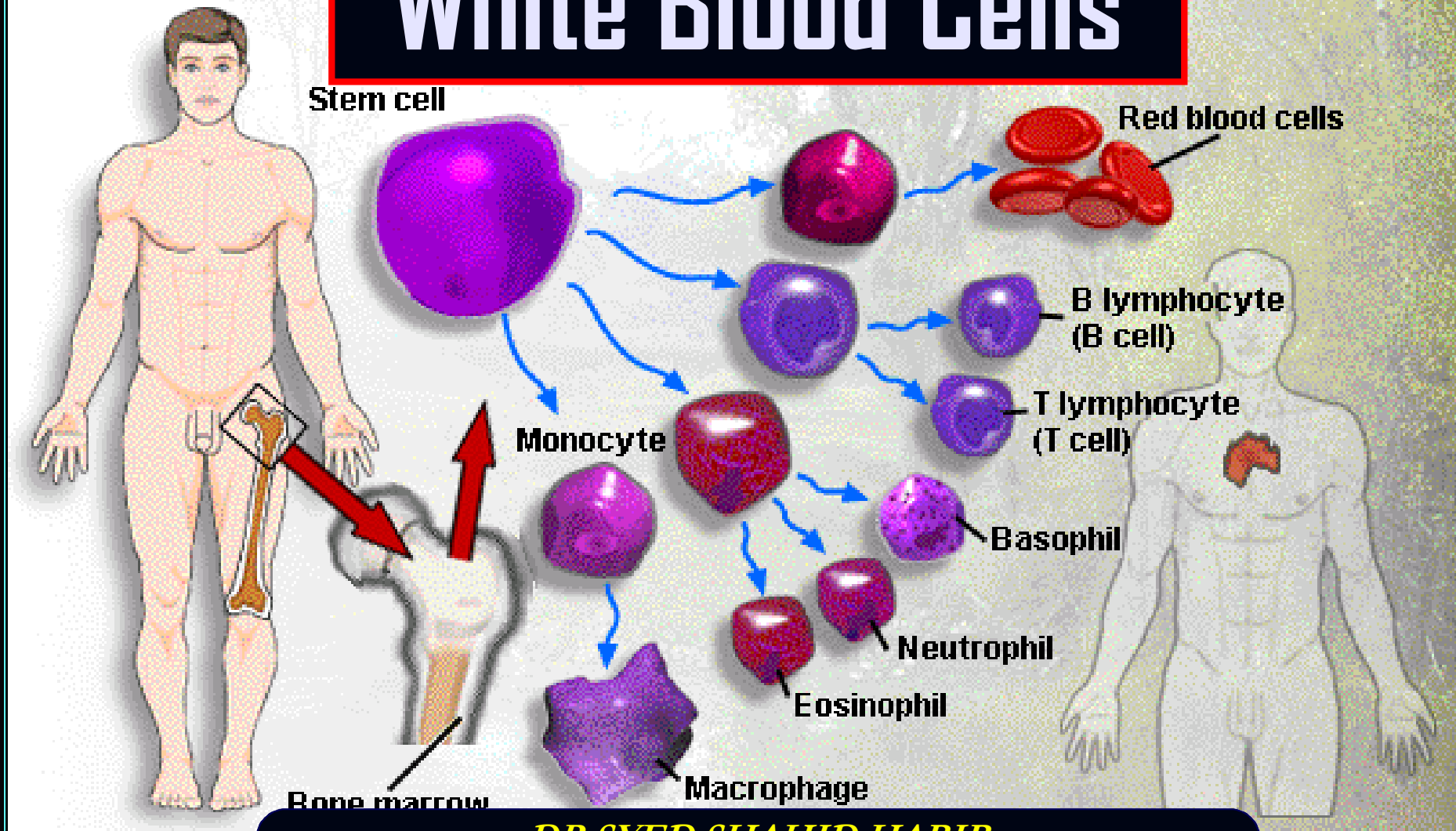


White Blood Cells



DR SYED SHAHID HABIB
MBBS DSDM PGDCR FCPS
Professor & Consultant Clinical Neurophysiology
College of Medicine & KKHU

OBJECTIVES

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

- ▶ Describe different types and formation of WBC
- ▶ Recognize the general functions of WBC
- ▶ Describe genesis and site of formation of WBC
- ▶ Describe stages of neutrophil formation
- ▶ Describe role of neutrophils in defending against infection
- ▶ Describe the process of phagocytosis.

IMMUNITY

```
graph TD; A[IMMUNITY] --> B["Innate immunity  
(non specific)"]; A --> C["Acquired immunity  
(specific, adaptive)"]; B --> D["• Phagocytes  
• Complement  
• Barriers"]; C --> E["Cell mediated  
T lymphocytes"]; C --> F["Humoral  
Antibody  
mediated  
B lymphocytes"]; G["Note: Macrophages are key components of the innate immunity and activate adaptive immunity by transforming into Antigen Presenting Cells"];
```

Innate immunity

(non specific)

Examples:

- Phagocytes
- Complement
- Barriers

Acquired immunity

(specific, adaptive)

Cell mediated

T lymphocytes

Humoral

Antibody
mediated

B lymphocytes

Note: Macrophages are key components of the innate immunity and activate adaptive immunity by transforming into Antigen Presenting Cells

BARRIERS

(Chemical barriers)

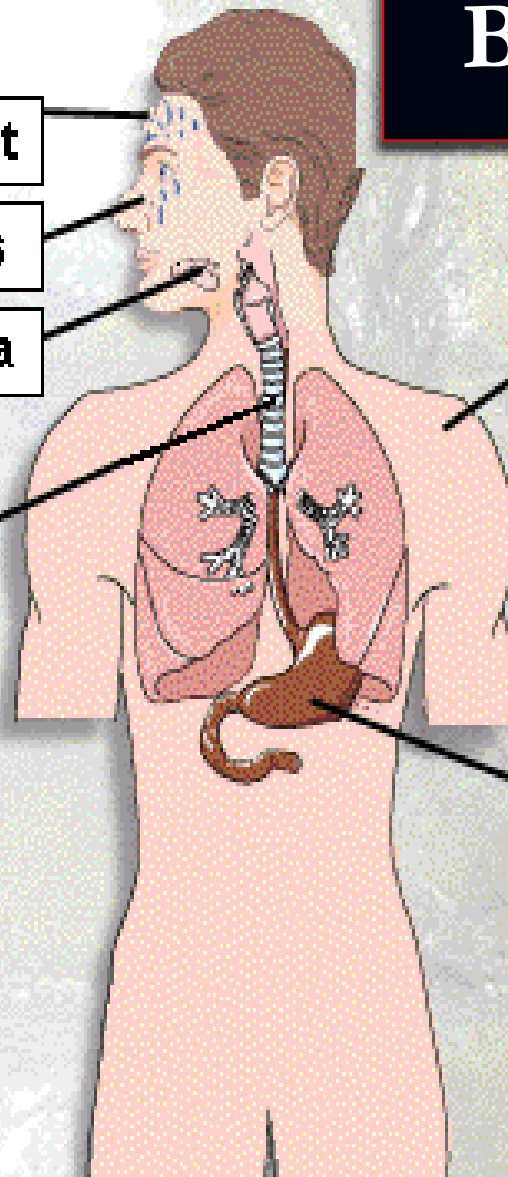
Sweat

Tears

Saliva



Trachea / Cilia
(Physical barrier)



Skin

(Physical barrier)

Stomach acid

(Chemical barrier)

WBC TYPES (CLASSIFICATION)

■ Granulocytes

- Polymorphonuclear leukocytes (PMNs)
 - Neutrophils (10-16um, 2-5lobes of Nucleus)
 - Eosinophils (12-18um, Bilobed, coarse red granules)
 - Basophils (10-14um, rarely segmented Nucleus hidden by large round bluish granules)

