Chapter 9

Lectures 19,20

Immunity and the Lymphatic System

The Immune System

- **The immune system is a defensive and counter-attacking system**
  - It attempts to prevent, or to stop, invasions of pathogens from causing disease
  - Pathogens are disease-causing agents, such as fungus, bacteria, virus
- **There are two systems that provide the ability to defend against pathogens**
  - Nonspecific (or innate) immunity
    - Inborn
    - Mounts the same defenses each time, regardless of the pathogen type
  - Specific (or acquired) immunity
    - Part is inborn – part develops over course of life
    - Mounts a specific attack against a specific pathogen

Our Immune System Has Three Lines of Defense

- **Innate immunity (nonspecific)**
  - **First line of defense - physical and chemical surface barriers**
    - Skin, mucous membranes, mucus, hairs, tears, saliva, urine, defecation, and vomiting
    - Sebum, lysozyme, gastric juice, vaginal secretions
  - **Second line of defense - internal cellular and chemical defenses**
    - Antimicrobial proteins – interferons and the complement system
    - Fever, inflammation, and phagocytes
- **Specific immunity**
  - **Third line of defense - immune responses**
    - Interactions of white blood cells, antibodies, and macrophages
    - Also, helps to protect against cancer

First Line of Defense: Physical Surface Barriers "Mucous Membranes"

- **Mucous membranes provide nonspecific immunity**
  - Mucous membranes are epithelium
  - They line any cavity open to the exterior
    - Mouth
    - Digestive tract
    - Respiratory tract
    - Urinary tract
    - Reproductive tract
- **Mucous is secreted by some of the epithelial cells (called goblet cells)**
  - Mucus retards pathogens by trapping pathogens
  - The mucous with trapped pathogens is moved out of the body

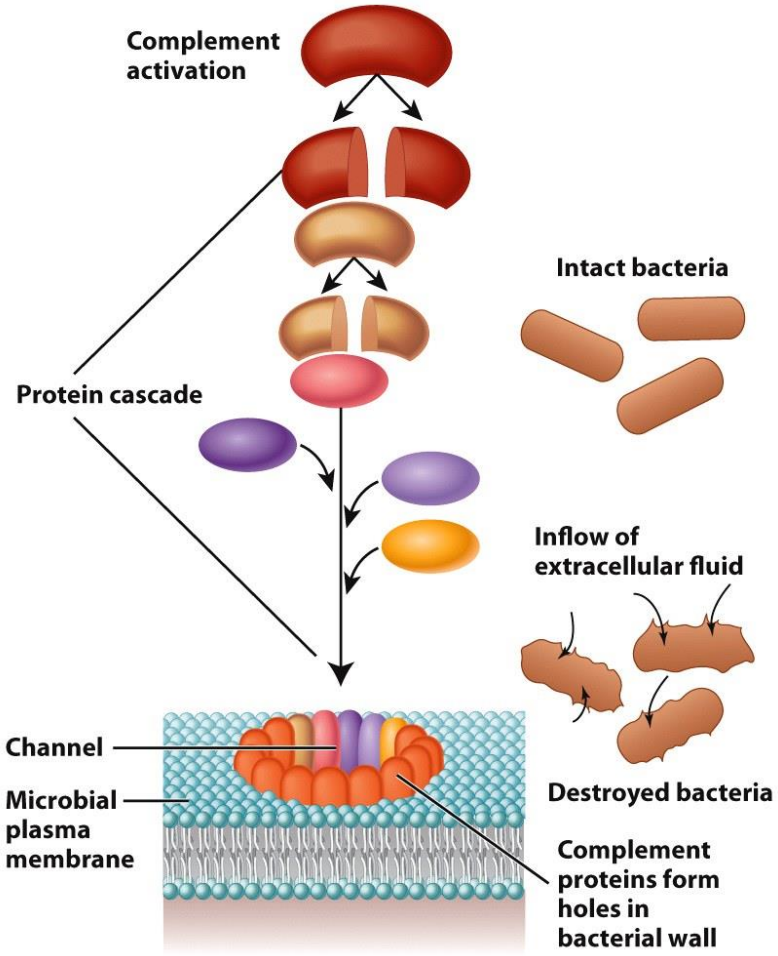
First Line of Defense: Chemical Surface Barriers "Innate Chemical Barriers"

- **When the physical innate barriers fail to stop a pathogen, chemical barriers aid in the first line of defense**
- **Chemical barriers include**
  - Sebum (oil from sebaceous glands)
    - Forms a protective acidic film over the skin surface that is hostile to many bacteria
  - Perspiration, tears, saliva
    - Contain an enzyme called lysozyme, which is a natural antibacterial chemical
  - Gastric acid (produced by stomach lining)
    - The extremely low pH of the acid kills many pathogens
  - Bacteria
    - Help create a hostile environment for other microbes

Second Line of Defense: Antimicrobial Proteins "The Complement System"

