MEDAVIE HealthEd ÉduSanté

Immunology and the Lymphatic System

Advanced Care Paramedicine

Module: 04

Section: 02/03

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Immunology

LYMPHATIC SYSTEM

Lymphatic System

- Maintains fluid balance
- Immunity

- A specialized portion of the circulatory system
- Contains
  - Lymph (moving fluid)
  - Lymphatics (group of vessels)

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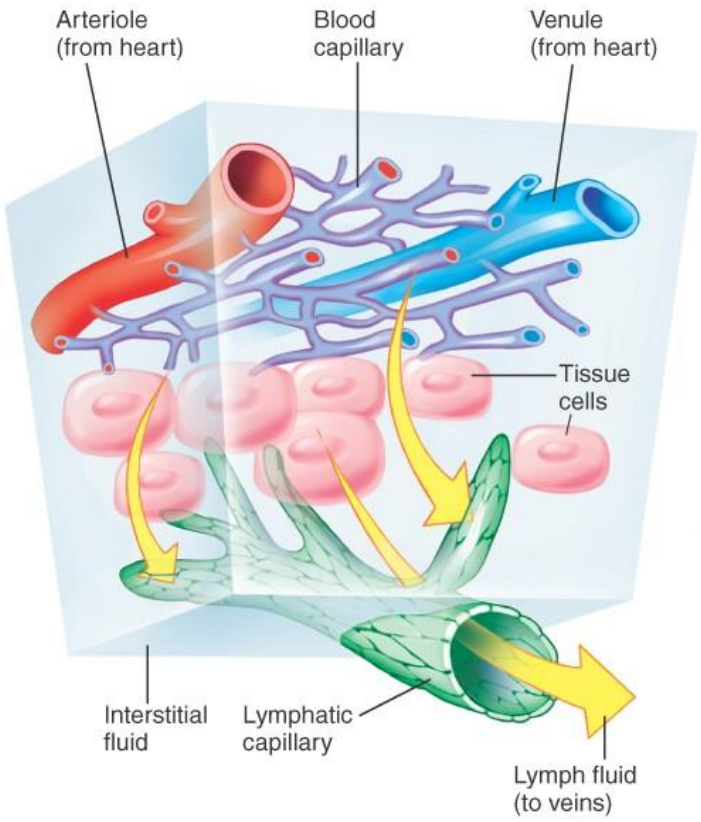
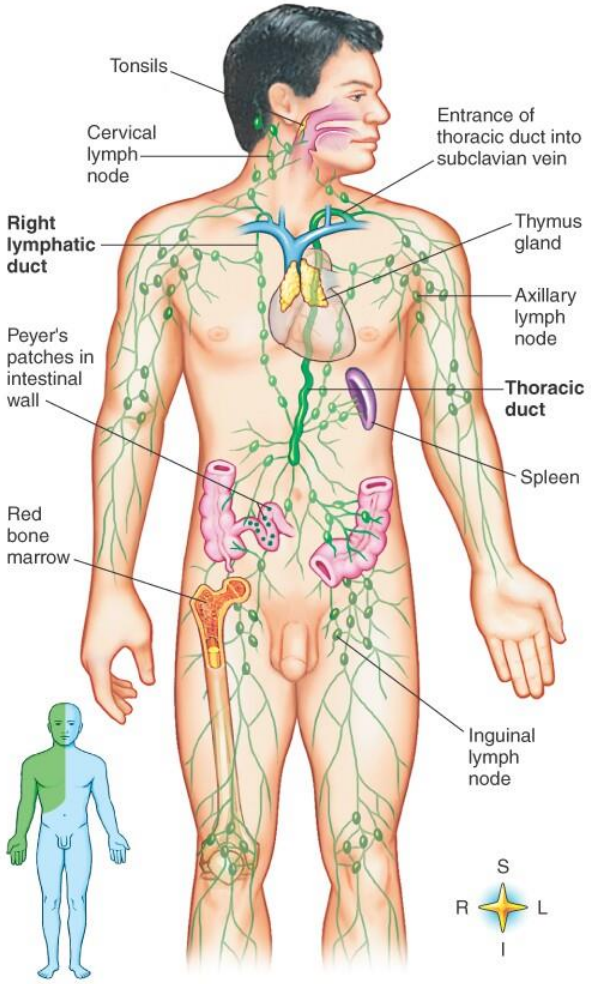
Lymphatic System