■ Agranulocytes

- Lymphocytes (Round Nucleus, Small [5-8um] & large [9-15um])
 - T lymphocyte
 - B lymphocyte
- **Monocytes** (15-20um, Kidney shaped Nucleus) → **make macrophage system**

Concentration (Normal Counts)

Cells	Approximate Normal range (/μL)	Percentage of Total WBC	Life Span
Total WBC	4000-11000	- - -	
Granulocytes • Neutrophils • Eosinophils • Basophils	3000-6000 150-300 0-100	50-70 1-4 0.4	4-8 hours in blood and 4-5 days in tissues
Lymphocytes	1500-4000	20-40	Weeks-months
Monocytes (macrophages)	300-600	2-8	10-20 hours (months)

Polymorphonuclear neutrophils	62.0%
Polymorphonuclear eosinophils	2.3%
Polymorphonuclear basophils	0.4%
Monocytes	5.3%
Lymphocytes	30.0%

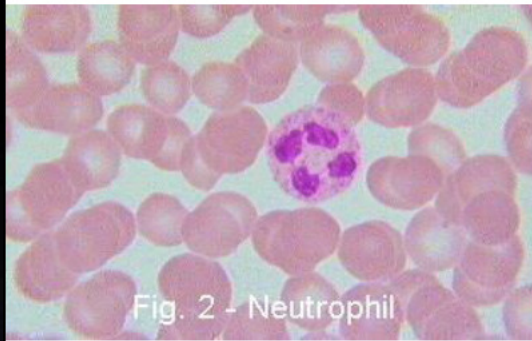


Fig. 2 - Neutrophil

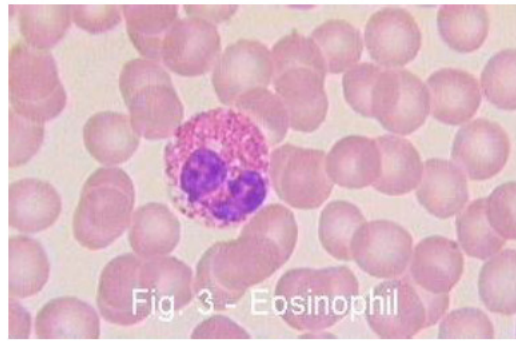


Fig. 3 - Eosinophil

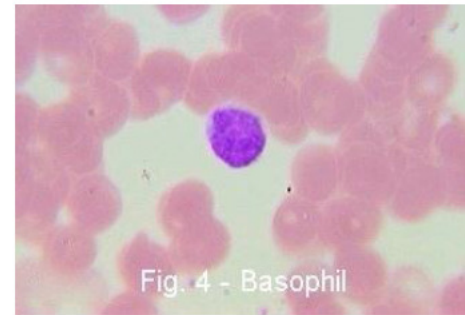


Fig. 4 - Basophil

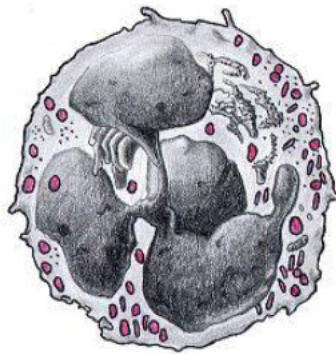


Fig. 8 - Neutrophil

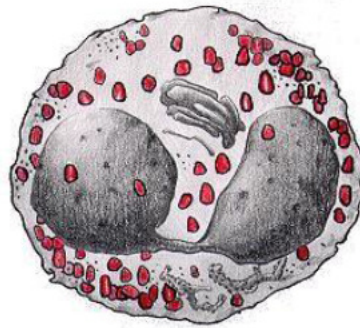


Fig. 9 - Eosinophil

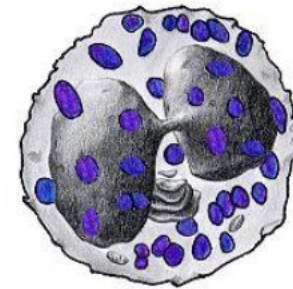


fig. 10 - Basophil

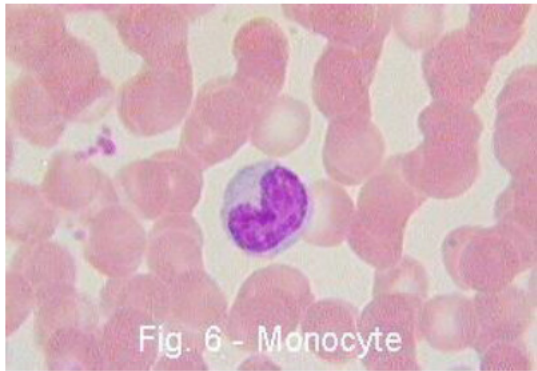


Fig. 6 - Monocyte

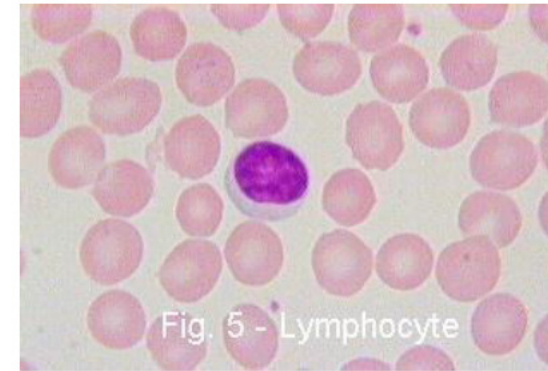


Fig. 5 - Lymphocyte

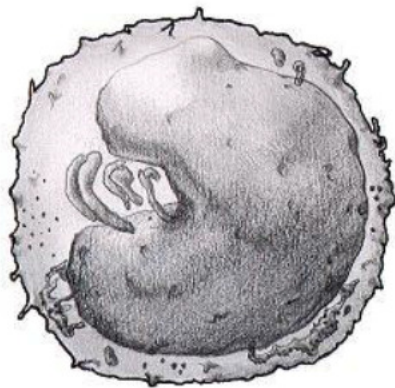


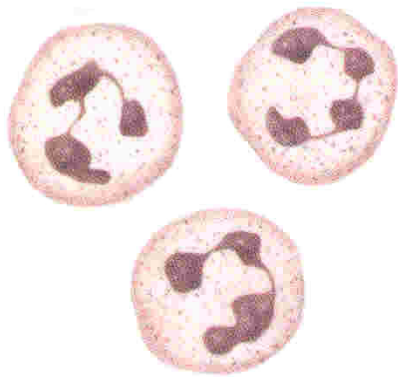
Fig. 12 - Monocyte



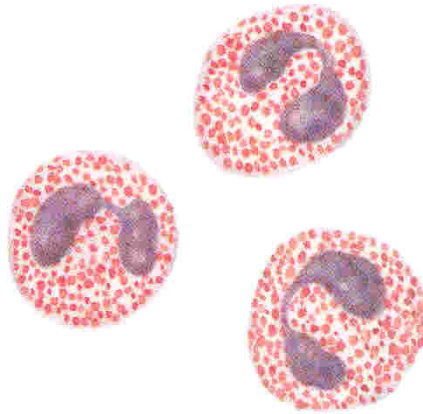
Fig. 11 - Lymphocyte

Macrophage and Neutrophil Responses During Inflammation

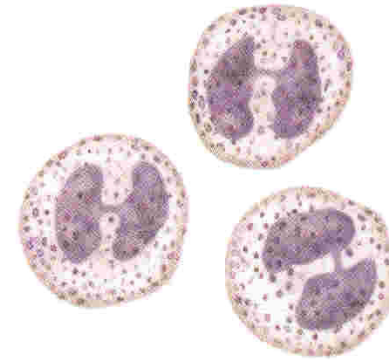
- ❑ **1st** line of defense – Tissue macrophages & Physical Barriers
- ❑ **2nd** line of defense – Neutrophil Invasion of the inflamed area
- ❑ **3rd** line of defense – Monocytes –macrophage invasion of inflamed area
- ❑ **4th** line of defense – Increased production of granulocytes and Monocytes by Bone marrow



