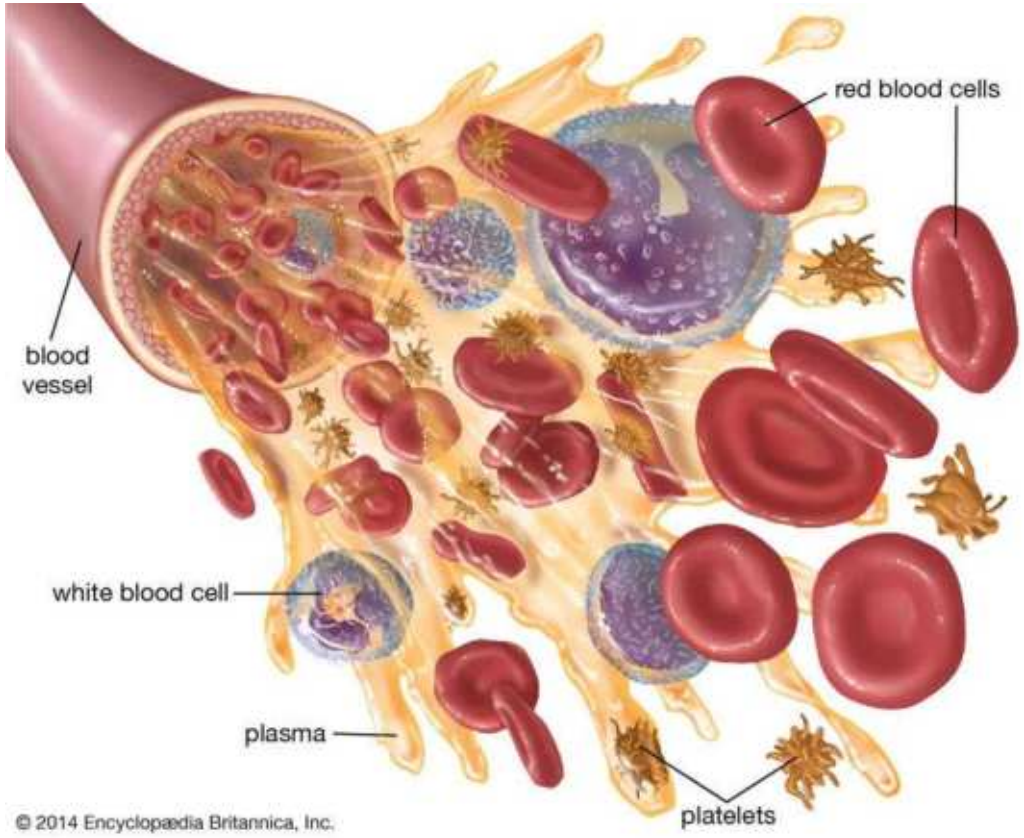
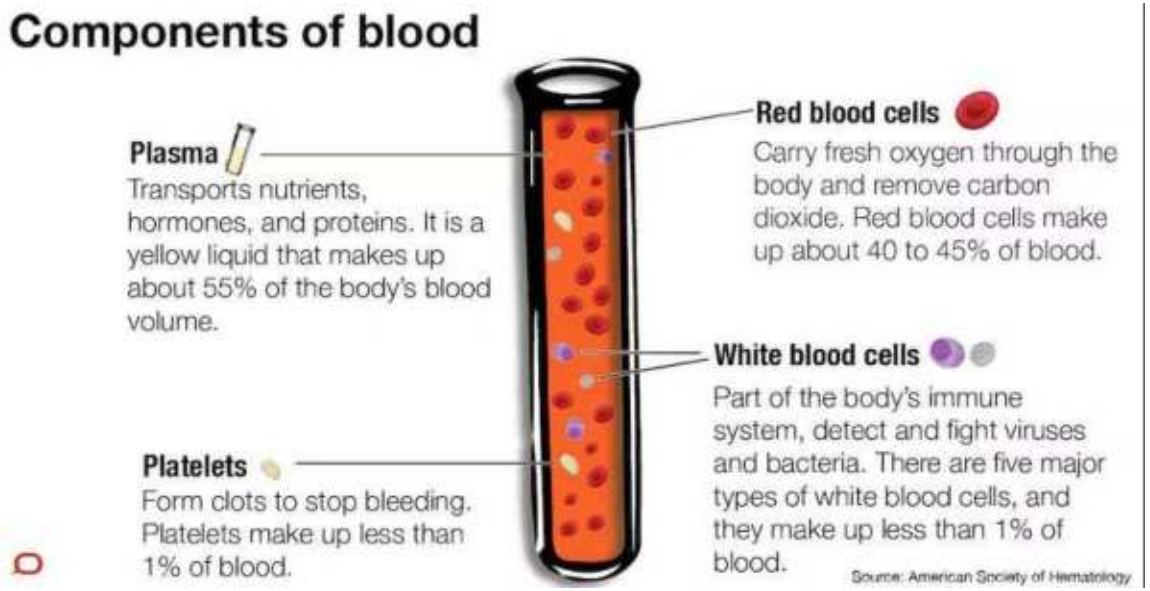
Blood

