Physiology

Blood Composition, Plasma Proteins, and Hemoglobin

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Blood has several vital functions in the body, categorized into three main areas:

1. Transport

- Oxygen transport: Red blood cells (RBCs) carry oxygen from the lungs to tissues via hemoglobin.
- Carbon dioxide removal: Blood transports CO_2 from tissues to the lungs for exhalation.
- Nutrient delivery: Carries glucose, amino acids, fatty acids, vitamins, and minerals to cells.
- Waste removal: Transports metabolic waste products (e.g., urea, creatinine) to the kidneys and liver for excretion.
- Hormone transport: Carries hormones from endocrine glands to target organs.

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

2. Regulation

- Body temperature regulation: Distributes heat generated by metabolism and adjusts blood flow to the skin.
- pH balance: Buffers (e.g., bicarbonate, proteins) help maintain blood pH between 7.35–7.45.
- Fluid balance: Plasma proteins (e.g., albumin) and electrolytes regulate osmotic pressure and fluid distribution.

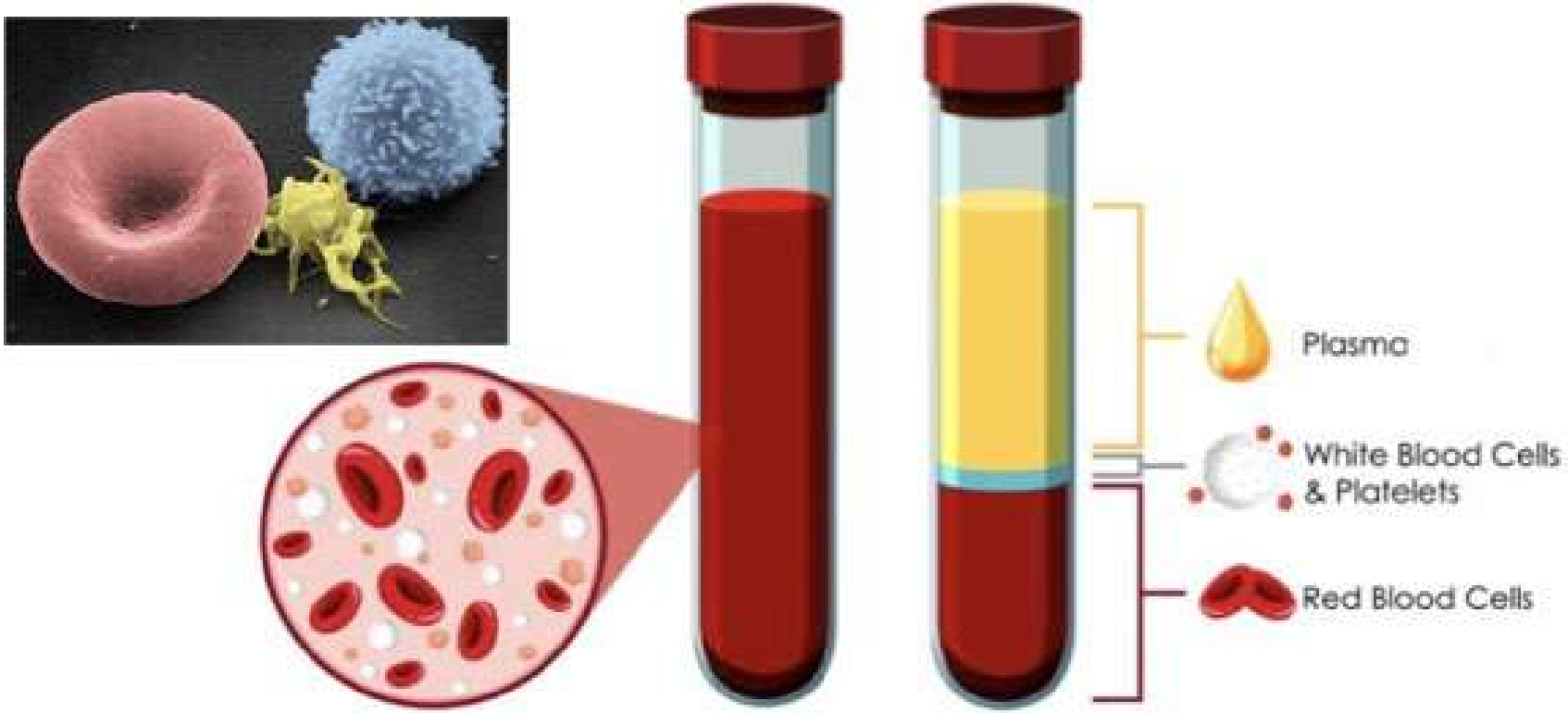
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

3. Protection

- Immune defense: White blood cells (WBCs) and antibodies fight infections and pathogens.
- Clotting mechanism: Platelets and clotting factors prevent excessive blood loss by forming clots.

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Blood is a vital fluid that performs essential functions such as transportation, immunity, and homeostasis.

