasma.

- Blood cells:



Cell type	Typical cell count
1- Erythrocytes (red blood cells-RBCs)	5X 10^{12} (men) 4.5 X 10^{12} (women)
2-leukocytes (white blood cells-WBCs):	7 x 10^{12}
Neutrophils	5X10^{9} (40-75%)
Eosinophils	I00X10^{4} (1-6%)
Basophils	40 X I0^{6}(<1 %)
Lymphocytes	0.4 X 10^{7} (2-10%)
Monocytes	1.5 X 10^{7}(20-45%)
3-Platelets	250 X 10^{7}

-> Normal red blood cell values are: (number of cells/ Volume unit):
- **In males**: about **5** million cells per µl
- **In females**: about **4** million cells per µl
- Males have higher RBC count than females because of **hormones** like **androgens** (i.e.: testosterone) which stimulate **RBC synthesis.**
-Volume units used when counting RBCs are:
1) Microlitre (µl) = Millimetre cubed (mm^3)
2) Millilitres (mL)
3) Litres (L).
- if the RBC count was 5 million cells (5x10^{6} cells) then:
5x10^{6} (cells/ µl) = 5x10^{6} (cells/ mm^3) = 5x10^{9} (cells/mL) = 5x10^{12} (cells/Litre).

- Plasma composition:
  Plasma is the blood without cells. It contains everything, but the main components of the plasma are:
  1. Water (%90-%92)
  2. Electrolytes like Na^+, K^+, Cl^-… (less than 1 percent)
  3. Gases O2, CO2… (very low since they don't dissolve well in water)
  4. Nutrients (amino acids, glucose…) about %3.
  5. Waste products (bilirubin, uric acid). About %1
  6. Plasma proteins (albumins, fibrinogens, globulins and prothrombin)→ about 6-7%.

- **Plasma proteins:**

●One of the most important components of the plasma are proteins as they are the functional part in the plasma.
Main plasma proteins are:

1. **Albumins**
2. **Fibrinogens**
3. **Globulins**
4. **Prothrombins**

-There are over 1400 different plasma proteins but the ones mentioned above are the most important, and **almost all plasma proteins are produced in the liver, so any disease that affect the liver will affect the production of those proteins.** (Special type of globulins, immunoglobulins, has another source of production which is **the lymphocytes**).

*__Clinical issue__: In liver diseases (like hepatitis or cirrhosis), the rate of proteins produced by the liver **will decrease**; therefore, the concentration of such proteins decreases. This will cause edema (due to albumin deficiency) and coagulopathy (due to fibrinogens deficiency).

-**Functions** of plasma proteins:

1. **Transport** functions (for gases, hormones, nutrients... etc.)
2. **Defence** functions by the **immunoglobulins** (produced by lymphocytes)
3. Blood **coagulation (fibrinogen and prothrombin)**
4. **Reserving body proteins**.
5. **Viscosity**: Fibrinogen and globulins contribute to the overall blood viscosity**. (**However**,** red blood cells have the greatest effect on blood viscosity.)
6. **Exchange of fluids between the capillaries and tissues by the oncotic or colloidal pressure** which is:

- produced mostly by **albumins**.
- Ranges from 25-28 millimetre mercury. (Some books say it's 32)

*Biochemical correlation:

●Amino acids in proteins are either **essential** or **non-essential** amino acids→

- **Essential amino acids**: Amino acids that are required for life and growth but are not produced in the body, or are produced in insufficient amounts, and must be supplied by protein-rich diet.
- **Non-essential amino acids**: Amino acids that are required for protein synthesis and can be synthesized by humans.

Table 1. Dietary Requirements for Amino Acids in Humans	
Essential	**Nonessential**
Histidine	Alanine
Isoleucine	Arginine
Leucine	Asparagine
Lysine	Aspartate
Methionine	Cysteine
Phenylalanine	Glutamate
Threonine	Glutamine
Tryptophan	Glycine
Valine	Proline
	Serine
	Tyrosine

●Also, we have the terms: complete proteins and incomplete proteins→

- **Complete proteins** provide all essential amino acids to sustain normal growth (like albumin).
- The most important complete proteins are present in: eggs, chicken and fish.
- **Incomplete proteins are provided** by vegetables, so vegetarians usually have amino acid deficiency because incomplete proteins don't provide all the sufficient amino acids.

- **Blood PH:**

*To perform all physiological functions, it's important to maintain plasma PH in a limited range.

*The pH of **the gastric juice** is **less than that of lemon juice**.

-> The pH scale of blood is different than that of water.

->Water:

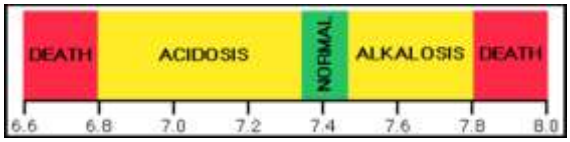
-acidic pH <7 -basic: pH>7

-> **Blood:**

-acidosis pH<7.35 -alkalosis: pH>7.45

* The range of the normal pH of the blood is from **7.35—7.45.**

* If the pH is below **6.8** or above **8,** death occurs.