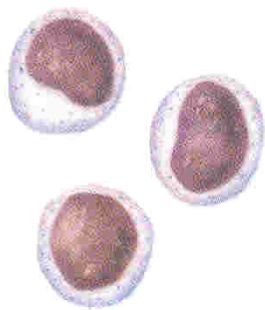
Neutrophils



Eosinophils



Basophils



Lymphocytes



Monocytes



Platelets



Erythrocytes

Lew

Genesis of WBC

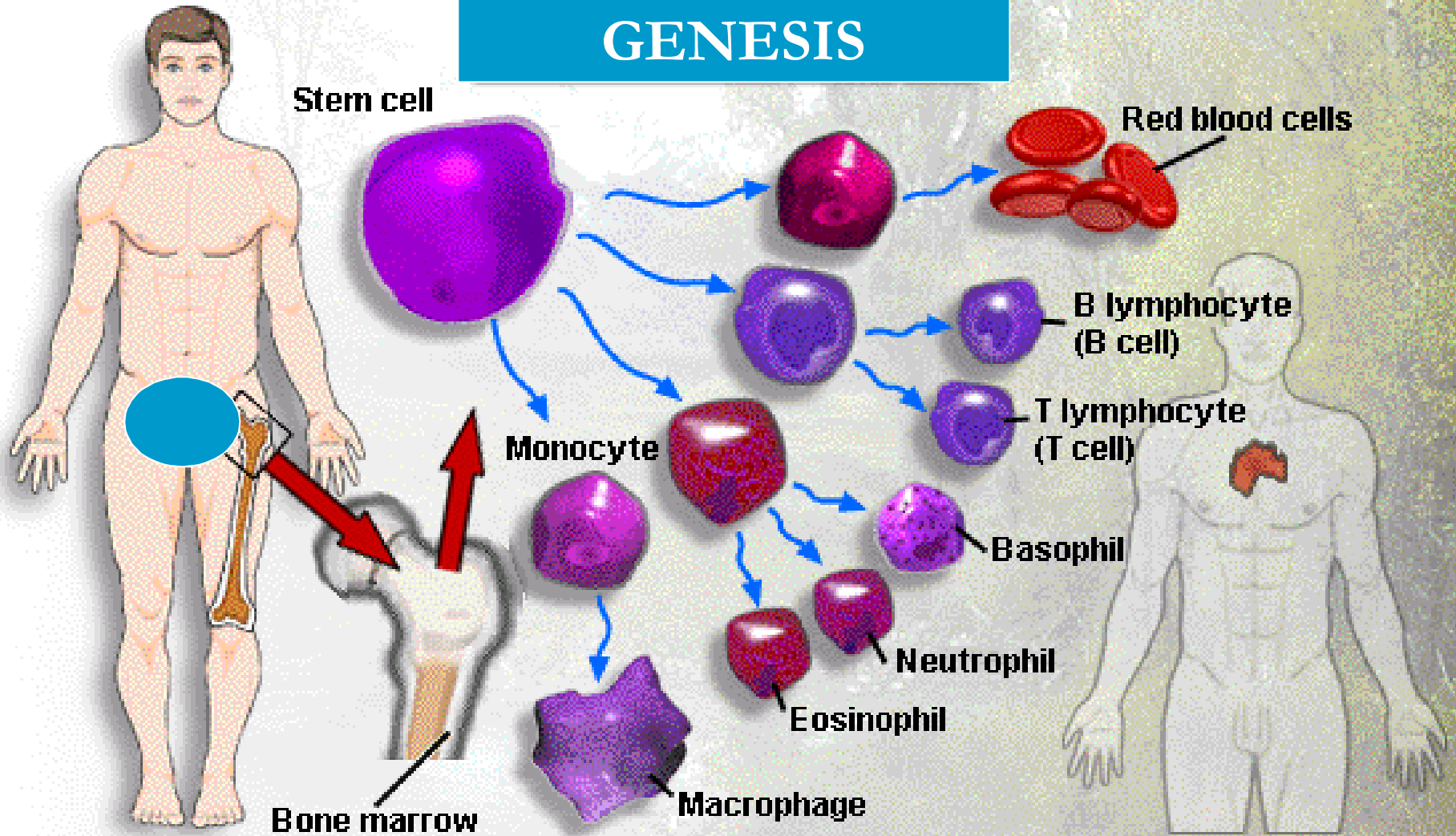
Two major lineage of WBC are formed:

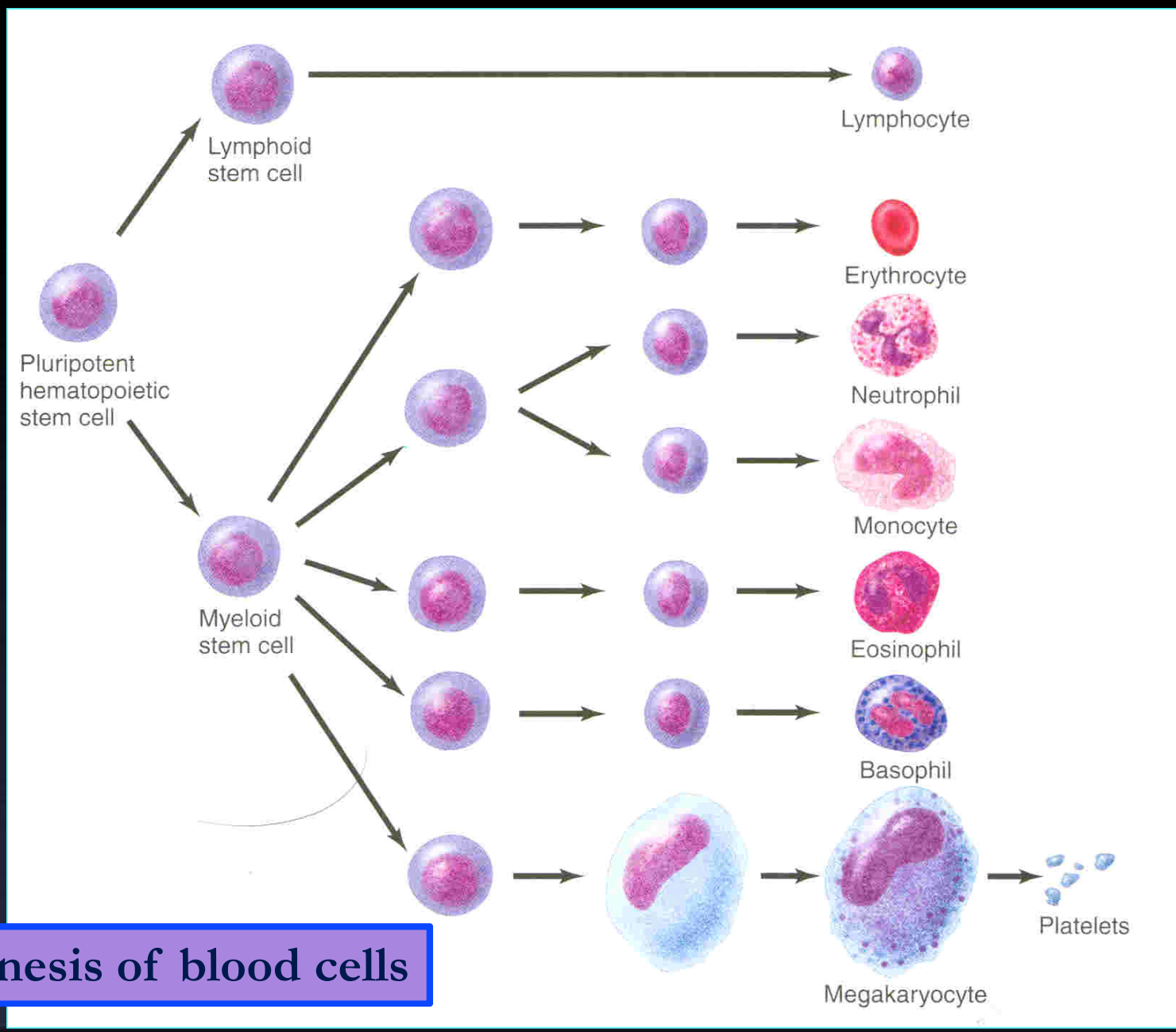
- 1. Myelocytic: granular, monocytes**
- 2. Lymphocytic: lymphocytes**

