PHYSIOLOGY OF BLOOD AND OTHER BODY FLUIDS

BY

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BLOOD

- Blood is the bright to *dark red fluid connective tissue* which *flows in a closed system of vessels*.
- It is an aqueous solution in which the major component, water dissolves many electrolytes

- and suspends other constituents such as cells, proteins, etc.

- Blood is made up of plasma (the fluid portion) and the formed elements (the blood corpuscles).

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Blood cont'd

- In the adult human being, there are about 5.6L of blood, making up 8% of the body weight.
- This volume is maintained within a normal range through control of water and electrolyte balance.

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Blood cont'd

- If a sample of blood is collected into a tube containing anticoagulant and is then left to stand vertically,

- the blood will separate out into three major components.

- The components separate due to their differences in relative densities.

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Blood cont'd

- These three components are:
- the supernatant yellowish fluid (**plasma**),
- a thin intermediate layer of WBCs & platelets known as **buffy coat** and
- the dense red layer of packed RBCs, known as **hematocrit** or packed cell volume (PCV).

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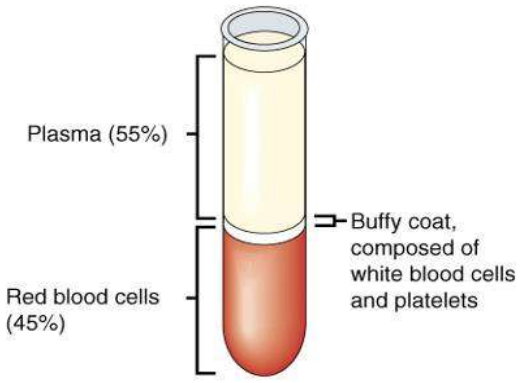

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Blood volume (BV)

- This is the amount of blood in circulation for an individual.

Factors affecting Blood Volume (BV)

- Blood volume (BV) varies with age, sex and health status.
  - Children:

Age	Blood volume (ml/kg)
3 months	87
6 months	86
1 year	80
6 years	80
10 years	75
15 years	71

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Factors affecting blood volume cont'd

- Sex: males have 5.0 – 5.6 litres, females have 3.5 – 4.5 litres, increasing during pregnancy.
- Many diseases which affect particularly the water and electrolyte composition of blood will alter BV.

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Factors affecting blood volume cont'd

- Abnormalities of BV: these are of two types:
  a) Hypovolaemia:
  - It is where the BV has fallen below the lower limit.
  - It can be due to dehydration, severe hemorrhage, etc.

  b) Hypervolaemia:
  - In this case, the BV is much higher than the upper limit of the normal range.
  - It is commonly a consequence of increased retention of NaCl, thus the osmotic retention of water.

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Functions of blood

- It is a medium of mass transport e.g. distribution of nutrients from the GIT to all body tissues.
- Thermoregulation: blood distributes the heat generated by the highly metabolic organs

- such as the liver and the skeletal muscles to all parts of the body.

- Homeostasis e.g. regulation of pH of the extra-cellular fluid (ECF) in the body.

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Functions of blood cont'd

- Body defense: blood has elements that take part in defending the body against invading pathogens.
- Protective functions: the unique ability to clot enables blood to prevent

- excessive loss of body fluids and electrolytes in the event of damage to tissues.

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Composition of blood

1. Plasma

- It is the straw coloured aqueous fluid portion of blood containing organic and inorganic molecules.
- **The major constituents of plasma include;**
  - Water: makes up 80% by weight of blood
  - Organic molecules: glucose, amino acids, lipo-proteins, urea, hormones, etc.

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Major constituents of plasma cont'd

- Inorganic salts of Na^+, K^+, Ca^{2+}, Mg^{2+}, etc., the organic & inorganic components together make up 2% by weight of blood.
- Plasma proteins: albumins, fibrinogen, globulins, making up 8% by weight of blood.

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Plasma cont'd

- All plasma proteins have a fairly high solubility in water.
- When left to stand, plasma clots and the fluid that remains is known as serum.
- In practice, serum is prepared by allowing whole blood to clot and removing the clot by centrifugation to leave serum.
- Serum has essentially the same composition as plasma, except that fibrinogen and the clotting factors have been removed.

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Plasma proteins: types and functions

i. Albumins:

- These are the most abundant plasma proteins, they are globular proteins & are synthesized in the liver.
- Normal adult blood contains 4500 – 5000 mg/dL of albumins.
- Up to 4.5 – 5.0g/kg body weight of albumin is degraded from skeletal muscles to supply the amino acids needed for repair of worn out tissues.

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The functions of albumins

- Maintenance of normal colloidal osmotic pressure (COP) of blood,
- Transportation of bile acids and bilirubin,
- Transportation of drugs such like aspirin
- Transportation of cations such as Cu^{2+}, Ca^{2+} and Zn^{2+}.
- Supply of amino acids for tissue repair
- Regulation of pH

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Plasma proteins cont'd

ii. Fibrinogen:

- This is a substrate for the formation of fibrin, the main component of blood clot.
- It is synthesized in the liver and normal adult blood contains 200-450 mg/dL.
- The functions of fibrinogen are:
  - Formation of fibrin during blood clotting
  - May participate in pH and COP regulation, but this is minor due to the low concentration

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Plasma proteins cont'd

iii. Globulins:

- Globulins are subdivided into four types: alpha one (α_1), alpha two (α_2), beta (β) and gamma (γ) globulins.
  - The α_1 globulin **(antitrypsin)**, inhibits trypsin and other proteases in serum and tissue secretions.
  - The α_2 globulin **(macroglobulin)** is a large protein & it inhibits proteolytic enzymes in serum.

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Globulins cont'd

- Another α_2 globulin, called **haptoglobin**, binds Hb which has been released into plasma after RBCs have been damaged, thus preventing loss of Hb in urine.
- The β-globulin exists in different forms that include;

a) Transferrin - responsible for the transportation of **Fe^{2+}** in plasma.

b) Ceruloplasmin - which binds with and transports **Cu^{2+}** in plasma.

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Globulins cont'd

c) Steroid hormone binding globulin which functions as the carrier of steroid hormones in blood.

d) Thyroxine binding globulin - the protein carrier for thyroid hormones in blood.

e) Hemopexin - that binds with porphyrins, particularly heme, and helps in the re-cycling of the heme for further synthesis of RBCs.

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Plasma proteins cont'd

Gamma globulins

- The gamma globulins comprise the **immunoglobulins** or **antibodies.**
- They are produced by the lymphocytes of blood and the plasma cells of the tissues.
- There are 5 classes:

a) **IgG** - is the most abundant type, making up 80% of all immunoglobulins & are found in blood and tissues.

Their MW is low enough to cross the placental barrier , and is therefore found in the blood of the new-born.

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Gamma globulins cont'd

b) **IgM** - is the naturally occurring antibody against RBCs in certain blood group types.

- Their presence causes specific antigen-antibody reactions, leading to agglutination and/or hemolysis.

c) **IgA** - is a glycoprotein found in external secretions such as saliva, tears and colostrum.

- It is effective in neutralizing micro-organisms present in the mouth and GIT.
- Their large MW does not allow them to cross the placenta but they are found in the blood of adults or colostrum for use by the neonate.

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Gamma globulins cont'd

d) **IgE** - is produced in response to allergic reactions.

- It causes release of histamine from basophils and mast cells during allergic reactions.

e) **IgD** - is involved in mediation of cellular immunity by facilitating the B-lymphocytes

- to recognize some antigens and stimulating the proliferation of the former.

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