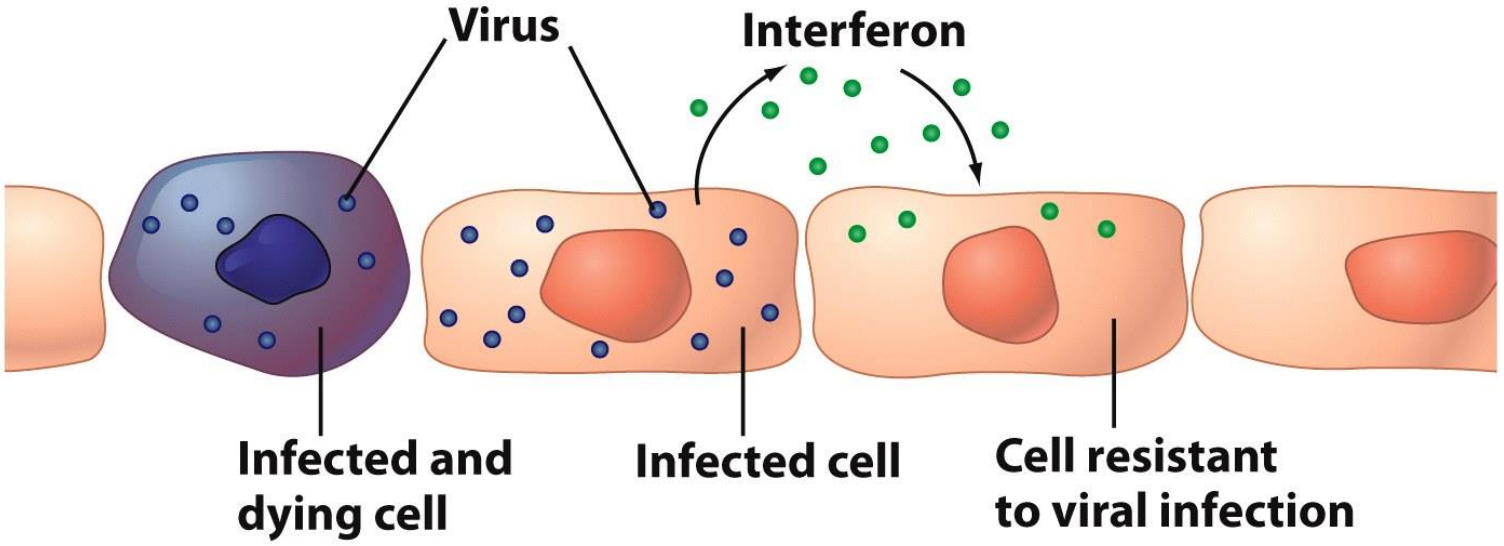
- **The complement system is effective against bacteria but not viruses**
- **The complement system**
  - A series of chemical reactions brings together a group of proteins that are usually floating freely in the plasma
  - These proteins organize in a specific order to create a "complement complex" of proteins
  - When a bacterial invasion is encountered, the complement complex assembles, attaches to the bacterial walls, and impales the cell with the protein complex
  - With the bacterial wall breached, osmotic pressure forces water into the bacterium, destroying its chemistry and killing it

Second Line of Defense: Antimicrobial Proteins "The Complement System"



Second Line of Defense: Antimicrobial Proteins "Interferons"

- **Interferon attacks virally infected cells**
  - Interferon is secreted by virus-infected cell and passes to nearby uninfected cells
  - If neighboring cells become infected with a virus, the interferon inside them will kill the virus - thus preventing the further spread of virus infection



Second Line of Defense: Internal Cellular Defenses "Fever"

- **Fever is defined as a change in the body's temperature set point**
  - Resulting in an elevation in basal body temperature above 37.0˚C (98.6˚F)
  - Proteins called pyrogens reset the body's thermostat to a higher temperature
- **Fever harms pathogens directly and indirectly**
  - Fever may harm the pathogen directly, but more likely it aids defensive mechanisms by raising the metabolic rate
  - At elevated temperatures, enzymes and repair processes work faster, cells move more quickly, and specific immune cells are mobilized more rapidly

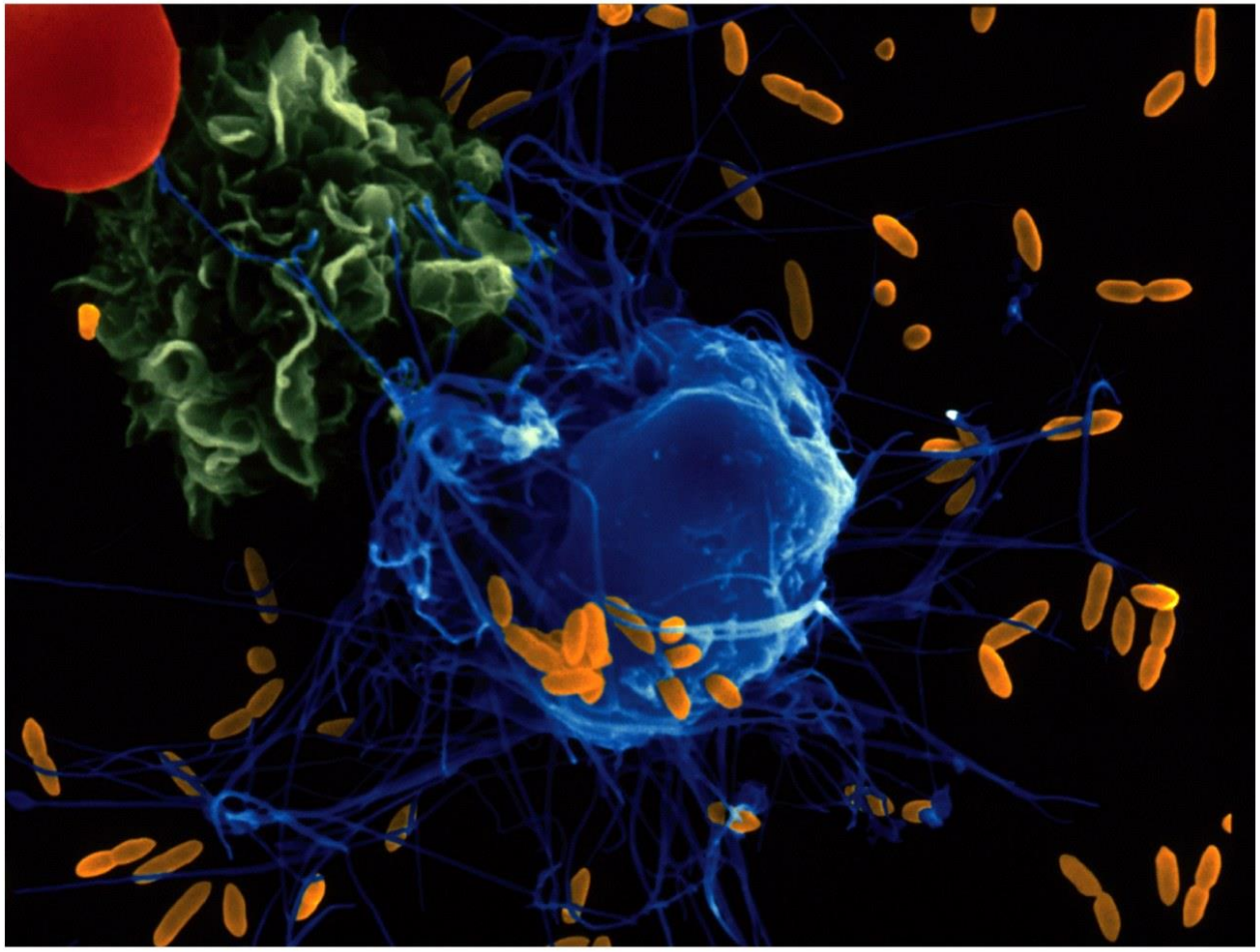
Second Line of Defense: Internal Cellular Defenses "Inflammation"

