**BLOOD**

This is the living tissue that delivers materials needed by the body cells.

Blood consists of a fluid matrix called **plasma** (liquid portion), which consists of approximately 97% water and various dissolved and suspended substances. The dissolved substances include glucose, urea, small quantities of gasses and salts. The suspended substances include enzymes, hormones, lipids, antibodies, antigens, proteins and blood cells, namely;

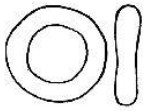
1. red blood cells 2. white blood cells 3. platelets

**Red blood cells (erythrocytes)**

**Characteristics**

- they have haemoglobin which is an iron-containing pigment
- they appear yellow when single and red in groups
- they are tiny disc-shaped cells
- They lack a nucleus in mammals when mature. Erythrocytes of amphibians, reptiles and birds have a nucleus.
- They have a life span of 120 days. Lack of a nucleus makes a red blood cell to have a short life span.

**Structure**



Front and side view of a red blood cell

**Function**

a. Transport of oxygen from the lungs (alveoli) to the other tissues
b. Transport of carbon dioxide from the tissues to the lungs

**Adaptations of red blood cells to their function**

1. They have haemoglobin which has a high affinity for oxygen, hence transporting oxygen to the cells
2. They have a biconcave shape (disc-shape) which allows a lot of haemoglobin to be accommodated inside and for carriage of more oxygen.
3. They have a thin membrane, which reduces on the diffusion distance, for faster diffusion of gasses.
4. They do not have a nucleus and this creates more space for the carriage of more oxygen
5. They are flexible, hence they easily move through the narrow lumen of capillaries
6. They are small hence can pass through the narrow lumen of blood capillaries
7. They are numerous in blood, which increases surface area for carrying more oxygen to the cells

**Note;**

- red blood cells have a nucleus when young
- Old or worn out red blood cells are destroyed in the spleen and liver resulting in the formation of bile pigments which are stored in the gall bladder. The iron is then stored in the liver.
- The number of red blood cells increases in people living in high altitude areas e.g. mountains. This is because at such altitudes there is less oxygen in air and so the extra red blood cells help them to have more haemoglobin which is needed to pick up as much oxygen as possible for the body metabolism
- The number of red blood cells is higher in infants than in adults; due to a higher metabolic rate in infants.

- There are about 5 million red blood cells per $mm^3$ of blood
- In adults, they are formed in the bone marrow of the short bones such as ribs, sternum and vertebrae, while in embryos and children; they are made in the liver and spleen.

**WHITE BLOOD CELLS (leucocytes)**

**Characteristics**

- They have a nucleus
- They are colourless because they lack haemoglobin
- They have no fixed shape i.e. they are amorphous and therefore exhibit amoeboid movement brought about by the changing of their shape.
- In adults they are produced and develop in the bone marrow and lymph glands while in embryos they are produced in the thymus gland, liver and spleen.
- They have a life span of 21 days

**Structure of a white blood cell e.g neutrophill**

**Function**

They are used for defense against invading micro-organisms. They do this by engulfing and feeding on the invading micro organisms or by producing antibodies which attack pathogens.

**Adaptations of white blood cells to their function**

1. They do not have a fixed shape and hence the amoebic movements used to engulf pathogens.
2. They are larger than the pathogens so as to engulf them
3. They are numerous and can multiply rapidly to eliminate the pathogens
4. They have an irregular shaped nucleus which allows them to squeeze through the narrow capillaries
5. They have a sensitive cell surface membrane that detects micro organisms
6. They have enzymes in their cytoplasm to digest the engulfed micro organisms
7. They are capable of moving out of capillaries hence they can access pathogens everywhere.
8. Some white blood cells(lymphocytes) can produce antibodies which attack and destroy pathogens

**Note;**

- There are five different types of white blood cells, each with its different characteristics
- There is an average of about 7500 white blood cells per $mm^3$ of blood, but the actual number vary between 4,000 and 13,000 white blood cells per $mm^3$ of blood
- The number of white blood cells increases during infection or disease. They also tend to accumulate at the site of an injury to destroy invading bacteria, and so preventing the spread of harmful bacteria.
- Abnormal increase in the number of white blood cells results into a clinical condition called leukemia. This results in the destruction of red blood cells.

