

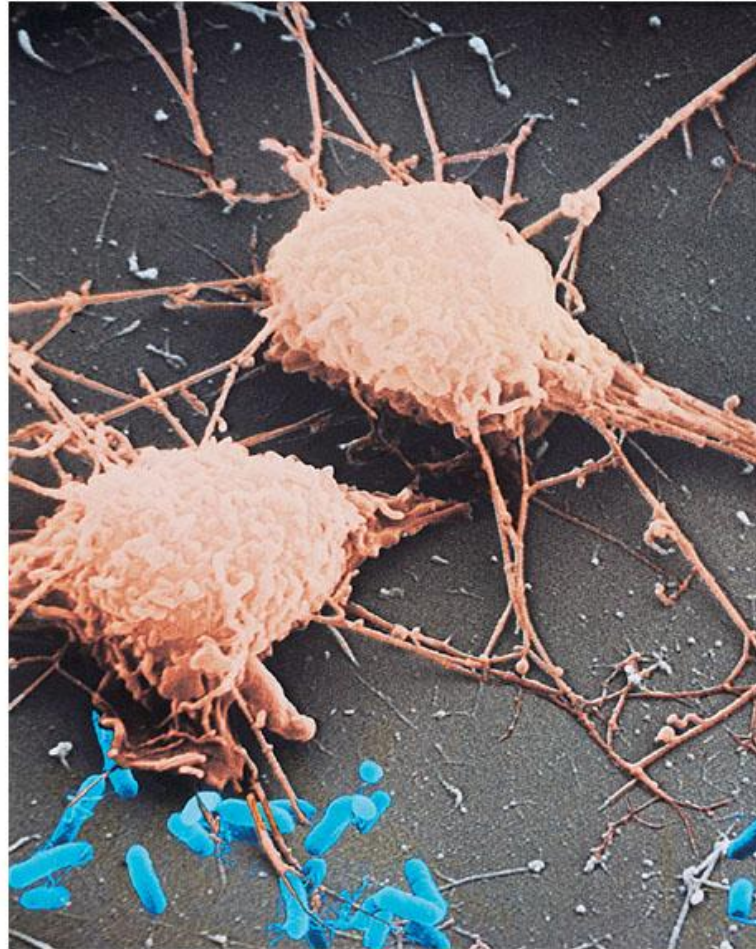
Foundations in Microbiology

Fifth Edition

Talaro

Chapter

14



The Nature of Host Defenses

Chapter 14

- **1st line of defense -**
 - intact skin
 - mucous membranes & their secretions
- **2nd line of defense -**
 - phagocytic white blood cells *nonspecific*
 - inflammation -complement
 - fever -interferon

- **3rd line of defense-**
 - B & T lymphocytes
specific
 - antibodies

Physical or anatomical barriers

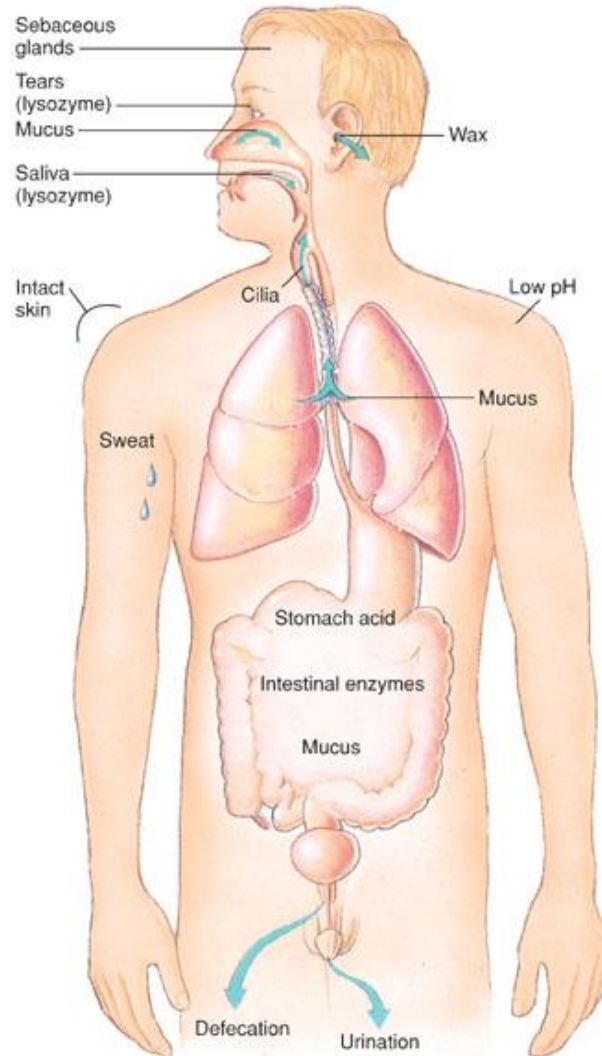
- Outermost layer of skin is composed of epithelial cells compacted, cemented together & impregnated with keratin
- Flushing effect of sweat glands
- Damaged cells are rapidly replaced
- Mucous coat impedes attachment & entry of bacteria
- Blinking & tear production
- Stomach acid
- Nasal hair traps larger particles

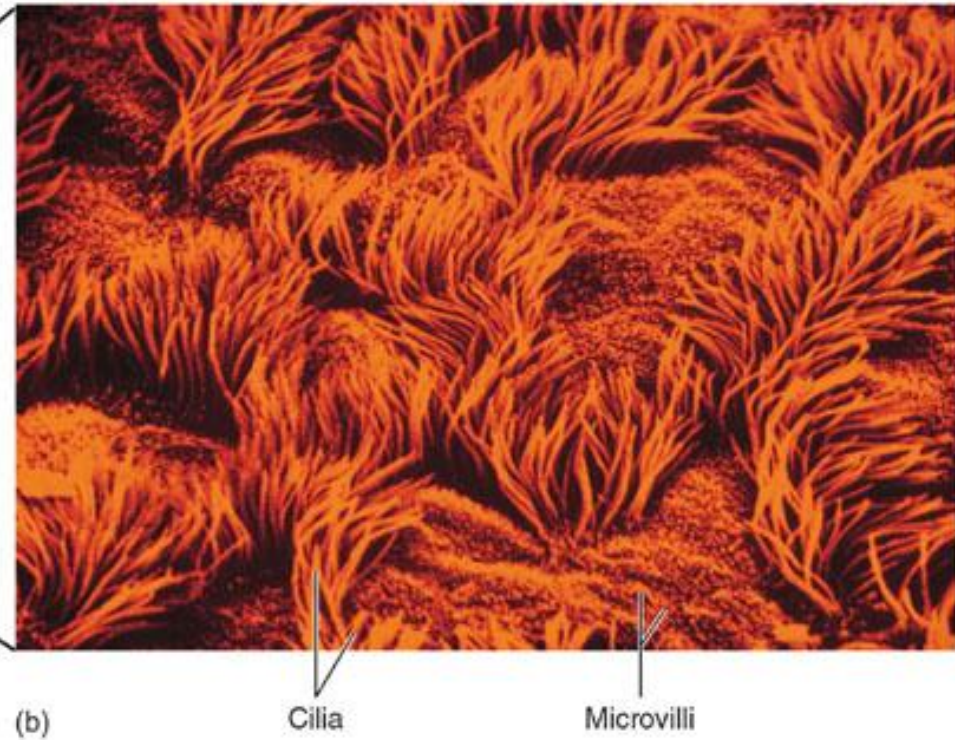
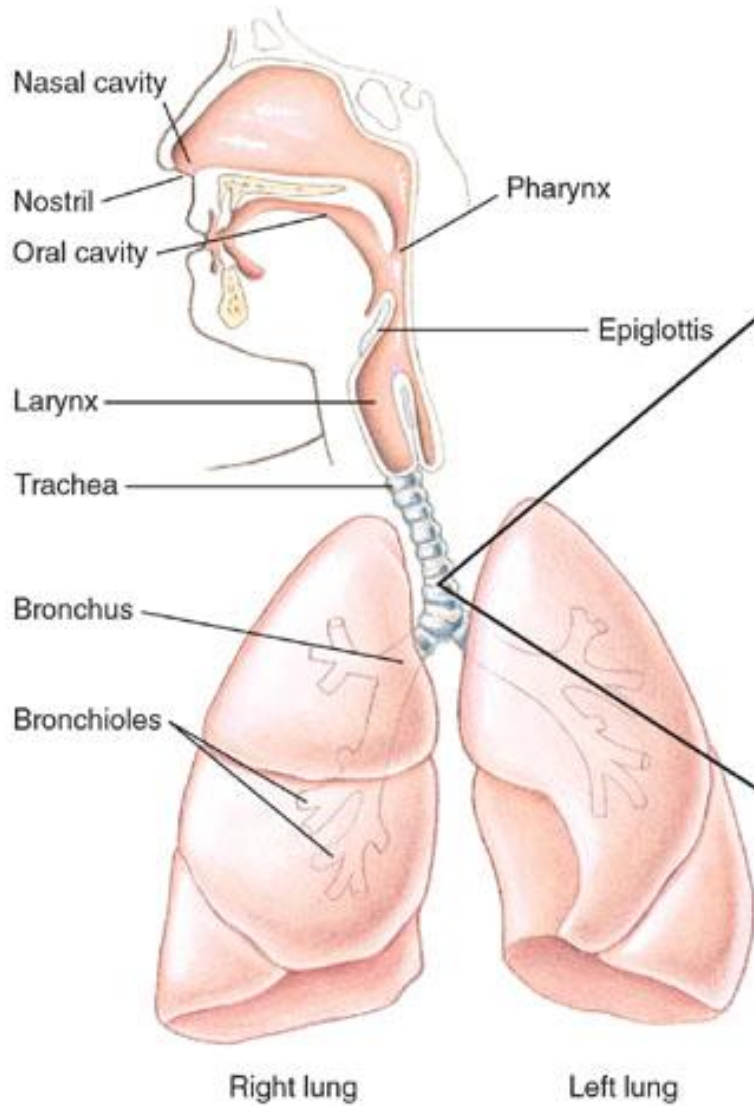
Chemical defenses

