

Blood tissue

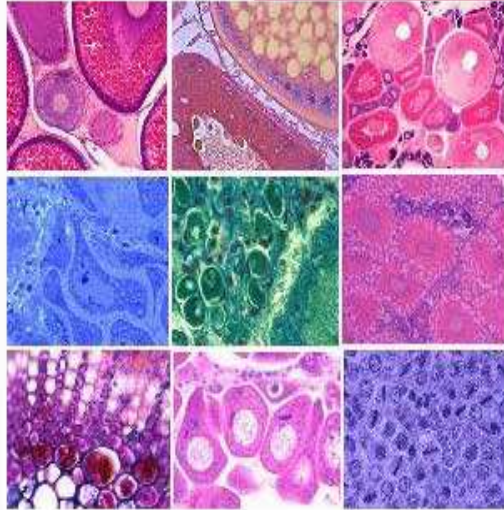
1. Blood as a tissue

2. Functions and composition of blood

3. Plasma. Antibodies

4. Formed elements of blood (blood cells):

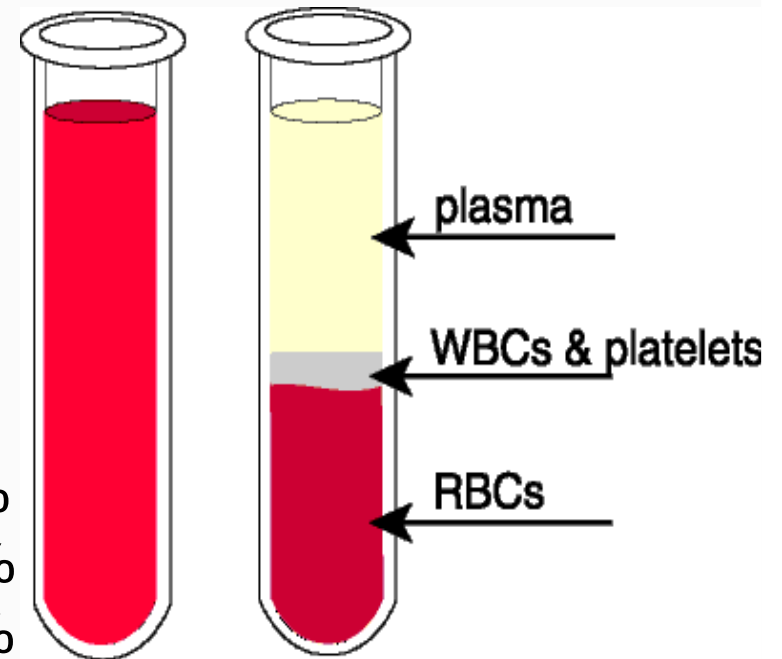
- ✓ erythrocytes
- ✓ leukocytes
- ✓ platelets



Blood as a tissue

■ Blood tissue – A. Hadjiolov, 1930

- ✓ specialized (trophic-defensive) fluid form of connective tissue
- ✓ liquid intercellular substance: plasma
- ✓ formed elements of blood (blood cells):
 - erythrocytes (red blood cells) – 96%
 - leukocytes (white blood cells) – 3%
 - thrombocytes (blood platelets) – 1%



Erythrocyte



Surface



Side



Lymphocyte



Monocyte



Eosinophil



Basophil

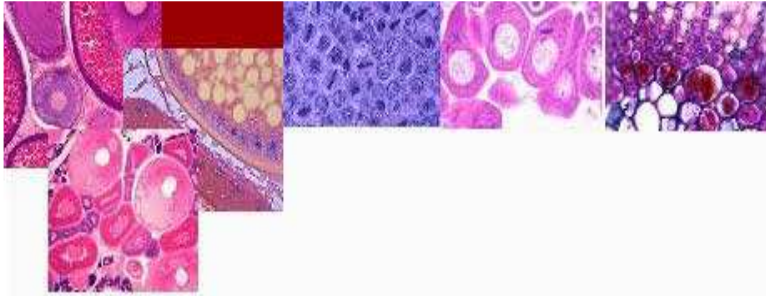


Neutrophil

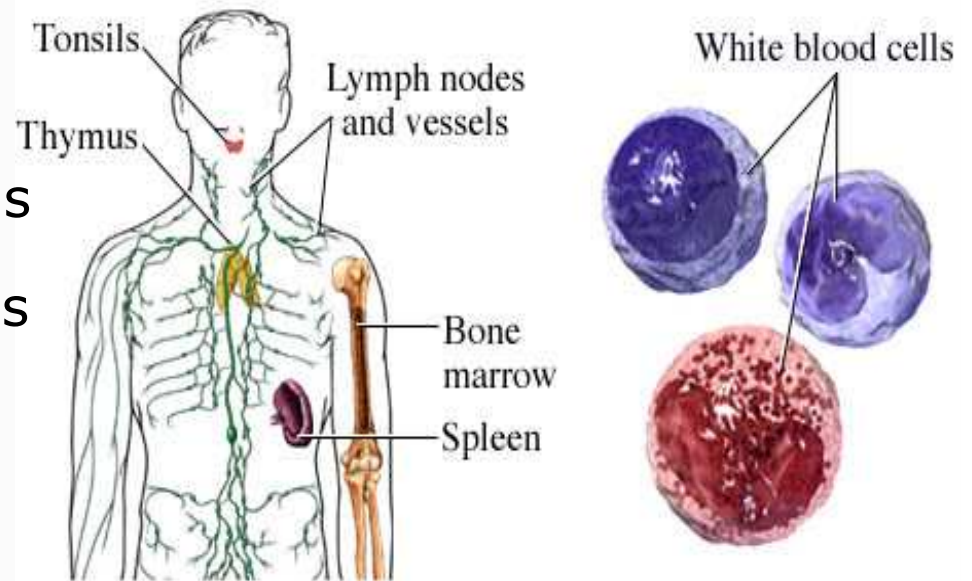
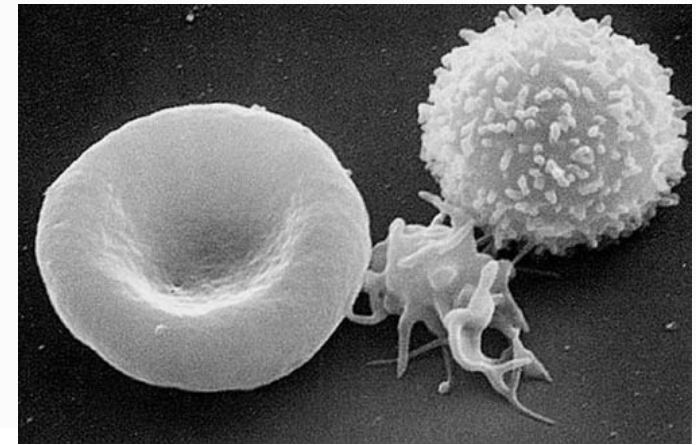
Platelets



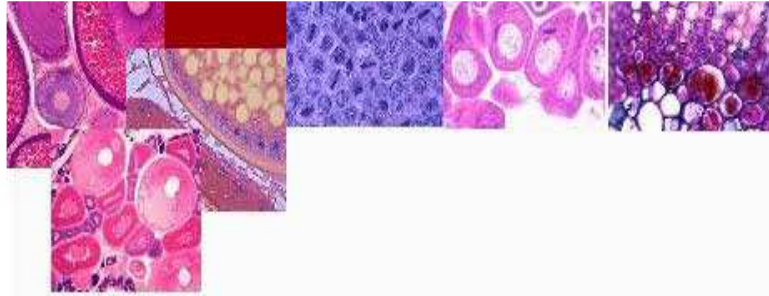
Functions of the blood



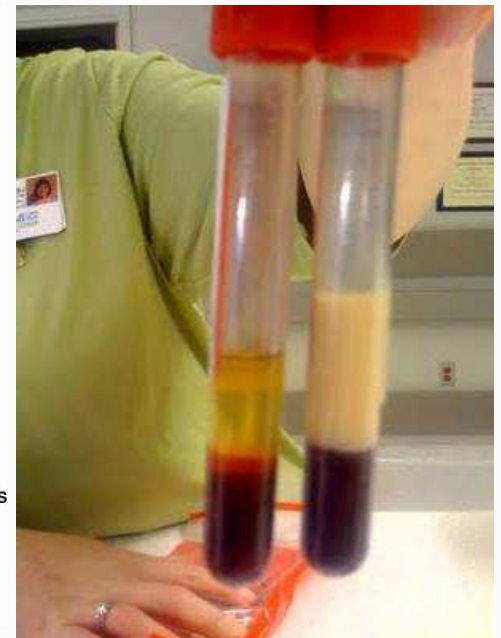
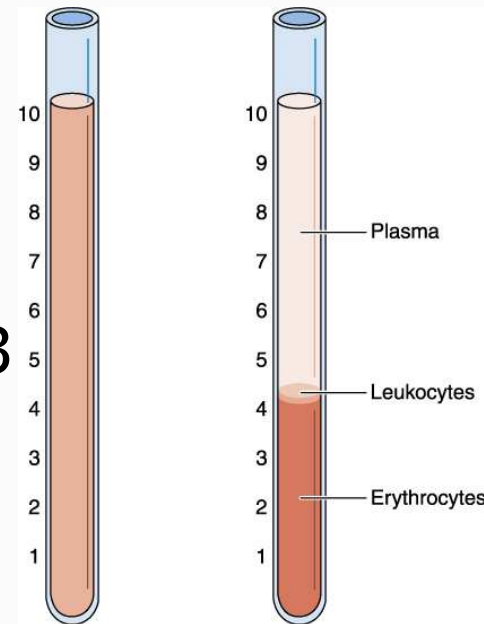
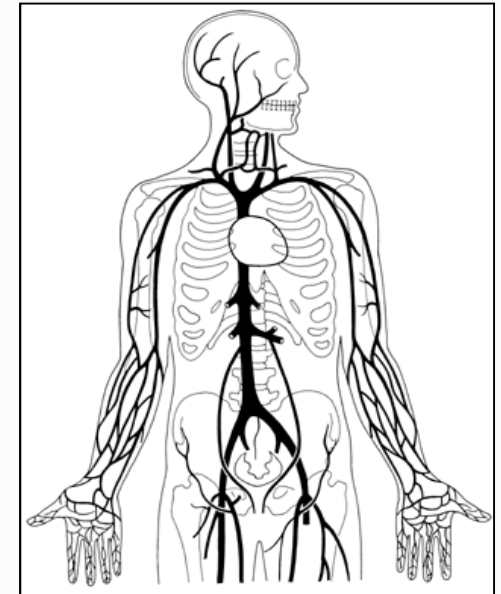
- ✓ transport – nutrients, gases (O_2 , CO_2), hormones, waste products of metabolism
- ✓ removes toxins from the body
- ✓ maintains body temperature
- ✓ buffer – pH control, homeostasis
- ✓ defense – leukocytes, antibodies
- ✓ blood clotting – prevention of hemorrhage



