

Blood Elements

Lecture Objectives

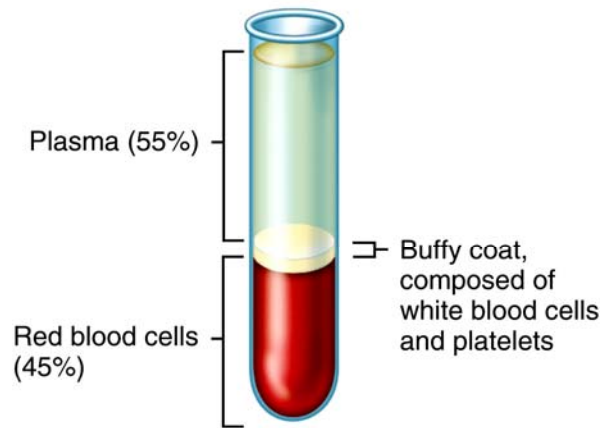
- List blood components.
- Classify formed elements of blood.
- Discuss the scientific basis of the above classification.
- Describe the basic structure of erythrocytes and criteria of their identification.
- List the components of cellular granulocytes.

Blood: Functions

- Liquid connective tissue
- 3 general functions
 1. Transportation
 - Gases, nutrients, hormones, waste products
 2. Regulation
 - pH, body temperature, osmotic pressure
 3. Protection
 - Clotting, white blood cells, proteins

