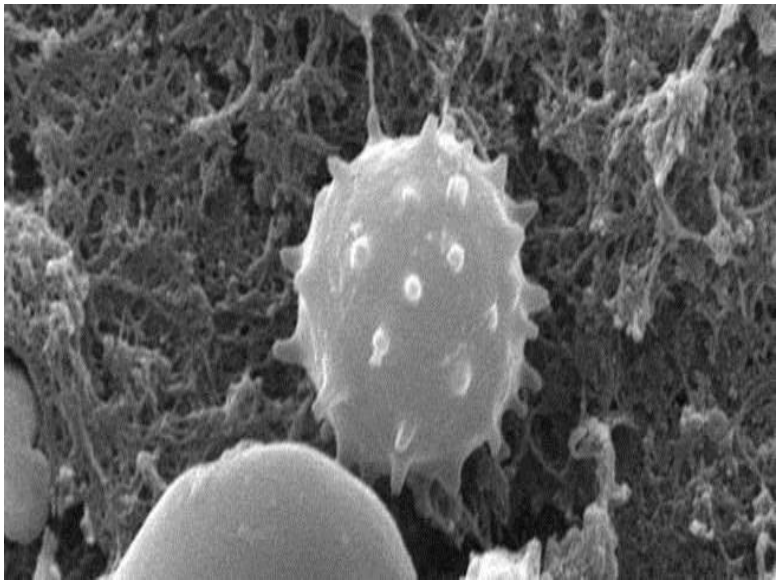
White Blood Cells (Leukocytes)



TEXTBOOK OF MEDICAL PHYSIOLOGY

GUYTON & HALL 11TH EDITION

UNIT VI CHAPTERS 33

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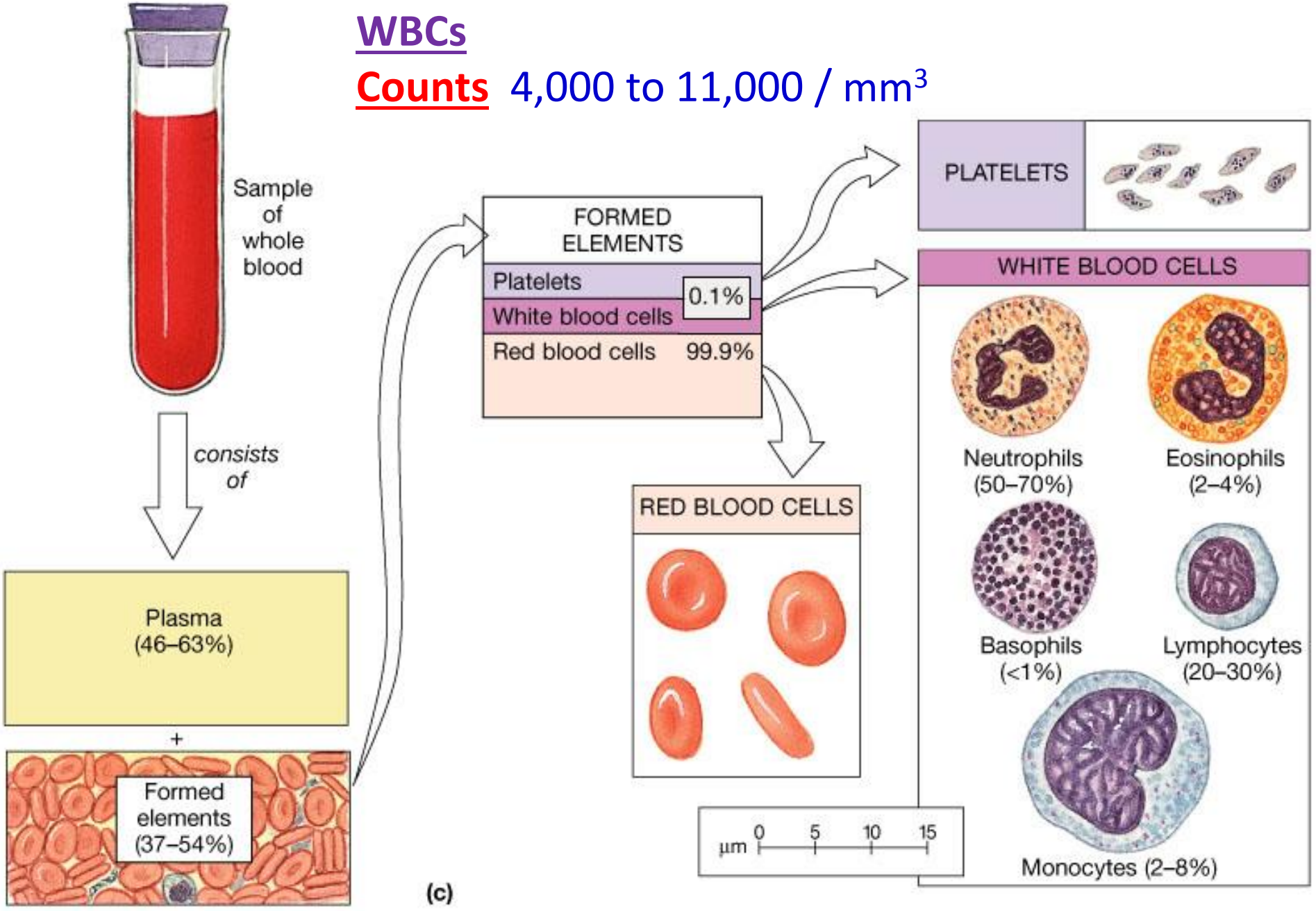
Objectives of Lecture

At the end of this lecture the student should be able to:

1. Describe the different types of WBCs
2. Recognize the general functions of WBCs
3. Describe the genesis and site of formation of WBCs
4. Describe the role of the neutrophil in defending the body against infections
5. Describe the process of phagocytosis
6. Describe the reticuloendothelial system components and function

