

# Chapter 24

## The Immune System 免疫系統

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PowerPoint Lectures for

***Biology: Concepts and Connections, Fifth Edition***

*– Campbell, Reece, Taylor, and Simon*

# Learning Objectives

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Understand:

- how **innate defenses** help our body act against infection.
- how **acquired immunity** plays its role in our immune responses.
- what common disorders of the immune system are.

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## An AIDS Uproar

- **Acquired immune deficiency syndrome (AIDS)**
  - Is epidemic throughout much of the world
- Thousands of people are infected every day

**40 million**

*people living with AIDS*

**3 million**

*died in 2003*

**5 million**

*newly infected in 2003*

**500,000**

*children under the age of  
15 who died in 2003*

- 
- **HIV**, the virus that causes AIDS, attacks the immune system
    - And eventually destroys the body's ability to fight infection



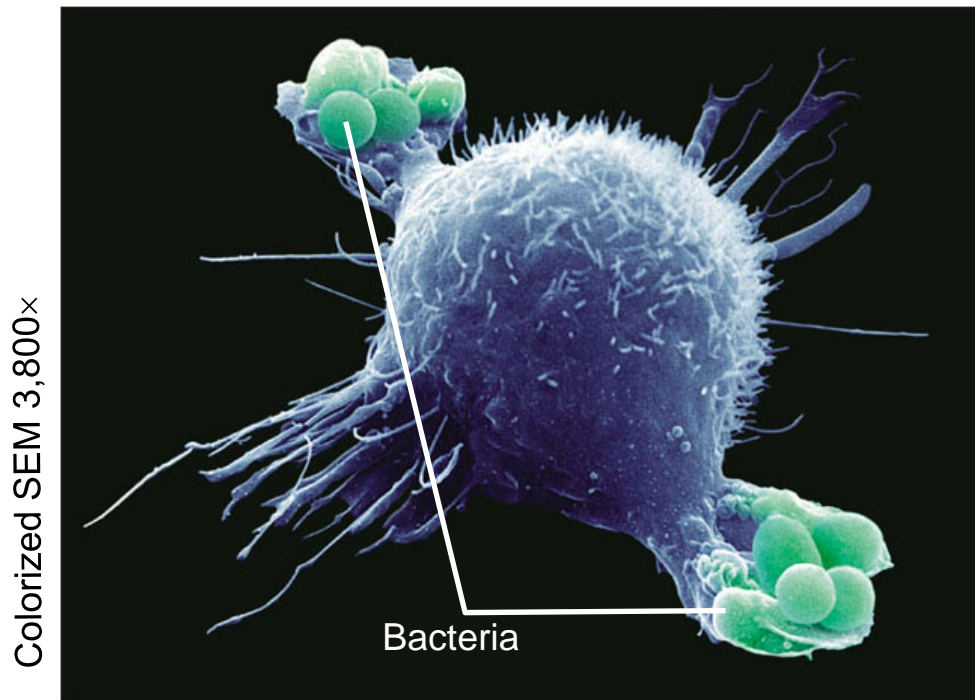
# Innate Defense Against Infection

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24.1 Innate defenses against infection include the skin and mucous membranes, phagocytic cells, and antimicrobial proteins

- Innate immunity (先天性免疫)
  - Is present and effective long before exposure to pathogens
    - 與生俱來。
    - 不需要病原菌刺激即存在。
    - 反應快速，但持續性低。
    - 專一性差，且無記憶性。

- 
- Microbes that breach the body's external defenses
    - Are engulfed and destroyed by **macrophages**

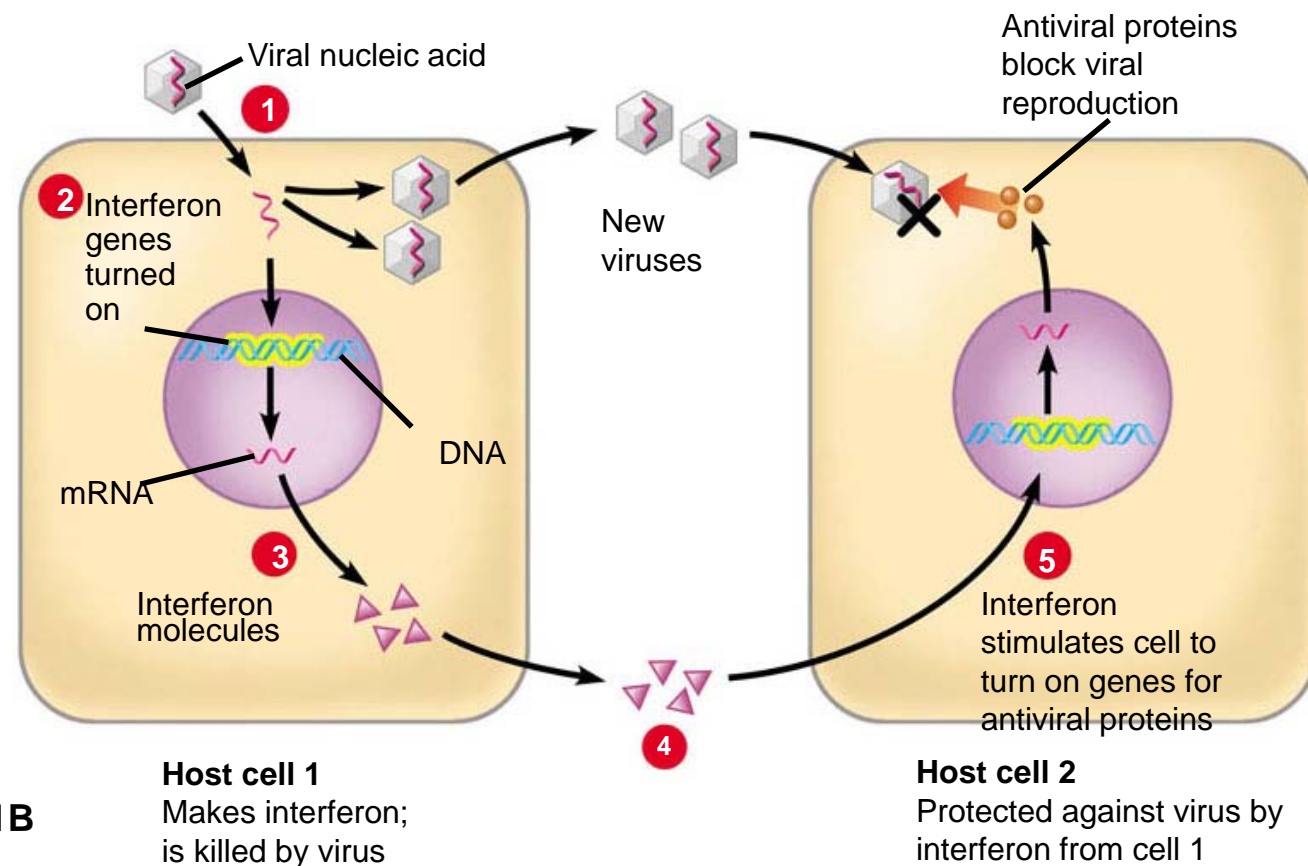


- An overview of animal immune system

<b><u>Innate immunity (24.1-3)</u></b> Response is the same whether or not pathogen has been previously encountered		<b><u>Acquired immunity (24.4-15)</u></b> Found only in vertebrates; previous exposure to pathogen enhances immune response
<b>External barriers</b>	<b>Internal defenses</b>	<ul style="list-style-type: none"> <li>•Antibodies (24.8-10)</li> <li>•Lymphocytes (24.11-14)</li> </ul>
<ul style="list-style-type: none"> <li>• Skin/exoskeleton</li> <li>• Secretions</li> <li>• Mucous membranes</li> </ul>	<ul style="list-style-type: none"> <li>• Phagocytic cells</li> <li>• NK cells</li> <li>• Defensive proteins</li> <li>• Inflammatory response (24.2)</li> </ul>	
<b>The lymphatic system (24.3)</b>		

Figure 24.1A

- **Interferons** are proteins produced by virus-infected cells
  - That help other cells resist viruses