- **Inflammation is similar to fever in its goal, but it is a localized, not whole-body, method**
  - Inflammation can be triggered by many factors, including pathogen entry, tissue abrasion, chemical irritation, or even extreme temperature
- **Inflammation produces swelling, redness, heat, and pain**
  - Damaged or irritated cells release prostaglandins, proteins, and potassium
  - These trigger inflammation when released into the interstitial fluid
- **The benefits of inflammation include**
  - Temporary tissue repair
  - Blockage of continued pathogen entry
  - Slowing of pathogen spreading
  - Quicker repair of the damaged tissue

Second Line of Defense: Defensive Cells "Phagocytes"

- **Phagocytes (white blood cells) wander through tissues, engulfing and removing anything that does not belong there**
  - Remove all dead or dying cells, cellular debris, pathogens, and foreign material
    - Infected and damaged cells release chemical messengers that trigger phagocyte activity
- **There are two kinds of phagocytes**
  - Neutrophils (microphages)
    - The first phagocytes to leave the blood vessels in response to infection or cell damage
  - Macrophages
    - Large actively patrolling white blood cells that left the blood vessels
    - Travel through every tissue looking for foreign material

Second Line of Defense – Defensive Cells "Phagocytes"



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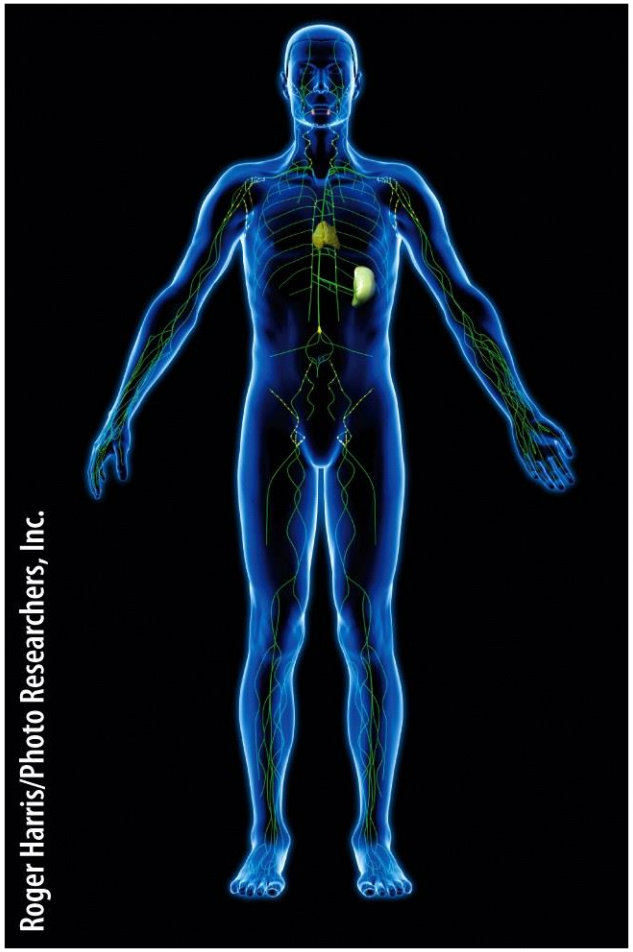
The Lymphatic System – Governs the Third Line of Defense "The Specific (Acquired) Immune Response"