- Sebaceous secretions
- Lysozyme, an enzyme that hydrolyzes the cell wall of bacteria, in tears
- High lactic acid & electrolyte concentration in sweat
- Skin's acidic pH
- Hydrochloric acid in stomach
- Digestive juices and bile of intestines
- Semen contains antimicrobial chemical
- Vagina has acidic pH

Physical & chemical barriers

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



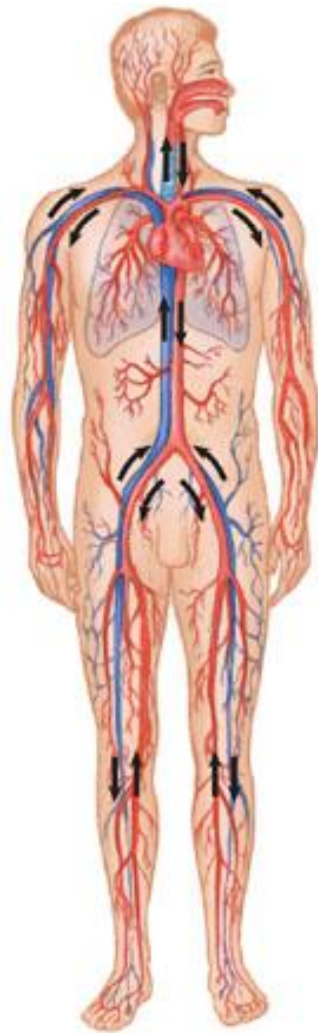


Genetic defenses

- Some hosts are genetically immune to the diseases of other hosts.
- Some pathogens have great specificity
- Some genetic differences exist in susceptibility

A healthy immune system is responsible for

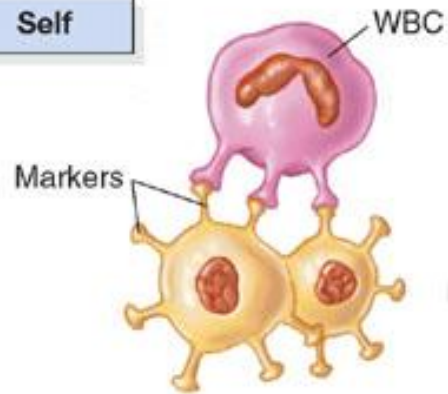
1. Surveillance of the body
2. Recognition of foreign material
3. Destruction of entities deemed to be foreign



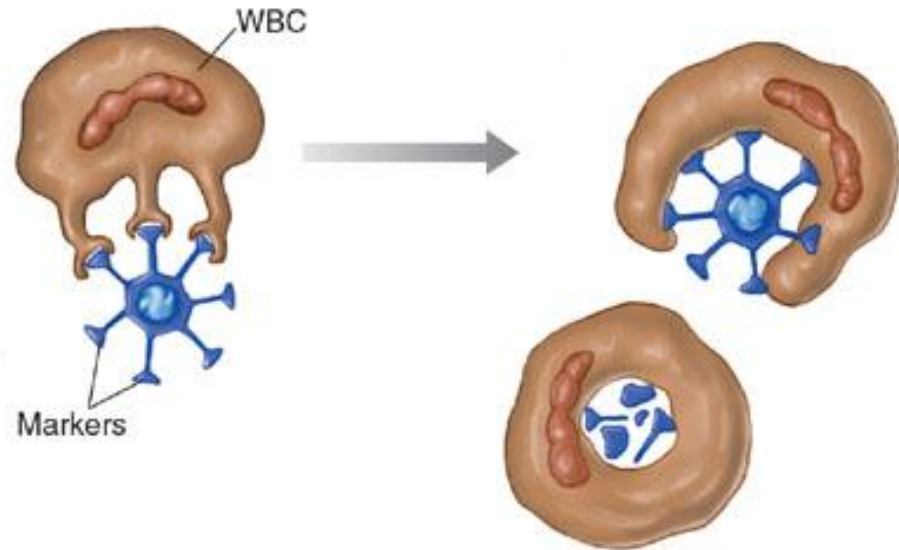
Surveillance

All body compartments are screened by circulating WBCs.

Self



Nonself

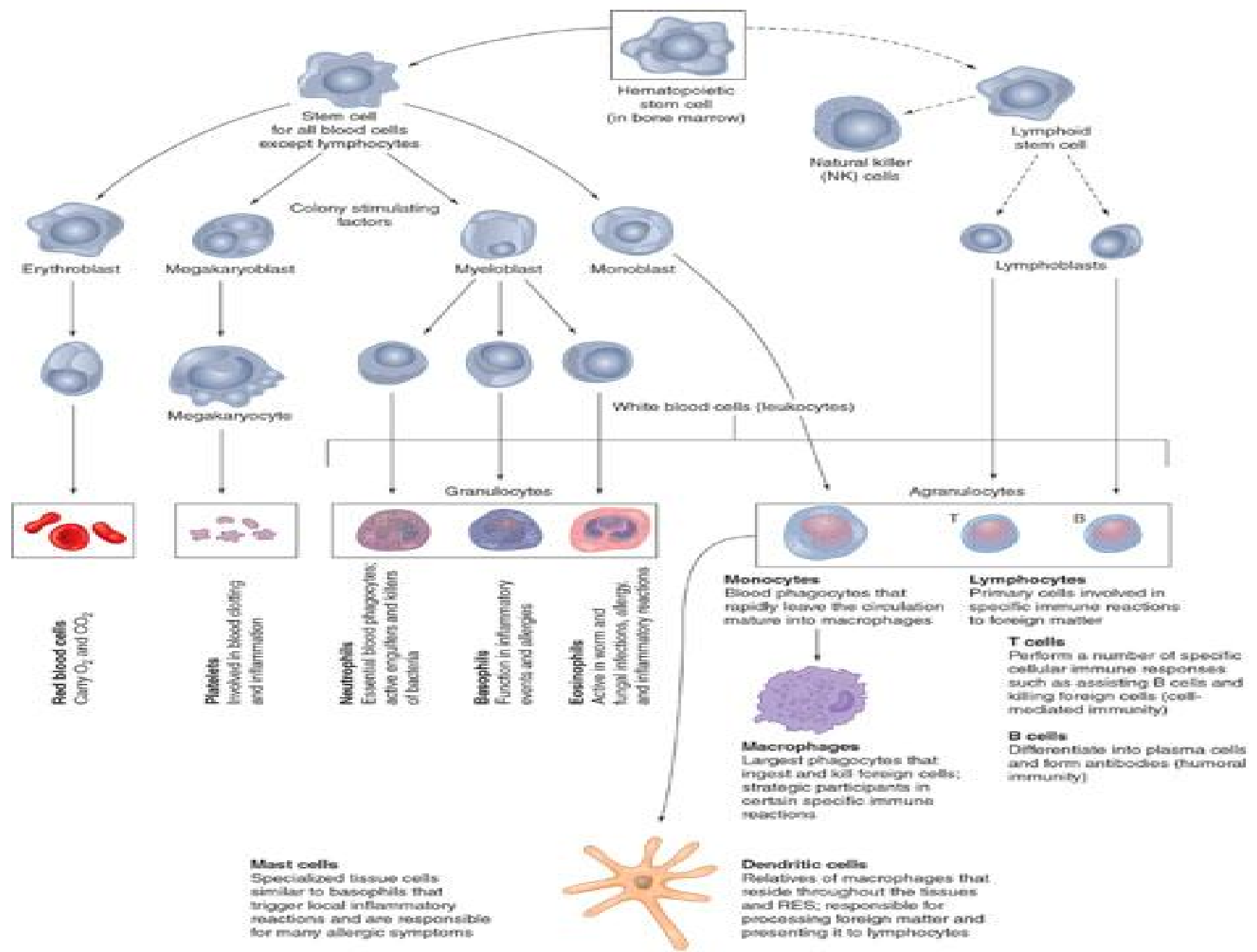


Detection and Recognition

Destruction

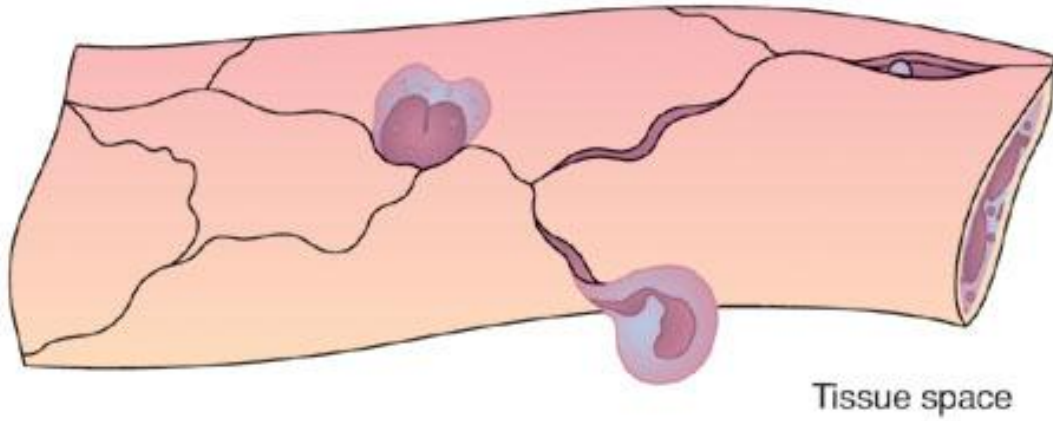
Leukocytes

- Neutrophils- 55-90% - lobed nuclei with lavender granules; phagocytes
- Eosinophils – 1-3% - orange granules & bilobed nucleus; destroy eucaryotic pathogens
- Basophils, mast cells – 0.5% constricted nuclei, dark blue granules; release potent chemical mediators
- Lymphocytes – 20-35% - large nucleus B & T cells involved in the specific immune response
- Monocytes, macrophages – 3-7%- large nucleus; phagocytic



