Blood and Body Fluids

Composition Of Blood :

Volume : 5 to 6 litres

Specific Gravity : 1.06

Colour : Red

PH : 7.2 to 7.4

Components : Plasma and Formed Elements

Formed or Cellular Elements include

Red Blood Cells (RBC) : 5to 6 millions / mm^3

White Blood Cells : 4000 to 11000 /mm3

Platelets : 1 to 3 lakhs / mm3

Plasma : 55 to 60 % of Blood

Colour : Straw Coloured

Water : 91 to 92 %

Solids : 8 to 9 %

Total Proteins : 7 to 8 gms %

Albumins : 4.3 to 4.6 gms % (68000 MW)

Globulins : 2.4gms % (140000 MW)

α globulins :

β globulins :

π globulins : Immunoglobulins

Fibrinogen : .3gms % (340000 to 400000 MW)

Other Solutes :

Electrolytes : Inorganic Salts Na^+ ,K^+ , Ca^{2+} ,Mg^+ (Cations) and Anions like Cl^- ,HCO_3 Phosphates and Sulfates

Nutrients : Products of digestion like glucose , amino acids ,fatty acids , glycerol , vitamins and minerals .

Gases : O_2 ,CO_2 and N_2

Regulatory Substances } : Enzymes , Hormones ,Vitamins

Waste Products : Urea ,Creatinine , Uric Acid ,bilirubin

Blood is the only **liquid connective tissue** that consists of **cells** surrounded by a liquid extracellular matrix called **Plasma .**

In the plasma are suspended **cellular elements** and **organic** and **inorganic substances .**

Physical Characteristics of Blood :

- Blood is denser and more viscous (thicker) than water and feels slightly sticky.
- The temperature of blood is 37.4^0C (98.4^0f), about 1^0 higher than oral or rectal body temperature .

It has a slightly **alkaline pH** ranging from **7.35 to 7.45.**

The **color** of blood varies with its **oxygen content.** When saturated with **oxygen,** it is **bright red.**

When unsaturated with oxygen, it is **dark red.**

Blood constitutes about **20%** of **extracellular fluid .**

It amounts to **8%** of the **total body mass.**

The **blood volume** is **5 to 6 liters** in an average adult male and **4 to 5 liters** in an average adult female.

The gender difference in volume is due to **differences** in **body size.**

Several hormones, regulated by negative feedback, ensure that **blood volume** and **osmotic pressure** remain relatively **constant.**

Especially important are the hormones **aldosterone**, **antidiuretic hormone**, and **atrial natriuretic peptide,** which regulate how much water is excreted in the urine .

Components of Blood

Whole blood has two components :

- **Plasma,** a watery liquid extracellular matrix that contains dissolved substances, and
- **formed elements**, which are **cells** and **cell fragments.**

If a sample of blood is centrifuged (spun) in a small glass tube, the red cells (which are more dense) sink to the bottom of the tube while the plasma (less dense) forms a layer on top .

The **percentage** of **total blood volume** occupied by **RBCs** is called the **hematocrit ;**

a **hematocrit** of **40** indicates that **40%** of the **volume** of blood is **composed** of **RBCs.**

The **normal range** of **hematocrit** for adult **females** is **38–46%** (average 42);

for **adult males,** it is **40–54%** (average 47).

The Hormone testosterone contributes to higher hematocrit in males.

Because the WBC are less dense than RBC but more dense than blood plasma, they form a very thin **buffy coat layer** between the **packed RBCs** and **plasma** in **centrifuged** blood .

Blood Plasma :

When the formed elements are removed from blood, a **straw-colored** liquid called **Blood Plasma** remains .

Blood plasma is about 91.5% water and 8.5% solutes, most of which (7% by weight) are proteins .

Blood is about **45% formed elements** and **55% blood plasma.**

More than **99%** of the formed elements are **red blood cells (RBCs).**

Pale, colorless white blood cells (WBCs) and platelets occupy less than 1% of the formed elements.

