

**Principles of Anatomy and Physiology**  
14<sup>th</sup> Edition  
Gerard J. Tortora / Bryan Derrickson  
WILEY

**CHAPTER 22**  
The Lymphatic System and Immunity

Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

**Introduction**

The purpose of this chapter is to:

1. Understand the lymphatic system structure and function
2. Compare and contrast the innate and adaptive immune systems
3. Compare and contrast cell-mediated and antibody-mediated immunity
4. Discuss the effects of stress and aging on immunity

Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

**Disease Resistance**

**Nonspecific Resistance (Innate Immunity)**

- Present at birth and includes defense mechanisms that provide general protection against invasion by a wide range of pathogens

**Immunity (Adaptive Immunity)**

- Involves activation of specific lymphocytes that combat a particular pathogen or other foreign substance

The body system that carries out immune responses is the lymphatic system

Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Lymphatic System

The lymphatic system consists of several structures and organs that contain lymphatic tissue, bone marrow, and a fluid called lymph that flows within lymphatic vessel

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

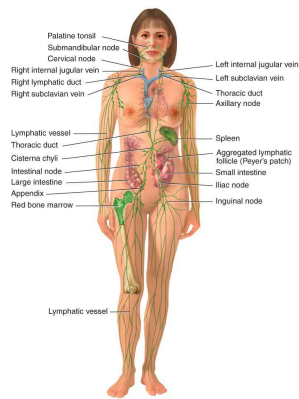
---

---

---

---

## Components of the Lymphatic System



(a) Anterior view of principal components of lymphatic system

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Lymphatic System and Disease Resistance

### Anatomy Overview:

- [The Lymphatic System and Disease Resistance](#)  
Phagocytosis, T and B Lymphocytes, Lymphatic Vessels, Spleen, Lymph Nodes, Thymus

You must be connected to the Internet and in Slideshow Mode to run this animation.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Functions of the Lymphatic System

The lymphatic system functions to:

1. Drain interstitial fluid
2. Transport dietary fats
3. Carry out immune responses

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Lymphatic Vessels and Capillaries

Lymphatic vessels begin as lymphatic capillaries, which are closed on one end

- Lymphatic capillaries are located between cells of many tissues
- Lymphatic capillaries merge to form lymphatic vessels, which have thin walls and many valves

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

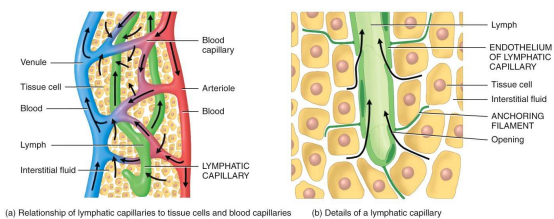
---

---

---

---

## Lymphatic Capillaries



Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Lymph Trunks and Ducts

From the lymphatic vessels, lymph passes through lymph nodes and then into lymph trunks

- Lymph trunks include the lumbar, intestinal, bronchomediastinal, subclavian, and jugular trunks

Lymph trunks then merge to form either the thoracic duct or the right lymphatic duct

Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

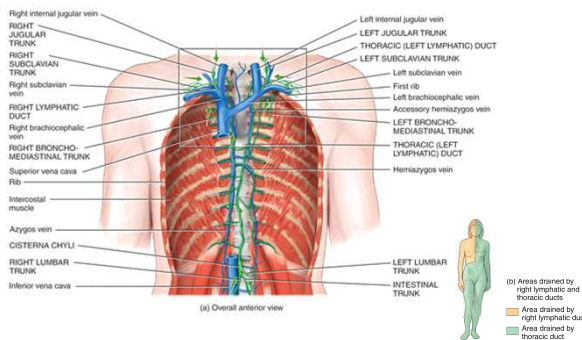
---

---

---

---

## Routes of Drainage



Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

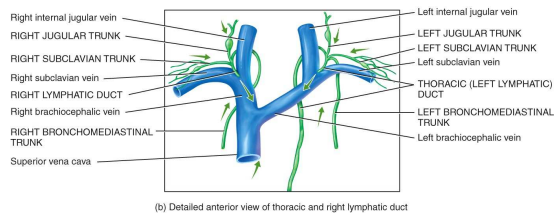
---

---

---

---

## Routes of Drainage



(b) Detailed anterior view of thoracic and right lymphatic duct

Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

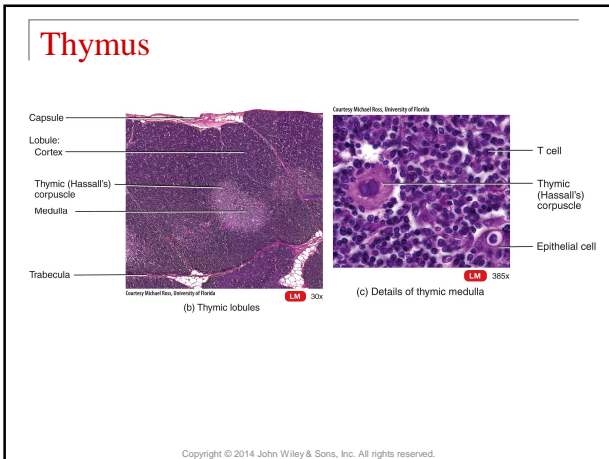
---

---

---

---






---

---

---

---

---

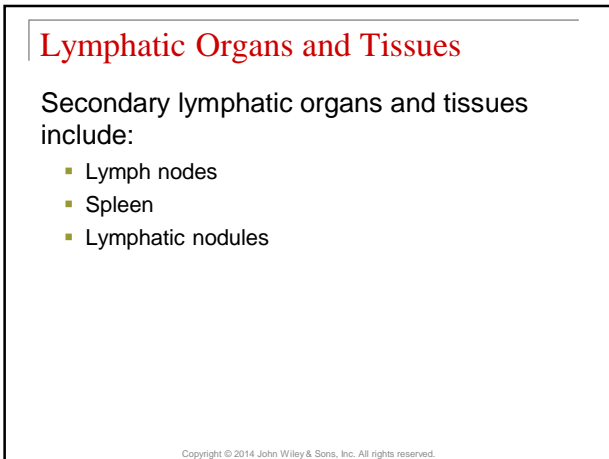
---

---

---

---

---




---

---

---

---

---

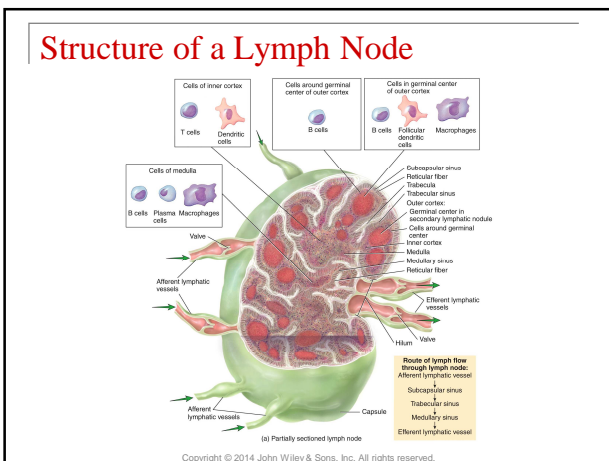
---

---

---

---

---




---

---

---

---

---

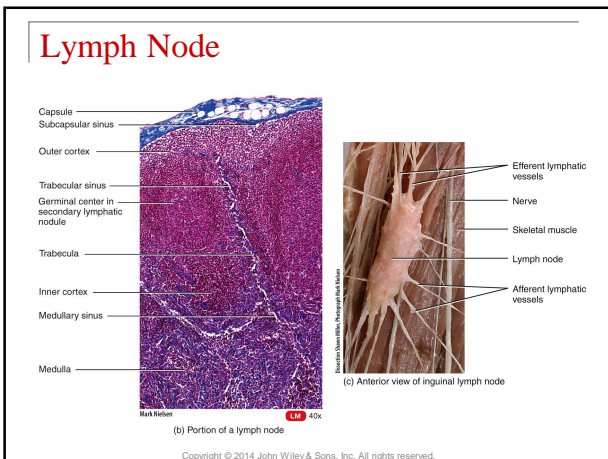
---

---

---

---

---




---

---

---

---

---

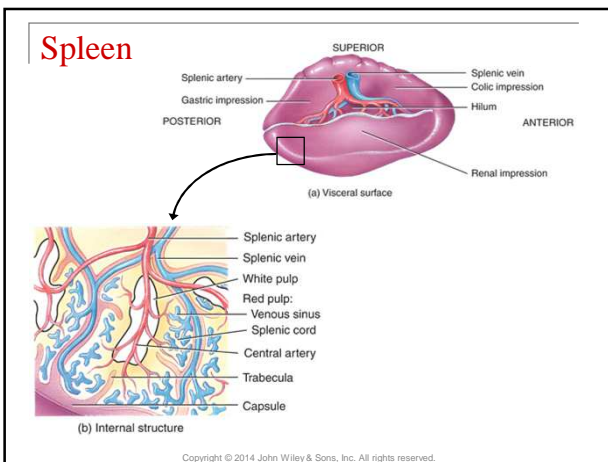
---

---

---

---

---




---

---

---

---

---

---

---

---

---

---

### Lymphatic Nodules

Lymphatic nodules are masses of lymphatic tissue that are not surrounded by a capsule