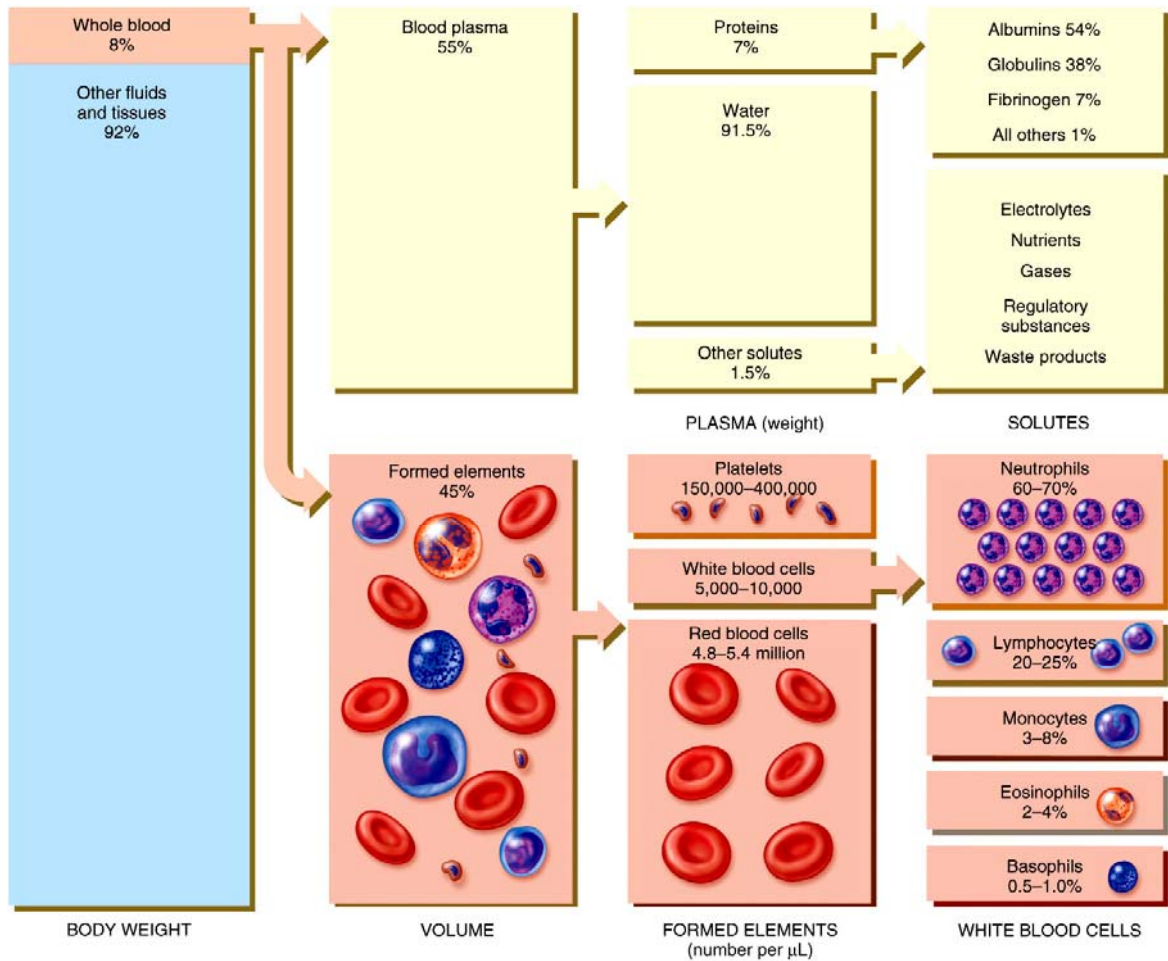
Components of Blood

- Blood plasma – water liquid extracellular matrix
 - 91.5% water, 8.5% solutes (primarily proteins)
 - Hepatocytes synthesize most plasma proteins
 - Albumins, fibrinogen, antibodies
 - Other solutes include electrolytes, nutrients, enzymes, hormones, gases and waste products
- Formed elements – cells and cell fragments
 - Erythrocytes (Red blood cells (RBCs))
 - Leukocytes (White blood cells (WBCs))
 - Platelets



(a) Appearance of centrifuged blood

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(b) Components of blood

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Formation and Destruction of RBC's

Red Blood Cells/ Erythrocytes

- Normal concentration in blood 3.9-5.5 million/ μL in women and 4.1-6 million/ μL in men
- Contain oxygen-carrying protein **hemoglobin**, which accounts for their acidophilia
- Production = destruction with at least 2 million new RBCs per second
- **Biconcave disc** – increases surface area
 - 7.5 μm in diameter
 - 2.6 μm thick at rim and 0.8 μm thick in center
- Strong, flexible plasma membrane
- Glycolipids in plasma membrane responsible for ABO and Rh blood groups
- Lack nucleus and other organelles
 - No mitochondria – doesn't use oxygen

Hemoglobin

- Globin – 4 polypeptide chains
- Heme in each of 4 chains
- Iron ion can combine reversibly with one oxygen molecule
- Also transports 23% of total carbon dioxide
 - Combines with amino acids of globin
- Hemoglobin combine reversibly with O₂ (oxyhemoglobin) and CO₂ (carbaminohemoglobin)
- Hemoglobin combine irreversibly with carbon monoxide (carboxyhemoglobin) causes a reduced capacity to transport O₂
- Nitric oxide (NO) binds to hemoglobin
 - Releases NO causing vasodilatation to improve blood flow and oxygen delivery