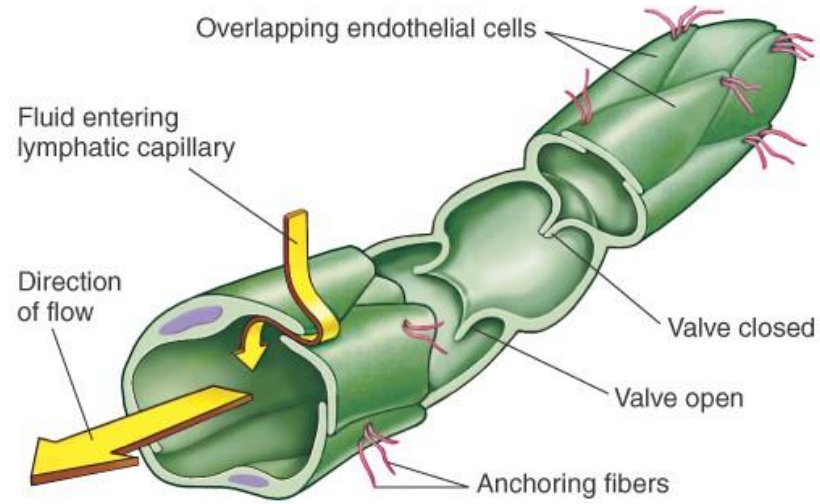




Lymphatic System

- Lymph
  - Clear, watery fluid
  - Results from fluid exiting circulation (c. 3000 ml daily)
  - Is similar to interstitial fluid (is isotonic to)
    - Usual contains more proteins
  - Most comes from the liver and small intestines (more then ½)

Lymphatic System

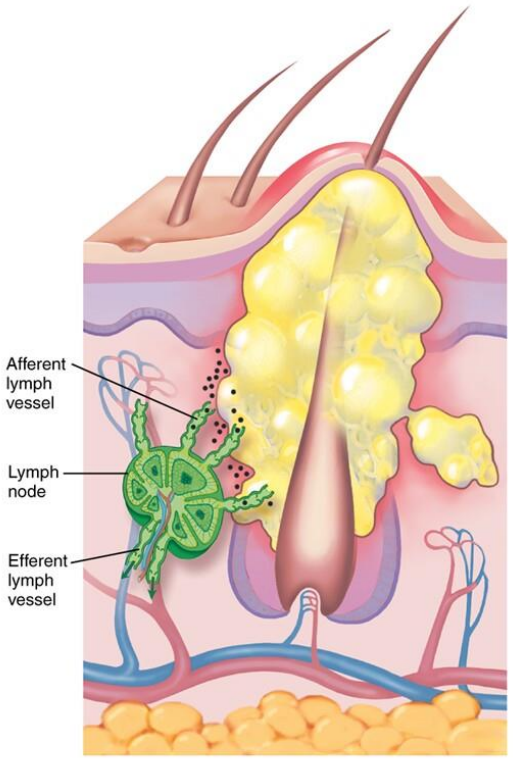


- Lymphatic Vessels
  - Originate as lymphatic capillaries
  - Lie side by side of the blood capillaries
    - Thinner
    - Have more valves
    - Have nodes
  - Continues to merge to form major ducts
    - Right lymphatic duct
      - Upper right quadrant of body
    - Thoracic duct
      - Rest of body

Lymphatic System

- Function of vessels
  - Permit particulate matter (which cannot be absorbed into capillary) to be removed from interstitial space
- Movement of fluid
  - Is uphill
  - Usually attributed to muscular movement

Lymphatic System



- Lymph nodes
- Have several lymph vessels entering into this “cellular hub”
  - One vessel leaving
- Function
  - Defense
    - Filtration
    - Phagocytosis
  - Hematopiesis
    - Site of maturation of some cells
- Spleen
  - Large lymphoid organ
    - Monitors blood for infection
    - Filters out old erythrocytes and platelets

Immune System

- A system that uses many mechanisms to ensure the integrity and survival of the internal environment.
- Two major categories:
  - Non-Specific “innate” Immunity
    - Ancient general defense system against common pattern elements found in pathogens
    - Able to attack the threat as soon as it is present
    - No memory
  - Specific “adaptive” Immunity
    - Recognizes specific pathogens and remembers them
    - Slow to recognize targets and overcome the threat (especially first time exposure)

Immune System

- The work of the system is completed by cells or substances created by cells
- Primary Type:
  - Non-specific Immunity
    - Neutrophils
    - Monocytes
    - Macrophages
    - Natural Killer (NK) Cells
  - Specific Immunity
    - Lymphocytes
      - T-Cells
      - B-Cells

Non-specific Immunity

- Species Resistance
  - Genetic characteristics to protect the body from certain pathogens
- Mechanical and Chemical Barriers
  - Skin and Mucosa
    - A continuous wall that separates the internal environment from the external environment
  - Secretions
    - Sebum, mucus and enzymes chemically inhibit the activity of pathogens
- Inflammation
  - Isolates pathogens and stimulates the speedy arrival of large numbers of immune cells

Non-specific Immunity

- Phagocytosis
  - Neutrophils
    - Granular leukocytes that are usually the first phagocytic cell to arrive due to the inflammatory response
  - Macrophages
    - Monocytes that have enlarged to become phagocytic cells (may be called by other names when found in specific tissues)
  - Dendritic Cells
    - Important bridge between innate and adaptive immune responses
    - Phagocytose pathogens in the tissues and carry them to lymph nodes for identification by T cells
- Natural Killer (NK) Cells
  - A group of lymphocytes that kill different types of cancer cells and virus infected cells

