HUMAN PHYSIOLOGY AND CLINICAL BIOCHEMISTRY

Topic: Circulation

Lecture 1

Components of Blood

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REFERENCE: OPEN ACCESS

Blood

Blood is a type of connective tissue whose cells are suspended in a liquid extracellular matrix.

Blood volume is typically about 8% of body weight. An average size adult has about 5 liters of blood.

Blood is vital in carrying substances between body cells and the external environment, thereby promoting homeostasis

The main components of blood are:

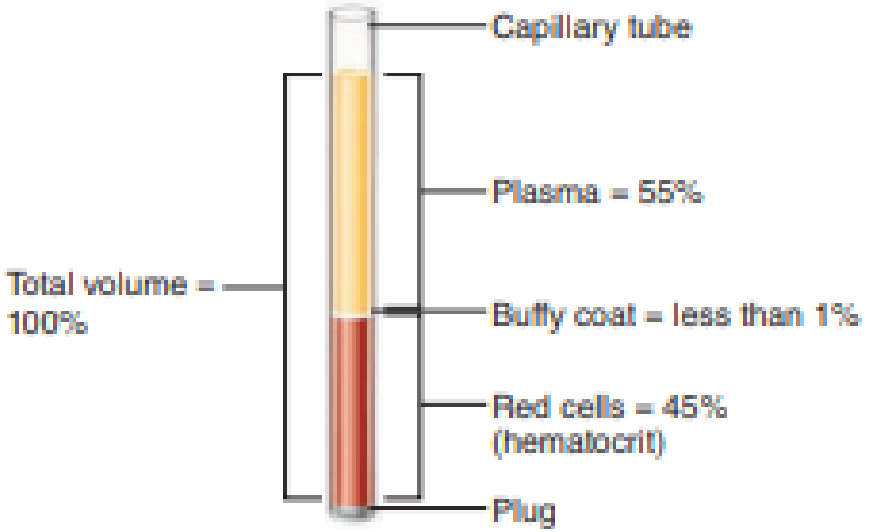
- plasma
- red blood cells
- white blood cells
- Platelets
- The cells and platelets are termed “formed elements” of the blood, in contrast to the liquid portion

REFERENCE: OPEN ACCESS

If a blood sample stands in a tube for a while and is prevented from clotting, the cells separate from the liquid portion and settle to the bottom.

Centrifuging the sample quickly packs the cells into the lower part of the centrifuge tube. The percentages of cells and liquid in the blood sample can then be calculated.

Most blood samples are about 45% red blood cells by volume. This percentage is called the hematocrit (HCT), or packed cell volume (PCV).



If a blood-filled capillary tube is centrifuged, the red cells pack in the lower portion and the percentage of red cells (hematocrit) can be determined. Values shown are within the normal range for healthy humans.

REFERENCE: OPEN ACCESS

The white blood cells and platelets account for less than 1%. The remaining blood sample, about 55%, is the clear, straw-colored plasma

Plasma is a complex solution that includes water, amino acids, proteins, carbohydrates, lipids, vitamins, hormones, electrolytes, and cellular wastes