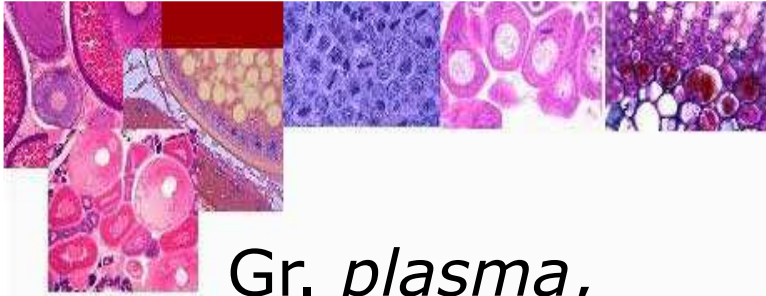
Composition of blood



- ✓ amount: 4-6 liters in a man, ~7-8% of its body weight
 - arteries - 1 liter
 - veins - 3 liters
 - heart
 - blood depots
- ✓ plasma: 55%
- ✓ blood cells: 45%
- ✓ hematocrit: 0.32-0.53
 - 0.40-0.50 in men
 - 0.35-0.45 in women



Blood plasma



Gr. *plasma*,
something molded or created

~55% of whole blood

✓ Composition:

➤ 92% water, 7-8% proteins,
1-2% electrolytes, nutrients
(glucose, amino acids, fatty
acids), vitamins, gases,
metabolites

✓ osmotic pressure: 0.85% NaCl

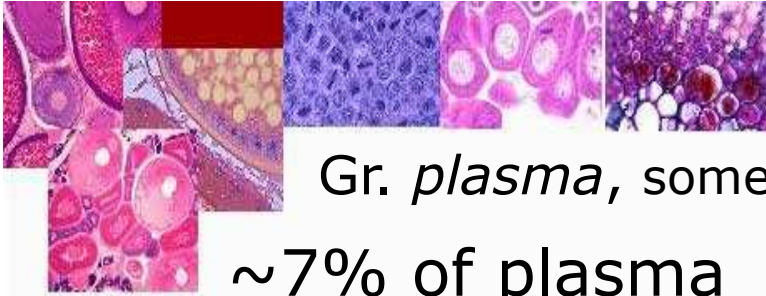
✓ pH: 7.35-7.45

✓ serum = plasma – fibrinogen

Plasma		
Water 92% by weight	Proteins 7% by weight	Other solutes 1% by weight
	Albumins 58%	Electrolytes
	Globulins 37%	Nutrients
	Fibrinogen 4%	Respiratory gases
	Regulatory proteins 1%	Waste products



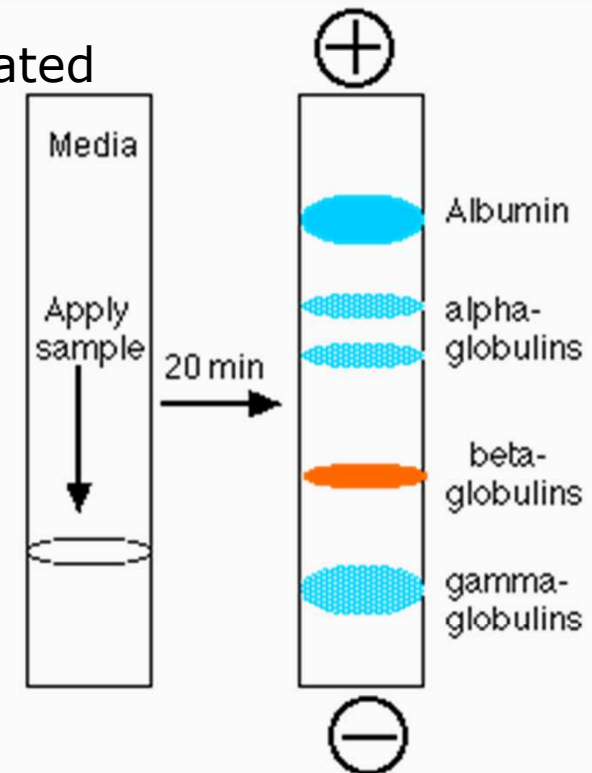
Plasma proteins



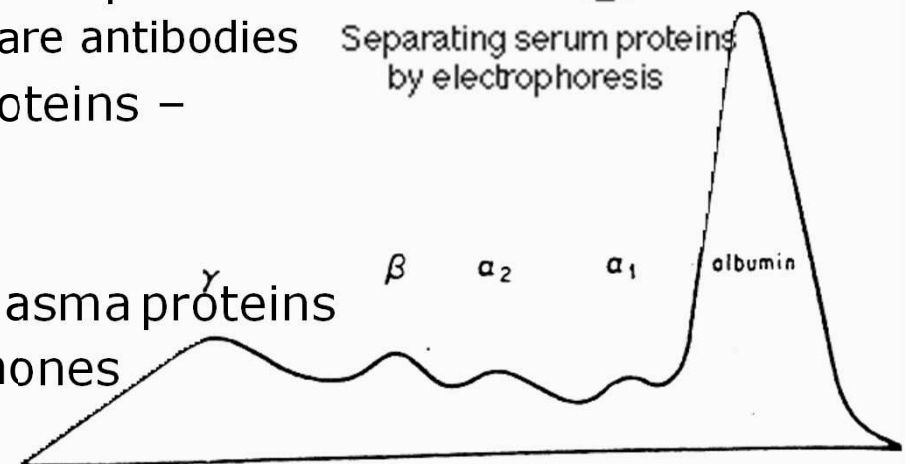
Gr. *plasma*, something molded or created

~7% of plasma

- ✓ serve to buffer against pH changes
- ✓ plasma proteins:
 - albumins (Lat. *albus*, white):
 - ~58% of plasma proteins – maintaining the osmotic pressure, contribute to blood's viscosity
 - globulins: ~37% of plasma proteins
 - α -globulins transport lipids and metal ions
 - β -globulins transport iron ions and lipids
 - γ -globulins (immunoglobulins) are antibodies
 - fibrinogen: ~4% of plasma proteins – participate in blood clotting
 - lipoproteins – HDL, LDL
 - regulatory proteins: >1% of plasma proteins
 - enzymes, proenzymes, hormones
 - complement proteins



Separating serum proteins by electrophoresis



Formed elements of blood

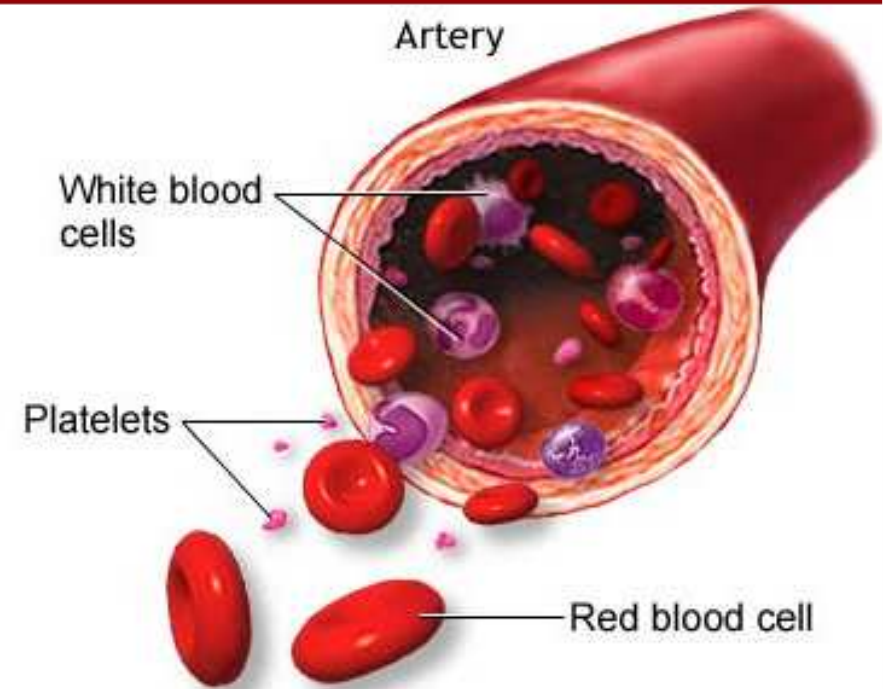
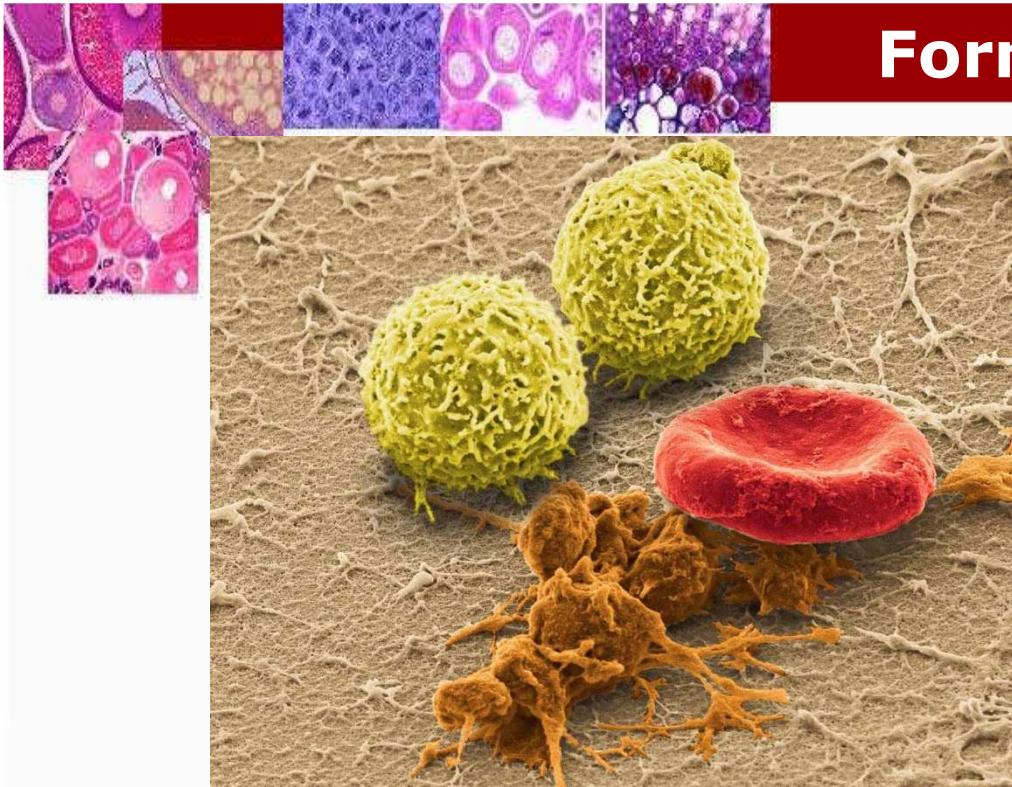
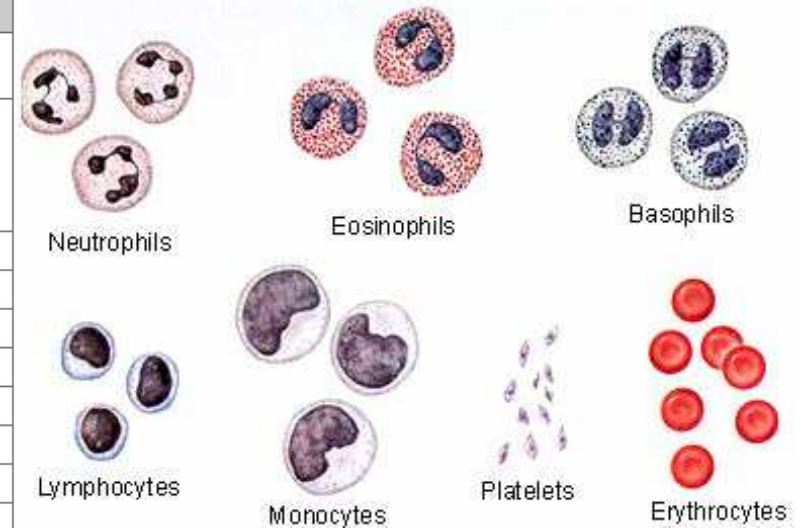


