

4b. Innate (nonspecific) Immunity

Chapter 16: Innate (nonspecific) Immunity

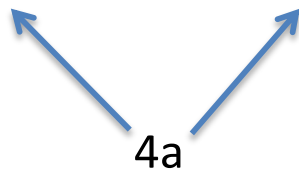
Some terms:

- Susceptibility: Lack of immunity to a disease.
- Immunity: Ability to ward off disease.
- Innate immunity: Defenses against any pathogen.
 - Does not involve specific recognition of a microbe
 - No memory response
- Adaptive immunity
 - Specific response to a specific microbe once a microbe has breached the innate immunity defenses!
 - Slower to respond but develops memory

An overview of the body's defenses

Innate Immunity		Adaptive Immunity (Chapter 17)
First line of defense	Second line of defense	Third line of defense
<ul style="list-style-type: none">• Intact skin• Mucous membranes and their secretions• Normal microbiota	<ul style="list-style-type: none">• Phagocytes, such as neutrophils, eosinophils, dendritic cells, and macrophages• Inflammation• Fever• Antimicrobial substances	<ul style="list-style-type: none">• Specialized lymphocytes: T cells and B cells• Antibodies

Copyright © 2010 Pearson Education, Inc.

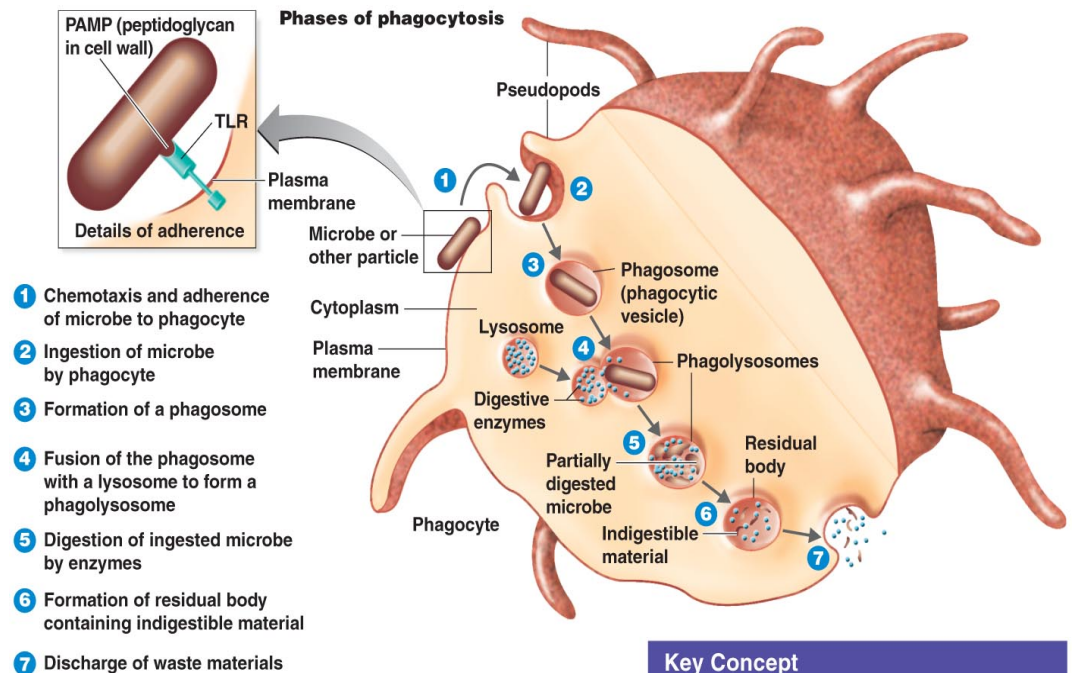


The Concept of Innate Immunity

- Host Toll-like receptors (**TLRs**) attach to
- Pathogen-associated molecular patterns (**PAMPs**)
- TLRs induce **cytokines** that regulate the intensity and duration of immune responses

On Your Cells!

On Pathogen!

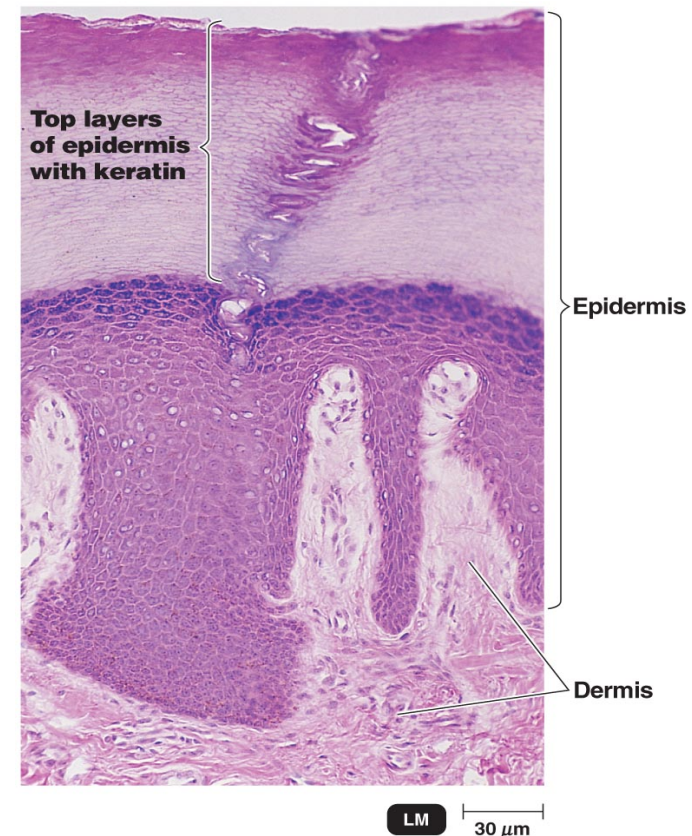
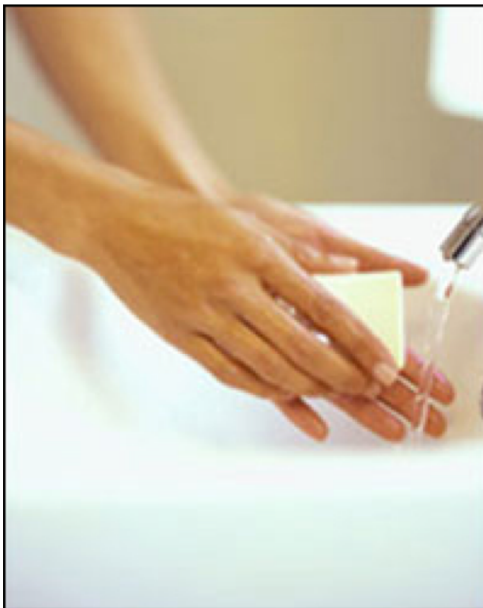


Key Concept

Phagocytes migrate to a site of infection and can destroy the infecting bacteria. The phases of phagocytosis are chemotaxis, adherence, ingestion, and digestion.