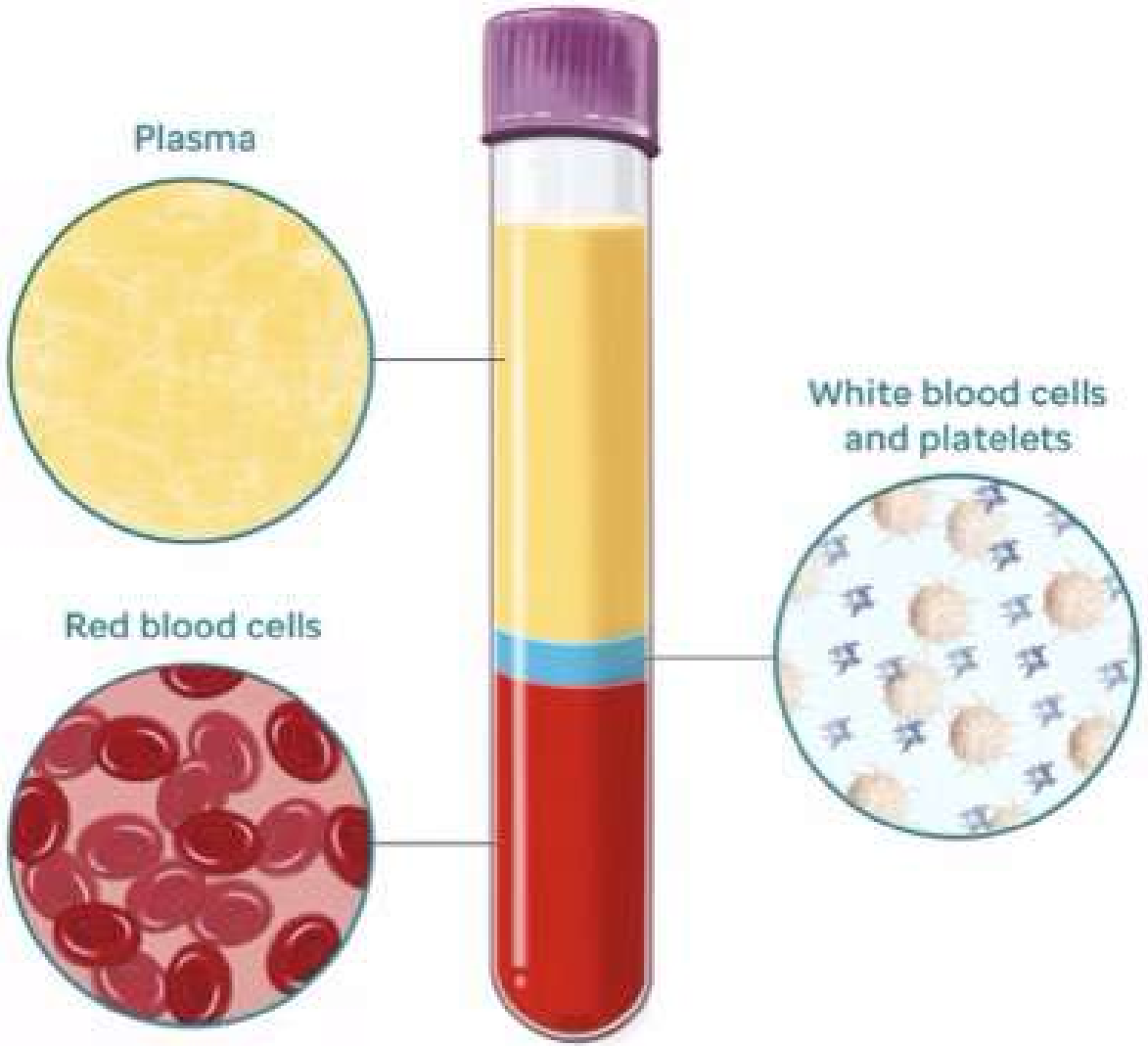


م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Composition and Functions of Blood Components

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Blood is composed of plasma (55%) and formed elements (45%), which include red blood cells (RBCs), white blood cells (WBCs), and platelets.



