

Blood Cell Mind Map 1

صلى الله
عليه
وسلم

لا تنسوا الصلاة على سيدنا محمد
ويا نبلس!

done by Hadeel Ramzi

Functions of Blood

- 1 Transport nutrients and respiratory gases
 - O_2 , CO_2 , glucose, amino acids, lipids, vitamins
- 2 Transport waste products
 - to organs and tissues for recycling or elimination
- 3 Transport hormones
 - endocrine regulation
- 4 Transport immune cells
 - throughout the body
- 5 Help regulate body temperature
 - via heat distribution
- 6 Maintain acid-base and osmotic balance
 - pH, electrolytes, water balance

Composition of Blood

Plasma (~55%)

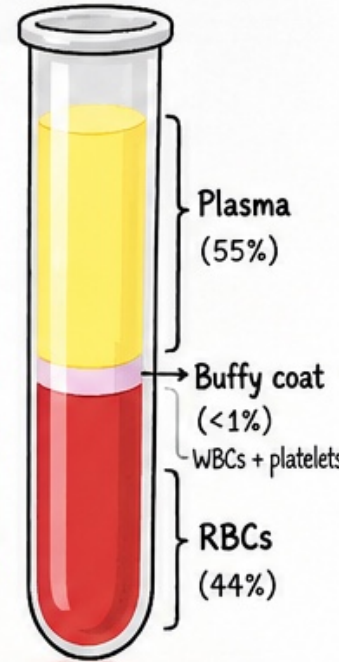
- Pale-yellow fluid
- ~90% water
- ~10% dissolved substances:
 - Plasma proteins
 - Electrolytes
 - Nutrients
 - Metabolic waste products
 - Dissolved gases
 - Hormones

Formed elements (~45%)

- Erythrocytes (RBCs)
 - transport oxygen
- Leukocytes (WBCs)
 - immune defense
- Platelets (thrombocytes)
 - blood clotting

Buffy coat: <1%

- Leukocytes + Platelets



BLOOD
Specialized form of
connective tissue

Blood Smear

Purpose

- Morphological study of blood cells
- Differential leukocyte count (DLC)

Method

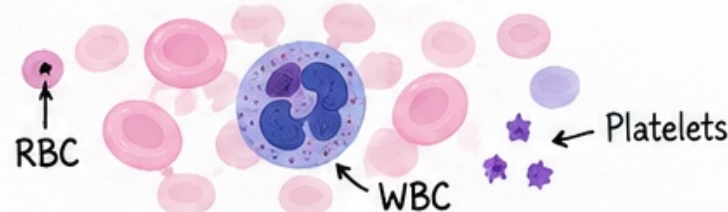
- 1 Thin film of peripheral blood
- 2 Air-dried
- 3 Fixed with methyl alcohol
- 4 Stained with Romanowsky stains

Stains (Romanowsky group)

- Giemsa stain
- Wright stain
- Leishman stain

Staining principle

- **Eosin** (acidic dye)
 - stains basic (acidophilic) components **pink/red**
 - e.g. cytoplasm, RBCs
- **Methylene blue** (basic dye)
 - stains acidic (basophilic) components **blue/purple**
 - e.g. nuclei, granules, DNA
- **Methyl alcohol**
 - fixative (preserves cells)



Plasma Proteins

Main plasma proteins:

1 Albumin (60%)

- Maintains oncotic (colloid osmotic) pressure
- Prevents fluid from leaving blood vessels
- Transport of various substances (e.g. hormones, fatty acids, drugs)

2 α -globulins (α_1, α_2) (10%)

- Transport proteins
- e.g. transcortin, α_1 -antitrypsin

3 β -globulins (10%)

- Transport proteins
- e.g. transferrin (iron), complement

4 γ -globulins (20%)

- Immunoglobulins (antibodies)
- produced by plasma cells

5 Fibrinogen

- Clotting factor
- Converted to fibrin during coagulation

Serum = Plasma - Clotting Factors

General Features

- Most numerous formed elements in blood
- Biconcave, anucleate discs
- Flexible
- Transport O_2 and CO_2
- Life span: about 120 days