I MSc PHYSIOLOGY

JAN 2022/23

COMPONENTS OF BLOOD





plasma

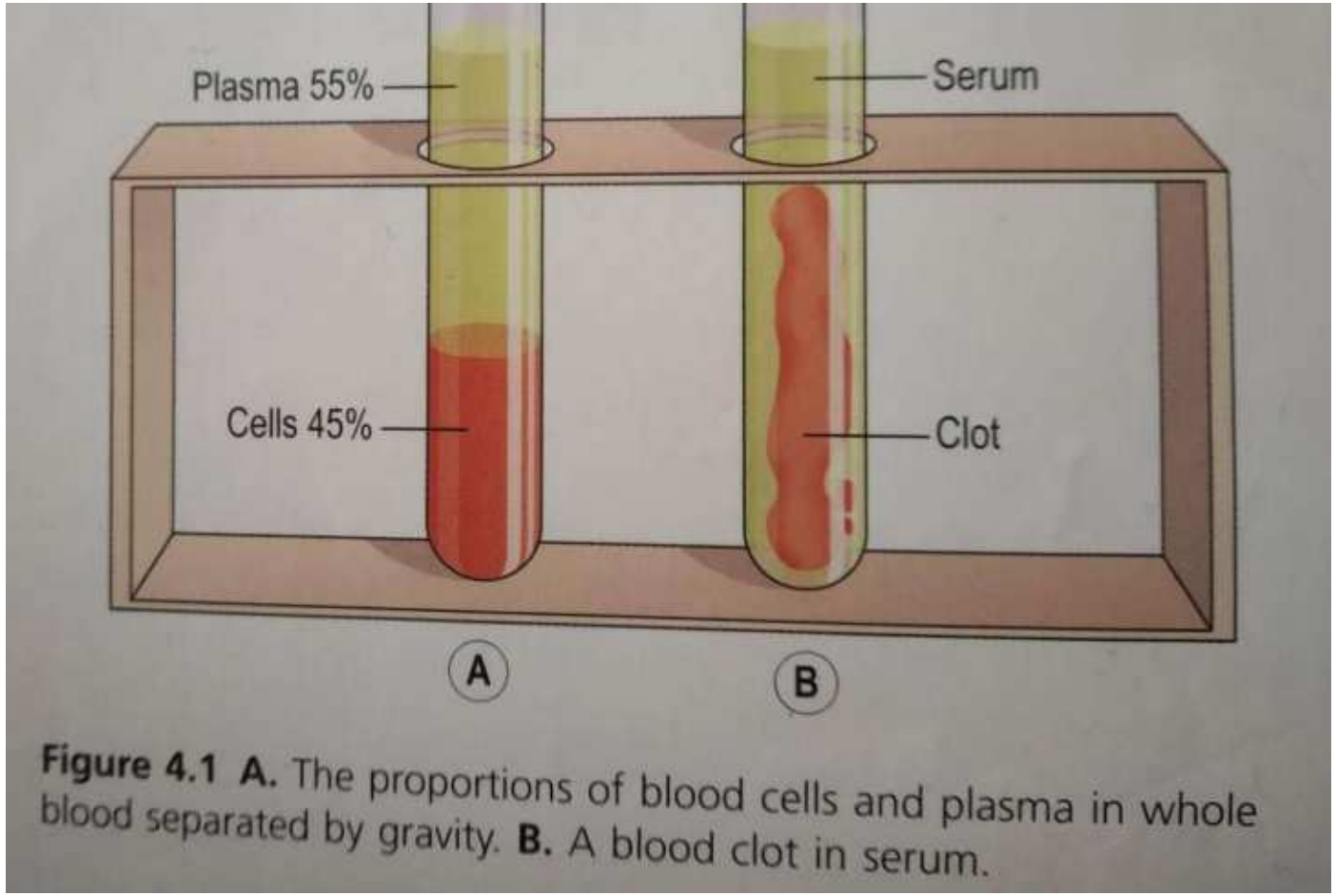


Figure 4.1 **A.** The proportions of blood cells and plasma in whole blood separated by gravity. **B.** A blood clot in serum.

1. Red Blood Cells

2. White Blood Cells

monocyte

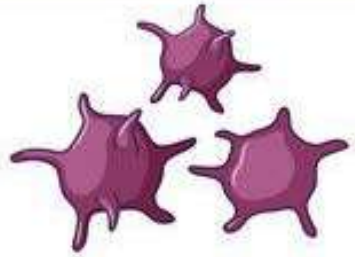
lymphocyte

eosinophil

neurophil

basophil

3. Platelets



TYPES OF BLOOD CELLS

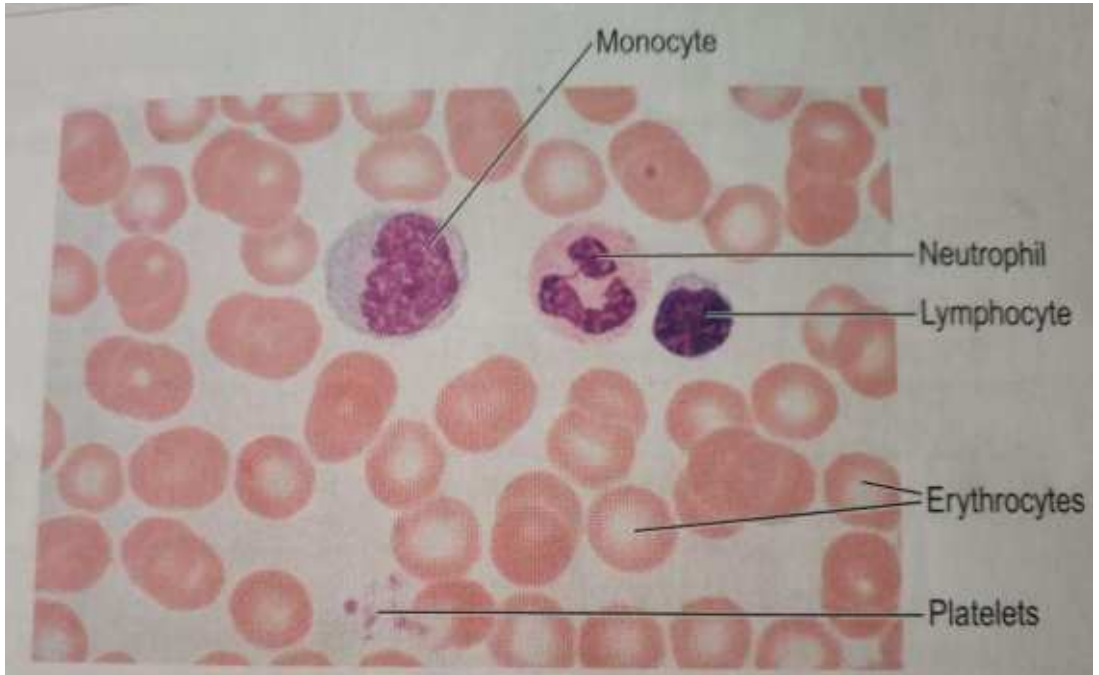
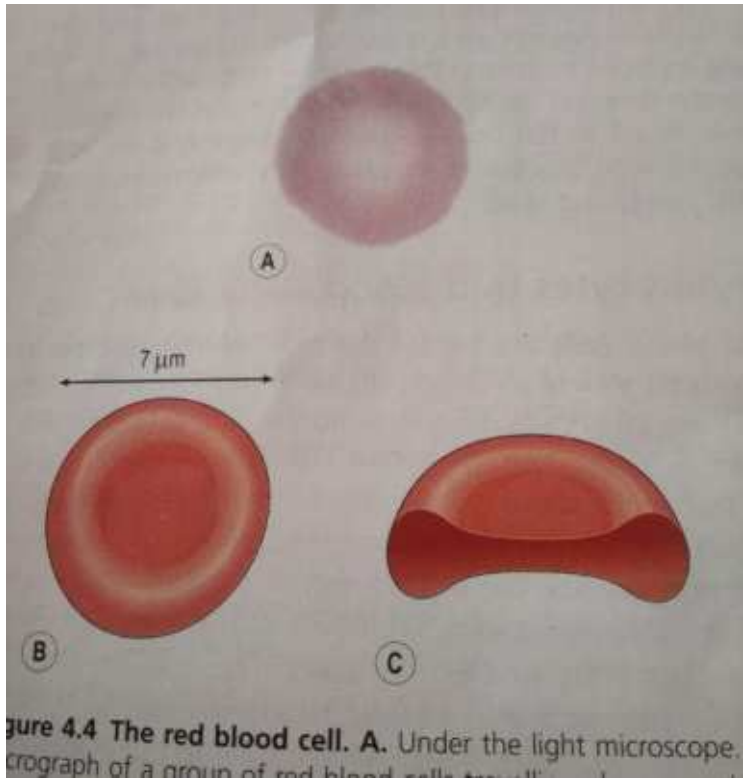


Figure 4.2 A blood smear, showing erythrocytes, a monocyte, a neutrophil, a lymphocyte and a platelet.

- Blood contains many types of cells: **white blood cells (monocytes, lymphocytes, neutrophils, eosinophils, basophils, and macrophages)**,
- red blood cells (erythrocytes)
- platelets.

Erthrthrocytes

RBCs are **disc-shaped with a flatter, concave center**. This biconcave shape allows the cells to flow smoothly through the narrowest blood vessels.



gure 4.4 The red blood cell. A. Under the light microscope, crograph of a group of red blood

