Blood

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Objectives

By the time you have finished this topic, you should know about:

*The functions and constituents of blood - cells and plasma)

* The properties of red blood cells (erythrocytes)

*The five different types of white blood cells and how to identify them in a blood smear.

*How and where blood cells are formed (Haemopoesis)

*Identify bone marrow and its type

Functions of blood

Transports gases, nutrients, waste, cells and hormones .throughout the body

.Transports O2, CO2, nutrients, hormones, heat and wastes

.Regulates pH, temperature, water content of cells

.Protects against blood loss through clotting

Protects against disease through phagocytic white blood .cells and antibodies

.The process by which blood is made is called Haemopoiesis

Blood Constituents

Blood consists of blood cells and plasma.

If blood is treated with an anticoagulant and centrifuged, the blood cells sediment leaving a supernatant of clear plasma.

Blood Cells

The sedimented blood cells account for 35-50% of the volume of blood and are of three basic types:

1.erythrocytes or red blood cells

2.leucocytes or white blood cells.

3.platelets or thrombocytes

Plasma

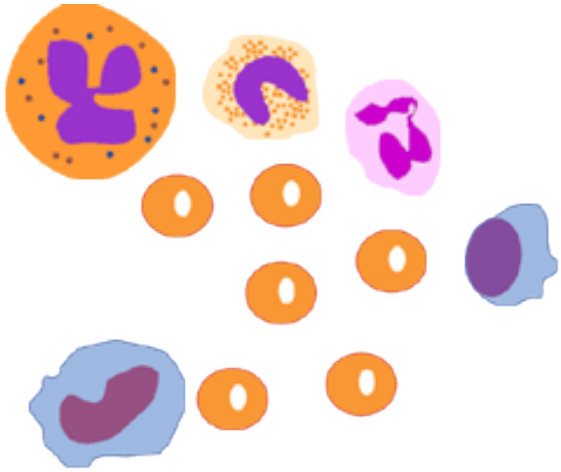
The plasma accounts for 55% of the blood volume. It consists of a solution of water (92%), proteins, lipids, inorganic ions (salts) and glucose. The proteins include hormones. The salts include urea, that are waste products of cells.

The proteins make up 6-7 % of blood and are made up mostly of serum albumin, and serum globulins. Serum albumin is made in the liver, and helps to maintain the osmotic pressure of blood. There are threee types of serum

globulins; alpha, beta and gamma. Alpha is involved in transporting vitamin A, beta in transporting transferrin, and most antibodies are gamma globulins.

Cholesterol is also found in the blood, in a mixture of high density and low density forms (HDL and LDL). High LDL levels are linked with atherosclerosis, where plaques can form on the inside of arteries. This can lead to cardiac disease and/or strokes. In contrast, high levels of HDL may protect against heart disease.

This is a diagram of the various different types of red and white cells found in blood



Red Blood Cells – Erythrocytes

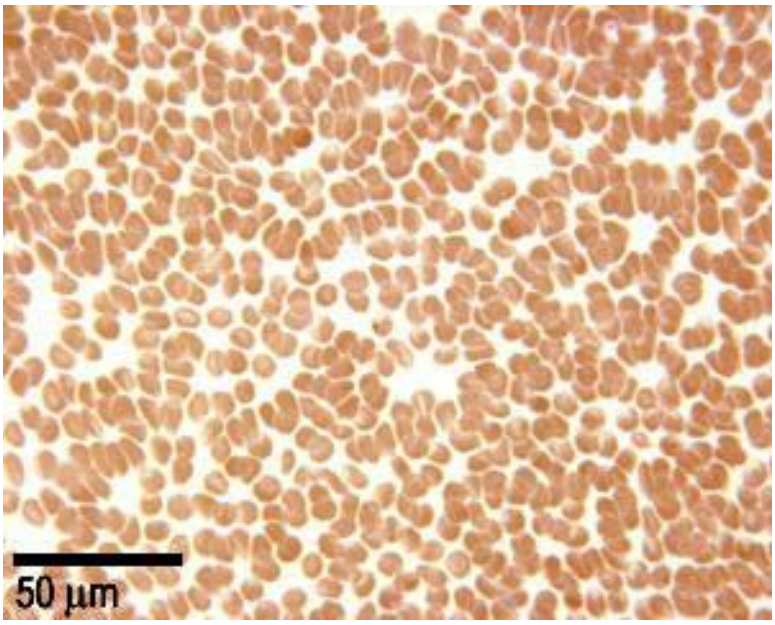
Red blood cells are the most numerous type of cell found in blood. One microliter of blood contains around 5 million cells. They are essential for transport of carbon dioxide and oxygen around the body.

They are 'born' and mature in the bone marrow.

