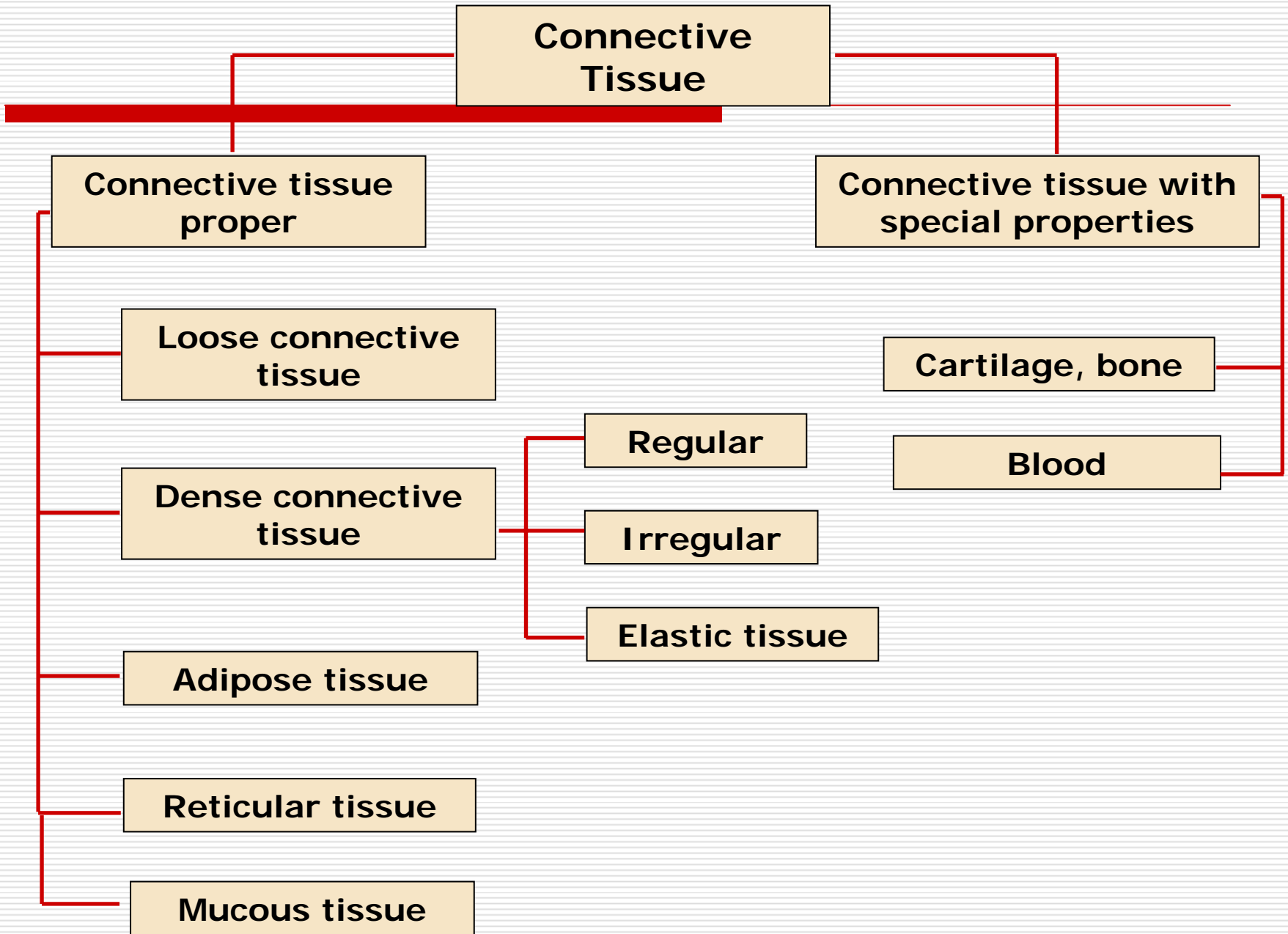


Blood and Haemopoiesis

Li Shulei

lishulei@tom.com

Department of Histology & Embryology



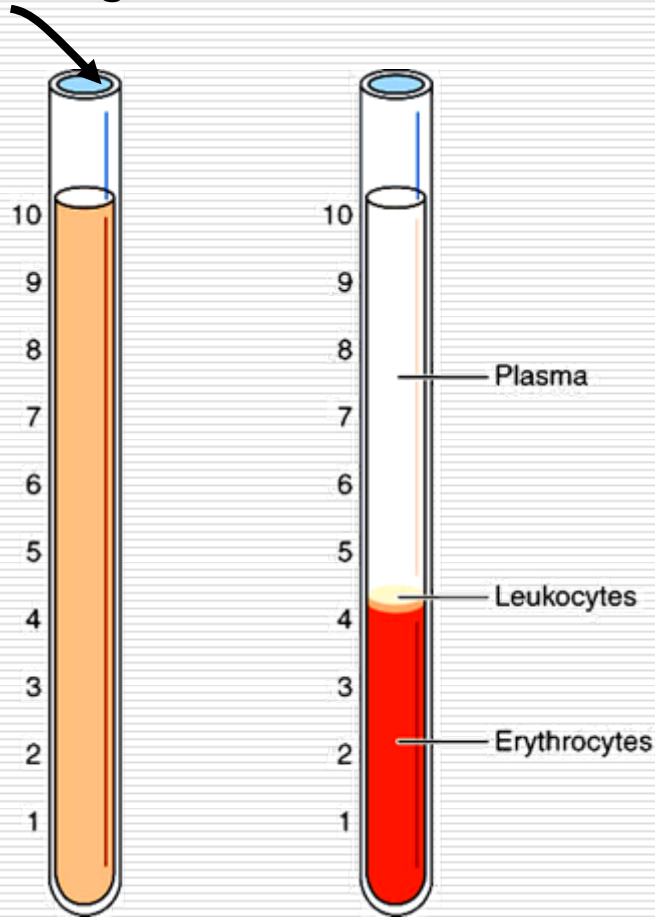
I Blood

1. General description

- Blood cells/ formed elements**
 - **Erythrocytes/ red blood cells**
 - **Platelets**
 - **leukocytes / white blood cells**
- Fluid**
 - **Plasma (intercellular substances+ water)**
 - **Serum= Plasma—fibrinogen**

Blood

anticoagulant



Hematocrit tubes with blood.

Left: Before centrifugation.

Right: After centrifugation.

The erythrocytes represent 43% of the blood volume in the centrifuged tube. Between the sedimented erythrocytes and the supernatant light-colored plasma is a thin layer of leukocytes called the buffy coat.

2. Blood cells

- Erythrocytes (Red blood cell)
- Leukocytes (White blood cell)
 - Granulocytes
 - Neutrophils
 - Eosinophils
 - Basophils
 - Agranulocytes
 - Lymphocytes
 - Monocytes
- Platelets

2.1 Erythrocytes (Red blood cell)

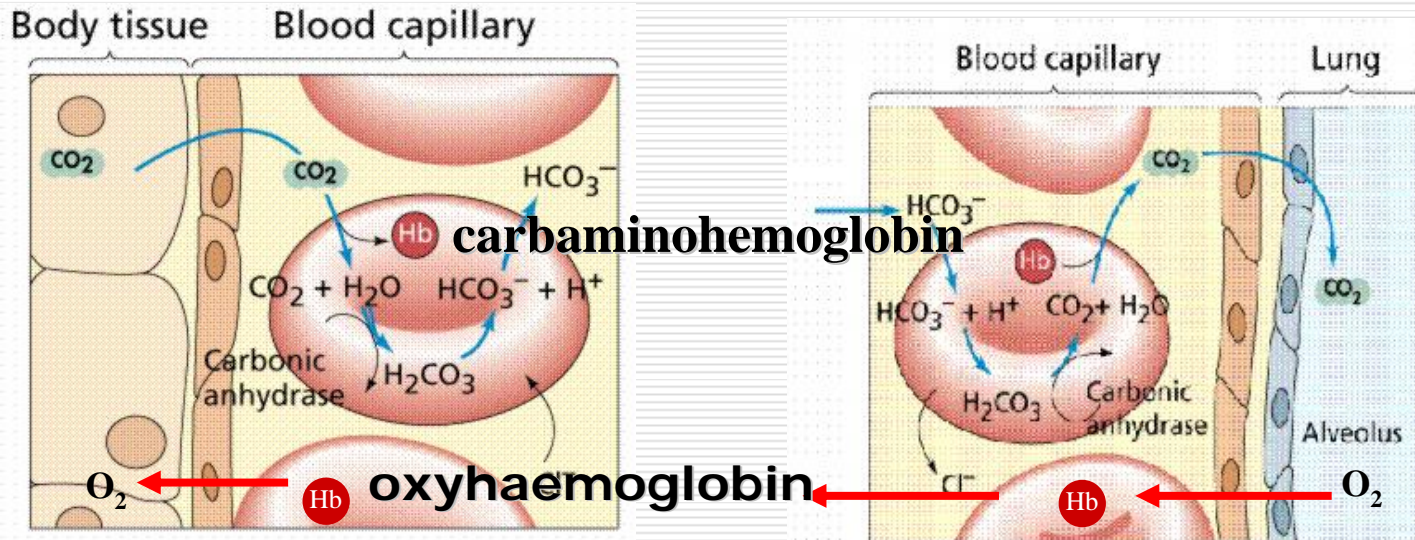
- **Concentration: $4.1 \sim 6 \times 10^{12}/L$ (male)**
 $3.9 \sim 5.5 \times 10^{12} /L$ (female)
- **Biconcave shape without nucleus**
 - a large surface-to-volume ratio
 - facilitating gas exchange.
- **Deformability**
 - meshwork : membrane- spectrin- cytoskeleton
 - reinforce the erythrocyte membrane
 - permit the flexibility of erythrocyte

Erythrocytes (Red blood cell)

- Hemoglobin (Hb): 120 ~ 150 g/L (male)
105 ~ 135 g/L (female)

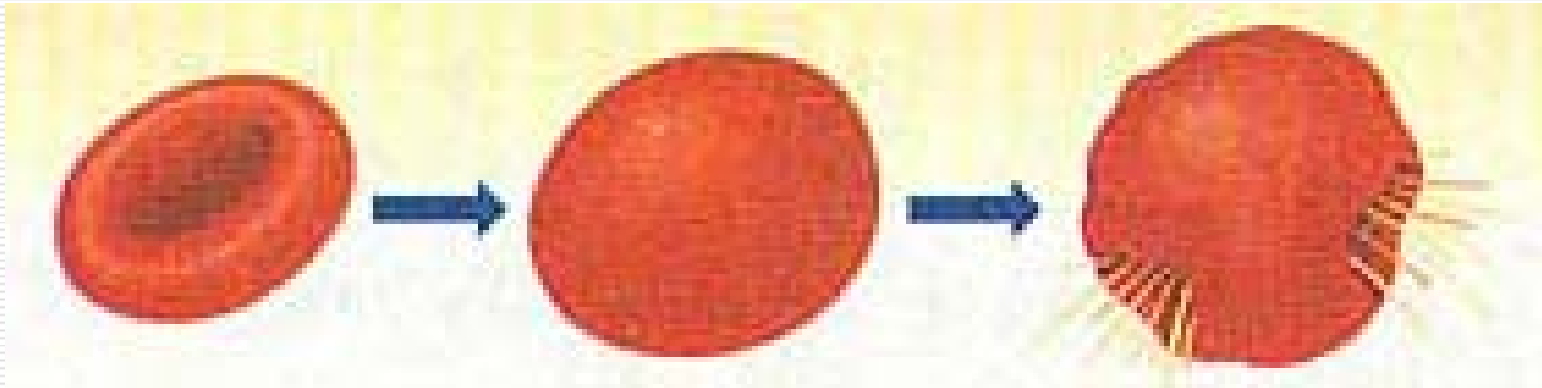
- Function: transport O_2 and CO_2

- oxyhaemoglobin $\xleftarrow{\text{oxygen}}$ carbaminohemoglobin
carbon dioxide
- hemoglobin $\xrightarrow{\text{carbon monoxide}}$ carboxyhemoglobin



Erythrocytes (Red blood cell)

