

# *Inquiry into Life*

*Eleventh Edition*

**Sylvia S. Mader**

## Chapter 13 Lecture Outline

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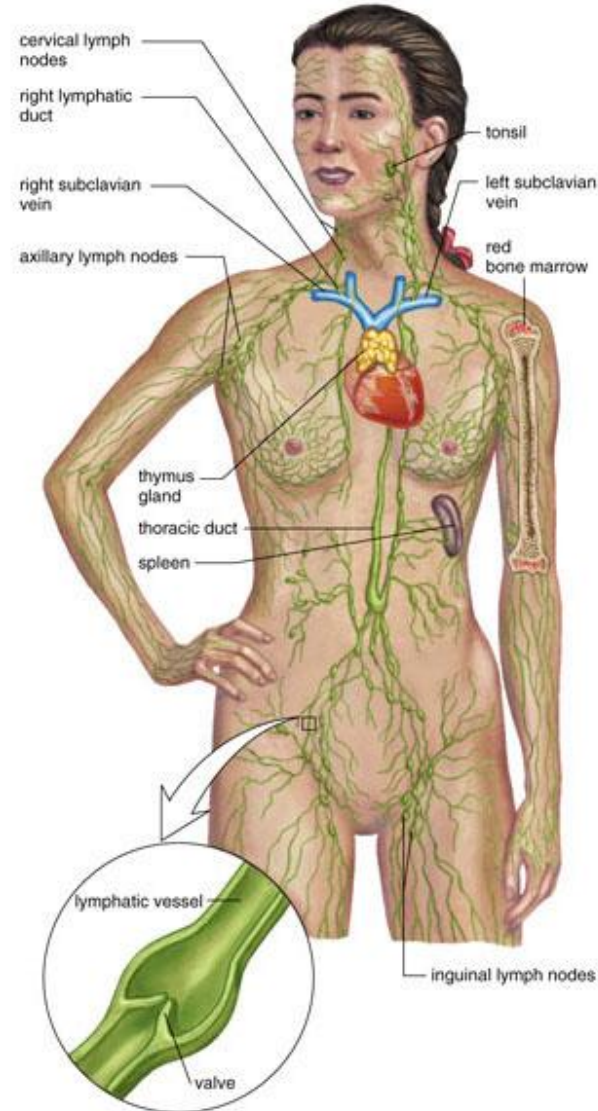


# 13.1 The lymphatic system

- Lymphatic system
  - Functions
    - Return excess tissue fluid to bloodstream
    - Lacteals absorb fats
    - Defense against disease
  - Lymphatic vessels
    - One-way system
    - Begins with capillaries in tissues
    - Walls composed of simple squamous epithelium
    - Fluid inside is lymph
      - Water
      - Nutrients
      - Electrolytes
      - Cell products like hormones

# Lymphatic system

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- Fig. 13.1

# The lymphatic system cont'd.

- Lymphatic vessels cont'd.
  - Lymphatic capillaries merge to form vessels
  - Vessels merge and empty into ducts
    - Thoracic duct-empties into left subclavian vein from
      - Body below thorax
      - Left side of head
      - Left arm
    - Right lymphatic duct-empties into right subclavian vein from
      - Right side of head
      - Right arm

# The lymphatic system cont'd.

- **Vessel structure**

- Small vessels
  - Simple squamous epithelium
- Large vessels
  - Similar to veins
  - Valves to prevent backflow
  - Skeletal muscles “pump” lymph

- **Edema**

- Accumulation of tissue fluid
- Occurs if not enough drainage, or too much produced
- Can cause tissue damage and death

# The lymphatic system cont'd.

- **Lymphatic organs**

- **Contain lymphocytes**

- Produced in thymus and bone marrow
- B lymphocytes-antibodies
- T lymphocytes-cellular immunity

- **Primary lymphatic organs**

- Red bone marrow
  - Network of connective tissue fibers with sinuses
  - Stem cells produce blood cells
  - Most bones in children contain red marrow
  - Adults- ends of long bones, skull, pelvis, clavicle, vertebrae
  - B lymphocytes mature in red marrow

# Lymphatic system cont'd.

- Primary lymphatic organs, cont'd.
  - Thymus
    - Between trachea and sternum above the heart
    - Shrinks with age
    - Divided into lobules by connective tissue
    - Lobules filled with T lymphocytes
      - Produced in bone marrow
      - Mature in the thymus
    - Produces hormones
      - Thymosin-aids maturation of T lymphocytes

# Lymphatic system cont'd.

- **Secondary lymphatic organs**
  - Lymphocytes encounter antigens in secondary organs
    - Lymphocytes then proliferate and active
  - Spleen
    - Upper left side of abdomen
    - red pulp
      - Vessels and sinuses
      - Filters blood
      - Macrophages destroy old RBC's
    - White pulp
      - Clumps of lymphatic tissue
    - Splenic capsule
      - Thin, easily ruptured

# Lymphatic system cont'd.

- Secondary lymphatic organs cont'd.
  - Lymph nodes
    - Located along lymphatic vessels
    - Divided into nodules by connective tissue
    - Nodules packed with B and T lymphocytes
      - Each contains a sinus
    - Lymph filters through nodules
      - Macrophages phagocytize pathogens and debris
    - Lymph nodes named for location
      - Inguinal nodes-groin
      - Axillary nodes-armpit
      - Cervical nodes-neck

# 13.2 Nonspecific and specific defenses

- Nonspecific defenses
  - Barriers to entry
    - Skin and mucus membranes
    - Oil glands secrete antibacterial substances
    - Mucus
    - Acidic pH of stomach
    - Normal flora
  - Inflammatory reaction
    - Initiated by chemical agents or pathogens
    - 4 signs
      - Redness
      - Heat
      - Swelling
      - Pain

