

The Immune System and Defenses



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Overview of the Body's Defense Mechanisms

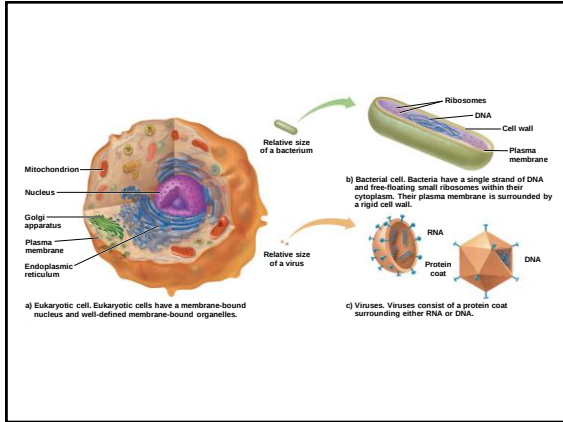
- Defense mechanisms include
 - Barriers to entry of pathogens
 - (Pathogens = disease-producing microorganisms)
 - Skin, stomach acid, tears, vomiting
 - Nonspecific defense mechanisms
 - Phagocytosis, inflammation
 - Specific defense mechanisms
 - Immune response
 - antibodies
 - T cells

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Pathogens Cause Disease

- Disease-causing agents include
 - Living organisms
 - Bacteria
 - unicellular prokaryotes
 - Fungi
 - unicellular and multicellular eukaryotes
 - Parasites
 - unicellular and multicellular eukaryotes
 - Nonliving infectious “particles”
 - Viruses
 - Prions

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Bacteria: Single-celled Living Organisms

- Characteristics
 - Prokaryotic
 - Single-celled
 - Use a variety of resources for growth and reproduction
- Infections
 - Pneumonia, tonsillitis, tuberculosis, botulism, toxic shock syndrome, syphilis, Lyme disease, etc.
- Generally treated with **antibiotics**

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Viruses: Tiny Infectious Agents

- Extremely small, much smaller than bacteria
- Living? Open to debate
 - Unable to reproduce outside of a host cell
 - No metabolic activity
- Structure
 - Contain DNA or RNA, not both
 - DNA/RNA is surrounded by a protein coat
- Diseases
 - AIDS, hepatitis, encephalitis, rabies, influenza, colds, warts, chicken pox

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Prions: Infectious Proteins

- Infectious proteins
- Normal brain proteins that are not folded correctly
 - The mis-folding becomes self-propagating, filling and disabling the cell with protein debris
- Resist cooking, freezing, drying
- Diseases
 - Bovine spongiform encephalitis (BSE, “mad cow disease”)
 - Creutzfeldt-Jakob disease (CJD)

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Transmissibility, Mode of Transmission, and Virulence Determine Health Risk

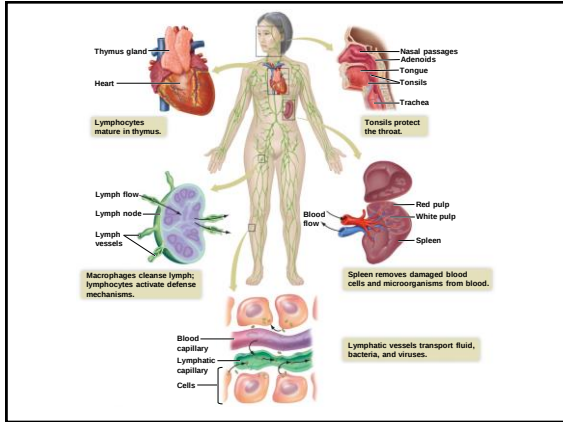
- Transmissibility
 - How easily a pathogen is passed from person to person
- Mode of transmission
 - Respiratory, fecal–oral, body fluids
- Virulence
 - How much damage is caused by the infection

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Lymphatic System Defends the Body

- Functions
 - Maintenance of blood volume in cardiovascular system
 - Transport of fats and fat-soluble material from digestive system
 - Filtration of foreign material to defend against infection

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Keeping Pathogens Out: The First Line of Defense

- **Skin**, an effective deterrent
- **Tears and saliva** – contain lysozyme (antibacterial enzyme)
- **Ear wax** – entraps microorganisms
- **Mucus** – entraps microorganisms
- **Stomach** – highly acidic, inhibits microorganisms
- **Vagina** – slightly acidic, inhibits some microorganisms
- **Vomiting, urination, and defecation** – remove microorganisms
- **Resident bacteria** – outcompete pathogens