Characteristics of leukocytes

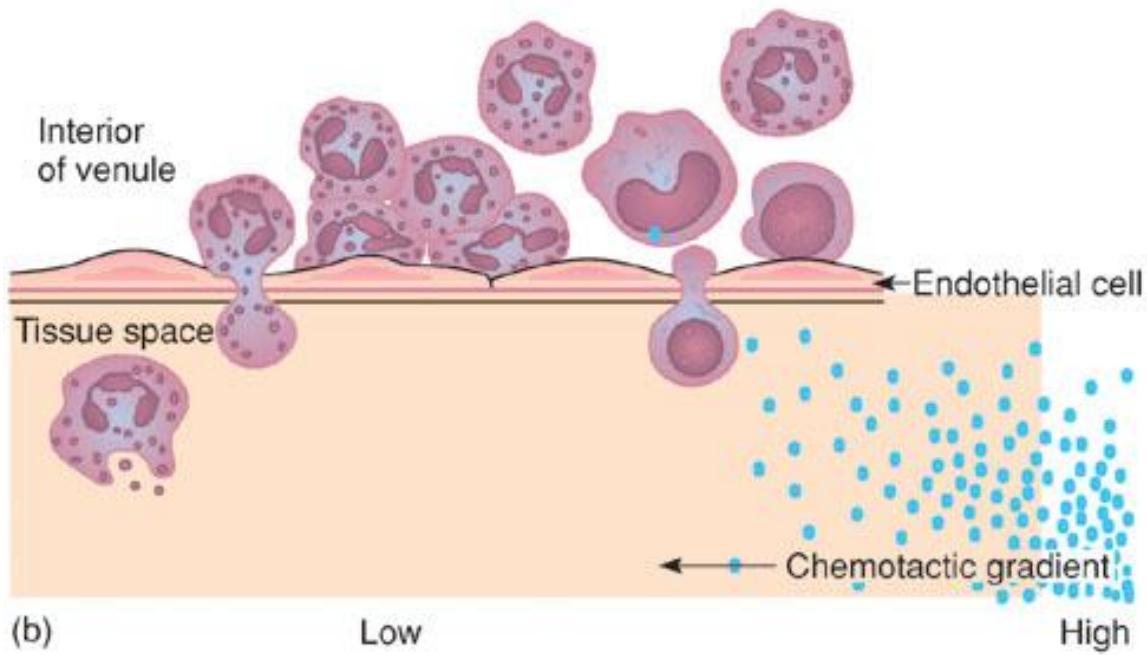
- Diapedesis – migration of cells out of blood vessels into the tissues
- Chemotaxis – migration in response to specific chemicals at the site of injury or infection



(a)



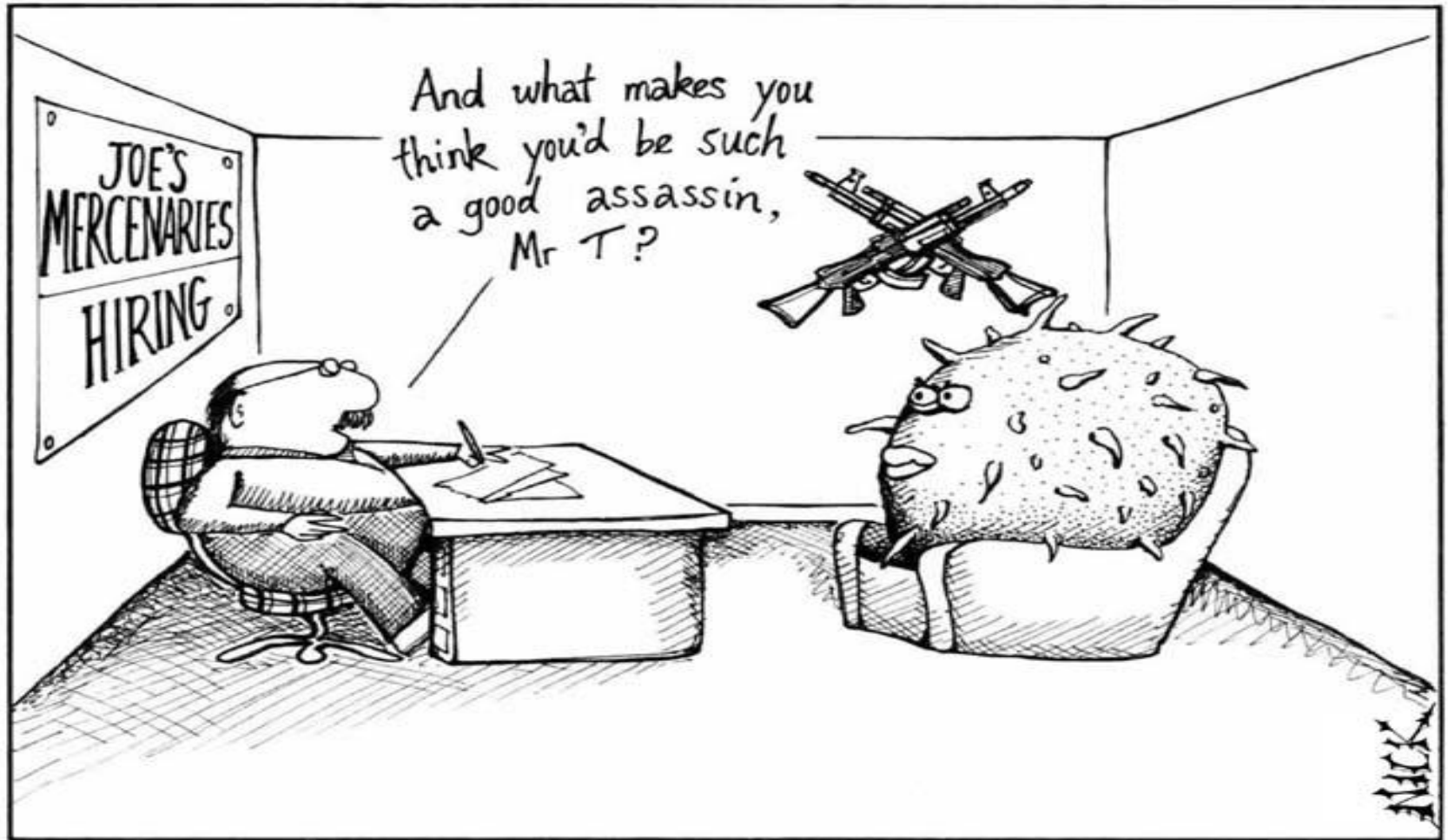
(c)



(b)

