CHAPTER 43: THE IMMUNE SYSTEM

AP Biology 2013

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IMMUNITY

- Animals must defend themselves from dangerous pathogens (agents that cause disease) they may encounter in the environment
- Innate immunity - present before any exposure to pathogens and is effective at the time of birth (nonspecific response to pathogens)
- Acquired immunity (adaptive immunity) - develops only after exposure to inducing agents such as microbes, toxins, or other foreign substances (very specific response to pathogens)

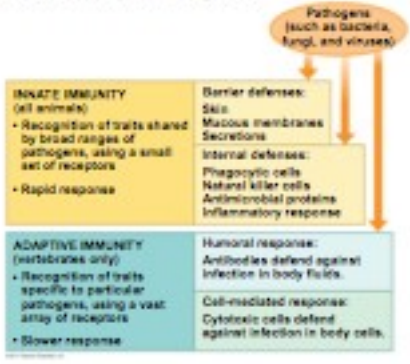

Fig. 43.2

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INNATE IMMUNITY

- Provides broad defenses against infection
- If a pathogen successfully breaks through an animal's external defenses, it encounters cellular and chemical mechanisms that impede the attack.
  - External defenses:
    - Intact skin and mucous (viscous fluid that traps microbes and other particles) membranes form a physical barrier
    - Ciliated epithelial cells in the trachea sweep mucus and any entrapped microbes upward preventing entry into the lungs
    - Secretions of the skin and mucous membranes provide an environment hostile to microbes
      - Skin is between pH 3 and 5 (acidic enough to prevent colonization of many microbes) and also includes proteins like lysozyme (an enzyme that digests bacterial cell walls

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INNATE IMMUNITY: INTERNAL CELLULAR AND CHEMICAL DEFENSES

- Internal defenses depend mainly on phagocytosis
  - Types of white blood cells ingest invading microorganisms
  - Initiate the inflammatory response
  - Attach to prey via surface receptors and engulf them forming a vacuole that fuses with a lysosome
- Macrophages (type of phagocyte) can be found throughout the body and in the organs of the lymphatic system

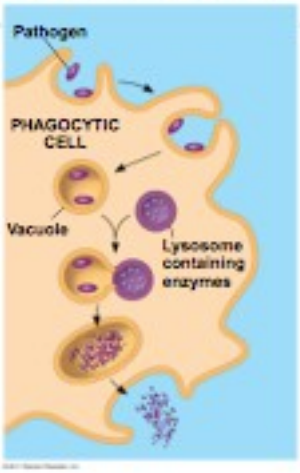

Fig. 43-3

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NATURAL KILLER CELLS

- Part of innate immune response
- NK cells patrol the body and attack virus-infected body cells and cancer cells by triggering apoptosis in the cells they attack
- Do not require antibodies to attack non-self cells

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ANTIMICROBIAL PROTEINS

- Proteins that function in defense by attacking microbes directly by impeding their reproduction
- About 30 proteins make up the complement system which can cause lysis of invading cells and help trigger inflammation
- Interferons provide innate defense against viruses and help activate macrophages

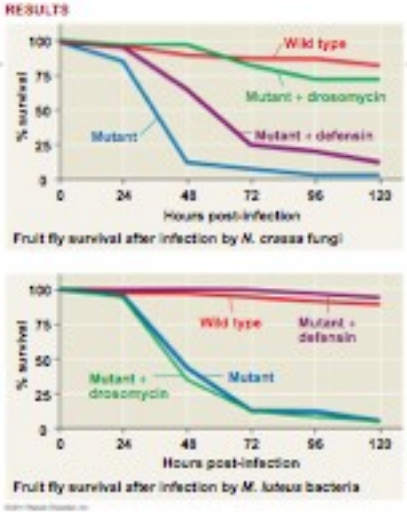

Fig. 43-5

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INFLAMMATORY RESPONSE

- Local inflammation - histamine and other chemicals are released from injured cells to promote changes in blood vessels that allow more fluid, more phagocytes, and antimicrobial proteins to enter tissues

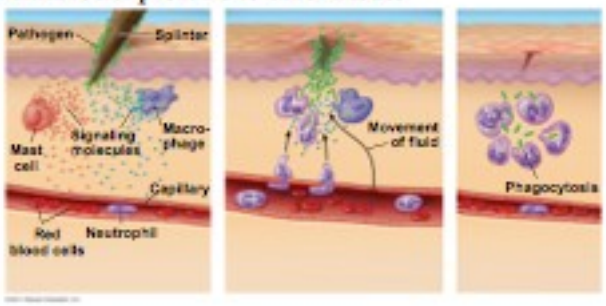
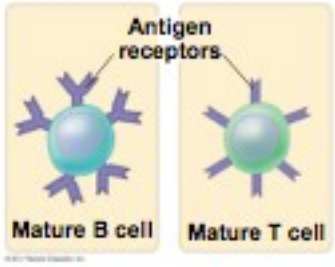