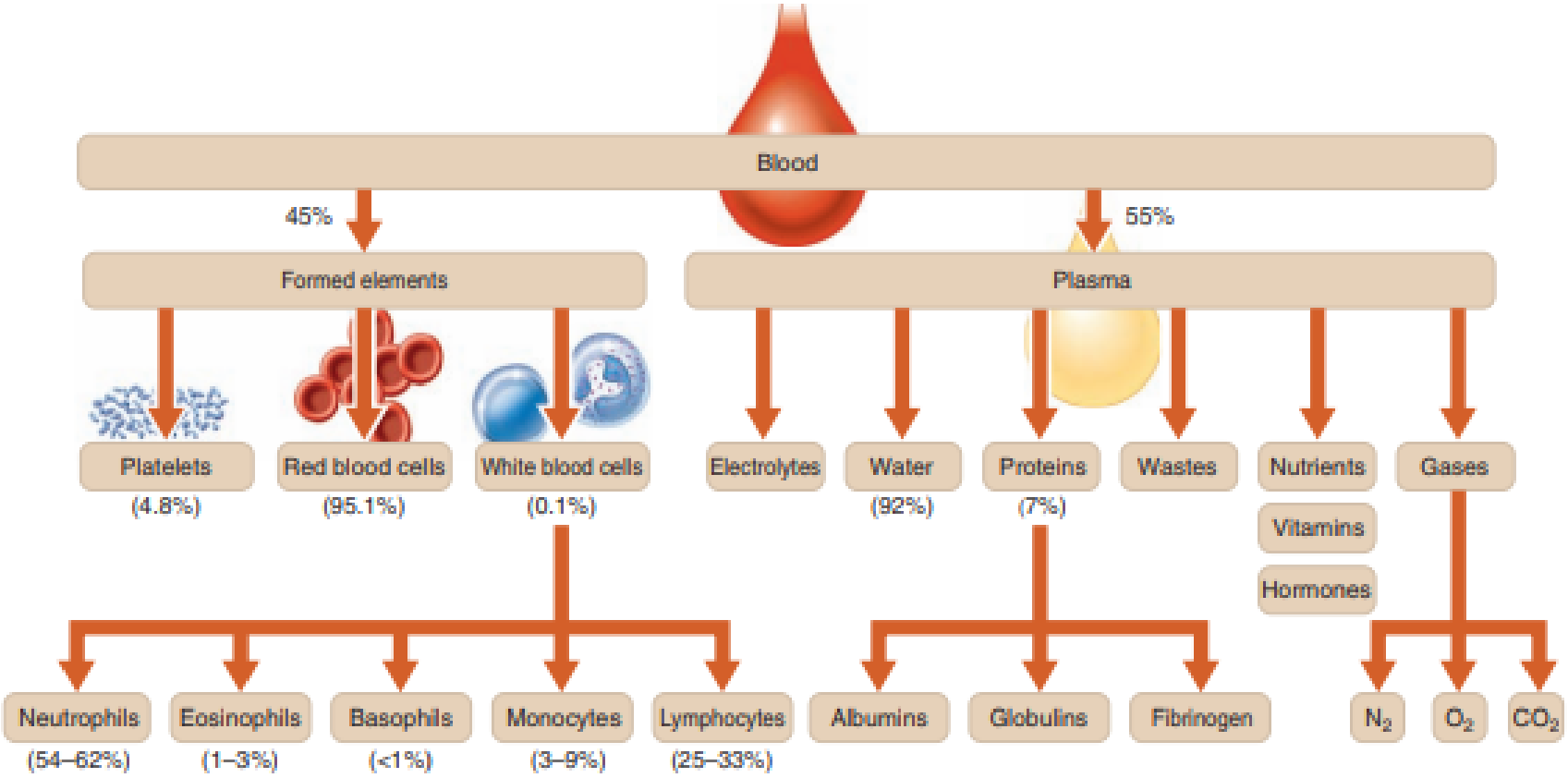
Hematopoiesis

Blood cells originate in red bone marrow from hematopoietic stem cells, also known as hemocytoblasts

Hematopoietic stem cells divide, into myeloid and lymphoid stem cells, respond to different secreted growth factors, called hematopoietic growth factors

This exposure to growth factors ultimately sculpts the distinctive formed elements of blood, including the cellular components of the immune system.

REFERENCE: OPEN ACCESS



Blood composition. Blood is a complex mixture of formed elements in a liquid extracellular matrix, plasma.

REFERENCE: OPEN ACCESS

Red Blood Cells

Red blood cells, also called erythrocytes, are tiny, approximately 7.5 µm in diameter. They are biconcave discs, thin near their centers and thicker around their rims.

This distinctive shape is an adaptation for the red blood cell's function of transporting gases—it increases the surface area through which gases can diffuse.

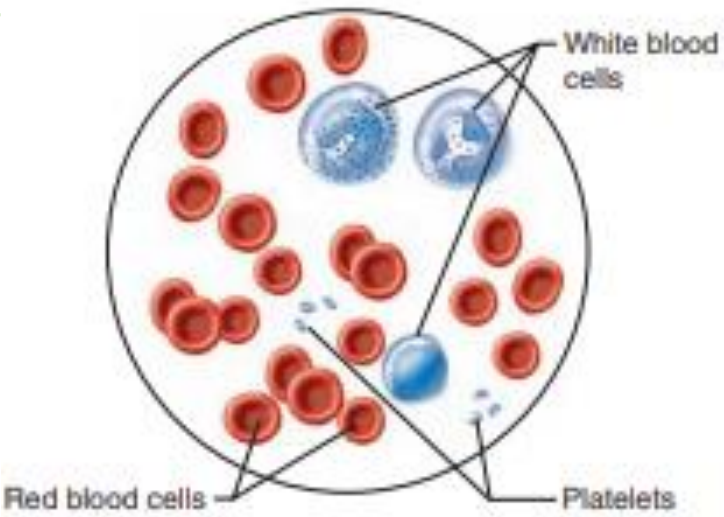
The shape also places the cell membrane closer to oxygen-carrying hemoglobin molecules in the cell.