Sites of WBC Formation

- Granulocytes (neutrophil, basophil, eosinophil) in bone marrow
- Monocytes- bone marrow
- lymphocytes- bone marrow, thymus, lymphoid tissues

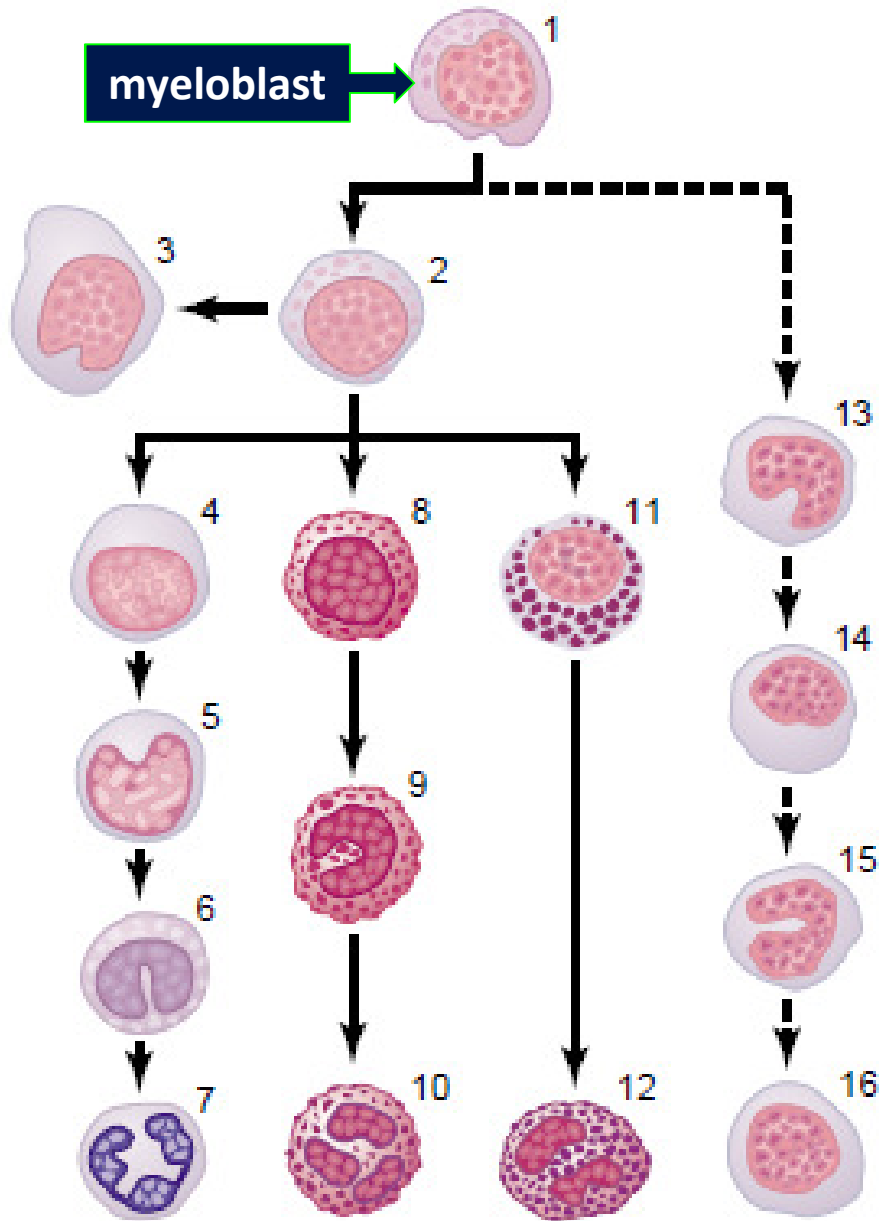
FORMATION GENESIS





Genesis of blood cells

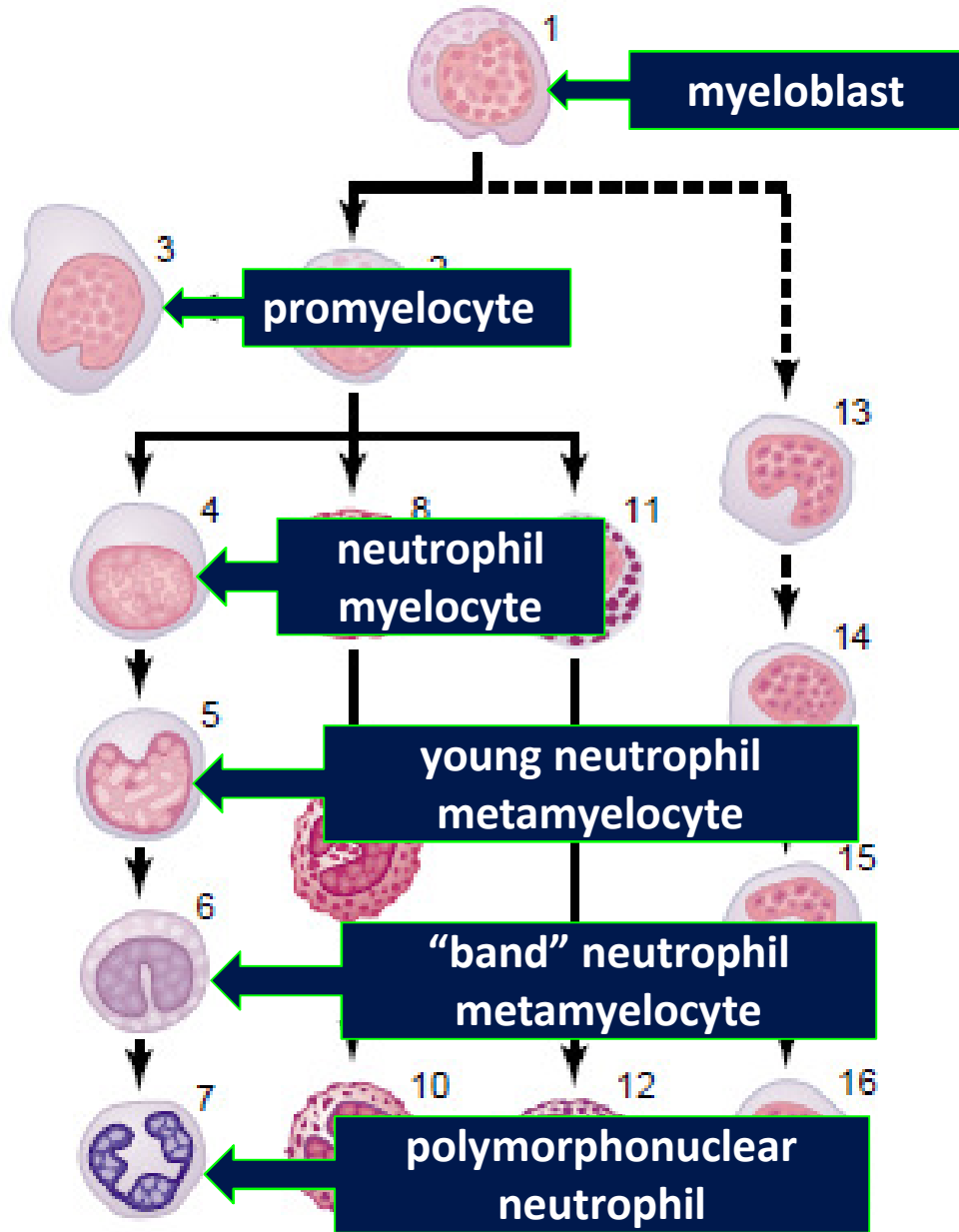
Genesis of Myelocytes



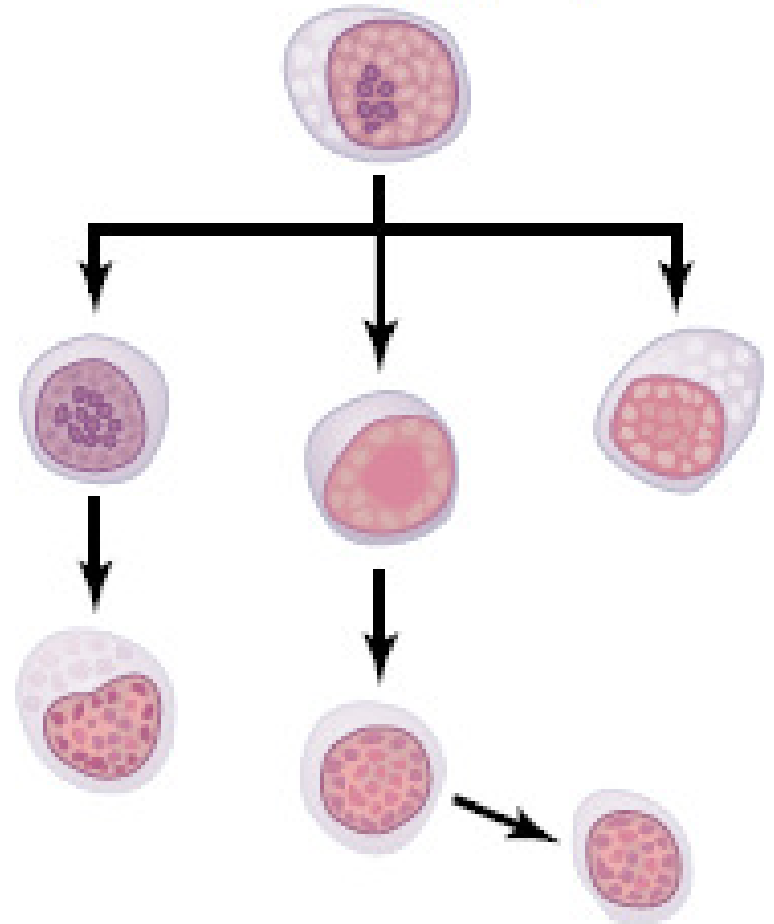
Genesis of white blood cells. The different cells of the myelocyte series are 1, myeloblast; 2, promyelocyte; 3, megakaryocyte; 4, neutrophil myelocyte; 5, young neutrophil