**Figure 24.1B**

**Host cell 1**  
Makes interferon;  
is killed by virus

**Host cell 2**  
Protected against virus by  
interferon from cell 1



## 24.2 The inflammatory response mobilizes nonspecific defense forces

- Tissue damage triggers the inflammatory response

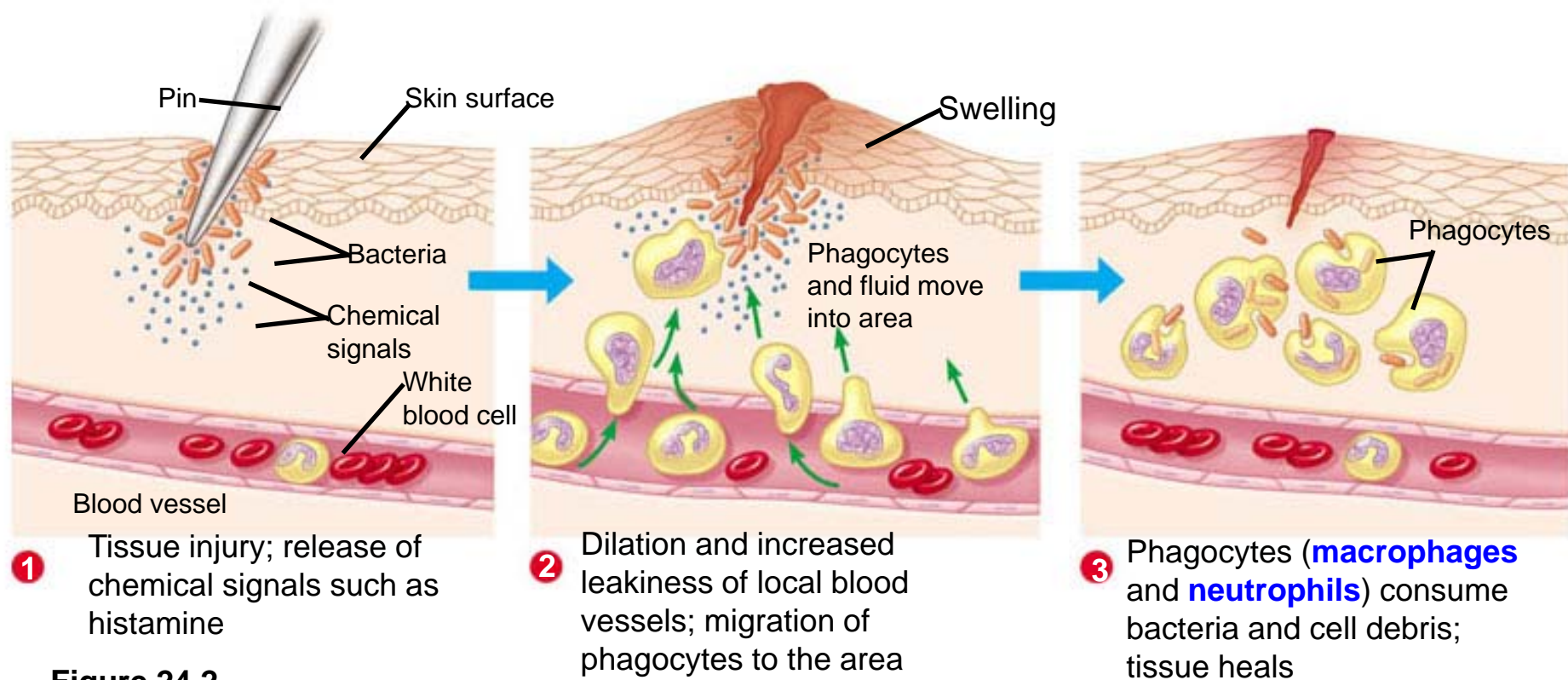


Figure 24.2

- 
- (Puposes) The inflammatory response
    - Can disinfect tissues, and
    - Can limit further infection from occurring
    - Can help heal the damaged tissues



Inflammation

## 24.3 The lymphatic system becomes a crucial battleground during infection

- The lymphatic system
  - Is a network of lymphatic vessels and organs

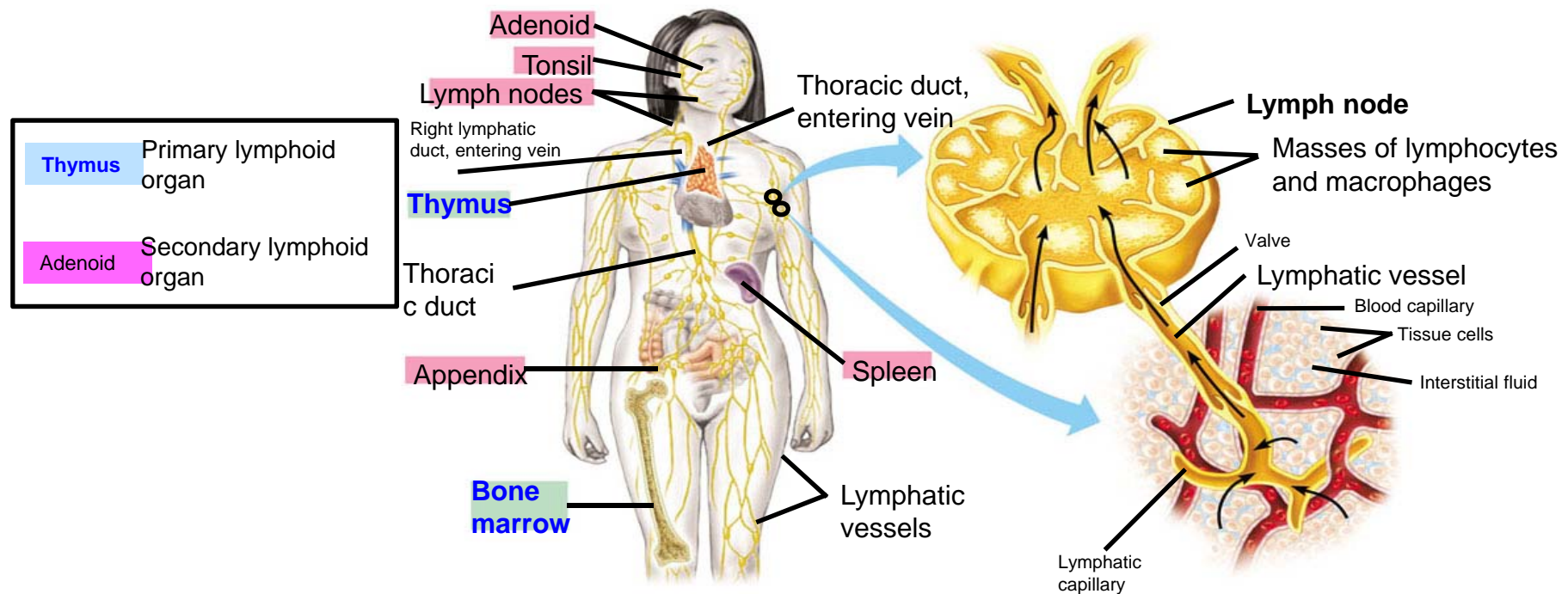


Figure 24.3

- 
- The vessels collect fluid from body tissues
    - And return it as lymph to the blood
  - Lymph organs such as the spleen and lymph nodes
    - Are packed with white blood cells that fight infections

Lymphatic system

= Lymphatic organs + lymphatic vessels + lymph

Circulation system

= Heart + blood vessels + blood

# Acquired Immunity (獲得性/後天性 免疫)

## 24.4 The immune response counters specific invaders

- Our immune system
  - Responds to foreign molecules called antigens (Ags)
- The immune system reacts to antigens
  - And “remembers” an invader

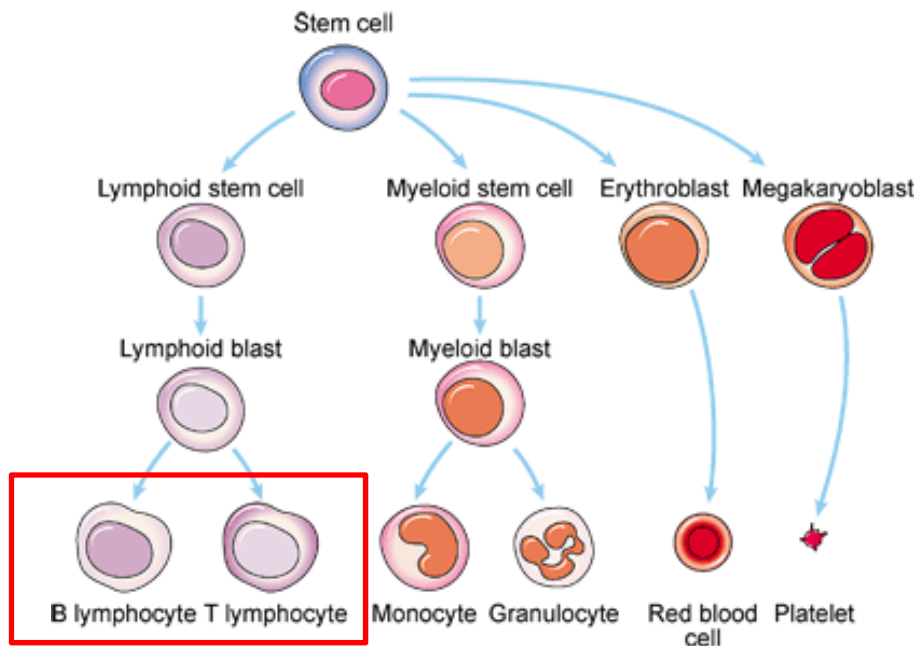
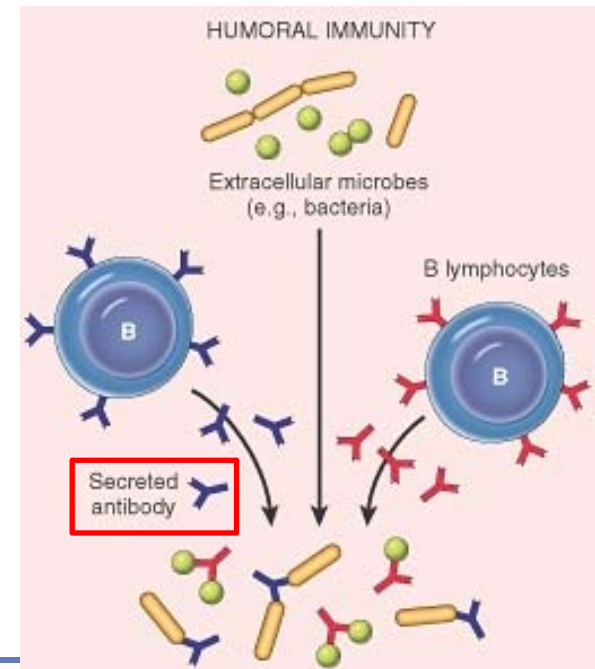