WBCs

Counts 4,000 to 11,000 / mm^3



Types of WBCs (Leukocytes)

- ✓ Classified according to cell morphology and cytoplasmic staining (*hematoxylin* and *eosin*)
  - **Granular leukocytes**
    - **Neutrophils**
    - **Eosinophils**
    - **Basophils**
  - **Agranular leukocytes**
    - **Lymphocytes**
    - **Monocytes**

General Characteristics & types of WBCs

❖ **Granular WBCs (Polymorphonuclear):**

1. Neutrophils 62%.

- Nucleus 2-5 lobes, purple cytoplasmic granules, main function is **phagocytosis**

2. Eosinophils 2.3%.

- 2 lobes nucleus, coarse red granules
- **Phagocytise allergens**
- High eosinophil count (eosinophilia):
  - Parasitic (hook worm, ascaris, bilharzia) infection.
  - Allergy (asthma, rhinitis, drug reaction).
  - Allergic skin diseases
- Eosinophils attach themselves to the parasites by way of special surface molecules and release substances that kill many of the parasites (by releasing *hydrolytic enzymes* from their granules)

General Characteristics & types of WBCs

3. Basophils 0.4%.

- Have 2 to 3 lobed nucleus, nucleus hidden by large round bluish granules, smaller than other granulocytes, easy to identify because of the numerous granules in their cytoplasm.

- They are very similar functionally to **mast cell.**
- Release histamine >>>> inflammation (redness, swelling, and pain)
- Release heparin >>>> anticoagulant (prevent clotting)

- The release of those substances cause local and vascular reactions characteristic of allergic manifestation

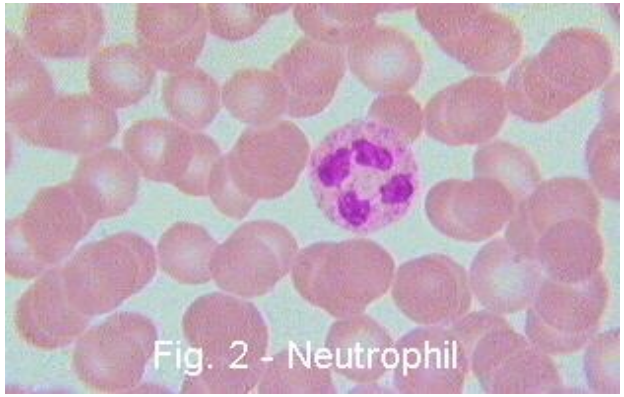


Fig. 2 - Neutrophil

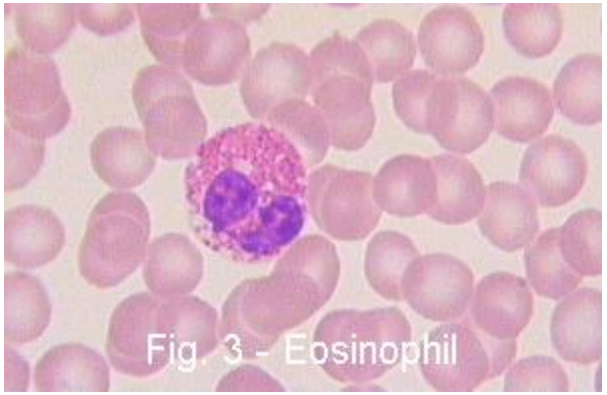


Fig. 3 - Eosinophil

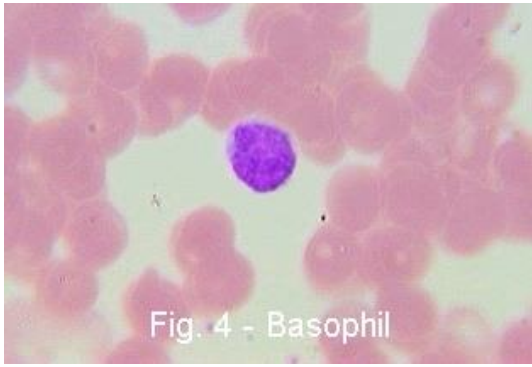


Fig. 4 - Basophil

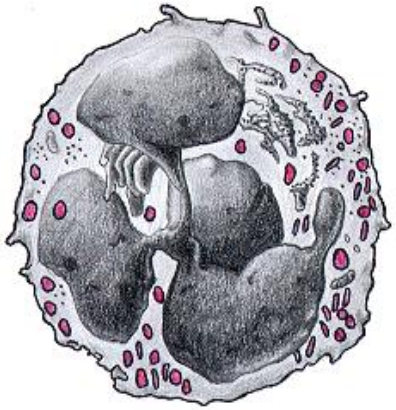


Fig. 8 - Neutrophil

Fig. 9 - Eosinophil

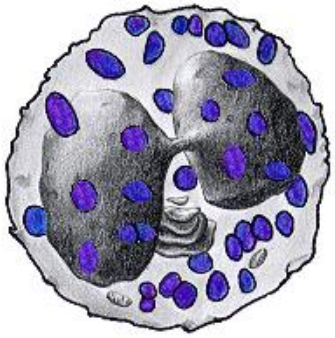


fig. 10 - Basophil

General Characteristics & types of WBCs, cont.