- They are scattered throughout the lamina propria of mucous membranes lining the gastrointestinal, urinary, and reproductive tracts and the respiratory airways
- Lymphatic nodules in these areas are also referred to as mucosa-associated lymphatic tissue (MALT)

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

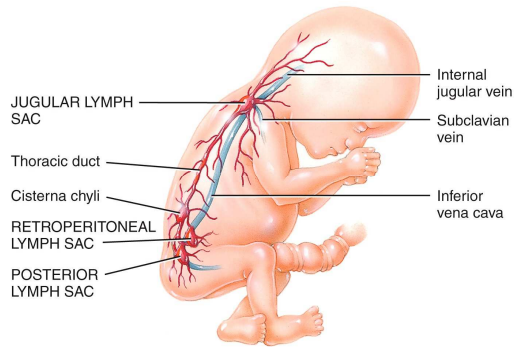
---

---

---

---

## Development of Lymphatic Tissues



Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Disease Resistance Overview

### Interactions Animation:

- [Introduction to Disease Resistance](#)

You must be connected to the Internet and in Slideshow Mode to run this animation.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Innate Immunity

- Innate immunity refers to a wide variety of body responses that serve to protect us against invasion of a wide variety of pathogens and their toxins
- We are born with this kind of immunity
- Two lines of defense:
  1. Skin and mucous membranes
  2. Internal defenses

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---



## Non-Specific Disease Resistance

### Interactions Animation:

- [Non-Specific Disease Resistance](#)

You must be connected to the Internet and in Slideshow Mode to run this animation.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Skin and Mucous Membranes

### Mechanical defenses

- Skin, mucous membranes, tears, saliva, mucus, cilia, epiglottis, urine flow, defecating, vomiting

### Chemical defenses

- Sebum, lysozyme, gastric juice

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

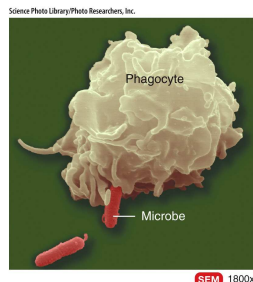
---

---

---

## Internal Defenses

- Antimicrobial proteins
- Phagocytes
- Natural killer cells
- Inflammation
- Fever



(b) Phagocyte (white blood cell) engulfing microbe.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