TABLE 19.1

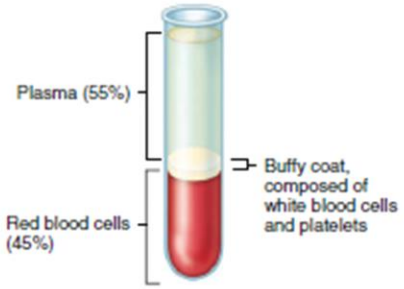
Substances in Blood Plasma

CONSTITUENT	DESCRIPTION	FUNCTION
Water (91.5%)	Liquid portion of blood.	Solvent and suspending medium. Absorbs, transports, and releases heat.
Plasma proteins (7%)	Most produced by liver.	Responsible for colloid osmotic pressure. Major contributors to blood viscosity. Transport hormones (steroid), fatty acids, and calcium. Help regulate blood pH.
Albumins	Smallest and most numerous plasma proteins.	Help maintain osmotic pressure, an important factor in the exchange of fluids across blood capillary walls.
Globulins	Large proteins (plasma cells produce immunoglobulins).	Immunoglobulins help attack viruses and bacteria. Alpha and beta globulins transport iron, lipids, and fat-soluble vitamins.
Fibrinogen	Large protein.	Plays essential role in blood clotting.
Other solutes (1.5%)		
Electrolytes	Inorganic salts; positively charged (cations) Na^+, K^+, Ca^{2+}, Mg^{2+}; negatively charged (anions) Cl^-, HPO_4^{2-}, SO_4^{2-}, HCO_3^-.	Help maintain osmotic pressure and play essential roles in cell functions.
Nutrients	Products of digestion, such as amino acids, glucose, fatty acids, glycerol, vitamins, and minerals.	Essential roles in cell functions, growth, and development.
Gases	Oxygen (O_2).	Important in many cellular functions.
	Carbon dioxide (CO_2).	Involved in the regulation of blood pH.
	Nitrogen (N_2).	No known function.
Regulatory substances	Enzymes.	Catalyze chemical reactions.
	Hormones.	Regulate metabolism, growth, and development.
	Vitamins.	Cofactors for enzymatic reactions.
Waste products	Urea, uric acid, creatine, creatinine, bilirubin, ammonia.	Most are breakdown products of protein metabolism that are carried by the blood to organs of excretion.

