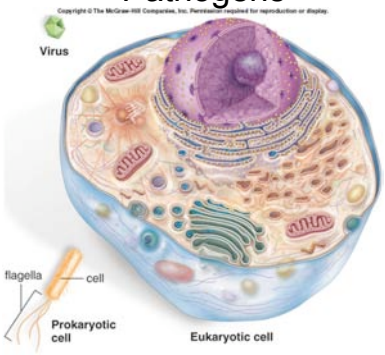
Body Defenses

Pathogens & Immunity

Pathogens

- Pathogen: an agent causing a disease
- Microbe: microscopic organism (most are **not** pathogens)
  - Bacteria
  - Protists (eukaryotic, single-celled)
  - Multicellular (fungi, parasites)
- Infectious particles (non-living)
  - Viruses: nucleic acids wrapped in protein capsid
  - Prions: rogue proteins

Pathogens



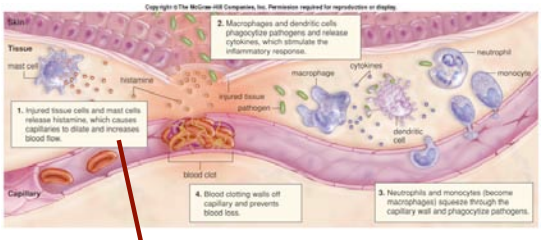
First line of Defense: Barriers

- Stratified squamous epithelia
  - Skin; mucous membranes
- Flushing action
  - Urine, tears, saliva, sweat, oil glands
- Mucus traps
  - Respiratory, digestive, and vaginal tracts
- Lysozyme (enzyme digests bacterial walls)
  - Tears, sweat, saliva
- Acidic pH
  - Stomach, vaginal secretions
- High body temperature
- Competition from microflora (resident microbes)

Second line of Defense: Non-specific Responses

- Macrophages and Fixed Phagocytes
  - Phagocytosis of any "non-self" cell
- Inflammation

Inflammatory Response



- Hallmark symptoms of inflammation: **redness, heat, swelling and pain**

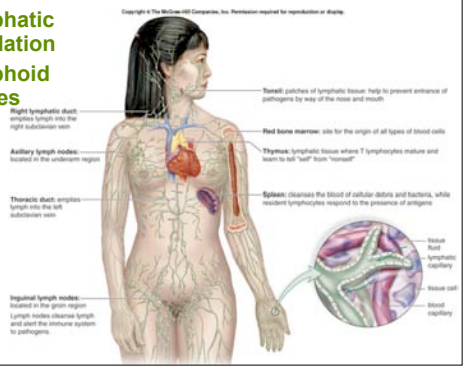
Third line of Defense:
Specific Responses (Immunity)

The Lymphatic System

- B-lymphocytes & **antibody-mediated defense**
  - Esp. vs. bacteria, chemical toxins, & free viruses
- T-lymphocytes & **cell-mediated defense**
  - Esp. vs. eukaryotic pathogens: parasites, viral-infected cells, cancerous cells, & transplanted tissues