- **Agranular WBC**
  - **Monocytes 5.3%**
    - These cells are the largest of all WBCs.
    - Kidney-shaped or horse-shoe nucleus, they develop into macrophages that phagocytose bacteria and debris in the tissues.
  - **Lymphocytes 30%**
    - Round and large nucleus which occupies most of the cell, the smallest of all WBCs, immunity cells

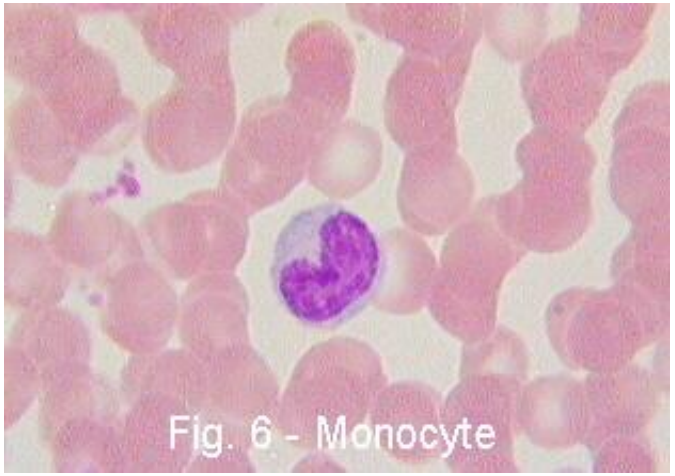


Fig. 6 - Monocyte

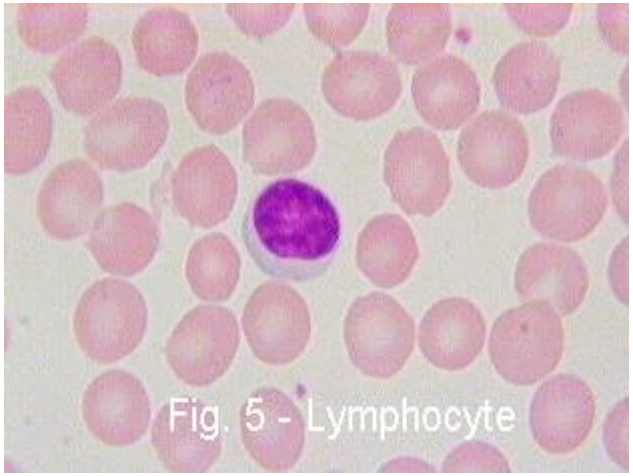


Fig. 5 - Lymphocyte

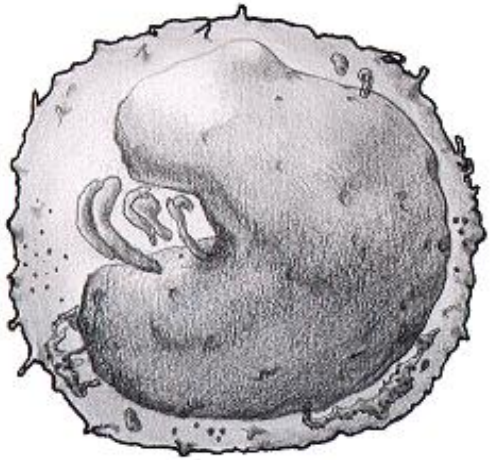


Fig. 12 - Monocyte

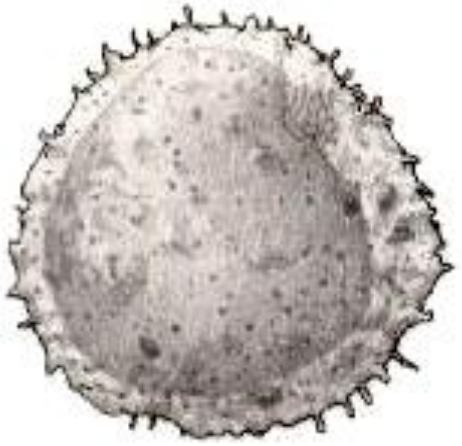
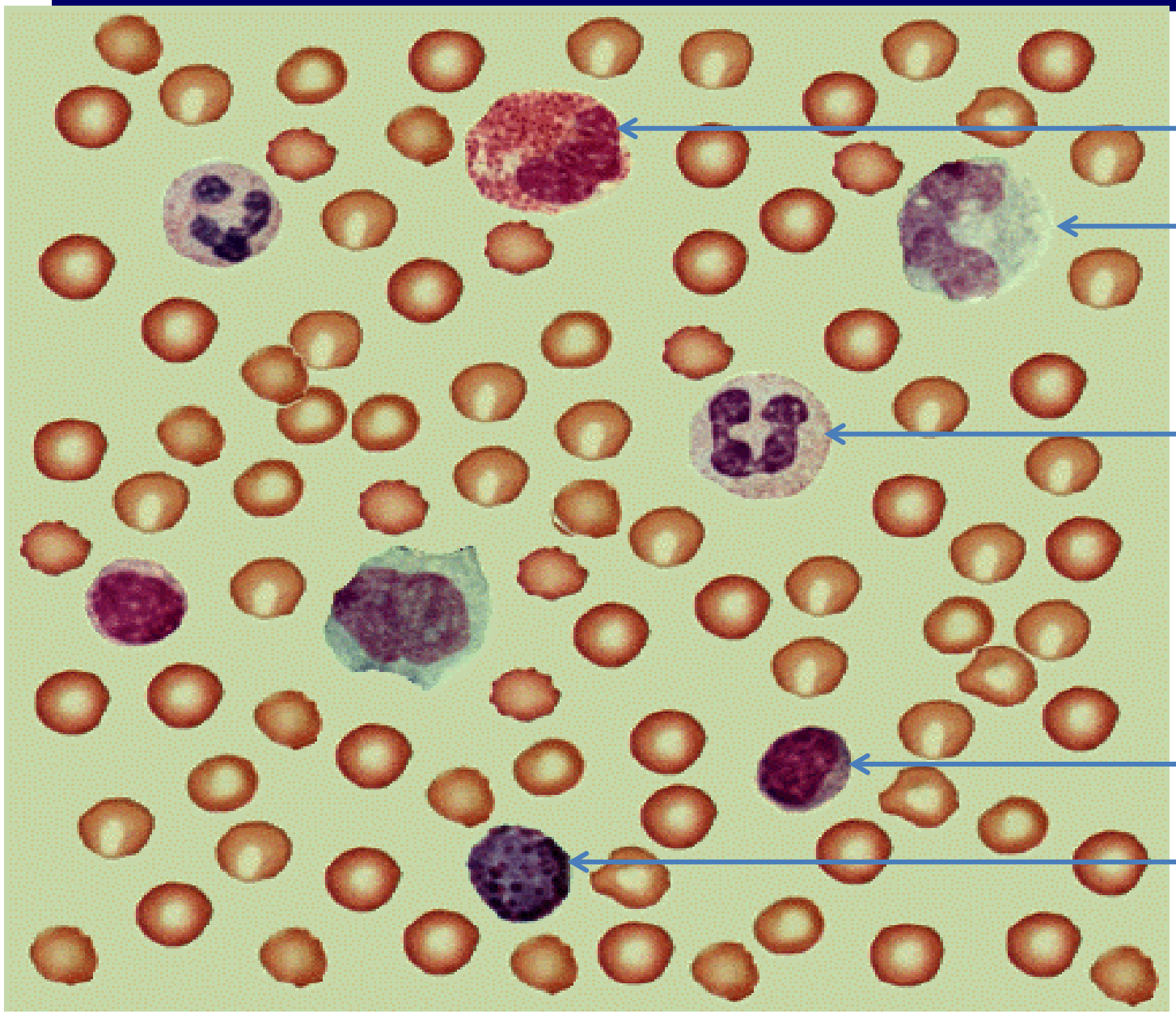
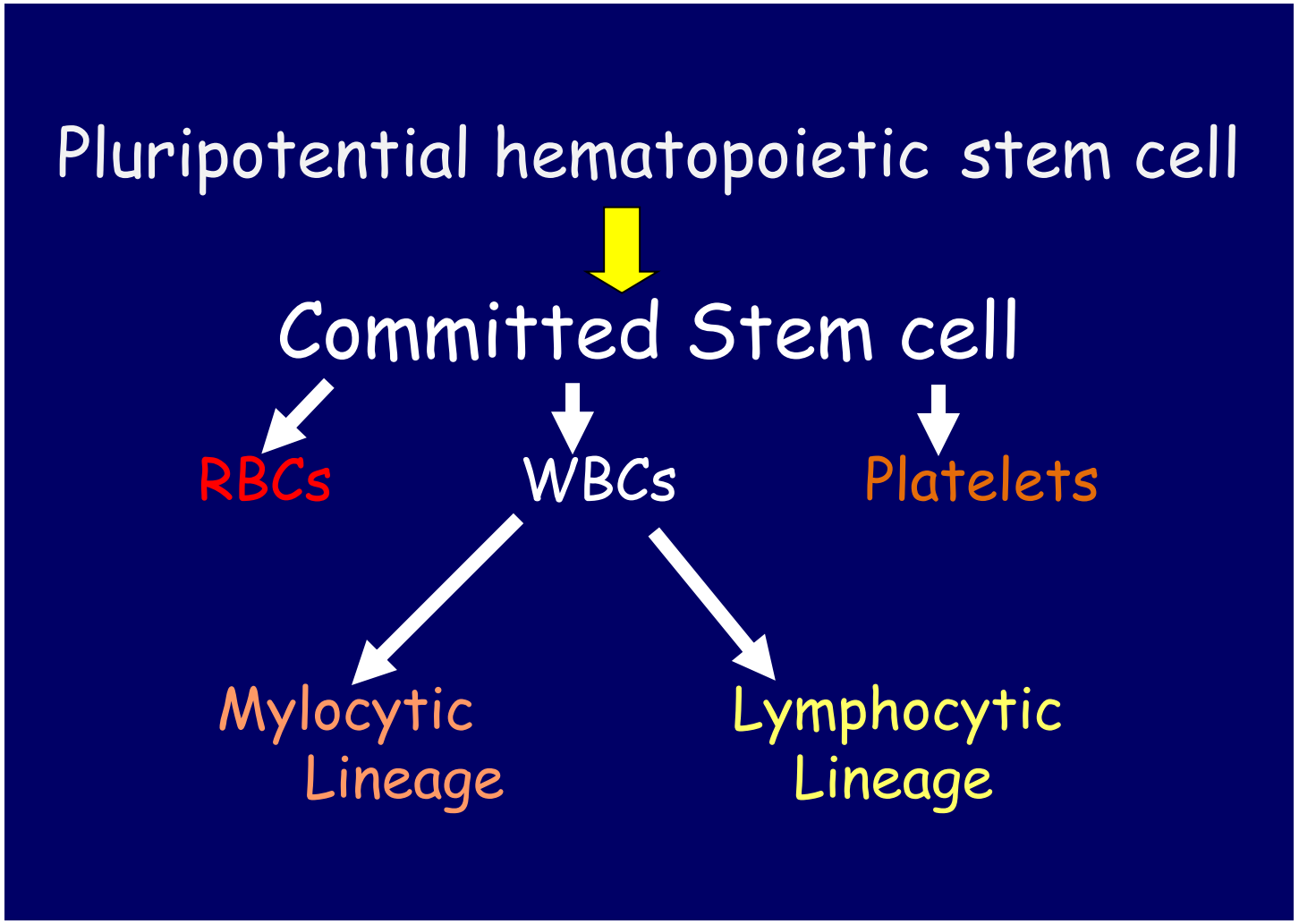