Shapes of RBC and Hemoglobin

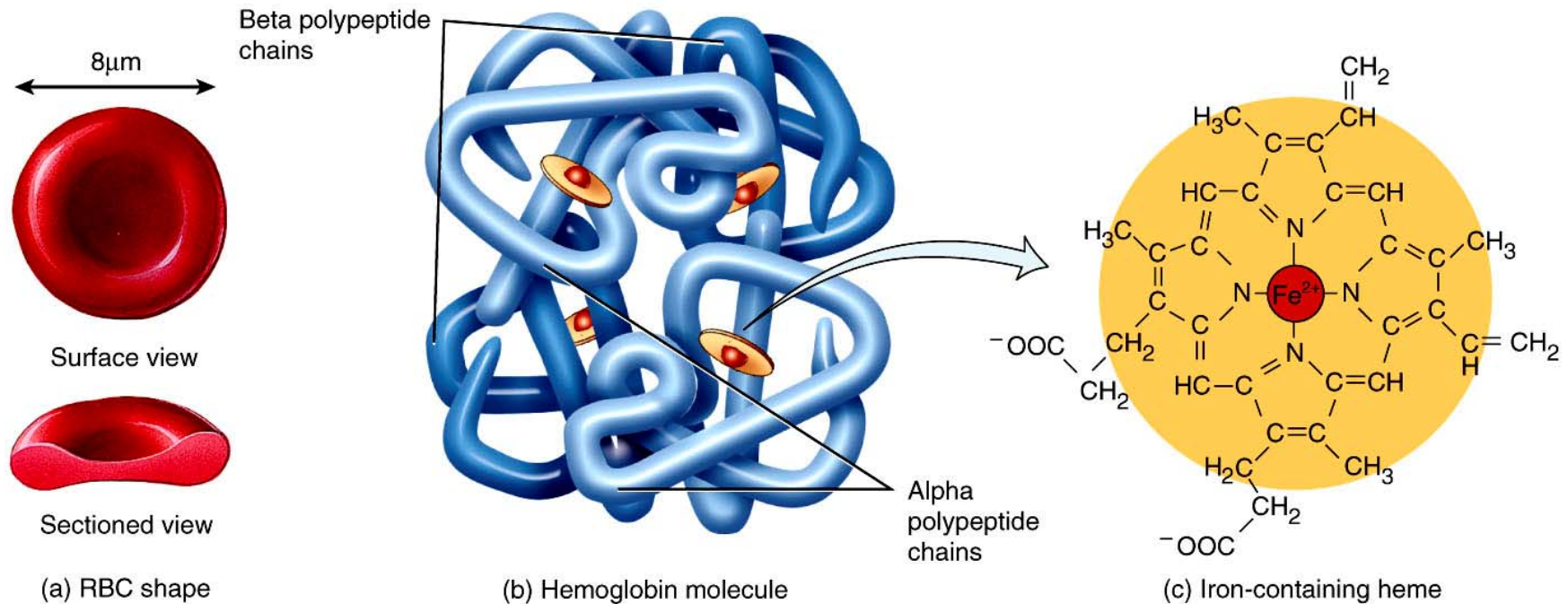


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RBC life cycle

- Starts in red bone marrow with proerythroblast
- Cell near the end of development ejects nucleus and becomes a **reticulocyte** and released into blood stream
 - Contain residual ribosomal RNA, which is precipitated and stained by some dyes (eg, brilliant cresyl blue)
 - Appear like few granules or net like structure in the cytoplasm
 - Normally constitute about 1% of total circulating erythrocytes
 - Increase number of reticulocyte may reflect increase demand for O₂
 - Develop into mature RBC within 1-2 days and loose its mitochondria, ribosomes and many cytoplasmic enzymes

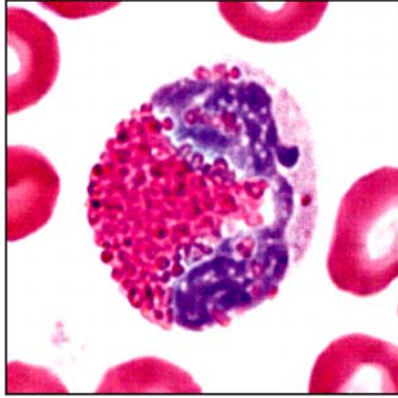
RBC life cycle

- Live only about 120 days
- Cannot synthesize new components – no nucleus
- Ruptured red blood cells removed from circulation and destroyed by fixed phagocytic macrophages in spleen and liver
- Breakdown products recycled
 - Globin's amino acids reused
 - Iron reused
 - Non-iron heme ends as yellow pigment urobilin in urine or brown pigment stercobilin in feces

