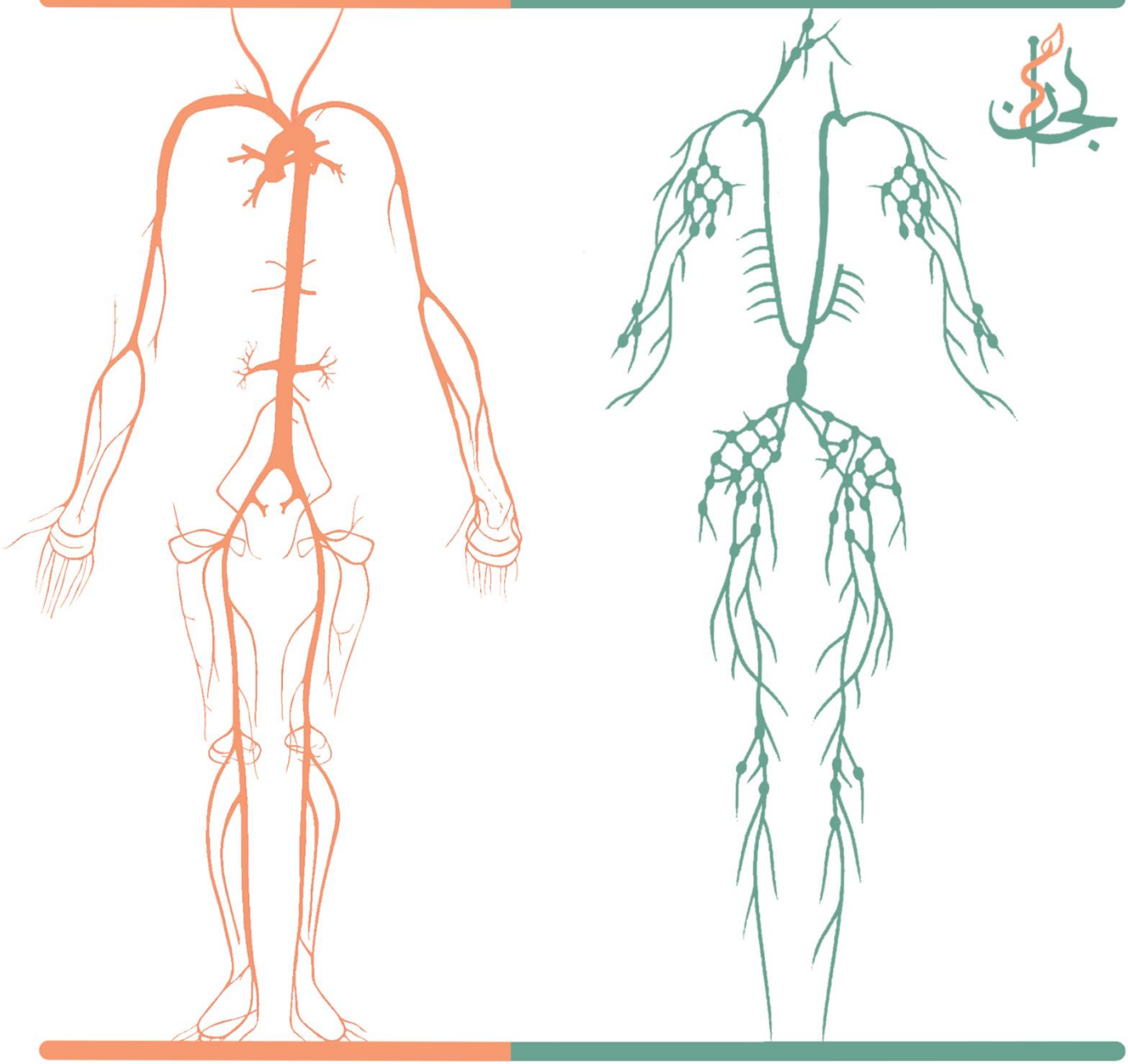
Physiology

HematoLymphatic



Title: Sheet 1 – Main Topic

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Introduction

Blood

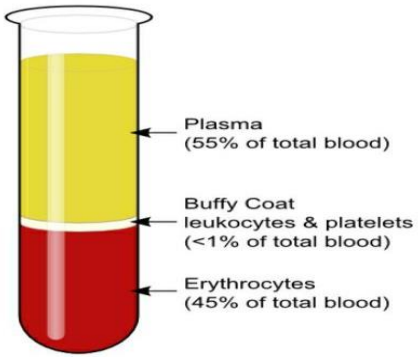
The total body fluid is 45L (about 65% of the bodyweight), 5L of these fluids are blood.

Blood is a specialized connective tissue composed of a **liquid portion** called plasma and a **cellular portion** (formed elements) consisting of various cells and cell fragments

If a sample of blood is centrifuged (spun) in a small glass tube, the cells sink to the bottom of the tube (sedimentate) while the lighter-weight plasma forms a layer on top of the tube.