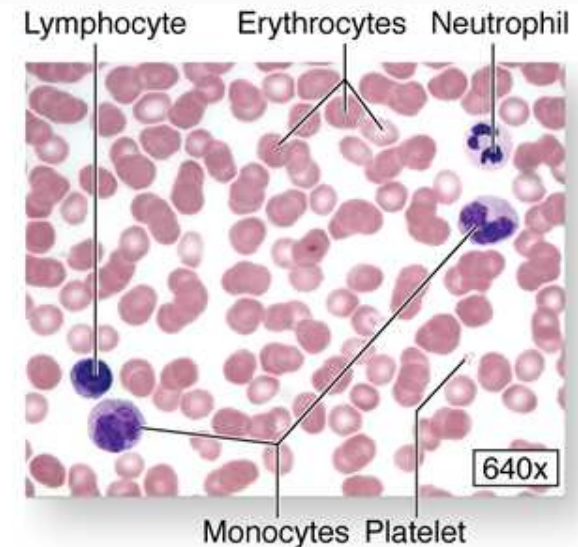
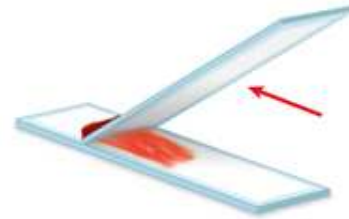
Table 12-3. Number and Percentage of Blood Corpuscles (Blood Count).

Corpuscle Type	Approximate Number per μL^a	Approximate Percentage
Erythrocyte	Female: $3.9\text{--}5.5 \times 10^6/\mu\text{L}$	
	Male: $4.1\text{--}6 \times 10^6/\mu\text{L}$	
Reticulocyte		1% of the erythrocyte count
Leukocyte	6000–10,000	
Neutrophil	5000	60–70%
Eosinophil	150	2–4%
Basophil	30	0.5%
Lymphocyte	2400	28%
Monocyte	350	5%
Platelet	300,000	



Formed elements of blood

Blood Cell Cookies



① Prick finger and collect a small amount of blood.

② Place a drop of blood on a slide.

③ Using a second slide, pull the drop of blood across the slide surface, leaving a thin layer of blood on the slide. After the blood dries, apply a stain for contrast. Place a coverslip on top.

④ When viewed under the microscope, blood smear reveals the components of the formed elements.

Erythrocytes



Jan Swammerdam
(1637-1680)



✓ Red Blood Cells (RBCs)
Gr. *erythros*, red

✓ total number: **25×10^{12}** /blood
 $\sim 4\text{-}6$ million/ mm^3

♂ - $4.1\text{-}6.0 \times 10^{12}/\text{l}$

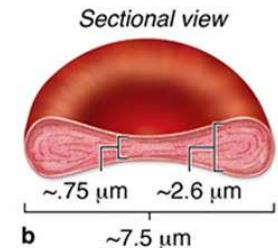
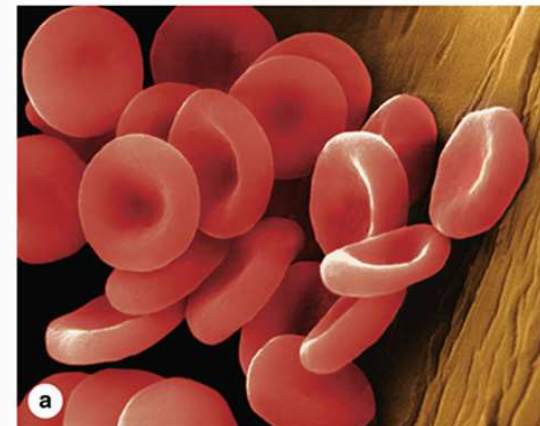
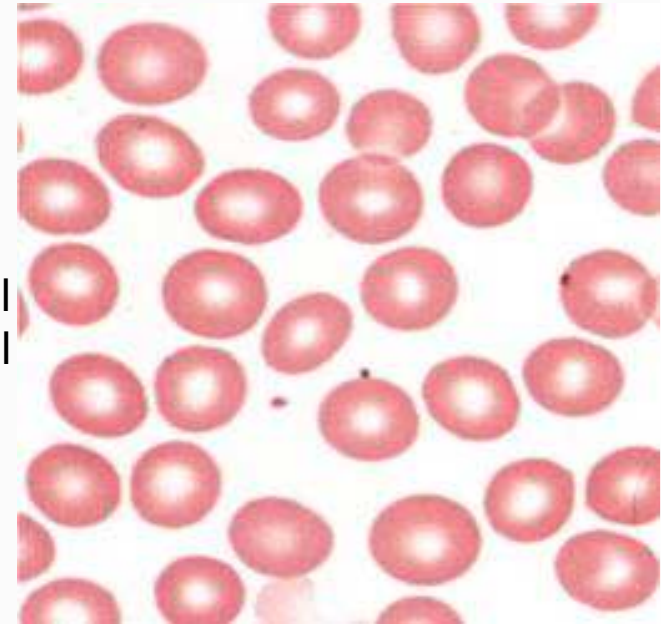
♀ - $3.9\text{-}5.5 \times 10^{12}/\text{l}$

- ↑ erythrocytosis (polycythemia)
- ↓ anemia

✓ size: $7.5 \pm 0.5 \mu\text{m}$

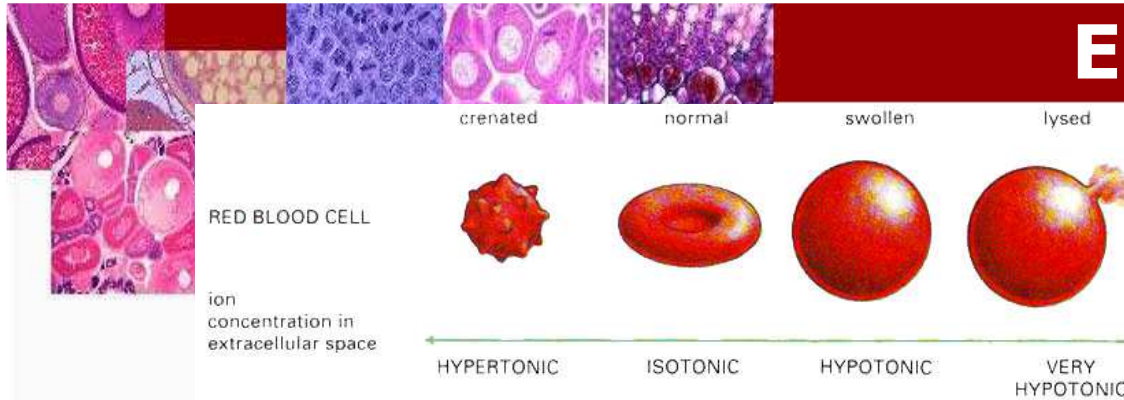
- $> 9 \mu\text{m}$: macrocytes
- $> 12 \mu\text{m}$: megalocytes
- $< 6 \mu\text{m}$: microcytes
- anisocytosis, Gr. *aniso*, uneven

✓ diameter: $0.8 \mu\text{m}$ in the center
 $2.6 \mu\text{m}$ at the rim



- ✓ shape: flexible biconcave disks – spectrin
- ✓ total surface: $140 \mu\text{m}^2$ (3500 m^2)

Erythrocytes



✓ lack a cell nucleus and most organelles

✓ hemoglobin > 90% of dry content:
120-180 g/l

➤ heme+globin

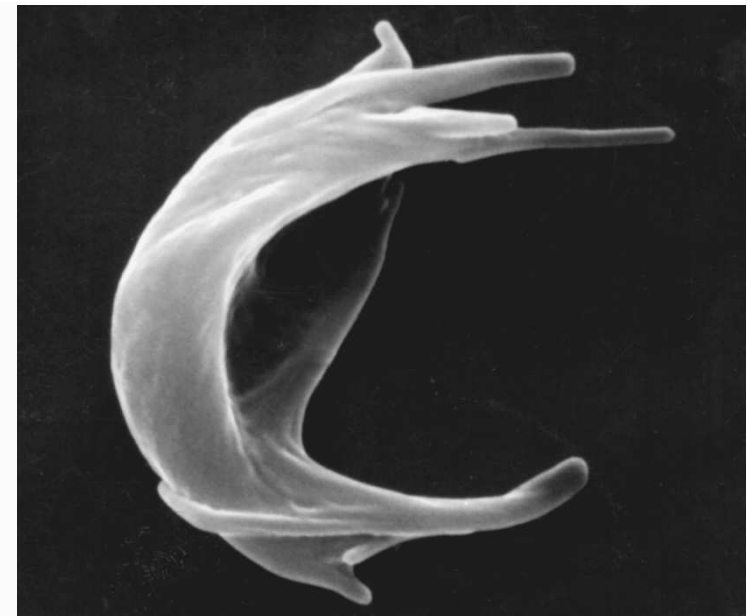
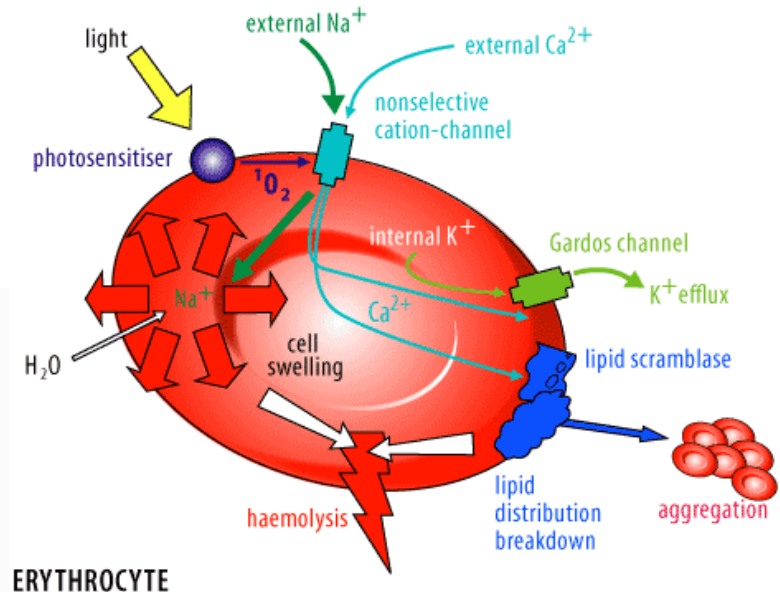
✓ hemoglobin types:

- HbA₁ (2α+2β): 96-97%
- HbA₂ (2α+2δ): 2%
- HbF (2α+2γ): 1-2% in adults,
80% in newborns



- increased level in thalassemia

➤ HbS – sickle cell disease



Erythrocytes



✓ Plastic plasmalemma
[40% lipids (incl. phospholipids, glycolipids, cholesterol),
50% proteins, 10% carbohydrates]:

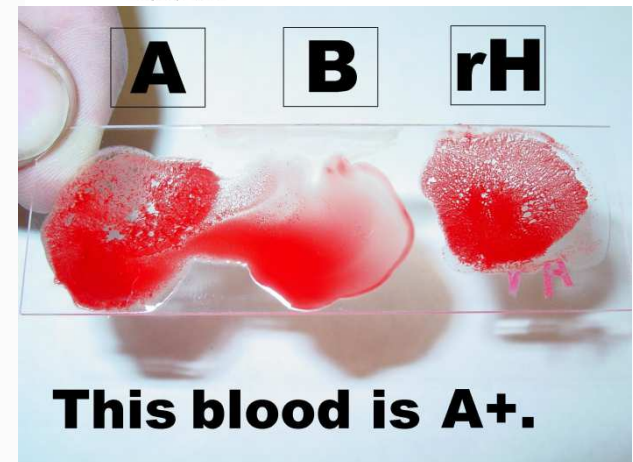
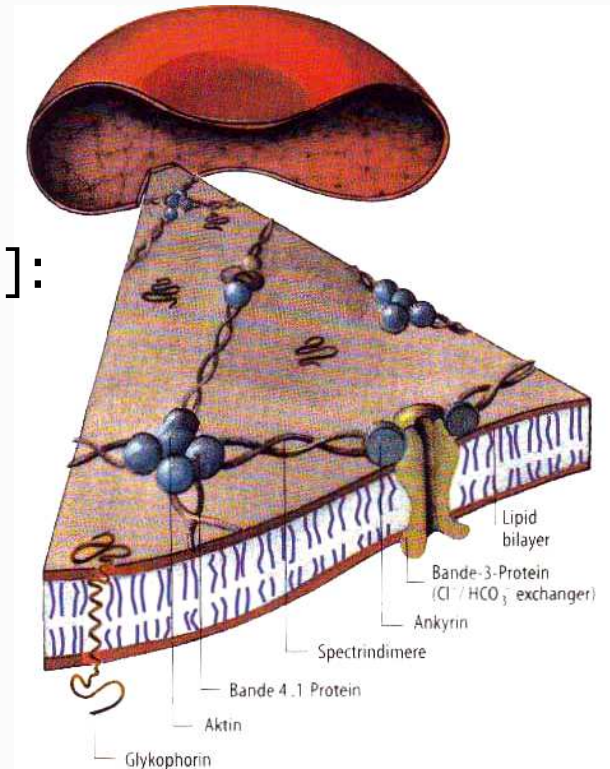
- glycoporphins A, B, C – transmembrane, single-pass glycoproteins that carry the MNS blood groups antigens
- protein Rh-antigen

✓ Main function: transport of oxygen

- O₂ – oxyhemoglobin
- CO – carboxyhemoglobin
- CO₂ – carbaminohemoglobin

✓ Lifespan in the bloodstream: 120 days

♂ ~140 days; ♀ ~109 days

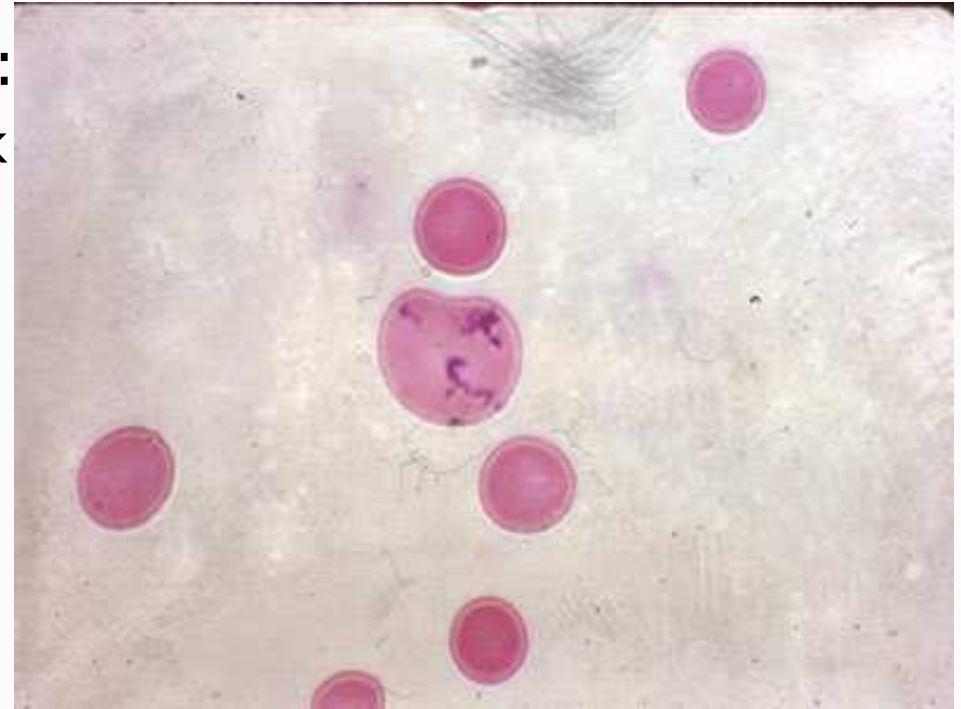


Reticulocytes



Lat. *rete*, network

- ✓ young erythrocytes = polychromatophilic erythrocytes (0.1-1.5% of the total number of RBCs)
- ✓ morphological characteristics:
 - reticular (mesh-like) network of rRNA (polyribosomes) – *substantia reticularis*
 - basophilic nuclear fragments of DNA – *Howell-Jolly* bodies
 - mitotic spindle (microtubule) remnants – *Cabot* rings
- ✓ pathological conditions:
 - reticulocytosis – elevation in the number of reticulocytes (after acute haemorrhage, ascent to high altitude, chronic haemolytic anaemia)
 - loss of reticulocytes in the peripheral blood: insufficient erythropoiesis

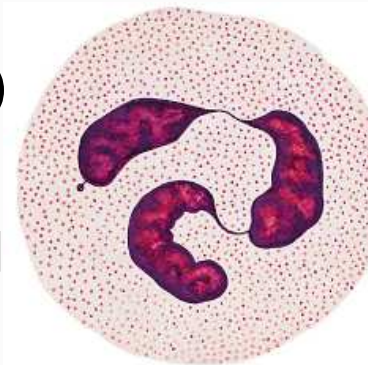


Leukocytes

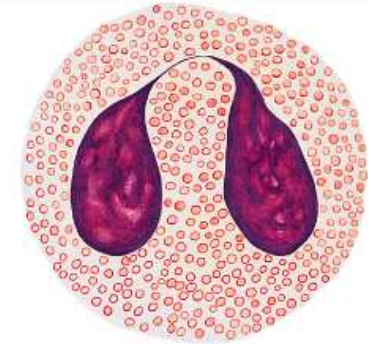


✓ White Blood Cells (WBCs)
Gr. λευκός, *leukos*, white

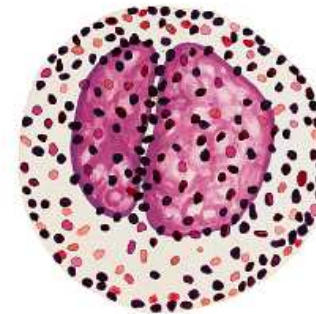
- ✓ total number: **4-10x10⁹/l** blood
- ↑ leukocytosis
 - ↓ leukopenia (Gr. λευκός, white + πενία, deficiency)
- ✓ two groups and five types leukocytes:
- granulocytes (polymorphonuclear leukocytes)
 - neutrophilic granulocytes
 - eosinophilic granulocytes
 - basophilic granulocytes
 - agranulocytes (mononuclear leukocytes)
 - lymphocytes
 - monocytes



Neutrophilic granulocyte



Eosinophilic granulocyte



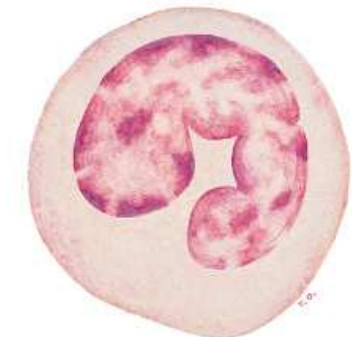
Basophilic granulocyte



Lymphocyte

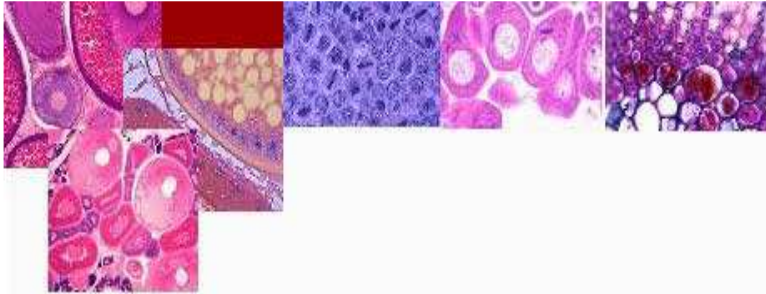


Monocyte



Monocyte

Percentage of leukocytes



- differential count (frequency) of blood leukocytes:

- ✓ granular leukocytes (granulocytes):

(Lat. *granulum*, granule + Gr. *kytos*)

- neutrophils 60 - 70%
 - eosinophils 2 - 4%
 - basophils 0.5 - 1%
 - band cells 2 - 3% (immature neutrophils)

- agranular leukocytes (agranulocytes):