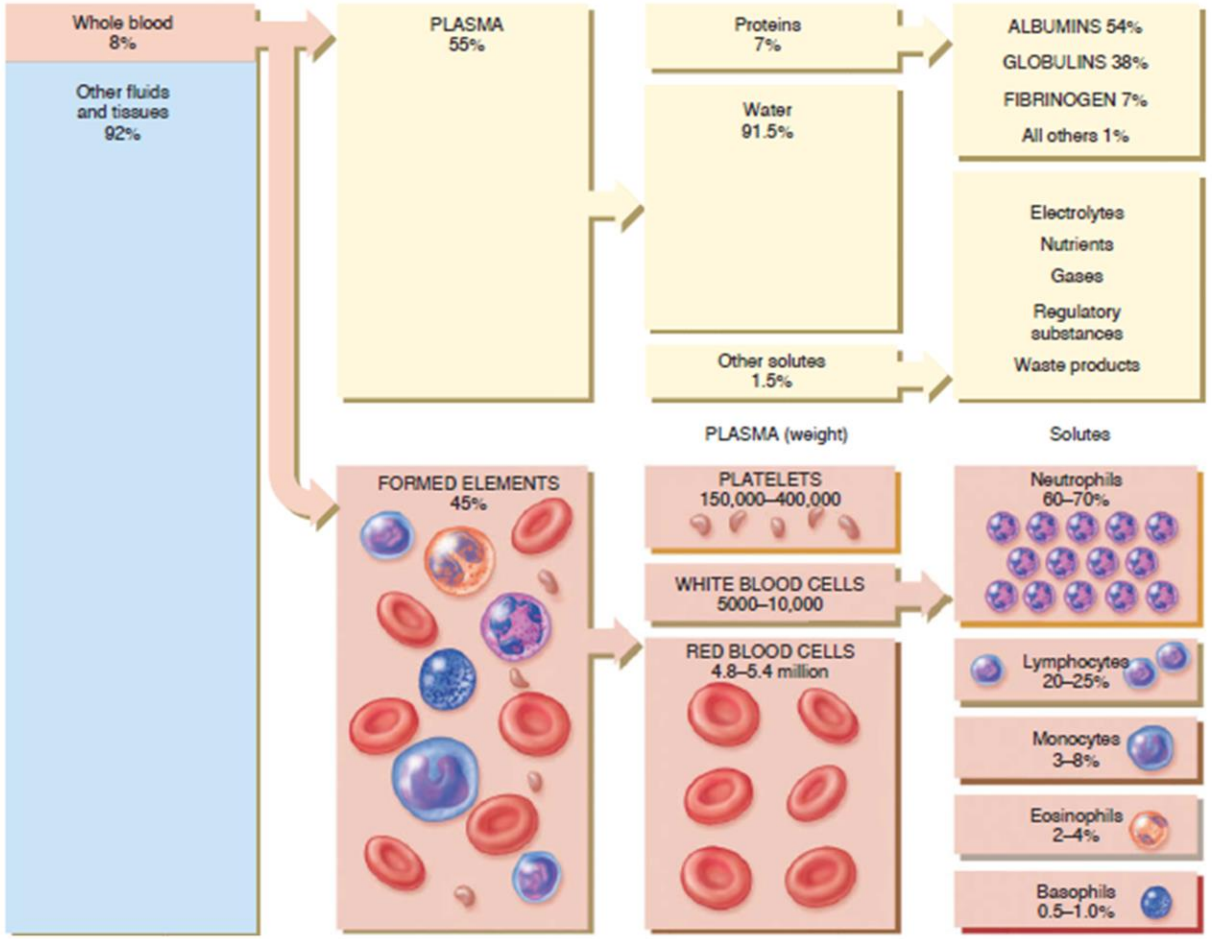
FUNCTIONS OF BLOOD

1. Transports oxygen, carbon dioxide, nutrients, hormones, heat, and wastes.
2. Regulates pH, body temperature, and water content of cells.
3. Protects against blood loss through clotting, and against disease through phagocytic white blood cells and proteins such as antibodies, interferons, and complement.

and complement.



(a) Appearance of centrifuged blood



Plasma Proteins constitute **7gms per 100 ml.** of blood .

Plasma Proteins are mainly **synthesized** in the **Liver .**

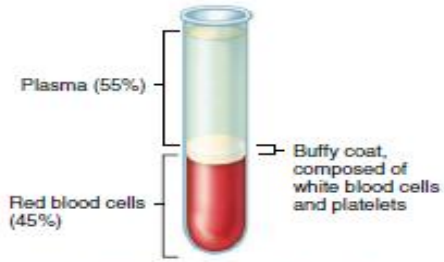
Albumins constitute **54 %** , **Globulins 38 %** and **Fibrinogen** 7% of the total weight of Plasma Proteins .

Certain blood cells develop into cells that produce gamma globulins, an important type of globulin. These **plasma proteins** are also called **antibodies** or **immunoglobulins** because they are produced during certain immune responses.

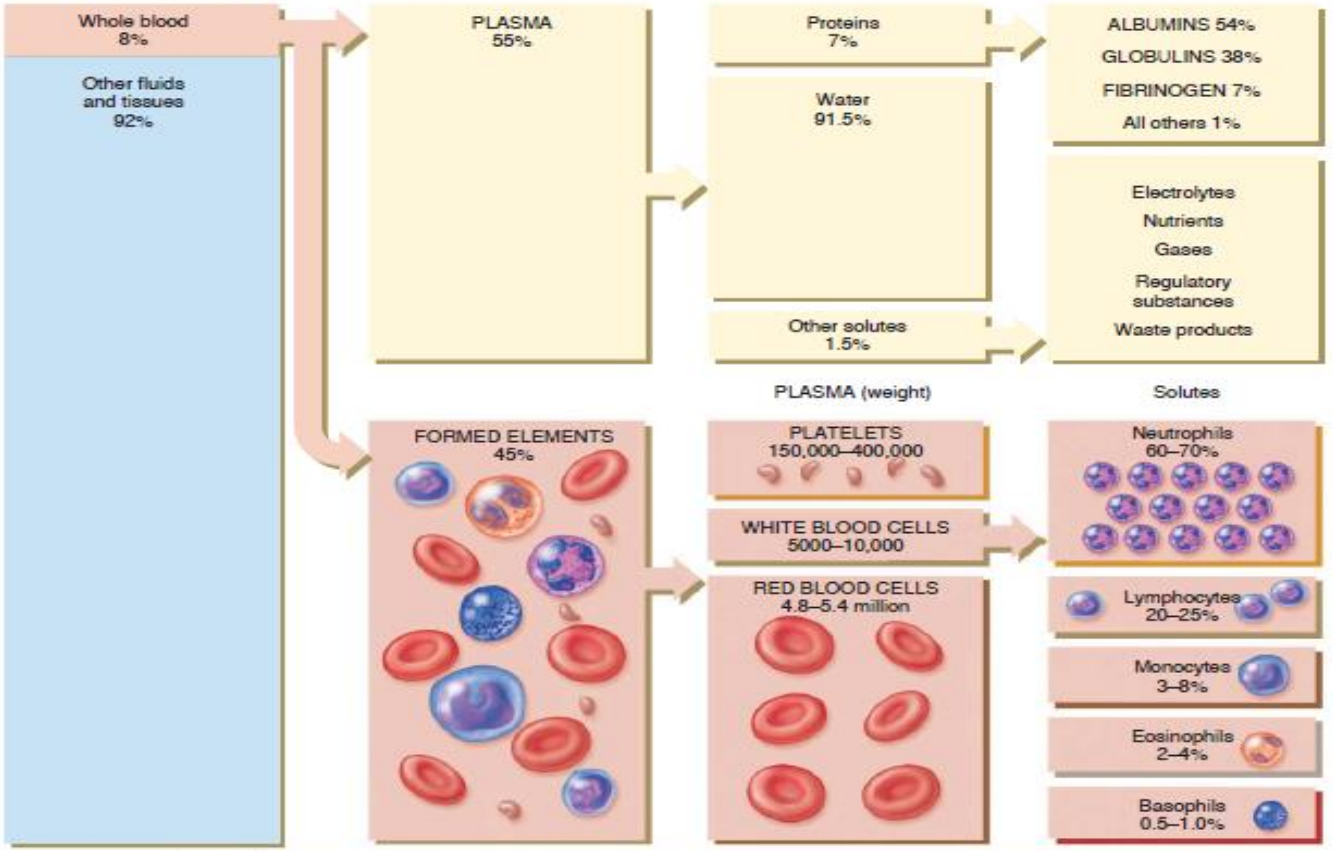
Besides proteins, other solutes in plasma include electrolytes, nutrients, regulatory substances such as enzymes and hormones, gases, and waste products such as urea, uric acid, creatinine, ammonia, and bilirubin.