Movement through the arteriole

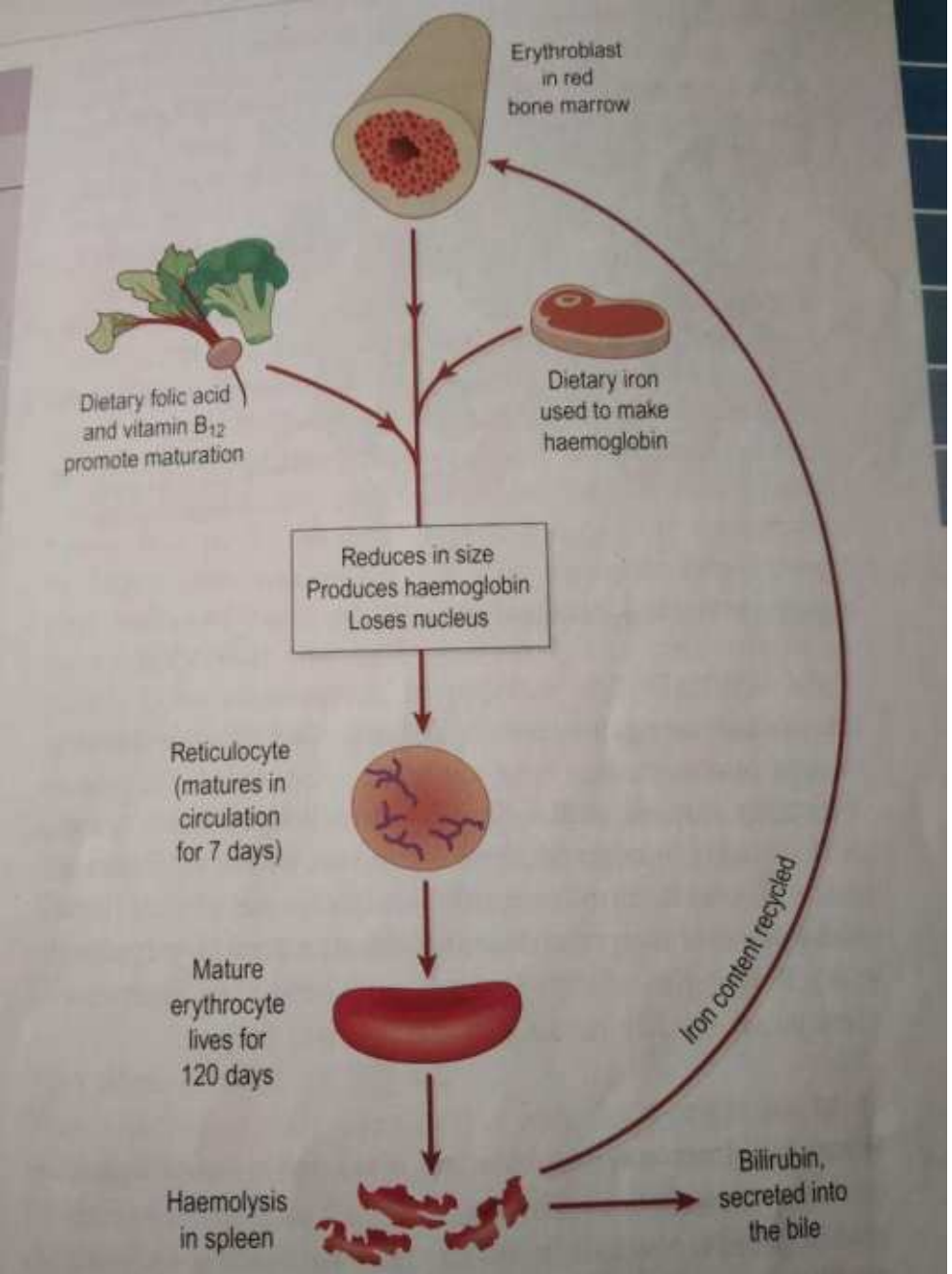


Figure 4.5 Life cycle of the erythrocyte.

FORMATION OF ERYTHROCYTES

- A number of nutrient substances are required for this process. Some nutrients are the building blocks of which the red cells are composed. For example, amino acids are needed in abundance for the construction of the proteins of the red cell, in particular of hemoglobin. Iron also is a necessary component of hemoglobin.Important among these are several vitamins such as riboflavin, vitamin B_{12}, and folic acid, necessary for the maturation of the developing red cell; and vitamin B_6 (pyridoxine), required for the synthesis of hemoglobin. The secretions of several endocrine glands influence red cell production.

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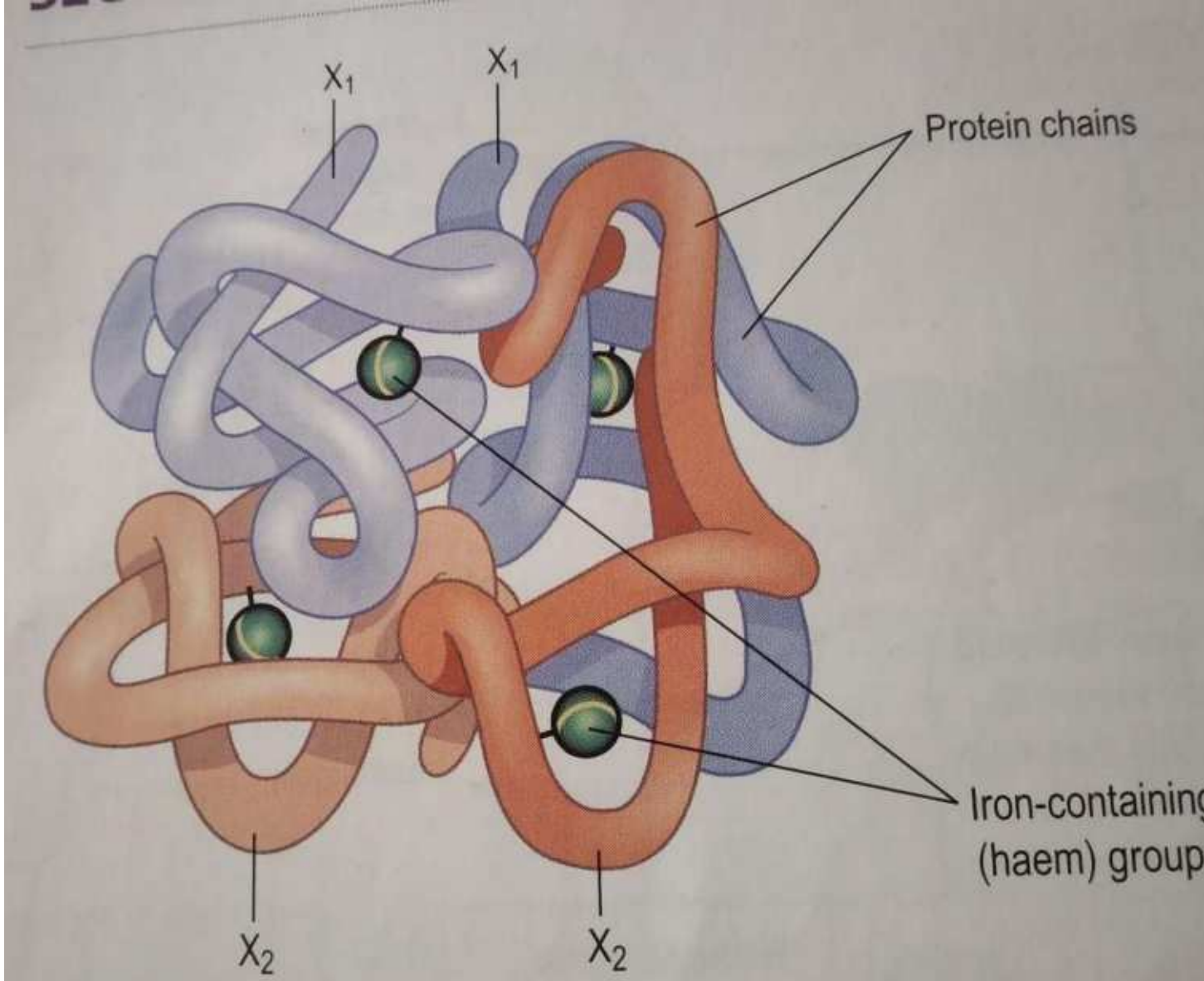
- There are **four iron atoms in each molecule of hemoglobin**, which, accordingly, can bind four atoms of oxygen. The complex porphyrin and protein structure provides the proper environment for the iron atom so that it binds and releases oxygen appropriately under physiological conditions.



igure 4.6 The haemoglobin molecule.