□ Haemolysis: hypotonic solution



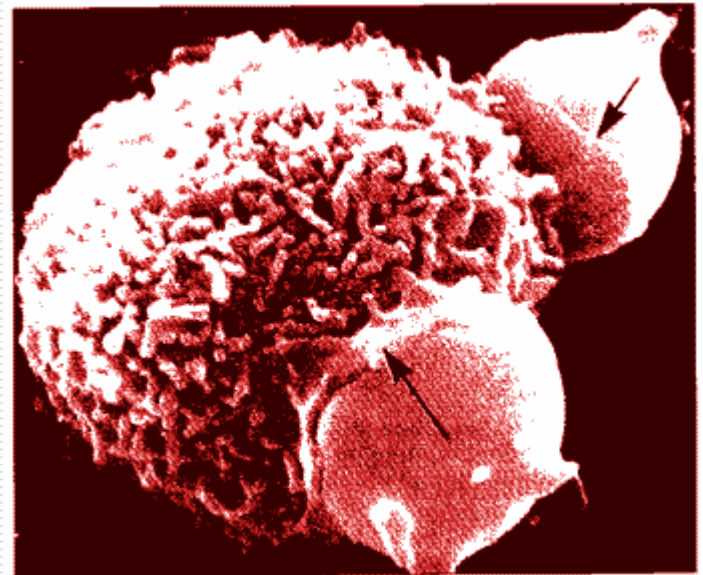
Normal
erythrocyte

Tumescent
(swollen),
spherical
erythrocyte

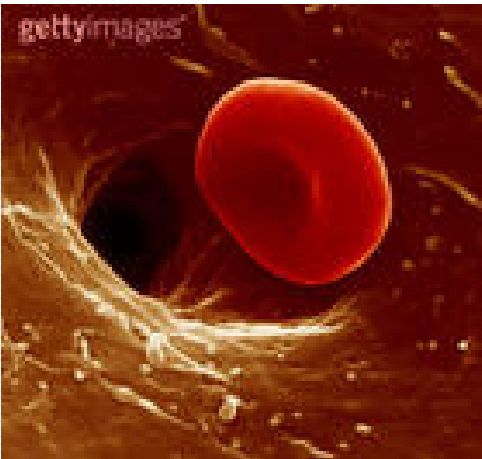
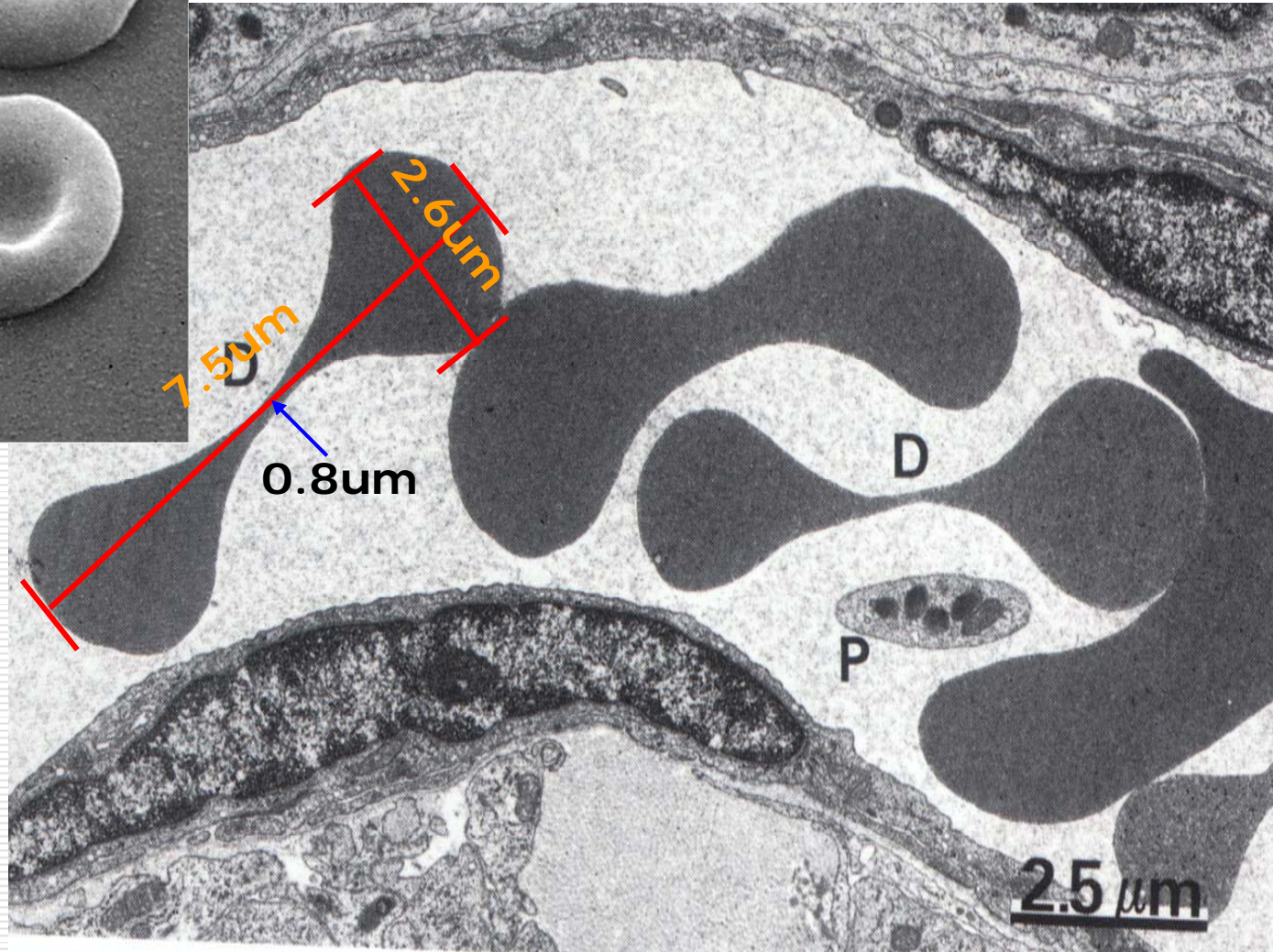
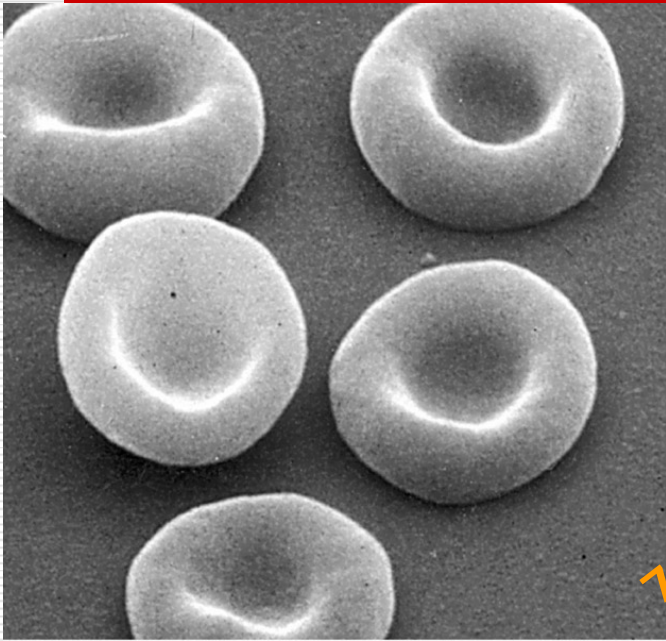
Broken
erythrocyte
releasing
hemoglobin

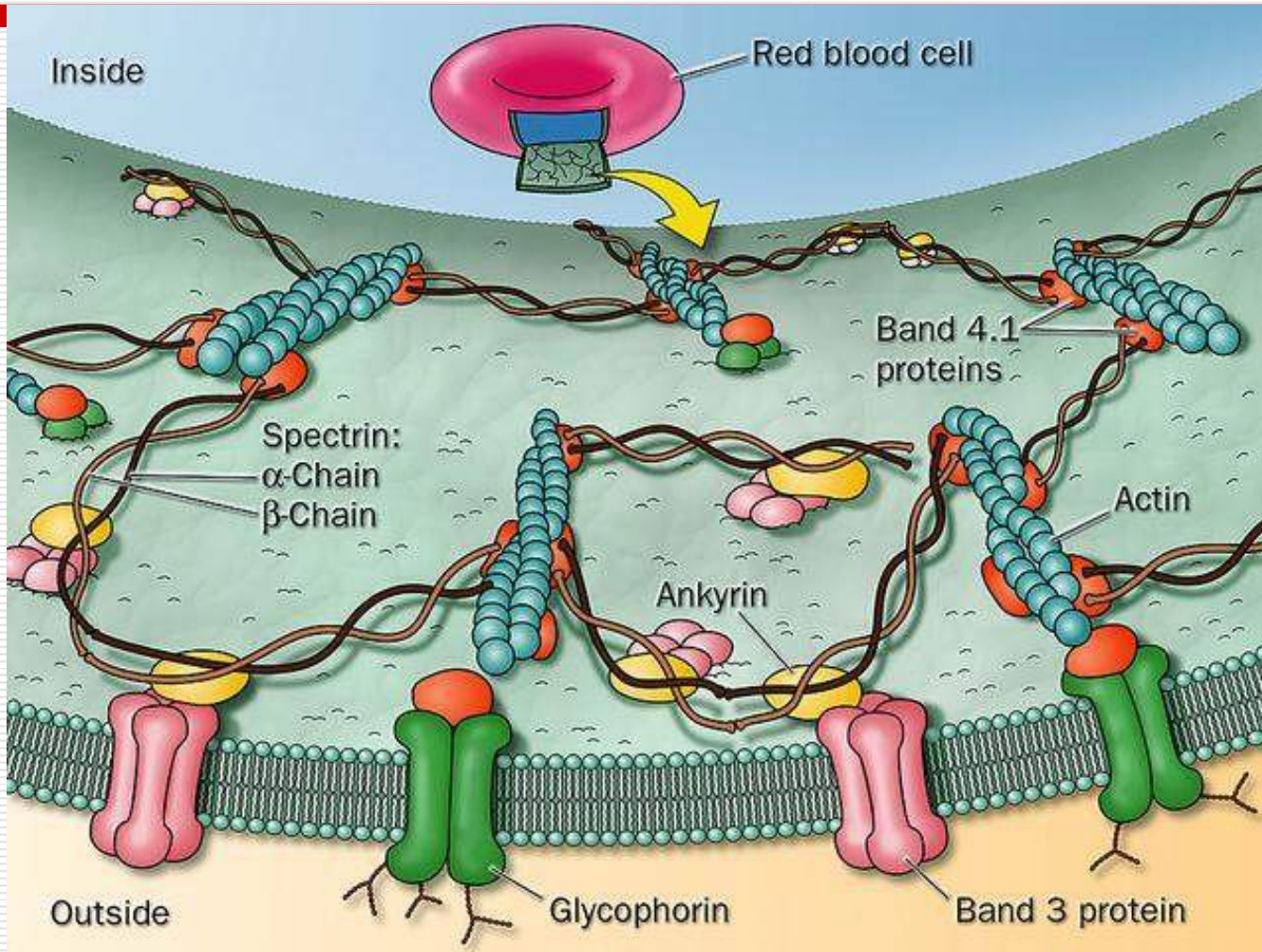
Erythrocytes

- ❑ **Origin:bone marrow**
- ❑ **Reticulocytes:**
 - **ribosomal RNA (brilliant cresyl blue)**
 - **a netlike structure in cytoplasm.**
 - **0.5 - 1.5% of total blood erythrocytes**
- ❑ **Lifespan:**
 - **120 days**
 - **Wore-out cells are removed by macrophages**



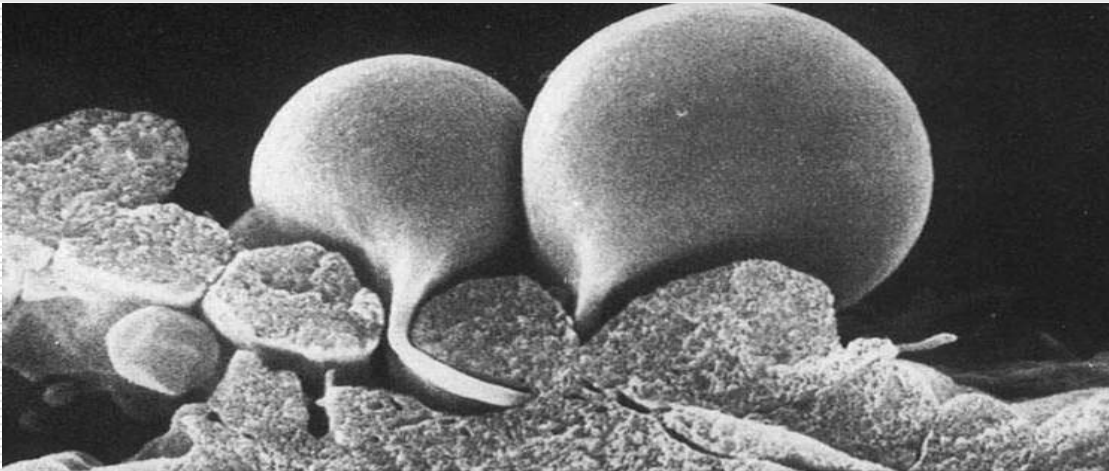
Erythrocytes





The meshwork not only reinforces the erythrocyte membrane but also permits the flexibility of erythrocyte.

Erythrocytes

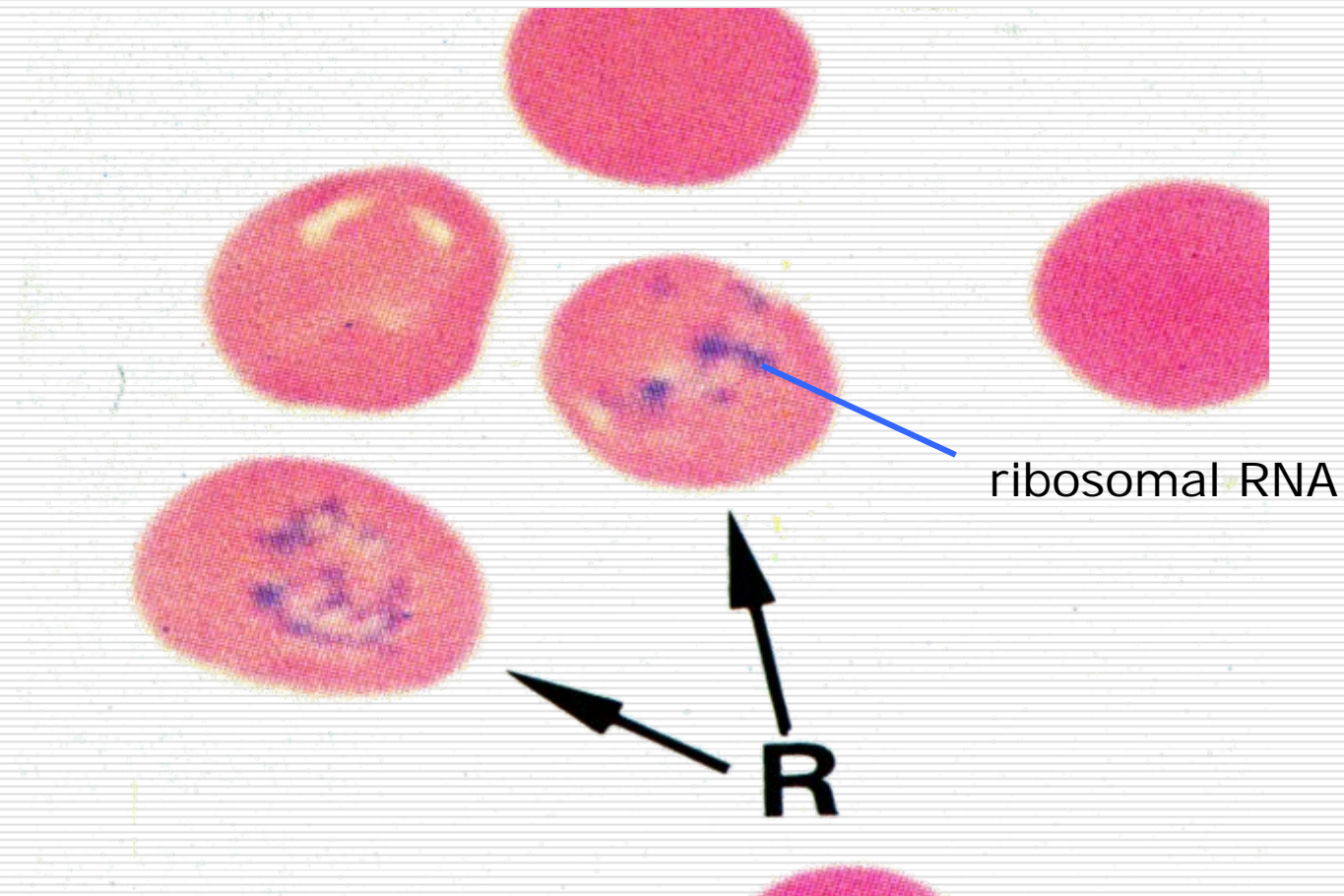


An erythrocyte is passing through the wall of splenic sinusoid.