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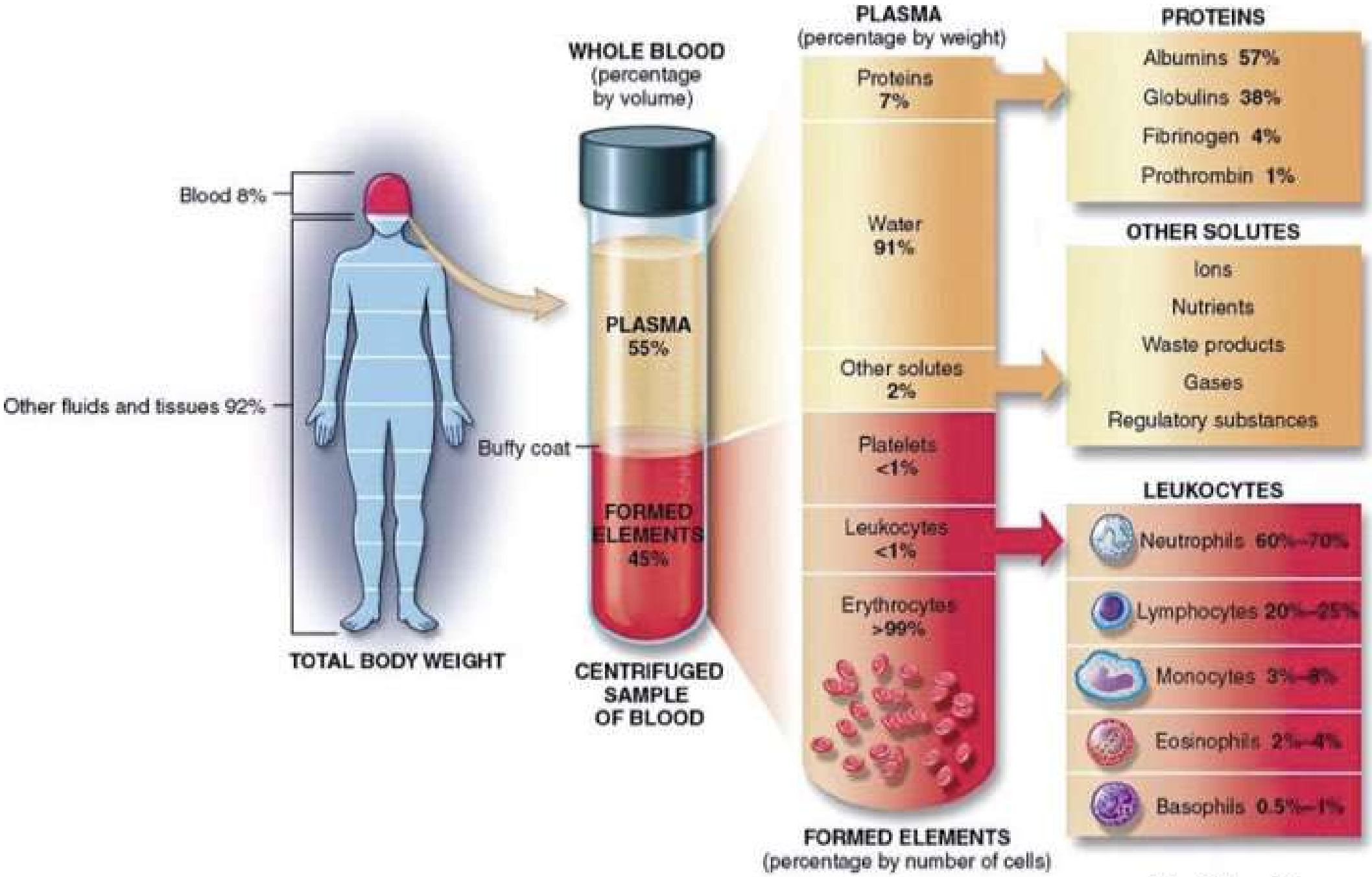

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A. **Plasma** (55% of blood volume)

• Composed of 90% water, 7% proteins, and 3% solutes (electrolytes, gases, nutrients, hormones, and waste products).

• Functions: Transporting nutrients, hormones, and waste; maintaining pH and osmotic balance; supporting immunity and clotting.

B. **Formed Elements** (45%)

1. **Red Blood Cells (Erythrocytes)**

• Contain hemoglobin for oxygen transport.

• Lack a nucleus to maximize space for oxygen-binding hemoglobin.

• Lifespan: ~120 days.

2. **White Blood Cells (Leukocytes)**

• Part of the immune system, classified as:

• Granulocytes (neutrophils, eosinophils, basophils) – involved in inflammation and immunity.

• Agranulocytes (lymphocytes, monocytes) – involved in adaptive immunity and phagocytosis.

3. **Platelets (Thrombocytes)**

• Cell fragments from megakaryocytes.

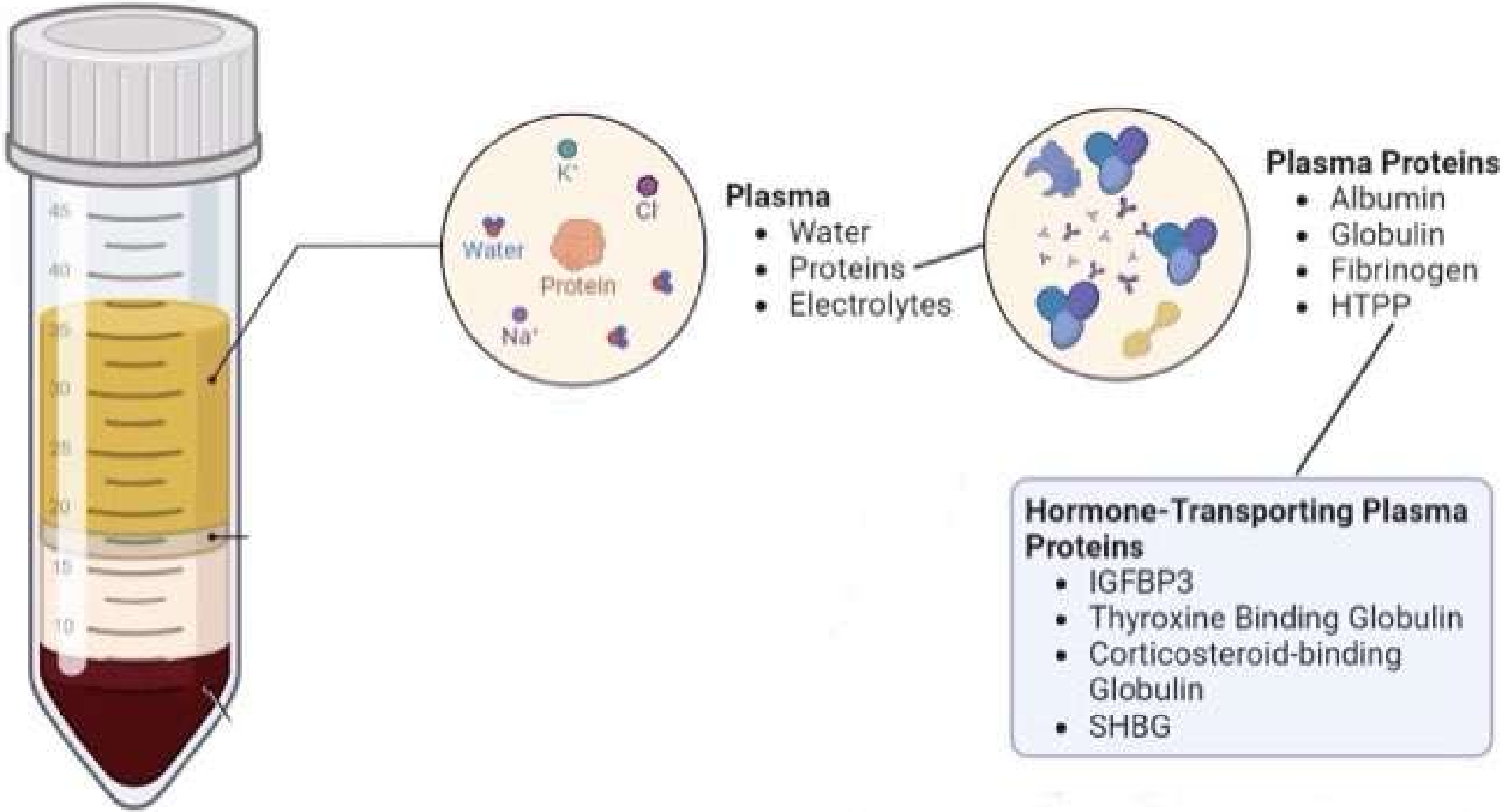
• Essential for blood clotting (hemostasis).