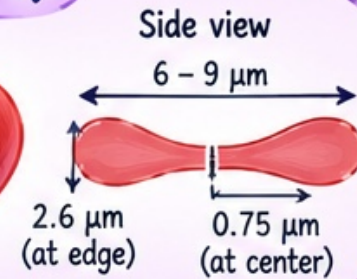
Number in Peripheral Blood

- Males: $4.5 - 5.5 \times 10^6 / mm^3$
- Females: $4.0 - 5.0 \times 10^6 / mm^3$



Shape (Biconcave Disc)

- Diameter: $6 - 9 \mu m$ (average $7.5 \mu m$)



Functions

- Transport O_2 from lungs to tissues (via hemoglobin)
- Transport CO_2 from tissues to lungs



Surface Area

- Biconcave shape → large surface area (about 20 - 30% more than a sphere of the same volume)



Erythrocytes (RBCs)

Slides 10 - 15

Membrane Structure

Composed of:

- 50% proteins
- 40% lipids (phospholipids + cholesterol)
- 10% carbohydrates



Membrane Proteins

- Spectrin
- Ankyrin



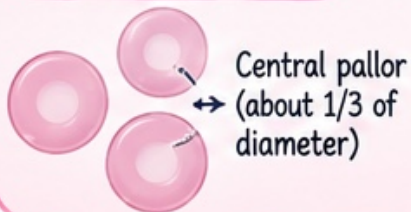
Properties

- Flexible → can pass through narrow capillaries
- No nucleus and no organelles
- Contain enzymes for glycolysis
- High content of hemoglobin
- Biconcave shape → helps gas exchange

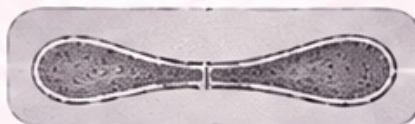


Appearance under Microscope

Light Microscope (LM)



Transmission EM (TEM)



Shows thin center and thicker edge

Scanning EM (SEM)



Shows biconcave shape

Hereditary Spherocytosis

- Defect in membrane proteins (spectrin or ankyrin)
- RBCs become spherical (spherocytes)
- Loss of surface area → less flexible
- More fragile → increased destruction in spleen (hemolysis)



Spherocyte (spherical RBC)



More fragile (hemolysis)

Rouleaux Formation

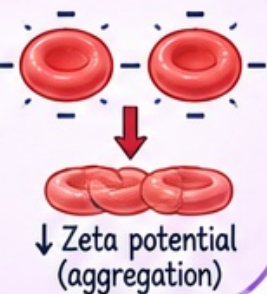
- RBCs stack like a pile of coins
- Occurs due to plasma proteins (mainly fibrinogen and globulins)
- Related to decreased Zeta potential



Rouleaux

Zeta Potential

- RBCs have a negative surface charge (Zeta potential) → causes repulsion between cells (preventing aggregation)
- Decreased in the presence of fibrinogen and globulins → allows Rouleaux formation



↓ Zeta potential (aggregation)

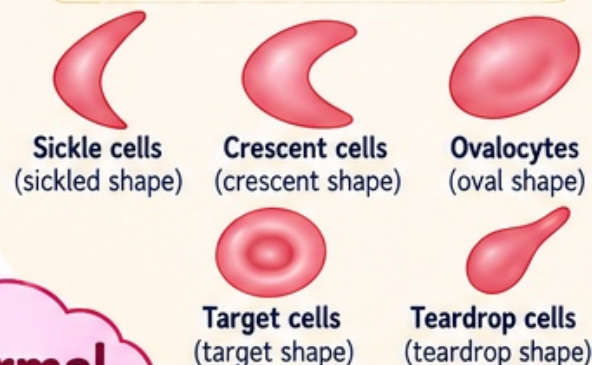
1. Variation in Size (Anisocytosis)

RBCs may be larger or smaller than normal.



2. Variation in Shape (Poikilocytosis)

RBCs may have abnormal shapes.