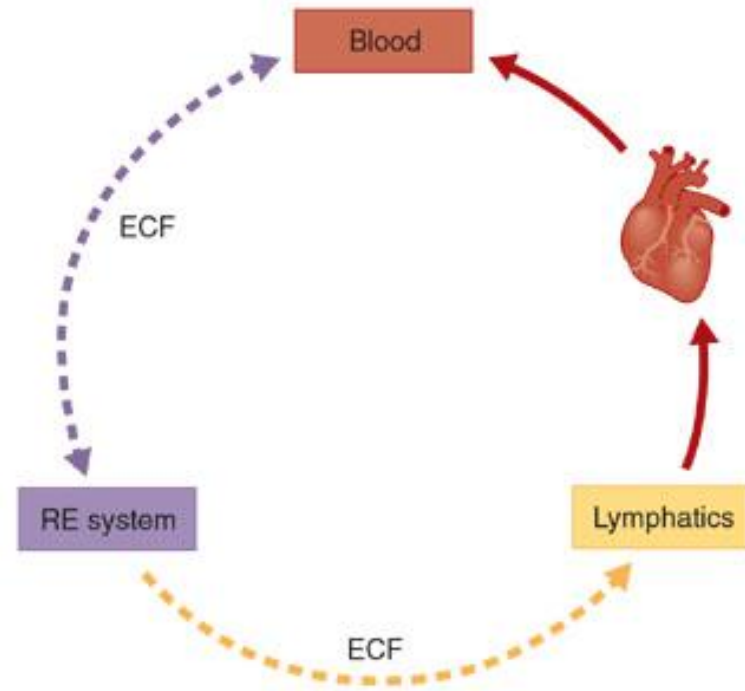
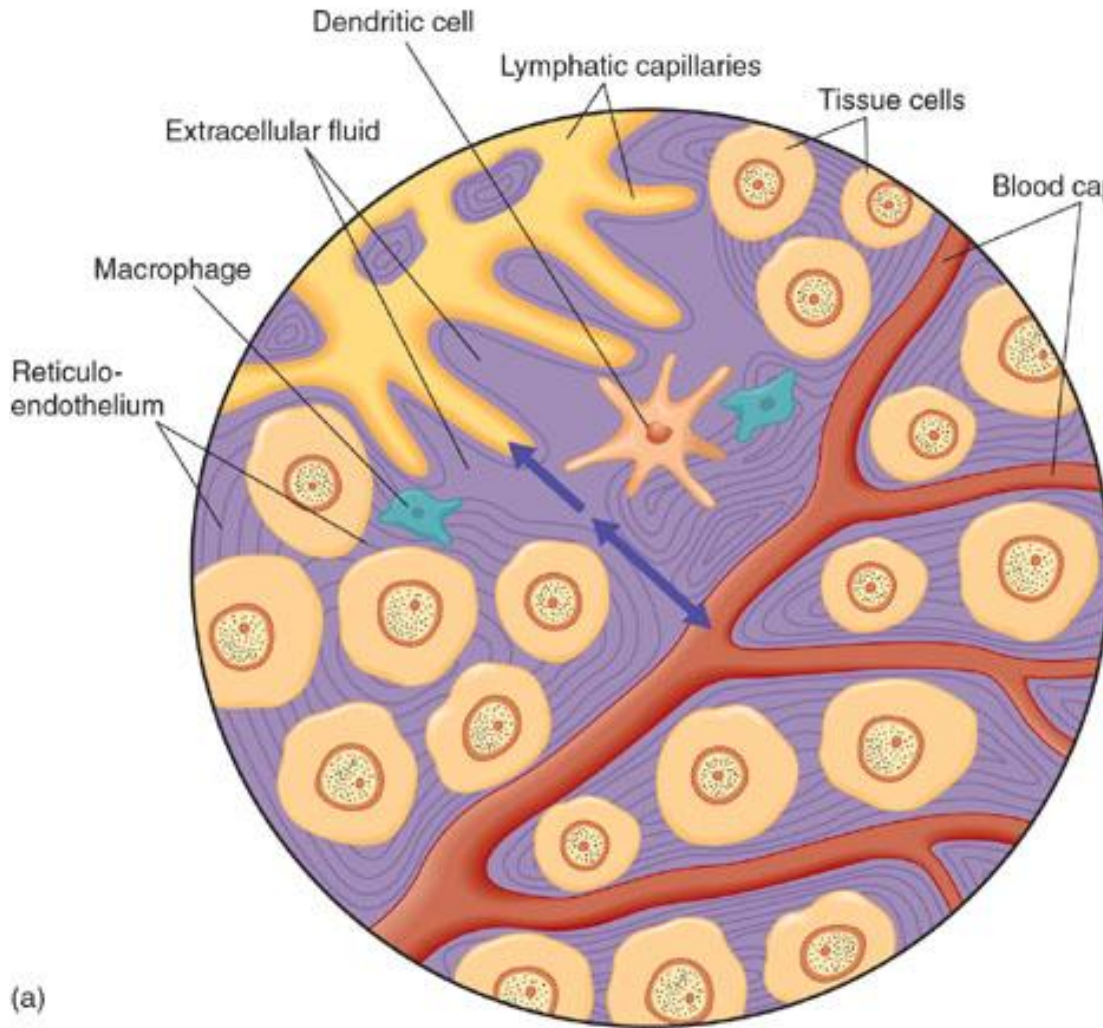
Lymphatic system

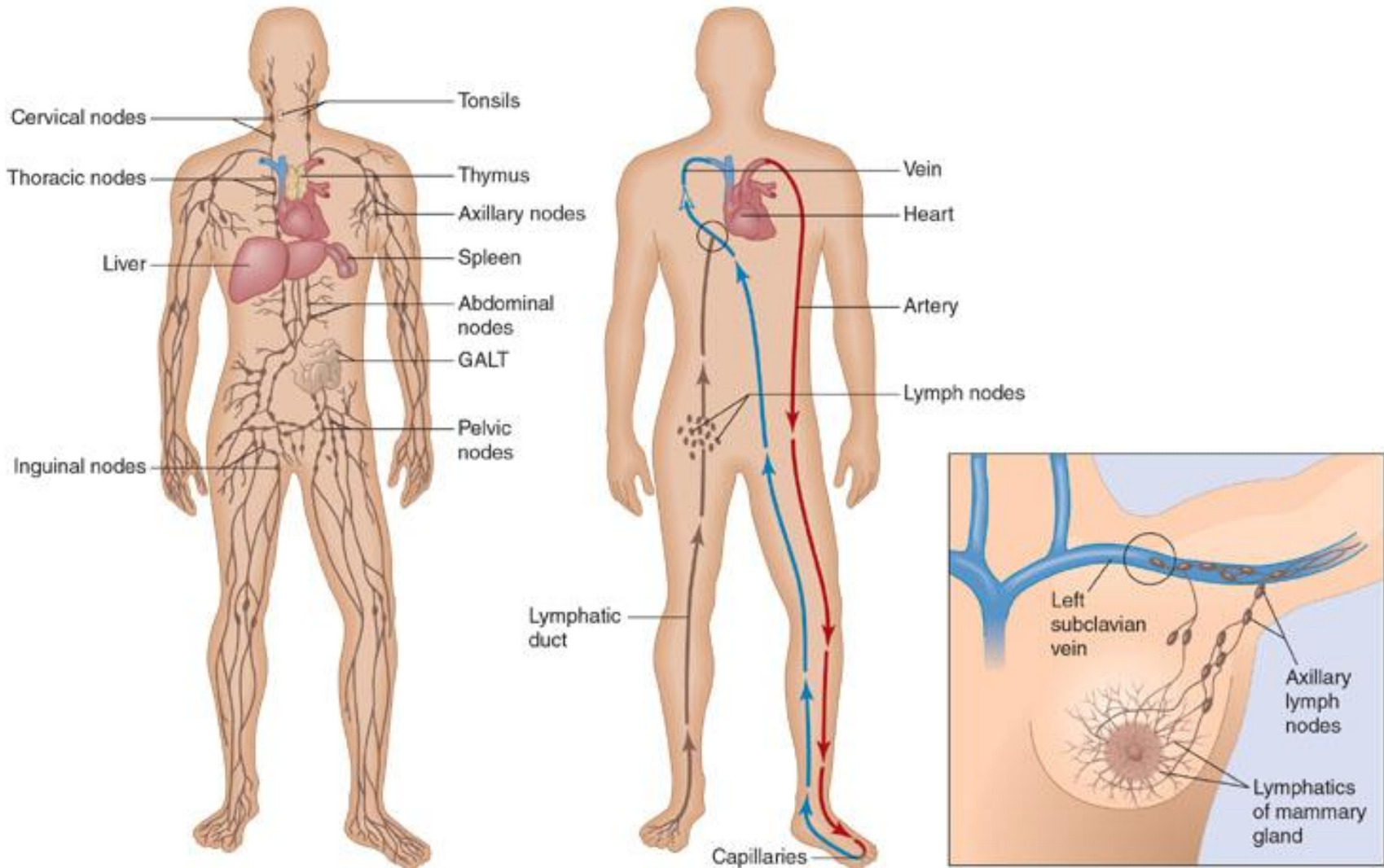
1. Provides an auxiliary route for return of extracellular fluid to the circulatory system
2. Acts as a drain-off system for the inflammatory response
3. Renders surveillance, recognition, and protection against foreign material



As each disease is finally eradicated, redundant lymphocytes increasingly find themselves looking for other work.

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.





(a) The lymphatic system consists of a branching network of vessels which extend into most body areas. Note the higher density of lymphatic vessels in the "dead-end" areas of the hands, feet, and breast, which are frequent contact points for infections. Other lymphatic organs include the lymph nodes, spleen, gut-associated lymphoid tissue (GALT), the thymus gland, and the tonsils.

(b) Comparison of the generalized circulation of the lymphatic system and the blood. Although the lymphatic vessels parallel the regular circulation, they transport in only one direction unlike the cyclic pattern of blood. Direct connection between the two circulations occurs at points near the heart where large lymph ducts empty their fluid into veins (circled area).