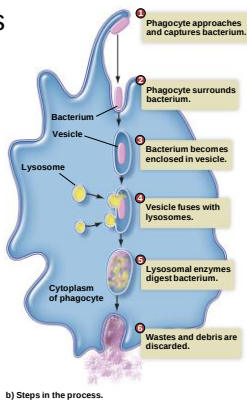
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Nonspecific Defenses: Phagocytes Engulf Foreign Cells

- **Phagocytic cells**
 - white blood cells that surround and engulf invading bacteria
 - Neutrophils, macrophages, eosinophils

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Phagocytes Engulf Foreign Cells



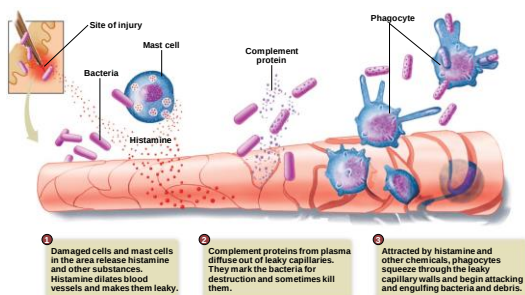
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Nonspecific Defenses: Phagocytes Engulf Foreign Cells

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 - white blood cells that surround and engulf invading bacteria
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- **Inflammation**
 - Redness, warmth, swelling, pain

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Inflammation Response



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Nonspecific Defenses: Phagocytes Engulf Foreign Cells

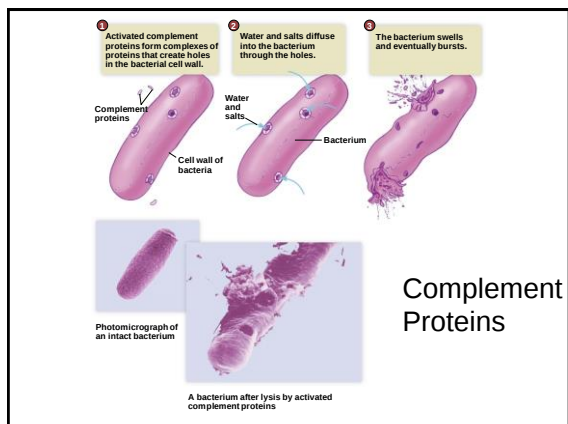
- **Phagocytic cells**
 - white blood cells that surround and engulf invading bacteria
 - Neutrophils, macrophages, eosinophils
- **Inflammation**
 - Redness, warmth, swelling, pain
- **Natural killer cells**
 - a type of lymphocyte that attacks tumor cells and virus-infected cells

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Nonspecific Defenses: Phagocytes Engulf Foreign Cells

- **Complement proteins**
 - lyse invading bacteria

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Nonspecific Defenses: Phagocytes Engulf Foreign Cells

- **Complement proteins**
 - lyse invading bacteria
- **Interferons**
 - antiviral proteins
- **Fever response**

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Specific Defense Mechanisms: Third Line of Defense (The Immune Response)

- **Characteristics**
 - Recognizes and targets specific pathogens and foreign substances
 - Has “memory” – “remembers” initial exposure and responds more quickly and aggressively on subsequent exposures
- **Able to distinguish between**
 - Self cells and foreign invaders
 - Healthy cells and abnormal (tumor) cells

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Specific Defense Mechanisms: Immune Response Targets Antigens

- **Antigen**
 - any substance that triggers an immune response
 - MHC (major histocompatibility complex) proteins
 - Self-antigens that are on human cell surfaces enabling recognition of “self”
 - Enable immune system to distinguish “self” from “nonself”

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Specific Defense Mechanisms: Lymphocytes Are Central to Specific Defenses

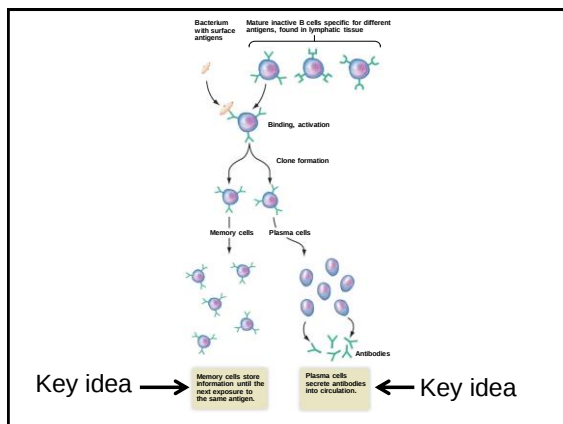
- B lymphocytes
 - Antibody-mediated immunity
 - **Antibodies:** proteins made by B lymphocytes that bind with and neutralize specific antigens
 - Active against viruses, bacteria, and soluble foreign molecules
 - B cells activated when they recognize an antigen