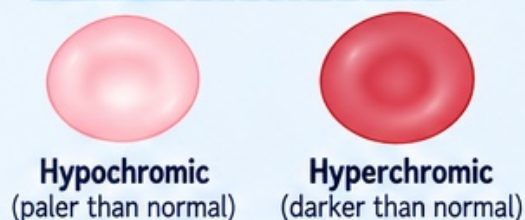


Abnormal RBCs

(Slide 16)

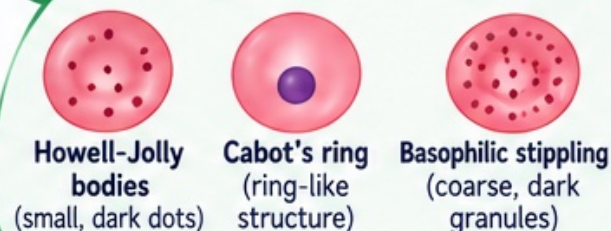
3. Variation in Color (Hypochromia / Hyperchromia)

RBCs may appear paler or darker than normal due to hemoglobin content.



4. Variation in Internal Structure

RBCs may contain abnormal internal structures.



Microcytic Hypochromic Anemia

- ↓ RBC size (small)
- **Pale** (↓ Hb content)
- **Example:**
Iron deficiency anemia

Classification of Anemia

(Slide 17)

Normocytic Normochromic Anemia

- Normal RBC size
- Normal color

Macrocytic Normochromic Anemia

- ↑ RBC size (large)
- Normal or slightly pale
- **Examples:**
 - Vitamin B12 deficiency
 - Folate deficiency

1. Hypoxia

Decreased O₂ delivery to kidneys.

2. Kidneys

Release erythropoietin (EPO).

3. EPO

Stimulates red bone marrow.

Regulation of RBC Production (Erythropoiesis)

(Slide 18)

Examples of conditions that increase RBC production

- High altitude
- Endurance athletes

4. Red bone marrow

Increases RBC production.

5. Increased RBCs

Group A

- A antigen
- Anti-B antibody in plasma

Group B

- B antigen
- Anti-A antibody in plasma

ABO Blood Groups

(Slide 19)

Group AB

- A and B antigens
- No antibodies

Group O

- No A or B antigens
- Anti-A and Anti-B antibodies in plasma

RBCs (Erythrocytes)

- Single type
- Anucleate (no nucleus)
- Male: 4.5 – 5.5 million/mm³
Female: 4.0 – 5.0 million/mm³
- 6 – 9 μm (Average ≈ 7.5 μm)
- ≈ 120 days
- Red bone marrow
- Biconcave discs
- Transport of O₂ and CO₂
- Non-motile
- Function exclusively within vascular system

WBCs (Leukocytes)

- Five types
- Nucleated (with nucleus)
- 4,500 – 11,000/mm³
- 7 – 20 μm (Depending on type)
- Hours/days to years, depending on type
- Red bone marrow and lymphoid tissue
- Variable; generally spherical in blood
- Defense and immunity
- Motile
- Function mainly outside blood vessels in tissues

Comparison between RBCs and WBCs

(Slide 20)

General Features

- Nucleated cells
- Larger than RBCs
- Defensive role in the body
- Divided into 2 main groups:

Granulocytes

- Have cytoplasmic granules
- Include:
 - Neutrophils
 - Eosinophils
 - Basophils

Agranulocytes

- No cytoplasmic granules
- Include:
 - Lymphocytes
 - Monocytes

White Blood Cells (Leukocytes)

Granulocytes – Common Features

- Cytoplasm contains specific granules
- Nucleus is **single, segmented (multilobed)**
- All are **phagocytic** (phagocytic ability varies)



Types of Granulocytes

Neutrophil



Most abundant type of WBC

Nucleus Single, segmented (multilobed)

Granules (Appearance)

Small, pale pink / salmon pink / pale lilac granules

Phagocytic ability

Prominent (strongest among granulocytes)

Staining reaction

- Neutrophilic granules
- No special affinity for either acidic or basic stains
 - Stained mildly by both

Summary

- ✓ Most abundant granulocyte
- ✓ Multilobed nucleus
- ✓ Small pale pink granules
- ✓ Prominent phagocytic ability
- ✓ Mildly stained by both acidic and basic stains