Diagram showing how blood cells are made  
© CancerHelp UK



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- We can temporarily acquire passive immunity
    - By receiving “premade” antibodies
  - Infection or vaccination
    - Triggers active immunity



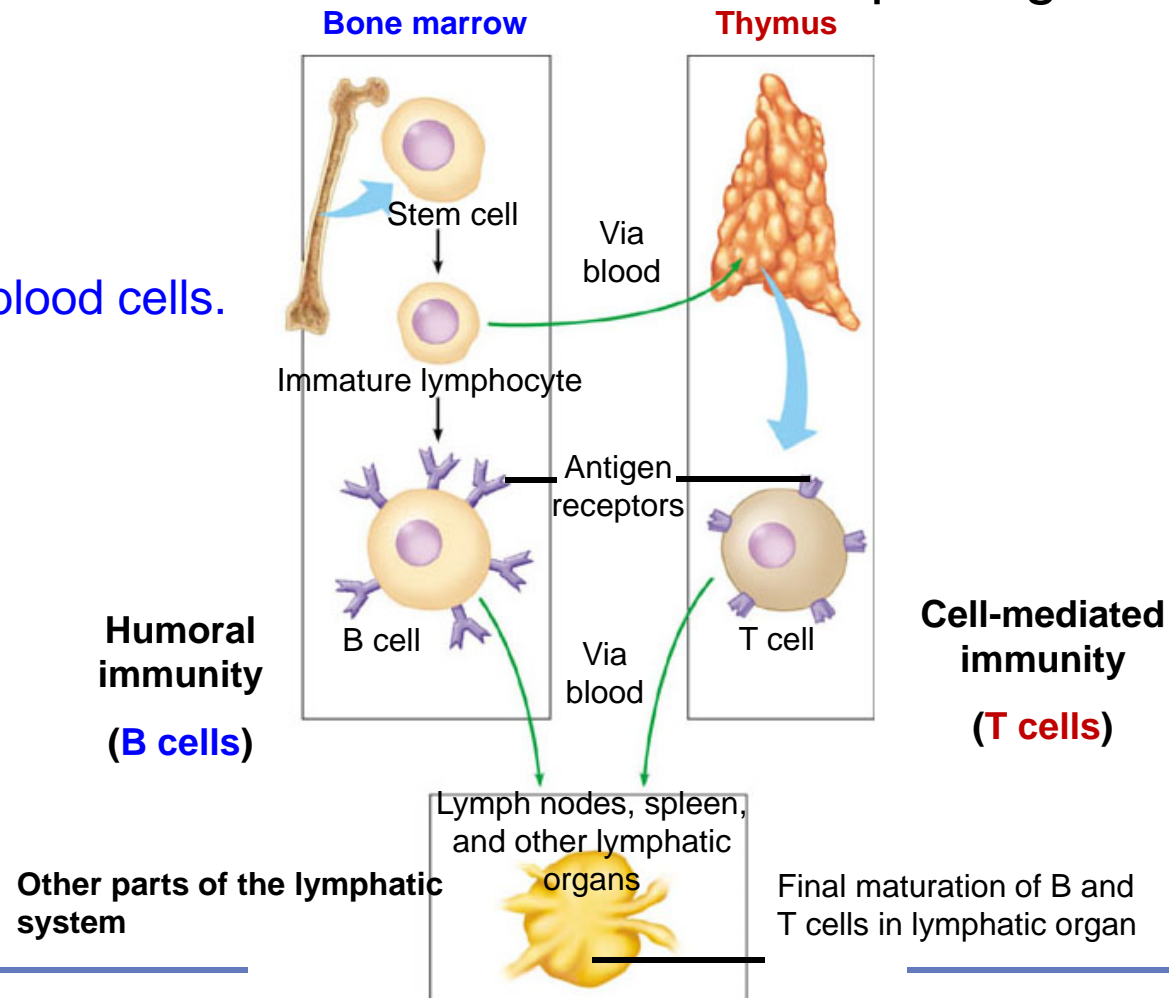
Figure 24.4

# 24.5 Lymphocytes mount a dual defense

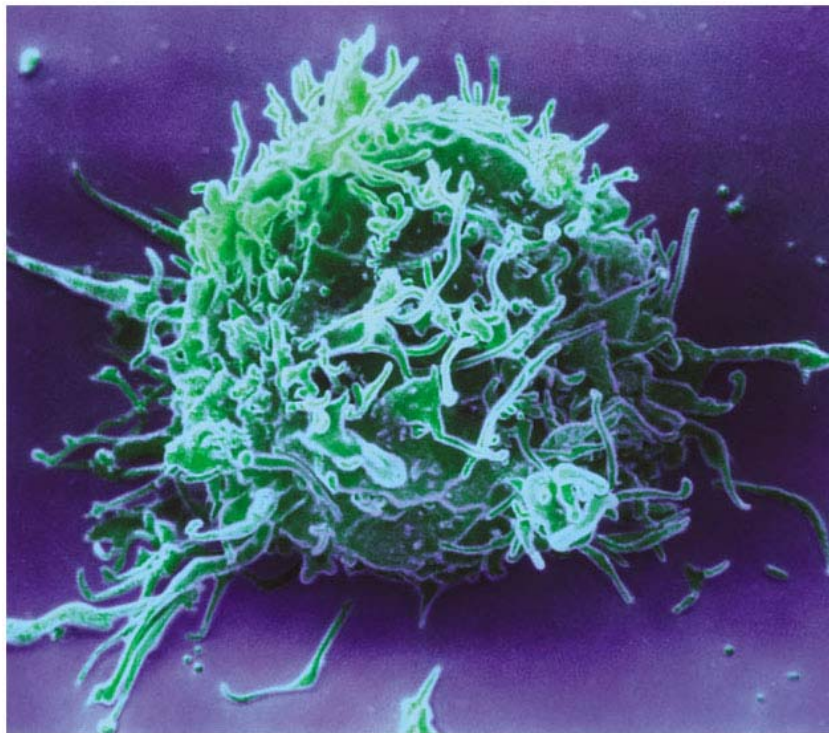
- Two kinds of lymphocytes carry out the immune response
  - B cells secrete antibodies that attack antigens
  - T cells attack cells infected with pathogens

Figure 24.5A

Bone marrow  
- The origin of ALL blood cells.



- 
- Millions of kinds of B cells and T cells, each with *different* membrane receptors
    - Wait in the lymphatic system, where they may respond to invaders



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Figure 24.5B



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## 24.6 Antigens have specific regions where antibodies bind to them

- Antigenic determinants ('epitopes')
  - Are the specific regions on an antigen to which antibodies bind