Blood tests

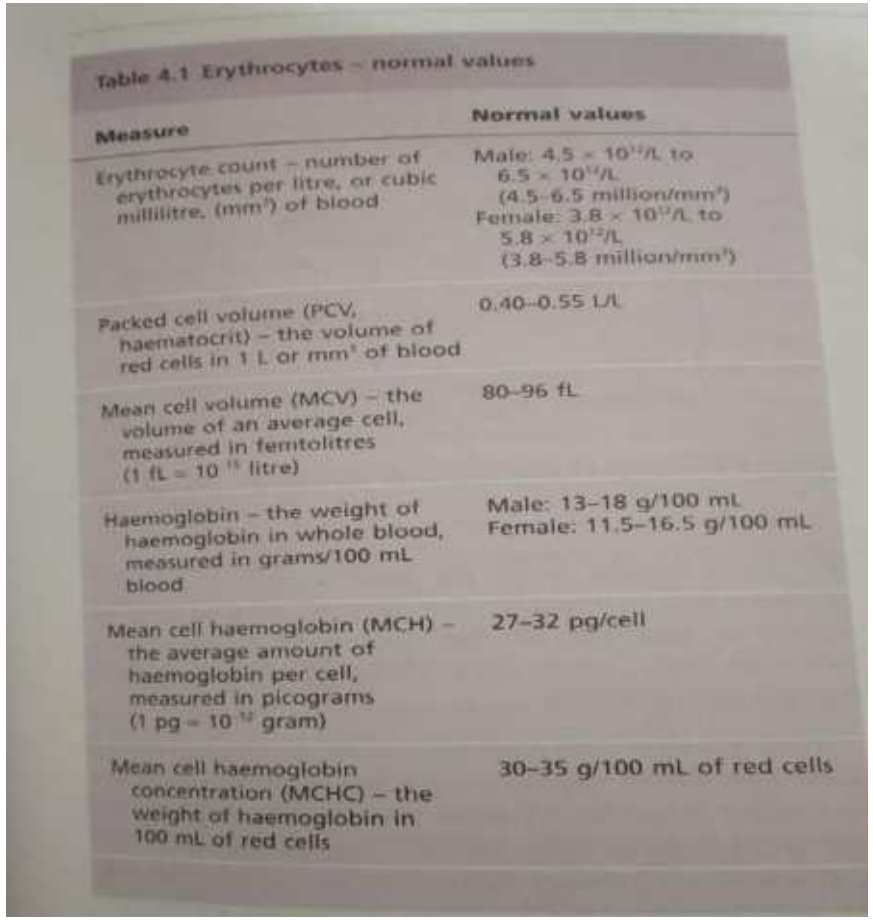


Table 4.1 Erythrocytes – normal values

Measure	Normal values
Erythrocyte count – number of erythrocytes per litre, or cubic millilitre, (mm^3) of blood	Male: 4.5×10^{12}/L to 6.5×10^{12}/L (4.5–6.5 million/mm^3) Female: 3.8×10^{12}/L to 5.8×10^{12}/L (3.8–5.8 million/mm^3)
Packed cell volume (PCV, haematocrit) – the volume of red cells in 1 L or mm^3 of blood	0.40–0.55 L/L
Mean cell volume (MCV) – the volume of an average cell, measured in femtolitres (1 fL = 10^{-15} litre)	80–96 fL
Haemoglobin – the weight of haemoglobin in whole blood, measured in grams/100 mL blood	Male: 13–18 g/100 mL Female: 11.5–16.5 g/100 mL
Mean cell haemoglobin (MCH) – the average amount of haemoglobin per cell, measured in picograms (1 pg = 10^{-12} gram)	27–32 pg/cell
Mean cell haemoglobin concentration (MCHC) – the weight of haemoglobin in 100 mL of red cells	30–35 g/100 mL of red cells

- A routine complete blood count (CBC) checks for levels of 10 different components of every major cell in your blood: white blood cells, red blood cells, and platelets.
- Important components this test measures include red blood cell count, hemoglobin, and hematocrit.
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- Specifically, blood tests can help doctors: **Evaluate how well organs**—such as the kidneys, liver, thyroid, and heart—are working. Diagnose diseases and conditions such as cancer, HIV/AIDS, diabetes, anemia (uh-NEE-me-eh), and coronary heart disease. Find out whether you have risk factors for heart disease.08-Dec-2021

Scanning electron micrograph showi
one sickled erythrocyte.

Red blood cell disorders

- There are multiple disorders of the red blood cells, including hemoglobinopathies, cytoskeletal abnormalities (spherocytosis and other membranopathies) and enzymopathies.
- Hemoglobinopathies are a group of rare, inherited disorders involving abnormal structure of the hemoglobin molecule. These disorders include hemoglobin C disease, hemoglobin S-C disease, sickle cell anemia and various types of thalassemia.