metamyelocyte; 6, "band" neutrophil metamyelocyte; 7, polymorphonuclear neutrophil; 8, eosinophil myelocyte; 9, eosinophil metamyelocyte; 10, polymorphonuclear eosinophil; 11, basophil myelocyte; 12, polymorphonuclear basophil; 13-16, stages of monocyte formation.

Genesis of white blood cells

Genesis of Myelocytes



Genesis of Lymphocytes



Genesis of white blood cells

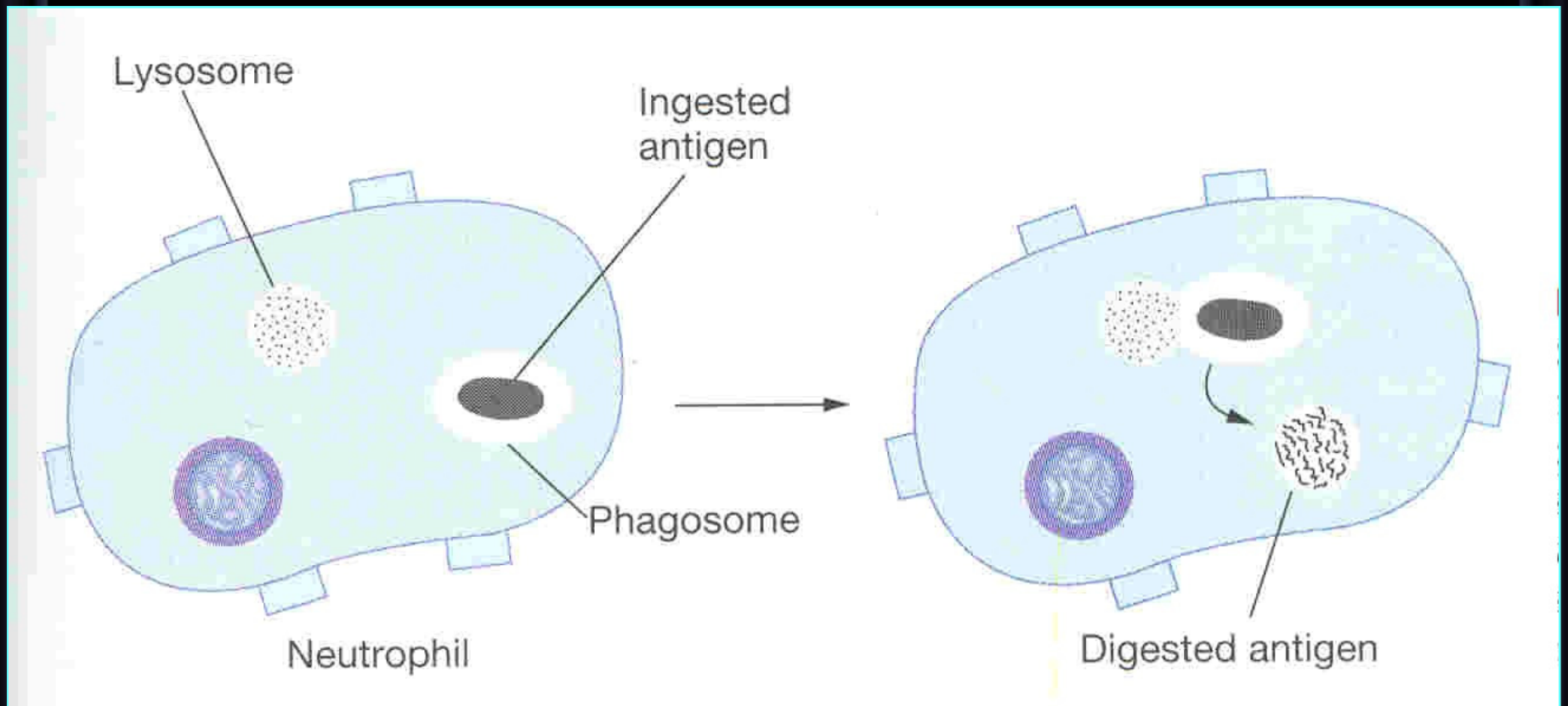
NEUTROPHILS

- **Most Abundant WBCs 60-70 %**
- **Size: 15-20 μm**
- **Nucleus: Multilobed 2-5 lobes**
- **Life span: 6-8 hours**