Non-specific Immunity

- Interferon
  - Protein produced by cells after they become infected by a virus which inhibits further spread of the viral infection
- Complement
  - Plasma proteins that produce a cascade of chemical reactions that cause lysis of foreign cells

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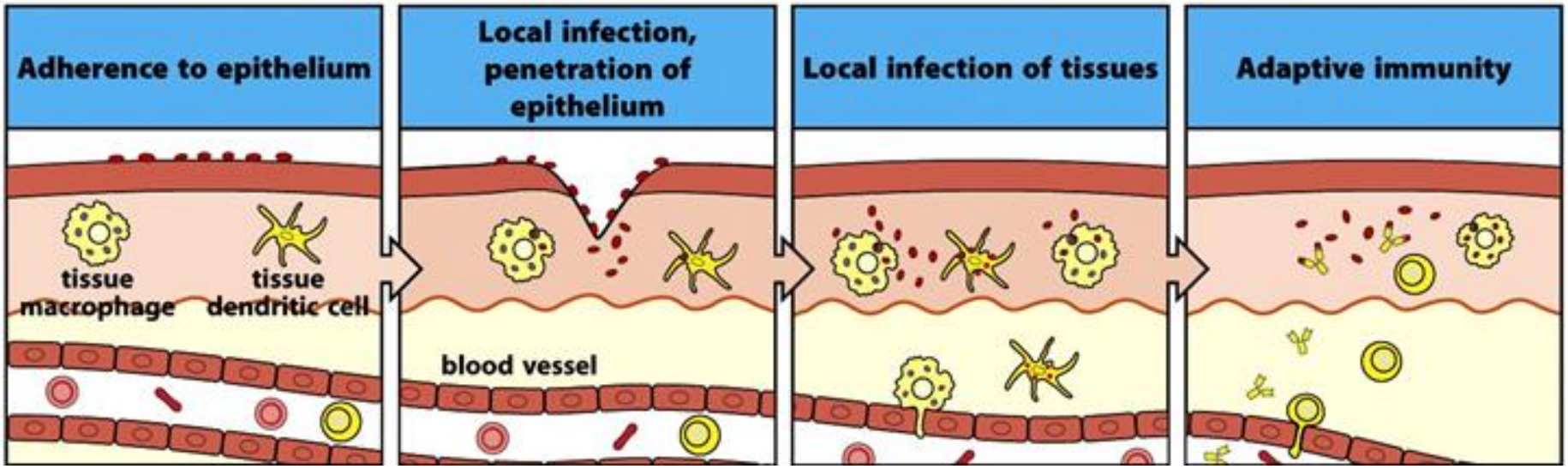
Immune System



Physical Barriers

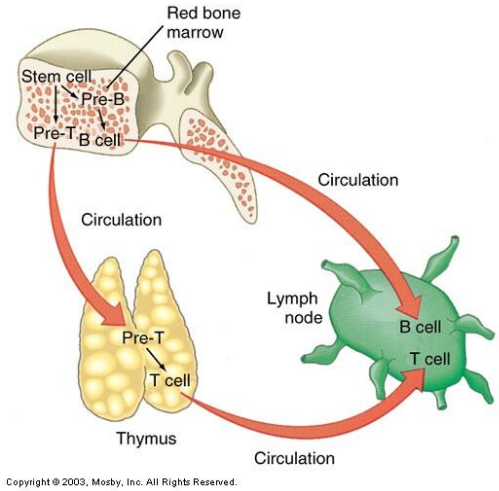
Innate non-specific Immunity

Adaptive specific Immunity

Specific Immunity

- Attack specific agents the body recognizes as “non-self”
- Adapts to pathogens and has a memory for future exposures
- Controlled by lymphocytes (a class of WBC)
- Lymphocytes are produced throughout life in the red bone marrow from the hematopoietic stem cells
- Develop into two major classes
  - B lymphocytes (B Cells)
    - Produce antibodies (antibody-mediated immunity)
  - T lymphocytes (T Cells)
    - Kill infected human cells or activate other cells to kill pathogens (cell-mediated immunity)

Antibody-Mediated Immunity



- Inactive B Cells
  - Produced in the yolk sac, then the red marrow or the fetal liver
  - Circulated to the lymph nodes and spleen
- Activate B Cells
  - When an inactive B cell encounters a specific antigen
  - This binding triggers a series of mitotic divisions producing clones of B cells
  - The clones can differentiate into plasma cells and secrete antibodies
  - Others remain in the lymphatic system as memory cells and will become plasma cells if introduced to the antigen at another time

- Antigen
  - A substance that introduced to the body that induces the formation of antibodies
  - Usually proteins located in the membranes of microorganisms or the outer coats of viruses
- Antigenic Determinants
  - Variously shaped, small regions on the surface of the antigen molecule (**epitope**)
  - Each kind of antigen has specific and uniquely shaped epitopes