# Nonspecific and specific defenses cont'd.

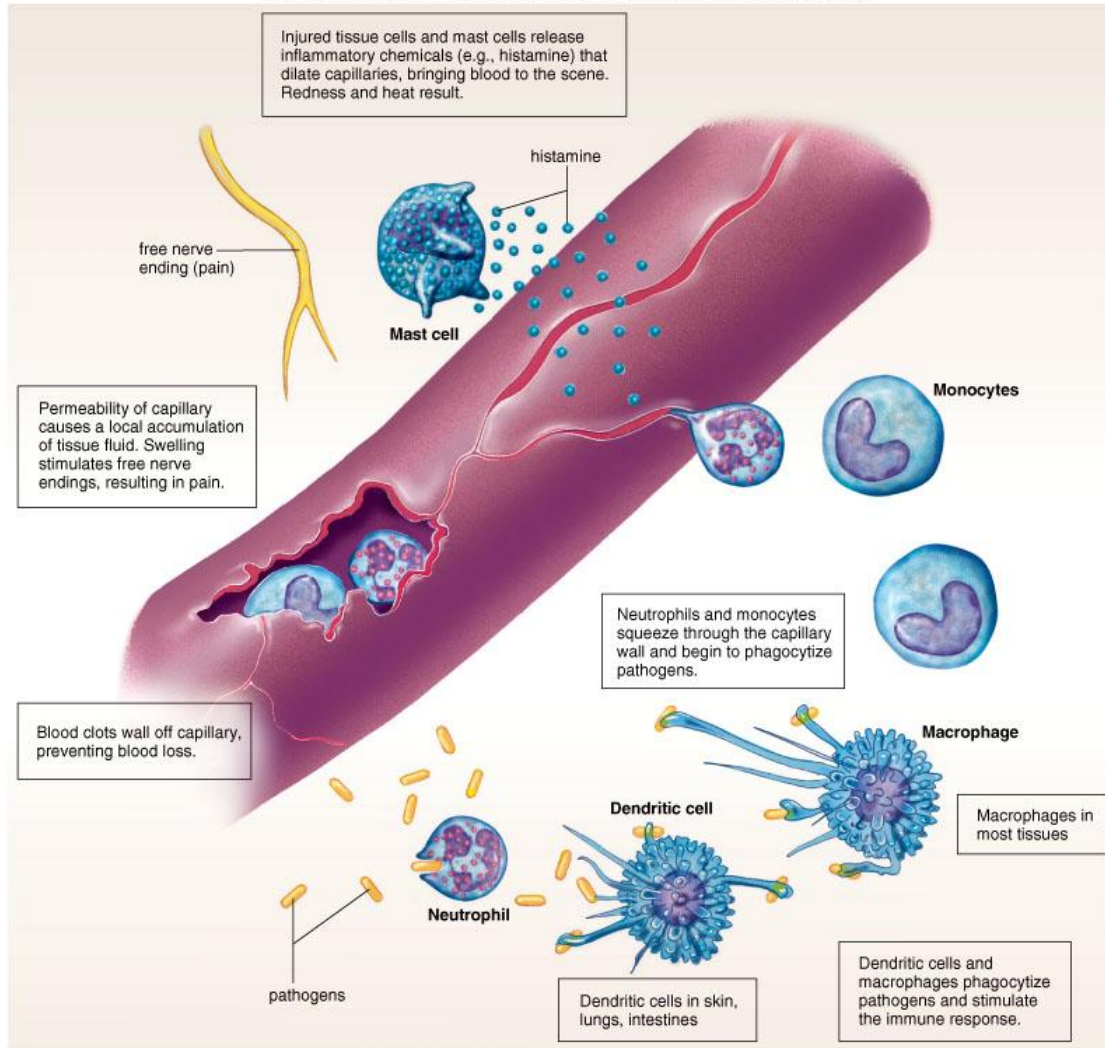
- **Inflammatory reaction cont'd.**
  - Signs due to capillary changes
    - Induced by chemical mediators
      - **Histamine**
        - » Produced by mast cells
        - » Vasodilator
        - » Increases capillary permeability
  - Migration of phagocytes to damaged area
    - **Neutrophils**-from bloodstream
    - **Monocytes**-from bloodstream
    - **Dendritic cells**- in skin
    - **Macrophages**-in tissues
  - **Pus**- dead phagocytes and debris

# Nonspecific defenses cont'd.

- Inflammation can be accompanied by other responses
  - Clot formation
  - Specific defenses mediated by T cells
- Chronic inflammation
  - Persistent
  - Anti-inflammatory agents
    - Aspirin, NSAIDs, cortisone
    - Act against chemicals released by WBC's in damaged area

# Inflammatory reaction

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• Fig. 13.3

# Nonspecific defenses cont'd.

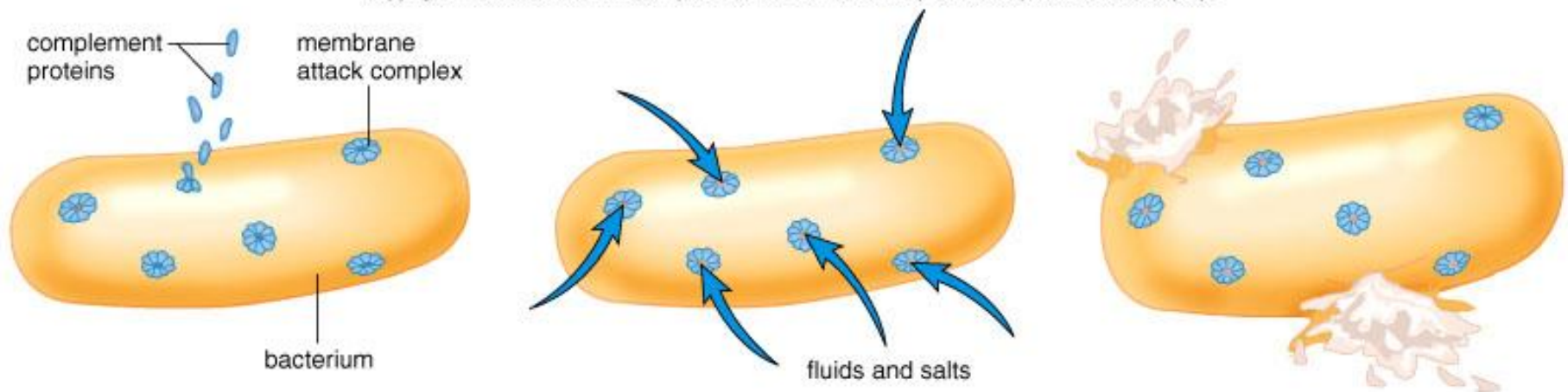
- **Natural killer cells**
  - Large, granular lymphocytes
    - Kill virus infected cells and tumor cells
    - Kill by cell to cell contact
  - Detect antigenic changes in cancerous cells and infected cells
  - Nonspecific
  - Have no memory
  - Do not increase in number upon antigen exposure

# Nonspecific defenses cont'd.

- **Protective proteins**
  - **Complement system**
    - Group of plasma proteins
    - Amplify inflammatory response
      - Bind to mast cells-stimulates histamine release
      - Attract phagocytes
      - Promote phagocytosis by binding to pathogens
    - Membrane attack complexes
      - Joined complement proteins
      - Produce holes in bacteria and viruses
      - Fluids and salts enter-lysis
    - Interferon
      - Produced by virus infected cells and binds to normal cells
      - Normal cells then release protective substances

# Action of the complement system against a bacterium

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Complement proteins form a membrane attack complex in the bacterial cell wall and membrane.