Eosinophil



Nucleus Single, segmented (bilobed - usually 2 lobes)

Granules (Appearance)

Large, red granules

Phagocytic ability

Limited

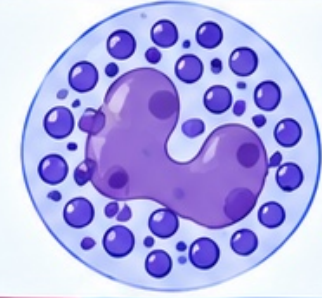
Staining reaction

Specific granules stain red with **acidic stains**

Summary

- ✓ Bilobed nucleus
- ✓ Large red granules
- ✓ Limited phagocytic ability
- ✓ Stain red with acidic stains

Basophil



Nucleus Single, segmented (multilobed)

Granules (Appearance)

Large, blue granules

Phagocytic ability

Very limited

Staining reaction

Specific granules stain with **basic stains**

Summary

- ✓ Multilobed nucleus
- ✓ Large blue granules
- ✓ Very limited phagocytic ability
- ✓ Stain with basic stains

NEUTROPHILS

Slides 24 – 29

1. IDENTITY & GENERAL FEATURES

- Most common leukocyte.
- A granulocyte.
- Cytoplasm is pale pink or lilac with numerous fine specific granules that are hard to distinguish by light microscopy.
- Shows equal uptake of acidic red and basic blue stains.
- Has few organelles.

Nucleus

- Usually 2–5 lobes (most commonly 3).
- Lobes are connected by thin chromatin connections.

As neutrophils mature, their nuclei become increasingly segmented.

Mature neutrophil: typically 3–5 lobes.



3 – 5 lobes

Hypersegmentation: ≥ 6 lobes (abnormal).



≥ 6 lobes

♀ Barr body (in females)

- The inactive X chromosome (Barr body) may appear as a drumstick-like appendage on one of the lobes of the nucleus.
- Found in about 3% of neutrophils in peripheral blood.



Barr body (drumstick)

8. OTHER NAMES

- Polymorphs
- Polymorphonuclear leukocytes (PMNs)
- Pus cells
- Microphages
- Cells of acute inflammation

7. PUS & RELATED TERMS

What is pus?

- Dead neutrophils, bacteria, lysed ECM, and tissue fluid form a viscous, usually yellow collection of fluid called pus.



- Dead neutrophils
- Bacteria
- Lysed ECM
- Tissue fluid

Viscous, usually yellow

Pyogenic

- Pus-producing infection.



Pyrogenic

- Fever-producing (associated with fever).



Neutrophilia

Increased neutrophil count.

Neutropenia

Decreased neutrophil count.

6. LIFESPAN

In circulation (half-life)



~ 6 – 8 hours

In tissues (survival)



~ 1 – 2 days

Then undergo apoptosis and are phagocytosed by macrophages.



2. SPECIFIC (SECONDARY) GRANULES

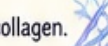
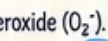
- Smaller and more numerous than primary granules.
- Formed later in neutrophil development.

Lysozyme → Destroys bacterial cell walls.

Lactoferrin → Sequesters iron (bacteriostatic).

Collagenase → Degrades ECM collagen.

NADPH oxidase → Produces superoxide (O_2^-).



3. AZUROPHILIC (PRIMARY) GRANULES

- Larger than specific granules.
- Formed early in neutrophil development.

Myeloperoxidase (MPO) → $H_2O_2 + Cl^- \rightarrow HOCl$ (antimicrobial).

Acid hydrolase → Digests microbes and debris after phagocytosis.

Defensins → Disrupt microbial membranes.

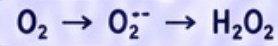
Protease (elastase) → Degrades microbial and ECM proteins (including elastin).



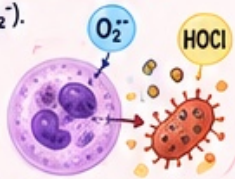
4. MICROBIAL KILLING MECHANISMS

A. Oxygen-dependent killing (Respiratory burst)

- NADPH oxidase produces superoxide (O_2^-).