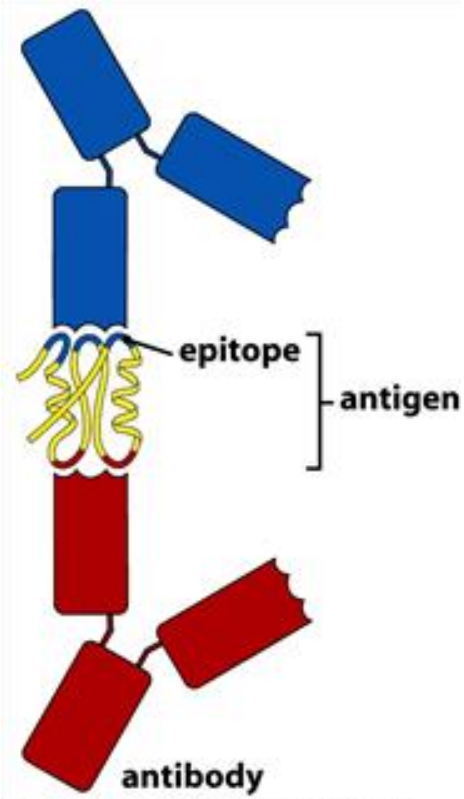


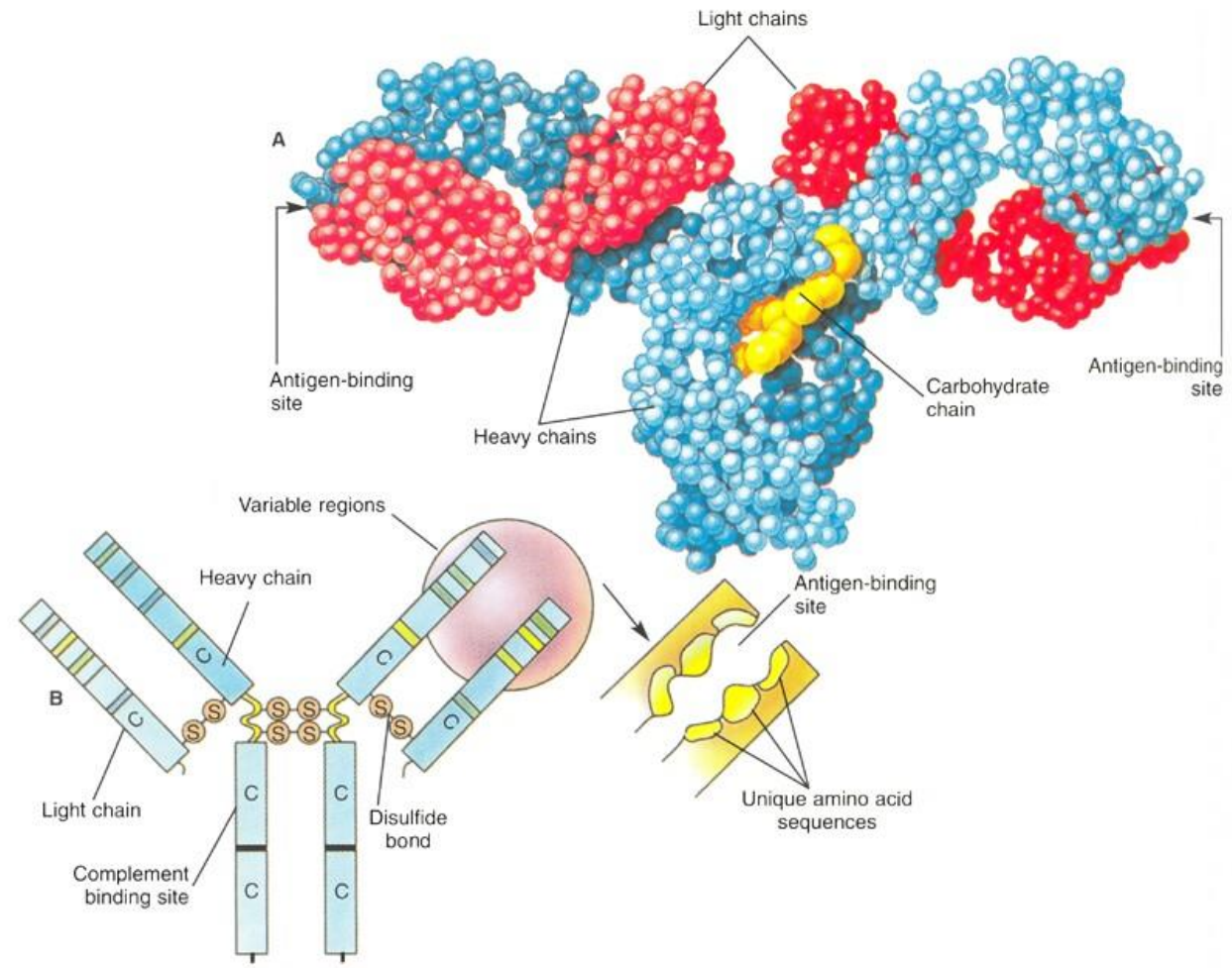
Figure 1-15 Immunobiology, 7ed. (© Garland Science 2008)