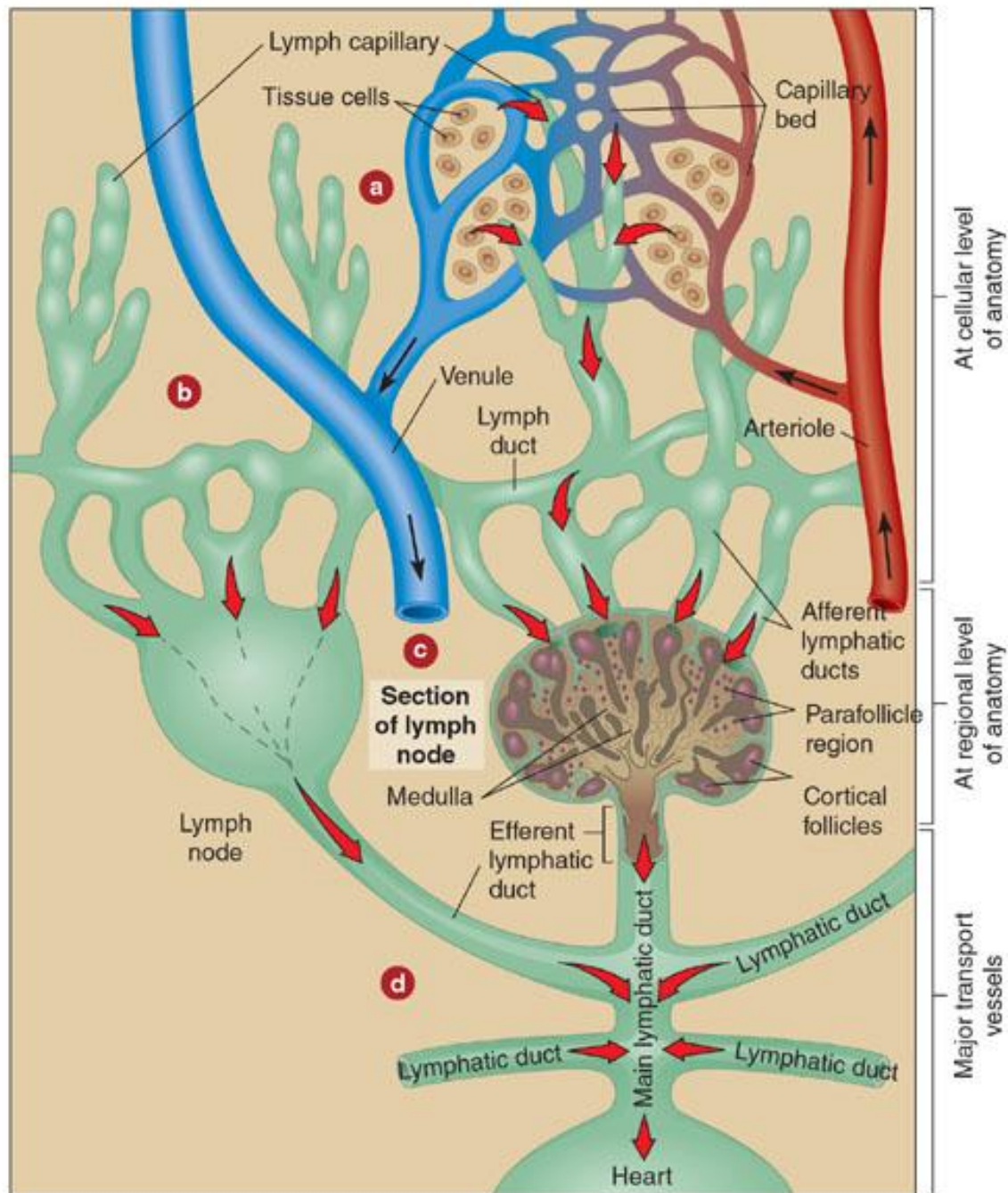
(c) Close-up to indicate a chain of lymph nodes near the axilla and breast and another point of contact between the two circulations (circled area).

(a) The finest level of lymphatic circulation begins with blind capillaries that pick up fluid, white blood cells, and microbes or other foreign matter from the surrounding tissues and transport this liquid mixture (lymph) away from the extremities via a system of small ducts.

(b) The ducts carry lymph into a circuit of larger ducts that ultimately flow into clusters of specialized filtering organs, the lymph nodes.

(c) The center diagram shows a section through a lymph node to reveal the afferent ducts draining into sinuses that house several types of white blood cells, primarily T lymphocytes, B lymphocytes, macrophages, and dendritic cells. Here, foreign material is filtered out, processed, and becomes the focus of various immune responses.

(d) Lymph continues to trickle from the lymph nodes via efferent ducts into a system of larger drainage vessels, which ultimately connect with large veins near the heart. In this way, cells and products of immunity continually enter the regular circulation.



At cellular level of anatomy

At regional level of anatomy

Major transport vessels

Lymphatic fluid

- Lymph is a plasmalike liquid carried by lymphatic circulation
- Formed when blood components move out of blood vessels into extracellular spaces
- Made up of water, dissolved salts, 2-5% proteins
- Transports white blood cells, fats, cellular debris & infectious agents

Lymph nodes

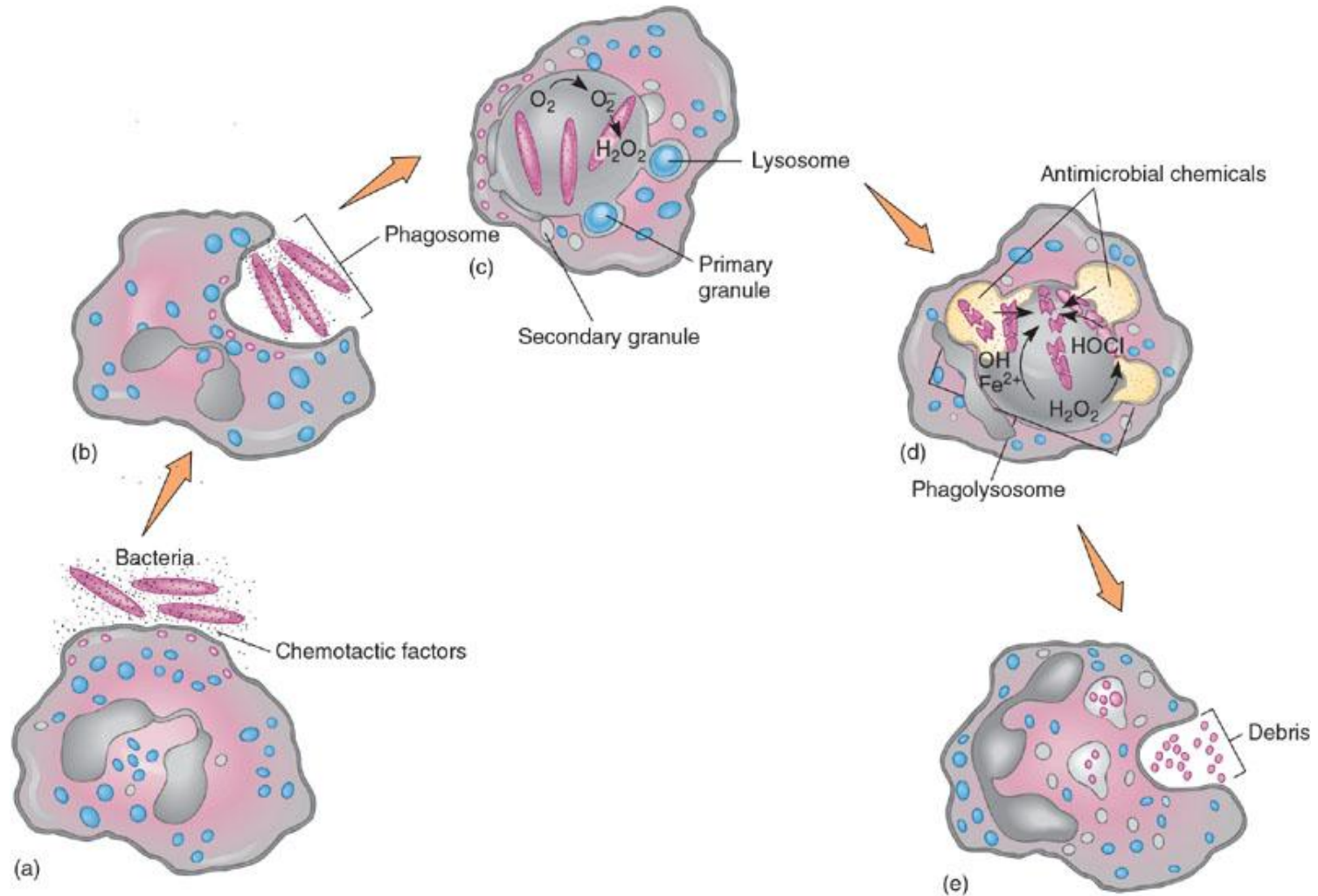
- Small, encapsulated, bean-shaped organs stationed along lymphatic channels & large blood vessels of the thoracic and abdominal cavities
- Houses two cellular types: lymphocytes and macrophages