Fig. 11 - Lymphocyte

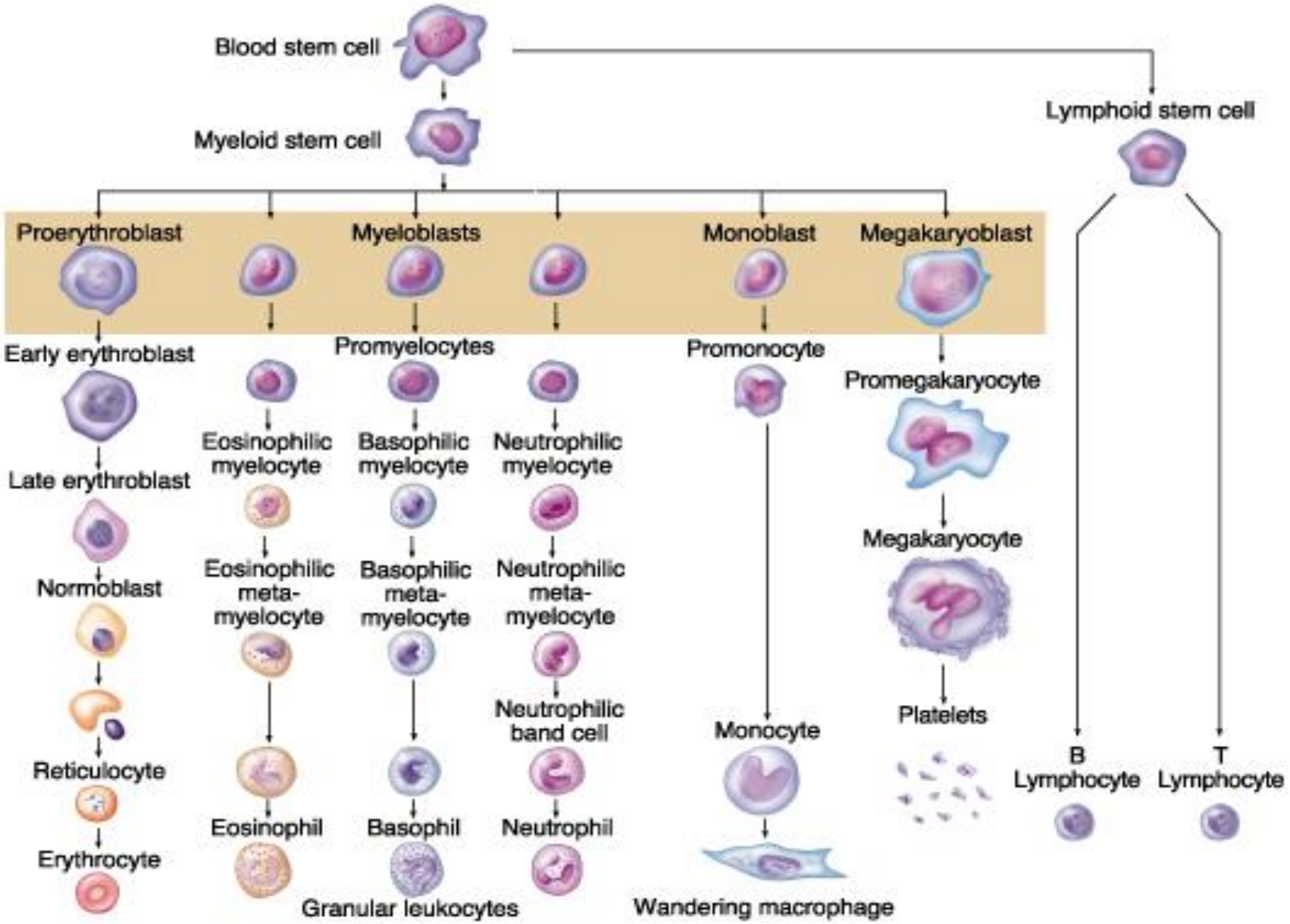
Blood Film



Genesis (Production) of WBCs



Leukopoiesis



Genesis (Production) of WBCs **(leukopoiesis)**

Sites of WBC formation:

- **Granulocytes** (neutrophil, basophil, eosinophil):
  - **bone marrow**

- **Agranulocytes**
  - **Lymphocytes**
  - **bone marrow, thymus, lymphoid tissues**

  - **Monocytes**
  - **bone marrow**

Life Span of WBCs

Granulocytes:

- 4 to 8 hrs (transit time) in blood circulation
- 4 to 5 days in tissues
  - In infections life span a few hours

Monocytes:

- 10 to 20 hrs in blood circulation
- Leave capillaries to tissues, increase in size to become tissue macrphages which live for months

Life Span of WBCs-cont.

Lymphocytes:

- A few hrs in blood circulation >> tissues >> lymph >>> Blood (Recirculation)

Life span: weeks to months

Defense properties of neutrophil

- Attack and destroy invading bacteria, viruses
- Sequence of events:
  - Chemotaxis
  - Margination
  - Diapedesis
  - Amaeboid Motion
  - Phagocytosis