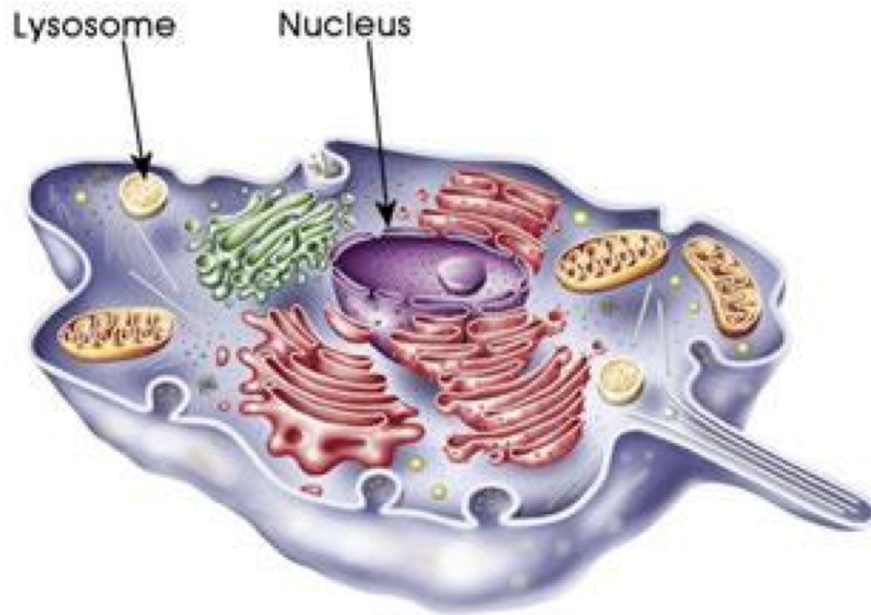
A. Physical barriers (first line of defense)

- skin, mucous membranes = prevent entry to most pathogens
- Epidermis consists of tightly packed cells with
 - **Keratin**, a protective protein



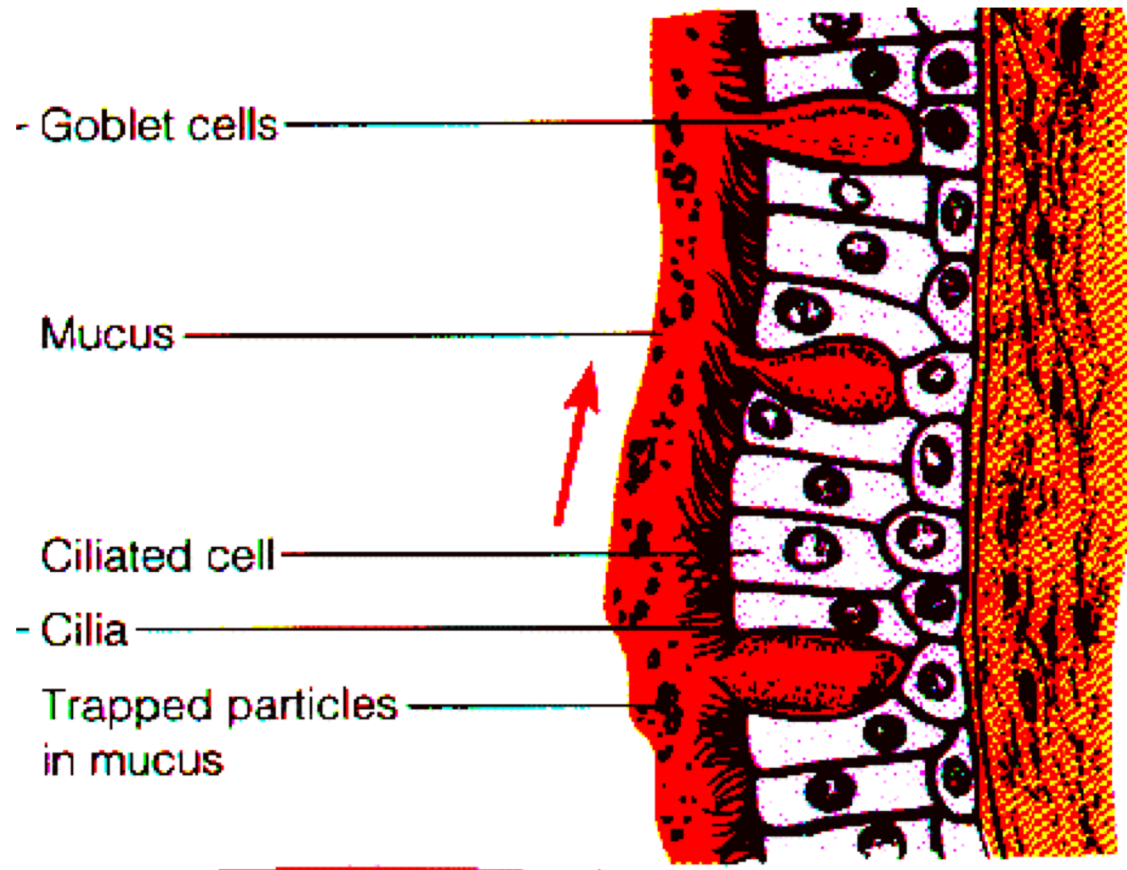
B. Lysozyme

- enzyme in tears, sweat, saliva, etc that dissolves bacterial cell walls (digests peptidoglycan)