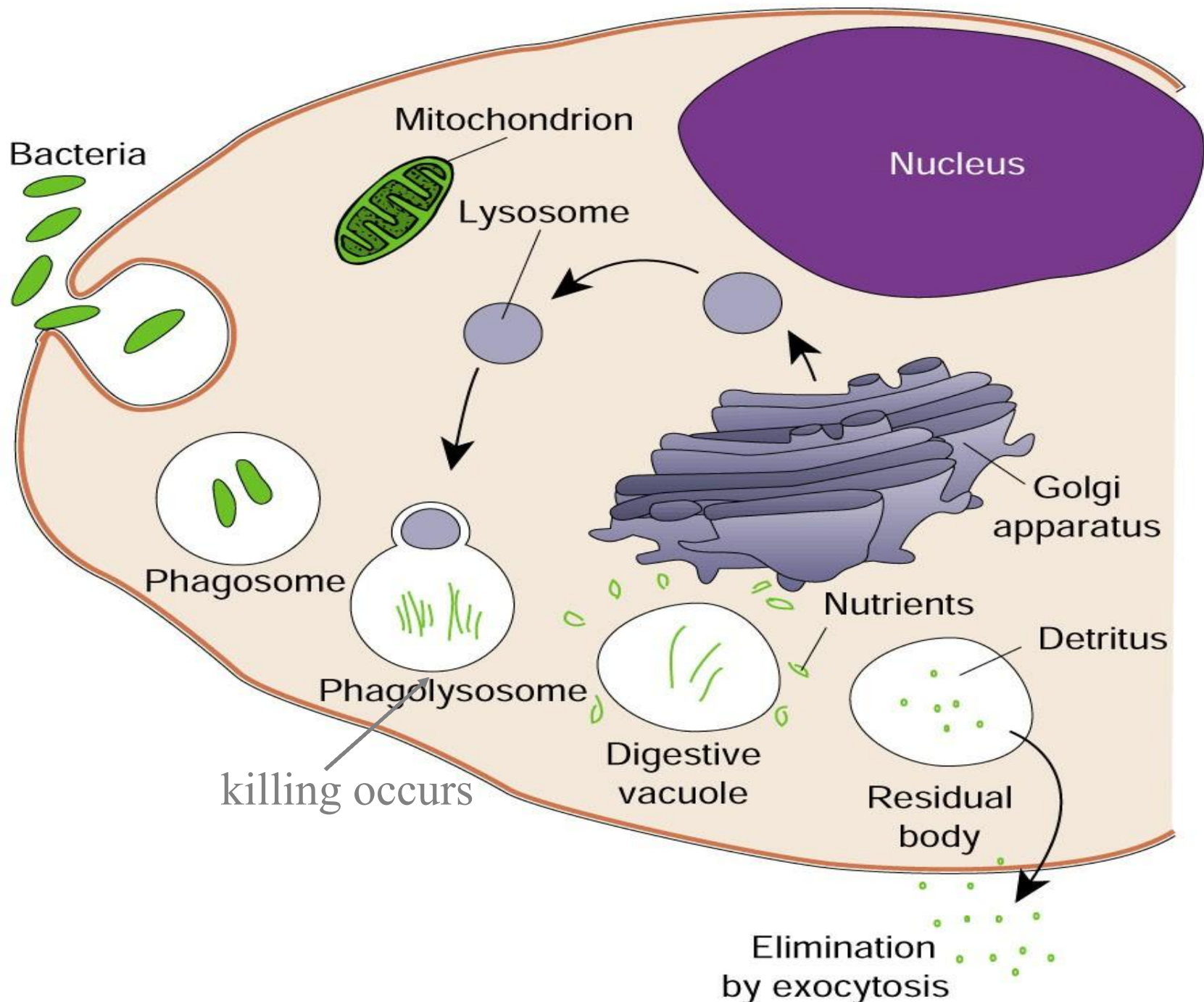
Activities of phagocytes

1. To survey tissue compartments & discover microbes, particulate matter & dead or injured cells
2. To ingest and eliminate these materials
3. To extract immunogenic information from foreign matter

Phases of phagocytosis

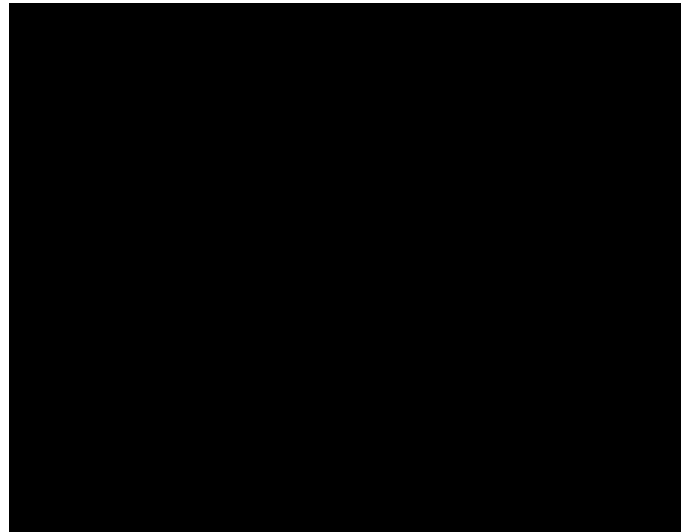
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.





[Video](#)

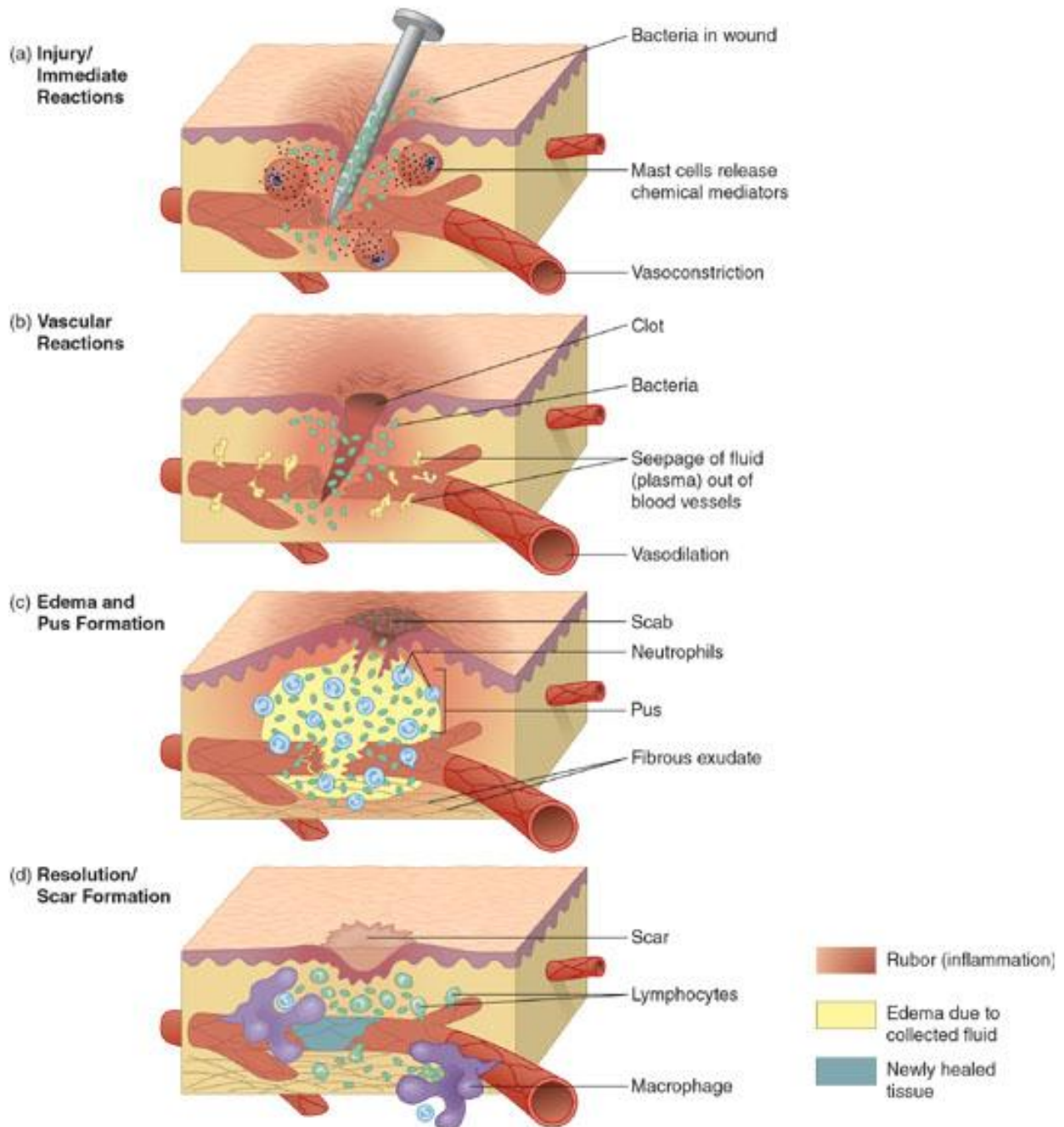
How phagocytes move in to kill...