- Antibodies
  - Plasma proteins (Immunoglobulins) secreted by B cells
- Combining sites
  - Two small concave regions on the surface of the antibody
  - Like epitopes, have specific and unique shapes
  - Shaped to allow the epitope of the antigen fit into it and thereby bind to form a antigen-antibody complex
- Clone
  - The genetic descendant of a cell
- Complement
  - A group of proteins that work together to destroy foreign cells, can be activated by antibodies

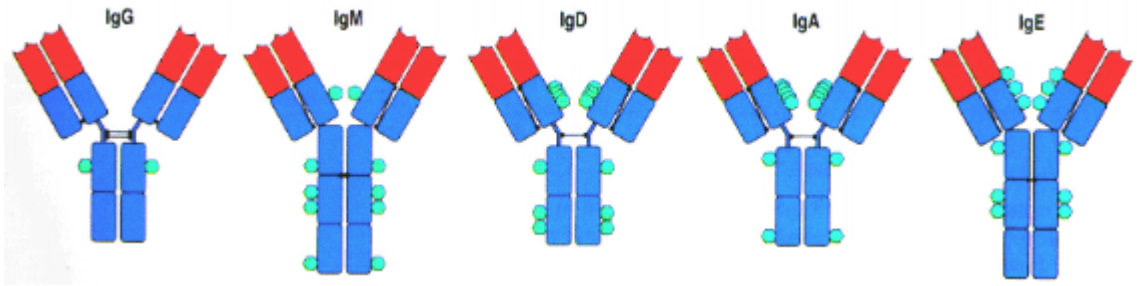
Antibodies

- Proteins of the Immunoglobulin family
- Large molecules composed of long chains of amino acids (polypeptides)
- Consists of four polypeptide chains
  - 2 Heavy
    - Twice as long and heavy
    - Has one variable and three constant regions
  - 2 Light
    - Has one variable and one constant region
- Formed to give a Y shape appearance (see Figure 21-8)
- Disulfide bonds join the 2 heavy chains to each other and their adjacent light chain
- Antigen-binding sites are located at the top of the variable regions
- Complement binding sites found in the constant regions

Antibodies



Antibodies



- Classes:
  - IgM
    - Produced by immature B cells and inserted into plasma membranes
    - Predominate antibody produced after initial contact with an antigen
  - IgG
    - Most abundant circulating antibody (75%)
    - Predominate in a secondary exposure
    - Cross the placenta barrier to provide natural passive immunity
  - IgA
    - Found in the mucous membranes, in saliva, tears, and breastmilk
  - IgE
    - Minor in amount
    - Can produce major effects (allergies)
  - IgD
    - Found in blood in small amounts (unknown function)

Antibodies

- Function to produce antibody-mediated immunity (humoral immunity)
- Antigen-Antibody reactions
  - Antibodies distinguish self-antigen and nonself-antigens at the binding site
  - This binding causes 5 main outcomes:
    1. Transforms toxins into nontoxic substances
    2. Exposes the complement-binding sites initiating the complement reaction
    3. Agglutinates antigens (clumps) for phagocytic disposal
    4. Facilitates phagocytosis (provides a handle for the white blood cells)
    5. Initiates release of inflammatory chemicals