The meshwork makes the erythrocyte to adapt to the irregular shape and small diameter of capillaries.

Reticulocytes



Reticulocytes with net-like ribosomal RNA.
Giemsa & brilliant cresyl blue stain

2.2 Leukocytes (White blood cell)

Classification

Granulocytes (polymorphnuclear leukocyte)

Neutrophils (neutrophilic granulocytes)

Eosinophil s (eosinophilic granulocytes)

Basophils (basophilic granulocytes)

Agranulocytes (mononuclear leukocyte)

Lymphocytes

Monocytes

Concentration: $6\sim 10 \times 10^9/L$

Function:

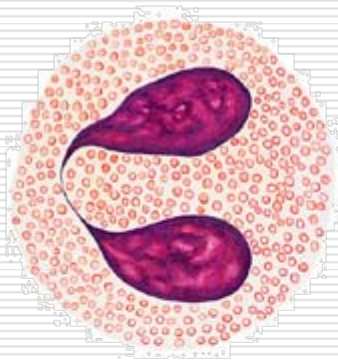
cellular and humoral defense within connective tissues.

amoeboid movement

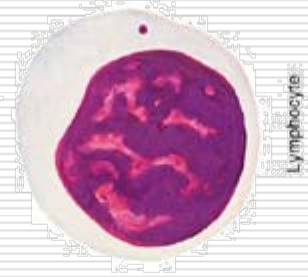
Classification of leukocytes

Granulocytes with irregular nuclei & specific granules

Agranulocytes with regular nuclei & azurophilic granules



eosinophil



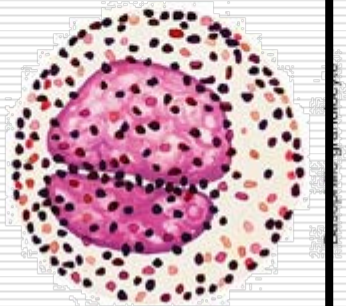
lymphocyte



monocyte



Neutrophil



basophil



monocyte

Neutrophils

Percentage: 60 ~ 70%

LM:

Polymorphous nucleus with 2 ~ 5 lobes linked with fine treads of chromatin.

Specific granules

0.3 ~ 0.8 μ m in diameter,

reddish

Azurophilic granules

Pale purple with Giemsa stain

lysosomes 0.5mm in diameter

Neutrophils

- ❑ **EM**: Granules are surrounded by membrane.
- **Azurophilic granules:**
 - ❑ large and high electron-dense
 - ❑ contain lysosomal enzymes and peroxidase.
- **Specific granules :**
 - ❑ More, smaller and irregularly-shaped
 - ❑ contain alkaline phosphatase, bactericidal phagocytins and lysozymes.
- **Glycogen: yield energy in anaerobic environment**

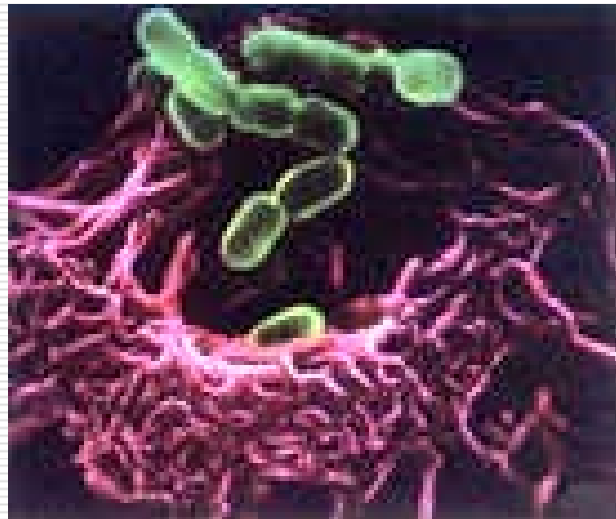
Neutrophils

□ Function

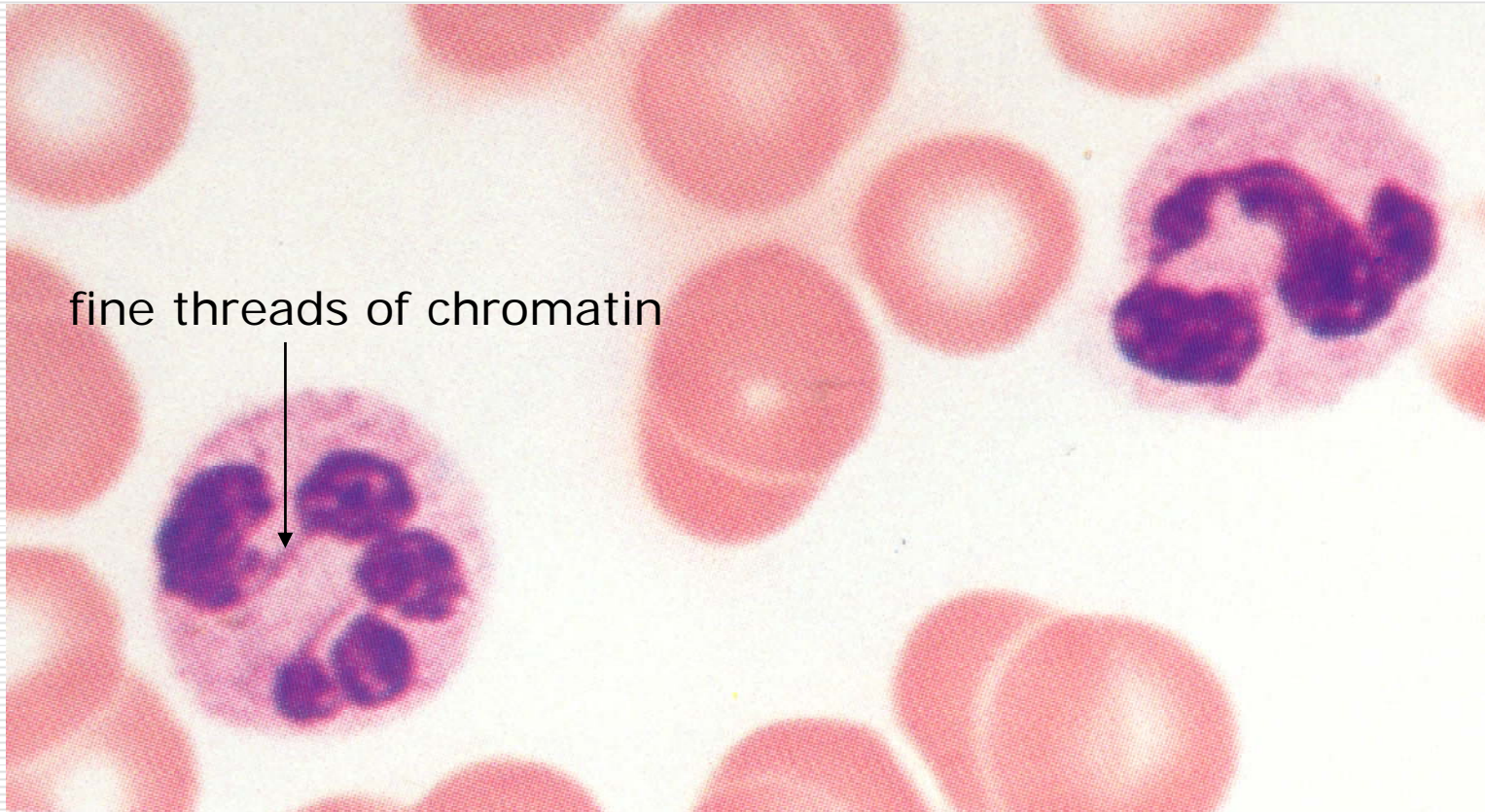
- mobile and phagocytic
- Defense against bacterial infection
- Participate in inflammatory processes

□ Lifespan: 1~3 days

- pus cells



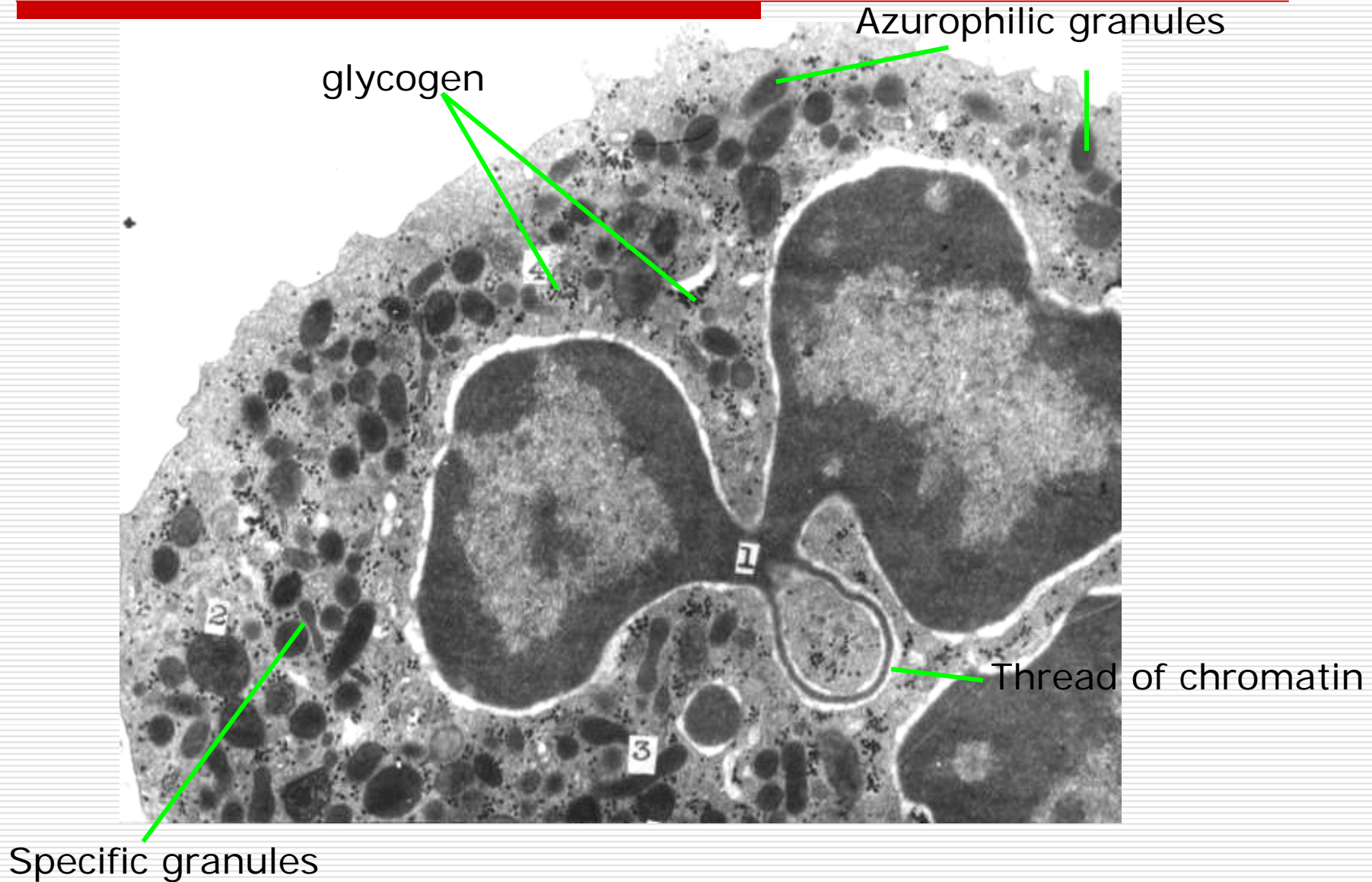
Neutrophils and erythrocytes



Blood smear. Giemsa stain .

Each neutrophil has only one nucleus, with a variable number of lobes. There are lots of fine granules in cytoplasm. Specific granules are reddish, but azurophilic granules are pale purple. Giemsa.

