**THE BLOOD**

Blood is a connective tissue. It provides one of the means of communication between the cells of different Parts of the body and the external environment, e.g. it carries

* oxygen from the lungs to the tissues, and carbon dioxide from the tissues to the lungs for excretion
* nutrients from the alimentary tract to the tissues, and cell wastes to the excretory organs, principally the kidneys
* hormones secreted by endocrine glands to their target glands and tissues
* protective substances, e.g. antibodies, to areas of infection
* clotting factors that coagulate blood, minimizing bleeding from ruptured blood vessels.

Blood in the blood vessels is always in motion because of the pumping action of the heart. The continual flow maintains a fairly constant environment for the body cells.

**Plasma**

Blood is composed of a straw-coloured transparent fluid, plasma, in which different types of cells are suspended. Plasma constitutes about 55% and cells about 45% of blood volume.

The constituents of plasma are water (90 to 92%) dissolved substances, including:

* Plasma proteins
* Inorganic salts
* nutrients, principally from digested foods
* waste materials
* hormones
* gases.

**Plasma proteins:** Plasma proteins, which make up about 7% of plasma, arenormally retained within the blood, because they are toobig to escape through the capillary pores into the tissues.

They are largely responsible for creating the osmotic pressure of blood (normally 25 mmHg or 3.3 kPa), which keeps plasma fluid within the circulation.

Plasma viscosity (thickness) is due to plasma proteins, mainly albumin and fibrinogen. Viscosity is used as a measure of the body's response to some diseases.

**Albumins:** Albumin is a protein made by liver. Albumin helps keep fluid in bloodstream so it doesn't leak into other tissues. It is also carries various substances throughout body, including hormones, vitamins, and enzymes.

**Globulins:** Most are formed in the liver and the remainder in lymphoid tissue. Their main functions are as antibodies (immunoglobulins), which are complex proteins produced by lymphocytes that play an important part in immunity. They bind to, and neutralize, foreign materials (antigens) such as micro-organisms. Transportation of some hormones and mineral salts;e.g. thyroglobulin carries the hormone thyroxine and transferrin carries the mineral iron

**Clotting factors**: These are substances essential foř coagulation of blood. Serum is plasma from which clotting factors have been removed.

**Fibrinogen:** This is synthesized in the liver and is essential for blood coagulation.

**Inorganic (mineral) salts**

These are involved in a wide variety of activities, including muscle contraction, transmission of nerve impulses, formation of secretions and maintenance of acid-base balance. In health the blood is slightly alkaline. The pH of blood is maintained between 7.35 and 7.45 by an ongoing complicated series of chemical activities, involving buffering systems.

**Nutrients**

In the alimentary tract, food is broken down into small molecules, e.g. monosaccharides, amino acids, fatty acids and glycerol, and are absorbed. Together with mineral salts they are required by all body cells to provide energy heat, materials for repair and replacement, and for the synthesis of other blood components and body secretions.

**Waste products**

Urea, creatinine and uric acid are the waste products of protein metabolism. They are formed in the liver and conveyed in blood to the kidneys for excretion.

**Hormones**

These are substances synthesised by endocrine glands. Hormones pass directly from the endocrine cells into the blood, which transports them to their target tissues and organs elsewhere in the body, where they influence cellular activity.

**Gases**

Oxygen, carbon dioxide and nitrogen are transported round the body dissolved in plasma. Oxygen and carbon dioxide are also transported in combination with haemoglobin in red blood cells. Most oxygen is carried in combination with haemoglobin and carbon dioxide as bicarbonate ions dissolved in plasma. Atmospheric nitrogen enters the body in the same way as other gases and is present in plasma but it has no physiological function.

**Cellular content of blood**

There are three types of blood cells

* erythrocytes (red cells)
* platelets (thrombocytes)
* leukocytes (white cells).

All blood cells originate from pluripotent stem cells and go through several developmental stages before entering the blood. Different types of blood cells follow separate lines of development. The process of blood cell formation is called haemopoiesis and takes place within red bone marrow. In adults, haemopoiesis in the skeleton is confined to flat bones, irregular bones and the ends (epiphyses) of long bones, the main sites being the sternum, ribs, pelvis and skull. In addition, some lymphocytes (white blood cells) are produced in lymphoid tissue.