and water content of cells.

and complement.



(a) Appearance of centrifuged blood



Formed Elements :

The **formed elements** of the blood include **three** principal components **:**

Red blood cells, White blood cells, and Platelets .

Red blood cells (RBCs) or **erythrocytes transport oxygen** from the lungs to body cells and deliver carbon dioxide from body cells to the lungs.

White blood cells (WBCs) or **leukocytes** protect the body from invading pathogens and other foreign substances.

White Blood Cells(4000 to 11000 /mm3)

are classified into :

- **Granulocytes** –Neutrophils----60 to 70 %

  Basophils ----- .15%

  Eosinophils---- 3 to4 %

- **Agranulocytes** – Lymphocytes-Large-10 to 15 %

  Small—30 %to 40%

  Monocytes --- 3 to 8%

Platelets - are fragments of cells that do not have a nucleus. Their Count is 1 to 3 lakhs /mm3

The **percentage** of **total blood volume** occupied by **RBCs** is called the **hematocrit ;**

a **hematocrit** of **40** indicates that **40%** of the **volume** of blood is **composed** of **RBCs.**

The **normal range** of **hematocrit** for adult **females** is **38–46%** (average 42);

for **adult males,** it is **40–54%** (average 47).

The Hormone testosterone contributes to higher hematocrit in males.

Lower values in women during their reproductive years also may be due to excessive loss of blood during menstruation.

A significant drop in hematocrit indicates **anemia,** a lower-than-normal number of RBCs.

In **polycythemia** the percentage of RBCs is abnormally high, and the h**ematocrit** may be **65%** or higher.

This **raises** the **viscosity** of blood, which **increases** the **resistance** to **flow** and makes the blood more difficult for the heart to pump.

Increased viscosity also contributes to **high blood pressure** and increased risk of **stroke.**

Causes of polycythemia include abnormal increases in **RBC production**, **tissue hypoxia, dehydration**, and **blood doping** or the use of EPO by athletes.

Red Blood Corpuscle :

The human mature RBC is a **biconcave** cell **without** a **nucleus .**

The average **diameter** of the RBC is about **7.5 microns .**

Its **thickness** at the **periphery** is **2.2 µ** and at the **centre** is **1 µ .**

The **red colour** of the RBC is due to the presence of **Hemoglobin** within its Cytoplasm .

Nearly 95 % of the weight of RBC is made up of Hemoglobin.

Normally an erythrocyte is almost saturated with Hemoglobin .

A healthy RBC can squeeze through a very narrow capillary without any damage to its stroma .

The **Life Span** of the RBC is **120 days .**

When the RBC becomes aged it becomes stiff and it ruptures as it squeezes through the capillaries .

Virtually al the functions of RBC are due to its Hemoglobin content .

Advantages of biconcavity of RBC :

1. The thickness of the RBC at its center is only 1 µ .This facilitates the diffusion of Oxygen through thin space .
2. It increase the Surface area of the RBC so that O2 has a bigger area for diffusion .
3. This facilitates the squeezing of the RBC through narrow Capillaries .