DEFENSIVE PROPERTIES OF MACROPHAGES & NEUTROPHILS

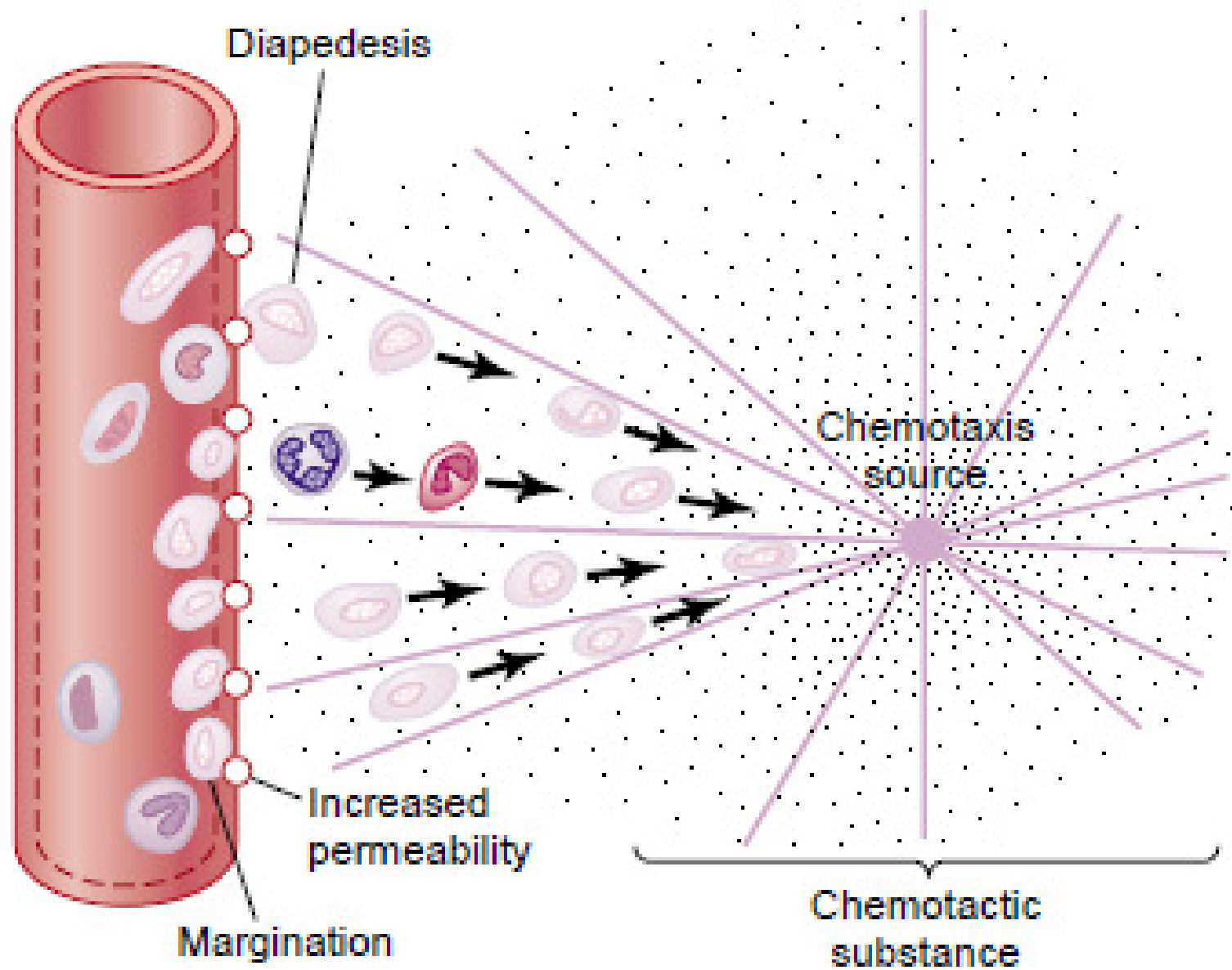
- 1. Margination**
- 2. Diapedesis**
- 3. Chemotaxis**
- 4. Opsonization**
- 5. Degranulation**
- 6. Phagocytosis & Digestion**

Phagocytosis & Digestion



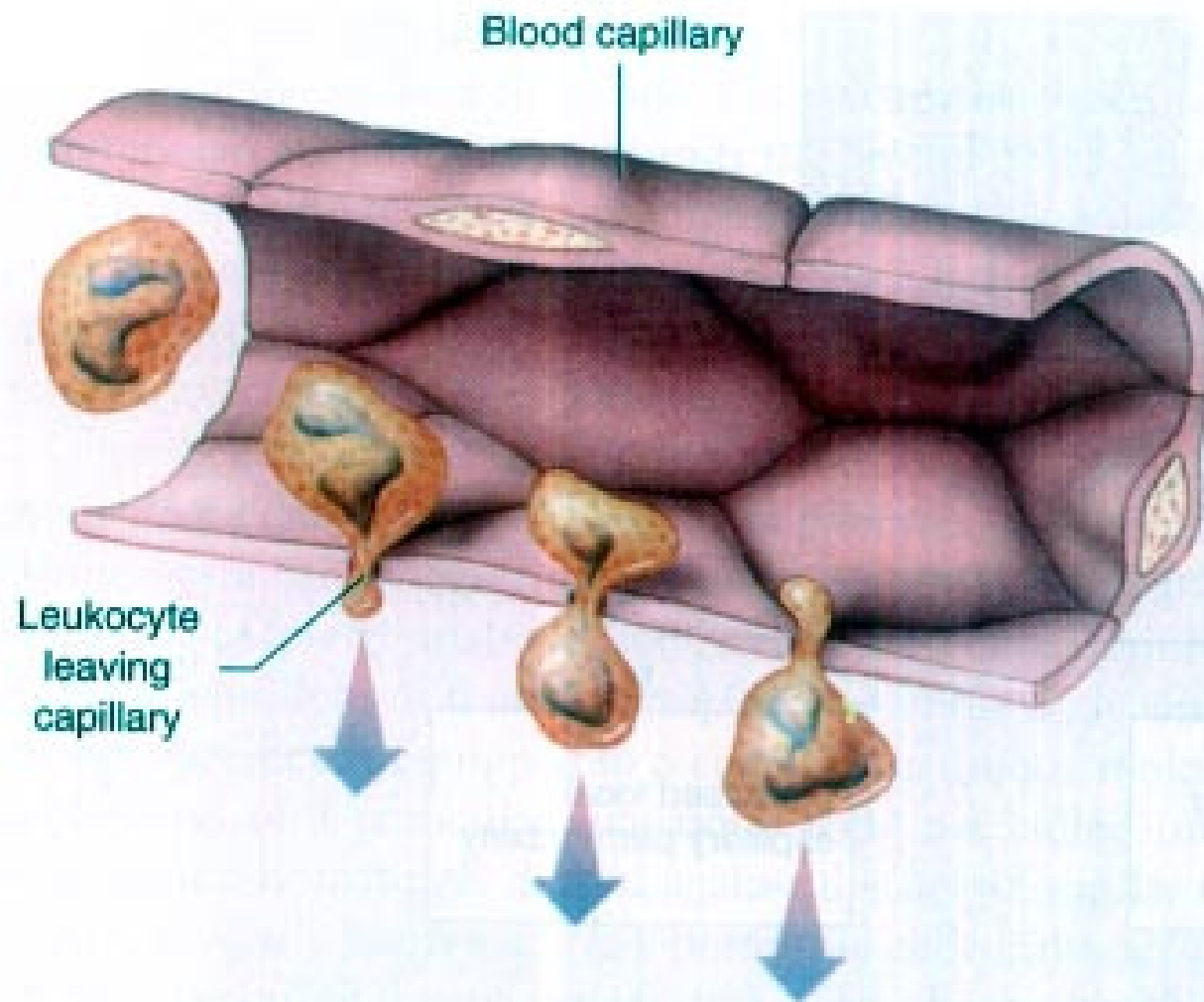
Chemotaxis

- **The attraction of the neutrophils to inflamed area following chemotactic substances release from infected site:**
- **Chemotactic substances:**
 - Bacterial toxin
 - Degenerative products of inflamed tissue
 - Complement system
 - 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 organism