- lymphocytes 20 - 30%
 - monocytes 3 - 8%



Leukocytes

white blood cells ~ WBC

agranular

granular

lymphocytes
20 - 25 %

monocytes
3 - 8%

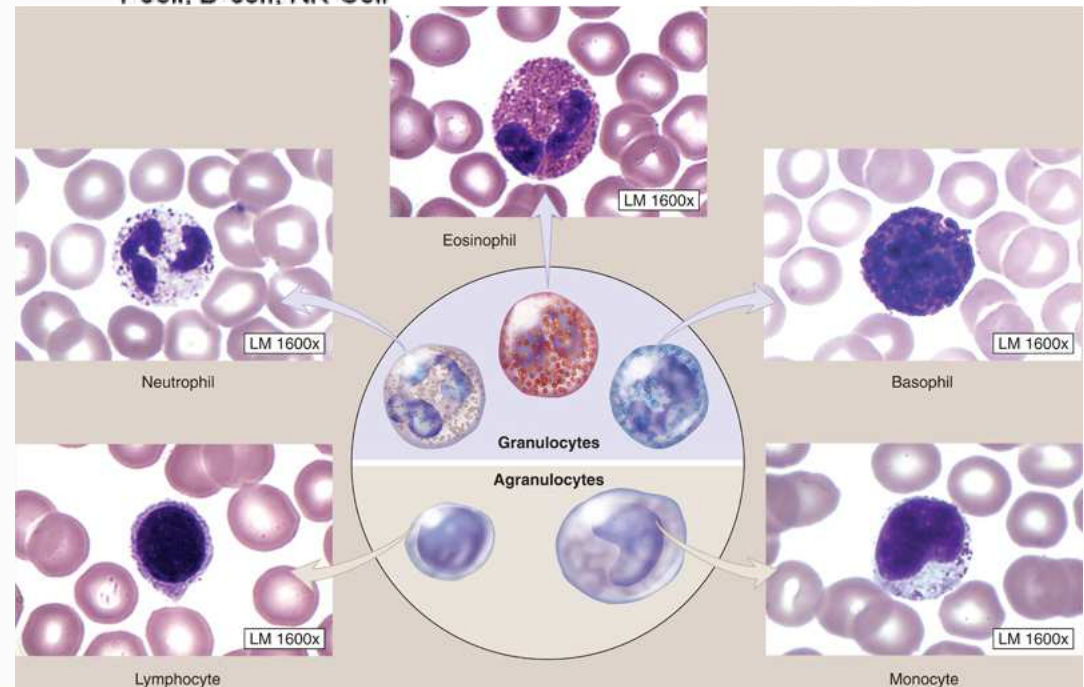
basophils
.5 - 1%

neutrophils
60 - 70%

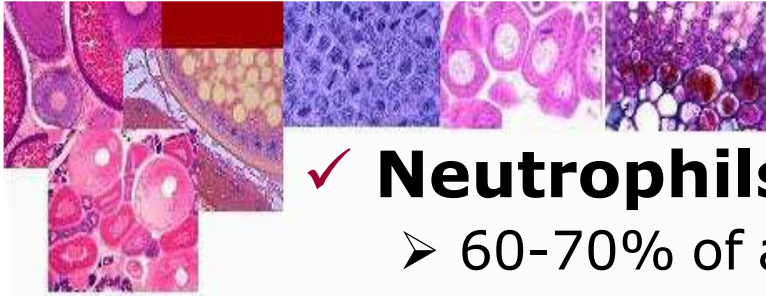
eosinophils
2 - 4%



T-cell, B-cell, NK Cell

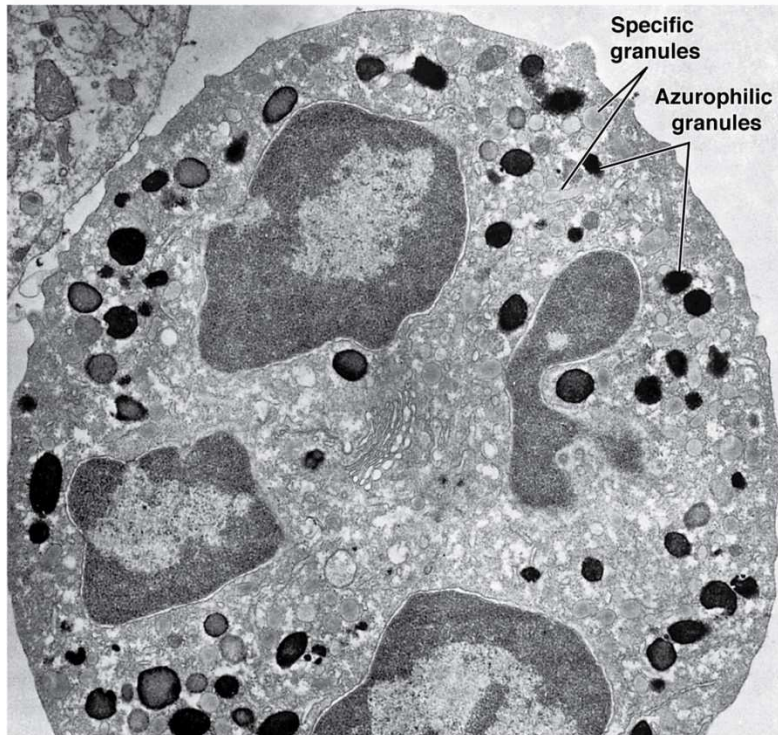
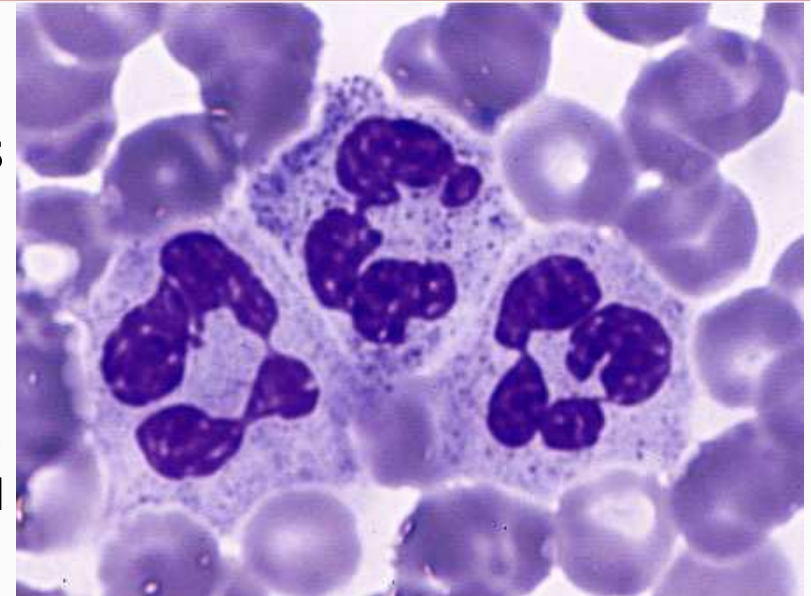


Polymorphonuclear leukocytes



✓ Neutrophils:

- 60-70% of all leukocytes
- size (in diameter):
 - 10-12 μm
- segmented nucleus
 - ⇒ 2-5 (usually 3) lobes
 - > 5 lobes ⇒ hypersegmented



Granules: total number 50-200

- specific (B-granules): 80%
 - ⇒ small-sized – 0.1-0.2 μm
 - ⇒ lysozyme, lactoferrin, collagenase, several nonenzymatic antibacterial basic proteins, alkaline phosphatase
- azurophilic (A-granules): 15%
 - ⇒ lysosomes – 0.4-0.5 μm
 - ⇒ acid hydrolases, peroxidase etc.

Functions of neutrophils



✓ Life span: 12-14 h in the bloodstream,
1-4 days in the connective tissue

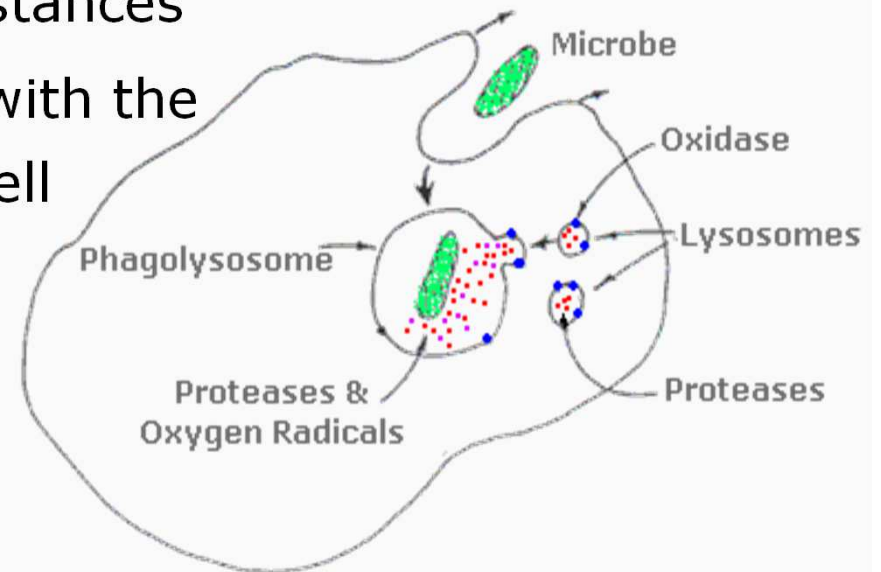
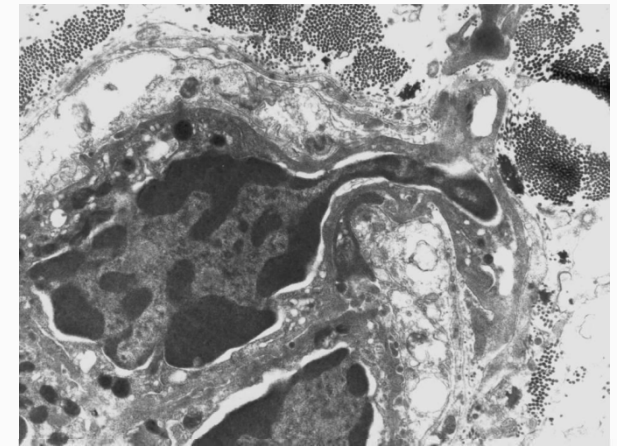
➤ diapedesis
through the blood vessel walls

➤ phagocytosis (microphages):

⇒ specific granules + membrane of the
phagosome ⇒ bactericide substances

⇒ azurophilic granules – fusion with the
phagosome ⇒ lysis of target cell

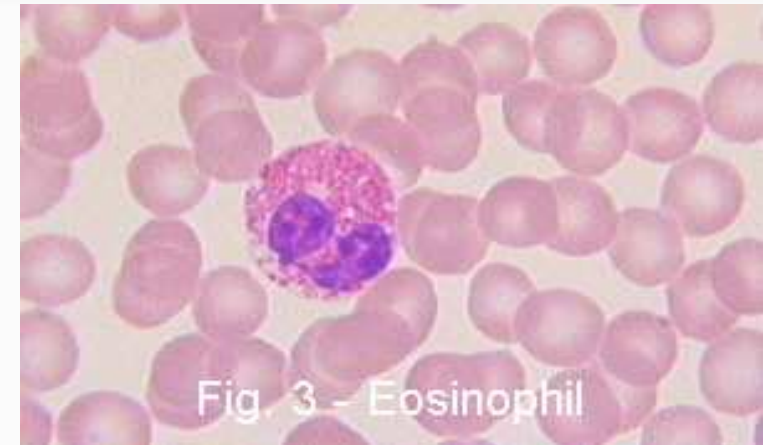
➤ exudative phase of
inflammation – *pus*
(dead neutrophils, bacteria
and semi-digested material)



Eosinophilic granulocytes

✓ Eosinophils:

- 2-4% of leukocytes
- size (in diameter):
 - 12-17 μm
- bilobed nucleus



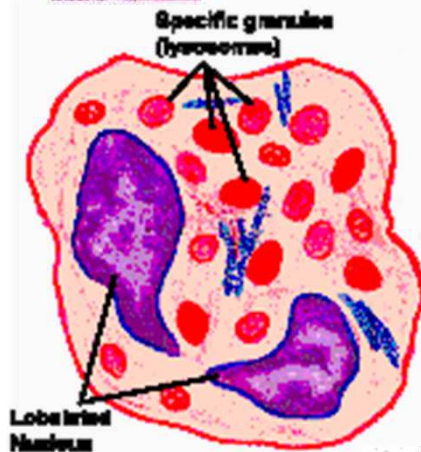
✓ specific granules:

about 200/cell, 0.5-1.5 μm /0.3-1 μm

- LM: acidophilic (eosinophilic)
 - ⇒ acid phosphatase, arylsulfatase, peroxidase, histaminase, protein cations (MBP, ECP, EPO, EDN)
- EM: ultrastructure
 - ⇒ unit membrane, crystalline core (major basic protein), parallel to the long axis of the granule

✓ azurophilic granules:

⇒ lysosomal enzymes



Functions of eosinophils



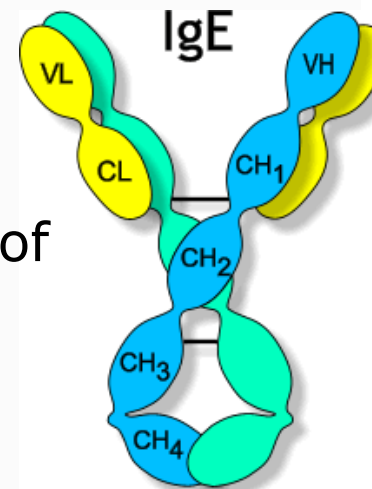
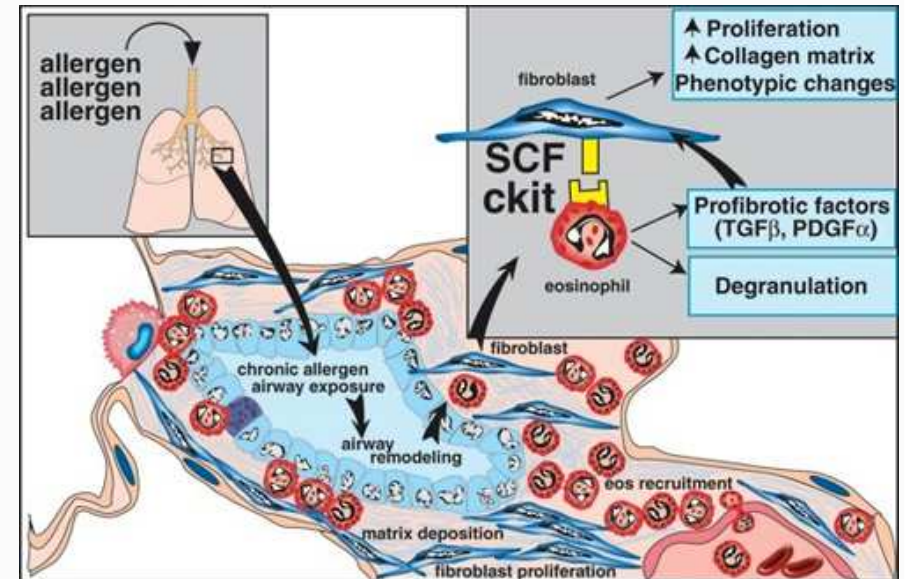
✓ Life span:

- 6-16 h in the blood
- 8-12 days in the connective tissue

✓ motile cells: chemotaxis (ECF-A) – mast cells

✓ expression of receptors for IgE:

- ⇒ destruction of parasites (helminthic infections)
- ⇒ allergic processes
- ⇒ anaphylaxis – inactivation of leukotrienes (SRS-A) and histamine produced by other cells

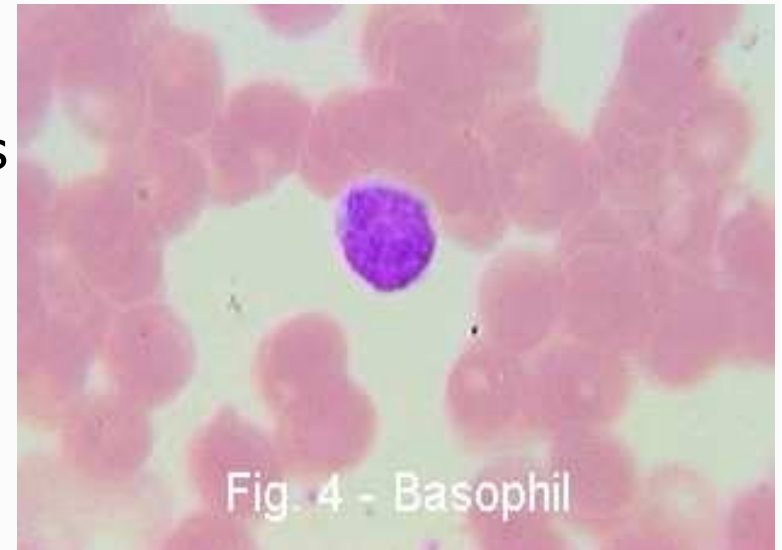
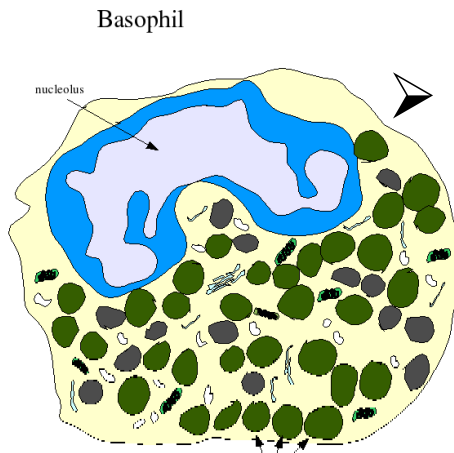


Basophilic granulocytes



✓ Basophils:

- less than 1% of leukocytes
- size (in diameter):
 - ⇒ 10-12 μm
- large nucleus
 - ⇒ irregular lobes
 - ⇒ U- or S-shaped



✓ specific granules: 0.5 μm

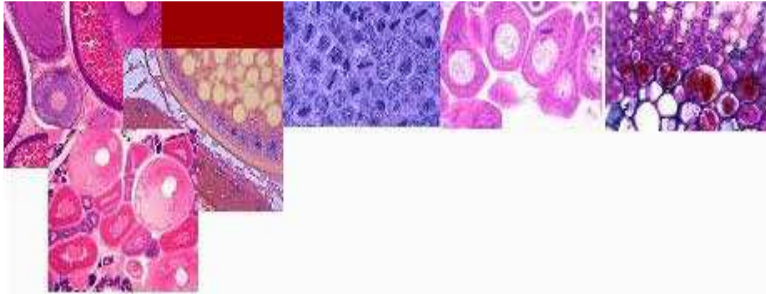
- metachromasia – similar to mast cells
 - ⇒ histamine, (serotonin), heparin, prostaglandins
- ultrastructure
 - ⇒ dense-cored granules

✓ azurophilic granules:

- ⇒ lysosomes ⇒ hydrolytic enzymes

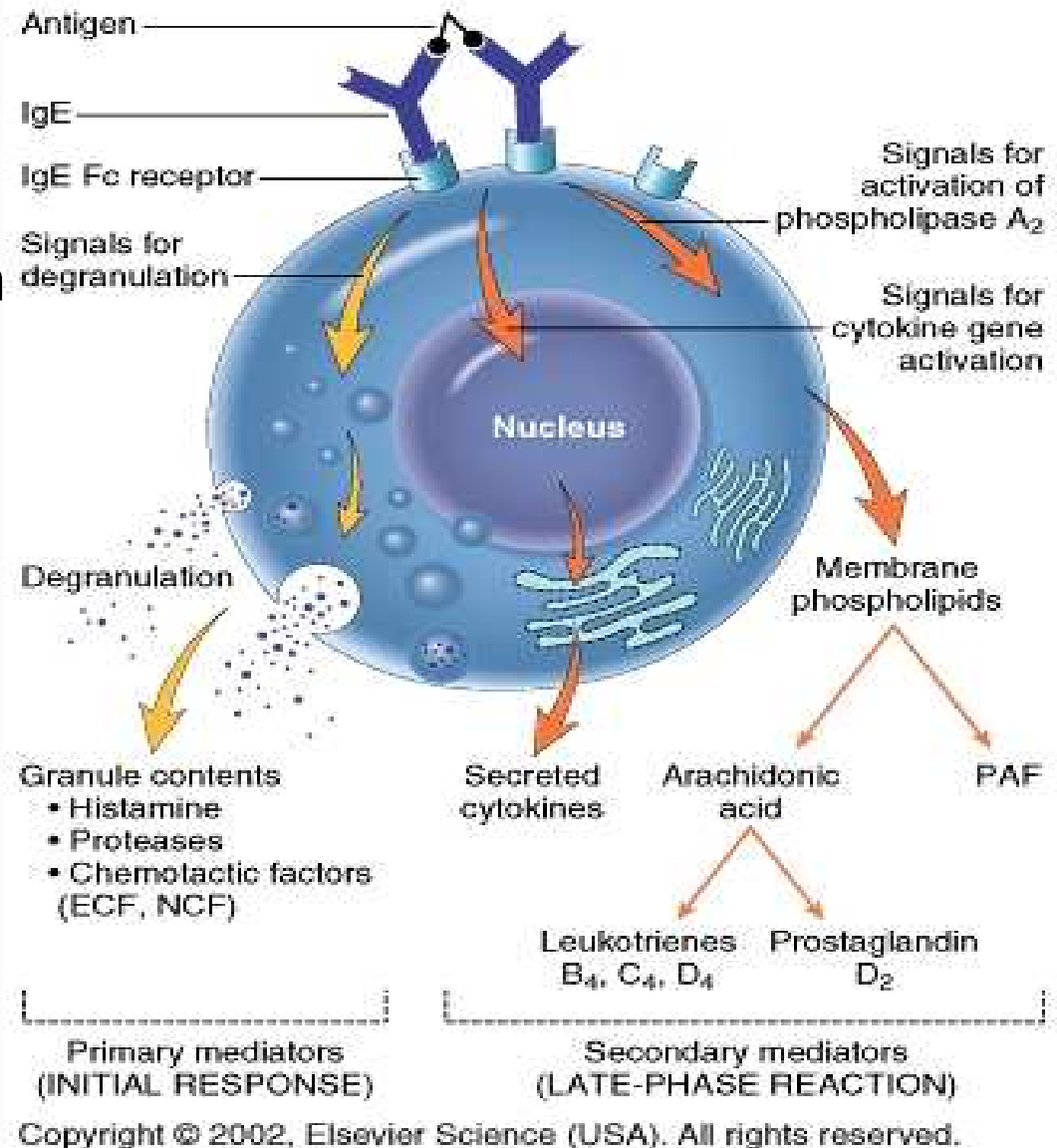


Functions of basophils



✓ Life span:
10-12h in the bloodstream

- motile cells:
chemotaxis
- expression of
receptors for IgE:
 - allergic processes
- cutaneous basophil
hypersensitivity