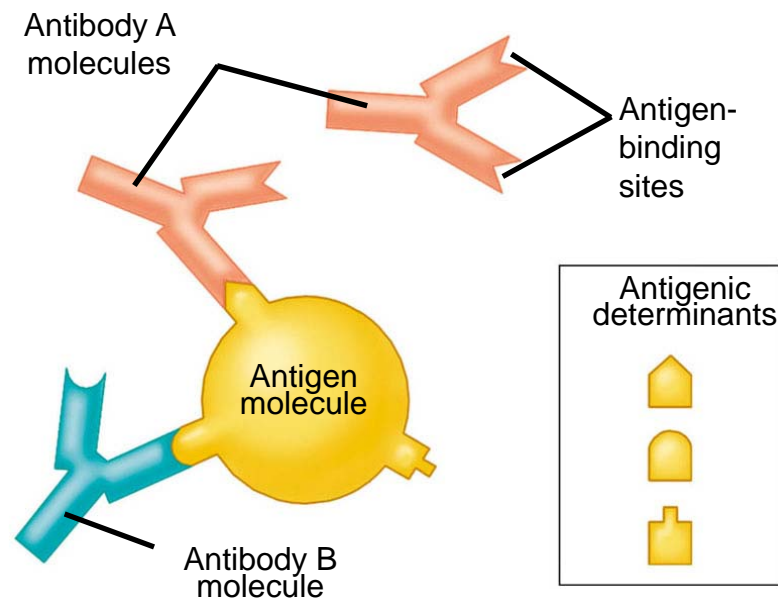


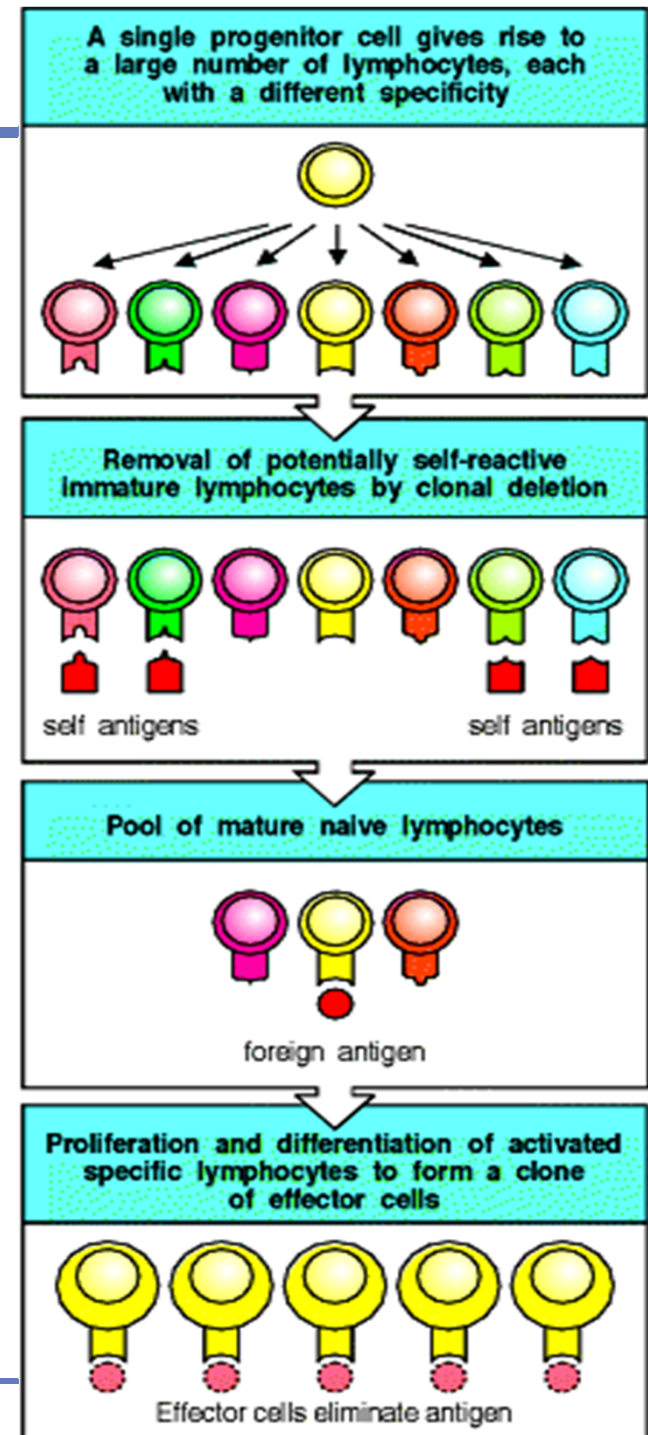
Figure 24.6

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## 24.7 Clonal selection musters defensive forces against specific antigens

- When an antigen enters the body
  - It activates only a small subset of lymphocytes with complementary receptors

- The selected lymphocyte cells multiply into **clones** of short-lived **effector cells**
  - Specialized for defending against the antigen that triggered the response



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## *The Steps of Clonal Selection*

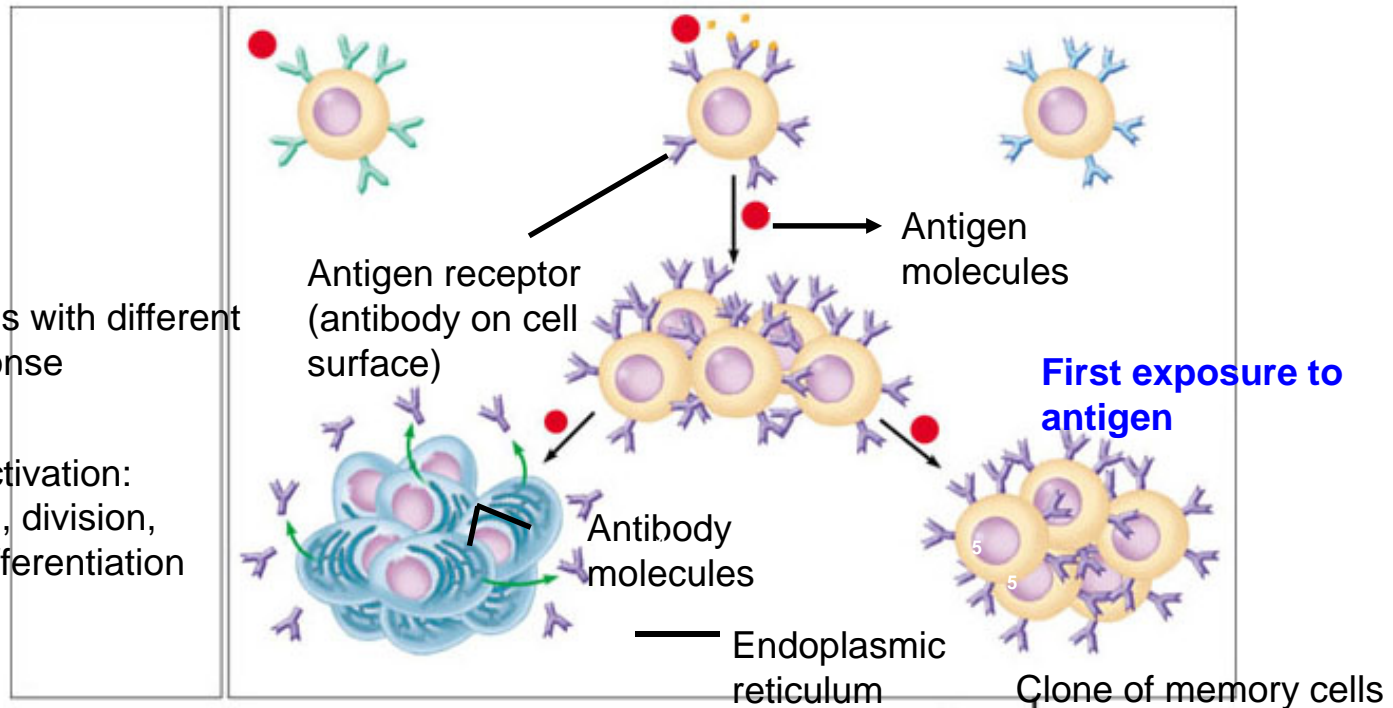
- In the **primary immune response**, clonal selection
  - Produces effector cells and memory cells that may confer lifelong immunity
- In the **secondary immune response**
  - **Memory cells** are activated by a second exposure to the same antigen, which initiates a faster and more massive response