White Blood Cells/ Leukocytes

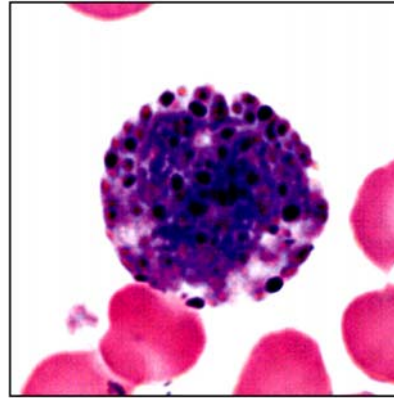
- Have nuclei
- Do not contain hemoglobin
- Spherical shape in blood plasma
- 6000-10000 leukocytes/ μ L
- Granular or agranular based on staining highlighting large conspicuous granules
- Granulocytes (polymorphonuclear leukocytes)
 - Neutrophils, eosinophils, basophils
- Agranulocytes (mononuclear leukocytes)
 - Lymphocytes and monocytes

Types of White Blood Cells



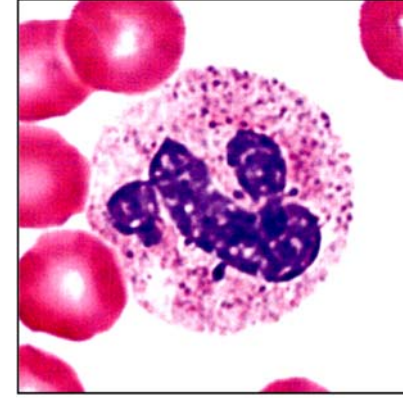
(a) Eosinophil

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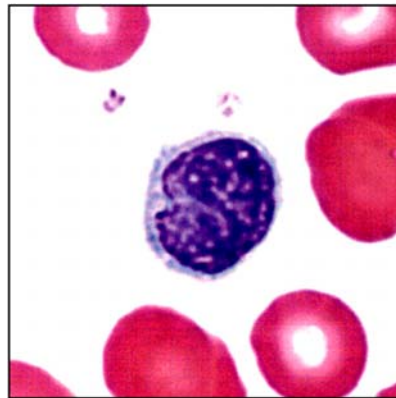
(b) Basophil

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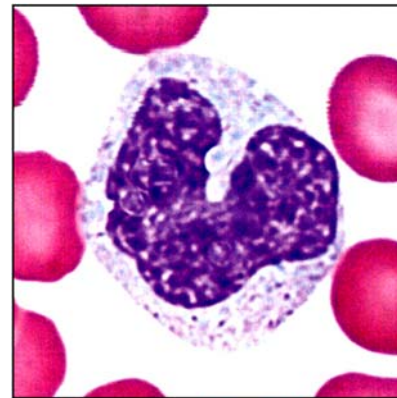
(c) Neutrophil

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(d) Lymphocyte

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(e) Monocyte

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Functions of WBCs

- Usually live a few days
- Except for lymphocytes – live for months or years
- Far less numerous than RBCs
- Leukocytosis is a normal protective response to invaders, strenuous exercise, anesthesia and surgery
- Leukopenia is never beneficial
- General function to combat invaders by phagocytosis or immune responses

Granulocytes

- Have two types of granules
 - Specific granules
 - Bind neutral, basic, or acidic components of dye mixture
 - Have specific functions
 - Azurophilic granules
 - Stain purple and are lysosomes
- Have nuclei with two or more lobes
- Include neutrophils, eosinophils, basophils
- Nondividing terminal cells

Agranulocytes

- Don't have specific granules
- Contain azurophilic granules that bind azure dyes
- The nucleus is round or indented
- Include lymphocytes and monocytes

Emigration of WBCs

- Many WBCs leave the bloodstream
- Emigration (formerly diapedesis)
- Roll along endothelium
- Stick to and then squeeze between endothelial cells
- Precise signals vary for different types of WBCs
- WBCs are spherical, non motile cells, but they are capable of becoming flattened and motile outside blood