Holes in the middle of the complexes allow fluids and salts to enter the bacterium.

Bacterium expands until it bursts.

- Fig. 13.4

# Specific defenses

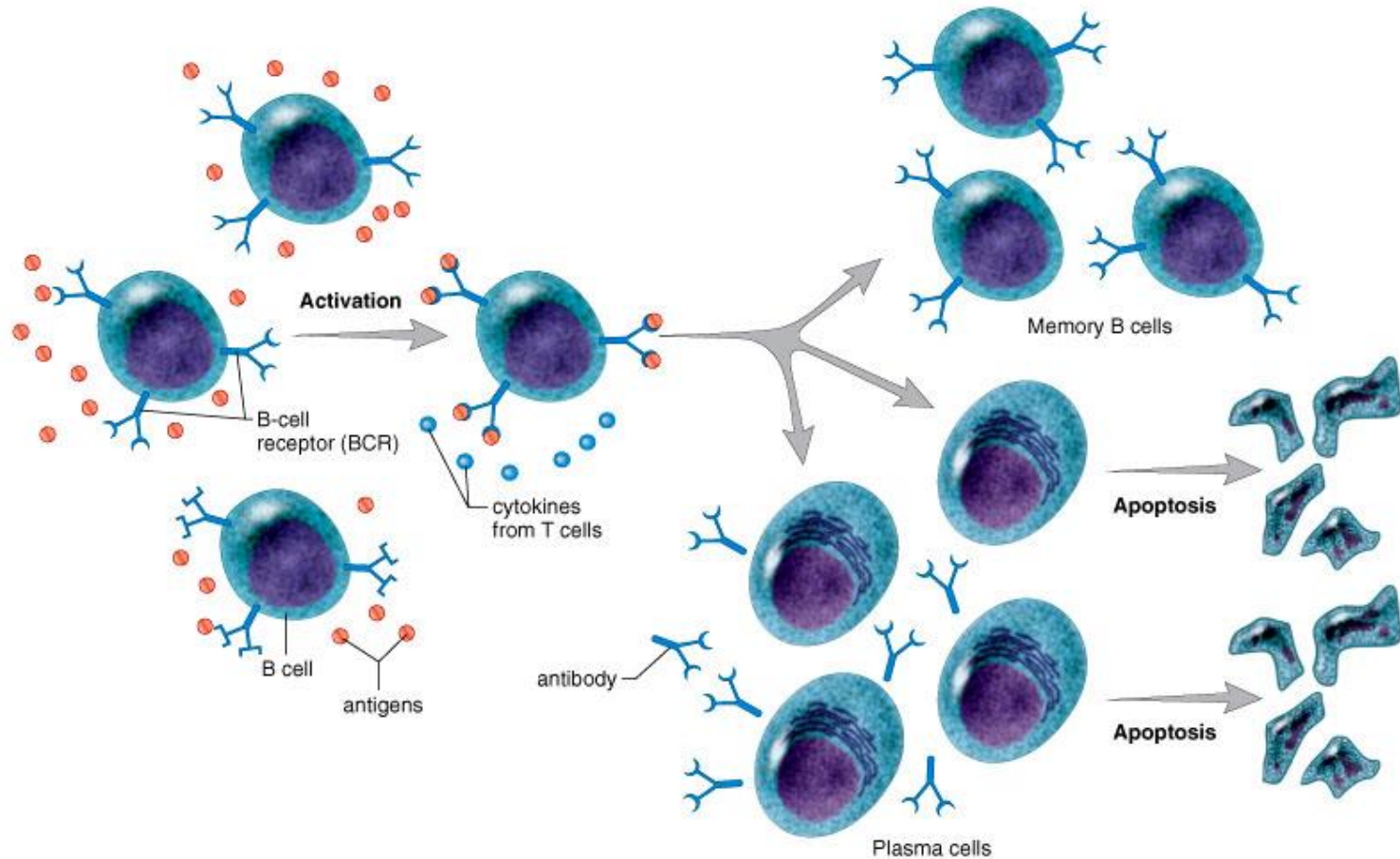
- Specific defenses
  - Function nonspecific have failed
  - Take 5-7 days to activate
  - Effects are long lasting
  - B cells and Antibody-mediated immunity
    - B cell receptor –BCR
    - BCR binds to specific antigen in lymph node or spleen
    - B cell then divides many times by mitosis-clone
    - Clones become
      - Plasma cells- produce antibodies to specific antigen
      - Memory cells-remember antigen for later exposure

# Specific defenses cont'd.

- B cells and Antibody-mediated immunity cont'd.
  - Clonal selection theory
    - Antigen selects and binds to BCR of only one B or T cell
    - This B or T cell then clones
    - During clonal expansion helper T cells produce cytokines
      - Stimulate B cells to clone
    - Some cloned B cells become memory cells
      - Long term immunity
      - Clone quickly on next exposure
    - Apoptosis-programmed cell death
      - Occurs when infection is over
      - Destroys plasma cells
    - Defense by B cells called antibody-mediated immunity