# • The primary and secondary immune responses

## Primary immune response

B cells with different response

Cell activation: growth, division, and differentiation



## Secondary immune response

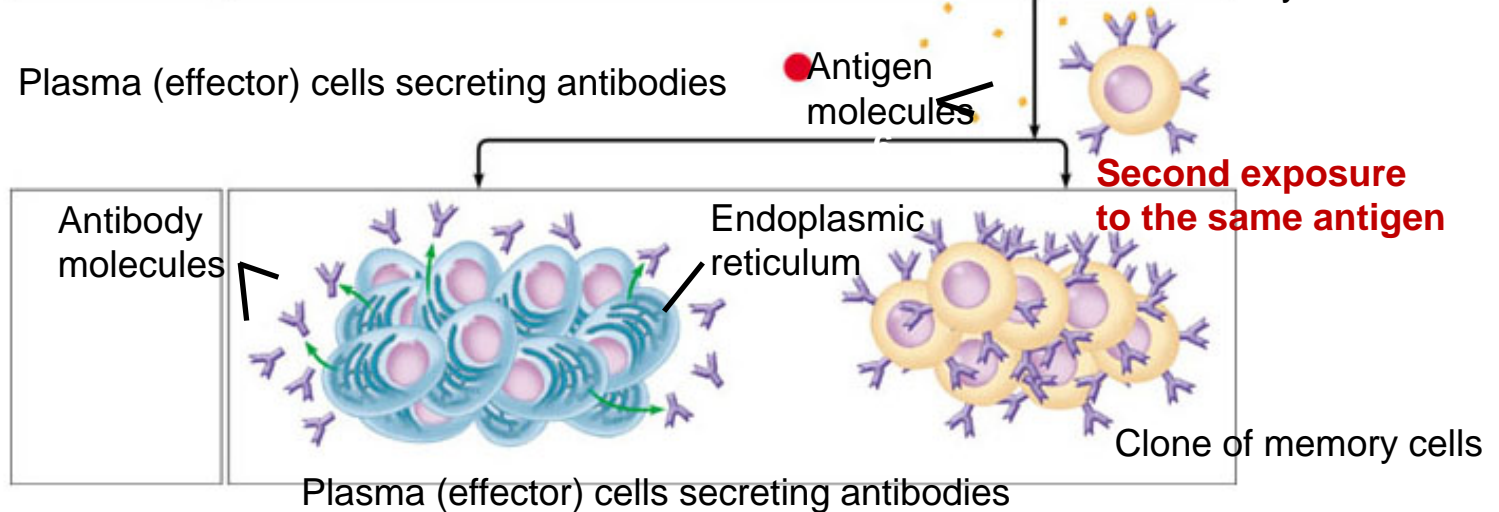


Figure 24.7A

# Primary vs. Secondary Immune Response

- The primary immune response
  - Is slower than the secondary immune response

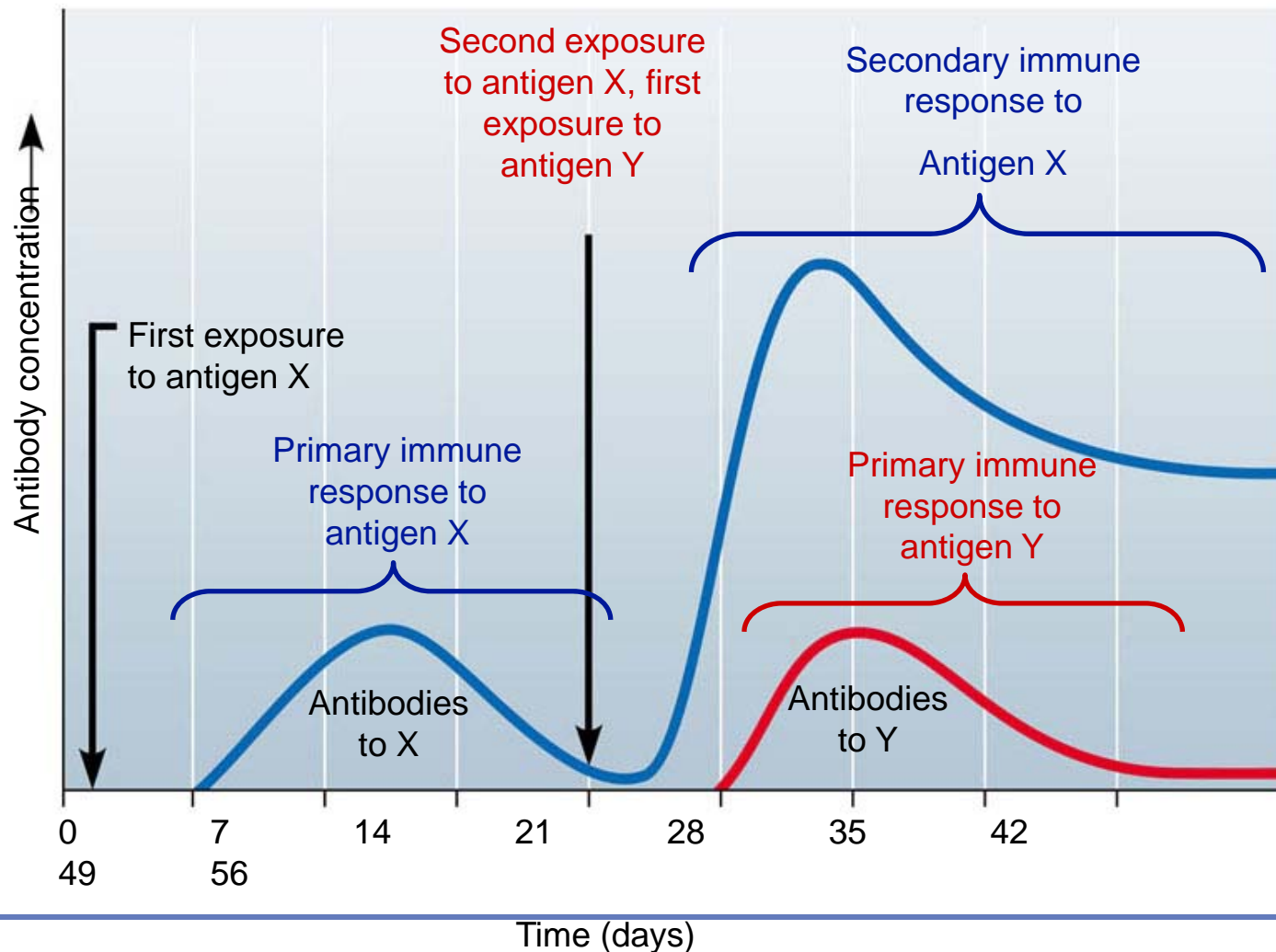


Figure 24.7B

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## 24.8 Antibodies are the weapons of humoral immunity

- Antibody molecules
  - Are secreted by **plasma (effector) B cells**

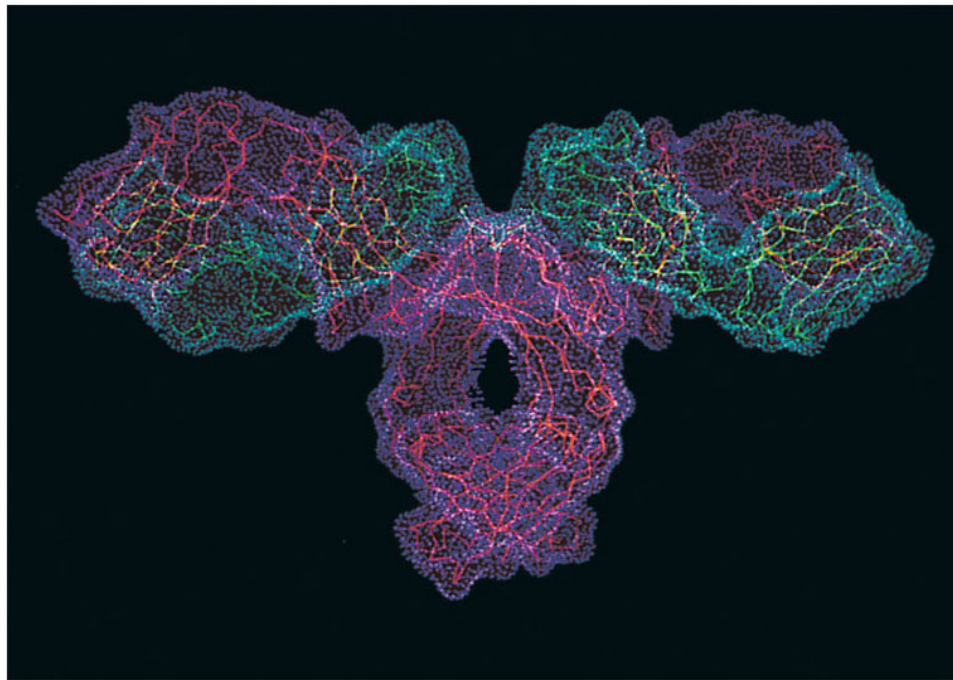
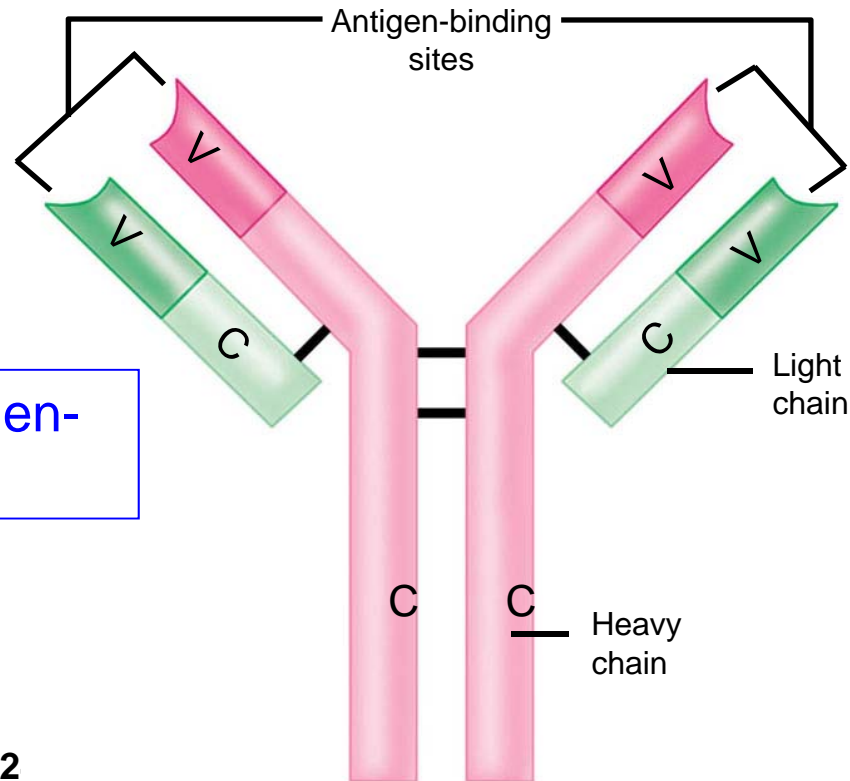


Figure 24.8A

- An antibody molecule
  - Has **antigen-binding sites** specific to the antigenic determinants that elicited its secretion