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Plasma Proteins: Origin, Forms, Variations, and Functions

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Plasma proteins are synthesized mainly in the liver and have diverse physiological roles.



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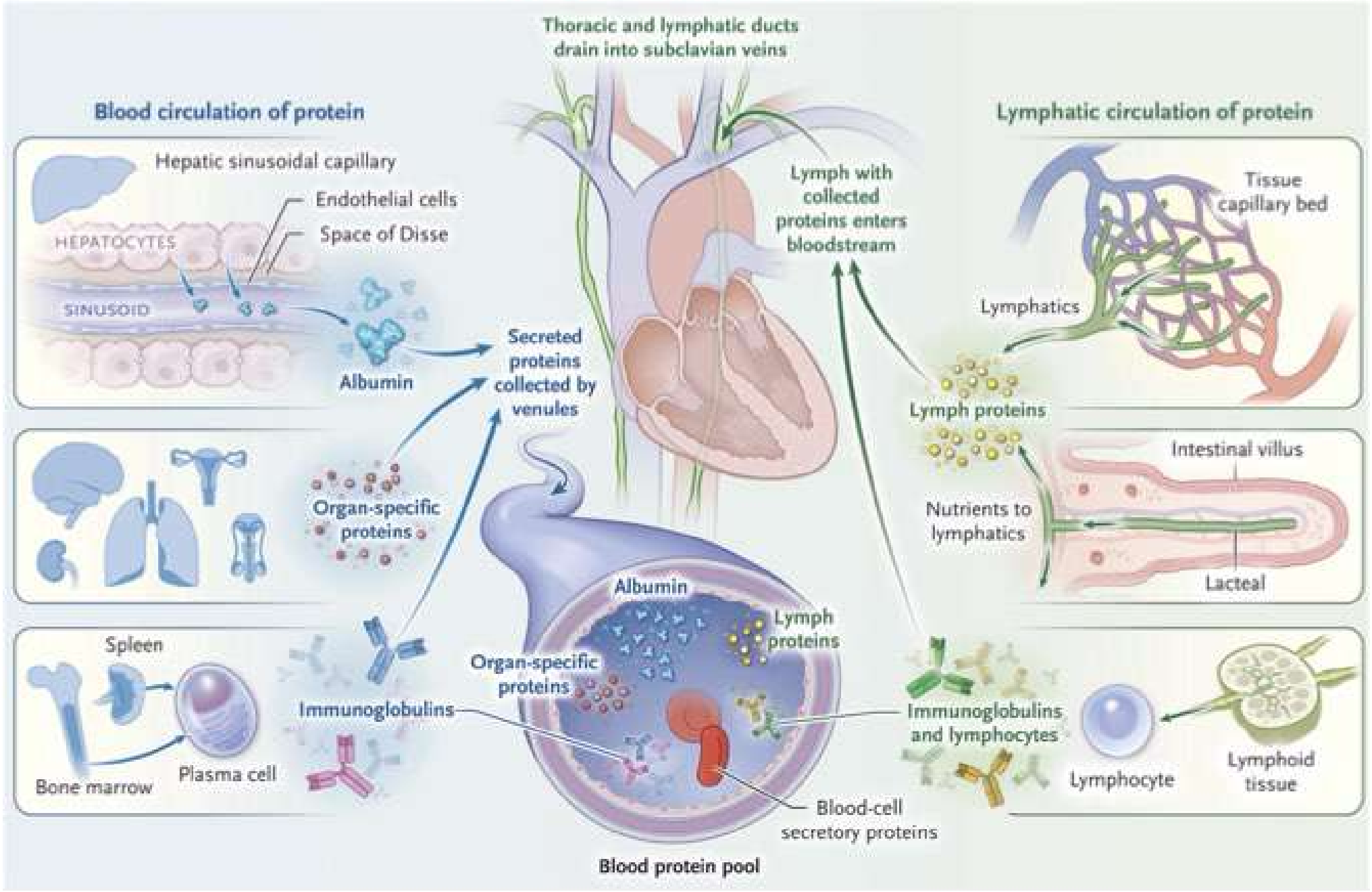
Major Types of Plasma Proteins



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Major Types of Plasma Proteins

1. **Albumin (60%)**

• Origin: Synthesized in the liver.