Clotting of blood

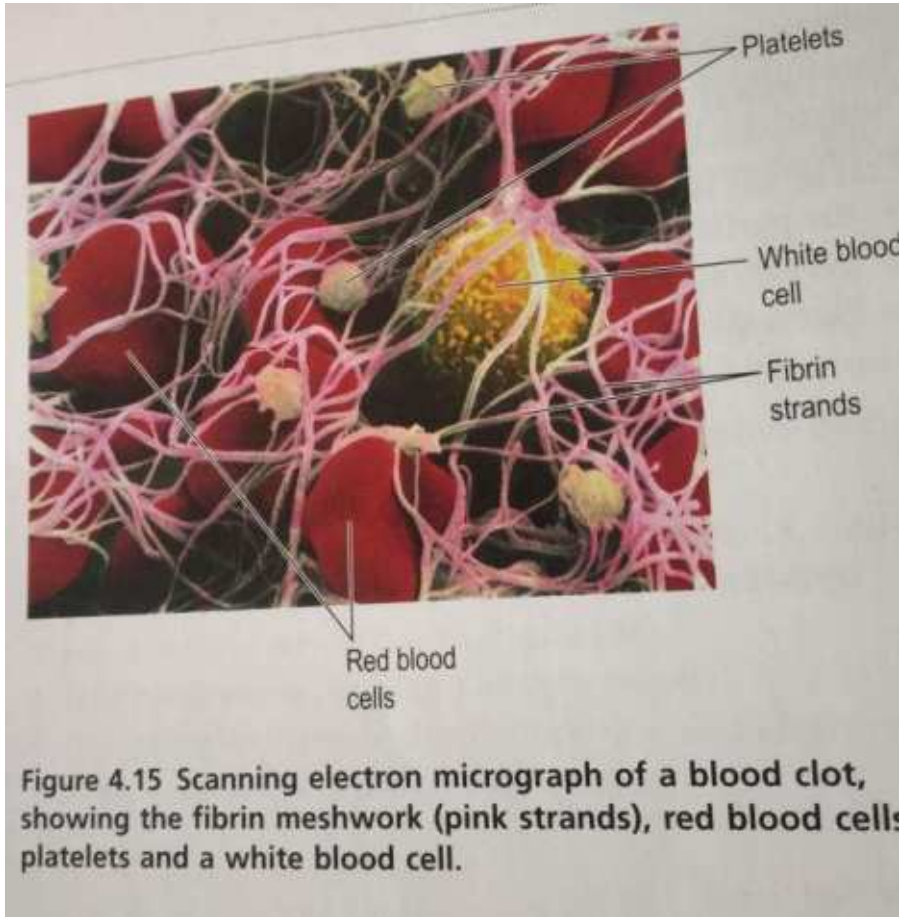


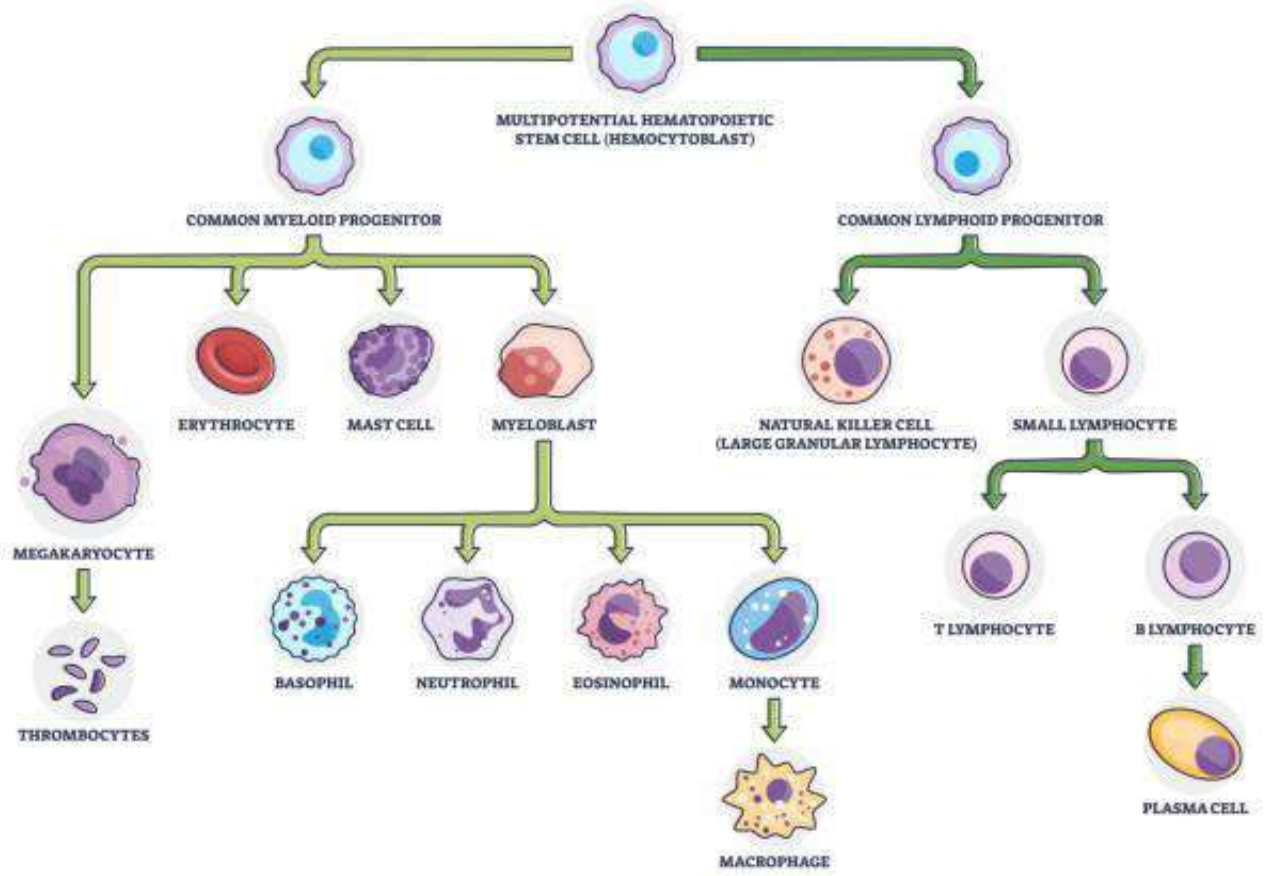
Figure 4.15 Scanning electron micrograph of a blood clot, showing the fibrin meshwork (pink strands), red blood cells, platelets and a white blood cell.

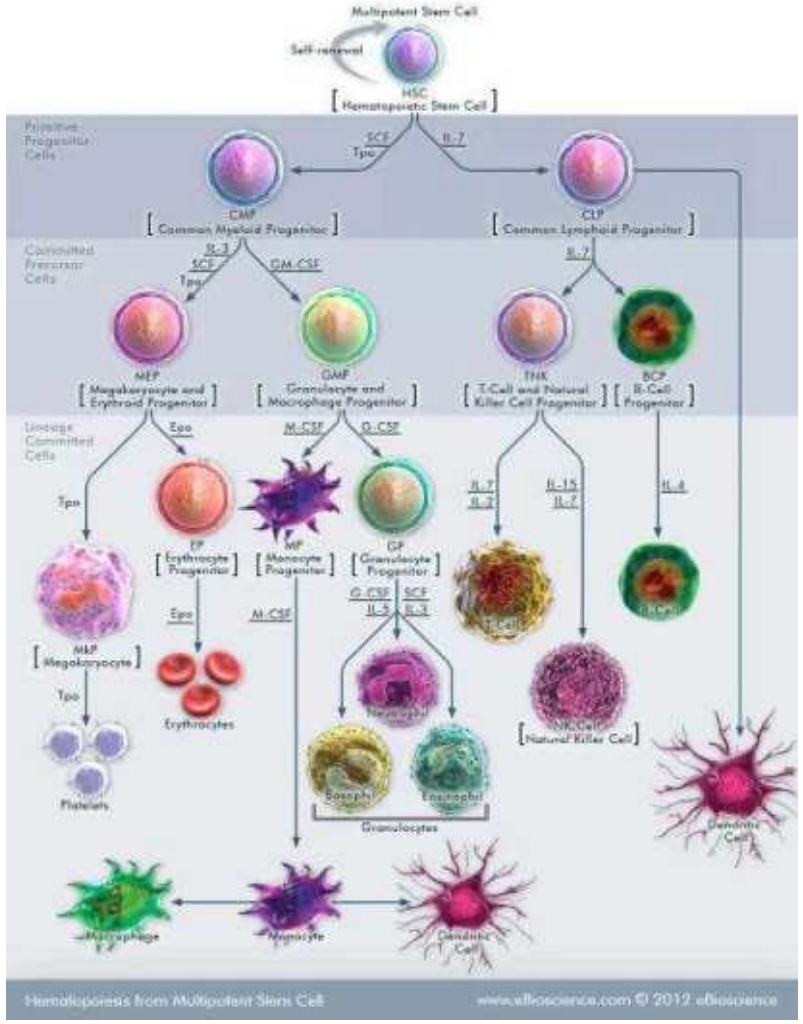
- when a blood vessel becomes injured, the coagulation factors or clotting factors in the blood are activated. The clotting factor proteins stimulate the production of fibrin, which is a strong and strand-like substance that forms a fibrin clot. For days or weeks, this fibrin clot strengthens and then dissolves when the injured blood vessel walls close and heal.

HEMATOPOIESIS

- **Hematopoiesis** is the process by which the body produces blood cells and blood plasma. It occurs in the bone marrow, spleen, liver, and other organs.
- Hematopoiesis is the process of creating a wide variety of blood and bone marrow cells, namely erythrocytes, platelets, granulocytes, lymphocytes, and monocytes. This process begins with multipotent hematopoietic stem cells (HSC) which have the capability of dividing into either a multipotent progenitor cell or to self-renew. Progenitor cells are then able to divide into increasing specialized cells, a process which repeats and eventually leads to mature white blood cells, red blood cells, or platelets.
- This series of divisions in hematopoiesis creates a chart with several branch points beginning with the multipotent progenitor cells dividing into either a common myeloid progenitor or a common lymphoid progenitor. Common myeloid progenitors eventually go on to create megakaryocytes, erythrocytes, basophils, neutrophils, eosinophils, and monocytes. Common lymphoid progenitors will produce Natural Killer cells as well as B and T lymphocytes.[1]
- Multi-potent progenitors and any cells the progenitors create lack the capacity to self-renew and must instead always divide into a further specialized cell. Which type of cell the HSCs and progenitor cells divide into is largely decided by the specific signaling factors such as erythropoietin