When they mature, they make haemoglobin, the protein that binds oxygen. Haemoglobin can also bind carbon dioxide, but at a different site to that for oxygen. Eventually around 90% of the dry weight of the cell is made up of this protein. The nucleus is lost from the cell, phagocytosed by macrophages, and the DNA broken down. The red blood cells can then enter the circulation

These cells only live for about 120 days. However, the iron in the haemoglobin is extracted from the erythrocytes by the liver and spleen, and the remaining heme is excreted by the liver as bile pigments.

Around 3 million RBCs die and are scavenged by the liver each second.



This is a low power image of a blood smear stained with May Grunwald Giemsa stain. This stains the acidic proteins in the erythrocytes pink, as haemoglobin is eosinophilic (acidophilic). All the cells in this image are red blood cell.

White blood cells

White blood cells are much less common than red blood cells. There are five types of white blood cell (leucocyte). These are divided into two main classes

*Granulocytes (includes Neutrophils, Eosinophils and Basophils)

*Agranulocytes (includes Lymphocytes and Monocytes)

This classification depends on whether granules can be distinguished in their cytoplasm using a light microscope and conventional staining methods.All the white blood cells are able to move like an amoeba, and can migrate out of blood vessels into the surrounding tissues.

Neutrophils

Neutrophils are the commonest type of white blood cell found in a blood smear. They make up 60-70% of the total amount of white blood cells.

Neutrophils have 3 types of granules:

azure granules (lysosomes)

secretory granules in salmon pink cytoplasm, anti-microbial enzymes.

have glycoproteins and gelatinase

Function:

Neutrophils are born in the bone marrow. They circulate in the blood for 6-10 hours, and then enter the tissues. They are motile, and phagocytic and will destroy damaged tissue and bacteria. They self destruct after one burst of activity

They are important in inflammatory reactions.

Eosinophils

Eosinophils are fairly rarely found in blood smears - making .up 1-6% of the total white blood cells

Function :

These cells are born in the bone marrow, and migrate from the peripheral blood system after a few hours, into loose connective tissue in the respiratory and gastointestinal tracts. They phagocytose antigen-antibody complexes. They also produce histaminase, and aryl suphatase B, two enzymes that inactivate two inflammatory agents released by mast cells. A high eosinophil blood count may indicate an allergic reaction.

Eosinophils are also important in killing parasitic worms.

Basophils

Basophils are the rarest type of white blood cell, making up only 1% of the white blood cells found in a blood smear.

Function:

These cells are involved in immune responses to parasites. They have IgE receptors and the granules are released when the cells bind IgE. These cells also accumulate at sites of infection, and the release of prostaglandins, serotonin and histamine help to increase blood flow to the area of damage, as part of the inflammatory response. The degranulation - release of histamine also plays a role in allergic reactions such as hay fever.

Agranulocytes:

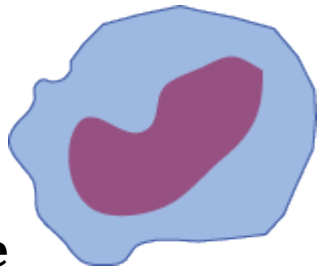
Lymphocyte

These are the second most common white blood cell (20-50%), and are easy to find in blood smears.

Although the cells look similar there are two main types, B-cells and T-cells.

B-cells develop in the bone marrow. T cells are born in the bone marrow, but are matured in the Thymus. There will be more on this in the section on the immune system.

The B-cells develop into plasma cells which make antibodies, The T-cells attack viruses, cancer cells, and transplants.



Monocyte

Monocytes are the third most common type of white blood cell; about 2-10% of leucocytes are monocytes.

Function:

Monocytes in the circulation are precursors of tissue macrophages that are actively phagocytic. Monocytes circulate in the blood for 1-3 days, and then migrate into body tissues, where they transform into macrophages. They will phagocytose dead cells and bacteria. Some monocytes can also transform into osteoclasts.

Monocytes are important in the inflammatory response.

Bone Marrow

Bone marrow lacks the rigidity of the surrounding bone. Instead, it is a jelly-like substance that fills the cavity left by the trabecular network of bone. Bone marrow accounts for

about 4 – 5% of the total body weight of an individual. Although it can be considered a “light-weight” system, the bone marrow does a lot of heavy lifting, as it is responsible for producing platelets, lymphocytes, erythrocytes, granulocytes, and monocytes.

Marrow has two principal functions; one is to produce blood cells and the other is to store fat. As a result, there are two types of marrow found in the body:

- the highly vascular red marrow which is haematopoietically active,
- and the fat rich yellow marrow that has significantly less haematopoietic centres and more adipocytes.

Red Bone Marrow

Clusters of haematopoietic cells known as haematopoietic islands are widely distributed throughout the loose connective tissue network observed in red marrow. These islands are found next to relatively large, yet thin walled, sinusoids that also communicate with nutrient vessels of the bone. The sinusoids are situated at a central part of a roundabout circulation such that the nutrient arteries that leave the nutrient canals to supply the bones anastomose in the bone marrow and subsequently terminate in arterioles that coalesce to form the sinusoids. The sinusoids then drain to significantly larger veins that form nutrient veins, which then leave the bone via the same nutrient canals that the arteries enter by.