- **Composed of**
  - Lymph
    - Fluid bathing tissues (interstitial fluid) that is inside the lymph vessels
  - Lymphatic organs and tissues
    - Filter and clean lymph
    - Check for pathogens
    - Tonsils, spleen, bone marrow, thymus, lymph nodes, and Peyer's patches
  - Lymphatic vessels
    - Connect lymphatic organs
  - Lymph nodes
    - Some phagocytic cells live in nodes
    - They become activated if pathogen is present in the lymph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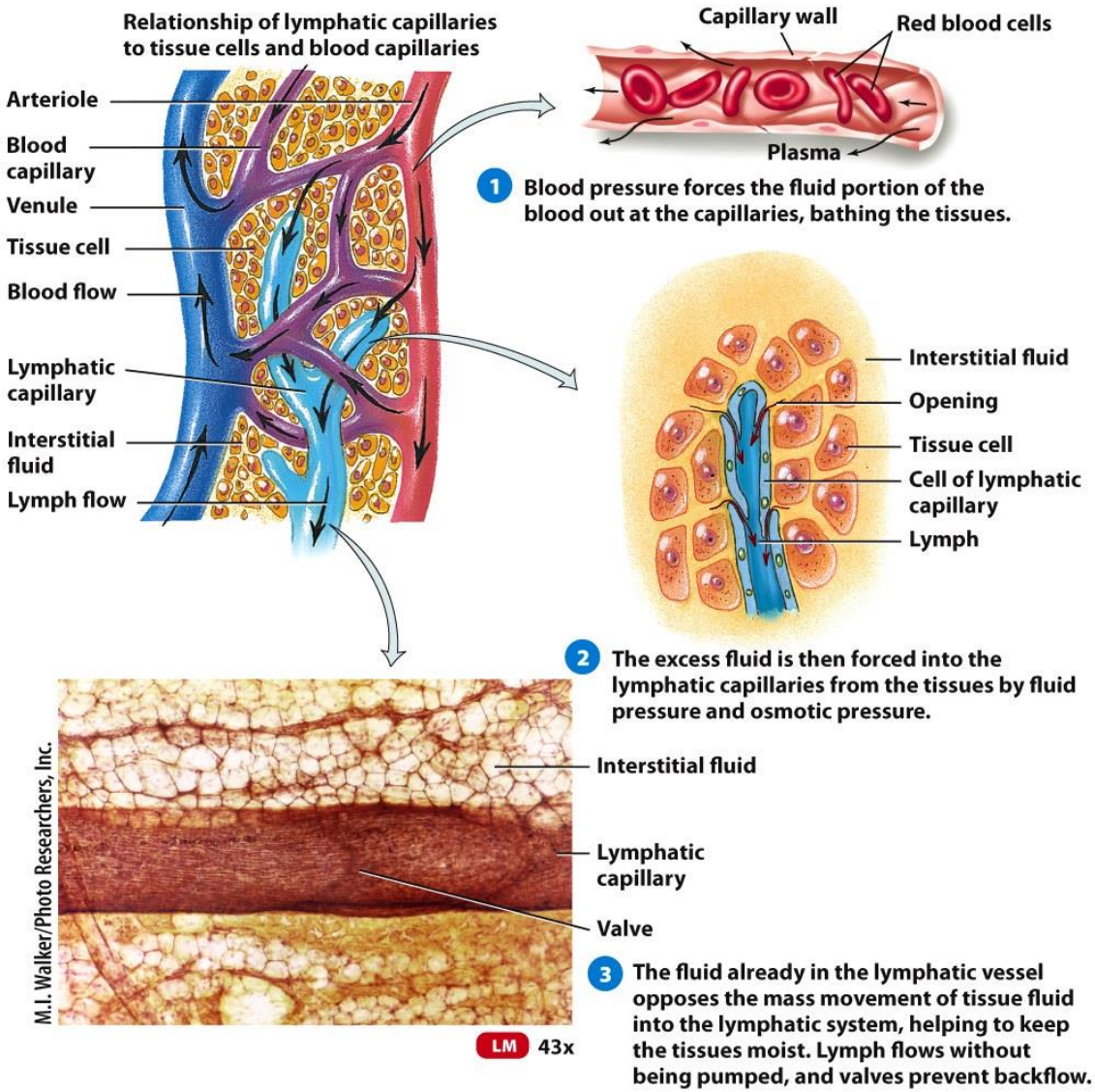
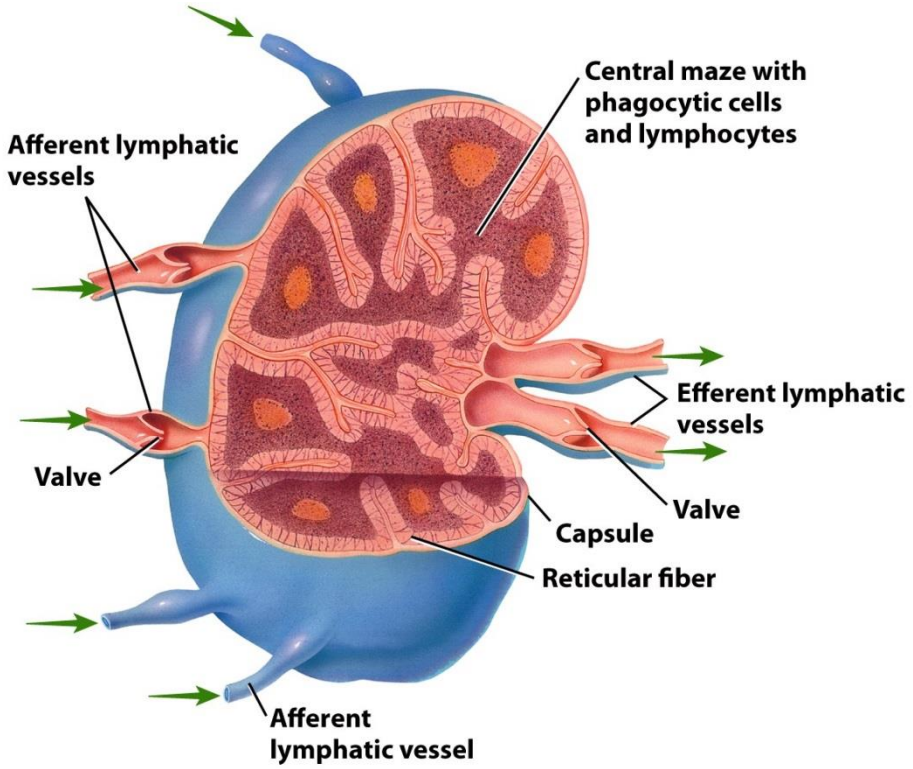
The Lymphatic System – "Lymphatic Vessels"