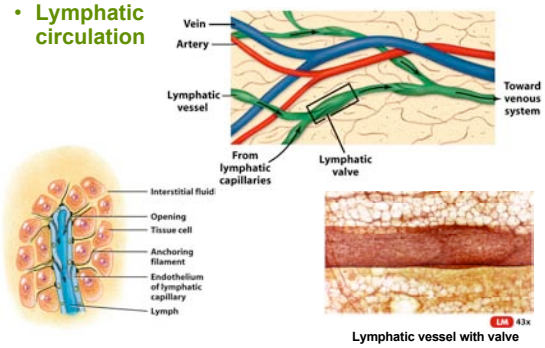
The Lymphatic System

- **Lymphatic circulation**
- **Lymphoid tissues**



The Lymphatic System

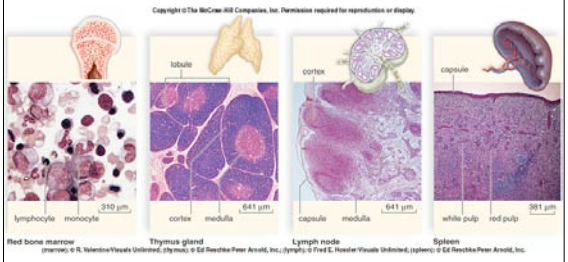
- **Lymphatic circulation**



Lymphatic vessel with valve

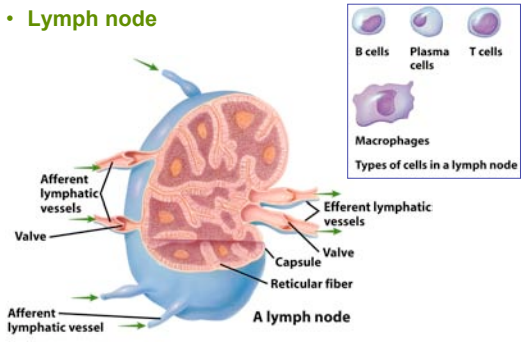
The Lymphatic System

- **Lymphoid tissues**



The Lymphatic System

- **Lymph node**



B-Lymphocytes (B-cells)

- Type of white blood cell produced from stem cells in **B**one marrow
- Secrete antibodies (binding proteins)
- Each primary B-cell produces only one specific antibody
- Each antibody binds one specific substance (antigen)
- **Clonal Selection**: If B-cell encounters its antigen, it replicates quickly to produce a large population (clone) of B-cells making that antibody

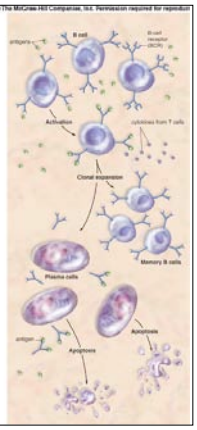
Table 7.1 Immunocell Type and Function

Cell	Function
B cells	Produce plasma cells and memory cells
Plasma cells	Produce specific antibodies
Memory cells	Ready to produce antibodies in the future

Antibody-mediated immunity by B-cells

B-cell clone

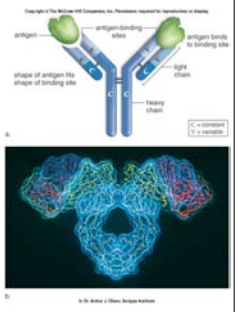
- Most as **plasma cells** — secrete lots of specific antibody to bind up specific antigen
  - Once antigen is gone, plasma cells self-destruct
- Some as **memory cells** — remain in body until antigen is again encountered
  - Then replicate to make more plasma & memory cells
  - The more often a specific antigen is encountered, the more memory cells. Thus faster, bigger response in future



Antibody-mediated immunity by B-cells

Antibody: Y-shaped protein with twin binding sites

- Bind to toxin molecule or infectious particle
  - Prevent it from reacting or entering cells
- Bind to molecule on surface of pathogen organism
  - Clump them together
  - "Tag" them for endocytosis
  - Initiate "complement fixation"
    - Plasma proteins insert into its cell membrane causing lysis



T-Lymphocytes (T-cells)

- Type of white blood cell produced from stem cells in bone marrow, but migrate and finish differentiation in **T**hymus
- Produce specific binding protein that remains anchored to T-cell surface (receptor)
- **Clonal Selection**: If T-cell encounters its antigen, it replicates quickly to produce a large population (clone) of T-cells making that receptor

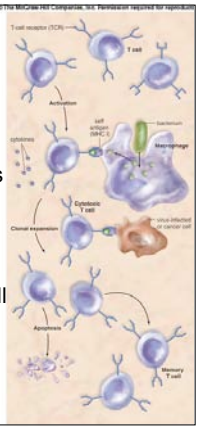
Table 7.1 Immunocell Type and Function

T cells	Regulate immune response; produce cytotoxic T cells and helper T cells
Cytotoxic T cells	Kill virus-infected cells and cancer cells
Helper T cells	Regulate immunity
Memory T cells	Ready to kill in the future

Cell-mediated immunity by T-cells

T-cell clone

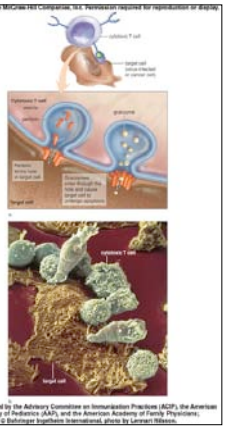
- Most as **helper T-cells** — secrete cytokines that attract/activate specific & nonspecific defense cells
  - Some cytokines are interferons: block viral replication in infected cells
- Many as **cytotoxic T-cells** — punch holes and cause self-destruct of pathogen or infected cell
- Some as **memory cells** — remain in body until antigen is again encountered