Chemotaxis

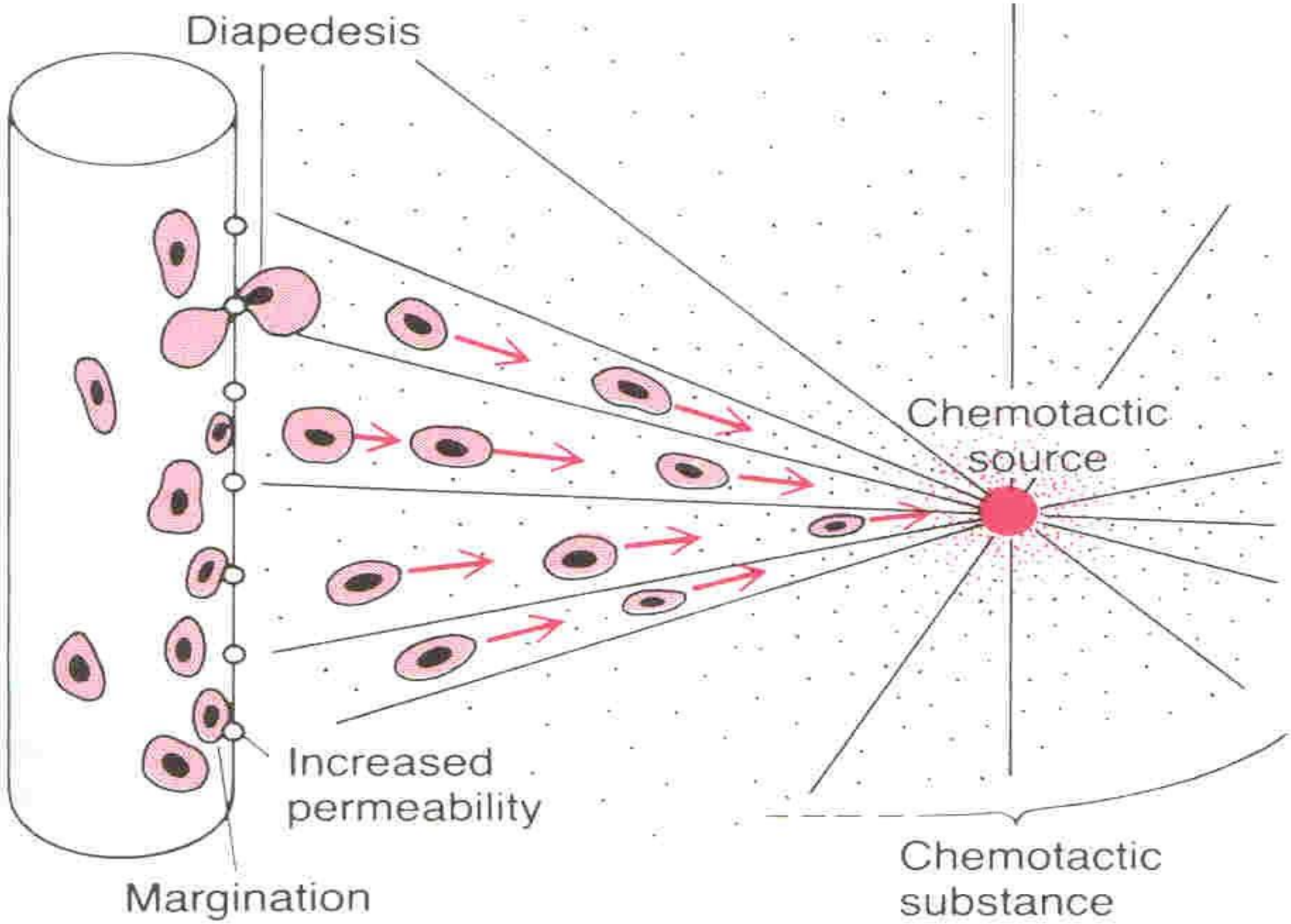
The attraction of the neutrophils to inflamed area following chemotactic substances that are released from the infected site.

Chemotactic substances:

- ✓ Bacterial toxin
- ✓ Complement system
- ✓ Degenerative products of inflamed tissue
- ✓ Reaction product of plasma clotting