When the biconcavity is lost many of the advantages are lost.

Variation in the sizes of RBC is called **spherocytosis .**

Abnormal shapes of the RBC is called **Poikilocytosis.**

In **Heriditary Spherocytosis** the RBC loses its biconcavity and is **round** in shape.

So it ruptures as it passes through the Capillaries .

Functions of Blood :

1. Respiratory function .
2. Excretory Function .
3. Nutritional Function .

4. Transport Function .

5. Body temperature regulation .

6. Acid Base buffer function .

7.Defence Function .

1. Respiratory Function :

In the **lungs** the **Oxygen** from the **inspired air** where the **pO2** is higher **diffuses** along the pressure gradient into the venous blood perfusing the lungs where the pO2 Is lower .

The Hemoglobin of the RBC bind with the Oxygen and carries it to the tissues .

The **partial pressure** of **Oxygen** in blood being higher than that in the tissues **Oxy Hb.** delivers its **O2** into the tissues .

The metabolic end product of the tissues the CO2 diffuses from the tissues into the venous blood which is carried back to the lungs to be expired out. .

2. Defence Function :

The WBC of the blood play an important role in killing bacteria , viruses and other organisms which attack the body .

The WBC also mediate inflammation and initiate immune responses to foreign materials .

The **antibodies** and its **complement system** play a **vital role** in these **defense** responses .

2. Excretory Function :

The blood carries the waste products of metabolism like **urea** , creatinine , **sulphates, Phosphates, H+ ions** etc. to the kidneys where the glomeruli excrete into the tubules .

3. Nutritional Function :

Glucose ,amino acids , peptides ,small proteins , fatty acids , vitamins and minerals like iron ,copper ,Mg++ and electrolytes like Na +, K+ iodide etc. which are absorbed from the GIT are carried to the tissues for metabolic use .

4. **Transport Functions :**

The albumins and globulins of blood bind with hormones like thyroxine , cortisol etc and with minerals like **Iron** ,**Copper** and transport them to tissues .

5. Body temperature regulation :

The blood plays an important role in the **temperature regulation** of the body .

In warm blooded animals the blood helps to transport the heat generated within the deep organs to the skin and lungs for dissipation .

Excretory Function :

Blood carries the waste products of metabolism to their organs of excretion– CO_2 to the lungs , bilirubin to the liver, urea ,creatinine ,H^+ ions , bicarbonates ,sulphates and phosphates to the kidneys for excretion .

Maintainance of pH and Electrolyte Balance :

The Hb. of blood acts as an important acid –base buffer.

Through a constant exchange of molecules with the interstitial fluid , blood helps to maintain the pH and electrolyte concentration of interstitial fluid within the ranges required for normal function of cells .

Synthesis of Plasma Proteins .

Albumins and the vast majority of globulins and fibrinogen are synthesised in the liver .

In severe **hepatocellular disease** the plasma levels of albumin and other plasma proteins ↓.

Other important proteins synthesized in the liver are :

1. α –fetoprotein – a carrier protein
2. Antithrombin III –Protease inhibitor of intrinsic Coagulation System

3. Apolipoprotein B : Assembly of lipoprotein molecules
4. Angiotensinogen : precursor to Angiotensin II
5. Antithrombin C :
   and Protein C : } Inhibit blood clotting

6 . Insulin like growth factor I
7. Steroid Hormone binding Globulin .
8 . Thyroxine binding Globulin .
9. Transthyretin .

Specific Plasma Proteins :

Albumin :

Makes up about 60% of the total Plasma proteins .

It has a Half life of 19 days .

It maintains the Colloid Osmotic Pressure of Plasma .

Functions as a Carrier Protein for transport of Free Fatty Acids in plasma .

It transports heme from macrophages of spleen to the liver for excretion .

It also acts as a secondary carrier for thyroxine , cortisol and heme when the capacity of their primary plasma transport proteins are saturated .

In addition it binds many of the drugs given for the cure of diseases .

In Chronic Illnesses ,synthesis of albumin decreases and the plasma albumin levels are low ..

Globulins :

- In the form of hemoglobin .
- Glycoproteins in RBC stroma and membrane .
- Lipoproteins .

  These consist of α2 globulins and lipids and are important for transport of lipids in blood . They are divided into HDL ,LDL,VLDL.
- Immunoglobulins :

Seperation and Measurement of Plasma Proteins :

1. Precipitation by salting out technique .
2. Electrophoresis