Movie Clip

Stages of inflammation

1. Blood vessels dilate in response to chemical mediators and cytokines
2. Edema swells tissues, helping prevent spread of infection
3. WBC's, microbes, debris and fluid collect to form pus
4. Pyrogens may induce fever
5. Macrophages and neutrophils engage phagocytosis



Inflammation

- response to tissue injury
 - can be caused by pathogen or physical trauma
- cardinal signs
 - redness
 - warmth
 - pain
 - swelling
 - altered function

[Video 1](#)

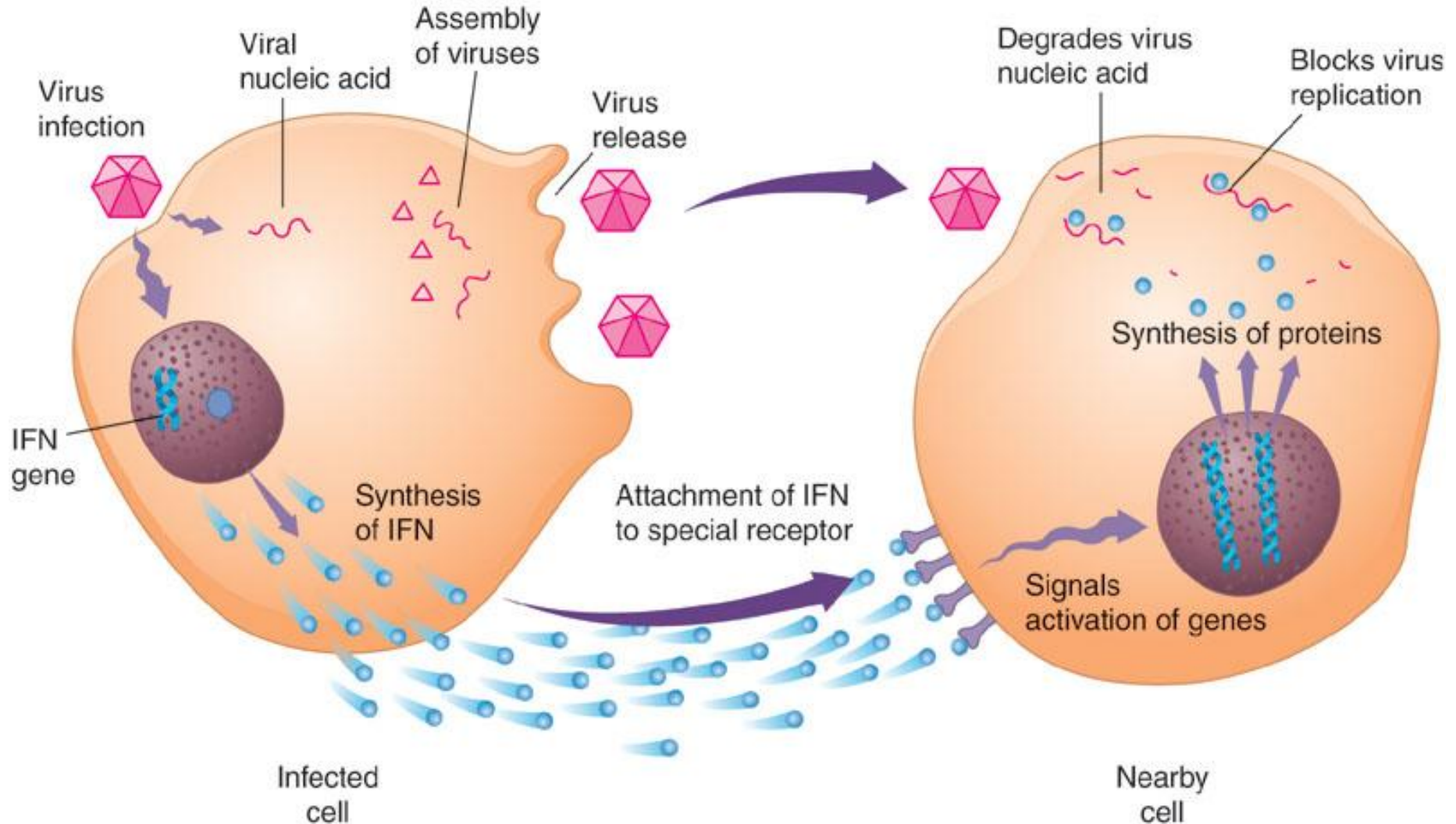
[Video 2](#)

Interferon

- Small protein produced by certain cells
 - Alpha interferon- lymphocytes & macrophages
 - Beta interferon – fibroblasts & epithelial cells
 - Gamma interferon – T cells
- Produced in response to viruses, RNA, immune products, and various antigens
- Bind to cell surfaces and induce expression of antiviral proteins
- Inhibit expression of cancer genes

Interferon

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Interferon Action

[Video : Interferon](#)

Complement

- Consists of 26 blood proteins that work in concert to destroy bacteria and viruses
- Complement proteins are activated by cleavage
- Classical pathway
- Alternative pathway

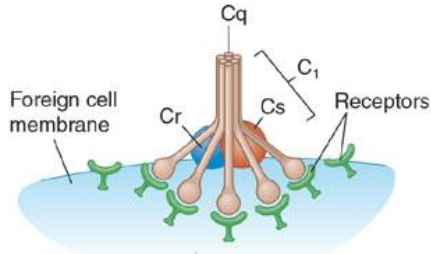
Complement Activation

Video : Complement

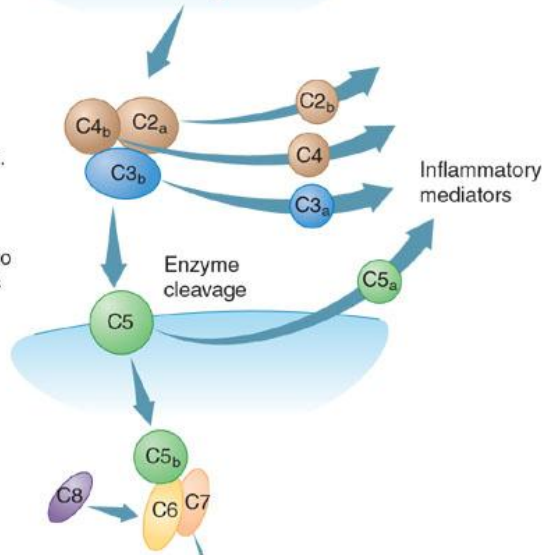
Complement

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

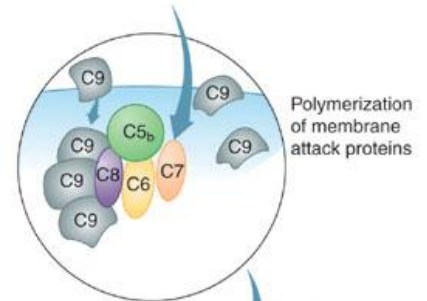
(a) **Initiation.** The classical pathway begins when C1 components bind to receptors on a foreign cell membrane.



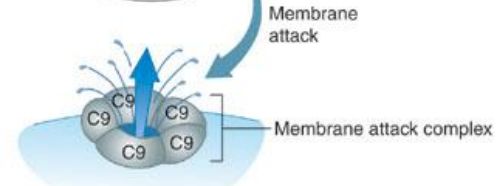
(b) **Amplification and cascade.** The C1 complex is an enzyme that activates a second series of components, C4 and C2. When these have been enzymatically cleaved into separate molecules, they become a second enzyme complex that activates C3. At this same site, C3 binds to C5 and cleaves it to form a product that is tightly bound to the membrane.



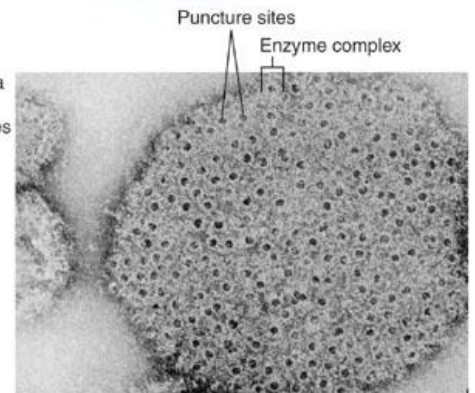
(c) **Polymerization.** C5_b is a reactive site for the final assembly of an attack complex. In series, C6, C7, and C8 aggregate with C5 and become integrated into the membrane. They form a substrate upon which the final component, C9 can bind. Up to 15 of these C9 units ring the central core of the complex.



(d) **Membrane attack.** The final product of these reactions is a large, donut-shaped enzyme that punctures small pores through the membrane, leading to cell lysis.



(e) An electron micrograph (187,000 \times) of a cell reveals multiple puncture sites over its surface. The lighter, ringlike structures are the actual enzyme complex.



Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

TABLE 14.2

Substances That Activate the Complement Pathways

Activators in the Classical Pathways	Activators in the Alternative Pathway
Complement-fixing antibodies: IgG, IgM	Cell wall components; e.g., yeast and bacteria
Bacterial lipopolysaccharide	Viruses; e.g., influenza virus
Pneumococcal C-reactive protein	Parasites; e.g., <i>Schistosoma</i>
Retroviruses	Fungi; e.g., <i>Cryptococcus</i>
Polynucleotides	Some tumor cells
Mitochondrial membranes	X-ray opaque media, dialysis membranes

Fever

- An adjunct to inflammation
- Abnormally elevated body temperature
- Initiated when a circulating substance resets the hypothalamic thermostat to a higher point
- Exogenous pyrogen- ex. LPS
- Endogenous pyrogen ex. TNF, IL-1

Benefits of Fever

- Inhibits multiplication of sensitive microbes
- Impedes the nutrition of bacteria by iron starvation
- Increases host metabolism and stimulates immune response including phagocytosis and specific immune response