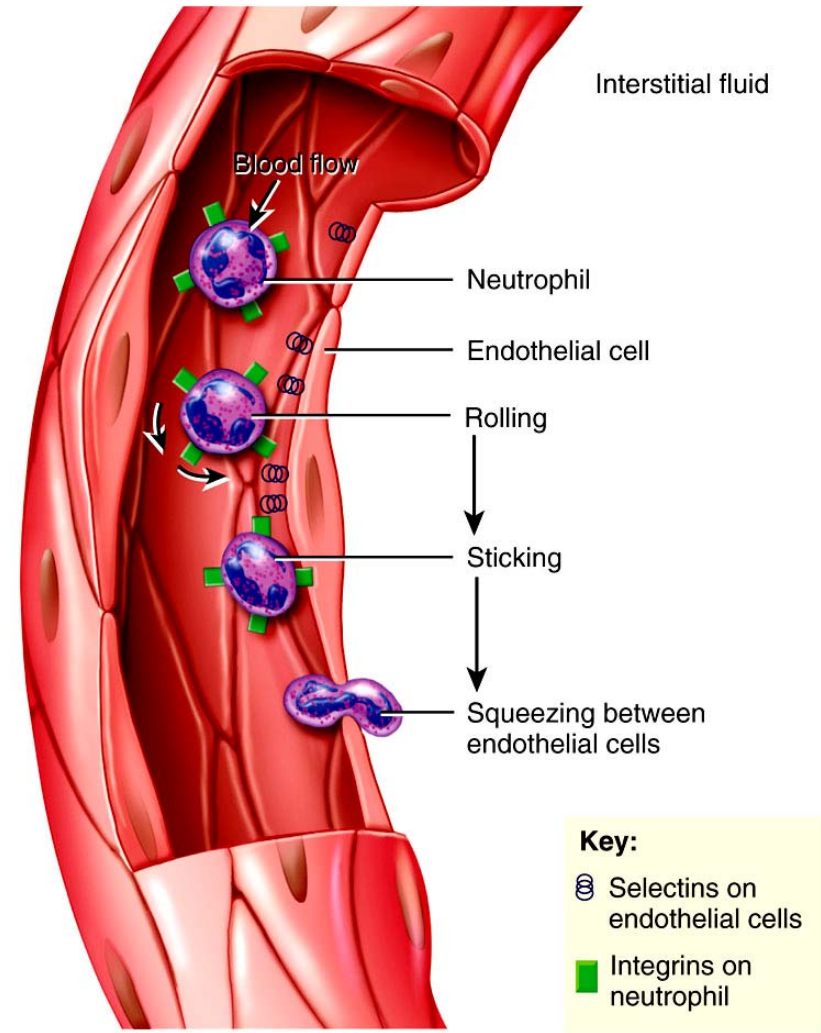
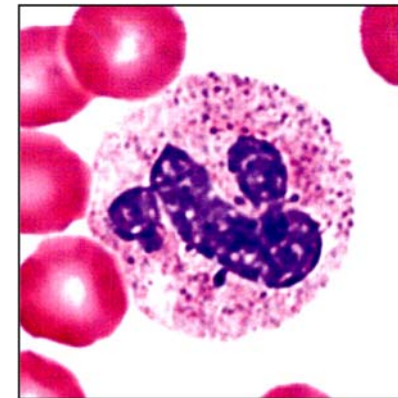
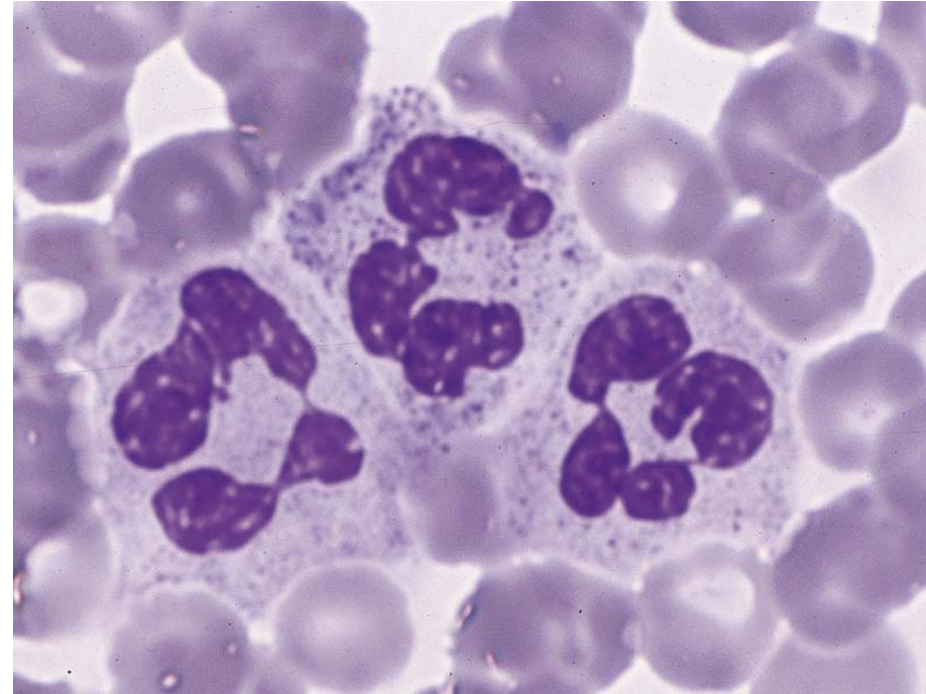