Neutrophil



Eosinophils

□ **Percentage: 2-4%**

□ **LM**

■ **10~12 μ m, Bilobed nucleus**

■ **Large, salmon-pink, refractile granules**

□ **EM**

■ **Eosinophilic granules :**

■ **unit membrane, crystal core, matrix**

■ **Major basic protein**

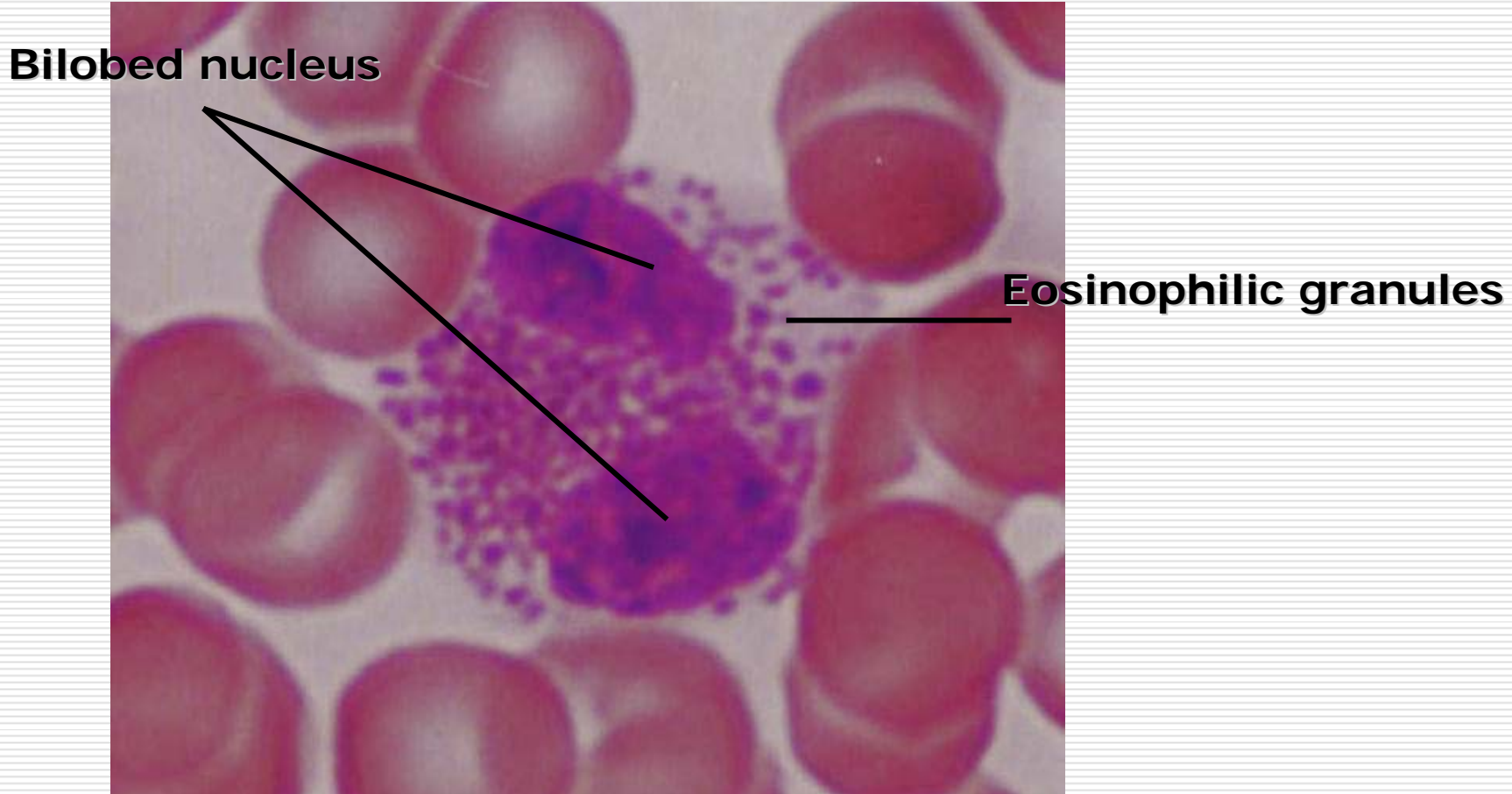
□ **Function**

■ **Phagocytose antigen-antibody complexes**

■ **Weaken allergic reaction; Kill parasite**

□ **Lifespan: 8~12 days**

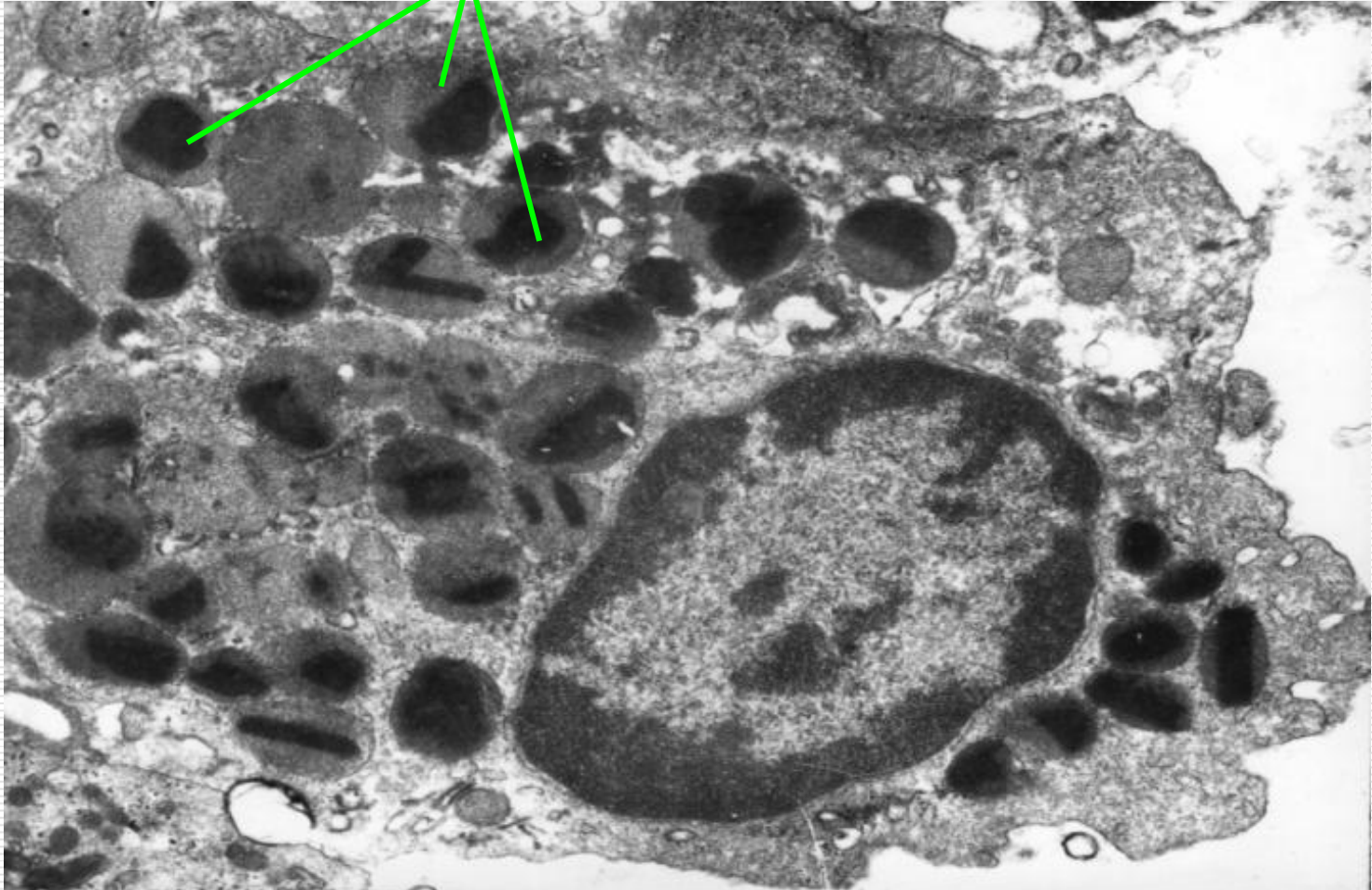
Eosinophils



typical bilobed nucleus and coarse cytoplasmic granules.

Eosinophil

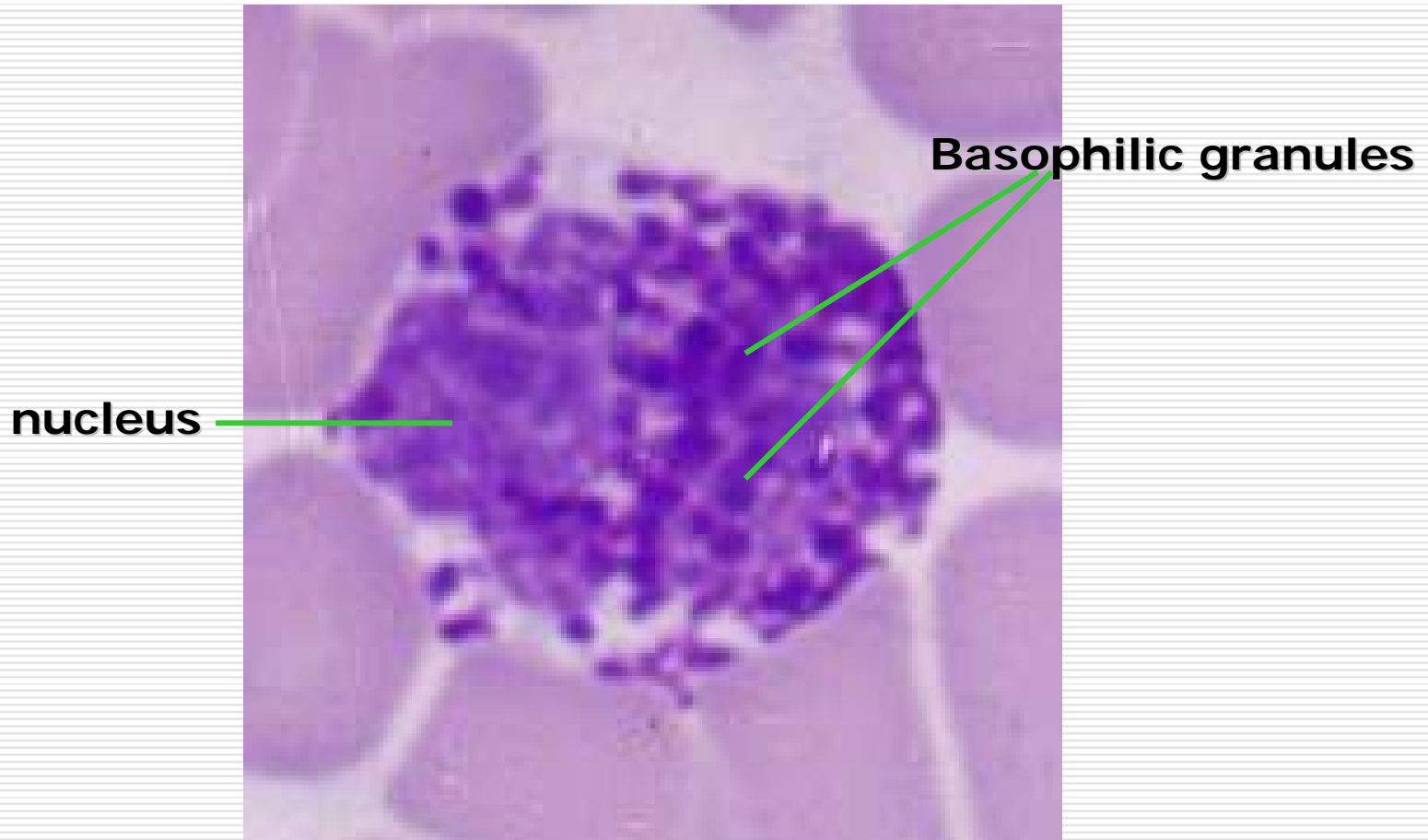
granules with crystalloid core and matrix



Basophils

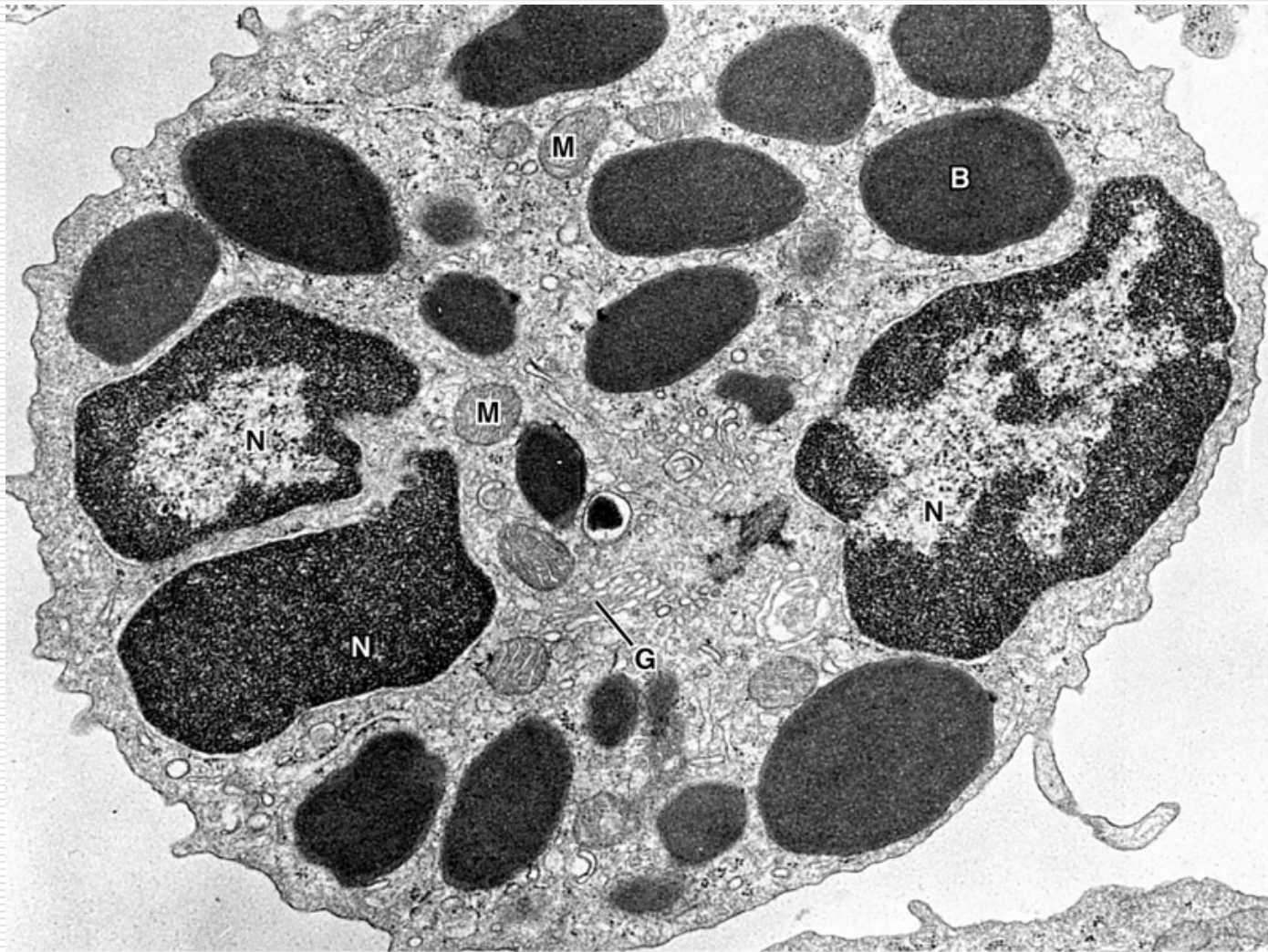
- **Percentage: 0 ~ 1 %**
- **LM**
 - 12~15 μ m, S-shaped nucleus
 - Basophilic granules
- **EM**
 - electron-dense, bounded by a membrane
 - Heparin and histamine
- **Function**
 - mobile and phagocytic
 - Allergic and inflammatory reactions
- **Lifespan: 12~15 days**

Basophils



A basophil with many basophilic granules covering the S-shaped nucleus.