Phagocytosis

Selective process: foreign substance recognize by:

1. Rough surface

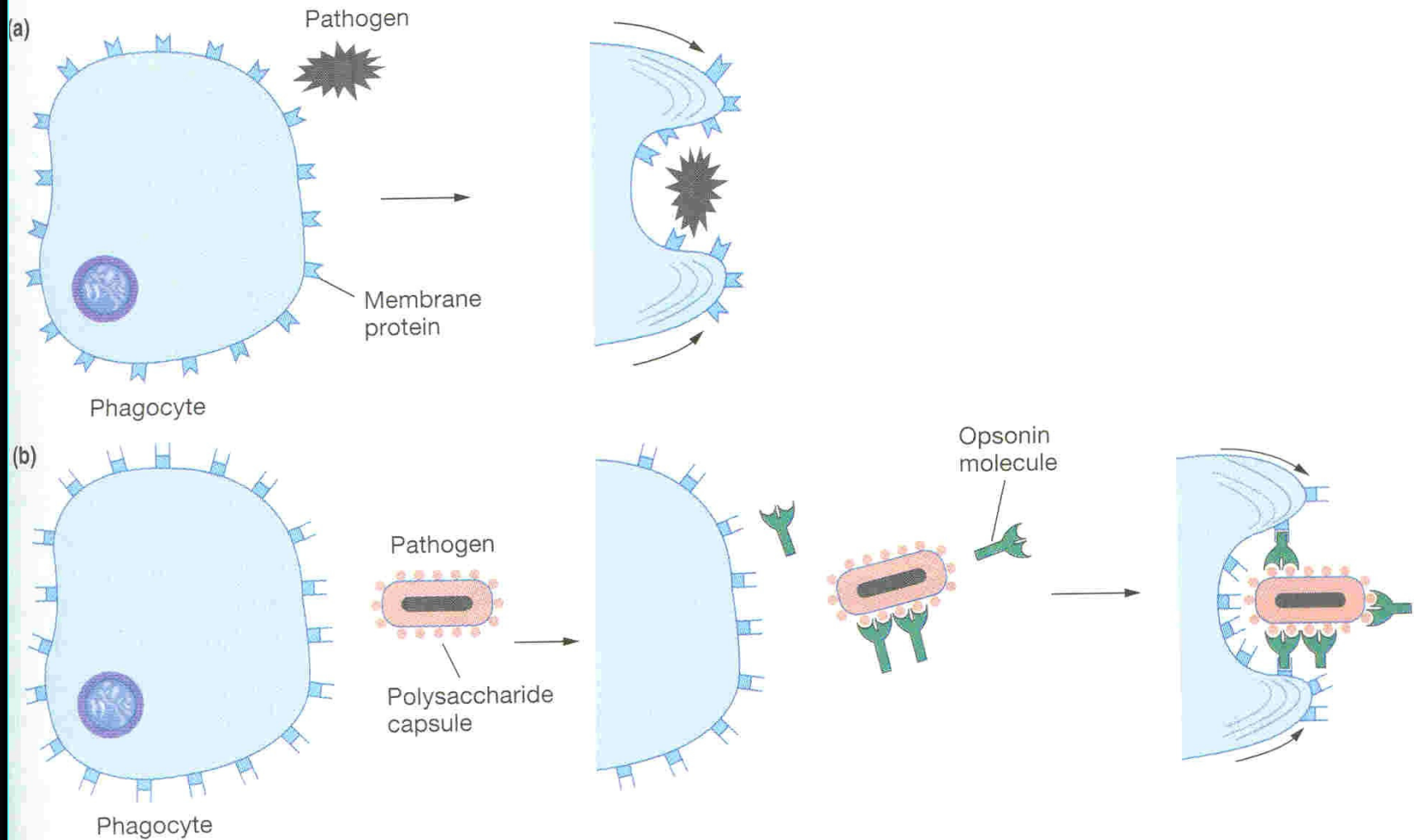
2. No protective protein coat, which prevents phagocytosis

3. Marked by certain substance e.g

- Complement 3 or antibodies making them ready for killing a process known as opsonization.

- Neutrophils encircled the bacteria with pseudopodia and engulf it inside into a vacuole (phagosome), takes 3-20 bacteria

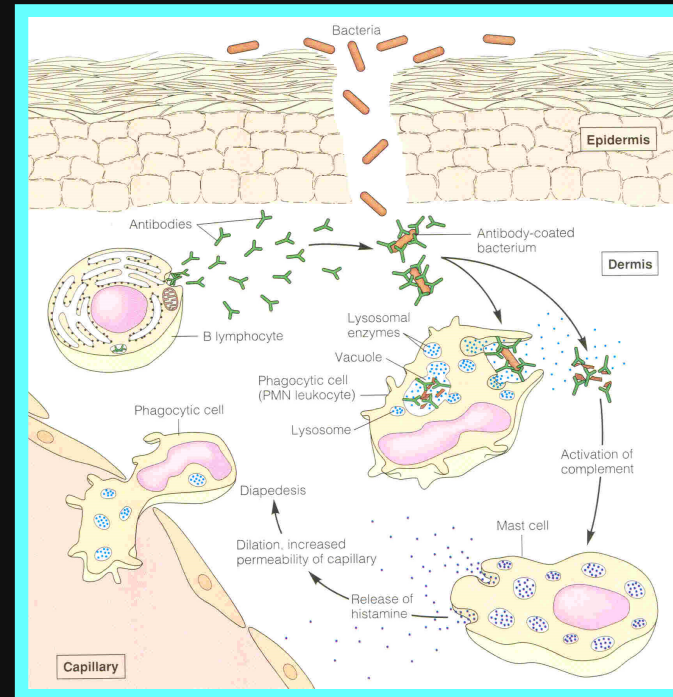
Opsonization & Phagocytosis



PMNs Digestive System (Antimicrobial system)

ENZYMATIC Granules

- Heparin
- Histamine
- Bradykinin
- Serotonin
- Defensins
- Lysosomal enzymes
- Slow reacting substance of anaphylaxis



PMNs Digestive System (Antimicrobial system)