Blood is about 45% formed elements and 55% plasma. Normally, more than 99% of the formed elements are red-colored **red blood cells** (RBCS).

Pale, colorless white blood cells (WBCs) and platelets occupy less than 1% of total blood volume. They form a very thin layer, called the buffy coat, between the packed RBCS and plasma in centrifuged blood.



1) Cellular portion (formed elements)

The formed elements of the blood include three principal components: red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes).

- Normal erythrocytes (RBCs) counts are:

In males: about 5 million cells per µL (4.3 - 5.9).
In females: about 4.5 million cells per µL (3.5 - 5.5).

- Males have higher RBCs count than females because of (1) hormones like androgens (i.e testosterone stimulates the synthesis of erythropoietin by the kidneys, which stimulates RBC synthesis (erythropoiesis)), also, (2)due to the excessive loss of blood during menstruation in women.
- Neutrophils are the most plentiful (abundant) leukocyte type.
- In a given blood sample, normal levels of eosinophils and basophils can be zero.

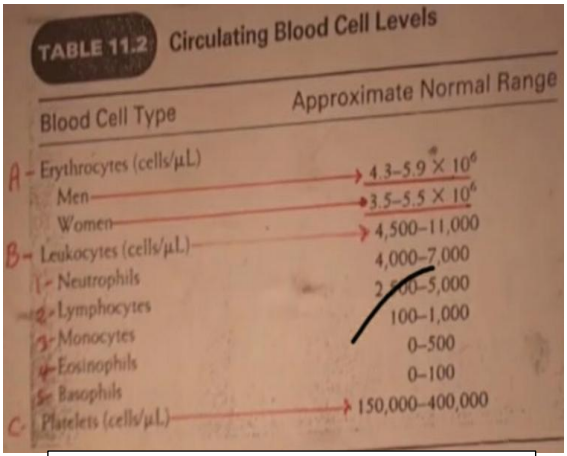


TABLE 11.2 Circulating Blood Cell Levels

Blood Cell Type	Approximate Normal Range
A- Erythrocytes (cells/µL)	
Men	$4.3–5.9 \times 10^6$
Women	$3.5–5.5 \times 10^6$
B- Leukocytes (cells/µL)	4,500–11,000
1- Neutrophils	4,000–7,000
2- Lymphocytes	2,000–5,000
3- Monocytes	100–1,000
4- Eosinophils	0–500
5- Basophils	0–100
C- Platelets (cells/µL)	150,000–400,000

- Used volume units when counting blood cells are: Microliter (µL) = Millimetre cubed (mm^3) ''identical units''.

2) Plasma

When the formed elements are removed from the blood, a liquid called blood plasma is left. Plasma is about 90% water and 10% solutes, most of which (**~6%** by weight=2.5mmol/L) are **proteins** (called plasma proteins), other solutes (~4%) in plasma include electrolytes (Na+,K+,Ca+2…) , nutrients (~3% of plasma ex: lipids , carbohydrates, vitamins, amino acids and trace elements..) , regulatory substances such as enzymes , hormones, gases, and waste products such as urea, uric acid, creatinine, ammonia, and bilirubin.

Plasma proteins: (12:24)

Almost all plasma proteins are produced in the liver, thus diseases affecting the liver function will influence the production of these proteins. There are over 1400 identified plasma proteins, the **main** plasma proteins are:

100 ml= 1 dl

a) Albumin (4.5 g/100 ml),the most abundant plasma protein and the main generator of oncotic pressure.
b) Fibrinogen (0.3 g/100 ml), contributes to plasma viscosity.
c) Globulins (2.5 g/100 ml). **Alpha and beta** globulins are produced by the liver, while **gamma** globulins (including Immunoglobins), are produced by the lymphocytes.
d) Prothrombins (<0.1 g/100 ml).

◇ Functions of plasma proteins:

1- Transportation (**α and β globulins**; for gases, hormones, nutrients, etc.)

2- Defense, through **immunoglobulins** (produced by lymphocytes).

3- Reserving body proteins even during hypoproteinemia; plasma protein may promptly pass out of the circulation to supply body needs for protein.

4- Viscosity, mainly due to **fibrinogen and globulins.**

5- Maintain exchange of fluids (osmotic functions) between the capillaries and tissues by the oncotic or colloid osmotic pressure which is mainly produced by **albumins.**

6- Blood clotting ‘’coagulation’’ through (fibrinogen (the precursor of fibrin), pro-thrombin (an α2-globulin), and other clotting factors (β-globulins).

¤Note: when we talk about blood, RBCs have the greatest effect on blood viscosity, but when we solely talk about plasma, fibrinogen has the greatest effect.
¤Note: Oncotic pressure normal value ranges from 25-28 millimeter mercury (mmHg)

◇ Complete and incomplete proteins

- Plasma proteins are made of amino acids. Amino acids are either essential, or nonessential.
Enzymes and many hormones are proteins. Proteins are composed of amino acids and have molecular weights of a few thousand to a few hundred thousand. More than 20 common amino acids form the building blocks for proteins . From these, nine are considered essential and must be provided by the diet . Although the nonessential amino acids are also required for normal protein synthesis , the body can synthesize them from other amino acids.