Red marrow is most abundant in all skeletal structures from intrauterine life up until around the 5th year of life. As time progresses, red marrow is restricted to the central flat bones

(i.e. cranial bones, clavicle, sternum, ribs, scapula, vertebrae, and pelvis) and the proximal ends of the proximal long bones of the upper and lower limbs.

The supporting substance that supports the haematopoietic and adipocyte cells in the marrow is made up of reticulin. This is a fine type III collagen that is produced by mesenchyme derived reticular cells (fibroblast-like cells). Other housekeeping cells like macrophages exist in the stroma and facilitate haematopoiesis by phagocytosing cellular debris generated from the process.

Yellow Bone Marrow

Depending on the age and haematological demand of an individual, the reticular cells become swollen as a result of increased lipid uptake. Subsequently, yellow marrow is formed. It contains mainly supportive connective tissue that provides scaffolding for the neurovascular structures that traverse the cavitation. There are also numerous adipocytes in addition to very few dormant haematopoietic clusters. These latent haematopoietic centres can be reactivated in the event of an increase demand for red blood cells.

Haemopoiesis

Haemopoiesis is the process by which mature blood cells develop from precursor cells. It continues continuously throughout embryonic and adult life and as a result new cells formed in the so-called haemopoietic regions constantly replace mature blood cells in the circulation.

In the embryo, haemopoiesis occurs at different stages in the yolk sac, the liver, the spleen, lymph nodes and the bone marrow.

In the adult, erythrocytes, granulocytes, monocytes and platelets are formed in the bone marrow while the lymphocytes are formed mainly in the lymph nodes, spleen, thymus and lymphatic nodules of the gastrointestinal tract. However, the lymphocytes present in these organs originate directly or indirectly from the bone marrow.

Precursor cells:

All precursor cells have some common features:

1.They are larger in diameter than mature red and white blood cells.

2.The nuclei have non-condensed chromatin.

3.The cytoplasm is rich in free ribosomes.

ERYTHROID SERIES:

Proerythroblast - Finely meshed chromatin in nucleus, generally two prominent nucleoli, cytoplasm moderately basophilic, due to the presence of ribosomes. An unstained region indicating the location of the Golgi apparatus is often visible.Basophilic erythroblast - This cell is usually smaller and the nucleus, which is intensely heterochromatic, is centrally located. The cytoplasm is a deeper blue color than that of the proerythroblast, due to the mixture of abundant free ribosomes and the initiation of hemoglobin synthesis. There is no longer a visible Golgi apparatus. Polychromatophilic erythroblast - The nucleus is intensely heterochromatic, and the cytoplasm is now a characteristic

lilac color. The basophilia is due to the cytoplasmic ribosomes, and the acidophilia is due to the increase in the 38 amount of hemoglobin being synthesized by the ribosomes. This is the last stage during which cell division occurs.

Normoblast (orthochromatic erythroblast) - The nucleus has become pyknoticband therefore is very dark in appearance. The abundant cytoplasmic hemoglobin is acidophilic.

Erythrocyte (RBC) - The extrusion of the nucleus from normoblasts results in the formation of anucleate erythrocytes. Occasionally there is still some residual basophilia in the cytoplasm of these cells, due to the retention of some ribosomes. Such immature red cells are called reticulocytes because of the so-called reticulated pattern of cytoplasmic basophilia. Under normal conditions, a small percentage of reticulocytes enter the circulation before completing their maturation. However, when there is a great increase in erythrocyte production the percentage of reticulocytes entering the blood increases. Reticulocyte counts can provide information about the rate of erythrocyte production.

GRANULOCYTIC SERIES:

Myeloblasts are stem cells that differentiate into the granulocytic series. The myeloblast is a large cell with a large ovoid pale-staining nucleus, 2 to 5 nucleoli, and lightly basophilic cytoplasm (due to a scattering of ribosomes). These cells are difficult to distinguish.

Promyelocyte: This large cell is very similar to a myeloblast, but can be distinguished by the presence of a few azurophilic granules (pink-purple, primary lysosomes) in its cytoplasm.

Myelocyte: The promyelocyte in turn gives rise to eosinophilic, neutrophilic and basophilic myelocytes, which have both azurophilic and specific granules according to their respective cell line. These cells can be identified by the round nucleus and by the accumulation of specific granules in their cytoplasm.

Metamyelocytes: This stage can be identified by the indented nucleus and the presence of their specific cytoplasmic granules. You may be able to identify the unstained image of the Golgi complex in the region where the nucleus is indented. In the neutrophilic lineage, the late metamyelocyte is called the band cell.

Mature granulocytes: The mature cells can be recognized by their complex nuclear morphologies and their specific granules. Do not confuse the fine granules of the neutrophil (which may appear lightly acidophilic) for the coarser granules of eosinophils or basophils. The highly lobulated nucleus of the mature neutrophil is helpful in its identification.

THANK YOU