Each Ab molecule has **2 antigen-binding sites!!**

Figure 2



# 24.9 Antibodies mark antigens for elimination

- Antibodies promote antigen elimination
  - Through several mechanisms

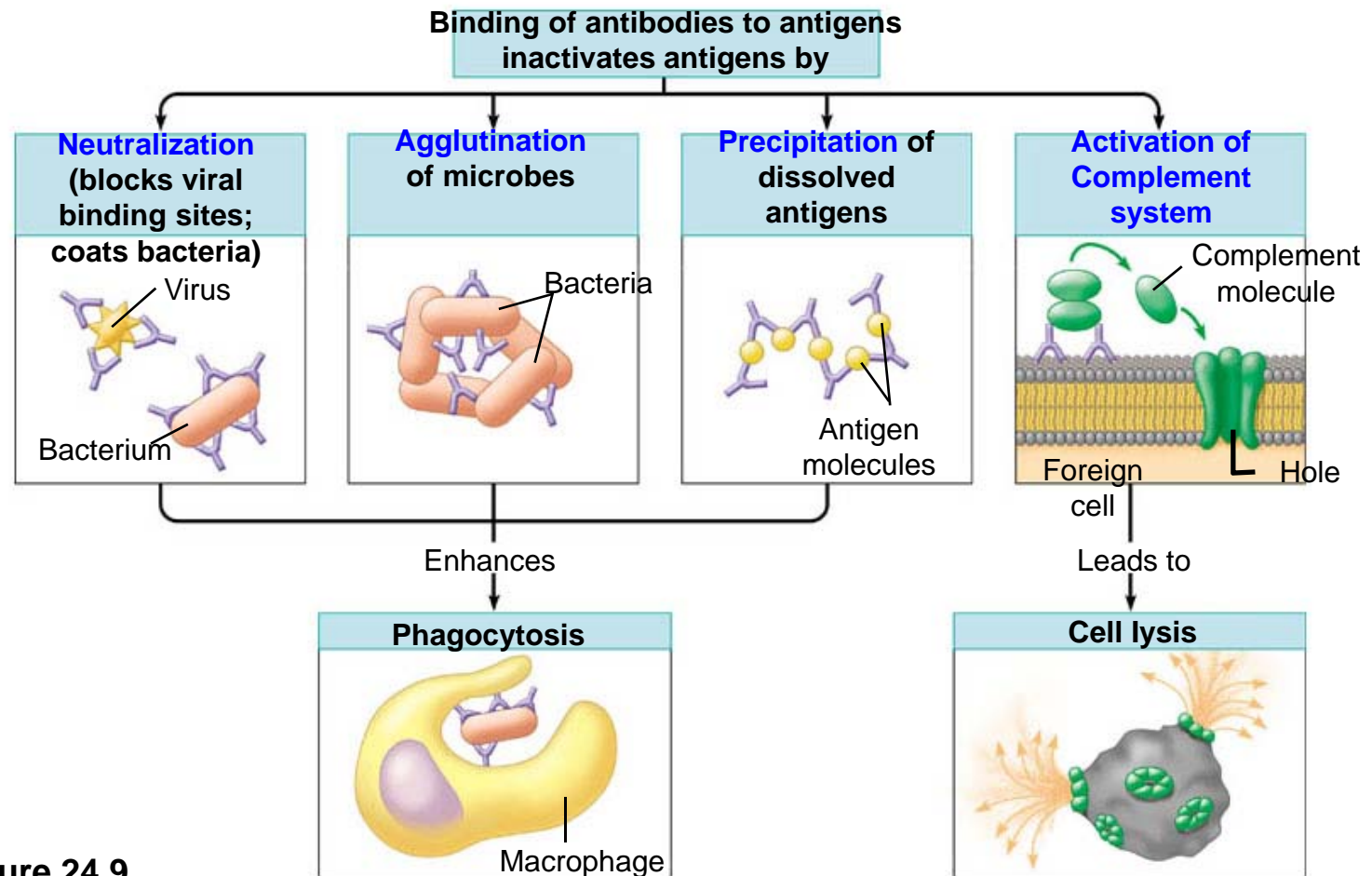
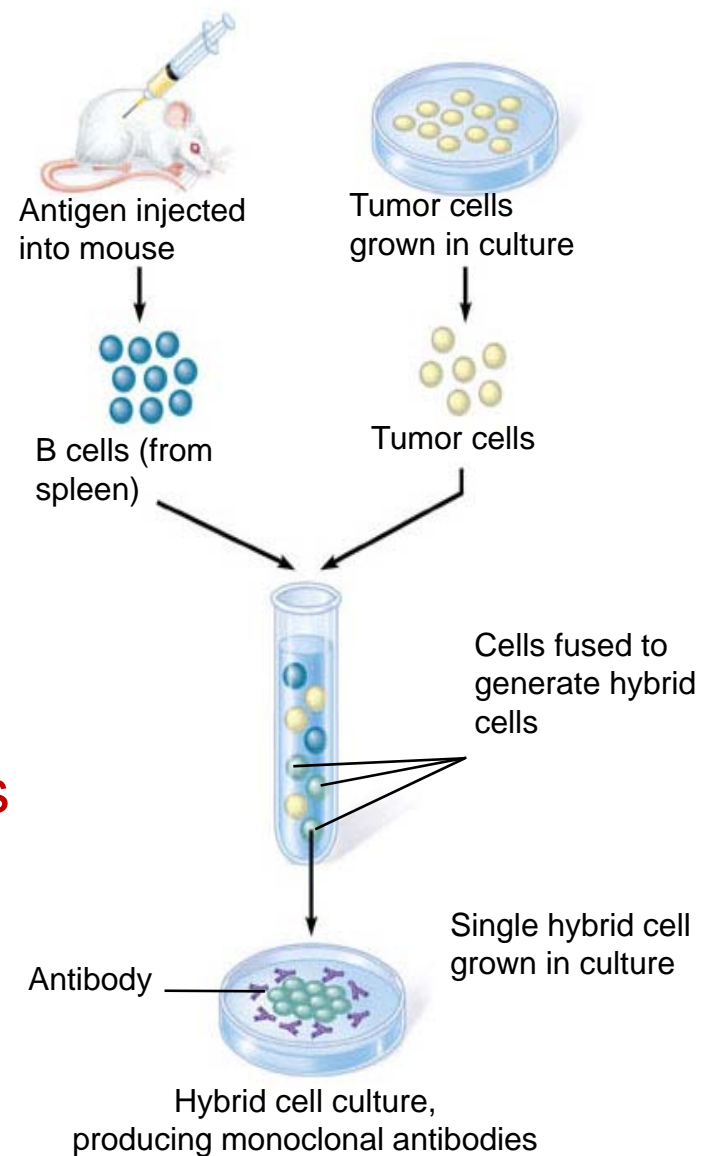


Figure 24.9

# CONNECTION

## 24.10 Monoclonal antibodies are powerful tools in the lab and clinic

- Monoclonal antibodies
  - Are produced by fusing B cells specific for a single antigenic determinant with easy to grow tumor cells
    - Tumor cell → immortality
    - B cells (spleen) → make Abs



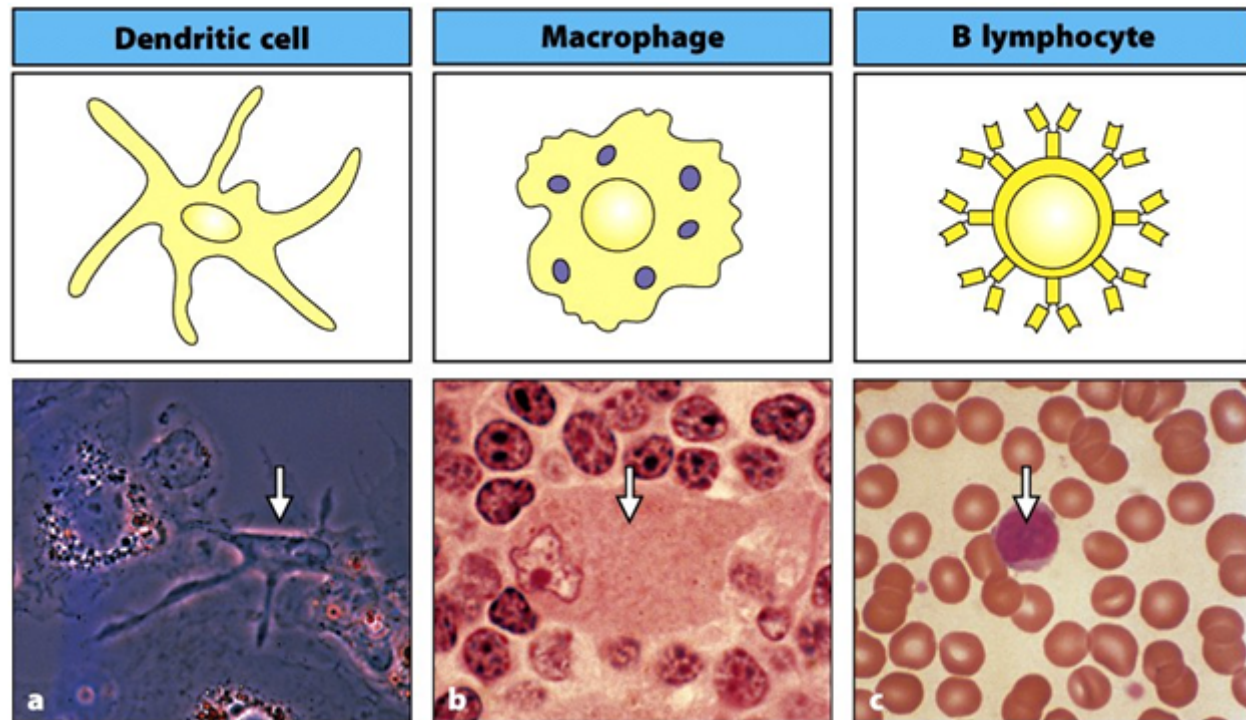
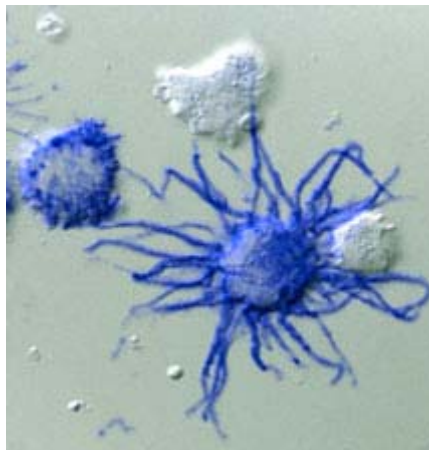
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- Monoclonal antibodies (mAbs)
    - are useful in research, diagnosis, and treatment of certain cancers