HEMATOPOIESIS




Multipotent Stem Cell
Self-renewal
HSC
[Hematopoietic Stem Cell]
Primitive Progenitor Cells
SCF
Tpo
IL-7
CMP
[Common Myeloid Progenitor]
CLP
[Common Lymphoid Progenitor]
Committed Precursor Cells
IL-3
SCF
Tpo
GM-CSF
IL-7
MEP
[Megakaryocyte and Erythroid Progenitor]
GMP
[Granulocyte and Macrophage Progenitor]
TNK
[T-Cell and Natural Killer Cell Progenitor]
BCP
[B-Cell Progenitor]
Lineage Committed Cells
Epo
M-CSF
G-CSF
IL-4
IL-7
IL-9
IL-15
IL-7
Tpo
EP
[Erythrocyte Progenitor]
MP
[Monocyte Progenitor]
GP
[Granulocyte Progenitor]
G-CSF
IL-5
SCF
IL-3
M&P
[Megakaryocyte]
Epo
M-CSF
Tpo
Erythrocytes
Platelets
T-Cell
[NK-Cell Natural Killer Cell]
Granulocytes
Macrophage
Monocyte
Dendritic Cell
Hematopoiesis from Multipotent Stem Cell
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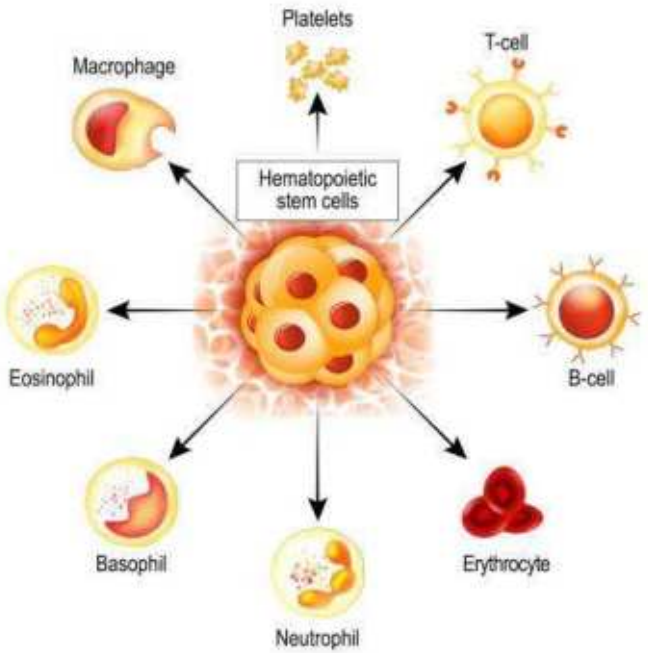
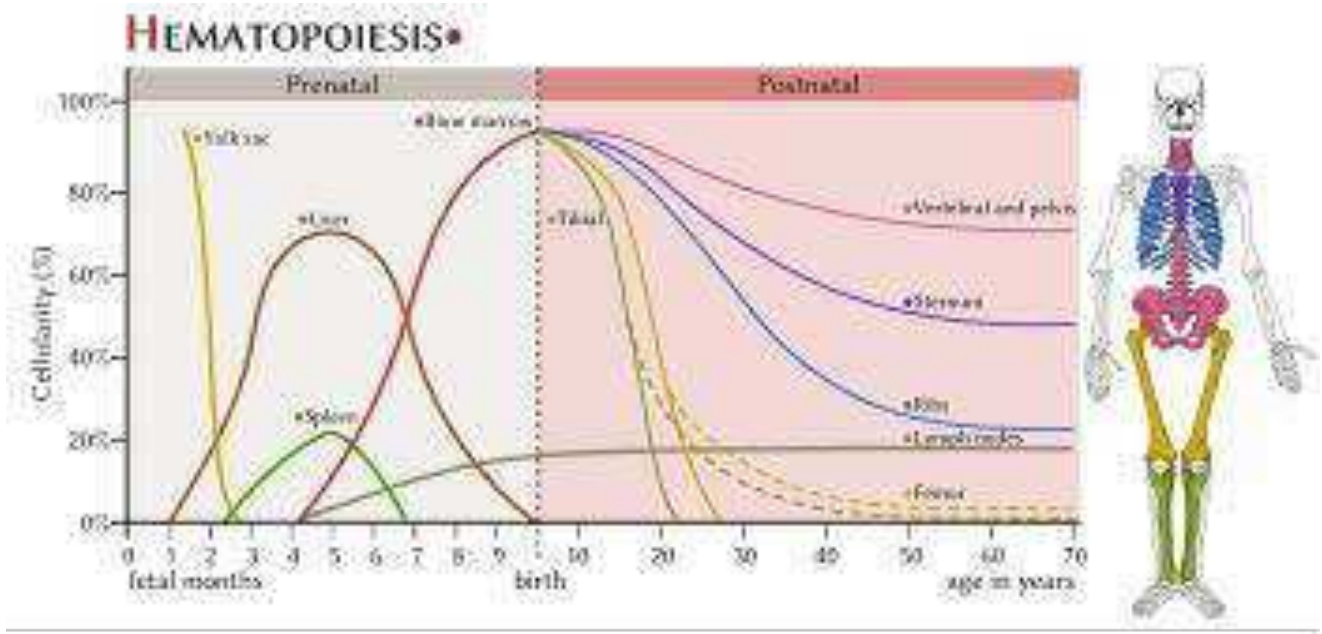
Haematopoiesis