• Function: Maintains osmotic pressure, transports hormones, fatty acids, and drugs.

2. **Globulins (35%)**

• Alpha and Beta Globulins: Transport proteins (e.g., transferrin, lipoproteins).

• Gamma Globulins (Immunoglobulins): Antibodies produced by plasma cells for immune defense.

3. **Fibrinogen (4%)**

• Precursor of fibrin, essential for blood clotting.

4. **Regulatory Proteins (1%)**

• Includes enzymes, hormones, and complement proteins involved in immune responses.

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Variations in Plasma Proteins

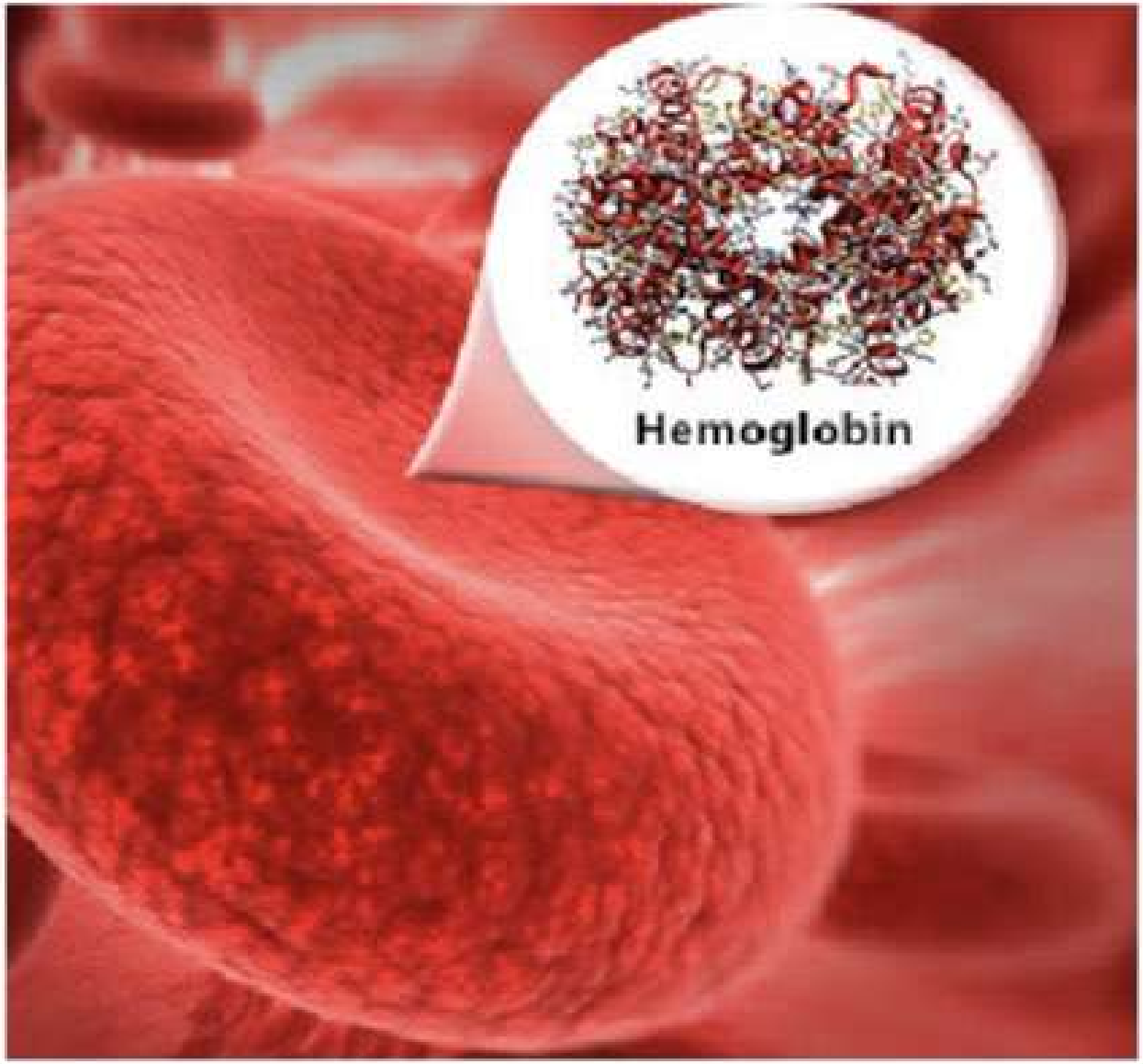
- Hypoproteinemia (low blood protein levels) – seen in malnutrition, liver disease, and kidney disorders.
- Hyperproteinemia (high blood protein levels) – seen in dehydration, infections, and multiple myeloma.