Basophil



N: Nucleus B: Basophilic granule M: Mitochondria G: Golgi complex

Lymphocytes

❑ **Percentage: 20 ~ 30%**

❑ **LM**

■ **Small, medium-sized, large**

■ **Spherical nucleus: dark blue, indentation**

■ **Cytoplasm: a thin rim, basophilic, light blue**

❑ **EM**

■ **azurophilic granules; mitochondria**

■ **small Golgi complex ; many free ribosomes**

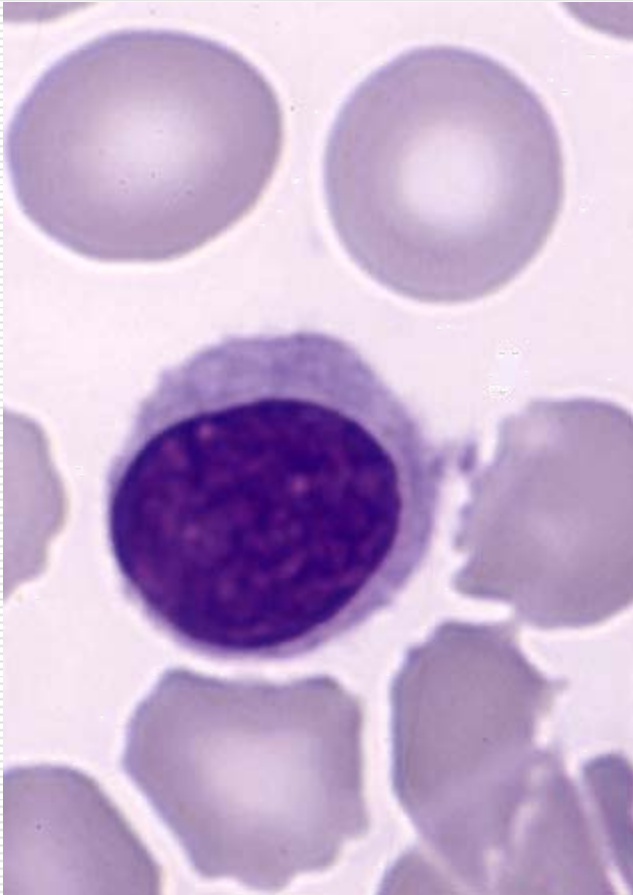
❑ **Classification and functions**

■ **T cell: cellular immunity**

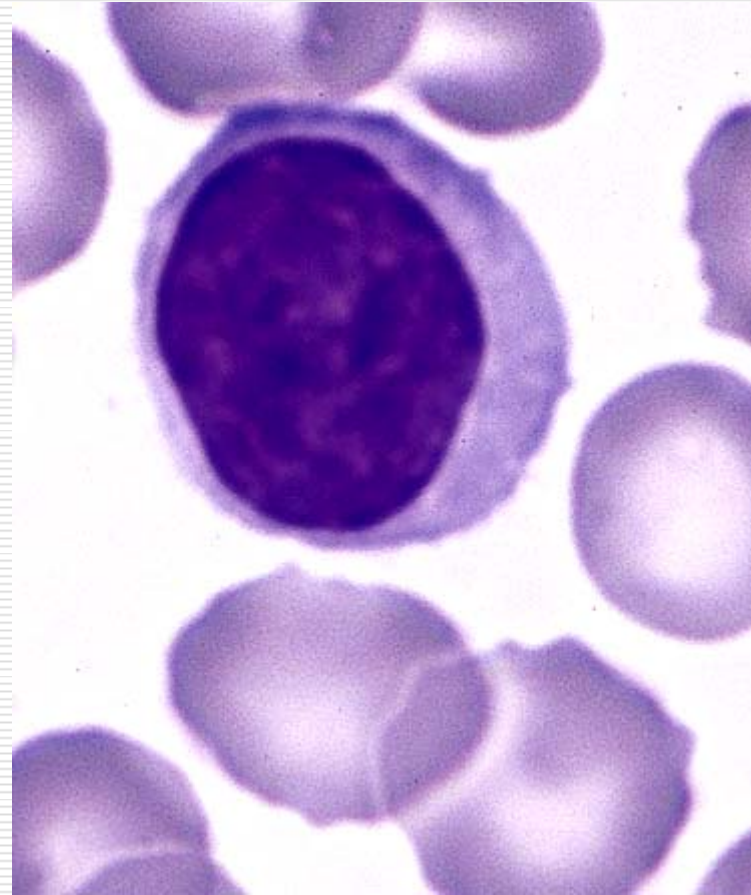
■ **B cell: humoral immunity**

■ **NK cell: attack virus-infected and cancer cells directly**

Lymphocytes



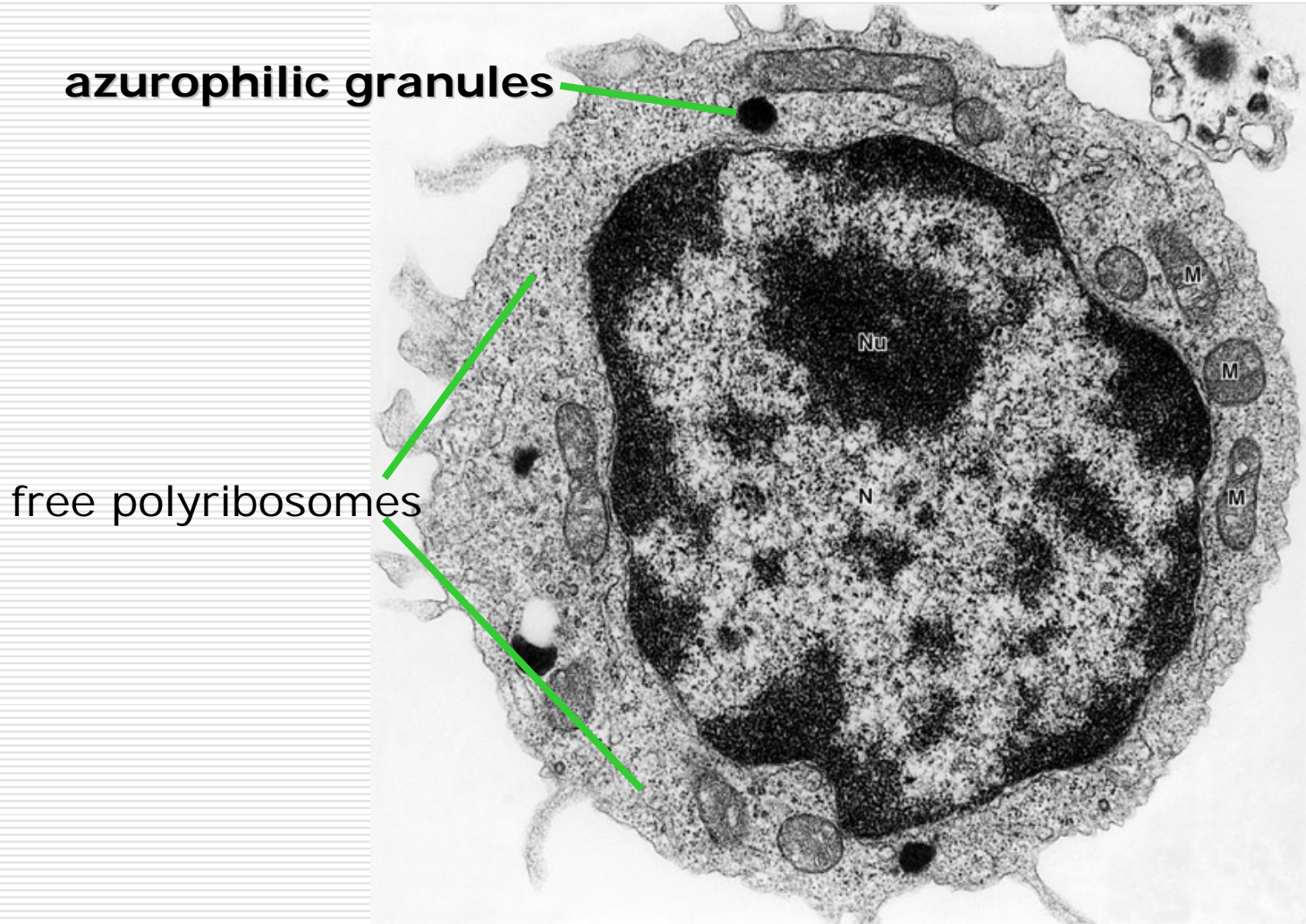
Small lymphocyte



large lymphocyte

an intensely stained spherical nucleus with indentation. The slightly basophilic, light-blue cytoplasm appears as a thin rim.

Lymphocyte

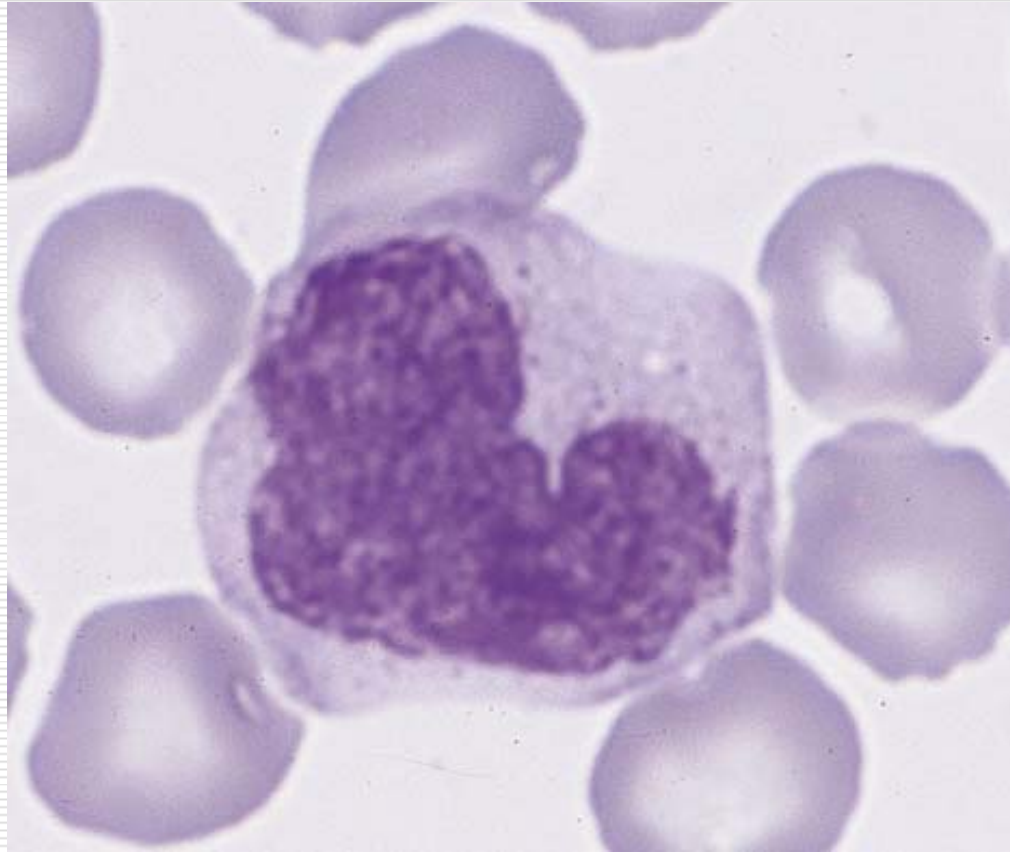


nucleus (N), the nucleolus (Nu), mitochondria (M).