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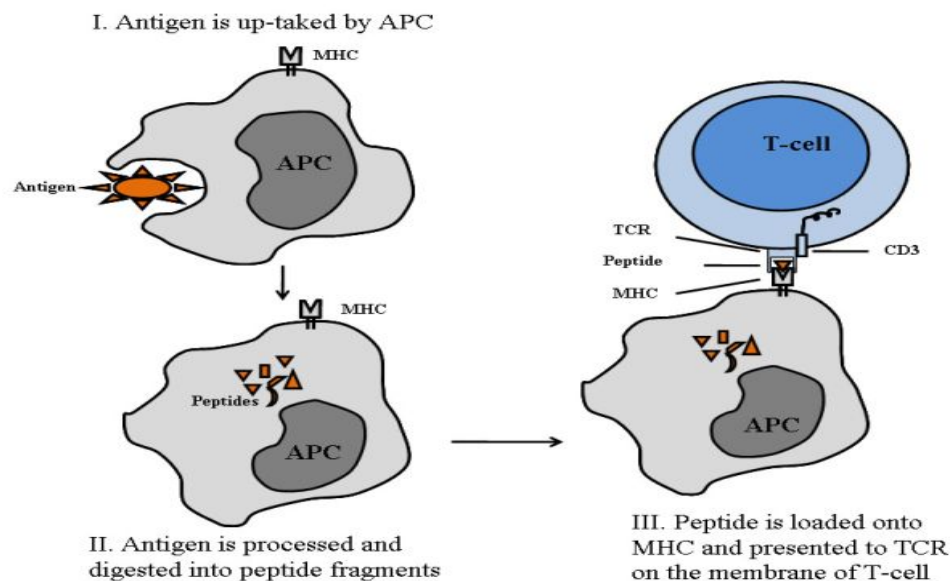
## 24.11 Helper T cells stimulate humoral and cell-mediated immunity

- **Helper** T cells and **cytotoxic** T cells
  - Are the main effectors of cell-mediated immunity
- **Helper** T cells
  - Also stimulate the **humoral responses**

- In cell-mediated immunity, an antigen-presenting cell (APC)
  - Displays a foreign antigen and one of the body's own self proteins to a helper T cell



- The helper T (Th) cell's receptors (TCR)
  - Recognize the self-nonself complexes and the interaction activates the helper T cells
- The helper T cell
  - Can then activate **cytotoxic T (Tc) cells** and **B cells**



- The activation of a helper T cell and its roles in immunity
  - Self-nonspecific complex = MHC + Ag fragment

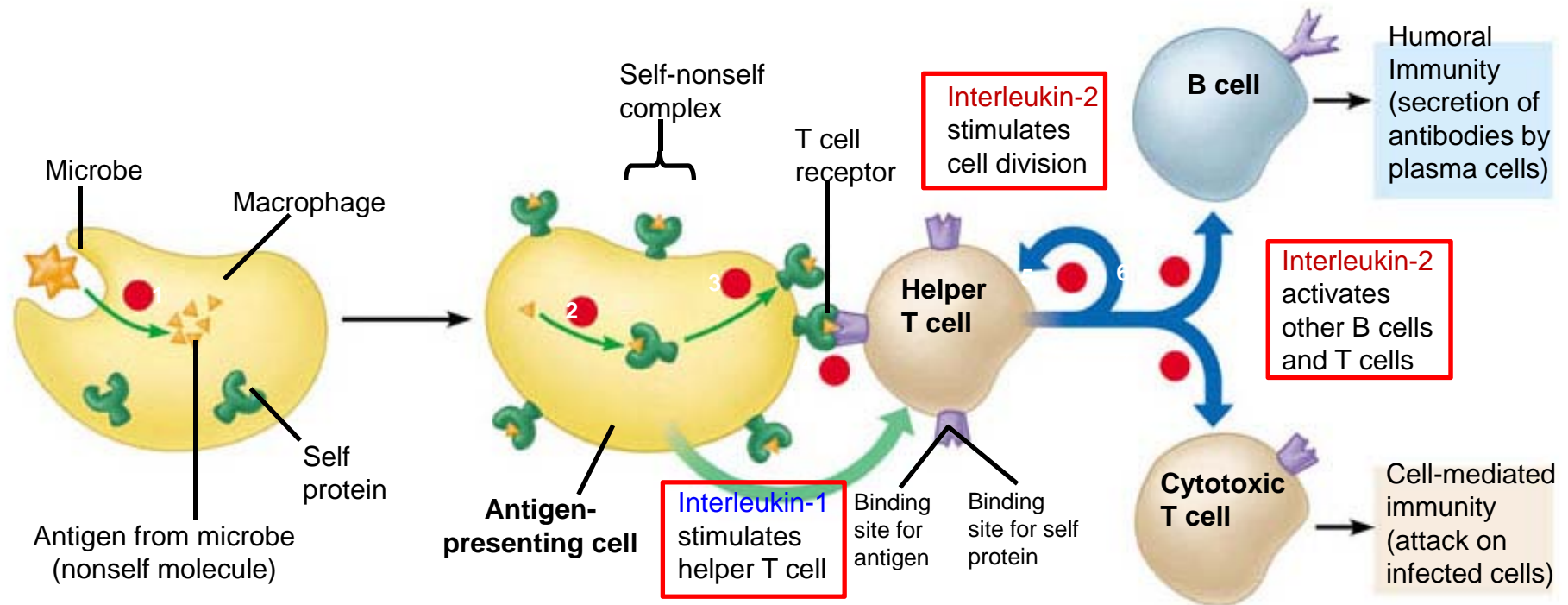


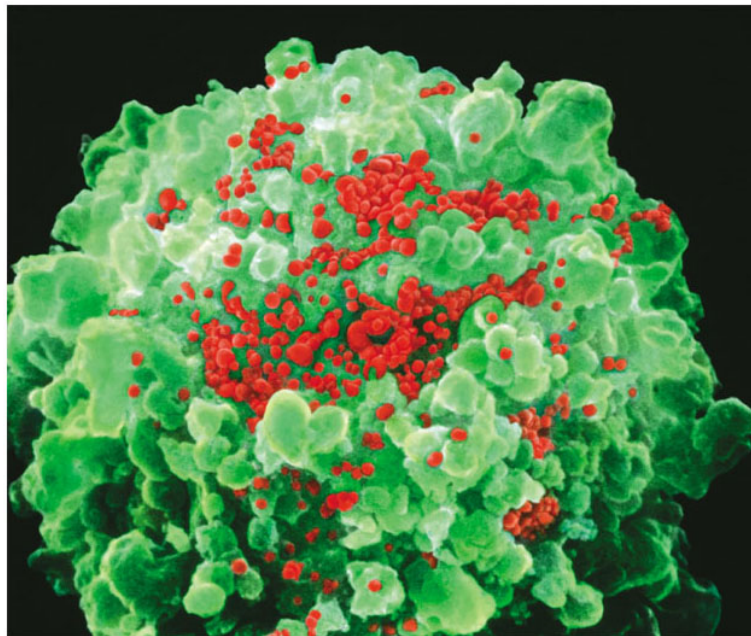
Figure 24.11

# CONNECTION

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## 24.12 HIV destroys helper T cells, compromising the body's defenses

- The AIDS virus attacks **helper T (Th) Cells**
  - Opening the way for opportunistic infection



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**A human helper T cell (green)  
under attack by HIV (red dots).**

**Figure 24.13**



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## 24.13 Cytotoxic T (Tc) cells destroy infected body cells