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Neutrophils

- Constitute 60-70% of circulating leukocytes
- 12-14 μ m in diameter (in blood smear)
- Nucleus consisting of 2-5 (usually 3) lobes connected by fine threads of chromatin
- Specific granules more abundant
- Cytoplasm contain glycogen for energy production
- Short lived cells with half life 6-7 h in blood and 1-4 days in CT
- are active phagocytes

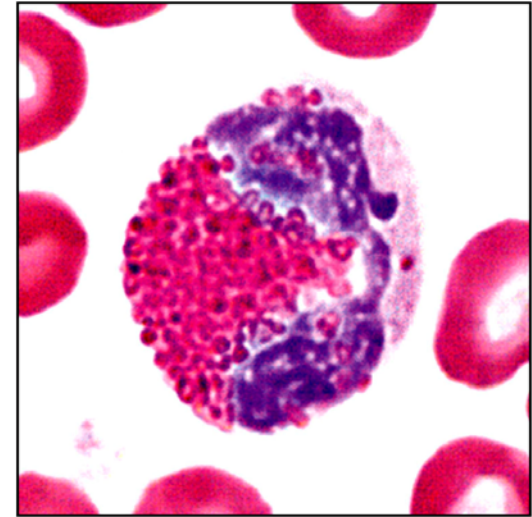


(c) Neutrophil

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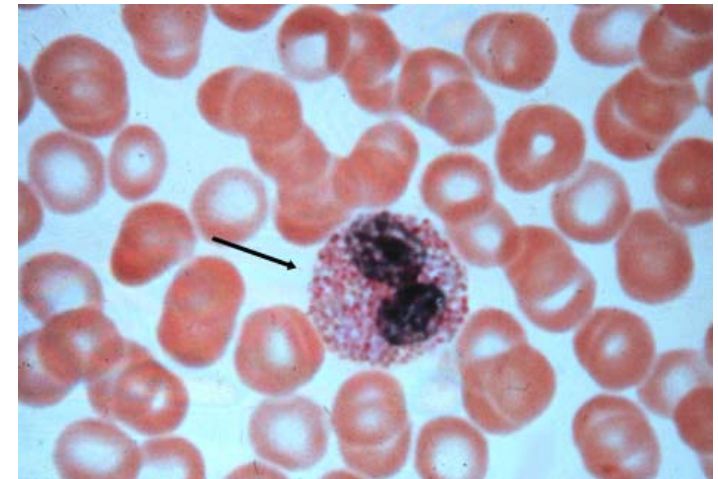
Eosinophils

- 2-4% of leukocytes in blood
- Same size as neutrophils in blood
- Bilobed nucleus
- The main identifying characteristics is the presence of many **large and elongated refractile specific granules** (about 200/cell) that are stained by eosin