Monocytes

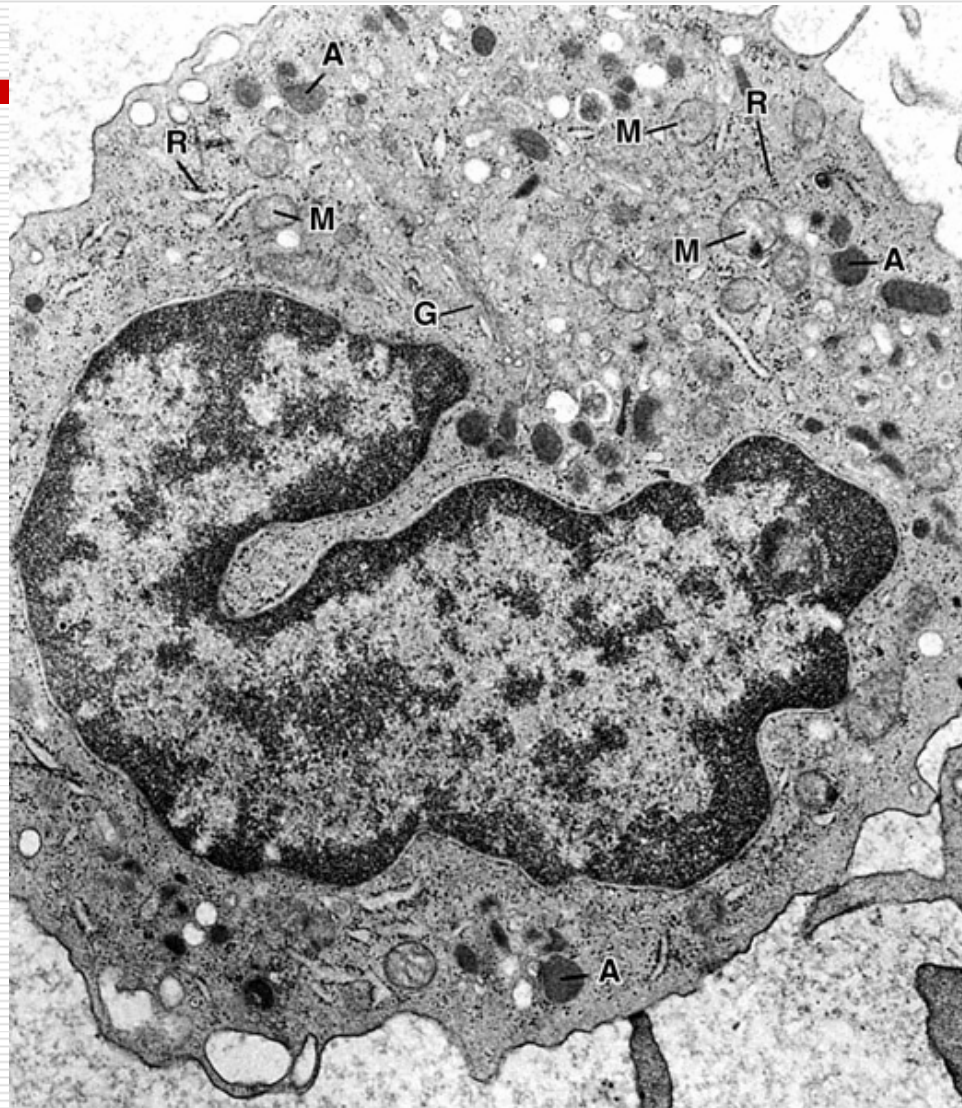
- **Percentage: 3-8%**
- **LM**
 - **12-20 μ m**
 - **Oval, horseshoe, or kidney-shaped nucleus with delicate chromatin**
 - **Cytoplasm: bluish-grey**
- **EM**
 - **Many fine azurophilic granules**
 - **rough endoplasmic reticulum**
 - **Few ribosomes**
- **Function**
 - **Migrate into tissues to become macrophages**

Monocytes



This cell has an eccentric kidney-shaped nucleus with delicately stained chromatin. The cytoplasm is slightly basophilic, bluish-grey in colour.

Monocyte



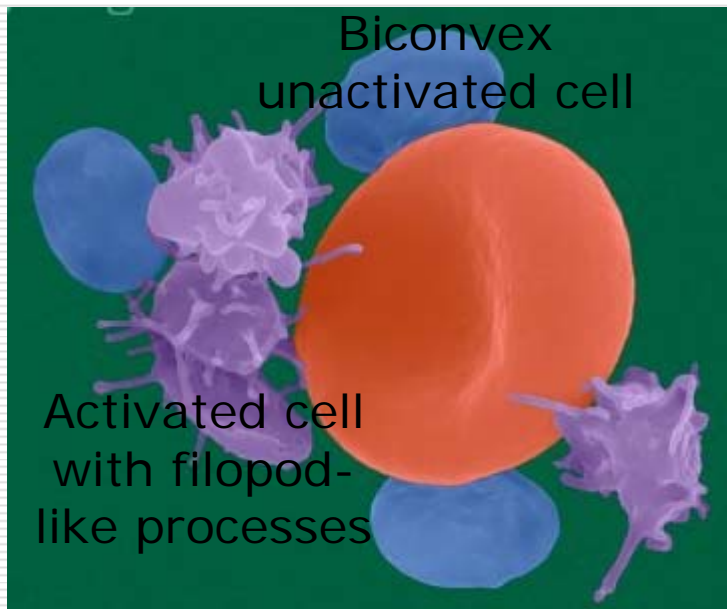
Golgi complex (G), mitochondria (M), azurophilic granule (A), free ribosomes (R).

2.3 Platelets (Thrombocytes)

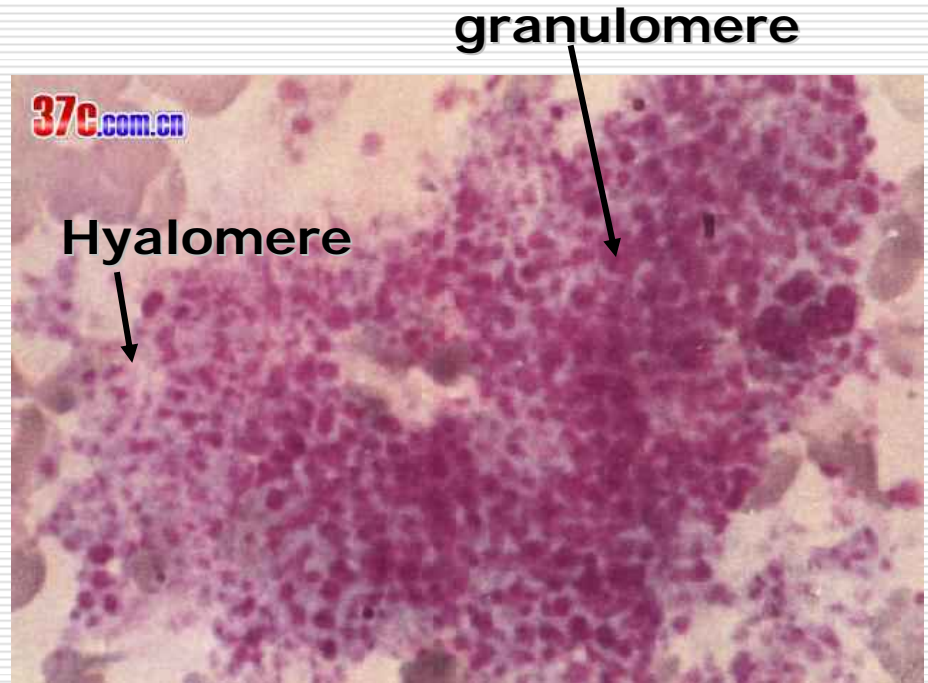
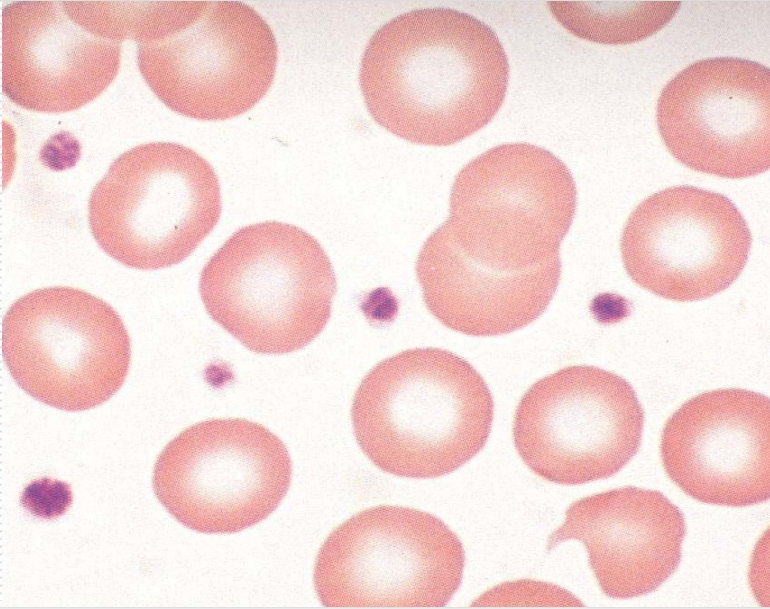
□ $(100\sim400) \times 10^9/L$

□ LM

- $2 \sim 4 \mu m$, anucleated, biconvex disk-like, fragments of cytoplasm of megakaryocytes,



Platelets



platelets often appear in clumps

Hyalomere: peripheral light blue-stained

granulomere: central purple

Platelets (Thrombocytes)

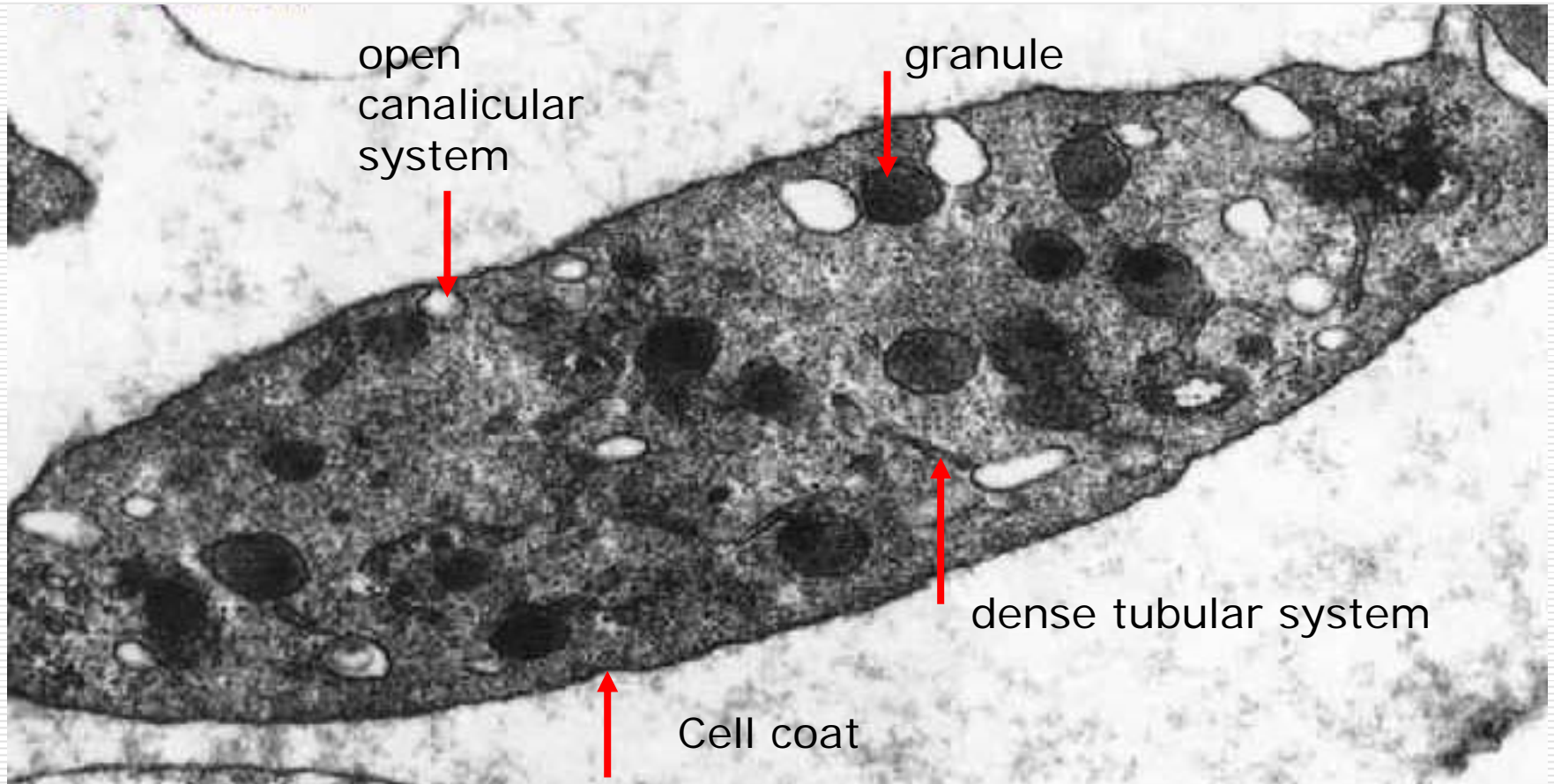
□ EM

- cell coat: adhesion
- Open canalicular system: easy to liberate active molecules
- dense tubular system:
- microtubules: maintain the platelet's ovoid shape
- Actin and myosin: platelet movement and aggregation
- membrane-bound granules (serotonin or lysosomes), mitochondria and glycogen particles