# Clonal selection theory as it applies to B cells

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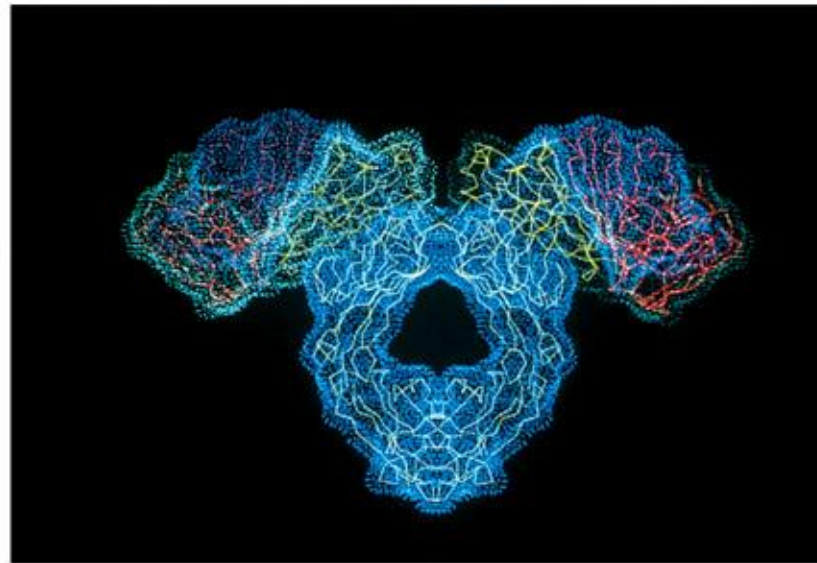
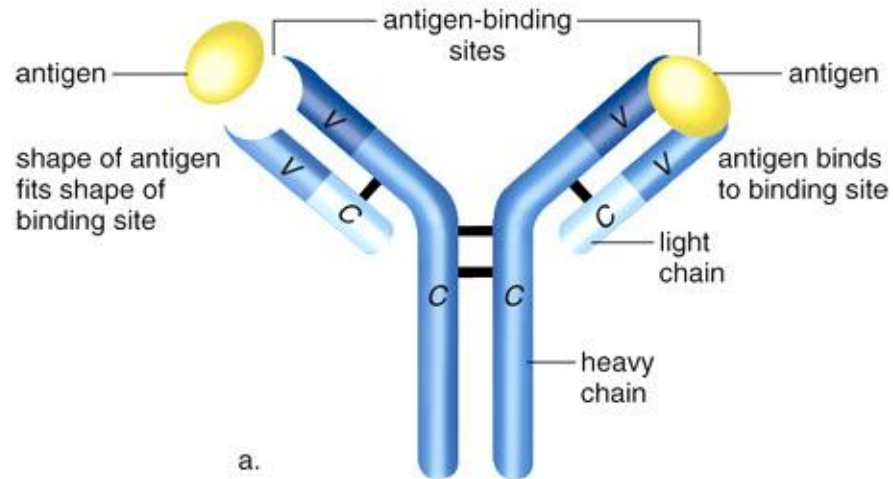
• Fig. 13.5

# Specific defenses cont'd.

- B cells and Antibody-mediated immunity cont'd.
  - Antibody structure
    - Y-shaped molecules with 2 “arms”
      - Each arm has a heavy and a light polypeptide chain
        - » Constant region- specific for antibody type
        - » Variable region-varies between antibodies
        - » Hypervariable region- at tips of arms
    - Variable and hypervariable regions-antigen binding site
      - Lock and key fit
  - Antigen-antibody binding
    - Forms a complex
    - Marks antigen for destruction

# Antibody structure

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- Fig. 13.6

# Specific defenses cont'd.

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**TABLE 13.1 CLASSES OF ANTIBODIES**

<b>Class</b>	<b>Presence</b>	<b>Function</b>
IgG	Main antibody type in circulation	Binds to pathogens, activates complement, and enhances phagocytosis
IgM	Antibody type found in circulation; largest antibody	Activates complement; clumps cells
IgA	Main antibody type in secretions such as saliva and milk	Prevents pathogens from attaching to epithelial cells in digestive and respiratory tract
IgD	Antibody type found on surface of immature B cells	Presence signifies readiness of B cell
IgE	Antibody type found as antigen receptors on basophils in blood and on mast cells in tissues	Responsible for immediate allergic response and protection against certain parasitic worms

- Table 13.1

# Specific defenses cont'd.

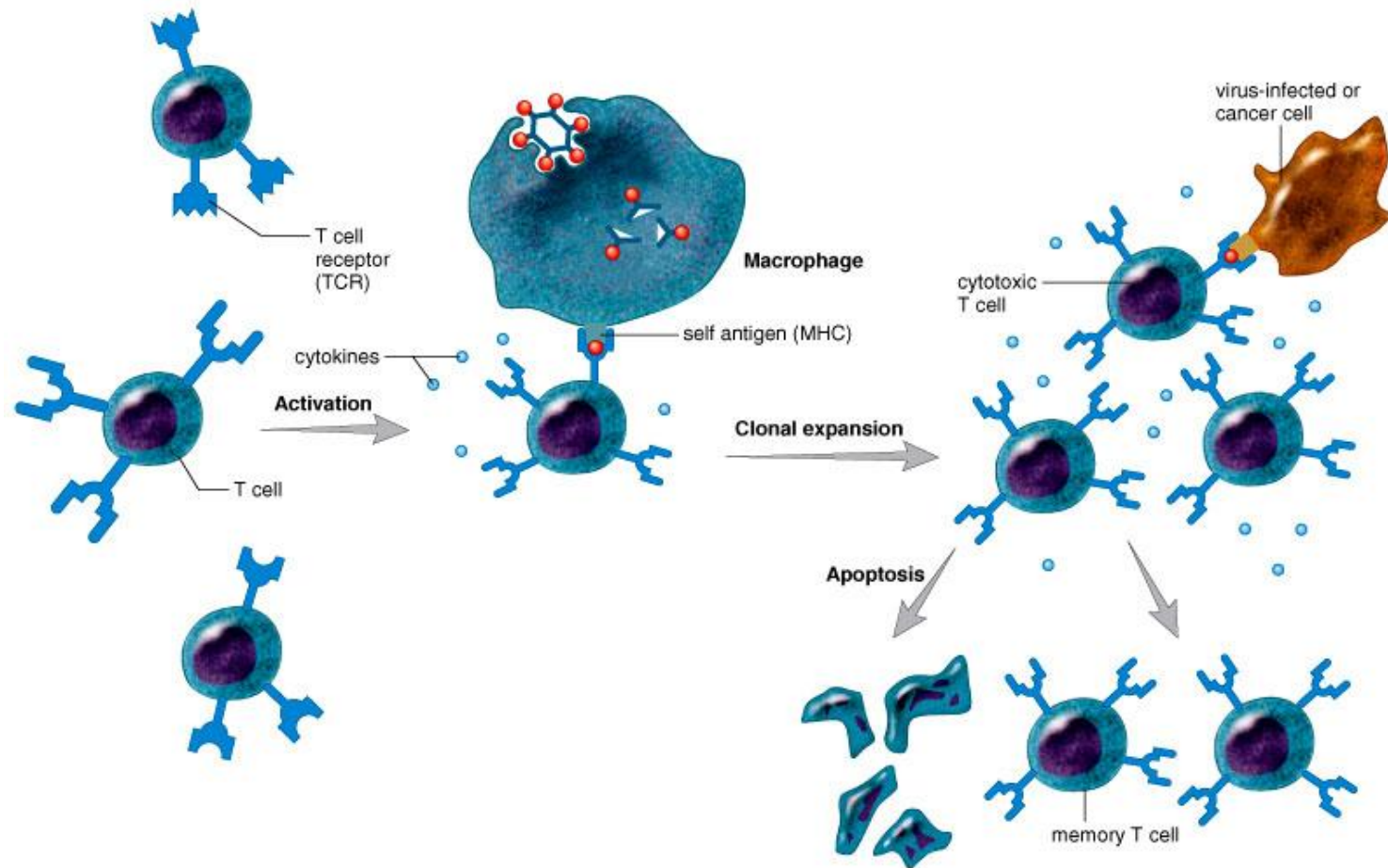
- T cells and cell-mediated immunity
  - TCR- T cell receptor
  - Cannot recognize antigen without help
    - APC- antigen-presenting cell
      - Dendritic cells or macrophages
      - Phagocytize pathogen first
      - Break pathogens down
      - Display a piece of pathogen in major histocompatibility complex (MHC)
        - » On surface of APC membrane
      - Travel to nodes
      - “Present” antigen to T lymphocytes