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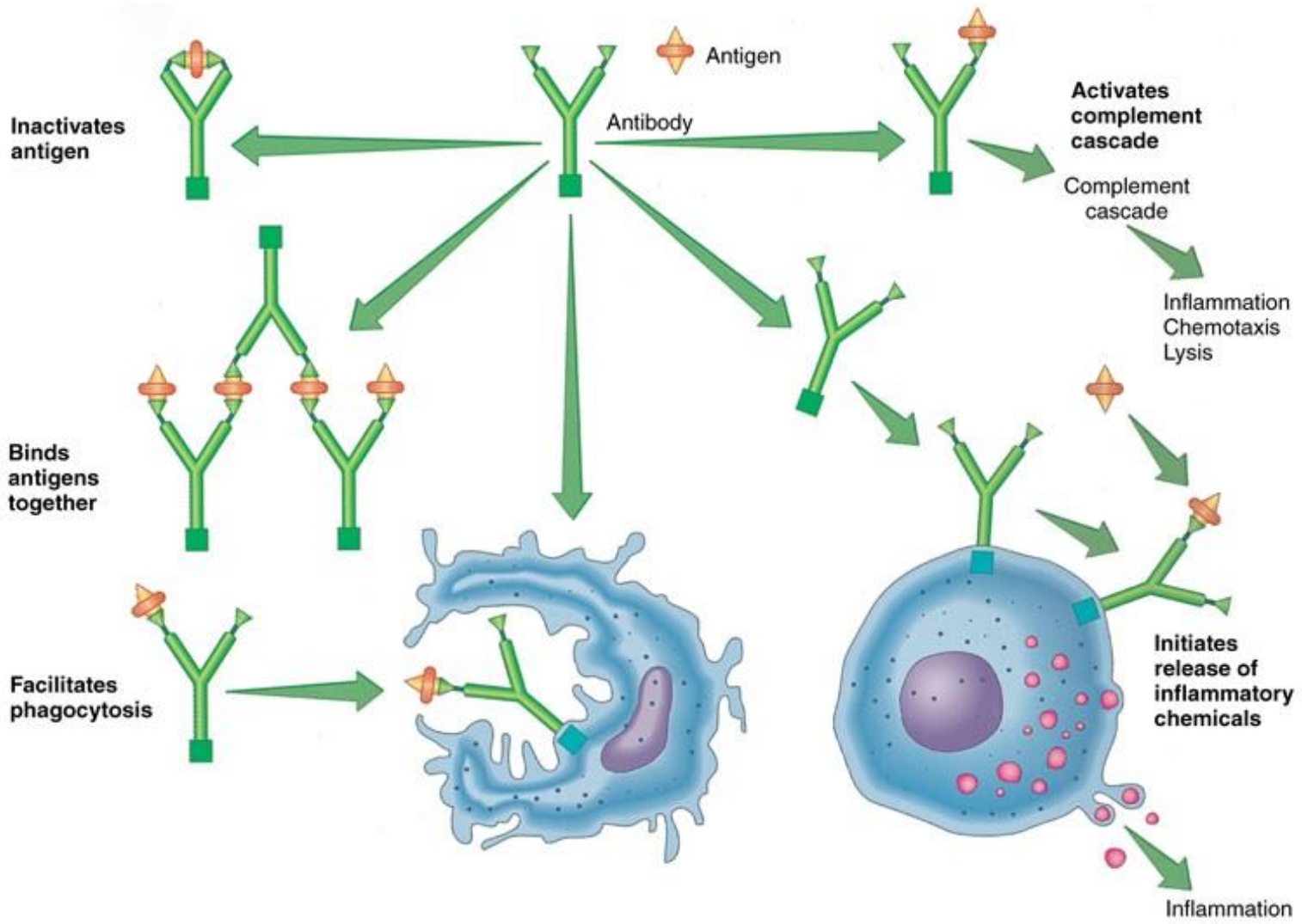
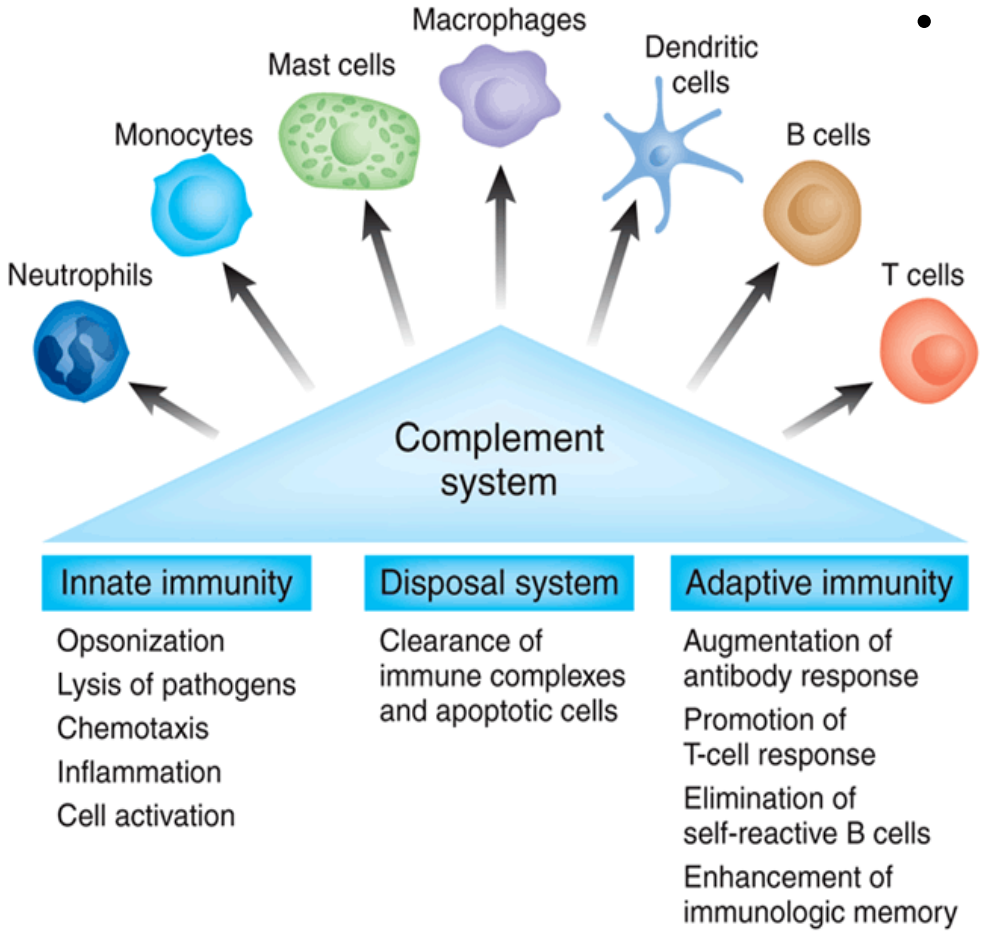
Antibodies