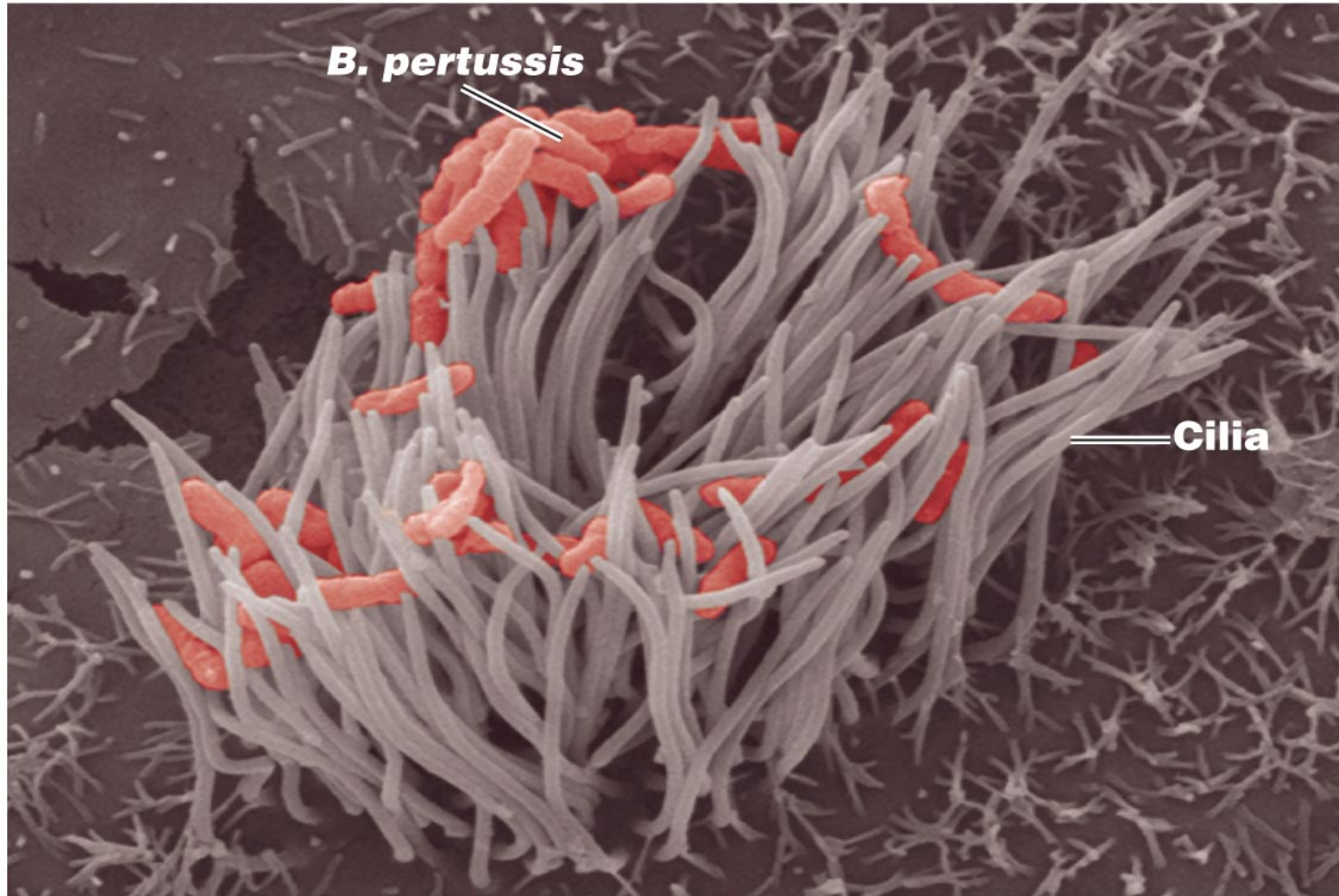


C. Respiratory cilia

- carry pathogens out of lungs



Respiratory cilia

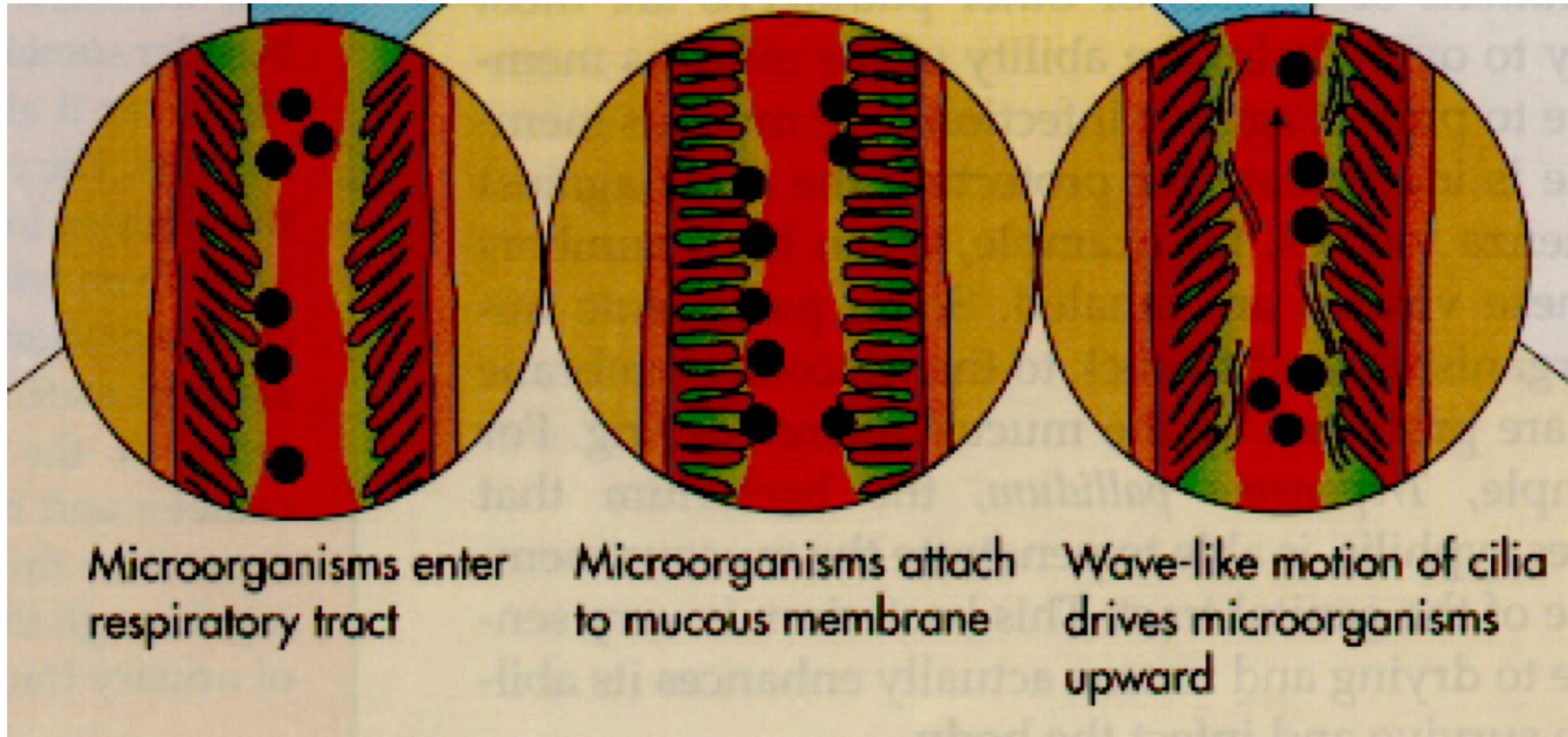


B. pertussis

Cilia

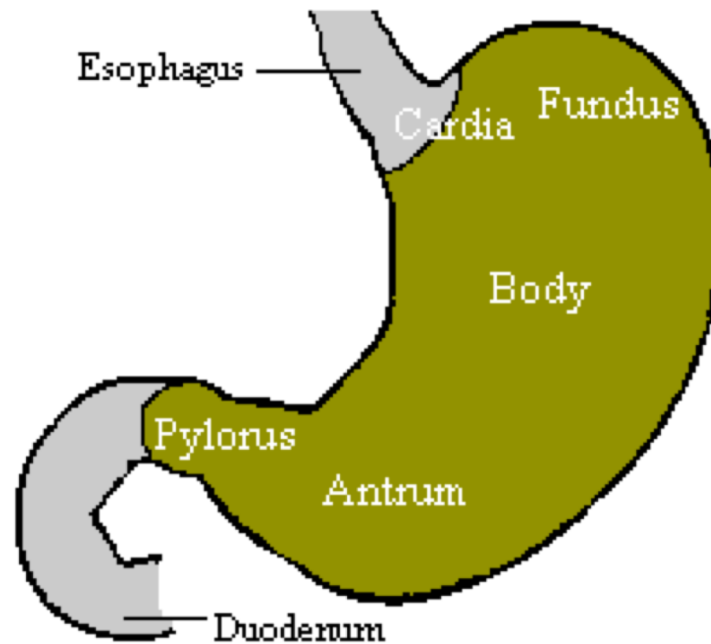
SEM

2 μ m



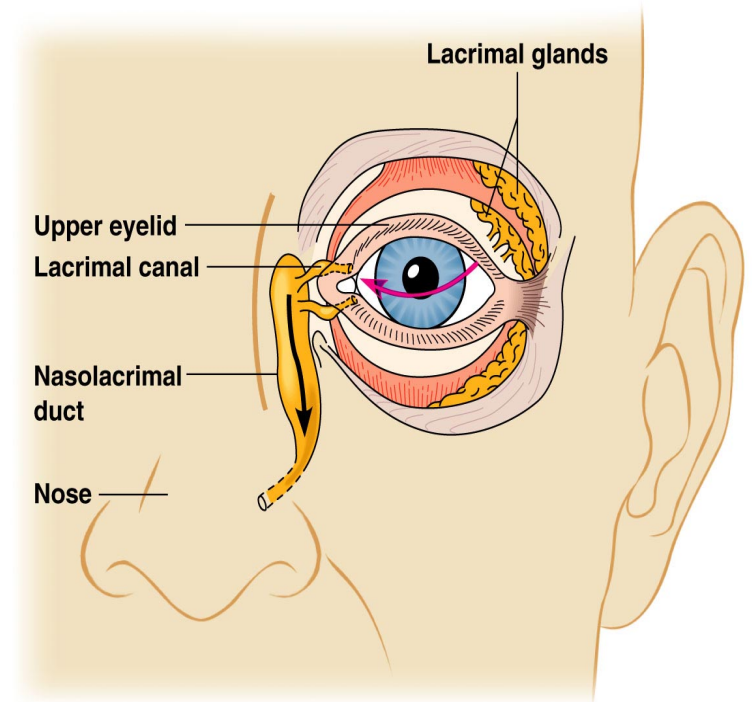
D. Stomach acid

- HCl at pH 1-2
- kills many, but not all pathogens



Physical factors

- Mucous membranes
- Ciliary escalator: Microbes trapped in mucus are transported away from the lungs.
- Lacrimal apparatus: Washes eye.
- Saliva: Washes microbes off.
- Urine: Flows out.
- Vaginal secretions: Flow out.