- Cytotoxic T cells
  - Bind to infected body cells and destroy them

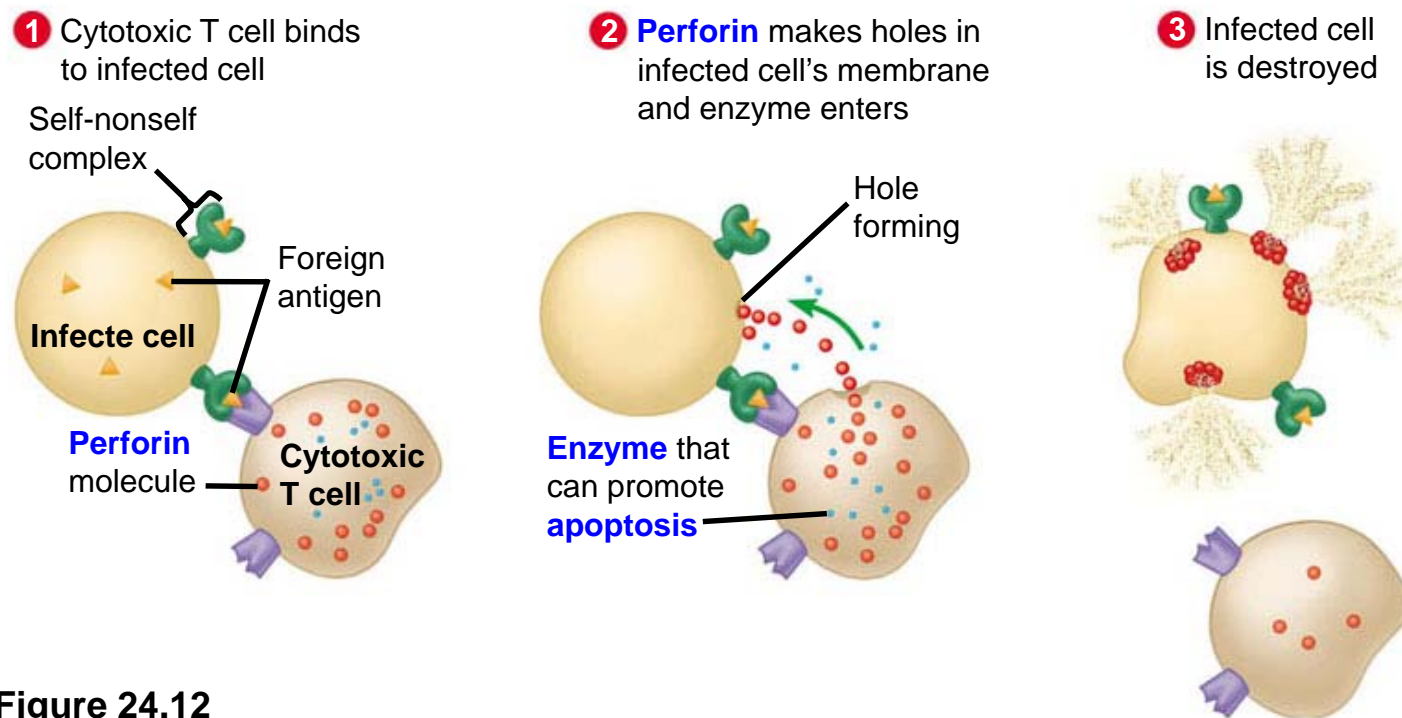
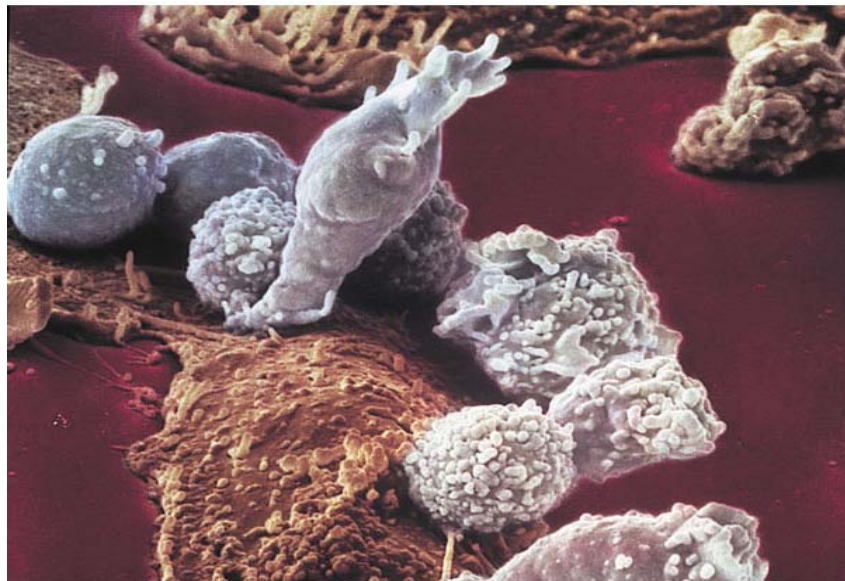


Figure 24.12

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## 24.14 Cytotoxic T (Tc) cells may help prevent cancer

- Cytotoxic T cells may attack cancer cells
  - Which have abnormal surface molecules



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## 24.15 The immune system depends on our molecular fingerprints

- The immune system
  - Normally reacts **only** against **nonsel**  
**substances**, not against self
  - May reject **transplanted organs** because these cells lack the unique “fingerprint” of the recipient’s self proteins

# DISORDERS OF THE IMMUNE SYSTEM CONNECTION

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24.16 Malfunction or failure of the immune system causes disease

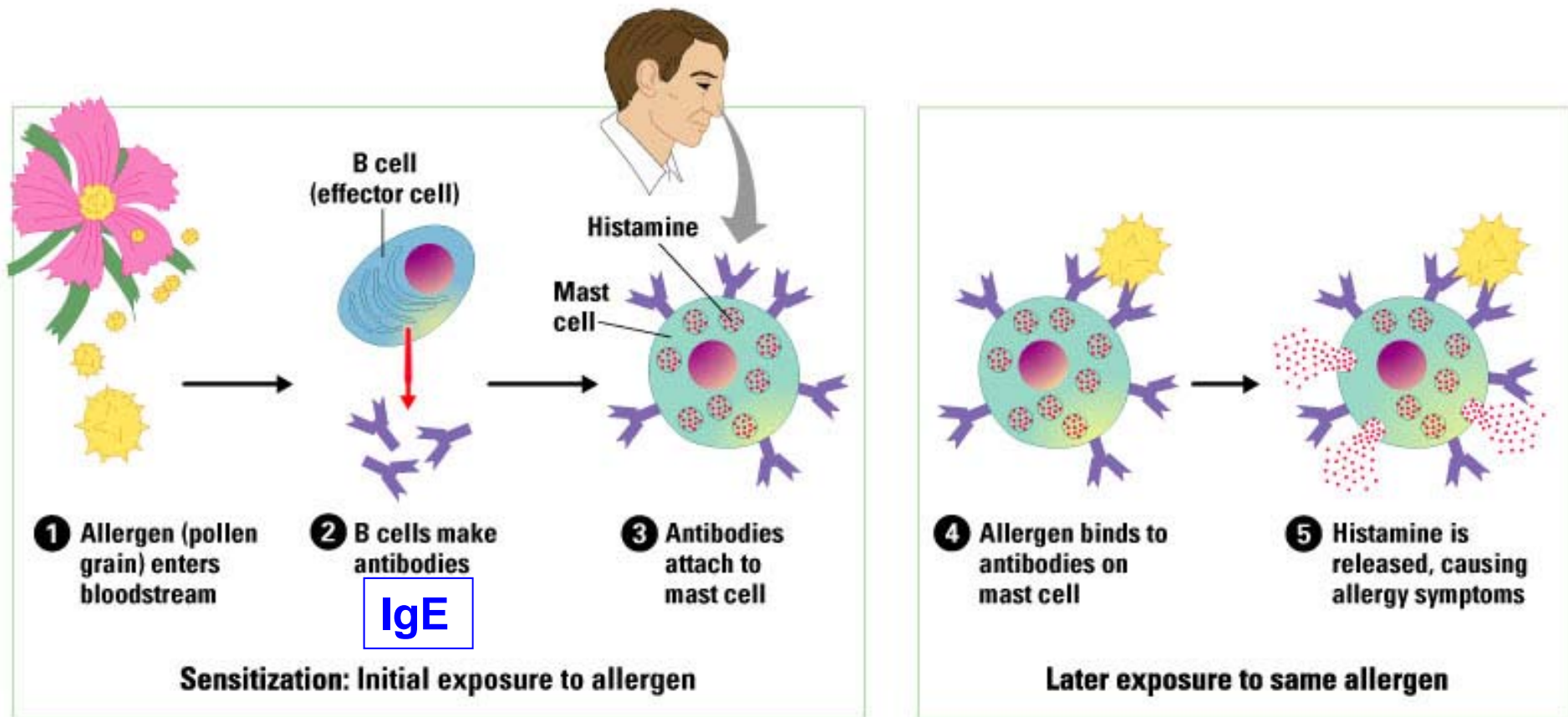
- In **autoimmune diseases**
  - The system turns against the body's own molecules
- In **immunodeficiency diseases**
  - Immune components are lacking, and frequent infections recur
- **Physical and emotional stress**
  - May weaken the immune system

## Connection

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24.17 **Allergies** are overreactions to certain environmental antigens

- Allergies
  - Are abnormal sensitivities to antigens (**allergens**) in the surroundings



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Figure 24.17

In mammals, there are 5 Ab types  
- IgG, IgM, IgA, IgD, IgE

# Summary

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- Innate defenses include the skin and mucous membranes, phagocytic cells, and anti-microbial proteins.
- The inflammation mobilizes nonspecific defense forces.
- The lymphatic system is a crucial system during infection.
- Antigens have specific regions where antibodies can bind.
- Helper T cells help stimulate humoral and cell-mediated immunity, whereas cytotoxic T cells destroy infected body cells.
- Allergies are overreactions to certain environmental antigens.

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# End of Chapter

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