- MPO catalyzes: $H_2O_2 + Cl^- \rightarrow HOCl$ (extremely toxic to microbes).



B. Oxygen-independent killing

- Granules fuse with phagosome and release antimicrobial substances.
- Can kill microbes without the need for ROS.



C. NETosis (when overwhelmed)

- A unique form of cell death.
- Releases DNA coated in antimicrobial proteins.
- Forms a sticky NET (neutrophil extracellular trap) that traps and kills extracellular microbes and prevents their spread.



5. DEFENSE FUNCTIONS & MIGRATION

- Provide a rapid defense against bacterial infections, especially acute pyogenic (pus-forming) infections.
- Kill bacteria by phagocytosis.



First to arrive

- Neutrophils are the first WBCs that leave the blood in large numbers to reach the site of inflammation (into connective tissue).



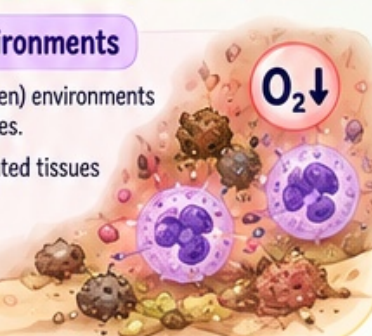
Why are they the first?

- 1 The most abundant.
- 2 The most motile (migrate rapidly).
- 3 Highly responsive to chemotactic factors.

Survival in low oxygen environments

- Can survive in anaerobic (low oxygen) environments such as necrotic or damaged tissues.
- Can kill bacteria in poorly oxygenated tissues and help clean up debris.

$O_2 \downarrow$



Granules Contents

Contain mainly:

- **Histamine**
- Heparin
- Lysosomal enzymes
- Other inflammatory mediators



Functions



Mediators of inflammatory and allergic reactions



Defense against parasites



Release of mediators (e.g. histamine, heparin) that increase vascular permeability and attract other inflammatory cells



Play a role in hypersensitivity reactions

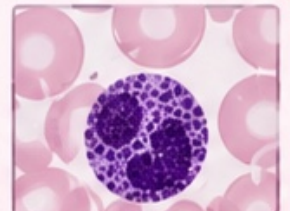
General Features

- Least common granulocyte in peripheral blood
- Large, coarse, deep purple granules (basophilic)
- Nucleus: usually bilobed (sometimes S-shaped) often obscured by granules
- Similar to mast cells but circulate in blood



Normal Percentage

0 – 1%
of circulating white blood cells



Blood smear (Basophil)

Location in Tissues

May constitute up to **15%** of infiltrating inflammatory cells in:

- Allergic dermatitis
- Skin allograft rejection



Basophils

IgE Binding

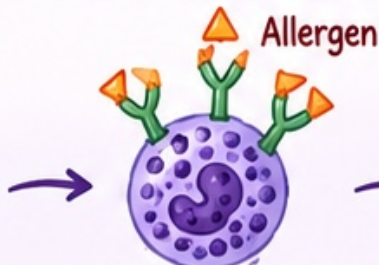
- Have high-affinity receptors (Fc receptors) for IgE on their surface
- Binding of IgE sensitizes basophils to specific antigens (allergens)



Degranulation Mechanism



1 IgE bound to basophil



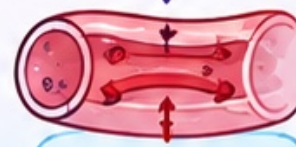
2 Cross-linking of IgE by allergen



3 Degranulation (release of granule contents)

Effects of Released Mediators

Histamine



Vasodilation (in many organs)

Other mediators



Increased vascular permeability (attracts other inflammatory cells)

Heparin



Anticoagulant effect

Role in Allergic Reactions

- Cross-linking of IgE by allergen → rapid degranulation
- Release of mediators (especially histamine)
- Responsible for immediate hypersensitivity reactions

Can cause:

Anaphylactic Shock

- Rapid degranulation of basophils (and mast cells)
- Vasodilation in many organs
- Sudden drop in blood pressure