Copyright © 2007 Pearson Education, Inc., publishing as Benjamin Cummings.

Chemical Factors

- Fungistatic fatty acid in sebum
- Low pH (3–5) of skin
- Lysozyme in perspiration, tears, saliva, and urine
- Low pH (1.2–3.0) of gastric juice
- Low pH (3–5) of vaginal secretions

Normal Microbiota and Innate Immunity

- Microbial antagonism/competitive exclusion: Normal microbiota compete with pathogens or alter the environment
- Commensal microbiota: One organism (microbe) benefits and the other (host) is unharmed
 - May be opportunistic pathogens

Innate (Nonspecific) Immunity

First line of defense

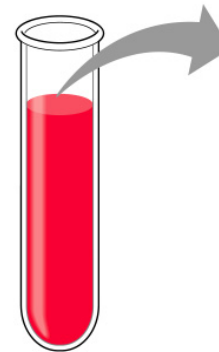
- Intact skin
- Mucous membranes and their secretions
- Normal microbiota

Second line of defense

- Natural killer cells and phagocytic white blood cells
- Inflammation
- Fever
- Antimicrobial substances

Mammalian Blood Composition

- Plasma (55%)
 - Water
 - Ions
 - Plasma Proteins
 - Nutrients
 - Waste
 - Gases
 - Hormones
- Cellular Elements (45%)
 - Erythrocytes
 - Leukocytes
 - Thrombocytes



Blood

Plasma 55%	Cellular elements 45%
Water (90% of plasma)	Red blood cells (erythrocytes)
Proteins	White blood cells (leukocytes)
Salts (e.g., sodium, potassium, calcium)	Platelets (thrombocytes)
Substances being transported (e.g., O₂, CO₂, nutrients, wastes, hormones)	

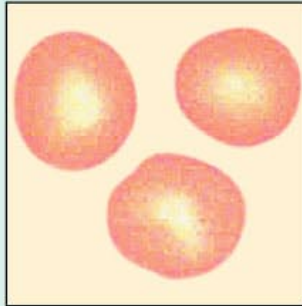
Formed Elements in Blood

TABLE 16.1

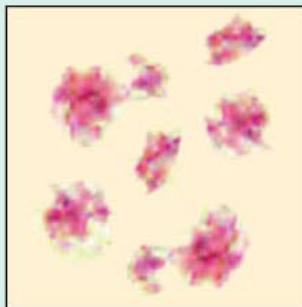
Formed Elements in Blood

Type of Cell

Erythrocytes (Red Blood Cells)



Platelets



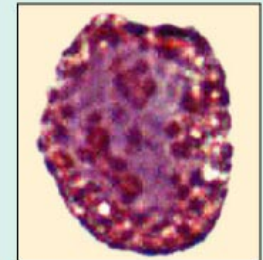
Type of Cell

Leukocytes (White Blood Cells)

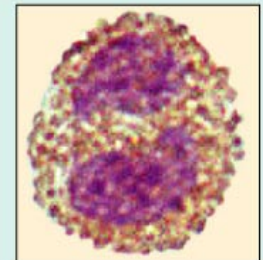
A. Granulocytes (stained)
1. Neutrophils (PMNs)
(60–70% of leukocytes)



2. Basophils (0.5–1%)



3. Eosinophils (2–4%)



4. Dendritic cells

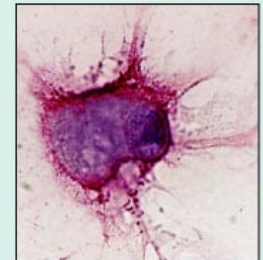

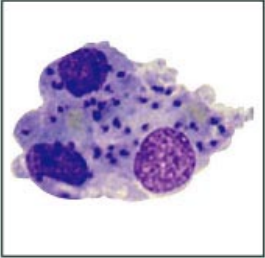
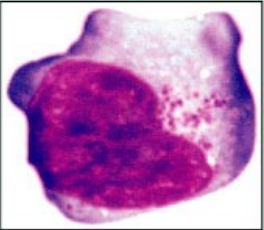

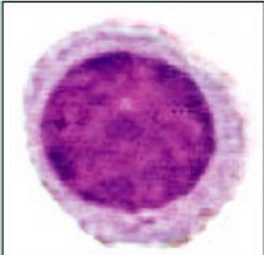


TABLE 16.1**Formed Elements in Blood** *(continued)*

Type of Cell	Numbers per Microliter (μL) or Cubic mm (mm^3)
B. Agranulocytes (stained) 1. Monocytes (3–8%)	 
2. Lymphocytes (20–25%) <ul style="list-style-type: none">• Natural killer (NK) cells• T cells• B cells	  

*Discussed in Chapter 17.

Differential White Cell Count

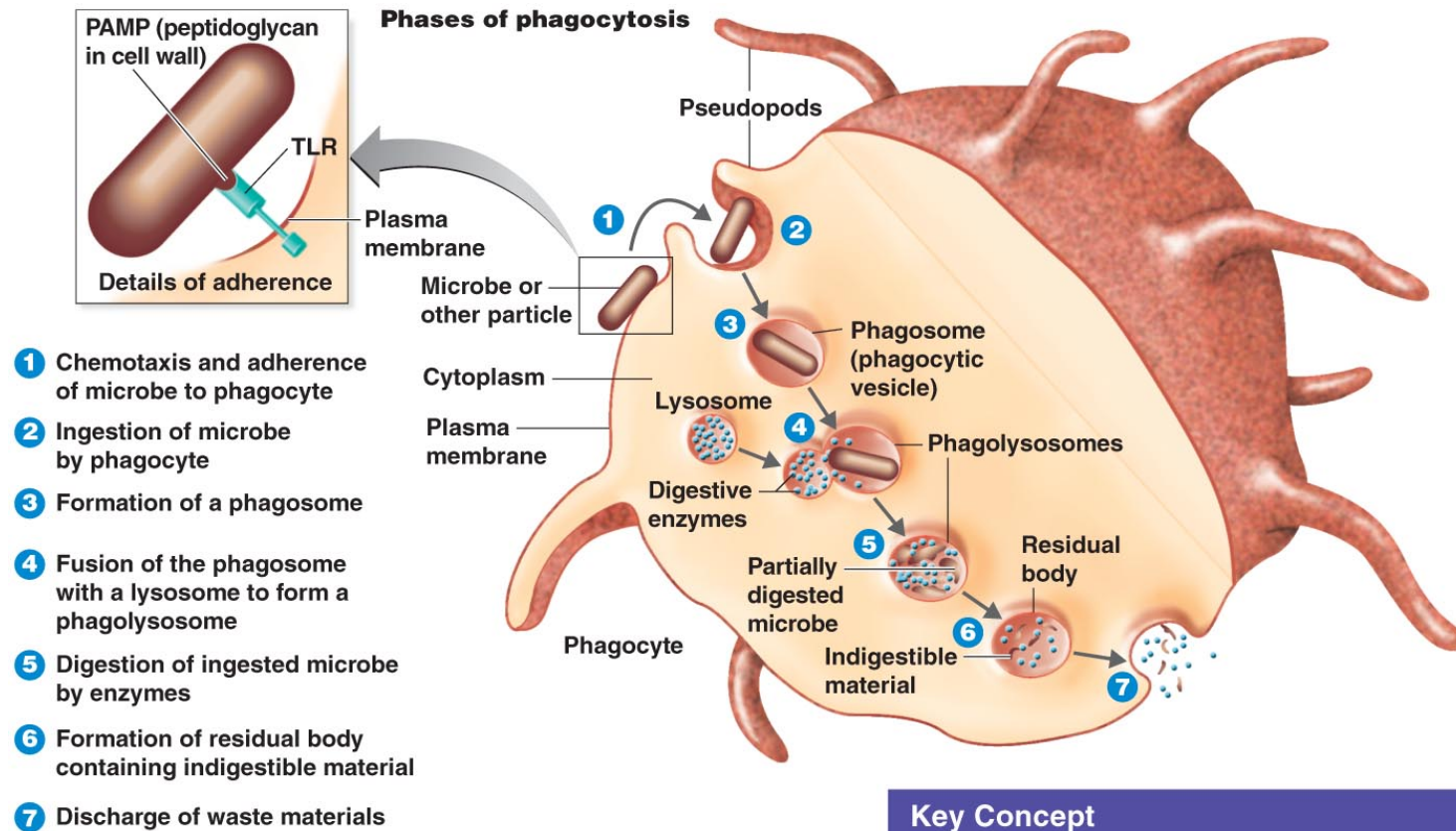
- Percentage of each type of white cell in a sample of 100 white blood cells