Fig. 43.8

ACQUIRED IMMUNITY

- Body's second major kind of defense
- Involves activity of the lymphocytes which mature in the thymus are called T cells and those that mature in the bone marrow are called B cells
- Antigen is any foreign molecule that is specifically recognized by lymphocytes and elicits a response
- Lymphocyte actually recognizes and binds to just a small accessible portion of the antigen called an epitope



ANTIGEN RECOGNITION

- Two main types of lymphocytes that circulate through the blood that have about 100,000 antigen receptors that recognize the same epitope

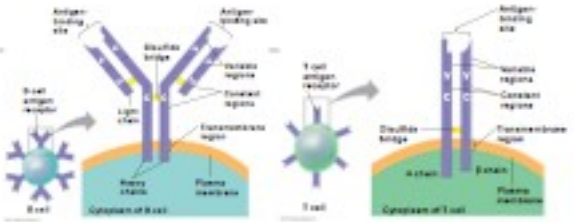


Fig. 43.9 & 43.11

- B lymphocytes (B cells)
  - Bind to specific intact antigens
- T lymphocytes (T cells)
  - Bind to small fragments of antigens that are bound to normal cell-surface proteins called MHC molecules

Fig. 43.8

T-CELL ACTION

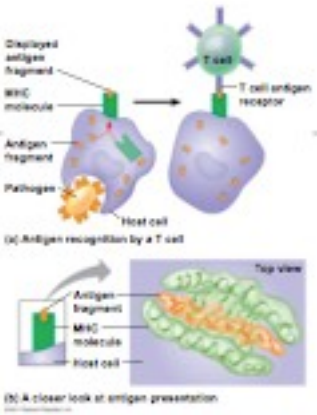


Fig. 43.12

- Infected cells produce MHC molecules which bind to antigen fragments and then are transported to the cell surface in a process called antigen presentation
- T cells can detect the antigen fragment displayed on the cell's surface
- Class I MHC molecules (found on almost all nucleated cells) display peptide antigens to cytotoxic T cells
- Class II MHC molecules (dendritic cells, macrophages and T cells) display antigens to helper T cells

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LYMPHOCYTE DEVELOPMENT

- Newly formed lymphocytes are all alike but develop into B cells or T cells depending on where they develop (B cells - bone marrow; T cells - thymus)
- As they mature their receptors are tested for self-reactivity and if they have receptors for antigens already present they are destroyed by apoptosis
- Clonal selection generates a clone of effector cells and memory cells

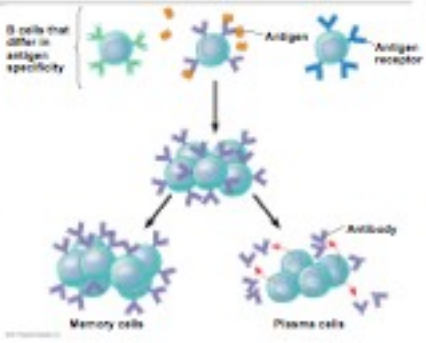

Fig. 43.14

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MEMORY CELLS

- In the secondary immune response, memory cells facilitate faster and more efficient responses

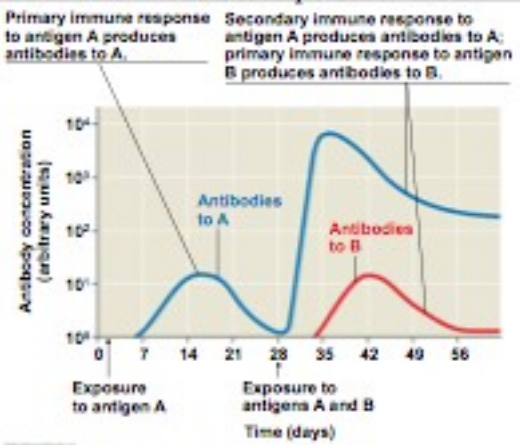

Fig. 43.15

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ADAPTIVE IMMUNITY

- Humoral response involves the activation and clonal selection of B cells resulting in the production of secreted antibodies
- Cell-mediated immune response involves the activation and clonal selection of cytotoxic T cells