# Specific defenses cont'd.

- T cells and cell-mediated immunity cont'd.
  - T cell with specific TCR bind to antigen on macrophage surface
    - T cell becomes activated
    - Undergoes clonal expansion
  - Type of T cell formed depends upon MHC
    - MHC I- T cells formed are cytotoxic T cells
    - MHC II- T cells formed are helper T cells
  - Small number of clonal cells become memory cells
  - When infection clears, T cells undergo apoptosis

# Clonal selection theory as it applies to T cells

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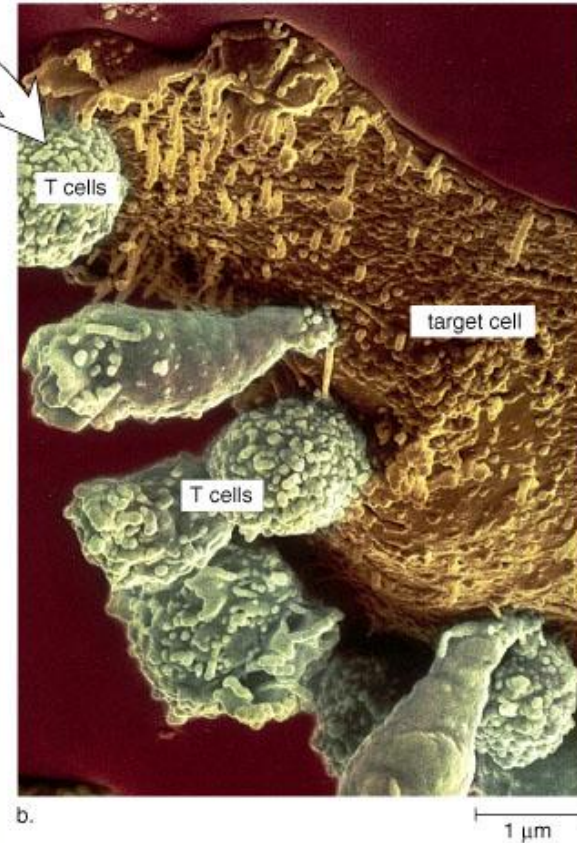
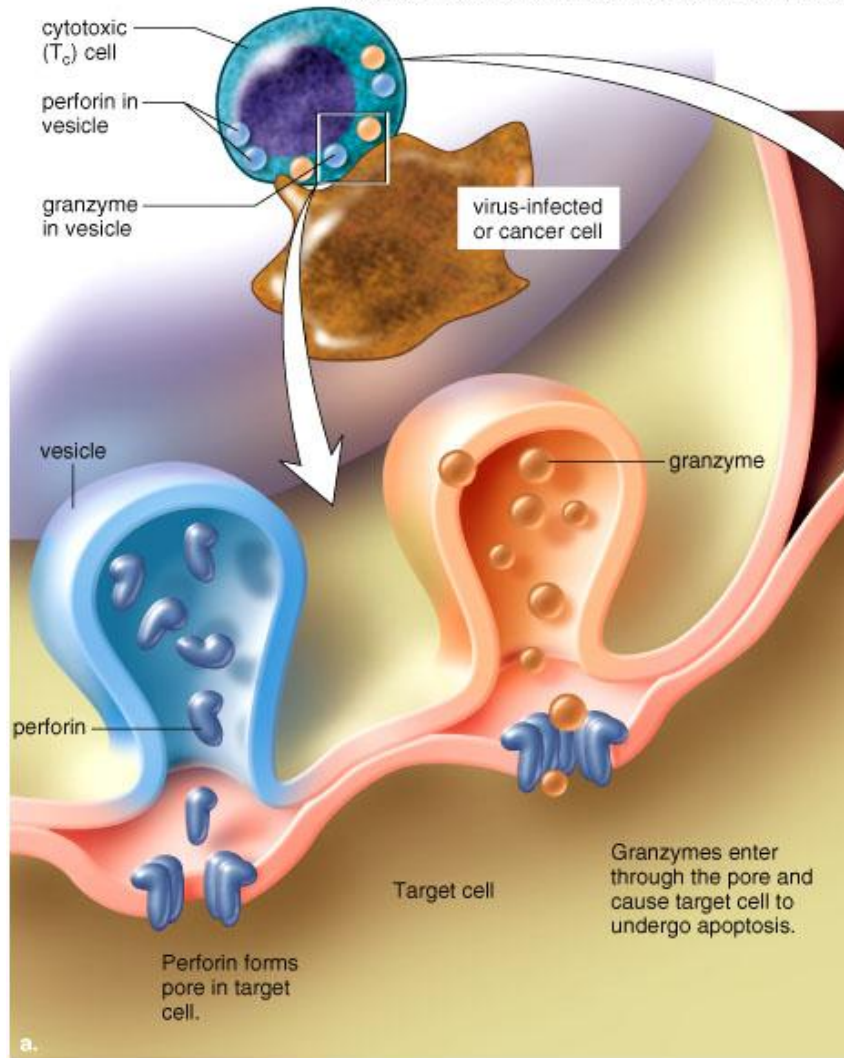
• Fig. 13.7

# Specific defenses cont'd.

- T cells and cell-mediated immunity
  - Types of T cells
    - Cytotoxic T cells-cell mediated- immunity
      - Contain granules of perforins or granzymes
      - Cytotoxic T cell binds to pathogen and releases perforin
      - Perforin or granzyme enters cell and destroys it
      - Cell can move on to another target cell
    - Helper T cells
      - Secrete cytokines which activate all immune cells
      - Helper T cells needed for B cell activation
      - Helper T cells are infected by HIV virus

# Cell-mediated immunity

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• Fig. 13.8

# 13.3 Induced immunity

- Immunity
  - Naturally through exposure
  - Artificially (induced) through vaccination
    - Active immunity-individual produces antibodies against antigen
    - Passive immunity-individual is given prepared antibodies by injection
- Active immunity
  - Immunization-use of vaccines to establish immunity
    - Vaccines-killed or attenuated pathogens