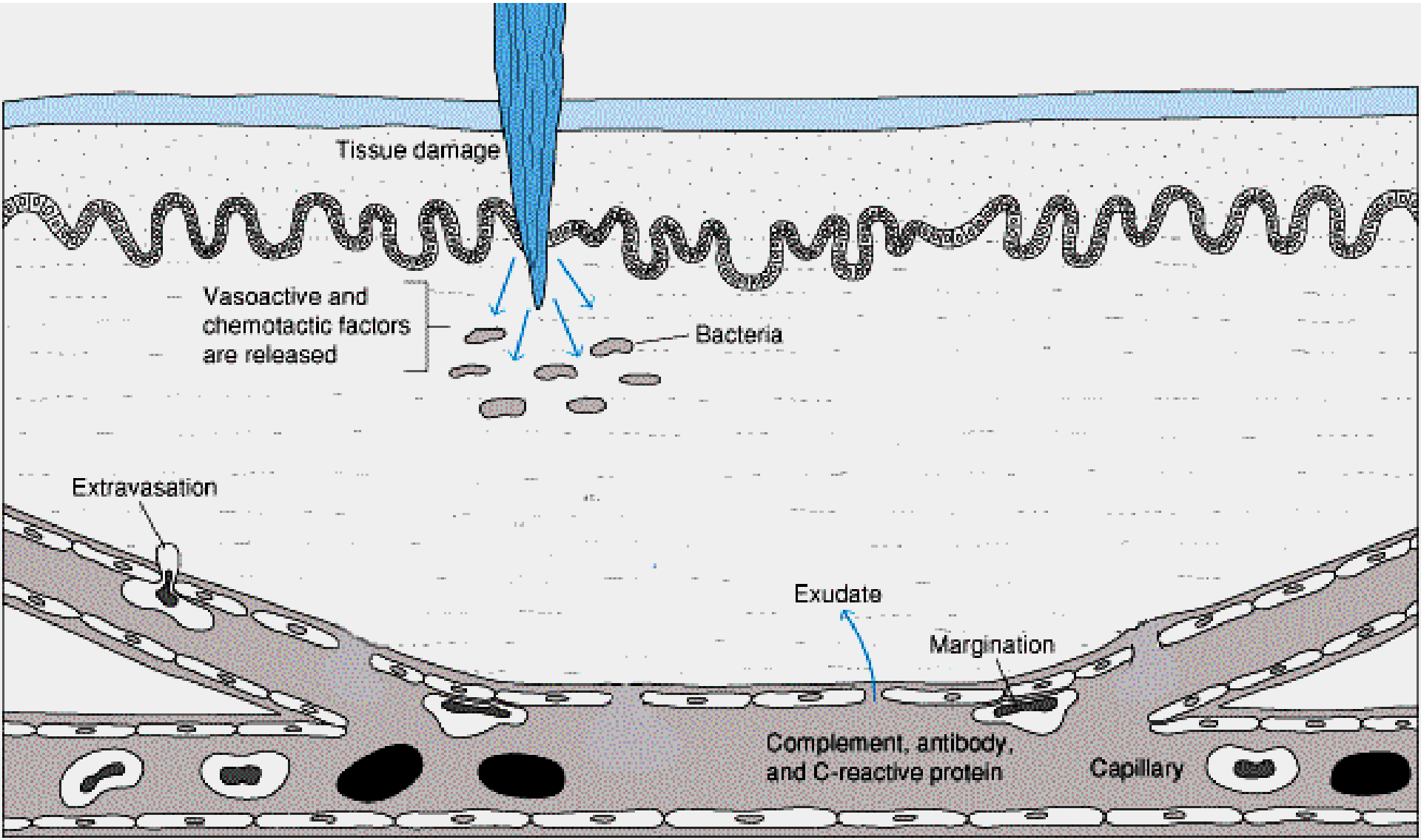
Margination & Diapedesis

- WBC marginate along the wall of blood capillaries
- WBC squeezes itself through endothelial holes leaving blood capillaries (diapedesis)
- WBC move by amoeboid motion towards inflammation area following chemotactic substance released from site of infection
- Upon reaching the site of infection,neutrophils start to engulf infecting organisms



Bacterial or viral toxins, degenerative products of the inflamed tissues

Diapedesis


Tissue damage
Vasoactive and
chemotactic factors
are released
Bacteria
Extravasation
Exudate
Margination
Complement, antibody,
and C-reactive protein
Capillary

Phagocytosis

Phagocytosis is selective process:

Foreign substances are recognized by:

- Rough surfaces.
- Does not have protective protein coats that repel phagocytes.
- Marked by certain substance e.g Complement 3 or antibodies making them ready for killing; a process known as opsonization

Phagocytosis by neutrophils

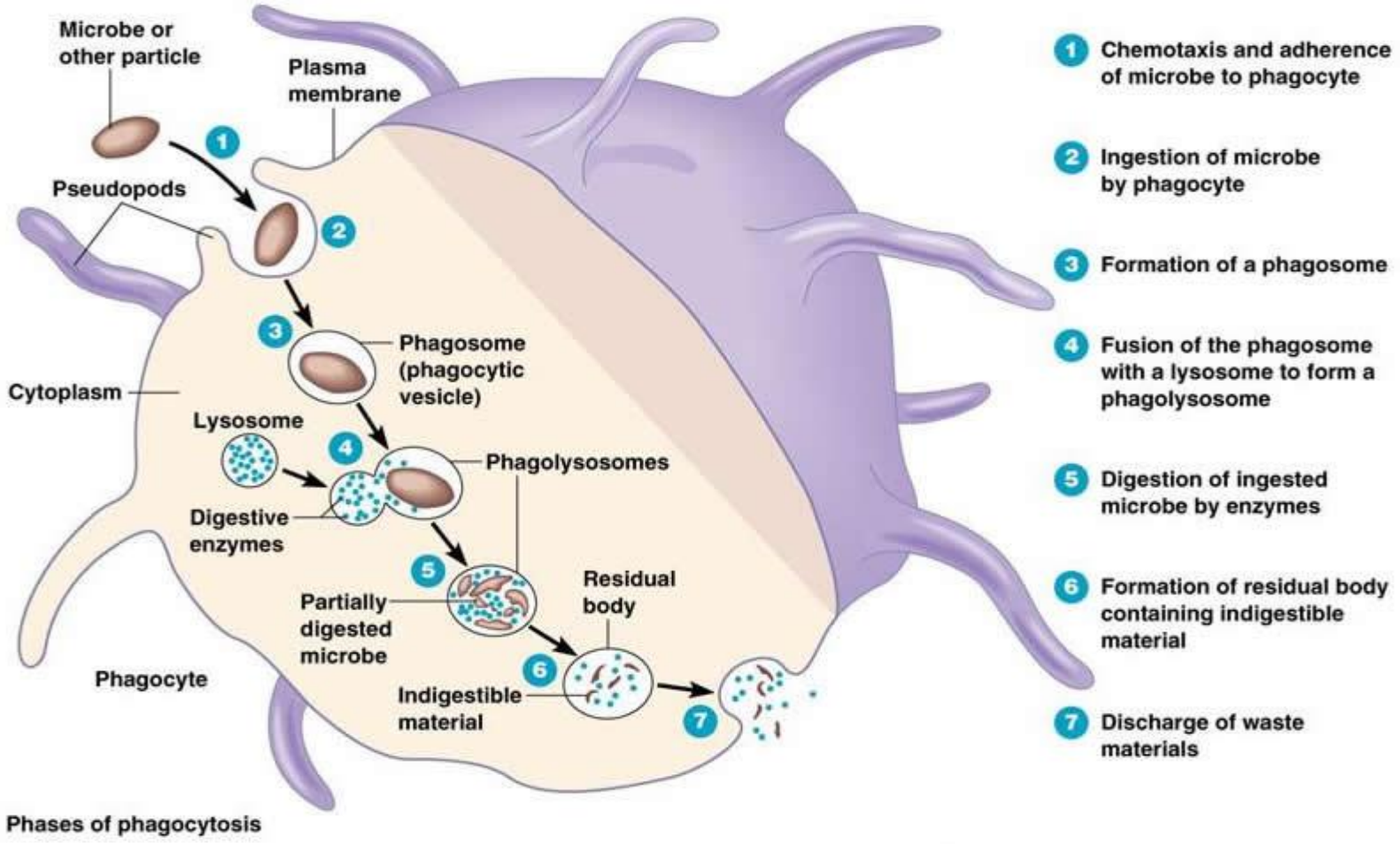
Neutrophils attach to bacteria & encircled it with pseudopodia and take it into a vacuole (phagosome).