A red blood cell's shape and flexibility enable it to readily squeeze through the narrow capillaries.

Each red blood cell is about one-third hemoglobin by volume. This protein imparts the color of blood.

The rest of the cell mainly consists of membrane, water, electrolytes, and enzymes. When hemoglobin combines with oxygen, the resulting oxyhemoglobin is bright red; when the oxygen is released, the resulting deoxyhemoglobin is darker.

Blood rich in deoxyhemoglobin may appear bluish when it is viewed through blood vessel walls.



Peripheral Blood Smear

REFERENCE: OPEN ACCESS

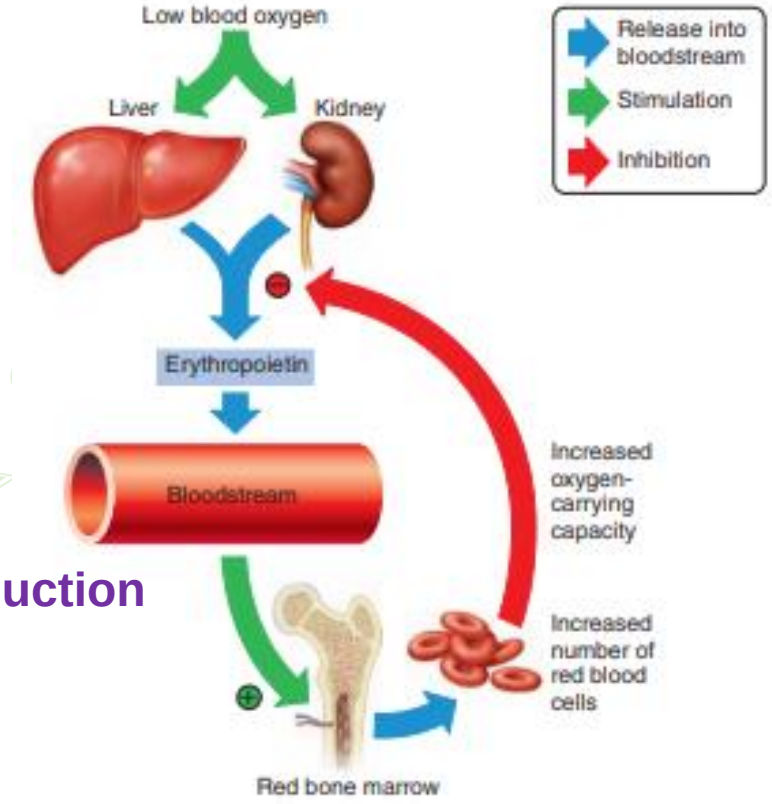
Red Blood Cells

- Red blood cells have nuclei during their early stages of development but extrude the nuclei as they mature, providing more space for hemoglobin.
- Because mature red blood cells lack nuclei, they cannot synthesize proteins or divide. Mature red blood cells produce ATP through glycolysis only and use none of the oxygen they carry because they also lack mitochondria.
- With time, however, red blood cells become less active, more rigid, and more likely to be damaged or worn. Eventually the spleen and liver remove older red blood cells from the circulation
- The number of red blood cells in a microliter (µL or mcL or 1 mm3) of blood is called the red blood cell count (RBCC or RCC).
- The typical range for adult males is 4,700,000–6,100,000 cells per microliter, and that for adult females is 4,200,000– 5,400,000 cells per microliter.
- **For children, the average range is 4,500,000–5,100,000 cells per micro liter.**
- The number of red blood cells generally increases for several days following strenuous exercise or an increase in altitude.

REFERENCE: OPEN ACCESS

Hormone erythropoietin (EPO) controls the rate of red blood cell formation

- Low blood oxygen causes the kidneys and, to a lesser degree, the liver to release erythropoietin.
- Erythropoietin stimulates target cells in the red bone marrow to increase the production of red blood cells, which carry oxygen to tissues.