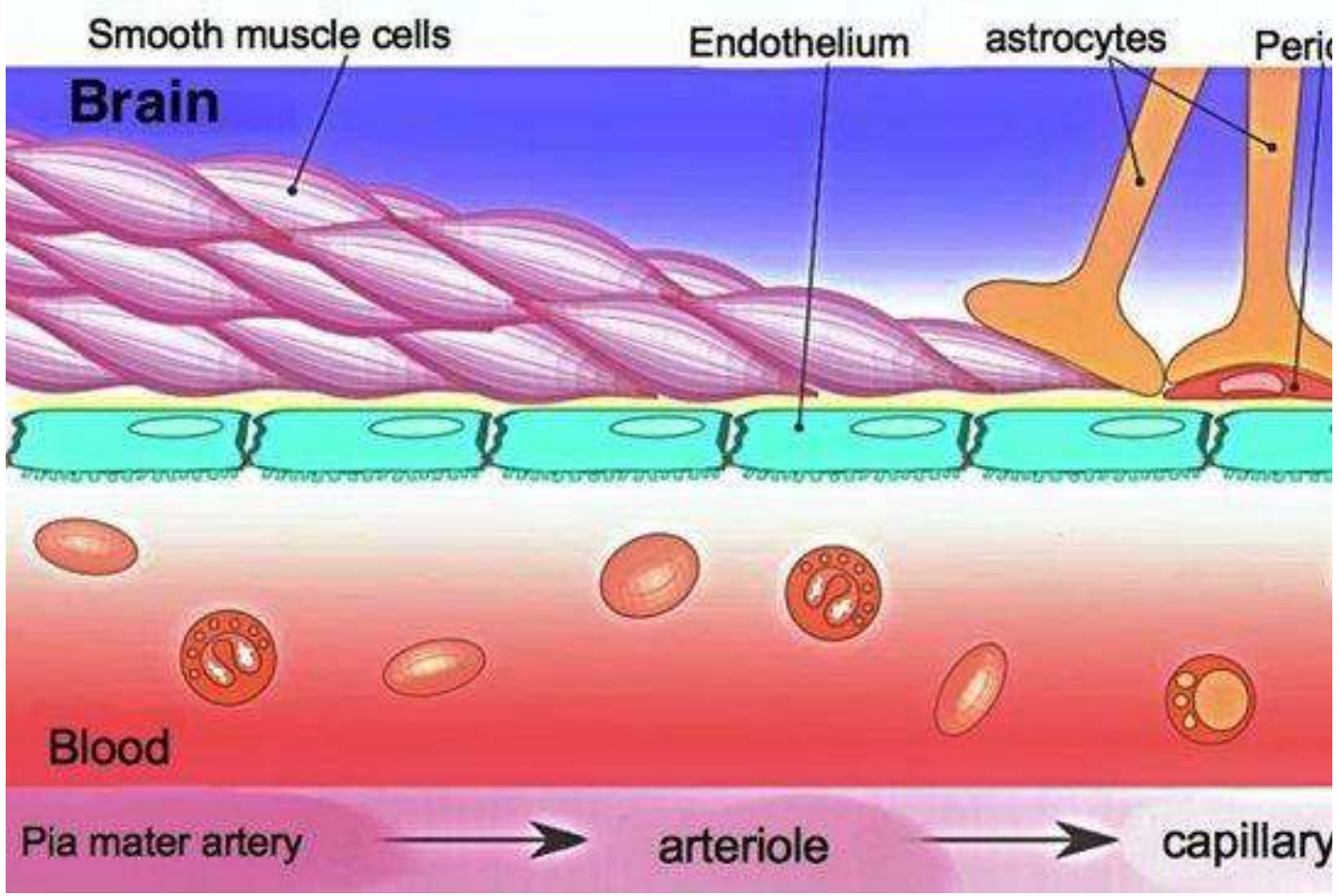


Location

- The primary locations of hematopoiesis change throughout life. At the beginning of the fetal period, it begins in the yolk sac and aorta-gonad-mesonephros, eventually transitioning into liver, spleen, and finally the bone marrow and lymph nodes. It is maintained in these final locations for the duration of adult life except in pathological cases where it can return to its former sites.
- Hematopoiesis in bone marrow takes place in islands of hematopoietic tissue surrounded by vascular sinuses and is interspersed with trabecular bone. Hematopoietic tissue contains a spectrum of blood cells, adipocytes, endothelial cells, and adventitial cells. As cells develop and mature, they enter the circulation through venous sinuses. The specific cells which are predominant in each microscopic area of the bone marrow are largely dependent on the niche of signaling cells at that site, which can include mature HSC, osteoblasts, macrophages, stromal cells, endothelial cells, and adipocytes among others. The location of hematopoiesis for certain cells can be tied to their function. For example, megakaryocytes, which are very large and bulky, are formed right next to the marrow sinuses into which they shed platelets.

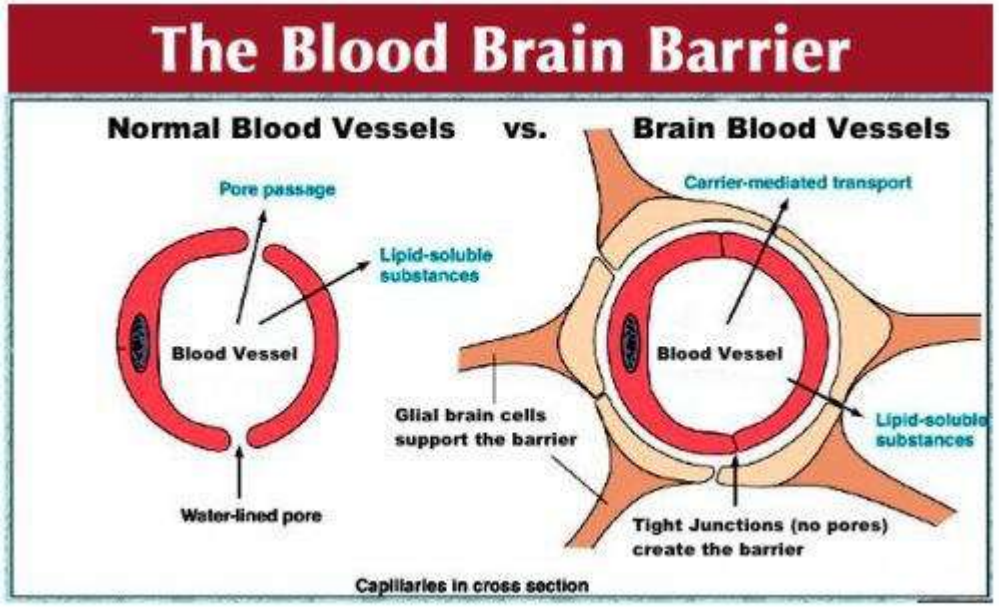


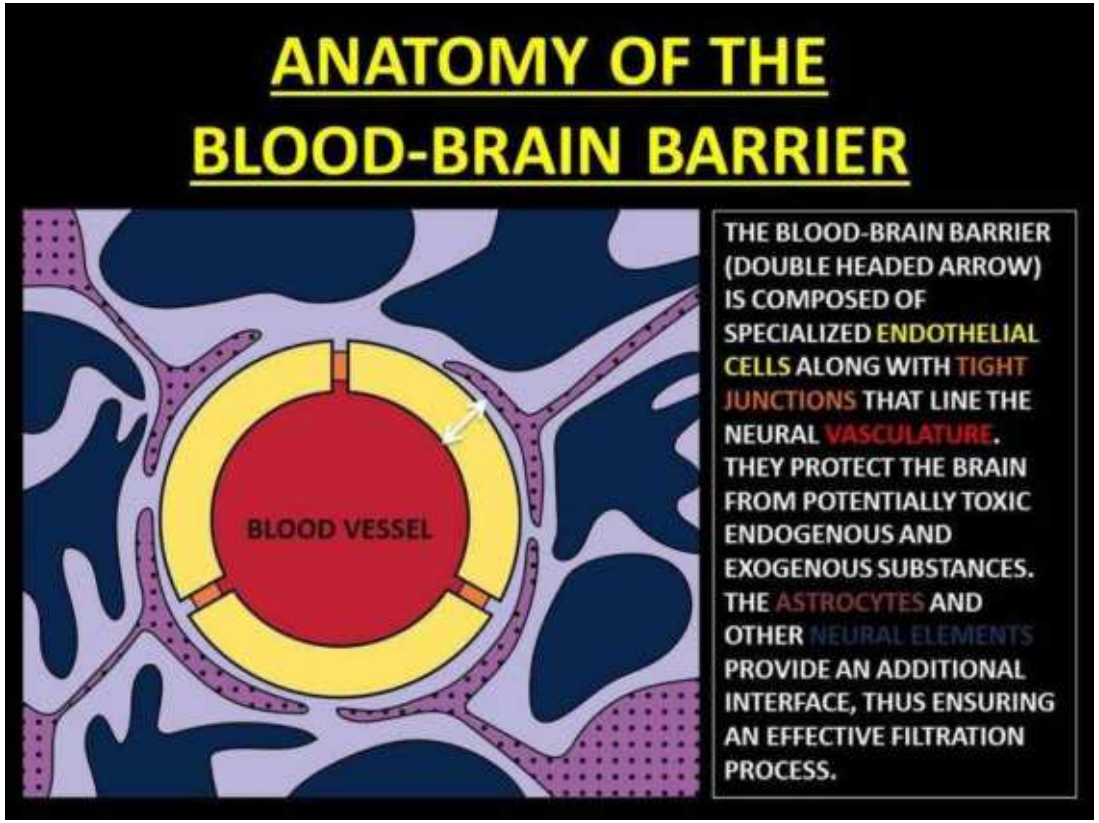
B LOOD BRAIN BARRIER



- The blood-brain barrier (BBB) is the specialized system of brain microvascular endothelial cells (BMVEC) that **shields the brain from toxic substances in the blood, supplies brain tissues with nutrients, and filters harmful compounds from the brain back to the bloodstream**.
- It is made up of **capillary endothelial cells and basement membrane, neuroglial membrane, and glial podocytes, i.e., projections of astrocytes**. These 3 components work in synchronicity with one another to limit the entry of various substances into the cerebral blood flow and subsequently the brain parenchyma.