# Induced immunity cont'd.

- **Active immunity cont'd.**
  - **Response to vaccination**
    - Monitored by antibody titre
    - After first exposure, get primary response
      - First few days, no detectable antibodies
      - Then slow rise in number which levels off
      - Gradual decline as apoptosis occurs
    - Booster response
      - Boosts titre to high level
      - Rapid rise in antibody level
      - Prevents disease symptoms on subsequent exposures
    - Active immunity depends on memory T and B cells

# Active immunity due to immunizations

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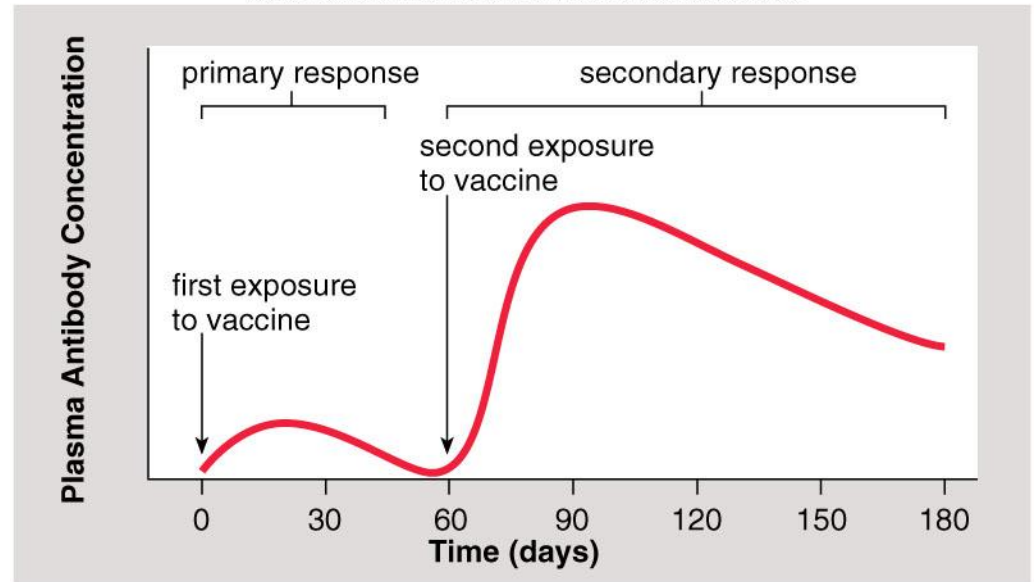


**Suggested Immunization Schedule**

Vaccine	Age (months)	Age (years)
Hepatitis B	Birth–18	11–12
Diphtheria, tetanus, pertussis (DTP)	2, 4, 6, 15–18	4–6
Tetanus only		11–12, 14–16
<i>Haemophilus influenzae</i> , type b	2, 4, 6, 12–15	
Polio	2, 4, 6–18	4–6
Pneumococcal	2, 4, 6, 12–15	
Measles, mumps, rubella (MMR)	12–15	4–6, 11–12
Varicella (chicken pox)	12–18	11–12
Hepatitis A (in selected areas)	24	4–12
Human papilloma-virus, type 16	–	12–14

a.

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b.

- Fig. 13.9

# Induced immunity cont'd.

- **Passive immunity**

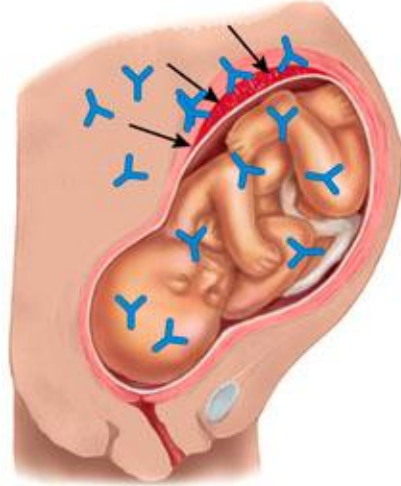
- From prepared antibodies
- Not produced by individual's body
- Temporary immunity
  - No memory cells formed
- Used to prevent illness

- **Cytokines and immunity**

- Signaling molecules produced by T lymphocytes and macrophages
- Interleukins
  - Cytokinins that enhance ability of T cells to fight cancer
  - May have many potential uses in medicine

# Passive immunity

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a. Antibodies (IgG) cross the placenta.



b. Antibodies (IgG, IgA) are secreted into breast milk.



c. Antibodies can be injected by a physician.