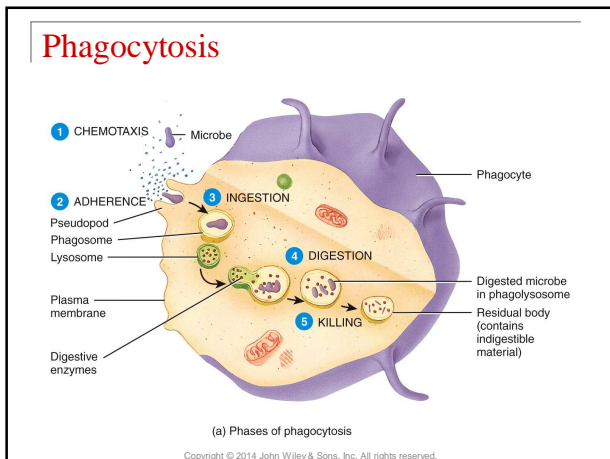
---

---

---

---

---




---

---

---

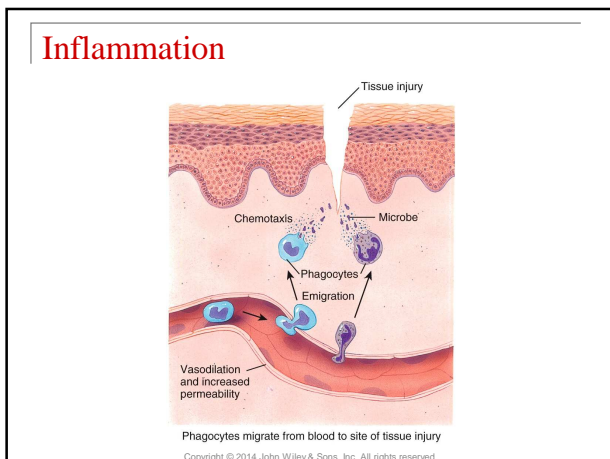
---

---

---

---

---




---

---

---

---

---

---

---

---

TABLE 22.1	
Summary of Innate Defenses	
COMPONENT	FUNCTIONS
<b>FIRST LINE OF DEFENSE: SKIN AND MUCOUS MEMBRANES</b>	
<b>Physical Factors</b>	
<b>Epidermis of skin</b>	Forms physical barrier to entrance of microbes.
<b>Mucous membranes</b>	Inhibit entrance of many microbes, but not as effective as intact skin.
<b>Mucus</b>	Traps microbes in respiratory and gastrointestinal tracts.
<b>Hairs</b>	Filter out microbes and dust in nose.
<b>Cilia</b>	Together with mucus, trap and remove microbes and dust from upper respiratory tract.
<b>Lacrimal apparatus</b>	Tears dilute and wash away irritating substances and microbes.
<b>Saliva</b>	Washes microbes from surfaces of teeth and mucous membranes of mouth.
<b>Urine</b>	Washes microbes from urethra.
<b>Defecation and vomiting</b>	Expel microbes from body.
<b>Chemical Factors</b>	
<b>Sebum</b>	Forms protective acidic film over skin surface that inhibits growth of many microbes.
<b>Lysozyme</b>	Antimicrobial substance in perspiration, tears, saliva, nasal secretions, and tissue fluids.
<b>Gastric juice</b>	Destroys bacteria and most toxins in stomach.
<b>Vaginal secretions</b>	Slight acidity discourages bacterial growth; flush microbes out of vagina.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

TABLE 22.1	
Summary of Innate Defenses	
COMPONENT	FUNCTIONS
<b>SECOND LINE OF DEFENSE: INTERNAL DEFENSES</b>	
<b>Antimicrobial Substances</b>	
Interferons (IFNs)	Protect uninfected host cells from viral infection.
Complement system	Causes cytolysis of microbes; promotes phagocytosis; contributes to inflammation.
Iron-binding proteins	Inhibit growth of certain bacteria by reducing amount of available iron.
Antimicrobial proteins (AMPs)	Have broad-spectrum antimicrobial activities and attract dendritic cells and mast cells.
Natural killer (NK) cells	Kill infected target cells by releasing granules that contain perforin and granzymes; phagocytes then kill released microbes.
Phagocytes	Ingest foreign particulate matter.
Inflammation	Confines and destroys microbes; initiates tissue repair.
Fever	Intensifies effects of interferons; inhibits growth of some microbes; speeds up body reactions that aid repair.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

---

---

---

---

## Adaptive Immunity

Adaptive immunity is the ability of the body to defend itself against specific invading agents

- Antigens are substances recognized as foreign that provoke immune responses

Adaptive immunity has both specificity and memory and is divided into 2 types

- Cell-mediated
- Antibody-mediated

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

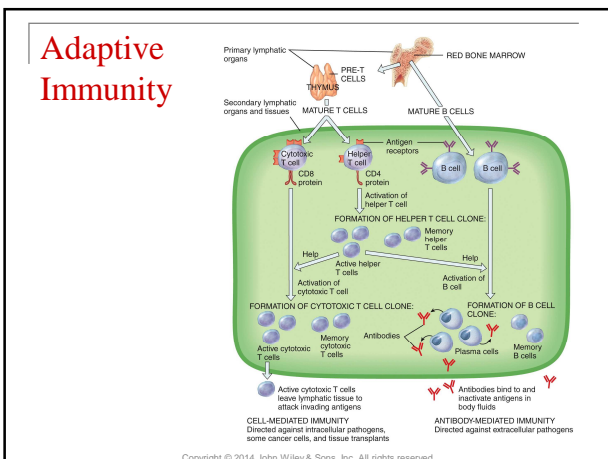
---

---

---

---

---




---

---

---

---

---

---

---

---

---

---

---

---

## Lymphocytes

### Anatomy Overview:

- [The Lymphatic and Immune Systems](#)  
Lymphocytes: Activated B Cells and Cytotoxic T cells

You must be connected to the Internet and in Slideshow Mode to run this animation.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Antigens and Antigen Receptors

- Immunogenicity
- Reactivity
- Entire microbes or just parts of microbes may act as antigens
  - Typically, just certain small parts of a large antigen molecule act as the triggers for immune responses. These small parts are called epitopes.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Antigens and Antibodies

### Anatomy Overview:

- [Antigens and Antibodies](#)

You must be connected to the Internet and in Slideshow Mode to run this animation.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