Neutrophils	60–70%
Basophils	0.5–1%
Eosinophils	2–4%
Monocytes	3–8%
Lymphocytes	20–25%

White Blood Cells

- **Neutrophils**: Phagocytic (most abundant)
- **Basophils**: Produce histamine
- **Eosinophils**: Toxic to parasites and some phagocytosis (worm infections)
- **Dendritic cells**: Initiate adaptive immune response
- **Monocytes**: Phagocytic as mature macrophages
 - Fixed macrophages in lungs, liver, and bronchi
 - Wandering macrophages roam tissues.
- **Lymphocytes**: Involved in specific immunity.

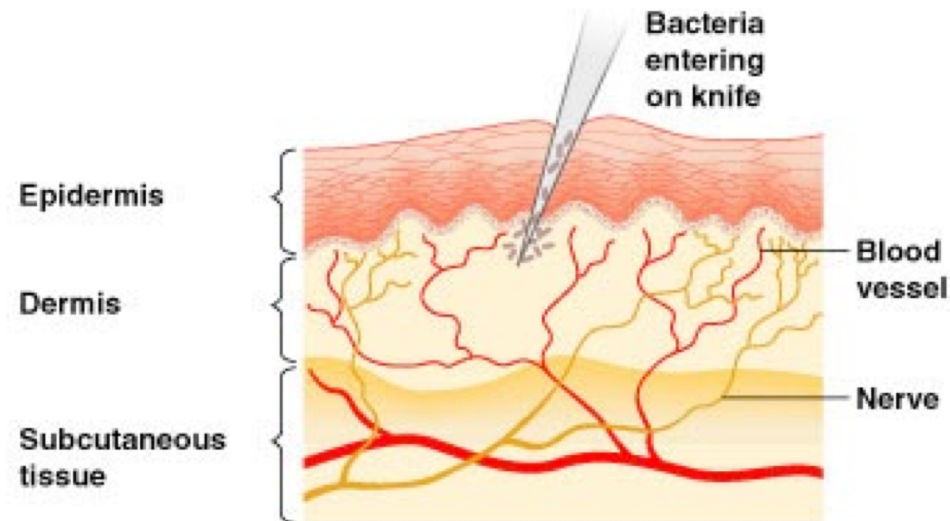
Figure 16.7



Microbial Evasion of Phagocytosis

Inhibit adherence: M protein, capsules	<i>Streptococcus pyogenes, S. pneumoniae</i>
Kill phagocytes: Leukocidins	<i>Staphylococcus aureus</i>
Lyse phagocytes: Membrane attack complex	<i>Listeria monocytogenes</i>
Escape phagosome	<i>Shigella, Rickettsia</i>
Prevent phagosome-lysosome fusion	HIV, <i>Mycobacterium tuberculosis</i>
Survive in phagolysosome	<i>Coxiella burnettii</i>