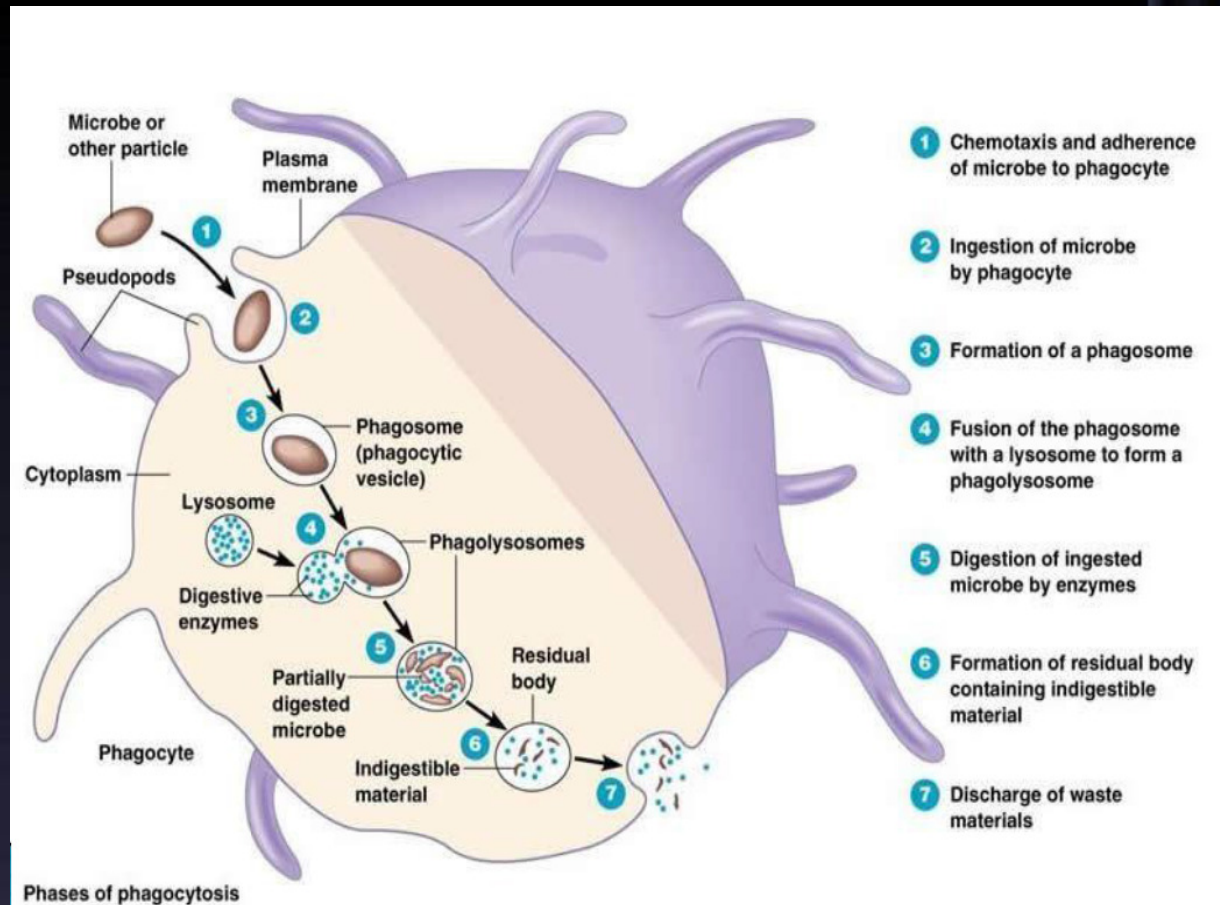
NON ENZYMATIC

respiratory burst

- O₂ Free Radicals (O⁻², H₂O₂, -OH)
- NADPH-oxidase
- Myeloperoxidase
- Cl⁻ → HOCl
- Hypochlorous acid “very toxic”

Microbial killing

- Digestion of organism inside the phagosome
- Fusion of intracellular lysosomes with phagosome vacuole
- Lysosomes discharge its proteolytic enzymes such as yeloperoxidase, catalase into the vacuole, killing and digesting the engulfed bacteria. and or Release of bactericidal such as superoxide, hydrogen peroxide to kill the bacteria



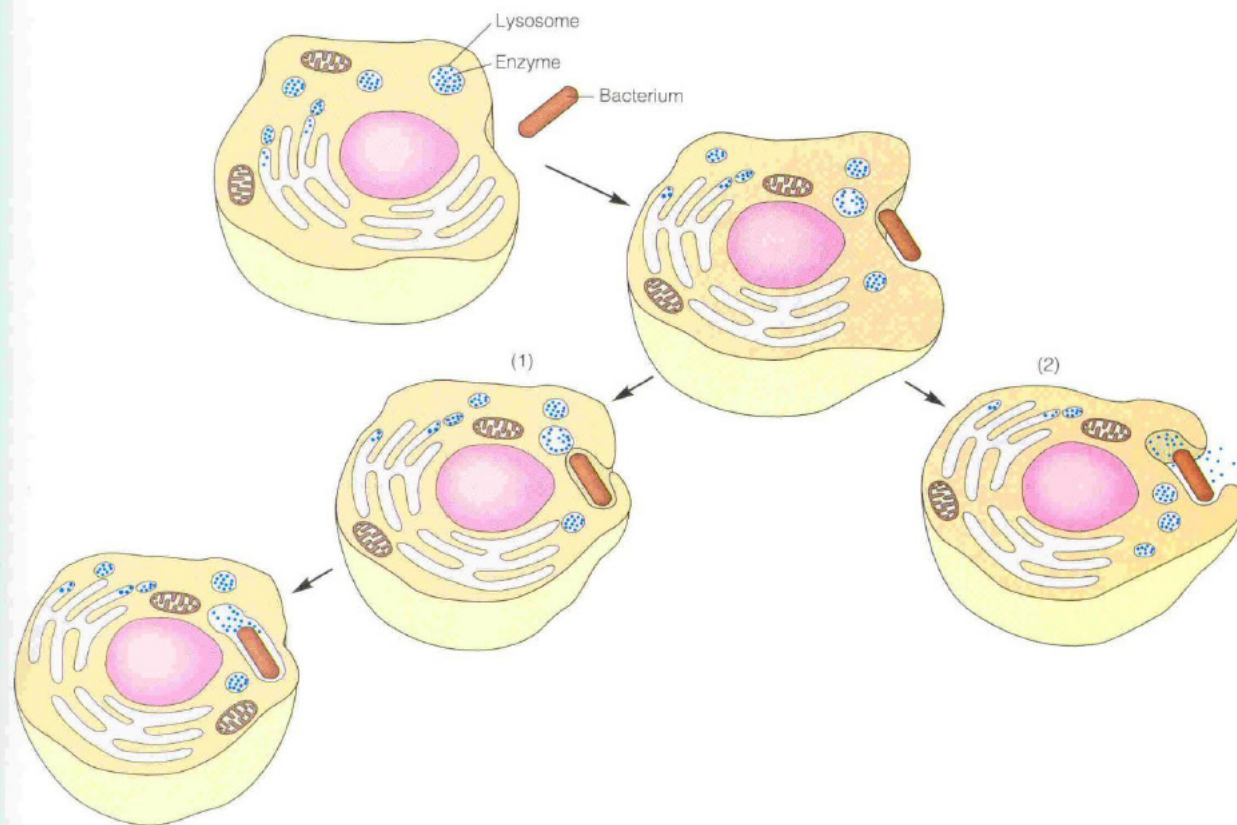
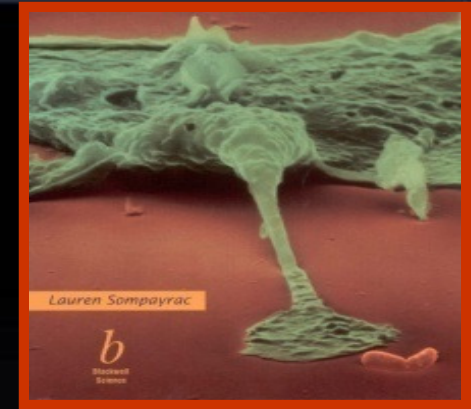


Figure 15.2

Phagocytosis by a neutrophil or macrophage. A phagocytic cell extends its pseudopods around the object to be engulfed (such as a bacterium). (Blue dots represent lysosomal enzymes.) (1) If the pseudopods fuse to form a complete food vacuole, lysosomal enzymes are restricted to the organelle formed by the lysosome and food vacuole. (2) If the lysosome fuses with the vacuole before fusion of the pseudopods is complete, lysosomal enzymes are released into the infected area of tissue.

MONOCYTES



- **No Granules but Vacoules**
- **Size: 15-20 μm (active cells 60-80 μm)**
- **More Efficient than Neutrophils (100 bacteria vs 3-20 by Neutr, larger particles like RBCs & malarial parasites)**
- **Life span: 10-20 hours in blood**
- **Two types: Mobile & Fixed**
- **Lysosomes contain lipases unlike Neut.**

RETICULOENDOTHELIAL SYSTEM

- Monocytes transform themselves into macrophages in tissue these macrophages are mononuclear cells, & this system of phagocytes is called as **Monocyte-Macrophage Cell System**
- This system of cells was known as reticuloendothelial system although neither they are reticular in appearance nor they have endothelial origin
- Therefore, the term reticuloendothelial system is obsolete.