**Erythrocytes (red blood cells)**

Red blood cells are biconcave discs: they have no nucleus, and their diameter is about 7 micrometres. Their main function is in gas transport, mainly of oxygen, but they also carry some carbon dioxide.

Their characteristics shape is suited to their purpose: the biconcavity increases their surface area for gas exchange, and the thinness of the central portion allows fast entry and exit of gases.

**Life span and function of erythrocytes**

Erythrocytes are produced in red bone marrow, which is present in the ends of long bones and in flat and irregular bones.

The red blood cell bones. They pass through several stages of development before entering the blood. Their life span in the circulation is about 120 days.

The process of development of red blood cells from pluripotent stem cells takes about 7 days and is called erythropoiesis. The immature cells are released into the bloodstream as reticulocytes, and then mature into erythrocytes over a day or two within the circulation.

Both vitamin B12 and folic acid are required for blood cell synthesis. They are absorbed in the intestines, although vitamin B12 must be bound to intrinsic factors to allow absorption to take place. Both vitamins are present in dairy products, meat and green vegetables.

The liver usually contains substantial stores of vitamin B12, several years worth, but signs of folic acid deficiency appear within a few months.

**Oxygen transport**

Haemoglobin is a large, complex protein containing a globular protein (globin) and a pigmented iron-containing complex called haem. Each haemoglobin molecule contains four globin chains and four haem units, each with one atom of iron. As each atom of iron can combine with an oxygen molecule, this means that a Single haemoglobin molecule can carry up to four molecules of oxygen. An average red blood cell carries about 280 million haemoglobin molecules, giving each cell a theoretical oxygen-carrying capacity of over a billion Oxygen molecules.

When all four oxygen-binding sites on a haemoglobin molecule are full, it is described as saturated. Haemoglobin binds reversibly to oxygen to form oxyhaemoglobin, according to the equation:

Haemoglobin + oxygen oxyhaemoglobin

(Hb) (O2) (HbO)

As the oxygen content of blood increases, its colour changes too. Blood rich in oxygen is bright red because of the high levels of oxyhaemoglobin it contains, compared with blood with lower oxygen levels, which is dark bluish in colour because it is not saturated.

**Control of erythropoiesis**

The number of red cells remains fairly constant, which means that the bone marrow produces erythrocytes at the rate at which they are destroyed. This is due to a homeostatic negative feedback mechanism.

The primary stimulus to increased erythropoiesis is hypoxia, i.e. deficient oxygen supply to body cells. This Occurs when:

the oxygen-carrying power of blood is reduced by e.g. hemorrhage or excessive erythrocyte breakdown (haemolysis) due to disease.

the oxygen tension in the air is reduced, as at high altitudes.

Hypoxia increases erythrocyte formation by stimulating the production of the hormone erythropoietin, mainly by the kidneys. Erythropoietin stimulates an increase in the production of proerythroblasts and the release of increased numbers of reticulocytes into the blood. These changes increase the oxygen-carrying capacity of the blood and reverse tissue hypoxia, the original stimulus. When the tissue hypoxia is overcome, erythropoietin production declines. When erythropoietin levels are low, red cell formation does not take place even in the presence of hypoxia, and anaemia (the inability of the blood to carry adequate oxygen for body needs) develops. Erythropoietin regulates normal red cell replacement, i.e. in the absence of hypoxia.

**Destruction of erythrocytes**

The life span of erythrocytes is about 120 days and their breakdown, or haemolysis, is carried out by phagocytic reticuloendothelial cells. These cells are found in many tissues but the main sites of haemolysis are the spleen, bone marrow and liver. As erythrocytes age, changes in their cell membranes make them more susceptible to haemolysis. Iron released by haemolysis is retained in the body and reused in the bone marrow to form new haemoglobin molecules. Biliverdin is formed from the haem part of the haemoglobin. It is almost completely reduced to the yellow pigment bilirubin, before being bound to plasma globulin an transported to the liver. In the liver it is changed from a fat-soluble to a water –soluble form to be excreted as a constituent of bile.