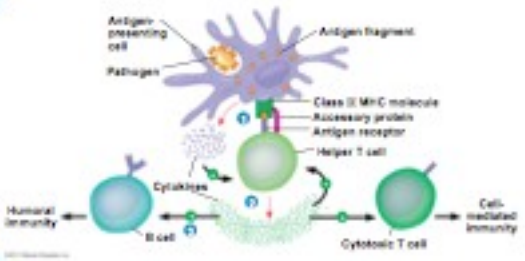

Fig. 43.16

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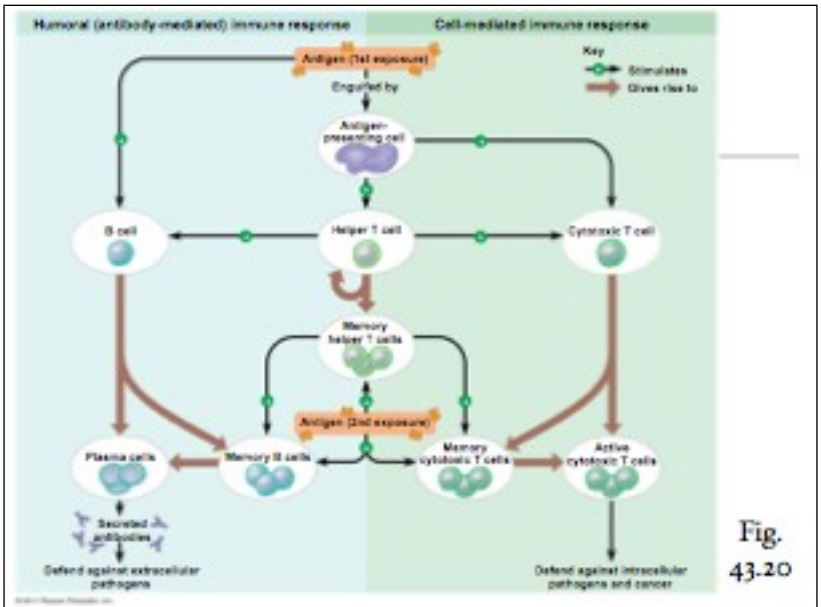

Fig. 43.20

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ACQUIRED IMMUNITY

- Make CD8 a surface protein that enhances the interaction between a target cell and a cytotoxic T cell
- Bind to infected cells, cancer cells, and transplanted tissue
- Binding to a class I MHC complex on an infected body cell activates cytotoxic T cells and differentiates them into an active killer
- Activated T cell secretes proteins that destroy infected target cells

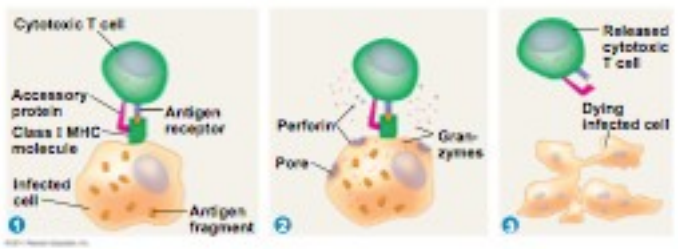

Fig. 43.17

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ACQUIRED IMMUNITY

- Activation of B cells is aided by cytokines and antigen binding to helper T cells

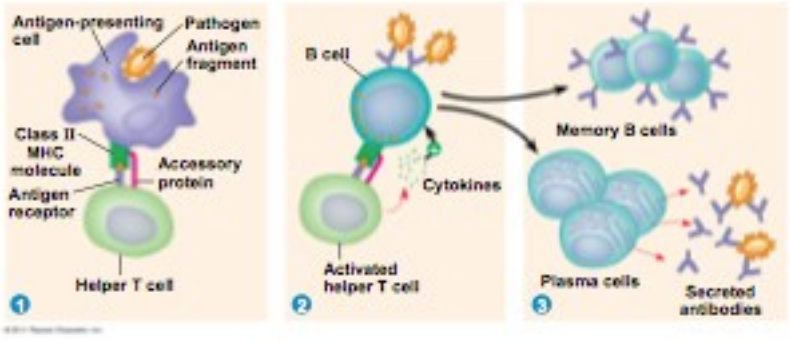

Fig. 43.18

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ANTIBODY FUNCTION

- Antibodies do not kill pathogens; they mark pathogens for destruction
- Neutralization - antibodies bind to viral surface proteins preventing infection of a host cell
- Antibodies may also bind to toxins in body fluids and prevent them from entering body cells
- Opsonization - antibodies bind to antigens on bacteria creating a target for macrophages or neutrophils, triggering phagocytosis
- Ultimately, a membrane attack complex forms a pore in the membrane of the foreign cell, leading to lysis