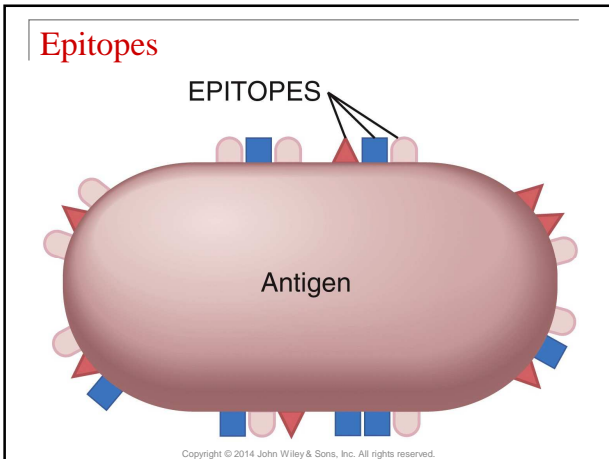
---

---

---

---

---



---

---

---

---

---

---

---

---

**Pathways of Antigen Processing**

For an immune response to occur, B cells and T cells must recognize that a foreign antigen is present.

- B cells can recognize and bind to antigens in lymph, interstitial fluid, or blood plasma
- T cells only recognize fragments of antigenic proteins that are processed and presented in a certain way

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

**Pathways of Antigen Processing**

- In antigen processing, antigenic proteins are broken down into peptide fragments that associate with MHC molecules
- The antigen–MHC complex is then inserted into the plasma membrane of a body cell
  - This process is called antigen presentation

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

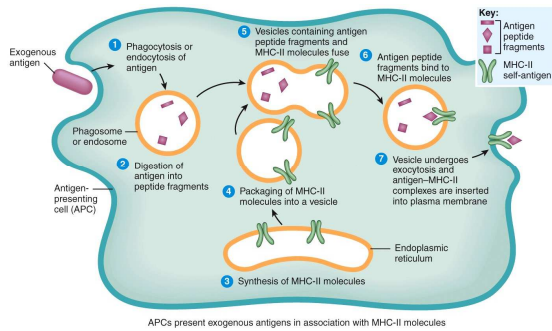
---

---

---

---

## Exogenous Antigen Processing




---

---

---

---

---

---

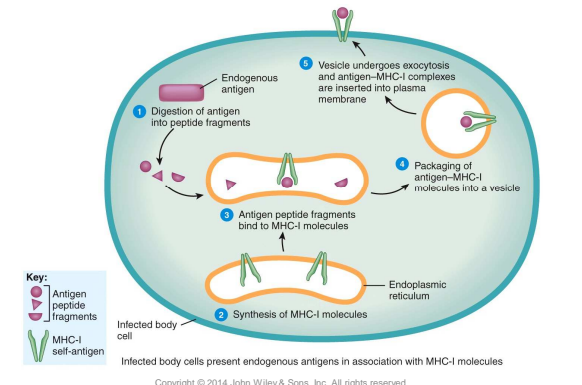
---

---

---

---

## Endogenous Antigen Processing




---

---

---

---

---

---

---

---

---

---

## Cytokines

Small protein hormones that stimulate or inhibit many normal cell functions

TABLE 22.2 Summary of Cytokines Participating in Immune Responses	
CYTOKINE	ORIGINS AND FUNCTIONS
Interleukin-1 (IL-1) ( <i>m</i> : ter-LOO-kin)	Produced by macrophages; promotes proliferation of helper T cells; acts on hypothalamus to cause fever.
Interleukin-2 (IL-2)	Secreted by helper T cells; costimulates proliferation of helper T cells, cytotoxic T cells, and B cells; activates NK cells.
Interleukin-4 (IL-4) (B cell-stimulating factor)	Produced by helper T cells; costimulator for B cells; causes plasma cells to secrete IgE antibodies (see Table 22.3); promotes growth of T cells.
Interleukin-5 (IL-5)	Produced by some helper T cells and mast cells; costimulator for B cells; causes plasma cells to secrete IgA antibodies.
Interleukin-6 (IL-6)	Produced by helper T cells; enhances B cell proliferation, B cell differentiation into plasma cells, and secretion of antibodies by plasma cells.
Tumor necrosis factor (TNF) ( <i>m</i> : sR2-s2)	Produced mainly by macrophages; stimulates accumulation of neutrophils and macrophages at sites of inflammation and stimulates their killing of microbes.
Interferons (IFNs) ( <i>m</i> : ter-FER-oms)	Produced by virus-infected cells to inhibit viral replication in uninfected cells; activate cytotoxic T cells and natural killer cells, inhibit cell division, and suppress the formation of tumors.
Macrophage migration inhibiting factor	Produced by cytotoxic T cells; prevents macrophages from leaving site of infection.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

---

---

## Cell-Mediated Immunity

In cell-mediated immunity:

- An antigen is recognized and bound
- A small number of T cells proliferate and differentiate into a clone of effector cells
- The antigen is eliminated

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Cell-Mediated Immunity

Interactions Animation:

- [Cell-Mediated Immunity](#)

You must be connected to the Internet and in Slideshow Mode to run this animation.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

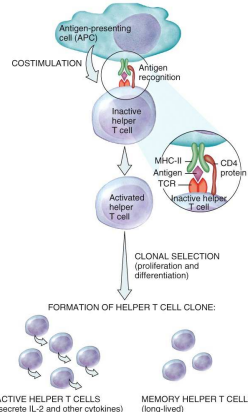
---

---

---

---

## Activation and Clonal Selection of a Helper T Cell



Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---





## Antibody-Mediated Immunity

### Interactions Animation:

- [Antibody-Mediated Immunity](#)

You must be connected to the Internet and in Slideshow Mode to run this animation.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

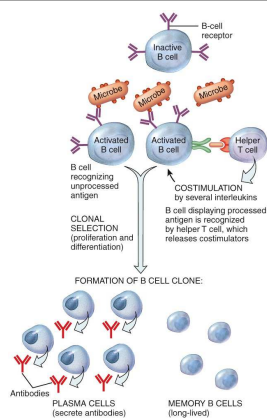
---

---

---

---

## Activation and Clonal Selection of a B Cells



Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

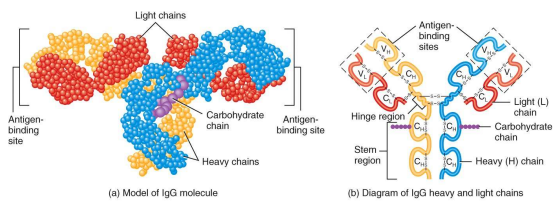
---

---

---

---

## IgG Antibody Structure



Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---






---

---

---

---

---

TABLE 22.3 Classes of Immunoglobulins (Igs)	
NAME AND STRUCTURE	CHARACTERISTICS AND FUNCTIONS
<p><b>IgG</b></p> 	<p>Most abundant; about 80% of all antibodies in blood; found in blood, lymph, and intestines; monomer (one-unit) structure. Protects against bacteria and viruses by enhancing phagocytosis, neutralizing toxins, and triggering complement system. Is the only class of antibody to cross placenta from mother to fetus, conferring considerable immune protection in newborns.</p>
<p><b>IgA</b></p> 	<p>Found mainly in sweat, tears, saliva, mucus, breast milk, and gastrointestinal secretions. Smaller quantities are present in blood and lymph. Makes up 10–15% of all antibodies in blood; occurs as monomers and dimers (two units). Levels decrease during stress. Provides resistance to infections. Provides localized protection of mucous secretions against bacteria and viruses.</p>
<p><b>IgM</b></p> 	<p>About 5–10% of all antibodies in blood; also found in lymph. Occurs as pentamers (five units); first antibody class to be secreted by plasma cells after initial exposure to any antigen. Activates complement and causes agglutination and lysis of microbes. Also present as monomers on surfaces of B cells, where they serve as antigen receptors. In blood plasma, anti-A and anti-B antibodies of ABO blood group, which bind to A and B antigens during incompatible blood transfusions, are also IgM antibodies (see Figure 19.13).</p>
<p><b>IgD</b></p> 	<p>Mainly found on surfaces of B cells as antigen receptors, where it occurs as monomers; involved in activation of B cells. About 0.2% of all antibodies in blood.</p>
<p><b>IgE</b></p> 	<p>Less than 0.1% of all antibodies in blood; occurs as monomers located on mast cells and basophils. Involved in allergic and hypersensitivity reactions; provides protection against parasitic worms.</p>

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

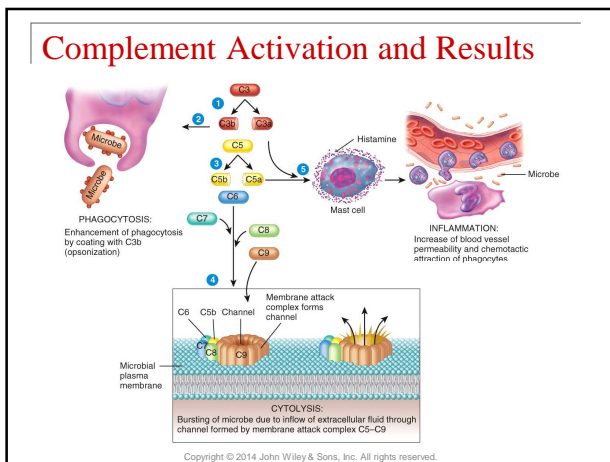
---

---

---

---

---




---

---

---

---

---

---

---

---

---

---

---

---

## Introduction to Disease Resistance

Interactions Animation:

- [Disease Resistance Overview - section 2.1 discusses complement proteins](#)

You must be connected to the Internet and in Slideshow Mode to run this animation.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

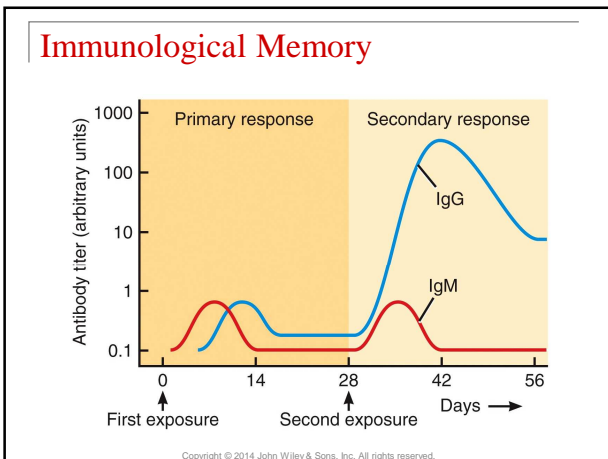
---

---

---

---

---




---

---

---

---

---

---

---

---

---

---

### Introduction to Disease Resistance

Interactions Animation:

- [Disease Resistance Overview - section 4.1 discusses immunological memory](#)

You must be connected to the Internet and in Slideshow Mode to run this animation.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

---

---

TABLE 22.4	
Ways to Acquire Adaptive Immunity	
METHOD	DESCRIPTION
Naturally acquired active immunity	Following exposure to a microbe, antigen recognition by B cells and T cells and costimulation lead to formation of antibody-secreting plasma cells, cytotoxic T cells, and B and T memory cells.
Naturally acquired passive immunity	IgG antibodies are transferred from mother to fetus across placenta, or IgA antibodies are transferred from mother to baby in milk during breast-feeding.
Artificially acquired active immunity	Antigens introduced during vaccination stimulate cell-mediated and antibody-mediated immune responses, leading to production of memory cells. Antigens are pretreated to be immunogenic but not pathogenic (they will trigger an immune response but not cause significant illness).
Artificially acquired passive immunity	Intravenous injection of immunoglobulins (antibodies).

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

---

---

### Self-Recognition and Self-Tolerance

T cells undergo both positive and negative selection to ensure that they can recognize self-MHC (*self-recognition*) antigens and that they do not react to other self-proteins (*self-tolerance*)

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

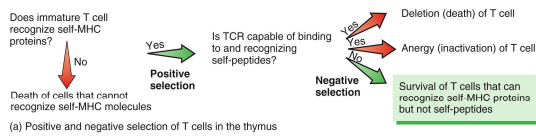
---

---

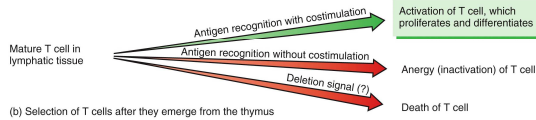
---

---

### T Cells: Development of Self-Recognition and Self-Tolerance



(a) Positive and negative selection of T cells in the thymus



(b) Selection of T cells after they emerge from the thymus

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

### Self-Recognition and Self-Tolerance

B cells develop tolerance through deletion and anergy

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

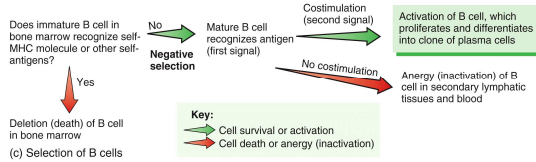
---

---

---

---

## B Cells: Development of Self-Recognition and Self-Tolerance



Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

**TABLE 22.5**  
Summary of Functions of Cells Participating in Adaptive Immune Responses

CELL	FUNCTIONS
<b>ANTIGEN PRESENTING CELLS (APCs)</b>	
<b>Macrophage</b>	Processing and presentation of foreign antigens to T cells; secretion of interleukin-1, which stimulates secretion of interleukin-2 by helper T cells and induces proliferation of B cells; secretion of interferon that stimulate T cell growth.
<b>Dendritic cell</b>	Processes and presents antigen to T cells and B cells; found in mucous membranes, skin, lymph nodes.
<b>B cell</b>	Processes and presents antigen to helper T cells.
<b>LYMPHOCYTES</b>	
<b>Cytotoxic T cell</b>	Kills host target cells by releasing granzymes that induce apoptosis, perforin that forms channels to cause cytolysis, granzysin that destroys microbes, lymphotoxin that destroys target cell DNA, gamma-interferon that attracts macrophages and increases their phagocytic activity, and macrophage migration inhibition factor that prevents macrophage migration from site of infection.
<b>Helper T cell</b>	Cooperates with B cells to amplify antibody production by plasma cells and secretes interleukin-2, which stimulates proliferation of T cells and B cells. May secrete gamma-IFN and tumor necrosis factor (TNF), which stimulate inflammatory response.
<b>Memory T cell</b>	Remains in lymphatic tissue and recognizes original invading antigens, even years after first encounter.
<b>B cell</b>	Differentiates into antibody-producing plasma cell.
<b>Plasma cell</b>	Descendant of B cell that produces and secretes antibodies.
<b>Memory B cell</b>	Descendant of B cell that remains after immune response and is ready to respond rapidly and forcefully should the same antigen enter body in future.

Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Stress and Immunity

Psychoneuroimmunology (PNI) is a field that deals with common pathways that link the nervous, endocrine, and immune systems

- Research in this field indicates that thoughts, feelings, moods, and beliefs influence your level of health and the course of disease

Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

## Aging and the Immune System

Aging results in:

- Increased susceptibility to infections and malignancies
- Increased production of autoantibodies
- Decreased response to vaccines
- Decreased immune system function

Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

---

---

### FOCUS on HOMEOSTASIS

**REGULATORY SYSTEM**

- Lymphatic vessels drain excess interstitial fluid and leaked plasma proteins from areas of edema.
- Macrophages in skin help protect skin.
- Lymphatics from mucosa help avoid infection in nose.

**RESPIRATORY SYSTEM**

- Tonsils, alveolar macrophages, and MALT (mucosa-associated lymphatic tissue) help protect large lungs.
- Lymphatic vessels drain excess interstitial fluid from lungs.

**SKELTAL SYSTEM**

- Lymphatic vessels drain excess interstitial fluid and leaked plasma proteins from connective tissue around bones.

**MUSCULAR SYSTEM**

- Lymphatic vessels drain excess interstitial fluid and leaked plasma proteins from muscle.

**ENDOCRINE SYSTEM**

- Flow of lymph helps distribute some hormones and cytokines.
- In certain cases, lymphatics invest interstitial fluid and leaked plasma proteins from endocrine glands.

**REPRODUCTIVE SYSTEMS**

- Lymphatic vessels drain excess interstitial fluid and leaked plasma proteins from testes.
- MALT helps defend against toxins and pathogens that penetrate the body via the urethra.
- The vagina and penis.
- Herpes, when established in the genital tract, is not shed.
- Immunity due to inhibition of immune response.
- IgG antibodies can cross the placenta to a developing fetus via the developing fetus.
- Lymphatic vessels drain excess interstitial fluid from the skin of a nursing mother.

**CONTRIBUTIONS OF THE LYMPHATIC SYSTEM AND IMMUNITY FOR ALL BODY SYSTEMS**

- B cells, T cells, and antibodies protect all body systems from attack by harmful foreign invaders (bacteria, fungi, cells, and cancer cells).

Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

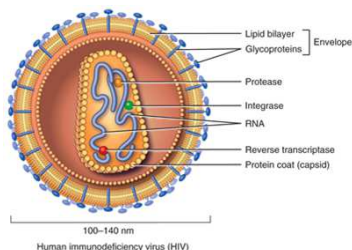
---

---

---

## Homeostatic Imbalances: HIV/AIDS

Acquired immunodeficiency syndrome (AIDS) is a condition in which a person experiences an assortment of infections due to the progressive destruction of immune system cells by the human immunodeficiency virus (HIV)



Copyright © 2014, John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

---

---

### Homeostatic Imbalances: Allergies

- Allergies occur when a person is overly reactive to a substance that is well-tolerated by most others
- When an allergic reaction occurs so does tissue damage
- There are 4 types of hypersensitivity reactions, Type I-IV

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

### Homeostatic Imbalances: Autoimmune Diseases

An autoimmune disease occurs when the immune system fails to display self-tolerance and, instead, attacks the person's own body tissue(s)

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---

### End of Chapter 22

#### Copyright 2014 John Wiley & Sons, Inc.

All rights reserved. Reproduction or translation of this work beyond that permitted in section 117 of the 1976 United States Copyright Act without express permission of the copyright owner is unlawful. Request for further information should be addressed to the Permission Department, John Wiley & Sons, Inc. The purchaser may make back-up copies for his/her own use only and not for distribution or resale. The Publisher assumes no responsibility for errors, omissions, or damages caused by the use of these programs or from the use of the information herein.

Copyright © 2014 John Wiley & Sons, Inc. All rights reserved.

---

---

---

---

---

---

---

---