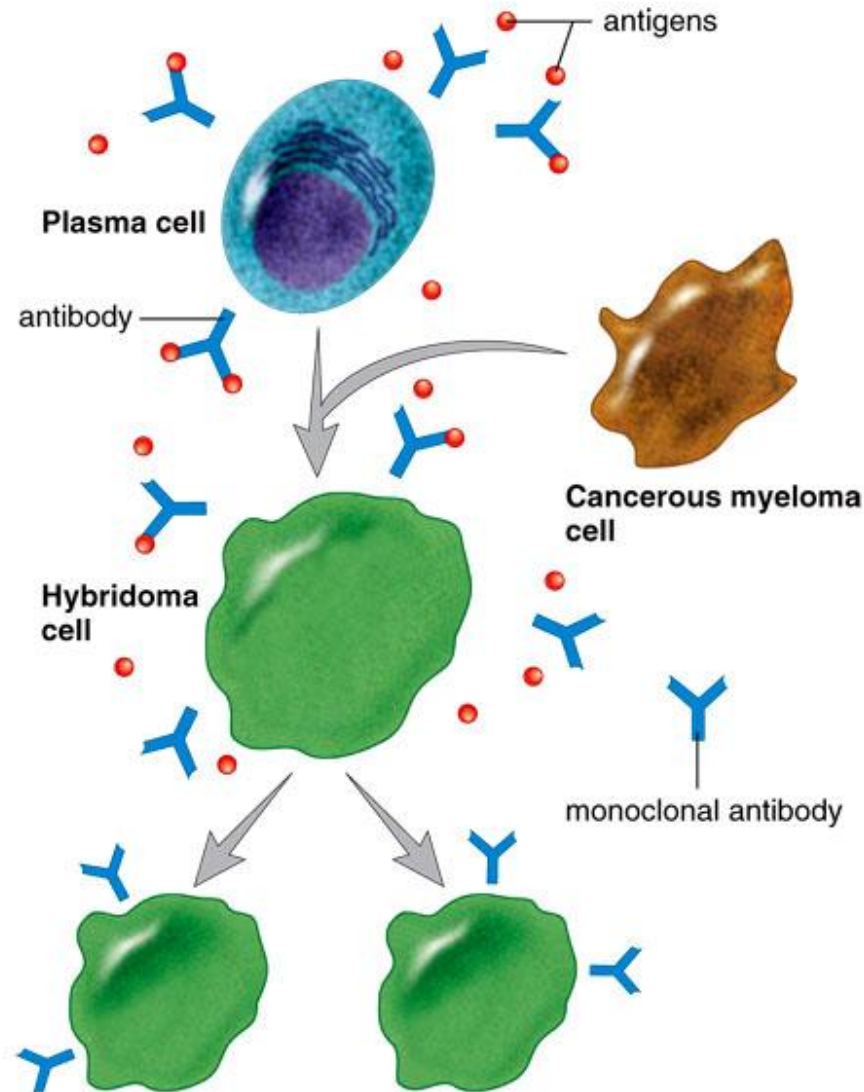
- Fig. 13.10

# Induced immunity cont'd.

- **Monoclonal antibodies**
  - Group of plasma cells from the same B cell all produce same antibody
  - Production of monoclonal antibodies
    - Mouse B lymphocytes exposed to antigen
    - Resulting cells fused with myeloma cells-hybridomas
  - Use of monoclonal antibodies
    - Diagnostic tests
      - Ex: pregnancy tests
    - Vehicles for drug delivery
    - Identification of infections

# Production of monoclonal antibodies

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• Fig. 13.11

# 13.4 Immunity side effects

- Allergies

- Hypersensitivities to allergens
- Immediate allergic response
  - Occurs within seconds
  - Mediated by IgE
    - Binding with antigen causes release of histamine from mast cells
  - Hay fever- reaction occurs in mucous membranes of nose and eyes
  - Asthma- reaction occurs in small airways
  - Anaphylactic shock
    - Can occur when allergen enters bloodstream
    - Life-threatening decrease in blood pressure from increased capillary permeability
    - Epinephrine can delay reaction

# Immunity side effects cont'd.

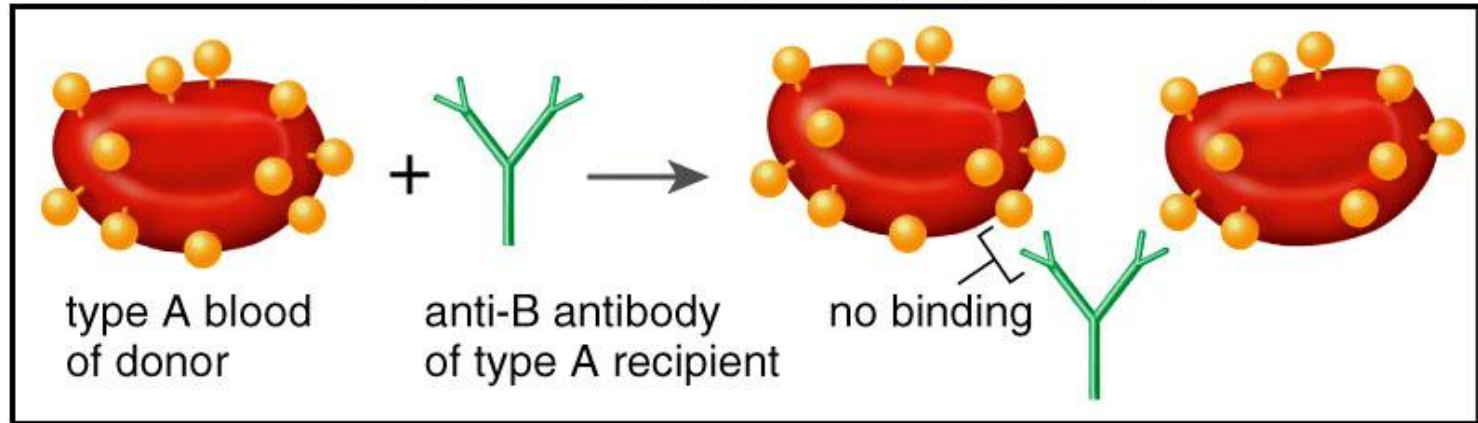
- **Allergies cont'd.**
  - Delayed allergic response
    - Initiated by helper T cells at site of allergen contact
    - Regulated by cytokines from macrophages and T cells
    - Ex: TB skin test
    - Tissue becomes red and hardened
- **Blood-type reactions**
  - ABO system
    - Based on presence or absence of A and B antigens on RBC's
      - If A present- blood is type A
      - If B present- blood is type B
      - If both present- blood is type AB
      - If neither is present- blood is type O

# Immunity side effects cont'd.

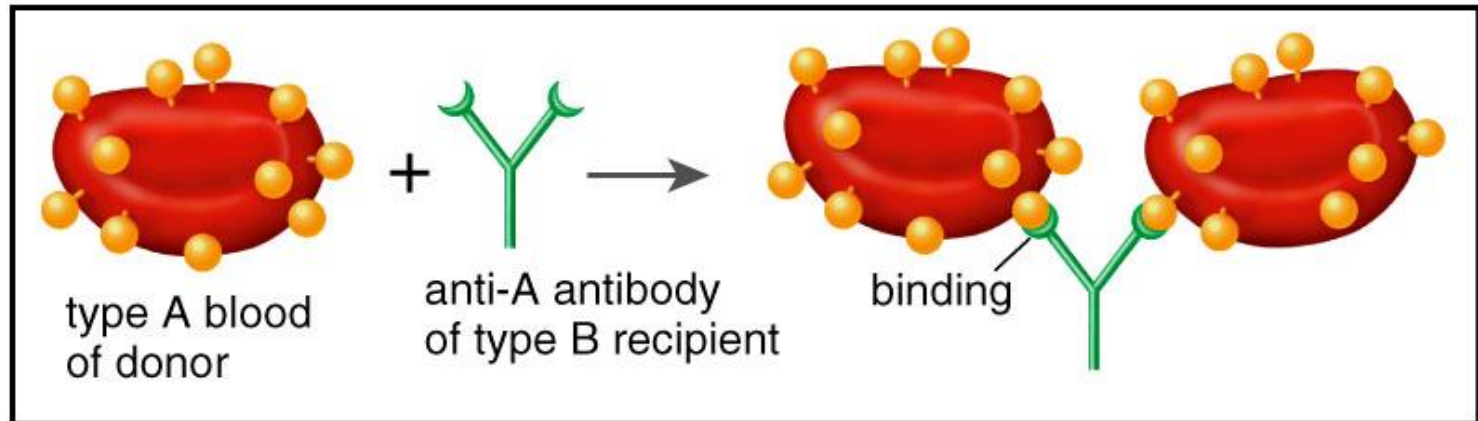
- **ABO system cont'd.**
  - Plasma antibodies to antigens NOT present
    - Type A and anti-B antibodies
    - Type B has anti-A antibodies
    - Type AB has neither
    - Type O has both
  - Transfusions
    - Must consider recipient's antibodies and donor's antigens to prevent agglutination and transfusion reaction
    - Type O is universal donor
      - Neither anti-A nor anti-B antibodies
    - Type AB is universal recipient
      - Neither A nor B antigens