**PLATELETS (thrombocytes)**

These are cell fragments that are rubbed off from special very large cells in the red bone marrow, but they assume a star-shaped appearance in extracted blood.

Their main function is to initiate (start) the process of blood clotting at the places of injury i.e. they stop bleeding.

**Mechanism of blood clotting**

Clotting is usually triggered off by damage of tissues, when they are cut. Platelets release an enzyme, thrombokinase (thromboplastin), which in the presence of calcium ions and vitamin K, converts the blood protein Prothrombin, to enzyme thrombin. Thrombin then converts the soluble fibrinogen in the blood plasma to an insoluble protein called fibrin, which is in form of fibres. Fibrin forms a network of fibres around the damaged tissues, in which blood cells are trapped and as a result, a blood clot forms which seals the wound, which dries and slowly heals.
**Note**, lack of clotting factor VIII in the body prevents clotting from taking place and individuals lacking this factor suffer from a genetic disease called **haemophilia** characterized by prolonged bleeding.

**Plasma**

Plasma is a fluid substance with dissolved and suspended substances.

**Functions**

1. Plasma transports
    - Blood cells e.g. red blood cells
    - Food nutrients
    - Metabolic waste products
    - Hormones
    - Mineral salts
    - Antibodies
    - Carbon dioxide
    - Plasma proteins eg: Albumin, Globulin, Fibrinogen, Prothrombin
    - Enzymes
2. Plasma is a medium of exchange for materials such as waste products
3. Plasma regulates the body temperature
4. It maintains a constant pH in the body fluid.

**Note;** plasma forms 55% of the blood in man and plasma without fibrinogen is called **serum**.
In general blood serves three main functions;

A. **Transport of oxygen,** dissolved food substances, excretory substances, hormones, antibodies and blood cells
B. **Protection** through clotting and presence of white blood cells
C. **Regulation** of body temperature, metabolic rate and amount of water in the body.

## BLOOD GROUPS

Blood can be grouped according to the **ABO** blood system or according to the Rhesus factor system.

**ABO blood system**

In the **ABO** system, blood groups are determined by factors on red blood cells, called **antigens**. An antigen is a protein molecule which is recognized as foreign by the body's white blood cells which attack them by producing **antibodies**. An antibody is a type of protein produced by white blood cells (lymphocytes) in response to specific foreign cells or other substances (antigens)

and help to destroy them. The type of antigen on the red blood cell determines the type of antibodies that can be in one's blood plasma.

In the **ABO** blood system, there are two types of antigens **A** and **B**. In this system, there are also two types of antibodies, antibody type band type **a**. If antigen **A** and antibody **a** occur together, this leads to a biochemical reaction called **agglutination**, which is the clumping together of red blood cells. Similarly if antigen **B** and antibody **b** occur together, agglutination occurs.

| Blood group | Antigen on the red blood cell membrane | Antibody in plasma |
|---|---|---|
| **A** | A | b |
| **B** | B | a |
| **AB** | A and B | No antibodies |
| **O** | No antigens | a and b |

Successful blood transfusion i.e. transfer of blood from a donor to a recipient's circulatory system, depends on the type of antibodies present in a recipients blood. The donor's blood must not contain antigens which can react with the recipient's antibodies.

**Blood group compatibilities**

| Recipient | | Donor's blood group | | | |
|---|---|---|---|---|---|
| **Blood group** | **Antibody in plasma** | **A** | **B** | **AB** | **O** |
| **A** | **b** | ✓ | X | X | ✓ |
| **B** | **a** | X | ✓ | X | ✓ |
| **AB** | None | ✓ | ✓ | ✓ | ✓ |
| **O** | **a** and **b** | X | X | X | ✓ |

✓ = compatible with recipients blood

X = Incompatible with recipient i.e. agglutination occurs

The following can be noted from the table above;

i. Blood group AB is the **universal recipient** i.e. it can receive blood from all other blood groups because it lacks antibodies

ii. Blood group O can be given to all other groups hence it is called the **universal donor** because it has no antigens.