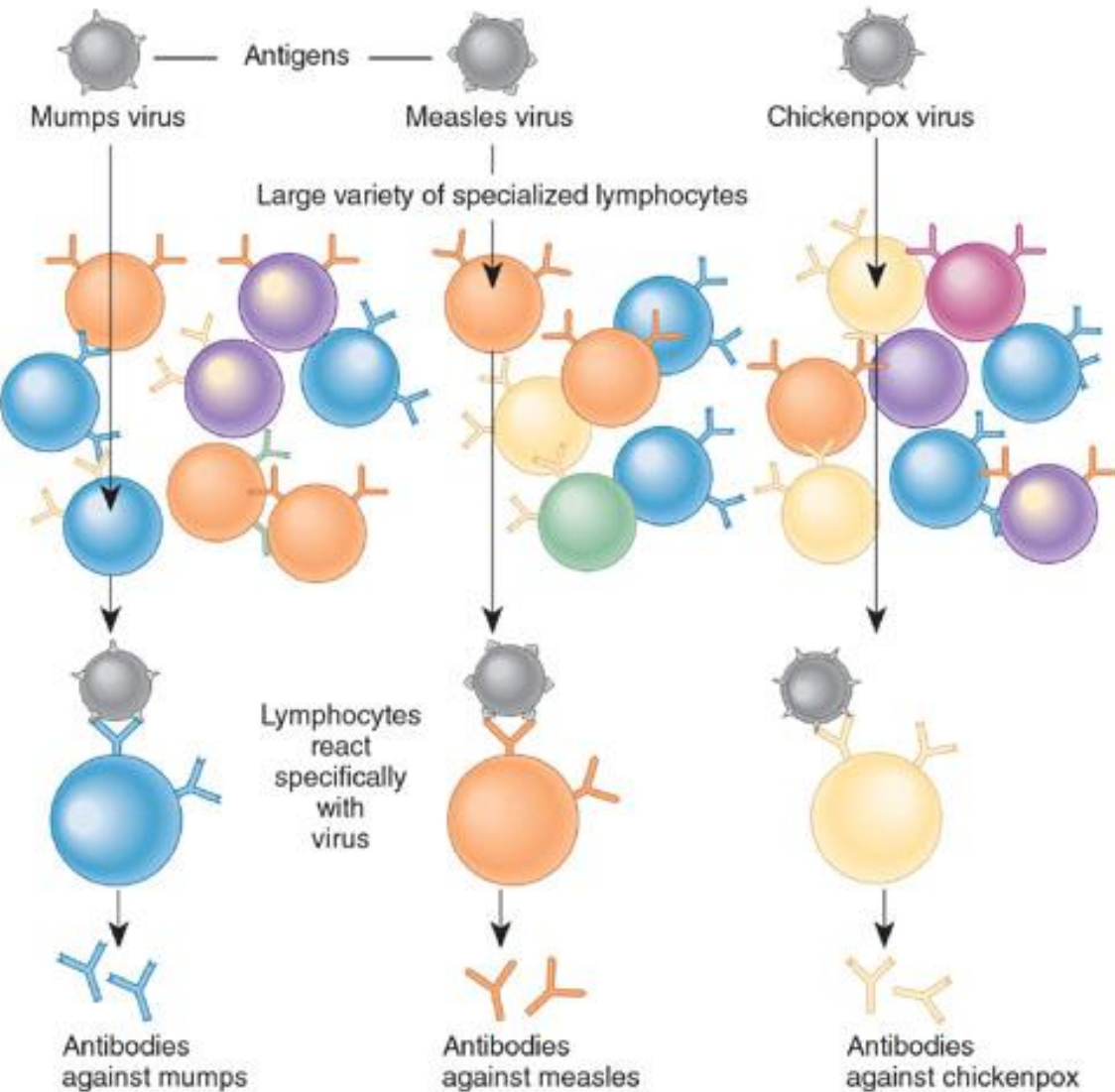
- **1st line of defense -**
 - intact skin
 - mucous membranes & their secretions
- **2nd line of defense -**
 - phagocytic white blood cells *nonspecific*
 - inflammation -complement
 - fever -interferon

- **3rd line of defense-**
 - B & T lymphocytes
specific
 - antibodies

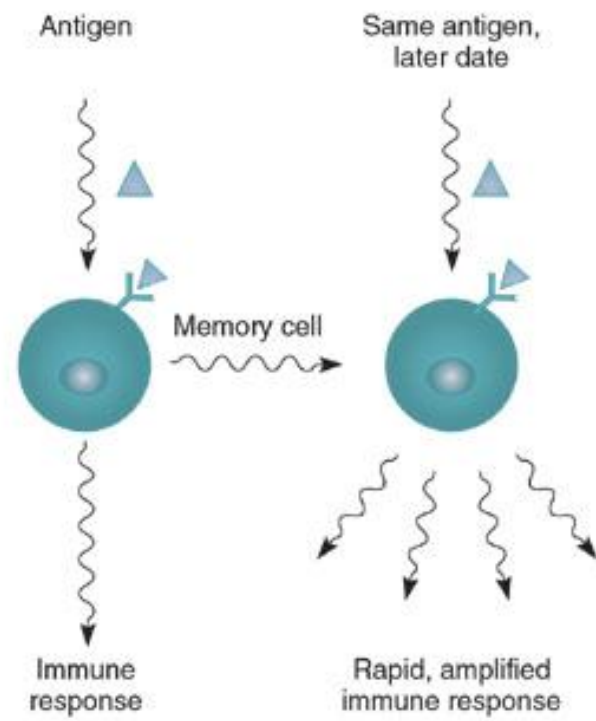
Specific immunities

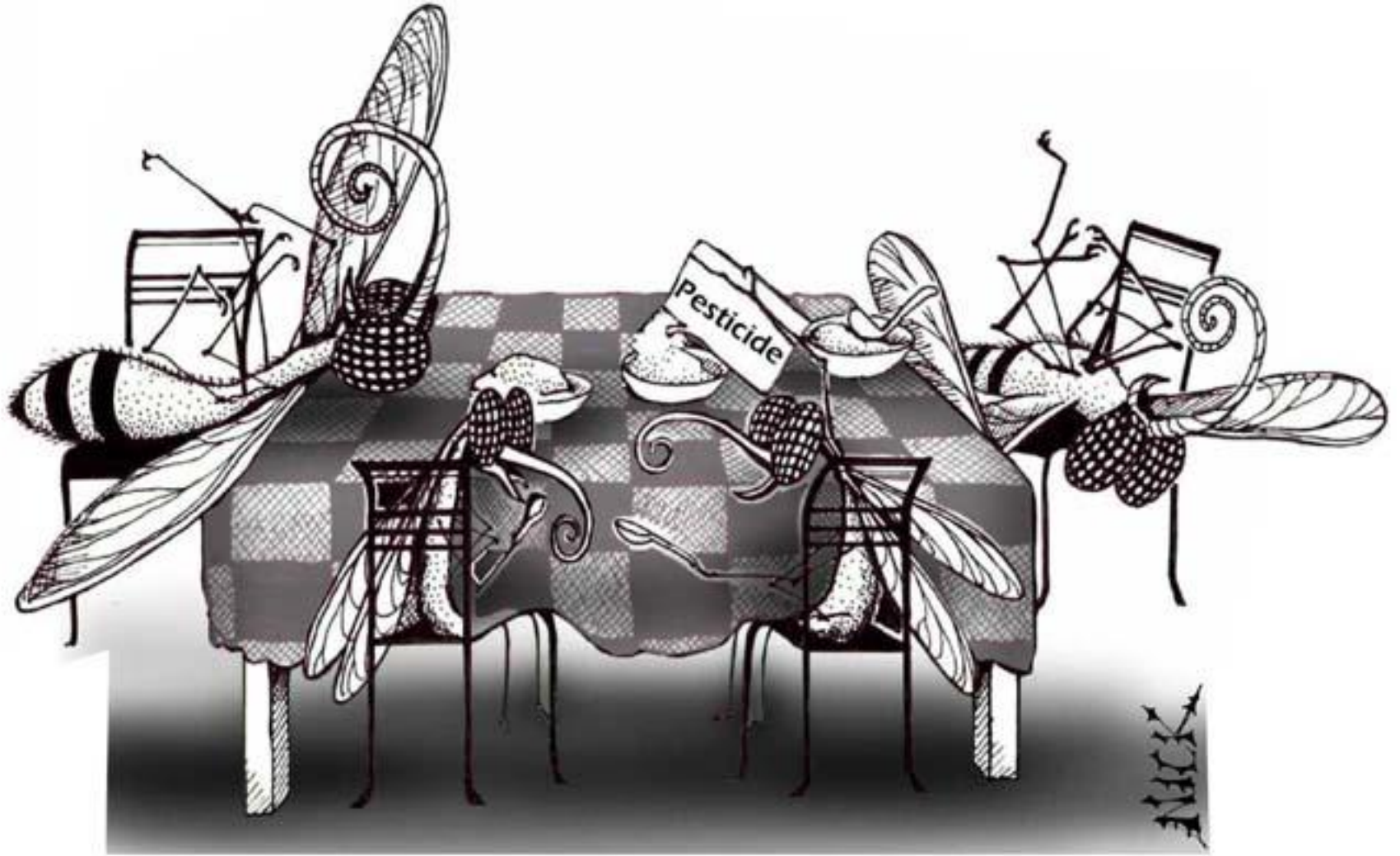
- B and T lymphocytes
- Specificity and memory

(a) **Specificity:** Viruses and other infectious agents contain antigen molecules that are specific to a single type of lymphocyte. One result of binding will be the production of virus-specific antibodies.



(b) **Memory:** First contact with antigen creates a unique programmed memory cell that provides quick recall upon second and other future contacts with that antigen.





“That’s the trouble with the older generation—they’re too intolerant.”