# Blood transfusions

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a. No agglutination



b. Agglutination

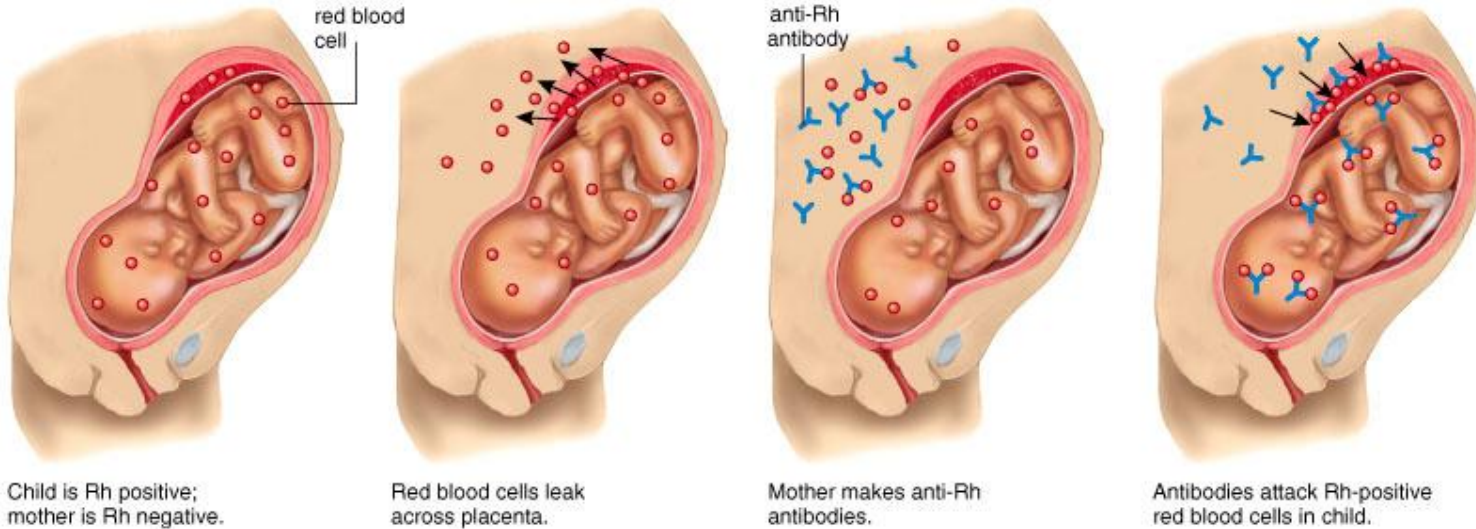
- Fig. 13.12

# Immunity side effects cont'd.

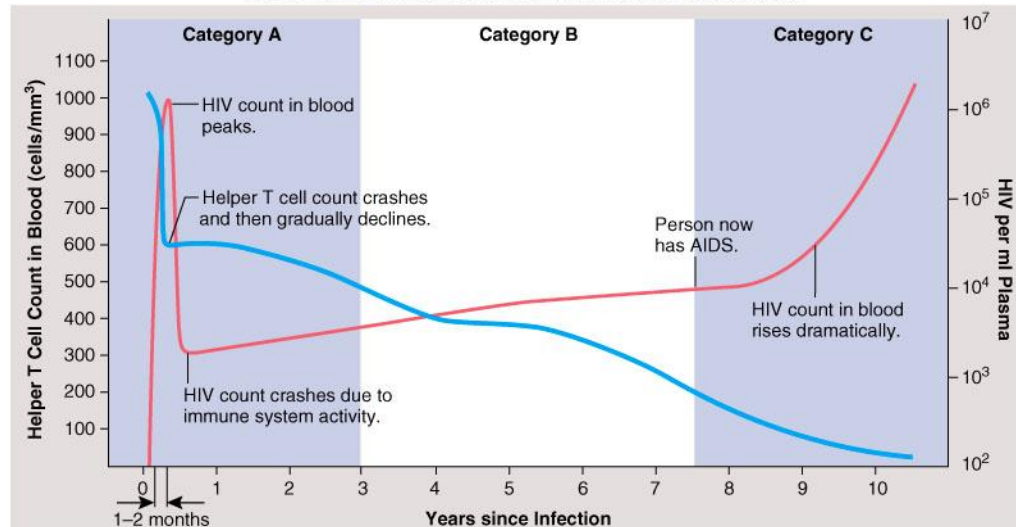
- Blood-type reactions cont'd.
  - Rh system
    - Another RBC antigen
      - Antigen present- Rh positive
      - Antigen absent- Rh negative
    - Significant in pregnancy
      - Rh neg mom pregnant with Rh pos baby
      - If baby's cells leak into mother's bloodstream, she forms anti-Rh antibodies
        - » Attack baby's RBC's- hemolytic disease of newborn (HDN)
        - » Can affect subsequent Rh pos pregnancies as well
      - Prevent by giving Rh neg mom anti-Rh immunoglobulins in an injection
        - » Must give BEFORE she becomes sensitized to produce her own

# Hemolytic disease of the newborn

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• Fig. 13.13

# Immunity side effects cont'd.

- Tissue rejection
  - Cytotoxic T cells recognize foreign antigens on transplanted organ or tissue
  - Transplanted organ is destroyed
  - Controlled by immunosuppressive drugs
    - Act by suppressing cytokines
  - Best success attained when MHC antigens of donor and recipient are closely matched
  - Xerotransplantation
    - Using organs of another species for transplantation
    - Pig is most commonly used-prolific, widely available
    - Genetic engineering can make pig organs less antigenic

# Immunity side effects cont'd.

- Diseases of the immune system
  - Autoimmune diseases
    - Cytotoxic T cells or antibodies attack body's cells
    - No cures available; controlled with drugs
      - Myasthenia gravis- neuromuscular junctions do not work
      - Multiple sclerosis-myelin sheath of neurons break down
      - Systemic lupus erythematosus- many systemic signs
      - Rheumatoid arthritis- affects joints
  - Immunodeficiency diseases
    - Immune system unable to protect against disease
    - Can be congenital from defect in lymphocyte formation
    - Can be infectious- HIV
    - Severe combined immunodeficiency disease-both T cells and B cells affected