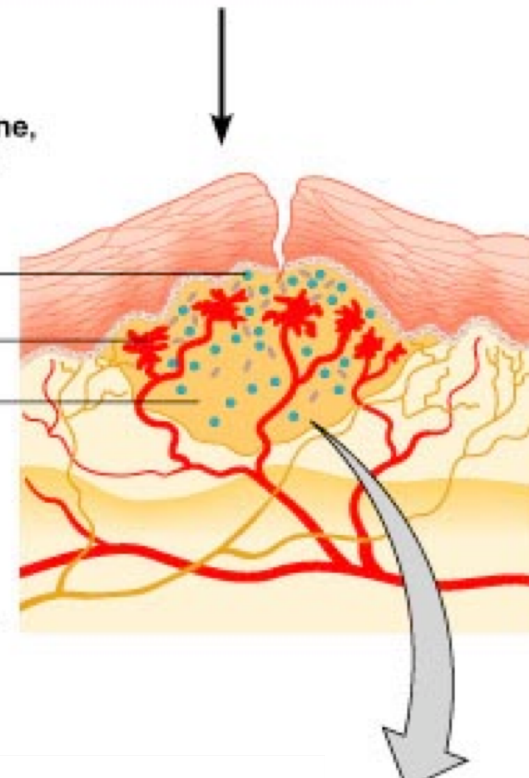
Inflammation



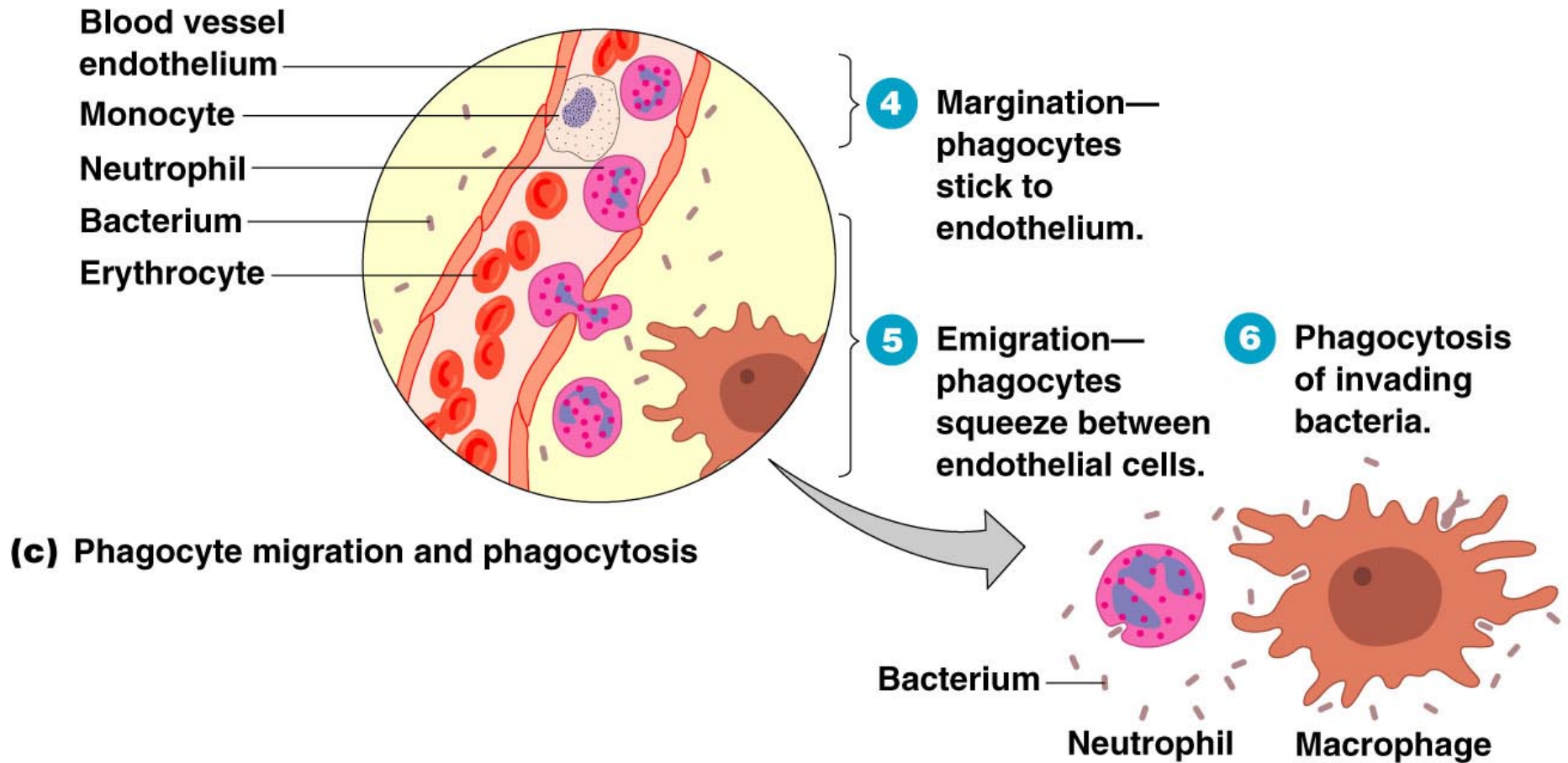
(a) Tissue damage

- 1** Chemicals such as histamine, kinins, prostaglandins, and leukotrienes (represented as blue dots) are released by damaged cells.
- 2** Blood clot forms.
- 3** Abscess starts to form (dark yellow area).