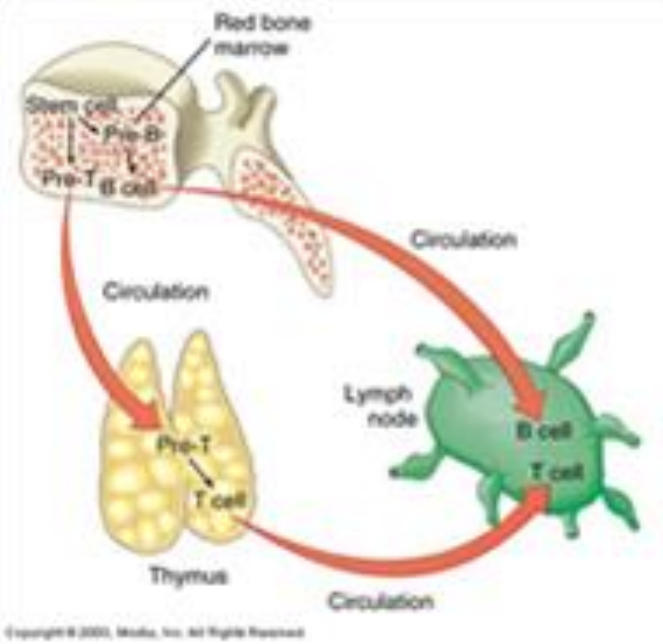
Antibodies



- Complement
  - Component of blood plasma
  - Are inactive enzymes that are activated in a definitive sequence to catalyst a series of reactions
    - The reactions are produced as proteins react with the complement-binding site
    - Molecules produce by the reactions assemble on the surface of the foreign cell to form a donut-shaped structure
    - Water and ions are diffused into the cell and cause cytolysis
  - Various complement proteins may produce other reactions
    - Vasodilatation in the invaded area
    - Attract Neutrophils and enhance phagocytosis

Cell-Mediated Immunity

- T cells are lymphocytes that have passed through the thymus gland where they learn to distinguish between self and foreign antigens
- Pre-T cells are released from bone marrow
- Pre-T cells develop into thymocytes in the thymus
- Thymocytes are rapidly reproduced (can divide 3 - 4 times a day)
- Once released into the blood from the thymus they locate in areas of the lymph nodes and spleen (T-dependant zones)
- Now they are T cells