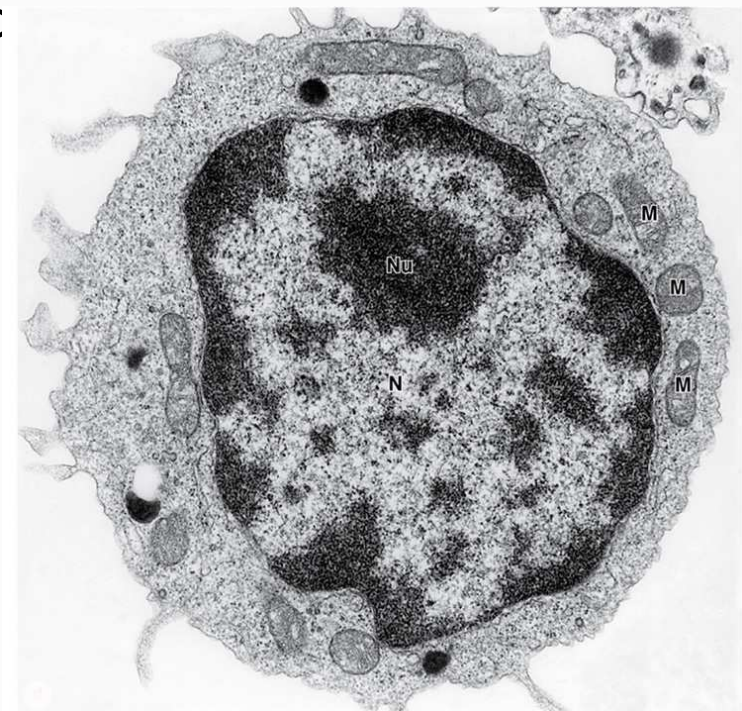
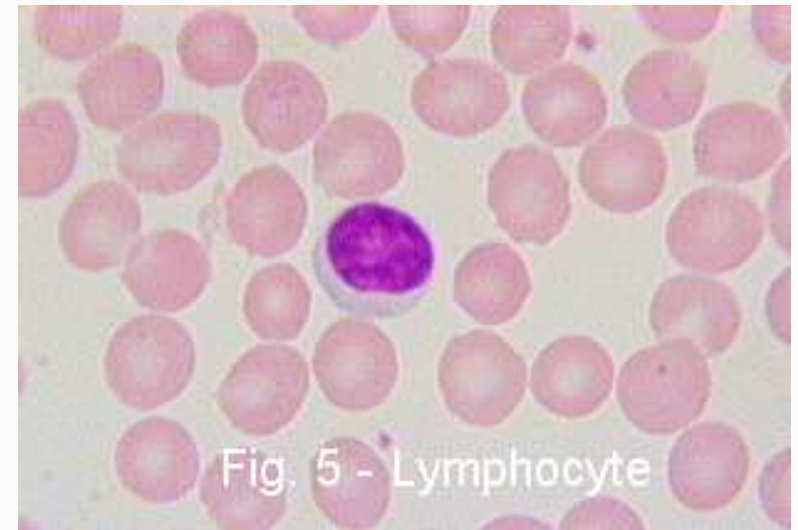
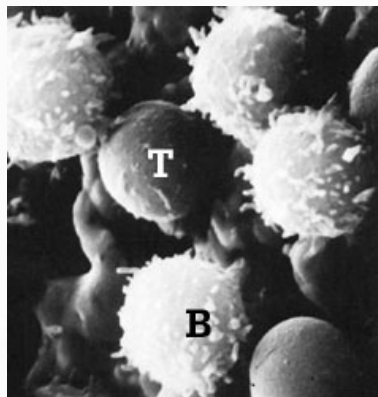
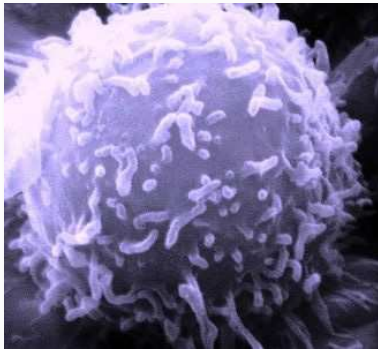


Agranulocytes

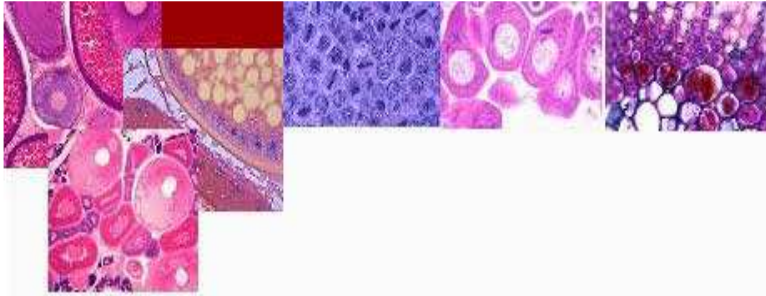


✓ Lymphocytes:

- size (in diameter):
 - small – 6-8 μm
 - medium – 8-12 μm
 - large – 12-18 μm
 - nucleus:
 - large, hyperchromatic
eccentrically located
 - cytoplasm:
 - ⇒ scanty, thin rim
around the nucleus
 - ⇒ basophilic with many
free polyribosomes
- ⇒ **B-lymphocytes**
⇒ **T-lymphocytes**
⇒ **NK cells (NKC)**



Functions of lymphocytes

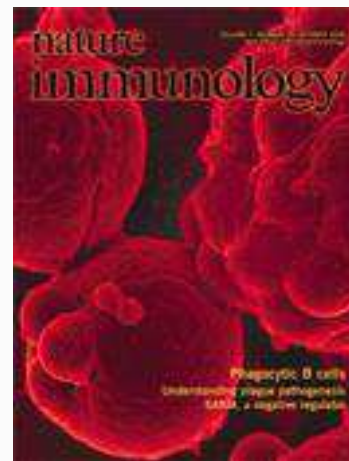
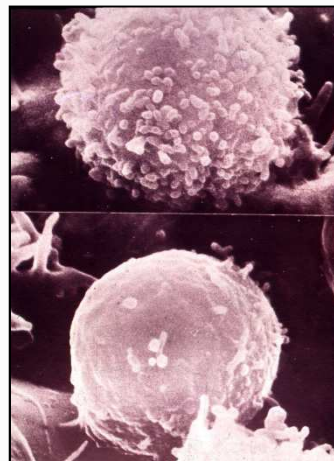


- ✓ humoral immune response
 - B-lymphocyte \Rightarrow plasma cells \Rightarrow antibodies



- ✓ cell-mediated immune response
 - T-lymphocyte \Rightarrow lymphokines \Rightarrow cell-bound antibodies

T_H1
 T_H2
 T_S
 T_K (NKC)
 T_A
 T_M

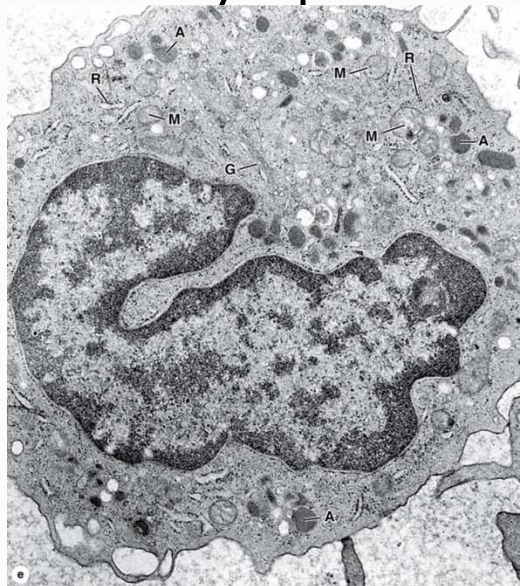
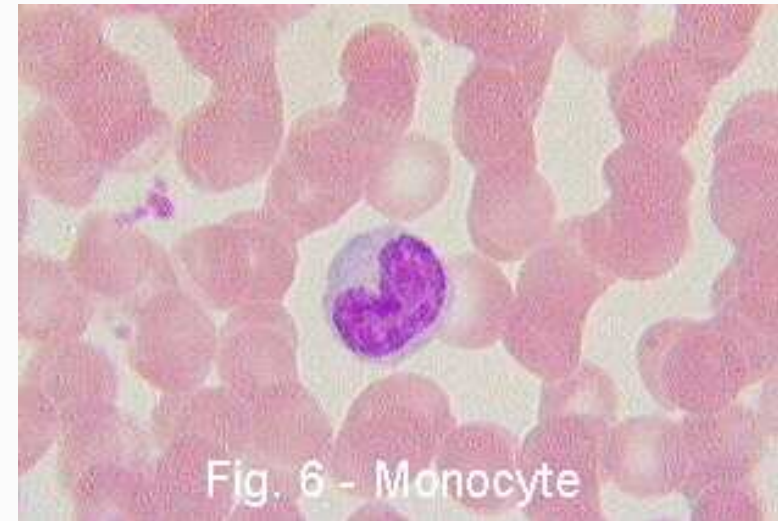


Agranulocytes



✓ Monocytes:

- size (in diameter):
 - 13-20 μm
- nucleus:
 - ⇒ eccentrically placed, oval, horseshoe- or kidney-shaped with 1-2 nucleoli
- pinocytotic vesicles and many microvilli
- cytoplasm – basophilic (bluish-gray color)

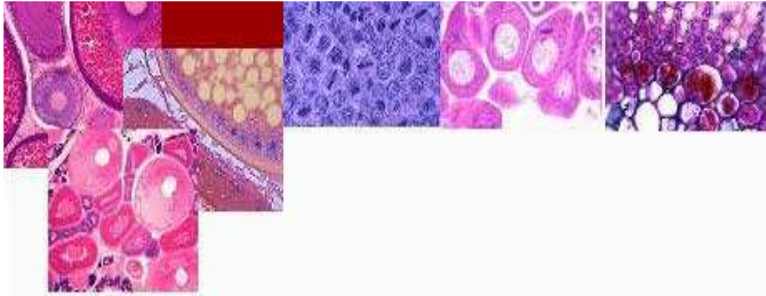


✓ Granules:

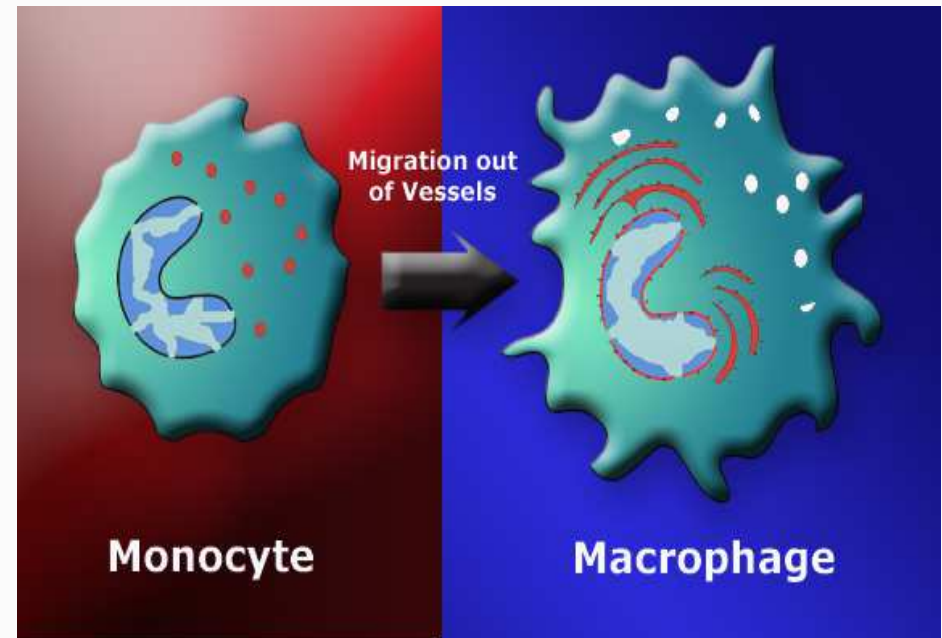
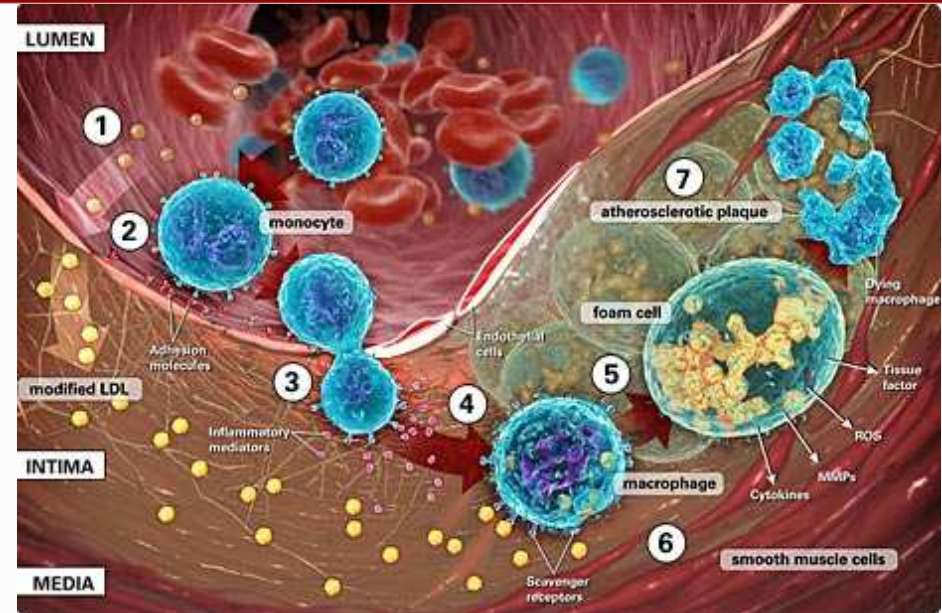
- very fine azurophilic (lysosomes)
 - ⇒ peroxidase-positive (acid phosphatase)
 - ⇒ peroxidase-negative (nonspecific esterase)