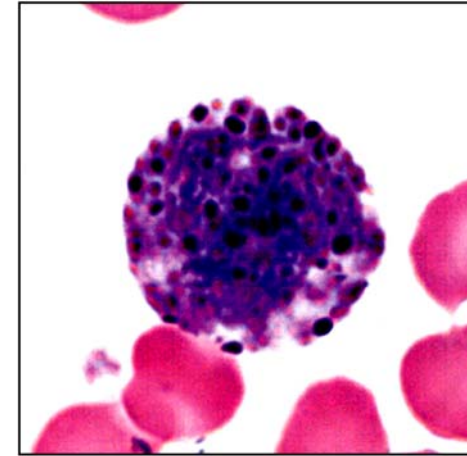
(a) Eosinophil

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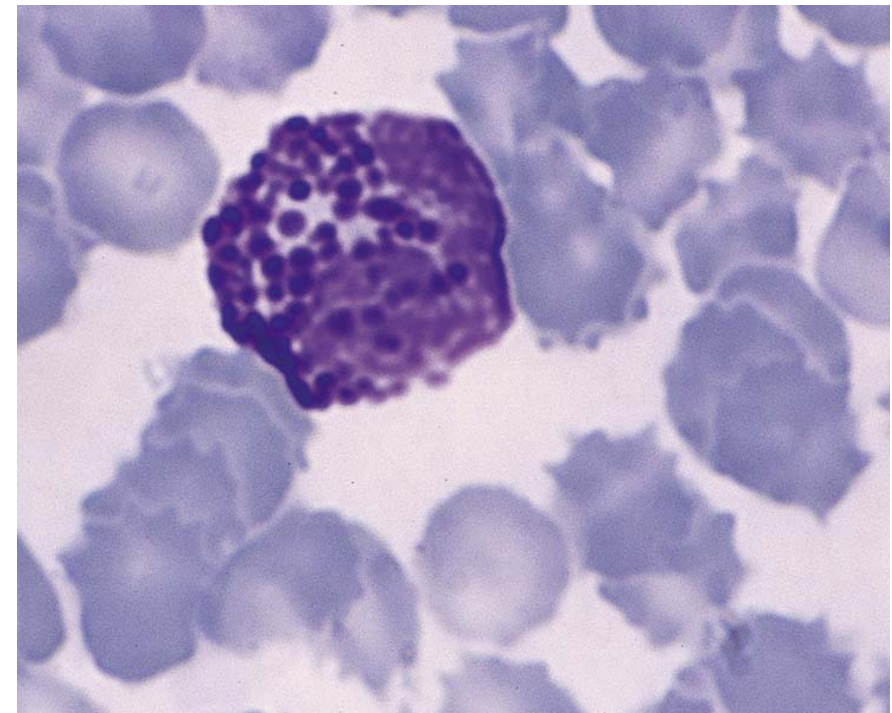
Basophils

- Less than 1% of leukocytes in blood
- 12-15 μm in diameter
- Nucleus is divided into irregular lobes, but the overlying specific granules usually obscure the division
- The specific granules 0.5 μm in diameter
- Basophils may supplement the function of mast cells in immediate hypersensitivity reactions by migrating into CT
- There is some similarity between granules of basophils and mast cells; both are metachromatic and contain heparin and histamine