(b) Vasodilation and increased permeability of blood vessels



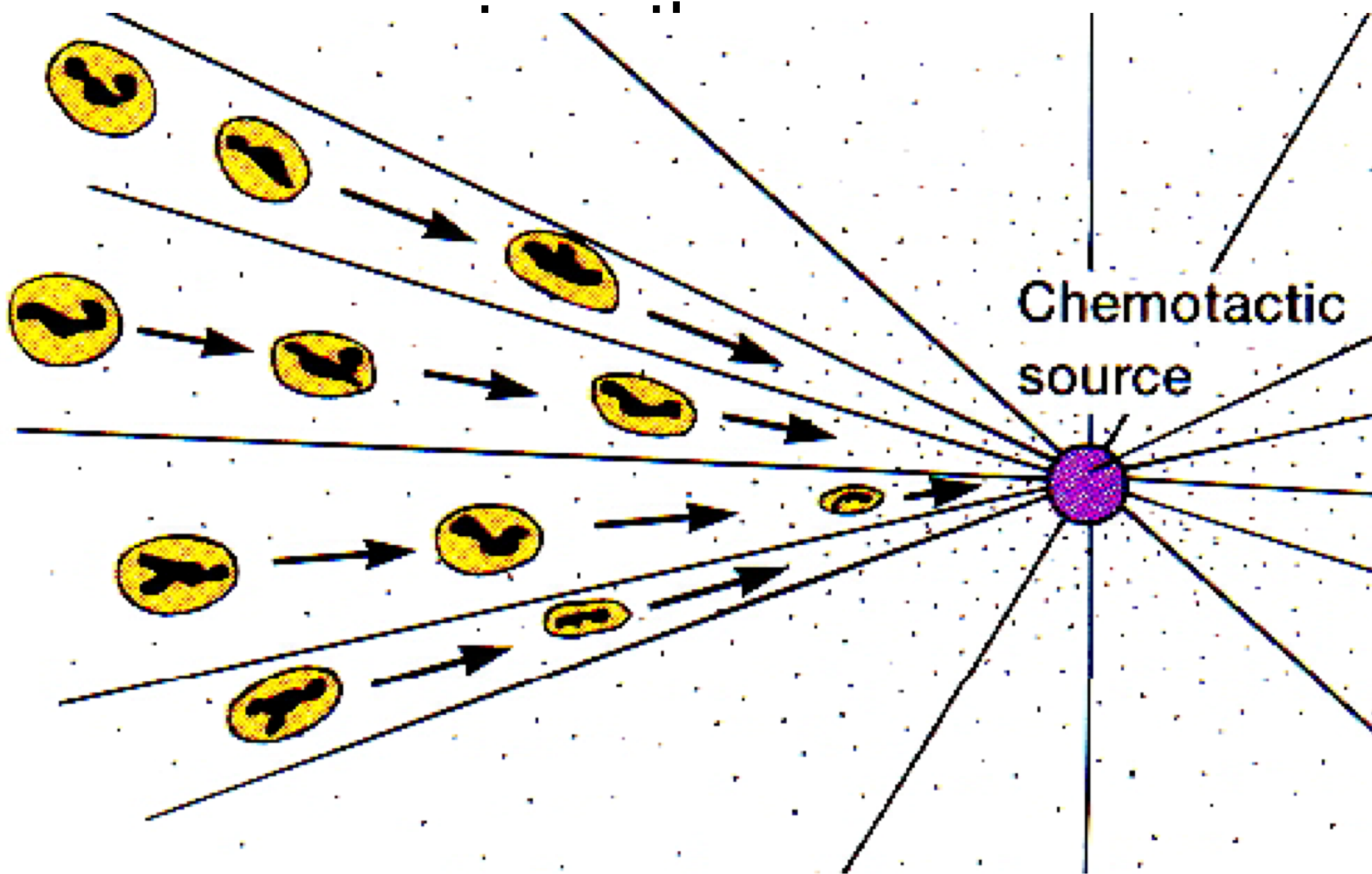
Inflammation



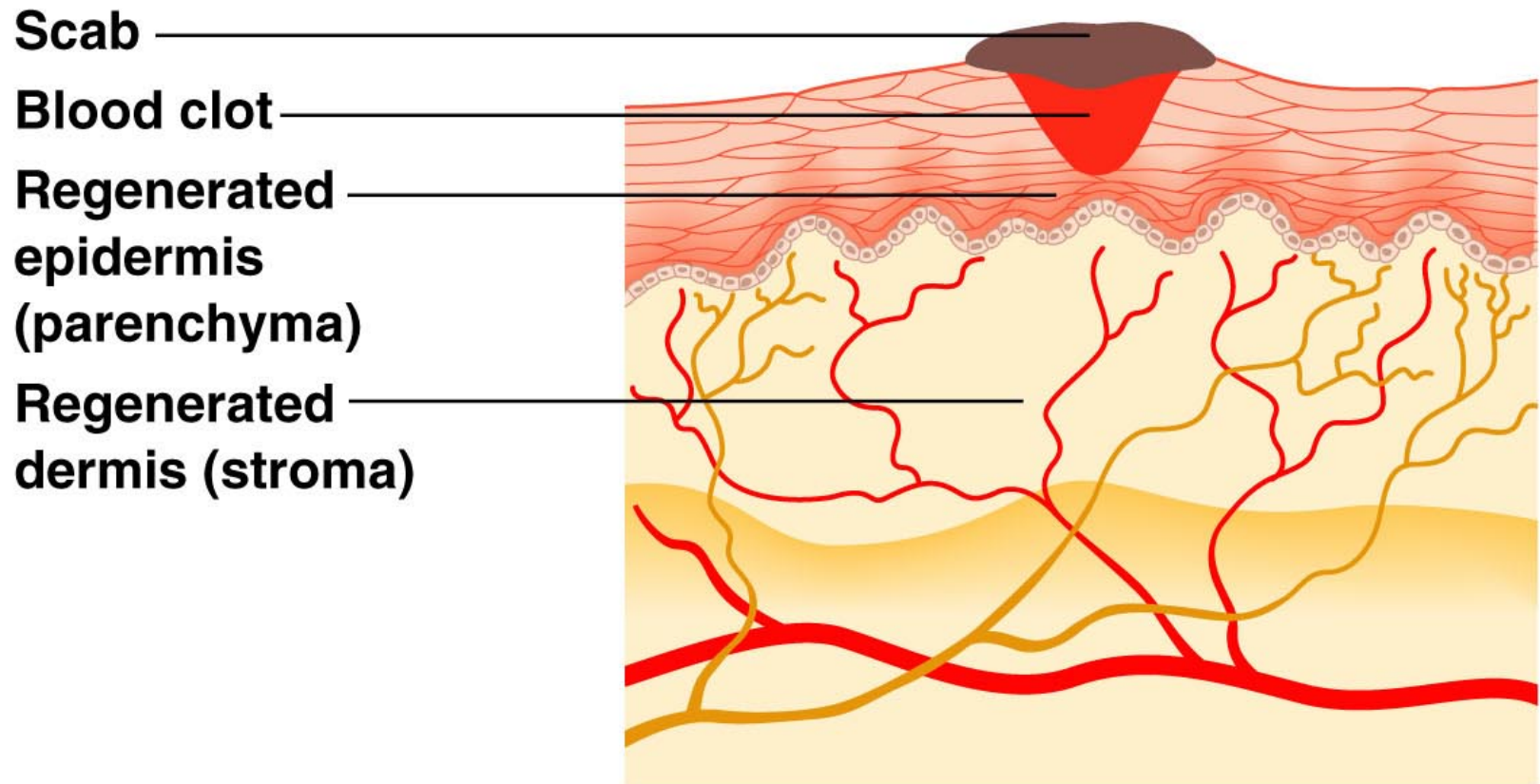
Inflammation

- Redness
- Pain
- Heat
- Swelling (edema)
- Acute-phase proteins activated (complement, cytokine, and kinins)
- Vasodilation (histamine, kinins, prostaglandins, and leukotrienes)
- Margination and emigration of WBCs
- Tissue repair

chemotaxis: phagocytes attracted



Tissue Repair



(d) Tissue repair

Innate Immunity		Adaptive Immunity (Chapter 17)
First line of defense	Second line of defense	Third line of defense
<ul style="list-style-type: none"> • Intact skin • Mucous membranes and their secretions • Normal microbiota 	<ul style="list-style-type: none"> • Phagocytes, such as neutrophils, eosinophils, dendritic cells, and macrophages • Inflammation • Fever • Antimicrobial substances 	<ul style="list-style-type: none"> • Specialized lymphocytes: T cells and B cells • Antibodies

Fever

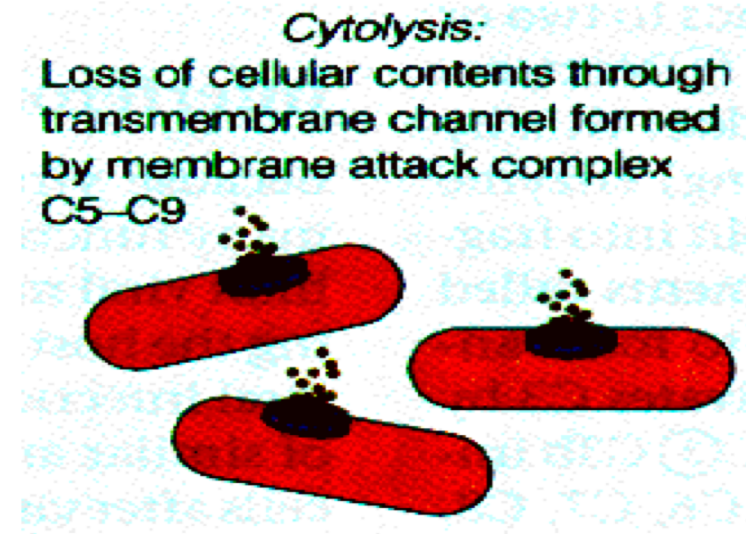
- Abnormally high body temperature
- Hypothalamus normally set at **37° C**
- **Gram-negative** endotoxin cause phagocytes to release **interleukin-1 (IL-1)**
- **Hypothalamus** releases **prostaglandins** that reset the hypothalamus to a high temperature
- Body increases rate of metabolism and shivering which raise temperature
- **Vasodilation** and sweating: Body temperature falls (crisis)

Fever

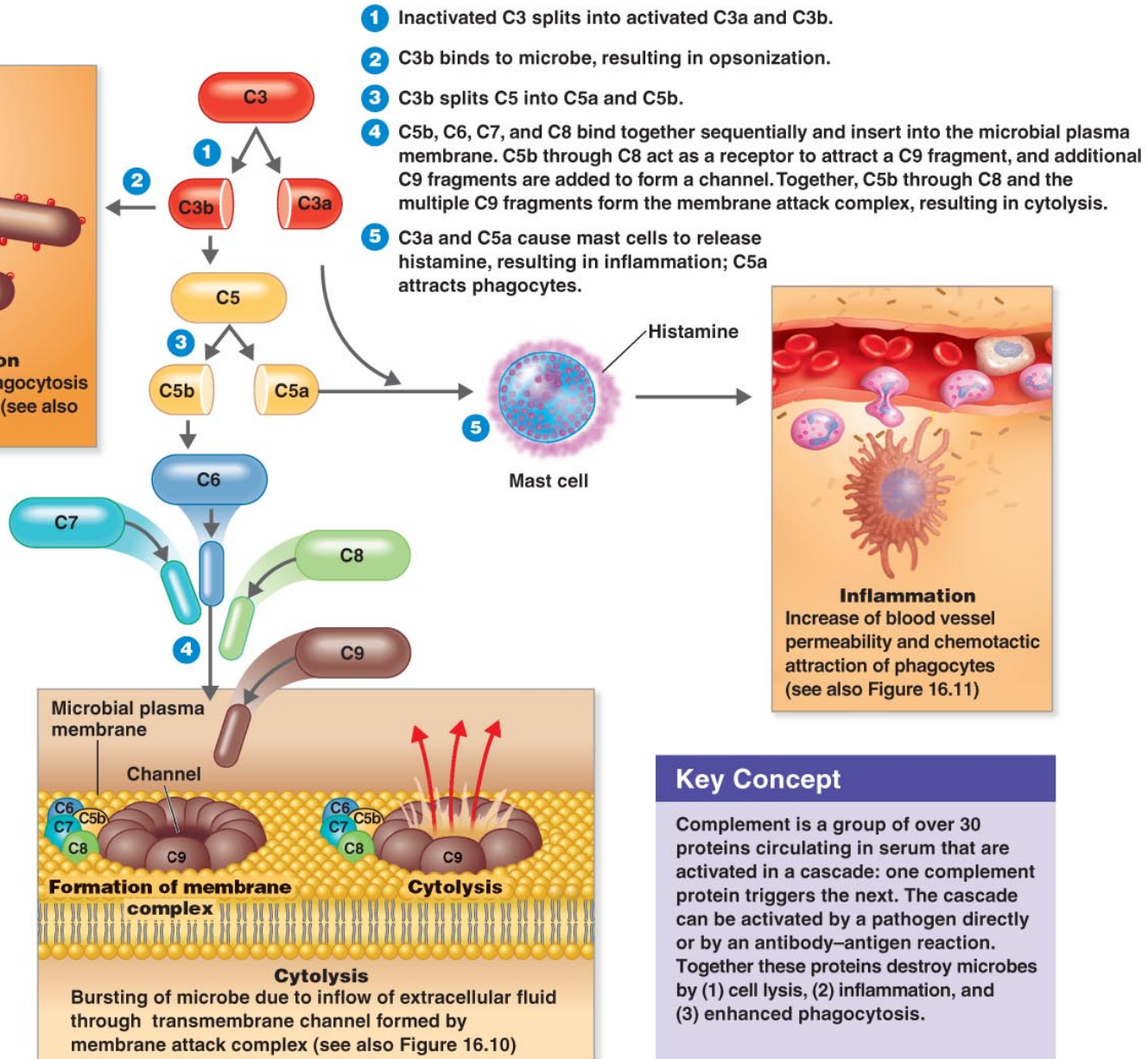
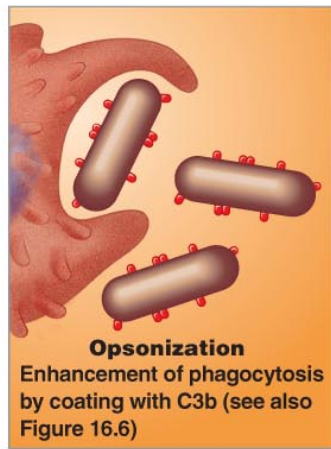
- A moderate fever is beneficial to host defenses
- speeds up body defenses; slows down growth of pathogens
- Fever producing *pyrogens* are produced by activated macrophages as well as bacteria, viruses, and other microbes
 - Stimulate hypothalamus to raise body temp.
 - Thus cell metabolism increases and blood vessels constrict keeping heat within (cold skin/chills with fever)
 - But, above **105⁰ F**, convulsions and death may result
 - Infants >100⁰F and older children >102⁰F need medical attention!