- **Complete proteins** contain all the nine essential amino acids, and they can supply all of the body cells in sufficient amounts to support normal growth and body maintainance.
  - ✓ The most important sources of complete proteins are **eggs, poultry and fish.**
- **Incomplete proteins** don't provide all of the essential amino acidds in amounts sufficient to sustain normal growth and body maintenance.
They are provided by vegetables. Vegetarians are exposed to develop amino acid deficiency because they don't take complete proteins , so they need to eat a variety of vegetables and soy proteins to avoid amino acids deficiency .

● Blood Distribution and Volume (18:24)

◇Blood distribution:

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

◇ Blood volume varies physiologically due to 7 factors:

1- Sex: for males, the blood volume is 10% higher than in females. This is due to greater number of RBCs.

2- Pregnancy: blood volume rises due to increase in **both cells and plasma.** In pregnant women, blood volume increases on the average by about 20 to 30%, in the last few weeks of pregnancy (due to hormonal changes).

3- Muscular exercise: it increases blood volume (probably due to contraction of the spleen: as it contains blood, it increases blood volume)

4- Posture: in the standing position (erect posture) there is a reduction in blood volume of about 15% (this15% "goes" into the interstitial fluid and tissue spaces).

5- Blood pressure: elevated blood pressure lowers blood volume by pressing out more fluid into the tissue spaces.

6- Altitude: at higher altitude the blood volume increases. Hypoxia (less oxygen is taken with each breath) stimulates RBCs production and thus increases blood volume.

7- Adrenaline injection /Excitement: when adrenaline is released, blood volume increases (probably due to Contraction of the spleen).

●Blood pH (7:42)

- Normal blood pH ranges from 7.35 - 7.45, the neutral point being 7.4.

- The pH scale of blood is different than that of water, due to having different neutral points; for water, it's 7 while in blood it's 7.4. Therefore, below 7.4 is acidic and above 7.4 is basic.

◇ When pH levels are above 8 or below 6.8, the following occurs:

1- Enzymes are denaturated and their function is disturbed. The most important enzyme that will be affected is the sodium-potassium pump (Na+ K+ ATPase).

2- Potassium levels are affected, and this disrupts the internal environment (blood homeostasis).

[extra: it's found that the plasma K+ concentration rises by 0.6 mEq/L for every 0.1 unit reduction of the extracellular pH].

3- Hyper- or hypo-excitability of the CNS.

● FUNCTIONS OF BLOOD (10:38)

1. It transports oxygen from the lungs to all cells of the body.

2. It transports carbon dioxide from the cells to the lungs.

3. It transports nutrients from the digestive organs to the cells.

4. It transports waste products from the cells to the kidneys, lungs, and sweat glands

5. It transports hormones from endocrine glands to the cells .

6. It transports enzymes to various cells .

7. It regulates body pH through buffers and amino acids .

8. It plays a role in the regulation of normal body temperature because it contains a large volume of water (an excellent heat absorber and coolant) .

9. It regulates the water content of cells, principally through dissolved sodium ions.

10. It prevents body fluid loss through the clotting mechanisms.

11. It protects against toxins and foreign microbes through special combat - unit cells.

● RBCs (Erythrocytes) (21:00)

- RBCs are circular, biconcave, anucluated cells. Sometimes minor changes in their shape occur to aid in passing through capillaries. They don't leave capillaries (non motile cells).

- Erythrocytes usually count for 5 million cells/ µL in males and 4.5 million cells/ µL in females → 5 million cell/µL in Humankind.

- µL= micro liter, is the most common used unit for RBC count.

◇Dimensions of RBCs:

1- MCV (mean corpuscular/cell volume): it is the most important parameter, which is a measure of the average **volume** of red blood cells. The usual normal range is (80-90) µm³ OR fL. It might be lower than that reaching (78-79) and or higher reaching (91-92) which is normal. **[fL (femtoliter) = µm³ (micron cubic)]**

2- Surface area: normal range 135 ± 16 µm².

3- Diameter: 7.5-7.8 µm.

- MCV is elevated or decreased in accordance with the other red cell dimensions; surface area and the diameter.

◇Blood Parameters

1- RBCs count: actual number of RBCs within a given blood sample.

2- Hematocrit (Hct) or packed cell volume (PCV) : percentage of the volume of red cells relative to the total blood volume. It can be measured by the following equation:

$$Hematocrit = Height\ of\ the\ RBCs\ column\ /\ Height\ of\ the\ total\ blood\ column$$

The shape of RBCs is not uniform, they are biconcave desks, and therefore, around 2% of plasma is trapped within the RBCs in the tube.

It has been shown that hematocrit tests give approximate values, due to plasma trapped in the RBC layer.(therefore, the 45% is not completely RBCs).

Good luck 🤍