□ Function: forming thrombus & control hemorrhage

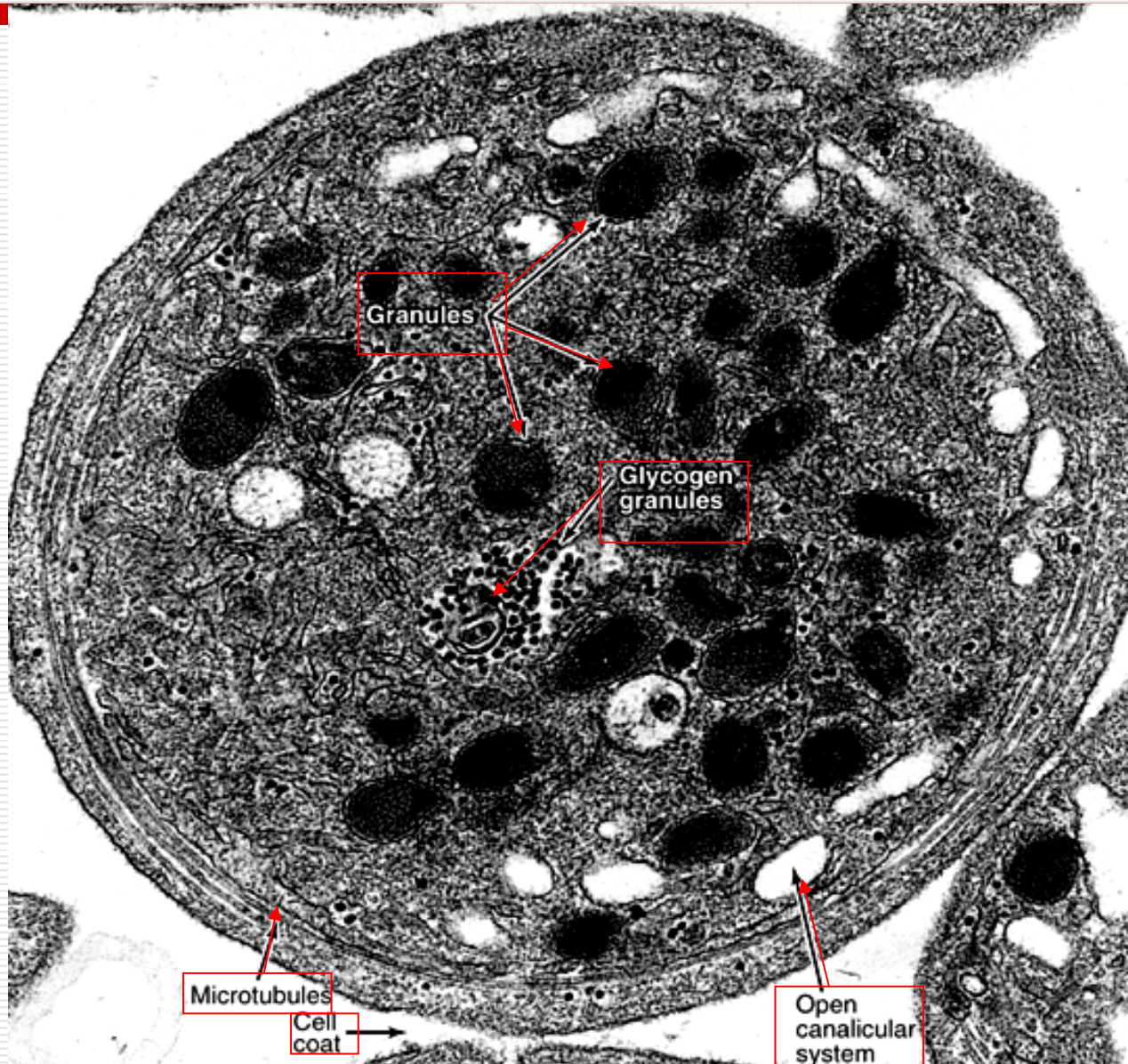
□ Life-span: 10 days

Platelets

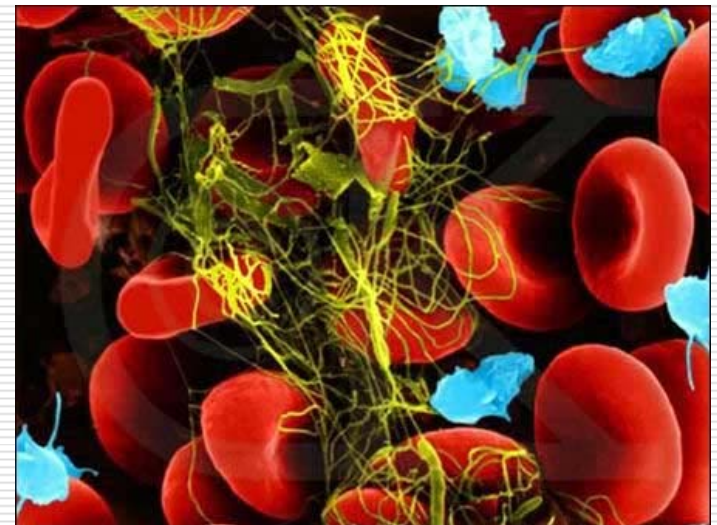
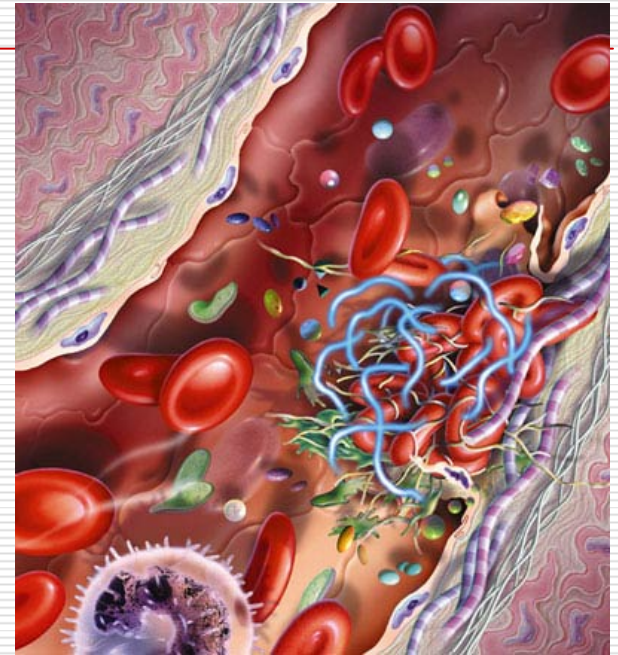
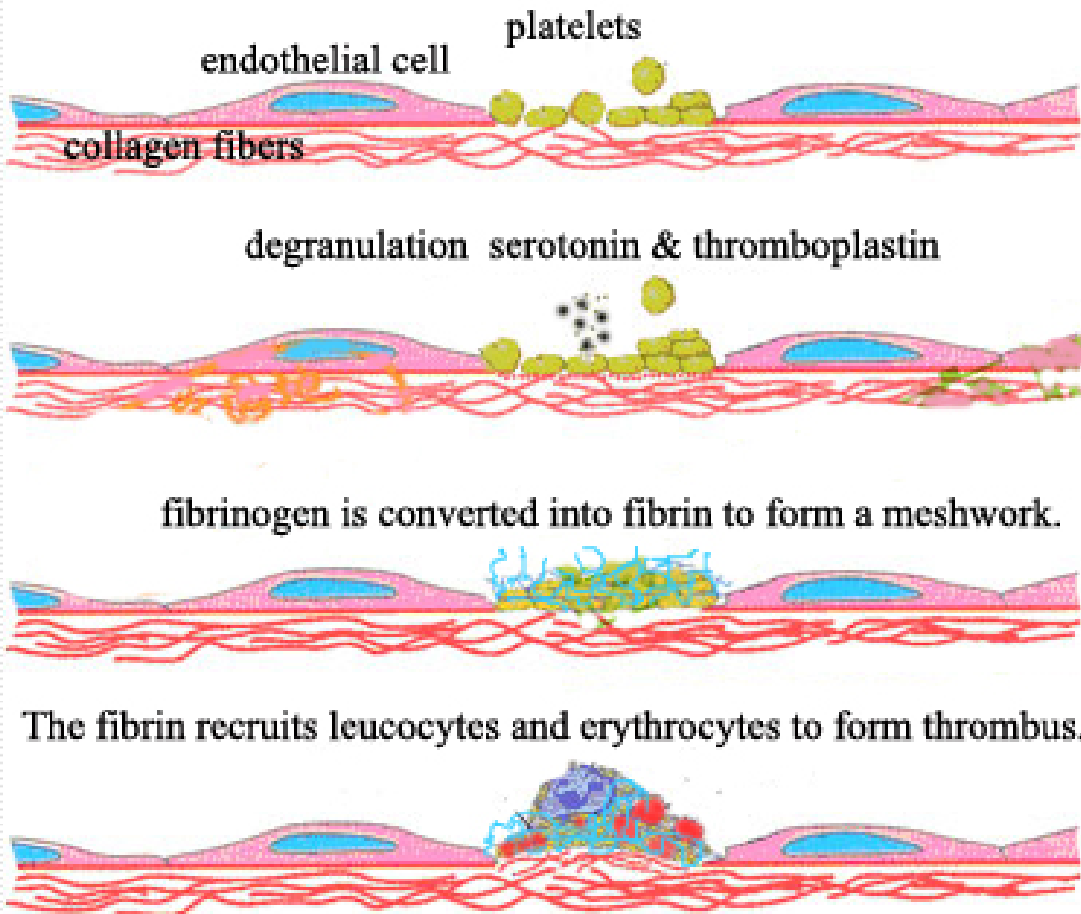


Biconvex disk-like. EM. Vertical section.

Platelets



Platelets



II Haemopoiesis

1. Haemopoietic stem cells

- Haemopoietic stem cells
(pluripotential stem cells)
- Haemopoietic progenitor cell
(committed stem cells)
- Haemopoietic precursor cells (blasts)
- mature blood cells

Phase	Stem Cells	Progenitor Cells	Precursor Cells (Blasts)	Mature Cells
Early morphologic	Not morphologically distinguishable; have the general aspect of lymphocytes		Beginning of morphologic differentiation	Clear morphologic differentiation
Mitotic activity	Low mitotic activity; self-renewing; scarce in bone marrow	High mitotic activity; self-renewing; common in marrow and lymphoid organs; mono- or bipotential	High mitotic activity; not self-renewing; common in marrow and lymphoid organs; monopotential	No mitotic activity; abundant in blood and hematopoietic organs

Haemopoiesis

2. Haemopoietic tissues

- Mesoderm of the yolk sac
- Liver and spleen
- lymphatic organs
- Bone marrow:
 - Red bone marrow: erythrocytes and precursors
 - Yellow bone marrow: adipose cells

Red bone marrow

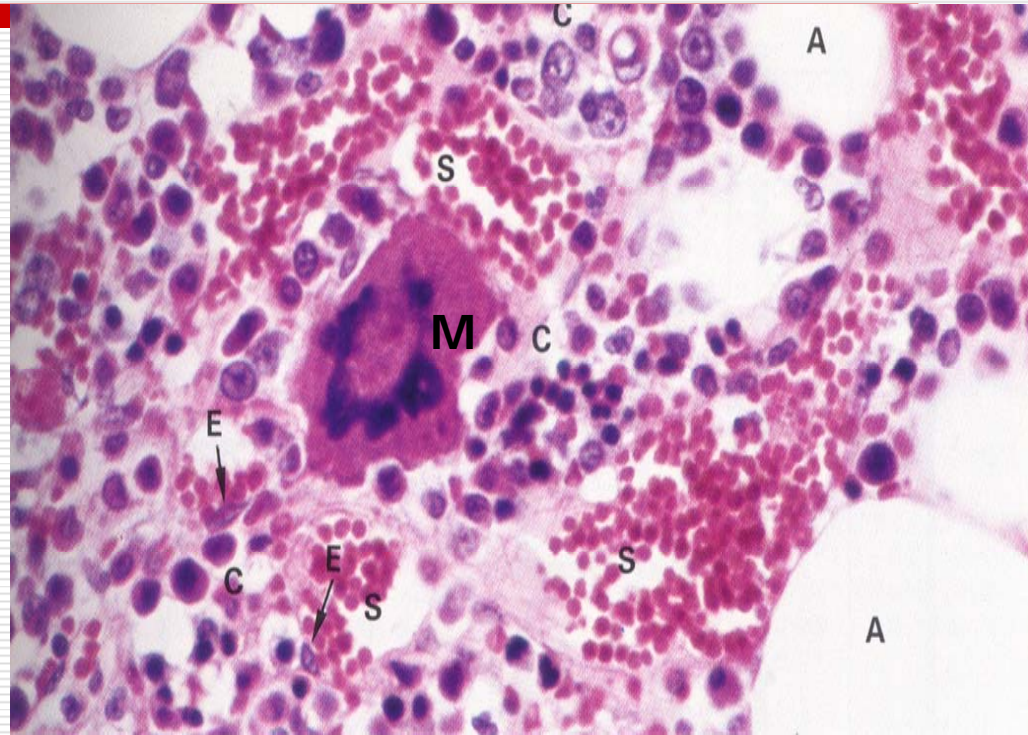
□ Stroma

- Reticular fibers
- Reticular cells
- Macrophages

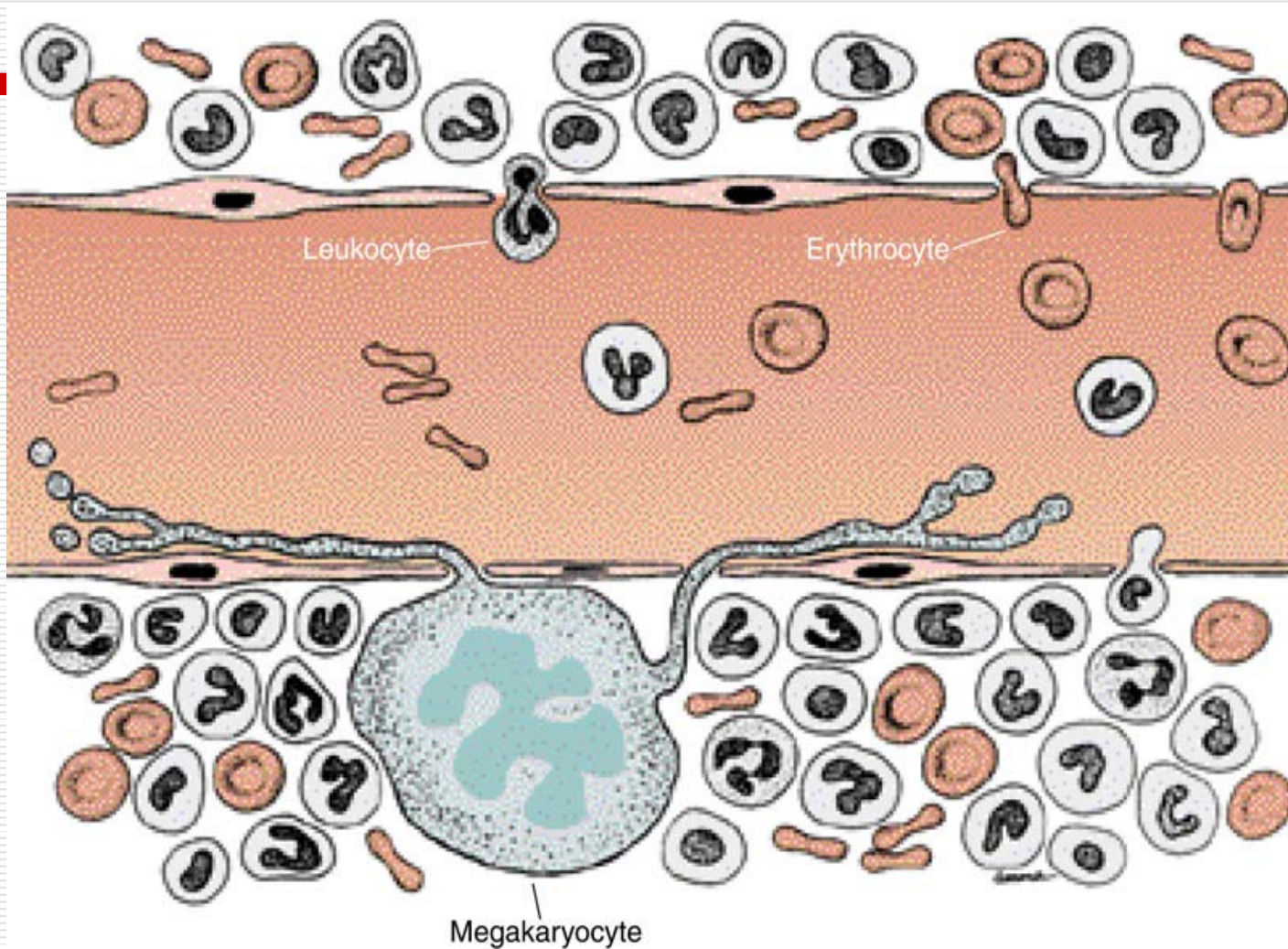
□ hematopoietic cords

□ sinusoidal capillaries

- Discontinuous endothelia
- Incomplete basement membrane



A: adipocyte;
E: erythrocyte in cluster;
M: macrophage;
S: sinusoid



The passage of erythrocytes, leukocytes, and platelets across a sinusoid capillary in red bone marrow.