Cell-Mediated Immunity

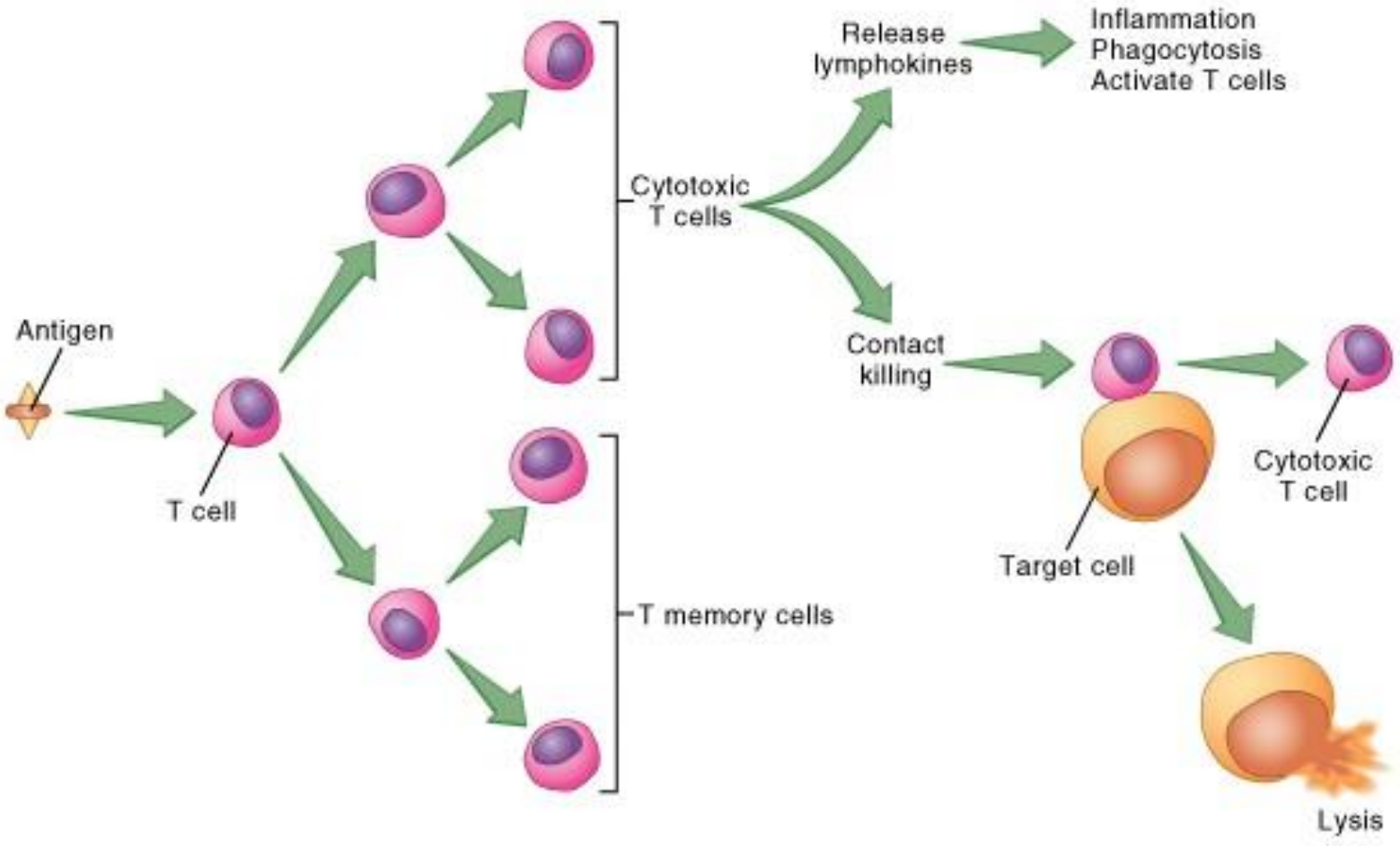
- T cells have antigen receptor sites (T cell receptors) on their membrane
- Dendritic cells phagocytose pathogens in the tissues and present antigens to the T cell receptor on the T cell
- Binding activates (sensitizes) the T cell causing it to divide and produce clone cells (activated T cells)
- These T cells will be either:
  - Cytotoxic T cell
    - Kills infected or cancerous human cells on contact
  - Helper T cell
    - Helps B cells make antibodies and helps innate cells kill pathogens

Cell-Mediated Immunity

- T cells do not directly kill bacteria or viruses
  - **Killer T cells** kill virus infected human cells or cancer cells
  - **Helper T cells** help macrophages phagocytose bacteria
  - **Helper T cells** help B cells make antibodies to target bacteria or viruses for disposal

Cell-Mediated Immunity

- Killer (cytotoxic) T cells in action:



Specific Immunity - Memory

- Some memory lymphocytes of each type (cytotoxic T cells, helper T cells, and B cells) can be saved for future encounters with the same pathogen
- This provides a memory for both:
  - Cell-mediated immunity
    - Memory Helper T cells
    - Memory Killer T cells
  - Antibody-mediated immunity
    - Memory B cells
- Innate immune cells (neutrophils, macrophages, and dendritic cells) don't have memory
- Immunologic memory is the principle that makes vaccination possible

Specific Immunity

- Inherited Immunity
  - Also known as Inborn Immunity
- Acquired Immunity
  - Natural (Exposure to the causative agent is not deliberate)
    - Active (exposure)
      - Exposure to infection (measles) and produces immunity
    - Passive (exposure)
      - Received from mother through the placenta barrier or through breast milk
  - Artificial (Exposure is deliberate)
    - Active (exposure)
      - Vaccinations
    - Passive (exposure)
      - Antibodies that are produced by another immune system (e.g.. Anti-venoms are typically horse or sheep antibodies that neutralize the venom toxins)

Canadian Pediatric Society
Routine Vaccine Schedule for healthy children and adolescents

	Vaccines							
Age:	**DTaP/IPV**	**Hib** Haemophilus influenza type b vaccine	**MMR**	**HBV**	**dTap**	**VZV**	**PCV-7**	**MenC-conjugate**
At 2 months	X	X		X			X (@ 2/3 mos)	X (@ 2/3 mos)
At 4 months	X	X		X			X (@ 4/5 mos)	X (@ 4/5 mos)
At 6 months	X	X		X			X (@ 6/7 mos)	X (@ 6/7 mos)
At 12 months			X			X	X (@12-15 mos)	
At 18 months	X	X	and X	or				
At age 4-6 years	X		or X	X 3 doses				
Teenage years				@ 0, 1 & 6 mos	dTap at 14-16 years			
Adult years				at any age	dT every 10 years			