The Lymphatic System – "Lymph Nodes"

- **Lymph nodes function in concert with lymphatic tissue, organs, and vessels**
  - Return excess fluid from the tissues to the bloodstream
  - Absorb fats from the intestine and transport them to the bloodstream
  - Defend the body against specific invaders



The Third Line of Defense
"The Specific (Acquired) Immune Response"

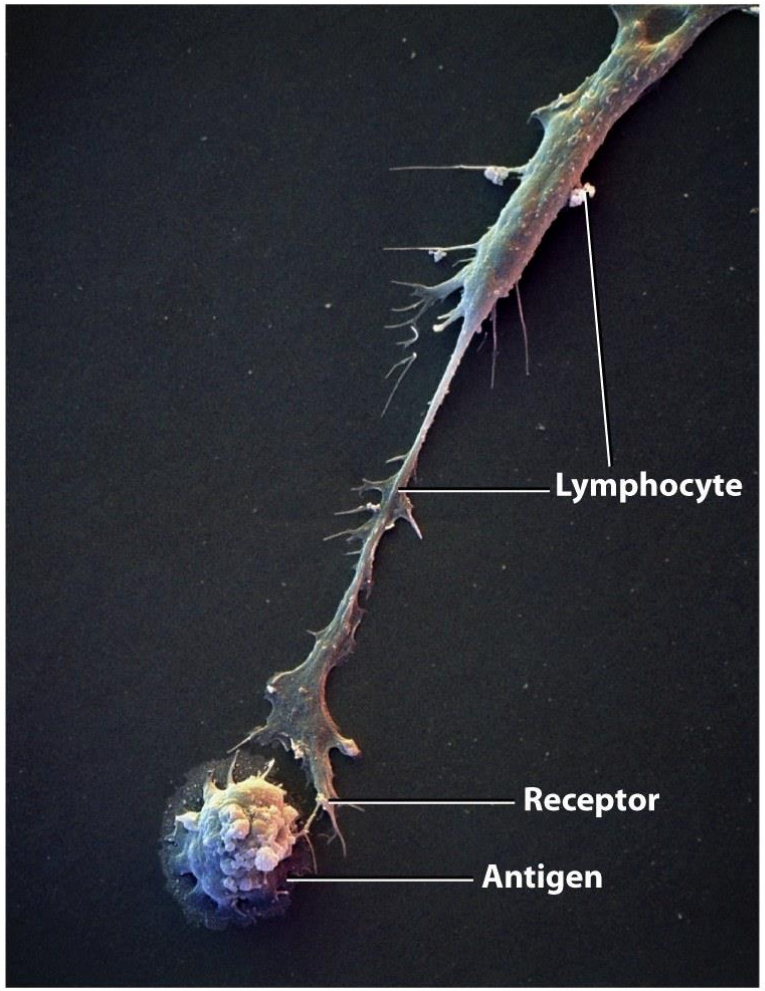
- **Specific immunity – the immune system**
  - Relies on a series of white blood cells, called lymphocytes, that recognize and remember pathogens
    - Can distinguish self from nonself
    - Each reacts only to a particular antigen (disease causing agent)
    - Remember certain pathogens and, therefore, can react more quickly when the pathogen re-infects
- **The immune system uses two methods for combating pathogens, both of which are carried out by lymphocytes**
  - Antibody-mediated (or humoral) immunity
    - Specialized B-lymphocytes create disease-fighting compounds called antibodies
  - Cell-mediated (or cellular) immunity
    - Specialized T-lymphocytes directly attack pathogen-containing cells
    - Through direct cell-to-cell contact

The Immune System – "Lymphocytes"

- **Two main classes of lymphocytes are involved in immunity**
  - B cells (B lymphocytes)
    - Mature in the bone marrow
    - Spend most of their time inside lymph nodes and interstitial fluid
    - Produce specific antibodies in response to a particular pathogen
  - T cells (T lymphocytes)
    - Mature in the thymus gland in response to thymic hormones
    - Make up about half of the circulating lymphocytes in the blood
    - Involved in direct destruction of antigen-containing cells
      - Through direct cell-to-cell contact
    - Some T cells stimulate B cells to produce antibodies
      - T cells do not produce antibodies

The Immune System – "Lymphocytes"

- **Lymphocytes have receptors on their cell membranes**
  - Detect the exact antigen
- **Each lymphocyte's receptors are specific to only one antigen**
  - Will ignore all others
  - i.e., specific immunity