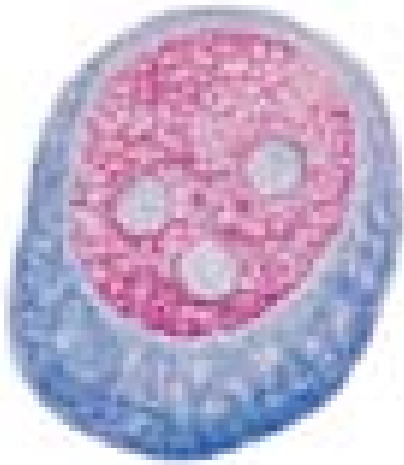
3. Maturation of blood cells

- **Basic process**
 - **The problast stage**
 - **The blast stage**
 - **The mature stage**

Maturation of erythrocytes

- Proerythroblasts**
- Basophilic erythroblasts**
(Early erythroblasts)
- Polychromatophilic erythroblasts**
(Intermediate erythroblasts)
- Orthochromatophilic erythroblasts**
(Late erythroblasts , Normoblasts)
- Reticulocytes**
- Mature erythrocyte**

Maturation of erythrocytes



Proerythroblast



Early erythroblasts



Intermediate erythroblasts



**Late erythroblasts
erythroblast**



Reticulocytes



Erythrocytes

Maturation of leukocytes



Myeloblast



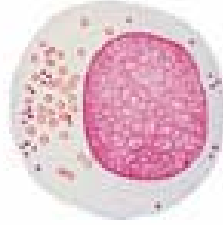
Promyelocyte



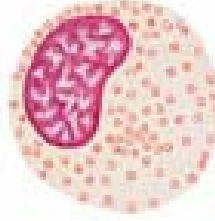
Early neutrophilic myelocyte



Early basophilic myelocyte



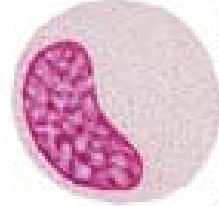
Early eosinophilic myelocyte



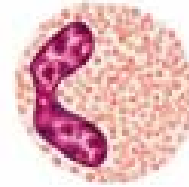
Late eosinophilic myelocyte



Late basophilic myelocyte



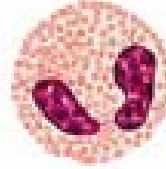
Late neutrophilic myelocyte



Eosinophilic metamyelocyte



Neutrophilic metamyelocyte



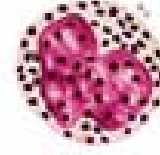
Mature eosinophil



Band cell



Mature neutrophil



Mature basophil

Summary ----- General rule

- The cell volume decreases;**
- The diameter of the nucleus decreases until they extruded from the cell or present lobes;**
- The acidophilic haemoglobin or granules increases within the cytoplasm gradually.**
- The cytoplasm becomes acidophilic or neutropholic, except for lymphocyte and monocyte.**
- The cell loses mitotic ability, except for lymphocyte.**

Maturation of Platelets

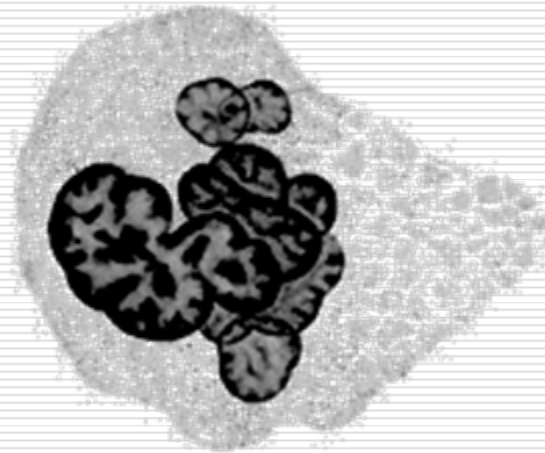
□ Megakaryocytes

□ Megakaryoblasts :

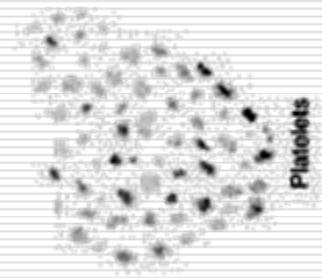
- nuclear division without cytoplasmic division.
- giant cells
- smooth endoplasmic reticulum:



Megakaryoblast

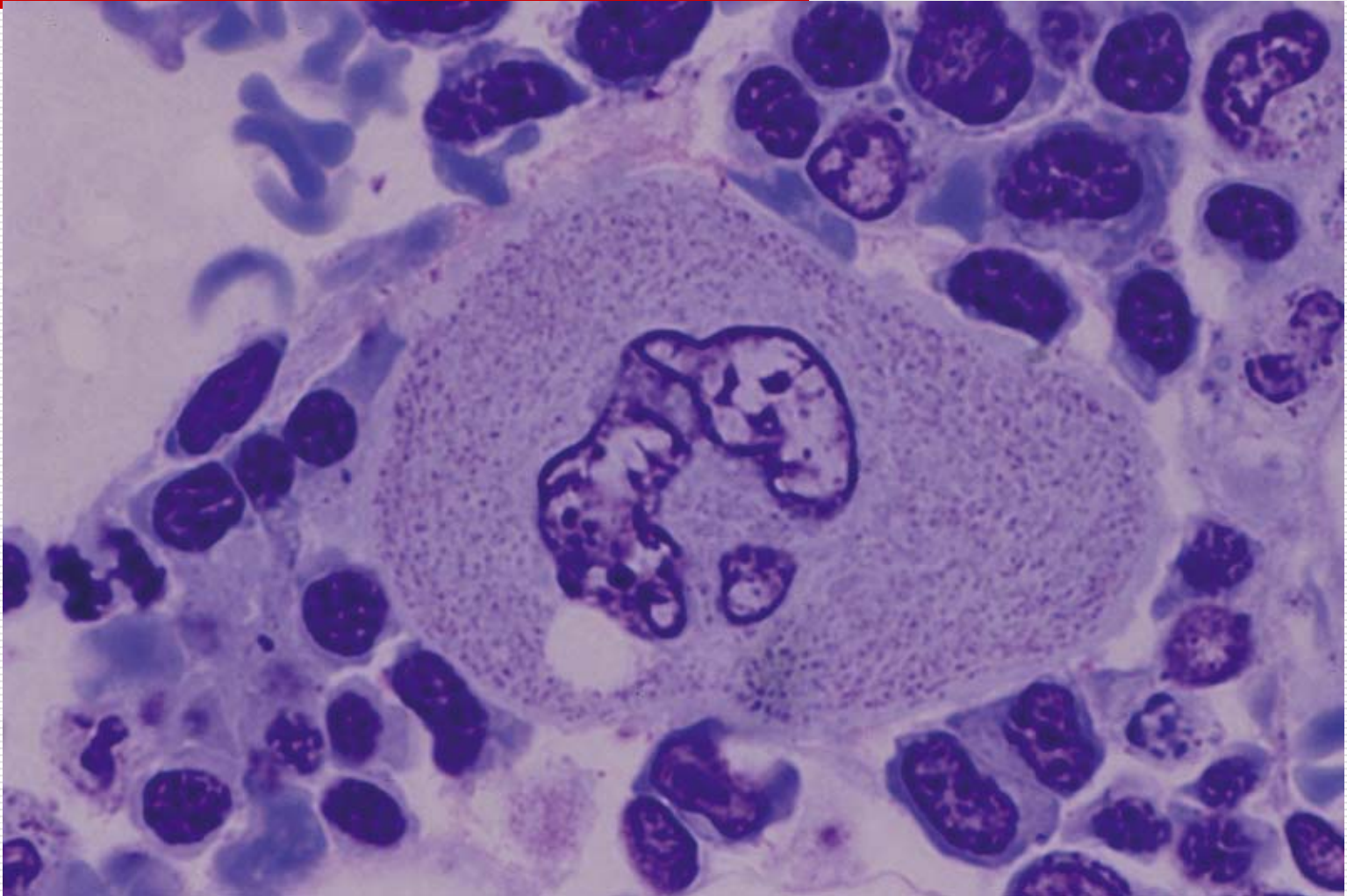


Megakaryocyte



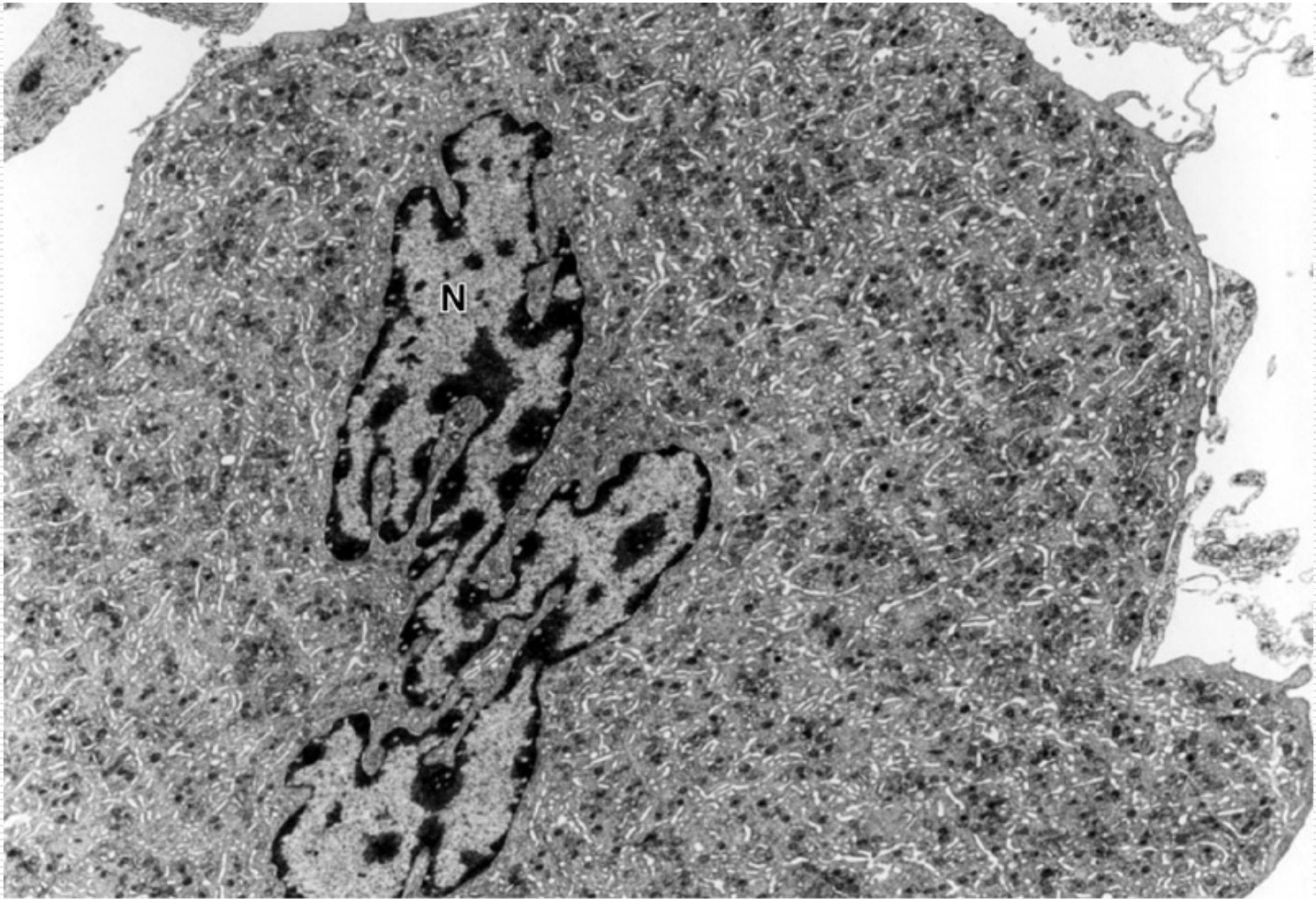
Platelets

Maturation of Platelets



The characteristic size and granular cytoplasm of megakaryocyte.

Maturation of Platelets



A megakaryocyte showing numerous cytoplasmic granules. The demarcation membranes are visible as tubular profiles.

Summary

- Master the structures in LM & EM and functions of erythrocyte, five types of leukocytes.**
- Master the concept of hemapoietic stem cell , hemapoietic progenitor cell and hemapoietic precursor cell.**