**RHESUS FACTOR SYSTEM**

- Red blood cells of some people have another antigen called the rhesus antigen. The antigen is named so because it was first identified in rhesus monkeys.
- Individuals with this factor (antigen) are said to be rhesus positive (Rh +ve) while those who do not have it are rhesus negative (Rh -ve).
- There are no antibodies in blood for Rh -ve, but if Rh +ve blood is introduced by transfusion or by leakage, from foetal blood during pregnancy, the antibodies are formed.
- If a mother is Rh -ve and the father is Rh +ve, the child normally is Rh +ve.

- If the Rh +ve antigens of the foetus leak into the mother's circulation during pregnancy or birth, then the antibodies are formed in the blood of the mother.
- These antibodies pass into the blood of the foetus since they are small sized.
- The rhesus antibodies then destroy many of the red blood cells in the foetal circulation which might lead to death or premature birth.
- This destruction of foetal red blood cells is called **erythroblastosis foetalis**. The baby is delivered with a *haemolytic* disease, which happens after a number of pregnancies since many Rh +ve antigens go into the maternal circulation leading to a massive production of antibodies.

**Diseases of blood**

1. **Haemophilia (bleeder's disease)**
   This is a hereditary disease in which one lacks the clotting factor, leading to internal bleeding, mainly along the joints, or prolonged bleeding in case of any wound. Continuous blood transfusion helps.
2. **Sickle cell anaemia**
   It is a hereditary disease. There is abnormal development of haemoglobin that makes the red blood cells collapse and attain a sickle shape which makes transportation of oxygen hard.
3. **Lukaemia** (blood cancer)
   This is caused by abnormal multiplication of white blood cells which tend to destroy other cells.
4. **Arteriosclerosis**
   This is the hardening of blood vessels due to deposition of cholesterol in the endothelium of blood vessels.

(5)Anaemia; A state in which hemoglobin in blood is below the reference range. Iron-deficiency anemia is anemia caused by a lack of iron which is a component of hemoglobin.

(6) Pernicious anaemia; A condition in which not enough red blood cells are produced due to deficiency of vitamin B12 in the body.

(6) HIV/AIDs.

**REVISION QUESTIONS**

1. (a) Define the following terms as used in blood transfusion

(i) Donor

(ii) Recipient

(b) (i) Complete the table below by indicating the antigens on the red blood cells and antibodies produced by individuals with the different blood groups.

| Blood group | RBC Antigen | Antibody produced |
|---|---|---|
| **A** | | |
| **B** | | |
| **AB** | | |
| **O** | | |

(ii) Where are the antibodies produced found and what is their role?

(c)(i)The table below shows blood groups of the donor (in the columns) and recipient (in rows). Complete the table to show compatibility of the different blood groups. Tick (√) where the blood groups are compatible and cross (X) in the boxes where the blood groups are not compatible.

| | | RECIPIENT | | | |
|---|---|---|---|---|---|
| | | **A** | **B** | **AB** | **O** |
| D O N O R | **A** | | | | |
| | **B** | | | | |
| | **AB** | | | | |
| | **O** | | | | |

(ii) Explain what happens when the blood groups of the recipient are not compatible.

d) Explain the following as regards to blood transfusion.

(i) Individuals of blood group O can donate blood to individuals of all blood groups but can only receive from individuals of their own type.

(ii) An individual of blood group AB is a universal recipient.

2 a) How are red blood cells suited to their function in mammals?

b) Describe the circulation of blood within the heart of human being.

c) Outline the structural differences between arteries and veins.

3 (a) Describe the processes in blood vessels which form a blood clot.

(b) Explain **three** major precautions that must be considered before a successful blood transfusion.

(c) Outline any three lines of defense against bacteria entering the blood system.

**-END-**