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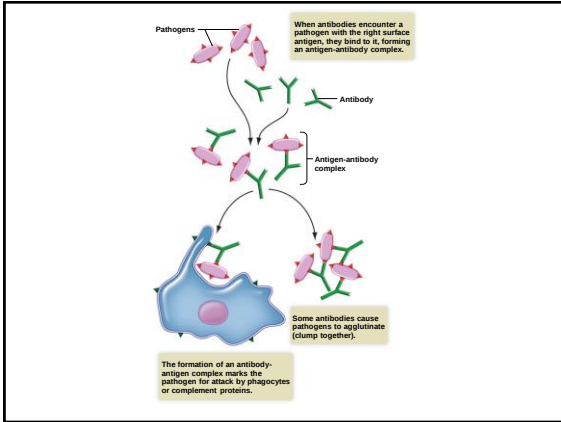
Specific Defense Mechanisms: Lymphocytes Are Central to Specific Defenses

- T lymphocytes
 - Cell-mediated immunity
 - Directly attack foreign cells
 - Coordinate the immune response
 - Active against parasites, viruses, fungi, intracellular bacteria, cancer cells, cells with “nonself” MHC

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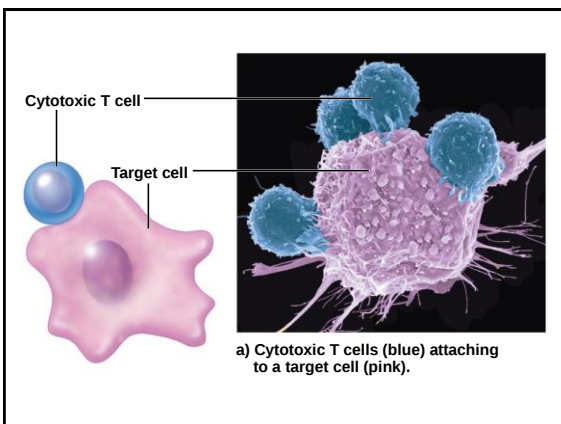


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T Cells: Cell-Mediated Immunity

- **Helper T cells**
 - Secrete cytokines, which stimulate other immune system cells
 - Play a key role in directing the immune response
- **Cytotoxic T cells**
 - Directly attack and destroy abnormal (tumor or viral-infected) cells and foreign cells
- **Memory T cells**
 - Reactivate during later exposures

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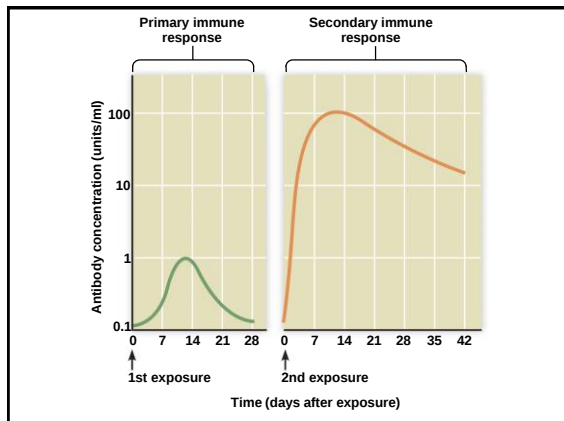


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Immune Memory Creates Immunity

- Primary immune response
 - Occurs on first exposure to antigen
 - Characteristics
 - Lag time of 3–6 days for antibody production
 - Peak at 10–12 days
- Secondary immune response
 - Occurs on second and subsequent exposure to antigen
 - Characteristics
 - Lag time in hours
 - Peak in few days

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Medical Assistance in the War Against Pathogens: Immunization

- A strategy for causing the body to develop immunity to a specific pathogen
- **Active immunization**
 - Intentionally expose individual to a form of the antigen that doesn't produce disease
 - Also known as **vaccination**
- **Passive immunization**
 - Administer protective antibodies to an individual

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Medical Assistance in the War Against Pathogens: Antibiotics Combat Bacteria

- Antibiotics kill bacteria or inhibit their growth
- Antibiotics are selectively toxic for bacteria by targeting features of bacterial cells that are different from eukaryotic cells
- Antibiotics are not effective against viruses

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Inappropriate Immune System Activity Causes Problems: Allergies