- One Neutrophil can engulf 3 to 20 bacteria
- One Macrophage can engulf up to 100 bacteria

Microbial killing: fusion of neutrophil granules with vacuole,

- Discharge of lysosomal enzymes (myeloperoxidase) into the vacuole, killing and digesting the engulfed bacteria.
- Release of bactericidal such as: superoxide, hydrogen peroxide to kill the bacteria

Microbial killing



Phases of phagocytosis

Reticuloendothelial system (RES)

It is an essential component of the immune system, comprised of phagocytic cells located in different organs of the human body

Consists of:

- **Monocytes**
- **Mobile and fixed macrophages**
- **Endothelial cells (bone marrow, spleen, lymph nodes)**

- **Located in all tissues especially: skin (histocytes), liver (kupffer), spleen, bone marrow, lymph nodes, lung**

Functions of Reticuloendothelial system (RES)

1. Phagocytosis: Bacterial, dead cells, foreign particles

2. Breakdown of Hb

3. Immune function: processing antigen and antibodies production (indirect)

4. Storage of iron

Lymphocytes formation and maturation

Lymphopoiesis

Stem cell

(thymus, lymphoid tissue & bone marrow)

lymphoblast

↓

intermediate pyronophilic blast cells

↓

lymphocytes

Lymphocytes (Immune cells)

Two types:

B-Lymphocytes (plasma cells)

(Thymus independent, B-cell immunity), Produce antibodies (Humoral Immunity)

T- lymphocytes

(Thymus dependent, T-cell immunity), Cellular mechanisms, (Cellular Immunity)

Types of T-lymphocytes:

- **T-helper**
- **T-cytotoxic**

Leukocytosis
(Increased WBC Count)

Causes:

- Physiological
  - Diurnal: ↓ morning ↑ evening
  - After physical exercise
  - Stress or during labour and pain
- Disease (pathological)
  - Bacterial infections (tonsillitis, appendicitis)

Leukopenia

(Decreased WBC Count)

Causes:

- Malnutrition
- Typhoid fever
- Depressed bone marrow
- Deficiency of Vit B12 or folic acid

Leukaemia

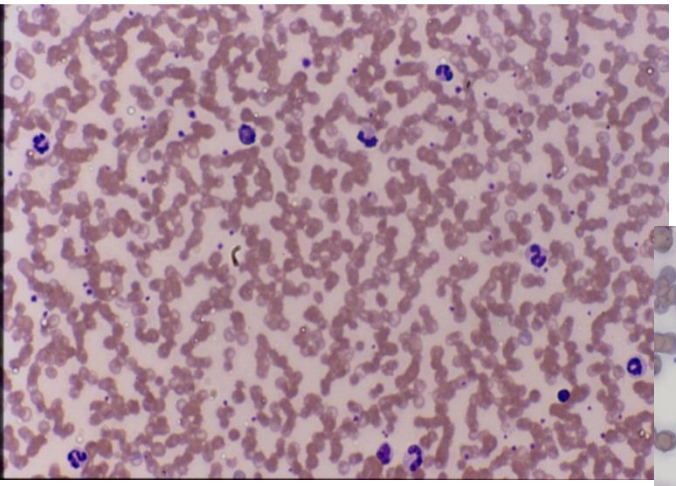
- Cancer of white blood cells due to chromosomal abnormality caused by chemicals, radiation, and viruses.
- WBC more than 50,000
- Types of leukaemia:

– Myeloblast leukaemia ⟶ cancerous production of young myeloid cells

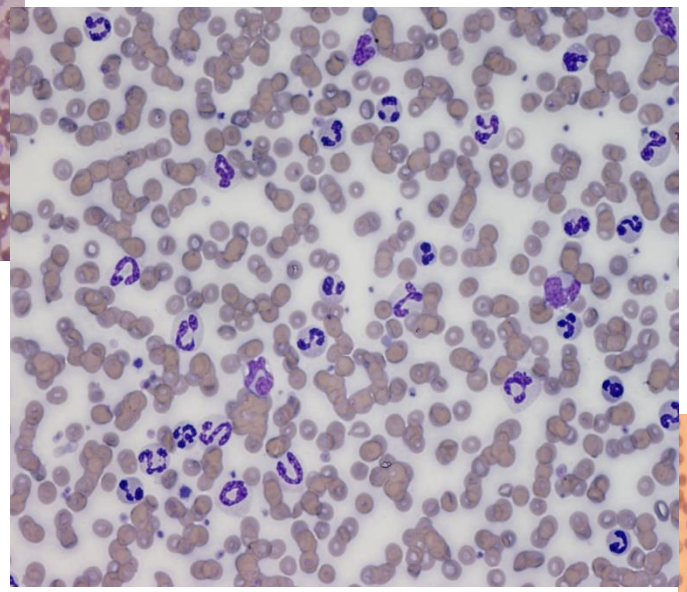
– Lymphoblast leukaemia ⟶ cancerous production of lymphocytic cells

- Acute or chronic onset
- Accompanied with anaemia, bleeding

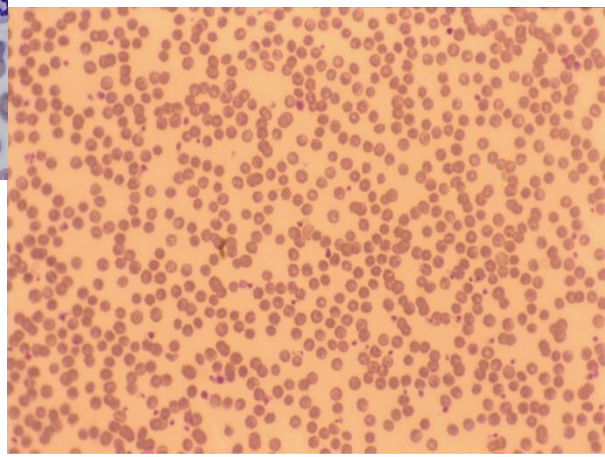
Leukocytes Estimation



Normal number



Increased



Decreased

Functions of Leukocytes- WBC

Summary

- Defence of the body against infections and foreign invadors

Neutrophils & monocytes (Blood macrophages)-

Phagocytosis/ + Immunity

Macrophage (RES) system Phagocytosis + Immunity

Lymphcytes ….. IMMUNITY