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Hemoglobin: Synthesis, Function, and Breakdown

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Hem-o-globin



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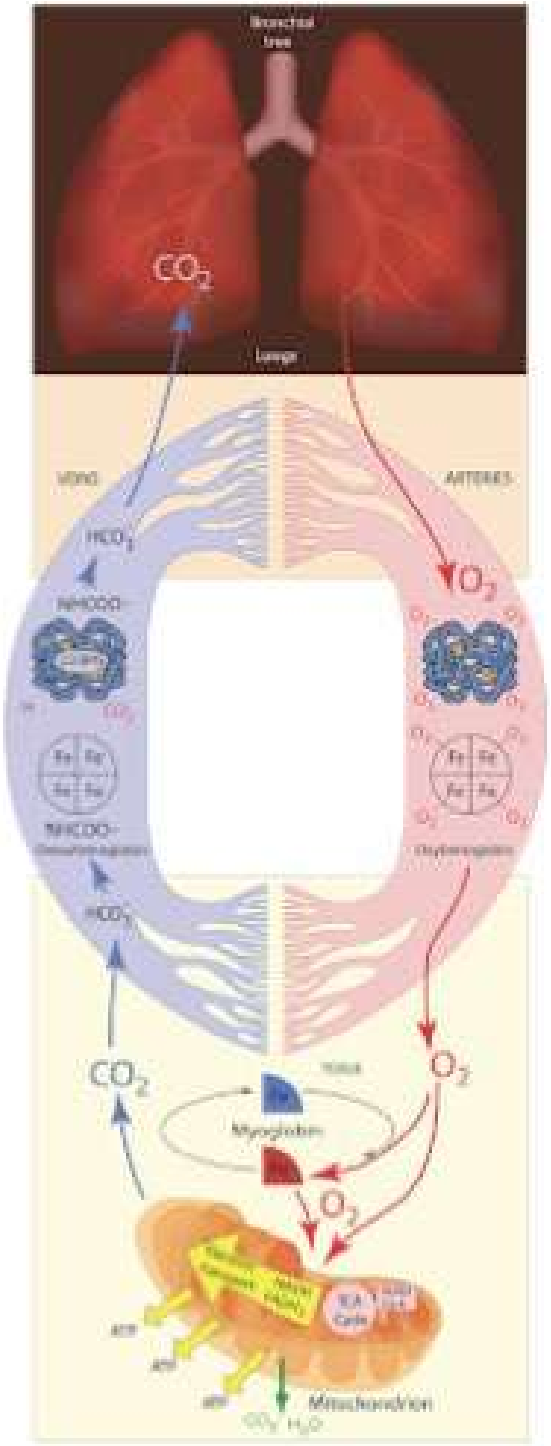

Functions of Hemoglobin

- Oxygen Transport: Binds oxygen in the lungs and releases it in tissues.
- Carbon Dioxide Transport: Carries CO_2 back to the lungs.
- Buffering Role: Helps maintain blood pH.

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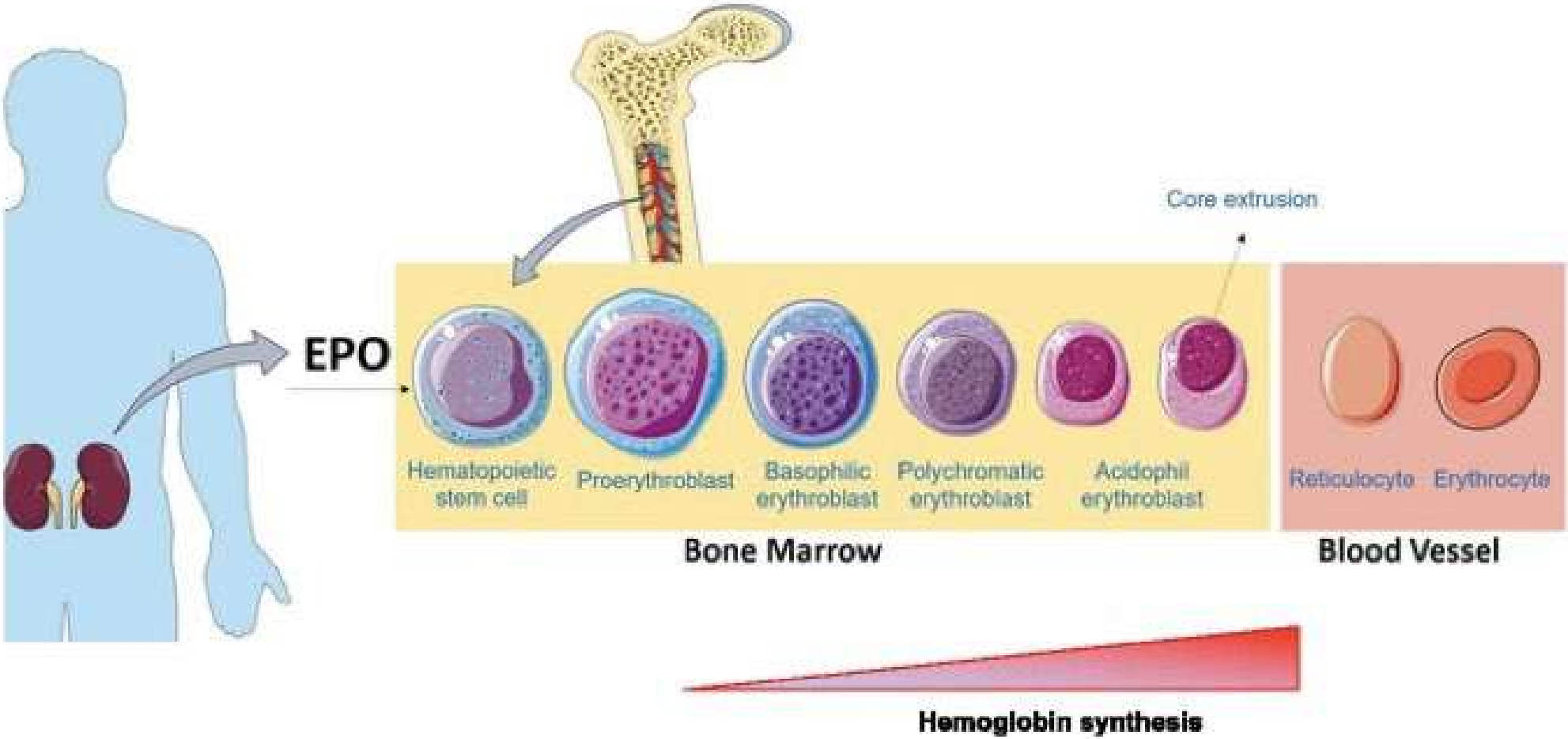
MBChB. MSc. PhD.