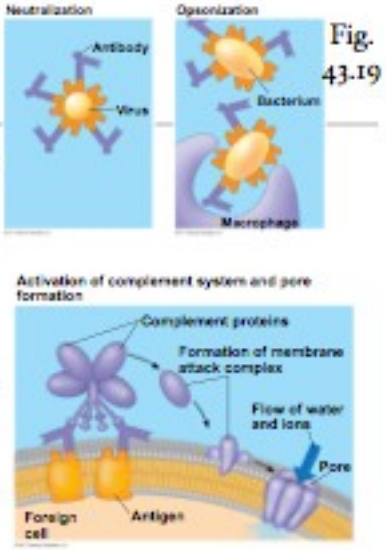

Fig. 43.19

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IMMUNIZATION

- Active immunity - develops naturally in response to infection and following immunization (vaccination)
  - Immunization - introduction of a nonpathogenic form of a microbe that elicits an immune response to immunological memory
- Passive immunity - provides immediate short-term protection
  - Conferred naturally when IgG crosses the placenta from mother to fetus or when IgA passes from mother to infant in breast milk (can be conferred artificially by injecting antibodies into a nonimmune person

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SELF VS. NONSELF

- Immune system can wage war against cells from other individuals
- Transplanted tissues are usually destroyed by the recipient's immune system
- Also true in blood transfusion (antibodies to nonself blood types exist in the body) where incompatible blood cells are destroyed
  - Rh factors can cause problems in Rh-negative mothers who carry successive Rh-positive fetuses
- Transplantation more successful if donor and recipient MHC tissue types are well matched and if the recipient is given immunosuppressive drugs

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IMMUNE SYSTEM DISRUPTION

- Allergies are exaggerated (hypersensitive) responses to certain antigens called allergens
  - Localized allergies (hay fever) IgE antibodies produced after first exposure to an allergen to receptors on mast cells
  - Next time allergen enters the body it binds to mast cell-associated IgE molecules and the mast cells release histamine that cause vascular changes and typical symptoms
- Acute allergy response can lead to anaphylactic shock

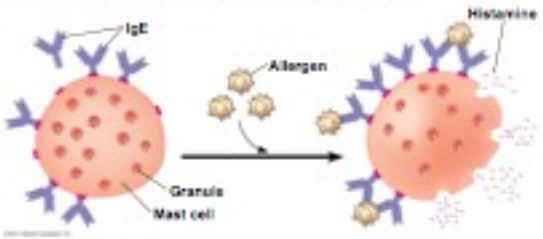

Fig. 43.22

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AUTOIMMUNE AND IMMUNODEFICIENCY DISEASES

Fig. 43.22

- Immune system loses tolerance for self and turns against certain molecules of the body
  - Rheumatoid arthritis - autoimmune disease that leads to damage and painful inflammation of the cartilage and bone of joints
  - Other examples: Systemic lupus, multiple sclerosis, insulin-dependent diabetes
- Primary Immunodeficiency - results from hereditary or congenital defects that prevent proper functioning of defenses
- Secondary immunodeficiency - results from exposure to various chemical and biological agents (can be temporary or chronic)

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IMMUNITY

- Physical and emotional stress can harm immunity
- Other immune diseases:
  - Acquired Immunodeficiency Syndrome (AIDS)
    - Highly susceptible to opportunistic infections and cancers that take advantage of damaged immune system
    - Arises from a loss of helper T cells because of infection by HIV

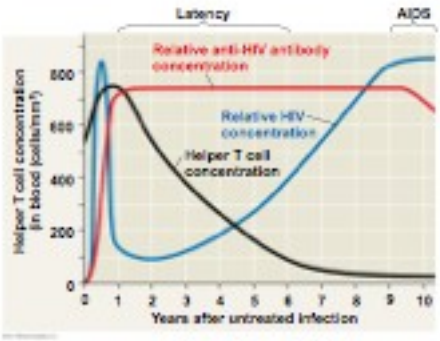

Fig. 43.25

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ANITGENIC VARIATION

- Some pathogens are able to change their expression to prevent recognition
- Human influenza virus mutates rapidly
- Human viruses occasionally exchange genes with the viruses of domesticated animals which causes a problem because human immune systems are unable to recognize the new viral strain

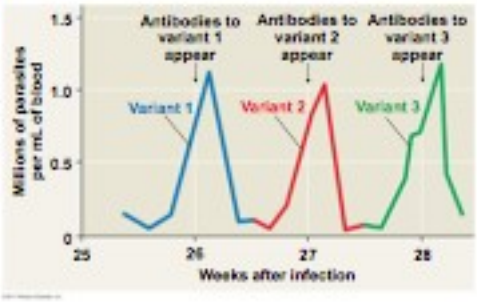

Fig. 43.24

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