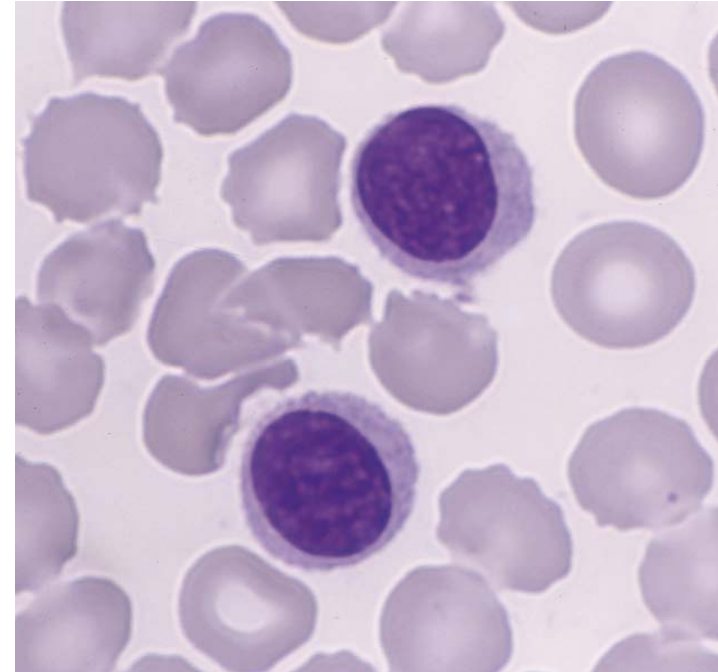
(b) Basophil

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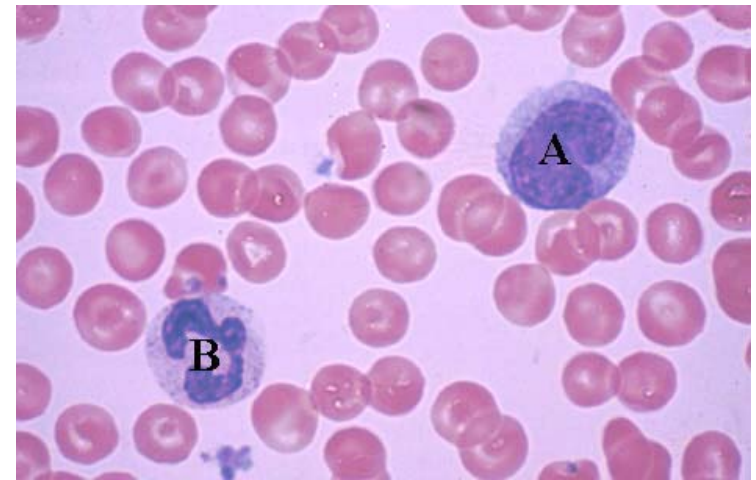
- A family of spherical cells with similar morphological characteristics
- Small lymphocytes with 6-8 μm in diameter
 - Has spherical nucleus
 - Its chromatin is condensed and appears as coarse clumps
 - Cytoplasm is scanty and appear as thin rim around the nucleus
- Small number of medium-sized and large lymphocytes with diameter up to 18 μm
- Vary in life span; some live few days and others survive in the circulating blood for many years
- The only type of leukocytes that return from tissue back into the blood
- Lymphocytes are the major soldiers of the immune system
 - B cells – destroying bacteria and inactivating their toxins
 - T cells – attack viruses, fungi, transplanted cells, cancer cells and some bacteria
 - Natural Killer (NK) cells – attack a wide variety of infectious microbes and certain tumor cells

Lymphocytes



Monocytes

- Bone marrow-derived agranulocytes
- 12-20 μm in diameter
- Nucleus is oval, horseshoe or kidney shaped and is generally eccentrically placed
- The chromatin is less condensed than that of lymphocytes, and so nucleus stain lighter
- Cytoplasm is basophilic and may contain very fine azurophilic granules, which gives cytoplasm a bluish-gray color
- It is not terminal cell
 - When enters CT, monocytes differentiate into macrophages



(A) Monocyte. (B) Neutrophil

Platelets/ Thrombocytes

- 200000-400000/ μ L
- Fragments of megakaryocyte
 - Myeloid stem cells develop eventually into a megakaryocyte
 - Splinters into 2000-3000 fragments
 - Each fragment enclosed in a piece of plasma membrane
- Disc-shaped with many vesicles but no nucleus
- Help stop blood loss by forming platelet plug
- Granules contain blood clot promoting chemicals
- Short life span – 5-9 days
- In stained blood smears, platelets often appear in clumps