- How does the pH affect the human being?

-It can **denature enzymes**

-Affects **CNS**

-Affects **Sodium-Potassium pumps** (because there is a close relationship between the hydrogen atoms and the potassium as they're always together); as a result, entry and exit of potassium is altered and the internal environment is disturbed.

- **Functions of the blood:**
  - **Transport** functions: transports carbon dioxide CO2, O2, free nutrients, waste products, hormones (from endocrine cells), and enzymes to various cells.
  - Regulates **body's pH** through **buffers** and **amino acids**.
  - Plays a role in **regulation of body temperature**, because the blood contains a **large volume of water**.
  - Regulates cells' **water content**, by dissolving sodium and chloride ions, the main electrolytes, **which in turn change the osmolarity of the blood**.
  - Prevents body fluid loss **through clotting mechanisms**.
  - **Protects against toxins and microbes** through special cells: white blood cells.

- **Blood distribution:**

  -> the blood is distributed as it follows:

Veins	**65-75%**
Arteries	**10-15%**
Lungs	**10%**
Capillaries	**5%**
Heart	**5%**

●Physiological changes in the blood volume are due to:

- **Gender**: there is a difference between males and females (males have a higher blood volume compared to that of females), due to hormones.
- **Pregnancy**: pregnant women have more plasma and blood volume.
- **Muscular exercise**: increases blood volume.
- **Posture**: In an upright posture, there is a reduction in blood volume of about 15% (it goes to the interstitial fluid).
- **Blood pressure**: rising blood pressure lowers blood volume
- **Altitude**: increases blood volume.
- **Excitement**: because of adrenaline release, blood volume is increased.
- **Contraction of spleen**, as it contains blood.

- **Dimensions of the Red Blood Cell (RBC):**

1- **MCV (the most important parameter)**:
MCV (mean corpuscular volume) which means **the average volume of red blood cells** (corpuscular is another name for RBCs).
The usual normal range (80-90) μm^3 OR fL*
-Sometimes, it might be lower than that, reaching (78,79) and sometimes it reaches (91,92) which is normal as well.
*fL (femtoliter) = μm^3 (micron cubic)

2- **Surface area**: normal range 132-138 μm^2.

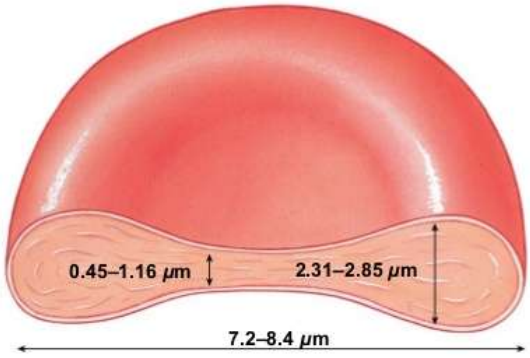
3- **Diameter**: 7.5-7.8 µm-- When the MCV changes, the other dimensions also change.

***Some numbers mentioned by the doctor differ from the one in slides.**

- By looking at RBCs, we can conclude that they do not have a nucleus inside (anucleated).
- Biconcave, disk shaped cells.

- They can change their shape to pass through capillaries (normally, RBCs are found in capillaries, and the absence of RBCs in capillaries indicates an abnormality.)

Figure 19-2c The Anatomy of Red Blood Cells



C A sectional view of a mature RBC, showing the normal ranges for its dimensions

- The main function of RBCs is:

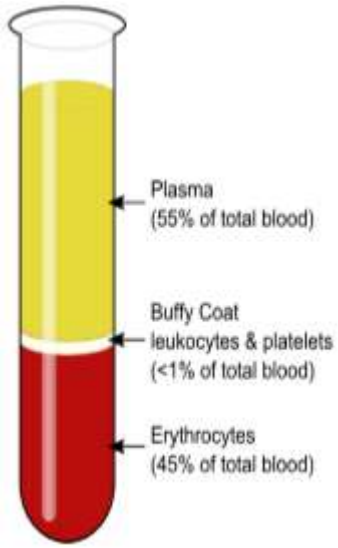
1- to carry and transport oxygen and CO2. The biconcave shape of RBCs gives the best surface area (higher than a spherical shape by 20-30 %) available to perform their function.

2- Retain haemoglobin inside the cell (if haemoglobin was free in plasma, this will raise the colloid osmotic pressure from 28 up to 70, which in turn will increase the load performed by the heart leading to death).

-Erythrocytes usually counts for:

5 million cell / µl in males 4 million cell / µl in females.

* µl= microliter -> the most common unit used for RBC count.



Blood = 45% cells + 55% plasma

This 45% represent mostly erythrocyte and less than 1% is Buffy coat (leukocytes and platelets).

The shape of RBCs is not uniform. Therefore, 2% of plasma are trapped in the RBC column and this plasma is called **trapped plasma**.

Haematocrit (HcT) is the volume of RBCs to the total blood volume, and can be referred to as the packed cell volume (PCV).