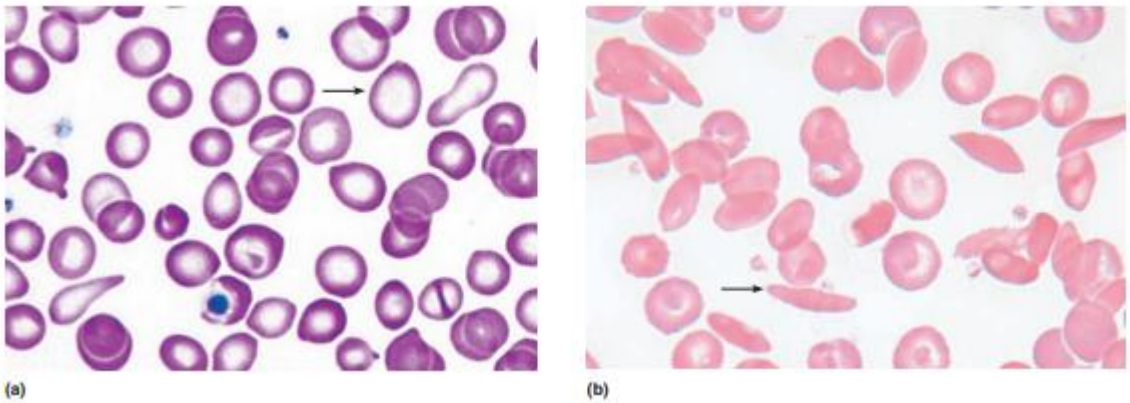
Dietary Factors Affecting Red Blood Cell Production

Substance	Source	Function
Vitamin B_{12} (requires intrinsic factor for absorption via small intestine)	Absorbed from small intestine	DNA synthesis
Iron	Absorbed from small intestine; conserved during red blood cell destruction and made available for reuse	Hemoglobin synthesis
Folic acid	Absorbed from small intestine	DNA synthesis

REFERENCE: OPEN ACCESS

REFERENCE: Human Physiology: Guyton
Open access

A defi ciency of red blood cells or a reduction in the amount of hemoglobin they contain results in a condition called anemia. This reduces the oxygen-carrying capacity of the blood, and the affected person may appear pale and lack energy



Abnormal red blood cells. (a) Light micrograph of erythrocytes with central pallor or paleness (arrow) as seen in iron-deficiency anemia (1,000×).
(b) Light micrograph of sickled erythrocytes (arrow) from a person with sickle cell disease (1,000×).

REFERENCE: OPEN ACCESS

Some Types Of Anemia.

Type	Cause	Defect
Aplastic anemia	Toxic chemicals, radiation	Damaged bone marrow
Hemolytic anemia	Toxic chemicals	Red blood cells destroyed
Iron-deficiency anemia	Dietary lack of iron	Hemoglobin deficient
Pernicious anemia	Inability to absorb vitamin B_{12}	Excess of large, fragile cells
Sickle cell disease	Defective gene	Red blood cells abnormally shaped
Thalassemia	Defective gene	Hemoglobin deficient; red blood cells short-lived

REFERENCE: OPEN ACCESS

Destruction Of Red Blood Cells

Red blood cells are elastic and fl exible, and they readily bend as they pass through small blood vessels. With age, however, these cells become more fragile, and may be damaged by passing through capillaries, particularly those in active muscles that must withstand strong forces.

Damaged or worn red blood cells rupture as they pass through the spleen or liver. In these organs, macrophages phagocytize and destroy damaged red blood cells and their contents. Hemoglobin molecules liberated from the red blood cells break down into their four component polypeptide “globin” chains, each surrounding a heme group

The heme further decomposes into iron and a greenish pigment called biliverdin.

The iron, combined with a protein called transferrin, may be carried by the blood to the hematopoietic tissue in the red bone marrow and reused in synthesizing new hemoglobin.

About 80% of the iron is stored in the liver cells in the form of an iron-protein complex called ferritin.

In time, the biliverdin is converted to an orange pigment called bilirubin.

Biliverdin and bilirubin are secreted in the bile as bile pigments

The polypeptide globin chains break down into amino acids. The individual amino acids are metabolized by the macrophages or released into the blood.

REFERENCE: OPEN ACCESS

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