- Allergies are hypersensitivity reactions
 - Inappropriate response to an allergen
- Treatment of allergies
 - Antihistamines – treatment of mild to moderate reactions
 - Epinephrine injection – treatment of anaphylactic shock
 - Allergy shots

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Inappropriate Immune System Activity Causes Problems: Autoimmune Disorders

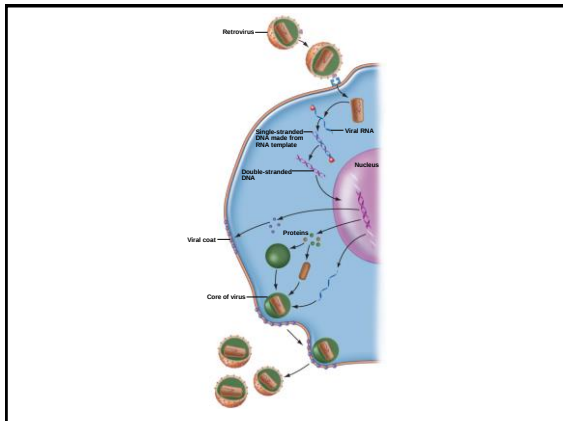
- Inability of immune system to distinguish “self” from “nonself”
- Autoantibodies and cytotoxic T cells target the body’s own tissues
- Examples
 - Lupus erythematosus (LE or lupus)
 - Inflamed connective tissue
 - Rheumatoid arthritis
 - Inflamed synovial membrane

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Immune Deficiency: The Special Case of AIDS

- AIDS
 - Acquired Immune Deficiency Syndrome
- Caused by infection with HIV (Human Immunodeficiency Virus)
- HIV targets helper T cells
- Transmission via body fluids (blood, semen, breast milk, vaginal secretions)

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AIDS Develops Slowly: Phase I

- Phase I
 - May last a few weeks to a few years
 - Brief period of flu-like symptoms
 - Swollen lymph nodes
 - Chills
 - Fever
 - Fatigue
 - Body aches
 - Most people don't exhibit recognizable symptoms
 - Virus is multiplying, antibodies are made but are ineffective for complete virus removal

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AIDS Develops Slowly: Phase II

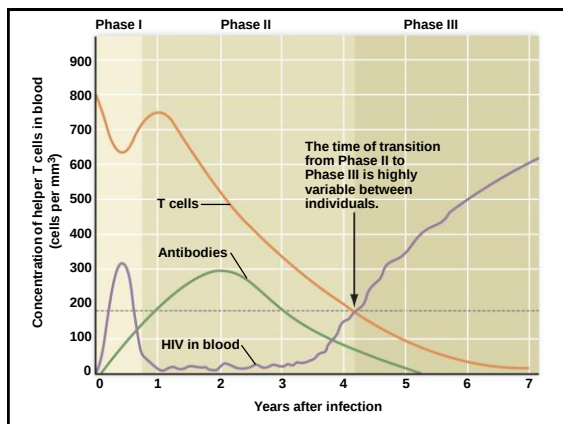
- Phase II
 - Occurs within 6 months to 10 years
 - Opportunistic infections present
 - Helper T cells affected, numbers are decreasing
 - If untreated, 95% will progress to next phase (AIDS)

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AIDS Develops Slowly: Phase III (AIDS)

- Phase III: Clinical AIDS
 - Helper T cells fall below 200 cells/mm³
 - Opportunistic infections and cancers present
 - Tuberculosis
 - Pneumonia
 - Meningitis
 - Encephalitis
 - Kaposi's sarcoma
 - Non-Hodgkins lymphoma
 - If untreated, nearly always fatal

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Risky Behaviors Increase Your Chances of Getting AIDS

- Males (3/4 of new cases)
 - Sex with other men
 - Sharing needles during intravenous drug use
 - Heterosexual sex with HIV-infected female
- Females (1/4 of new cases)
 - Sex with HIV-infected male
 - Sharing needles during intravenous drug use

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Sex Can Be Safer

- Abstinence
- Reduce number of sexual partners
- Choose sexual partners with low-risk behavior
- Avoid high-risk sexual practices
 - Anal-genital sex is a high-risk practice
- Use latex or polyurethane condoms or barriers
- GET TESTED

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New Treatments Offer Hope

- HIV Drugs
 - Reverse transcriptase inhibitors: AZT
 - Protease inhibitors: ritonavir, saquinavir
 - Maraviroc: new drug
 - Blocks entry of HIV into T cells
 - Early treatment may delay or prevent clinical AIDS
- Vaccine
 - Under development and testing
 - Challenge: Virus mutates rapidly

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