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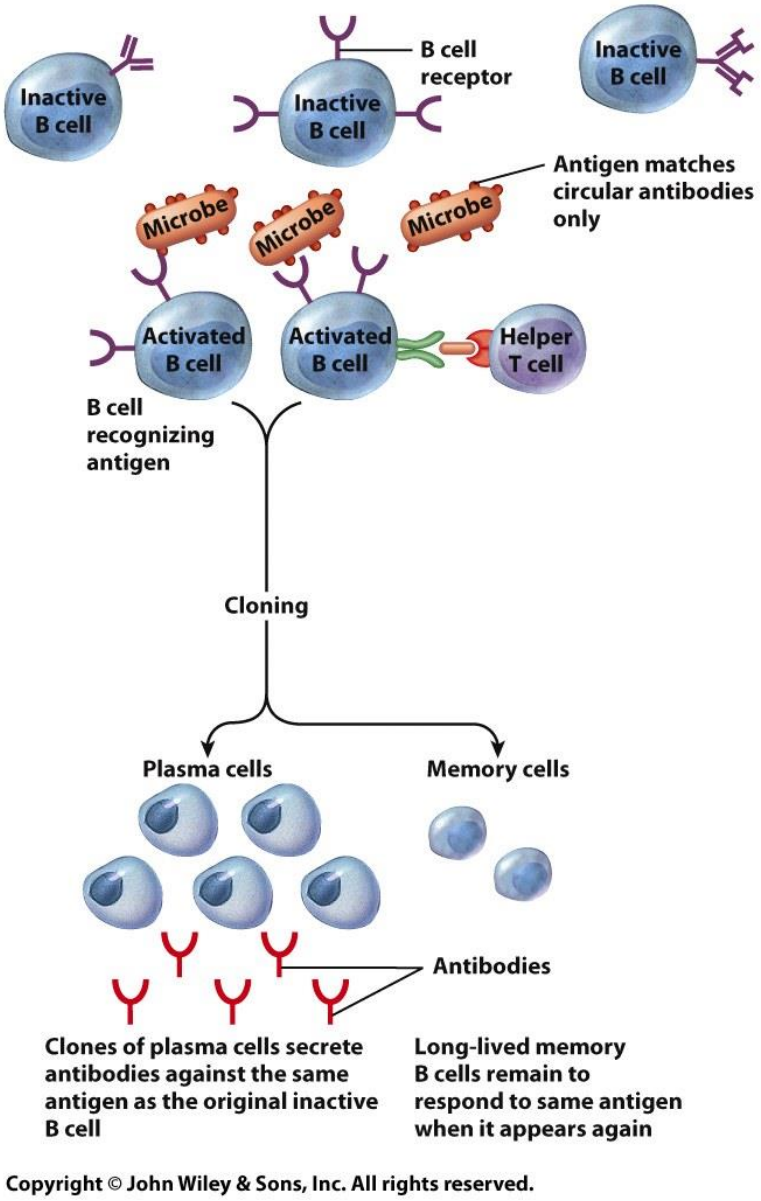
The Immune System - "Antibody-Mediated Immunity"

- **Also known as "humoral immunity" - involves B cells**
  - Each B cell produces a different antibody that is directed toward a specific antigen
  - Antibodies inactivate antigens, usually by causing them to agglutinate
- **When stimulated by an antigen, B cells begin to divide, creating a large population of clones – clonal selection**
  - Most of these cloned B cells will become plasma cells that produce antibodies specific to the antigen
  - A small population of the cloned B cells will become memory B cells
    - Serve as long-term immunity
    - If the pathogen reappears, these cells will quickly produce antibodies
    - Vaccinations rely on using memory B cells

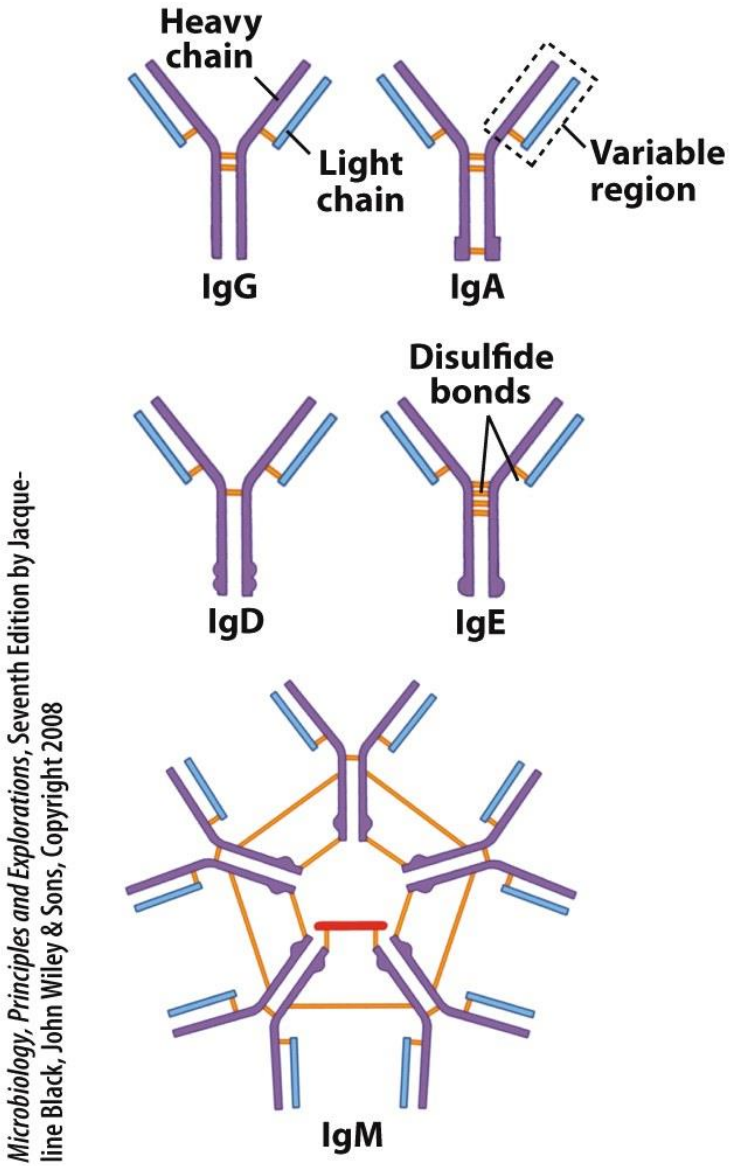
Antibody-Mediated Immunity



Antibody-Mediated Immunity – "Antibodies"