Synthesis of Hemoglobin

Hemoglobin (Hb) is synthesized in erythroid precursors in the bone marrow.



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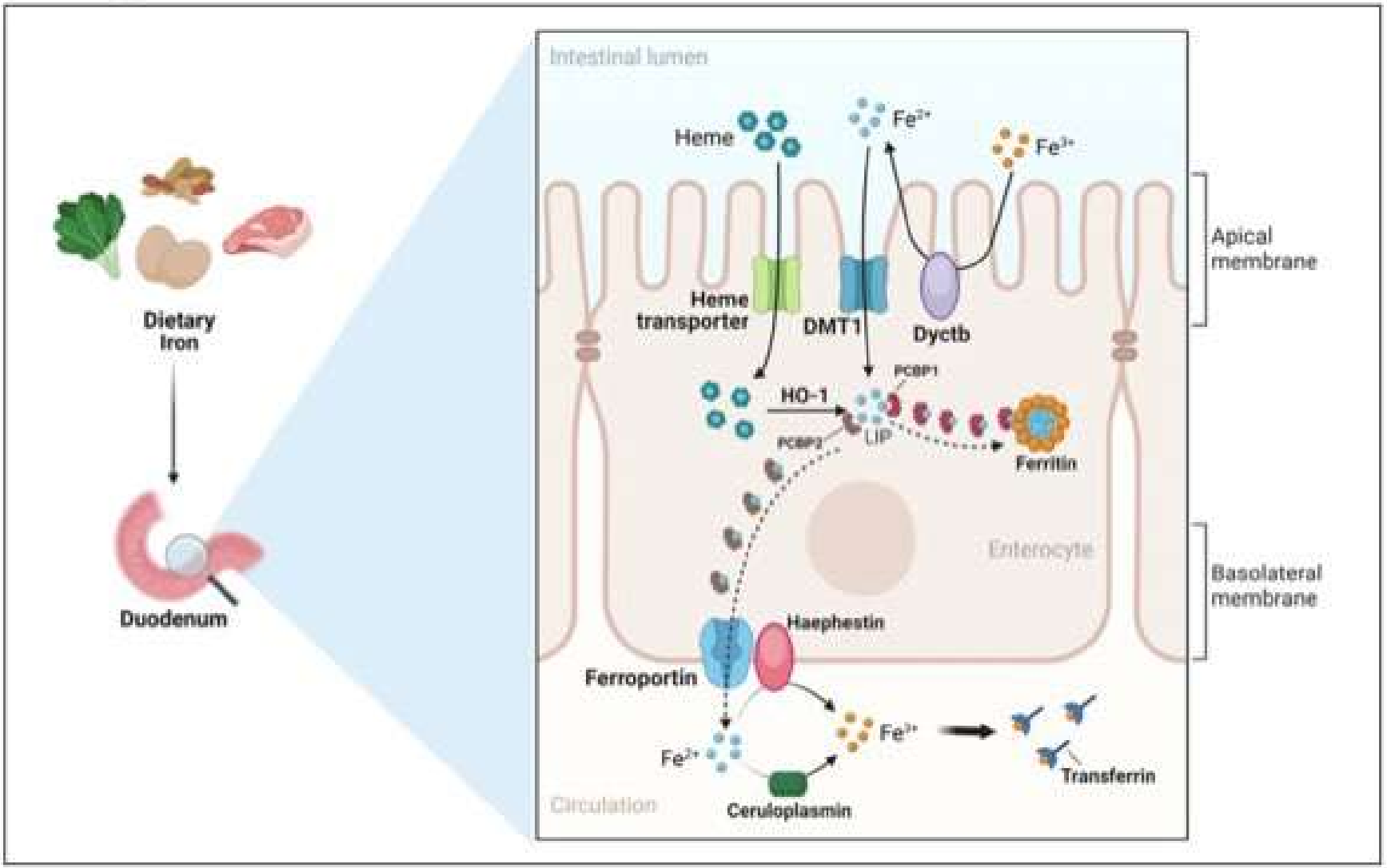
The process of hemoglobin synthesis involves:

1. Iron Uptake: Iron (Fe^{2+}) is absorbed in the small intestine and transported via transferrin to the bone marrow.



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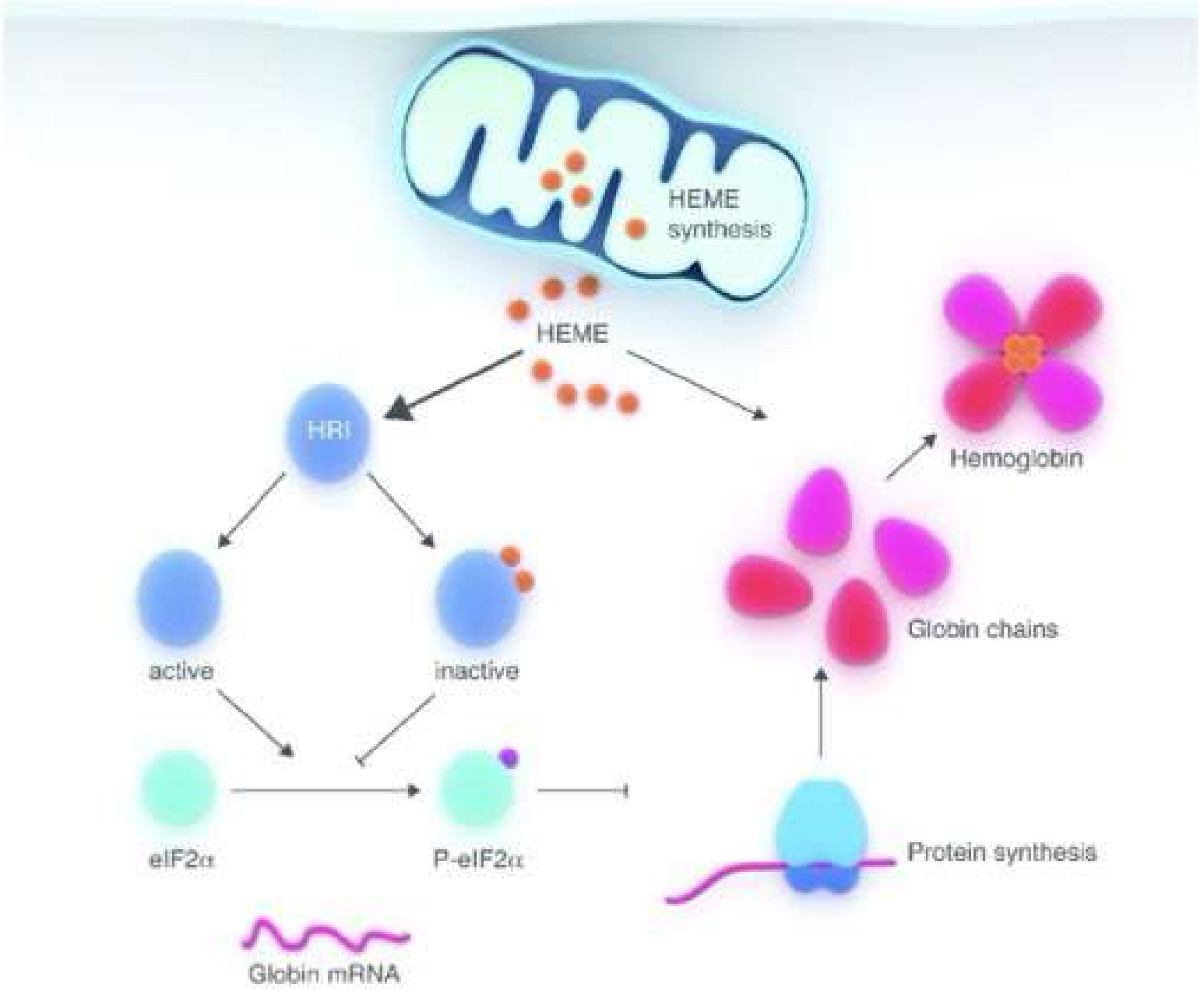

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MBChB. MSc. PhD.

Synthesis of Hemoglobin

The process of hemoglobin synthesis involves:

1. Iron Uptake: Iron (Fe^{2+}) is absorbed in the small intestine and transported via transferrin to the bone marrow.

2. Heme Synthesis: Occurs in mitochondria, involving protoporphyrin and iron.

3. Globin Synthesis: Alpha and beta globin chains are synthesized in ribosomes.

4. Assembly: Heme and globin combine to form hemoglobin (HbA: $\alpha_2\beta_2$).

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Breakdown of Hemoglobin

Occurs in macrophages of the spleen, liver, and bone marrow:

1. **Hemoglobin** → Heme + Globin

• Globin is broken down into amino acids for reuse.

2. **Heme** → Biliverdin → Bilirubin

• Bilirubin is transported to the liver, conjugated, and excreted via bile.

3. **Iron** Recycling: Stored as ferritin or transported via transferrin for new RBC production.

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Variants of Hemoglobin (Normal Hemoglobin Types):

- HbA ($\alpha_2\beta_2$) – Adult hemoglobin (97%).
- HbA_2 ($\alpha_2\delta_2$) – Minor adult form (2.5%).
- HbF ($\alpha_2\gamma_2$) – Fetal hemoglobin (higher O_2 affinity, replaced by HbA after birth).

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Abnormal Hemoglobin Variants

- HbS – Found in sickle cell anemia (mutation in the β-chain, causing sickling of RBCs).
- Thalassemias – Deficiency in globin chain production (α-thalassemia, β-thalassemia).

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Conclusion

Blood is a complex tissue with specialized components: plasma proteins contribute to transport and immunity, while hemoglobin is essential for oxygen delivery.

Understanding their synthesis, functions, and disorders provides insights into many hematological conditions and their management.

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