Cell-mediated immunity by T-cells

Cytotoxic T-cells

- Activated by **helper T-cell** cytokines
- T-cell receptor (TCR) binds to antigen on target cell
- Vesicles containing perforins and granzymes exocytosed onto target cell
- Perforins form pores in target cell membrane
- Granzymes initiate self-destruct

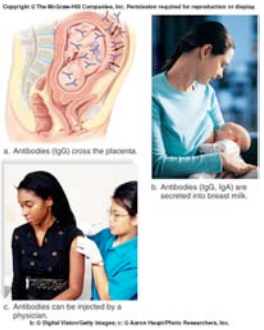


Immunization: Passive Immunity

Passive: inoculate with antibodies

- Maternal antibodies via placenta or breast-feeding
- Anti-venom
- General gamma-globulin shot (plasma protein fraction containing antibodies)
- Monoclonal antibodies

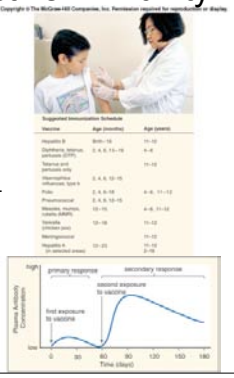
- Quick defense, but short duration immunity
  - Once antibodies are gone, so is immunity



Immunization: Active Immunity

Active: stimulate body to make antibodies and/or T-cells

- Exposure or inoculation with
  - Pathogen
  - Weakened or killed pathogen
  - Purified antigen from pathogen
- Slower initial response, but long-lasting immunity
  - Booster shots increase specific memory cell population
  - Faster & stronger response to subsequent exposures



Immune System Disorders

- **Allergies**
  - Hypersensitivity to certain antigens (allergens)
    antibodies initiate an inflammation response
    - Localized: hot, swelling, red, pain/itch
    - Respiratory: swelling restricts airway
    - Systemic: dilation of many arteries
      blood pressure anaphylactic shock
  - Delayed inflammation initiated by T-cells
    - Poison oak

Immune System Disorders

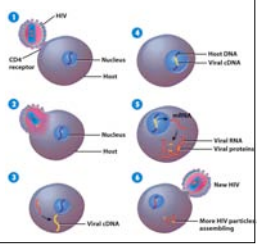
- **Autoimmune diseases**
  - Antibodies and/or cytotoxic TCRs bind to host molecules as if foreign
    healthy tissues self-destruct
    - Type I diabetes, multiple sclerosis, lupus, myasthenia gravis, rheumatoid arthritis
  - Very difficult to treat: if damaged organ recovers or replaced, attacked again

Immune System Disorders

- **Immunodeficiency diseases**
  - Immune cells destroyed or inactivated
    body vulnerable to broad-spectrum of secondary infections
  - Immunosuppression therapies
  - Bone marrow disease
  - Severe combined immunodeficiency disease (SCID)
  - Acquired immune deficiency syndrome (AIDS)

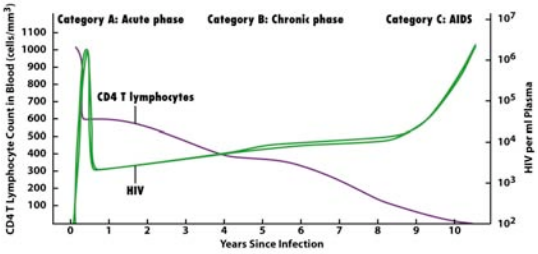
HIV & AIDS

- Human Immunodeficiency Virus (HIV)
  - Infects CD4 Helper T-cells
  - CD4 cells turned into virus factories; no longer function to activate immune responses
- HIV infection eventually results in AIDS
  - Syndrome symptoms:
    - Extreme loss of weight
    - Cancerous blotches on the skin
    - Opportunistic infection with anything
    - Persistent fevers and night sweats
    - Chronically swollen lymph nodes
    - Extreme fatigue



HIV & AIDS

- Stages of HIV infection:



CDC (2008) >56,000 new HIV cases reported per year, ~15,000 AIDS deaths per year in USA.
Pandemic: >2.1 million people died of AIDS over the past 25 years globally.