- **There are five classes of antibodies (also called immunoglobulins)**
  - **IgG** occurs in the circulating blood, lymph, and extracellular fluid
  - **IgM** is the first immunoglobulin released in any immune response and is also the predominant immunoglobulin produced in infants
  - **IgA** can be found in secretions such as saliva and can bind to pathogens before they enter the bloodstream
  - **IgD** binds antigens that stimulate B cell activation
    - Found on mature B cells
  - **IgE** appears on the surface of basophils and mast cells, both of which release histamines and other chemicals implicated in allergic symptoms
    - Responsible for immediate allergic reactions

Antibody-Mediated Immunity – "Antibody Structure"



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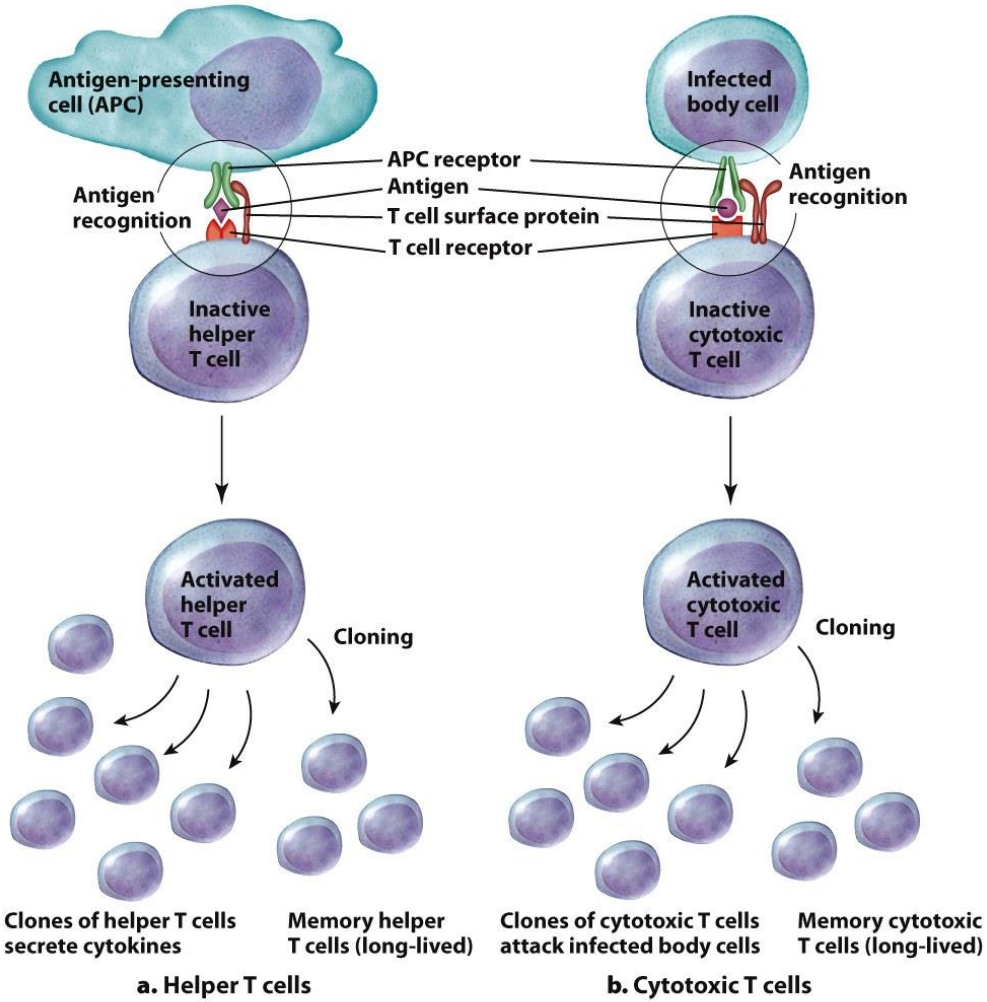
The Immune System - "Cell-Mediated Immunity"

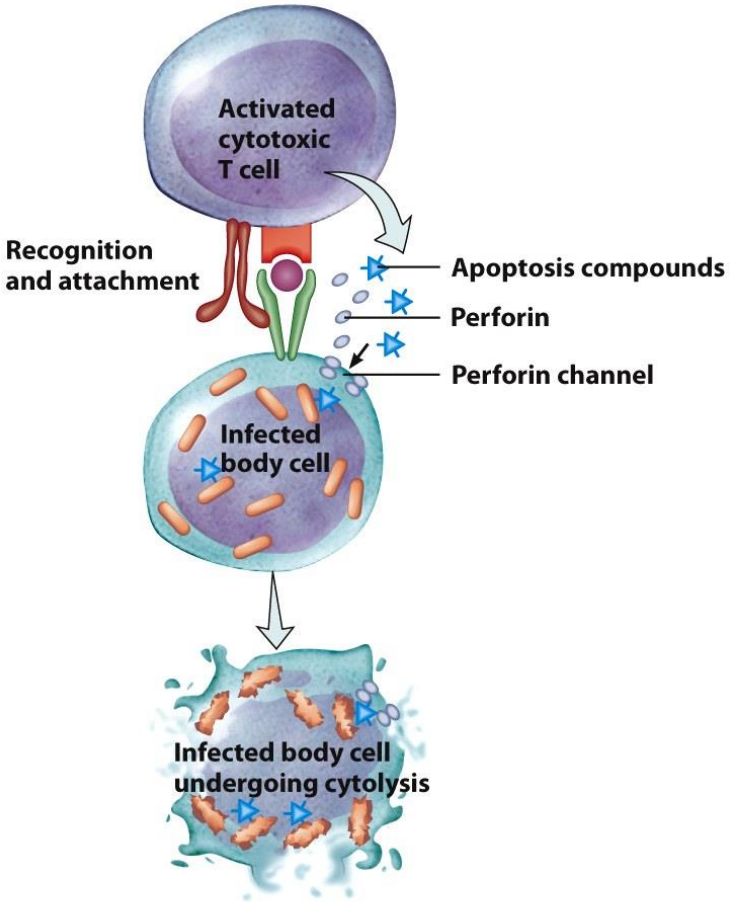
- **Governed by the T cells that are carried in the blood**
  - T cells must have the antigen presented to them
    - Carry receptors on their surface that will bind to specific antigens
- **There are two populations of T cells**
  - **Cytotoxic T cells**
    - Seek out and destroy the stimulating pathogen where ever it occurs in the body – make holes in cells, thus killing them
    - Stimulated to divide by cytokines released from helper T cells
    - Respond specifically to altered HLA (human leukocyte antigen) proteins
  - **Helper T cells**
    - Helper T cells travel through the blood and lymph to the lymph nodes
    - Stimulate cytotoxic T cells and ALSO matching B cells
- **When activated, both kinds of T cells make clones and memory T cells of themselves**