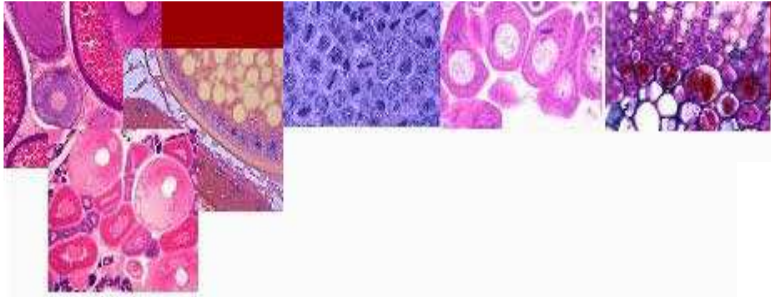


Functions of monocytes

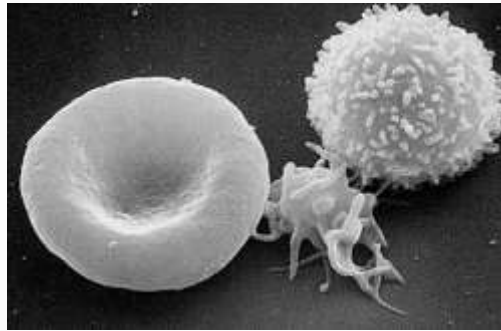
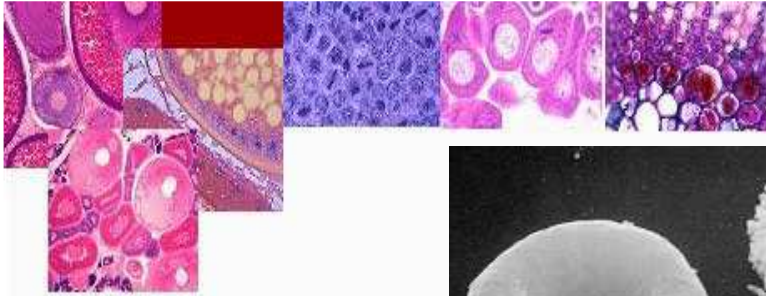


- ✓ Life span:
 - 1-8 h in the bloodstream
 - do not complete their differentiation
 - no functions in the blood vessels
- ✓ after crossing capillary wall they enter connective tissue: months-to-years life
 - phagocytosis ⇒ macrophages
 - antigen-presenting cells – play an essential role in recognition and interaction of antigen and immunocompetent cells



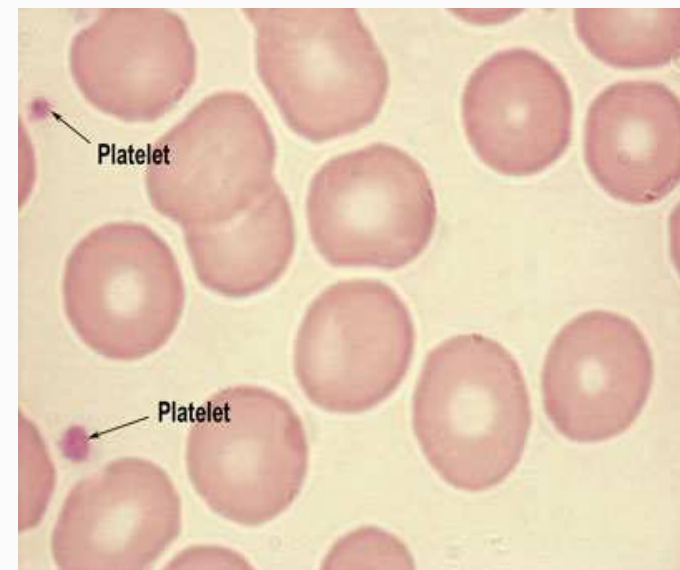
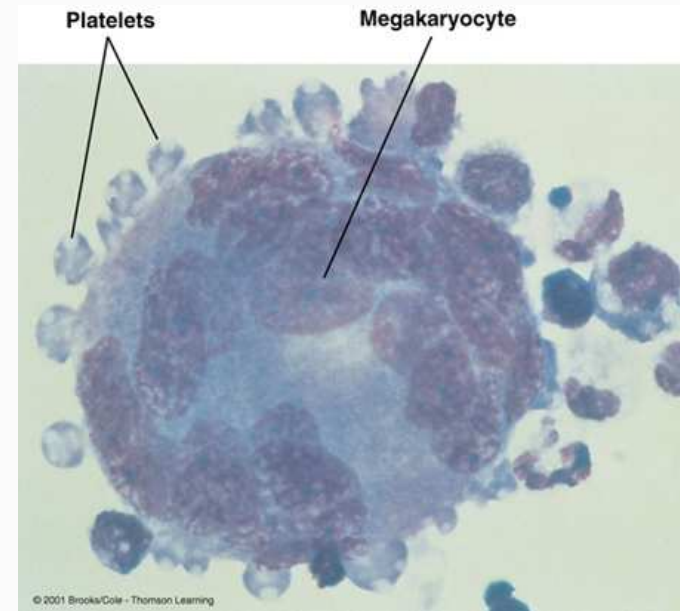


Platelets

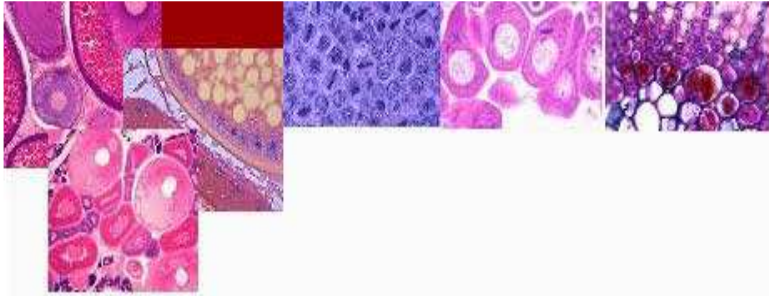


✓ fragmentations from giant polyploid megakaryocytes:

- number: $20-40 \times 10^9/l$
- ellipsoid or discoid in shape
- size: $1.5-5 \mu m$
- central zone – **granulomere** (chromomere) containing purple granules
- peripheral light-blue-stained transparent zone – **hyalomere** (microtubules and actin filaments)



Ultrastructure of platelets

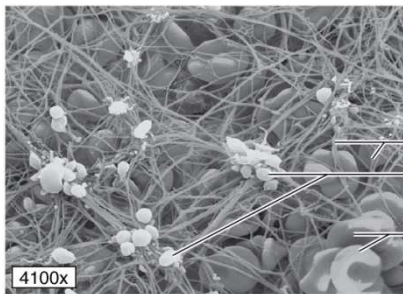
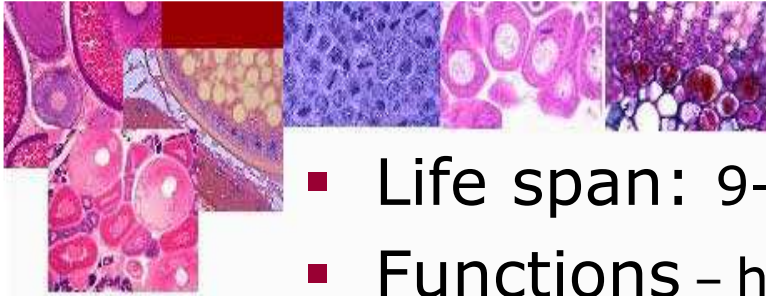
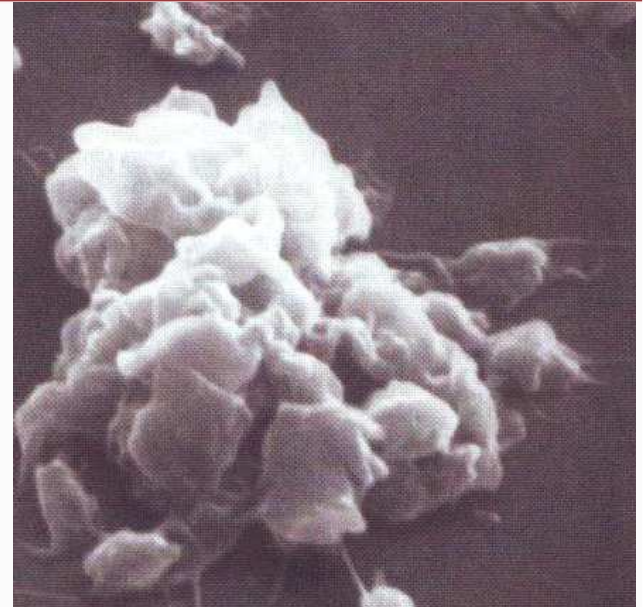


- ✓ membrane with prominent glycocalyx:
 - cell adhesion molecules – platelet adhesion to the capillary wall
- ✓ cytoplasm:
 - open canalicular system (channels)
 - actin-containing microfilaments
 - granules:
 - ⇒ alpha granules (0.2-0.5 μm) – platelet-derived growth factor (PDGF), platelet factor IV, other clotting proteins (thrombospondin and fibronectin, and von *Willebrand* factor)
 - ⇒ delta (beta) granules (0.25-0.3 μm) – dense bodies ⇒ Ca^{2+} , pyrophosphate, ADP, ATP, serotonin, histamine
 - ⇒ lambda granules (0.175-0.250 μm) – lysosomes ⇒ hydrolytic enzymes
 - ⇒ peroxisomes – peroxidase and probably catalase activity

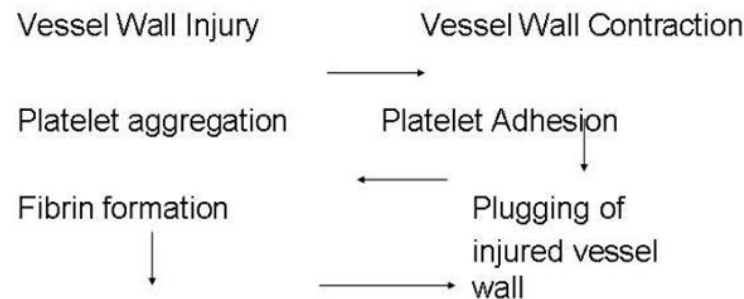


Platelet functions

- Life span: 9-12 days in blood
- Functions – hemorrhage control:
 - ✓ hemostatic mechanism:
 - platelet adhesion
 - platelet aggregation ⇨ platelet plug
 - blood coagulation ⇨ fibrin formation ⇨ blood clot (thrombus)
 - clot retraction
 - clot removal ⇨ plasmin



Mechanism of Clot Formation



Thank you ...

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