STRUCTURE


The Blood Brain Barrier
Normal Blood Vessels
vs.
Brain Blood Vessels
Pore passage
Lipid-soluble substances
Blood Vessel
Water-lined pore
Carrier-mediated transport
Blood Vessel
Glial brain cells support the barrier
Lipid-soluble substances
Tight Junctions (no pores) create the barrier
Capillaries in cross section


ANATOMY OF THE BLOOD-BRAIN BARRIER
BLOOD VESSEL
THE BLOOD-BRAIN BARRIER (DOUBLE HEADED ARROW) IS COMPOSED OF SPECIALIZED ENDOTHELIAL CELLS ALONG WITH TIGHT JUNCTIONS THAT LINE THE NEURAL VASCULATURE. THEY PROTECT THE BRAIN FROM POTENTIALLY TOXIC ENDOGENOUS AND EXOGENOUS SUBSTANCES. THE ASTROCYTES AND OTHER NEURAL ELEMENTS PROVIDE AN ADDITIONAL INTERFACE, THUS ENSURING AN EFFECTIVE FILTRATION PROCESS.

BLOOD – BRAIN BARRIER

- Blood vessels are critical to deliver oxygen and nutrients to all of the tissues and organs throughout the body. The blood vessels that vascularize the central nervous system (CNS) possess unique properties, termed the blood–brain barrier, which allow these vessels to tightly regulate the movement of ions, molecules, and cells between the blood and the brain. This precise control of CNS homeostasis allows for proper neuronal function and also protects the neural tissue from toxins and pathogens, and alterations of these barrier properties are an important component of pathology and progression of different neurological diseases. The physiological barrier is coordinated by a series of physical, transport, and metabolic properties possessed by the endothelial cells (ECs) that form the walls of the blood vessels, and these properties are regulated by interactions with different vascular, immune, and neural cells.

- The brain has a large network of arterial and venous vessels taking blood to and from (respectively) brain tissue. However, most of the action occurs at the level of the capillaries. Both the luminal and abluminal (outer surface of the vessel) sides are lined by key structures that contribute to the integrity of the cells. Firstly, squamous epithelial cells form the endothelial wall of the capillaries; the luminal surface of these cells comes into contact with circulating blood and its constituents. The abluminal surface is in contact with a circumferentially continuous basement membrane.

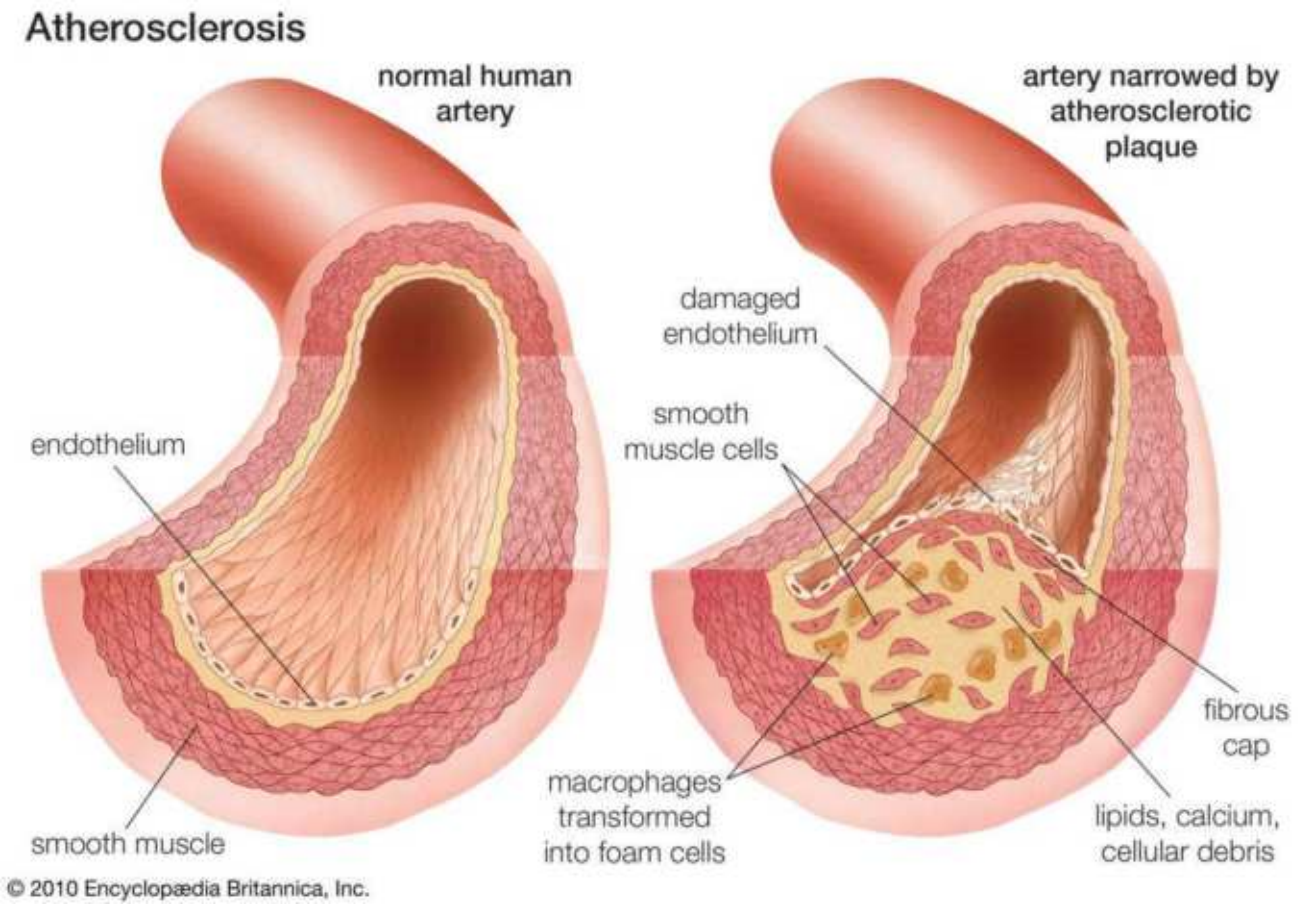
BLOOD PRESSURE

- Blood pressure is the pressure of blood pushing against the walls of your arteries. Arteries carry blood from your heart to other parts of your body.
- Your blood pressure normally rises and falls throughout the day.
- Blood pressure is measured using two numbers:
- The first number, called *systolic* blood pressure, measures the pressure in your arteries when your heart beats.
- The second number, called *diastolic* blood pressure, measures the pressure in your arteries when your heart rests between beats.
- If the measurement reads 120 systolic and 80 diastolic, you would say, “120 over 80,” or write, “120/80 mmHg.”

- High blood pressure, also called hypertension, is blood pressure that is higher than normal. Your blood pressure changes throughout the day based on your activities. Having blood pressure measures consistently above normal may result in a diagnosis of high blood pressure (or hypertension).
- The higher your blood pressure levels, the more risk you have for other health problems, such as heart disease, heart attack, and stroke.

ATHEROSCLEROSIS

- Atherosclerosis is the narrowing of arteries due to plaque buildup on the artery walls.
- Arteries carry blood from the heart to the rest of the body. A thin layer of cells forms a lining that keeps them smooth and allows blood to flow easily. This is called the endothelium.
- Atherosclerosis happens when the endothelium becomes damaged, due to factors such as smoking, high blood pressure, or high levels of glucose, fat, and cholesterol in the blood.
- This damage allows a collection of substances, known as plaque, to build up in the artery wall. These substances include fat and cholesterol.
- Over time, plaque can build up and become hard.
- If plaque continues to collect, it can block the artery and disrupt the flow of blood around the body.
- Sometimes, pieces of plaque break open. If this happens, particles from blood cells, known as platelets, gather in the affected area. These can stick together, forming blood clots.
- A clot can block the artery, leading to life threatening complications, such as stroke and heart attack.



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- National Library of Medicine journal,Joseph Chapman; Yaoping Zhang May 8, 2022.
- **The American College of Cardiology/American Heart Association Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults (2017 Guideline)[1]**