Cell-Mediated Immunity



Natural Killer Cells

- **Some T lymphocytes differentiate into natural killer cells**
  - Attack virus-infected cells and tumor cells, killing through cell-to-cell contact
- **Natural killer cells are actually part of the non-specific immune response**
  - They remove all foreign or infected cells in exactly the same way
  - They make holes in cells, thus killing them
    - ***Similar mechanism is used by Cytotoxic T cells***
  - They do not respond to immunization or produce clones of memory cells



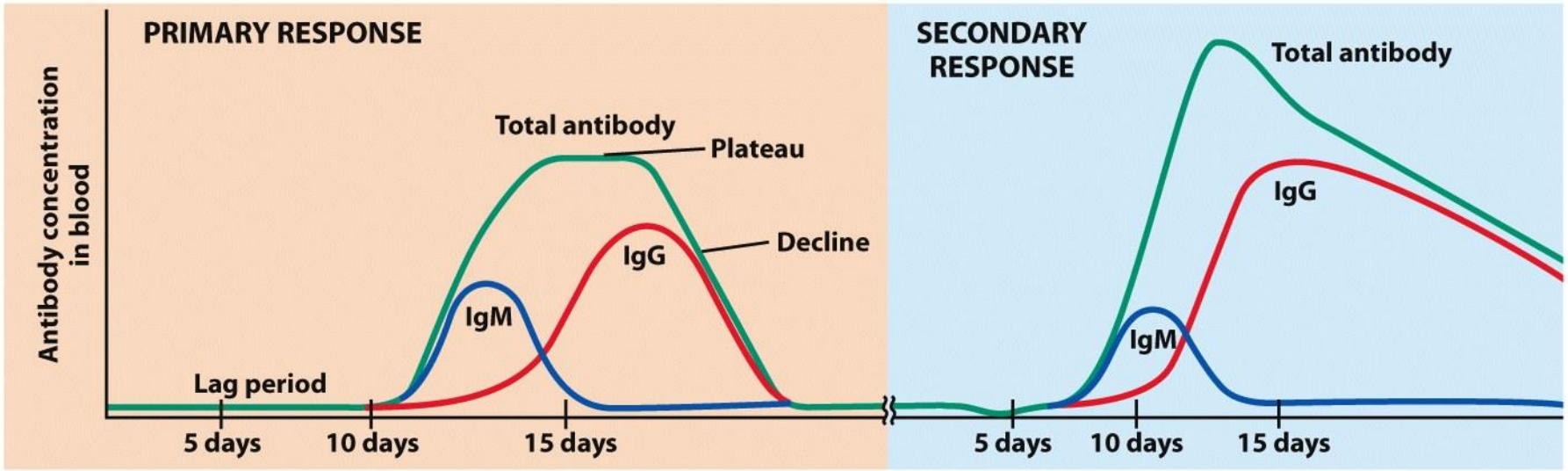
Cytotoxic T cell destruction of infected cell by release of perforins that cause cytolysis; microbes are destroyed by other released chemicals.

Active and Passive Immunity

- **Active immunity**
  - Immunity from experience
  - The immune system is exposed to the antigen in the natural course of life and immune cells respond and actively combat the pathogen
- **Passive immunity**
  - Occurs when antibodies are transferred without stimulating the immune system
    - i.e., from mother to infant (through breast milk)

Active Immunity

- **The advantage of active immunity comes from the creation of memory cells**
  - Memory cells produced during the primary response remain in the body for years until the same antigen reappears – then start the secondary response
  - The secondary response to that particular antigen will be faster because the immune system needs to stimulate and clone only the specific memory cells



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Passive Immunity

- **Passive immunity is the transfer of antibodies without stimulating the immune system**
  - Passive immunity does not expend energy creating antibodies or producing clones
  - Introduced antibodies provide the recipient with immediate resistance to specific antigens
- **Once the antibodies are used or broken down, however, the body cannot create more, and the immune protection is lost**

Autoimmune Diseases

- **An autoimmune response is an immune response in which the body attacks itself**
- **Autoimmune diseases have different effects depending on what tissue is under attack**
  - Multiple sclerosis – attacks nervous tissue
  - Crohn's disease – attacks the absorptive portion of the intestinal tract
  - Type I diabetes mellitus – attacks the pancreas
  - Lupus - site of attack varies - may affect the skin, joints, kidney, lungs
  - Rheumatoid arthritis – attacks the joints