Antimicrobial substances: The Complement System

- Complement (complement system): a series of over 30 blood proteins (produced by the liver) that circulate in the bloodstream and sequentially bond together to cause lysis of pathogens, inflammation and help phagocytosis
- “complements” the cells of the immune system in destroying microbes
- can be a specific or nonspecific defense



Compliment Sysmtem

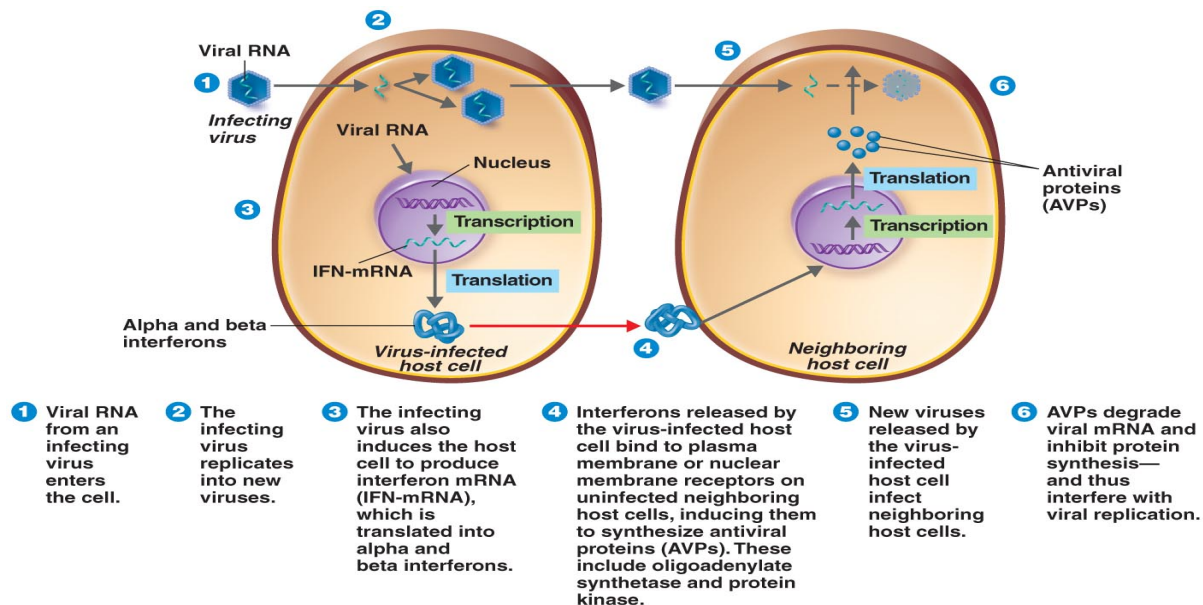


Key Concept

Complement is a group of over 30 proteins circulating in serum that are activated in a cascade: one complement protein triggers the next. The cascade can be activated by a pathogen directly or by an antibody-antigen reaction. Together these proteins destroy microbes by (1) cell lysis, (2) inflammation, and (3) enhanced phagocytosis.

Interferons (IFNs)

- messenger proteins produced by virus-infected cells
- tell surrounding cells to produce anti-viral protein
- also produced by genetic engineered microorganisms for injection as antiviral drugs



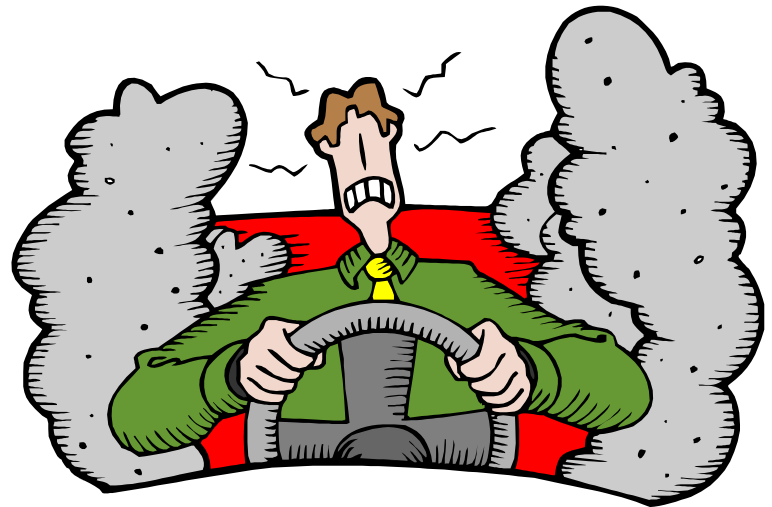
Summary of Second Line of Defense

Table 16.2 Summary of Innate Immunity Defenses (continued)

Component	Functions
SECOND LINE OF DEFENSE	
Defensive Cells	
Phagocytes	Phagocytosis by cells such as neutrophils, eosinophils, dendritic cells, and macrophages.
Natural killer (NK) cells	Kill infected target cells by releasing granules that contain perforin and granzymes. Phagocytes then kill the infected microbes.
Inflammation	Confines and destroys microbes and initiates tissue repair.
Fever	Intensifies the effects of interferons, inhibits growth of some microbes, and speeds up body reactions that aid repair.
Antimicrobial Substances	
Complement system	Causes cytolysis of microbes, promotes phagocytosis, and contributes to inflammation.
Interferons	Protect uninfected host cells from viral infection.
Iron-Binding Proteins	Inhibit growth of certain bacteria by reducing the amount of available iron.
Antimicrobial Peptides (AMPs)	Inhibit cell wall synthesis, form pores in the plasma membrane that cause lysis; and destroy DNA and RNA.

Stress theory of disease

- Hans Selye
- A. Stressor: any force that elicits the stress response
 - invasion by pathogen
 - trauma
 - surgery
 - emotional conflict
 - performance demands
 - difficult relationships
 - life changes (positive or negative)



B. Stress

- the body's response to any stressor
- includes many measurable physiological changes intended to increase resistance to stressors
- also called the *General Adaptation Syndrome*
- 1. Eustress: beneficial stress; appropriate in degree and duration; produces optimum physical and mental function and resistance to pathogens
- 2. Distress: harmful stress; excessive in degree and/or duration; impairs physical and mental function; reduces resistance to pathogens
- Stress management