BHARATHIDASAN UNIVERSITY

Tiruchirappalli- 620024,
Tamil Nadu, India

Programme: M.Sc., Biomedical science

Course Title : Human Anatomy & Physiology

Course Code : BM12C2

Unit-III

TOPIC: Lymphatic and Immune Systems

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Functions of Lymphatic System

- **Immunity**
  - **fluids from all capillary beds are filtered**
  - **immune cells stand ready to respond to foreign cells or chemicals encountered**
- **Lipid absorption**
  - **Lacteals in small intestine absorb dietary lipids**
- **Fluid recovery**
  - **absorbs plasma proteins and fluid (2 to 4 L/day) from tissues and returns it to the bloodstream**
    - **interference with lymphatic drainage leads to severe edema**

Lymph and Lymphatic Capillaries

- **Lymph**
  - **clear, colorless fluid, similar to plasma but much less protein**
- **Lymphatic capillaries**
  - **closed at one end**
  - **tethered to surrounding tissue by protein filaments**
  - **endothelial cells loosely overlapped**
    - **allow bacteria and cells entrance to lymphatic capillary**
    - **creates valve-like flaps that open when interstitial fluid pressure is high, and close when it is low**

Lymphatic Capillary

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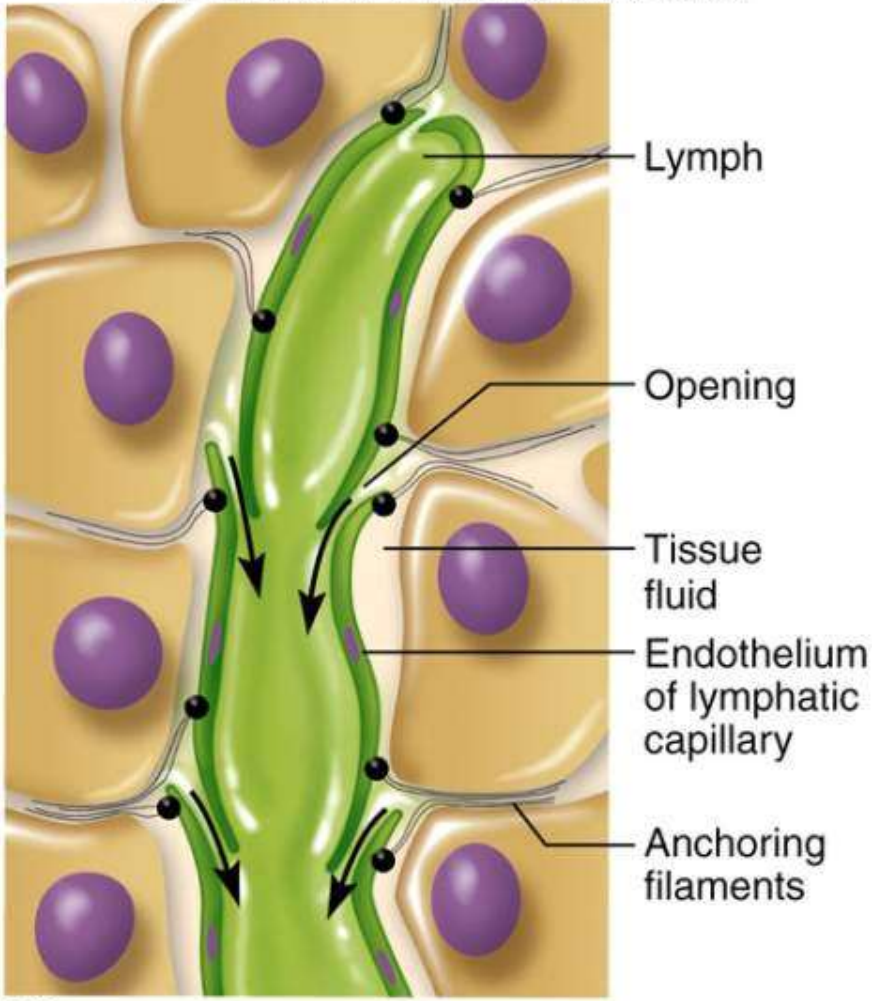

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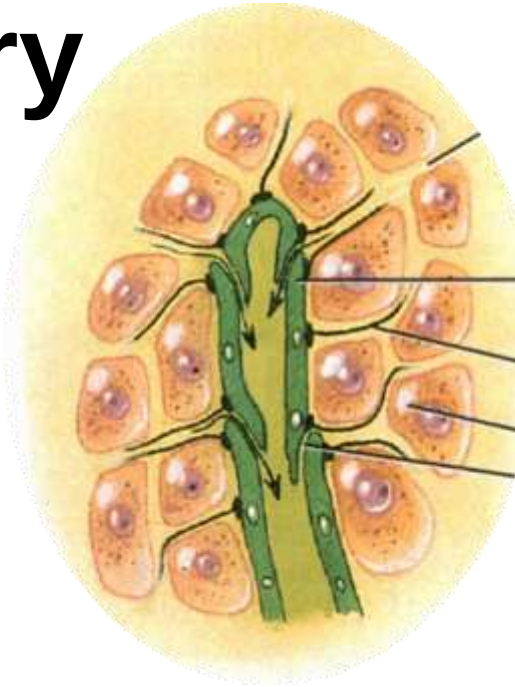


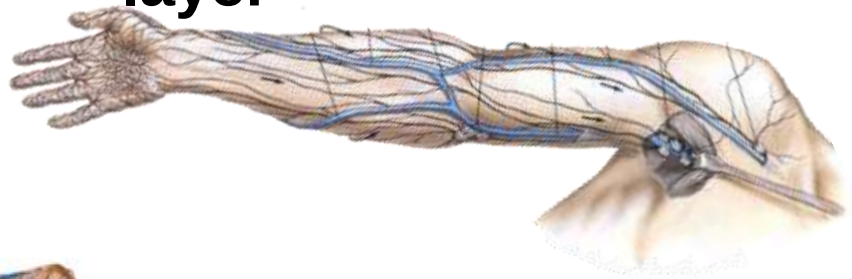
Single layer of overlapping endothelial cells
More permeable than that of blood capillary
Absent from avascular structures, brain, spinal cord splenic pulp and bone marrow

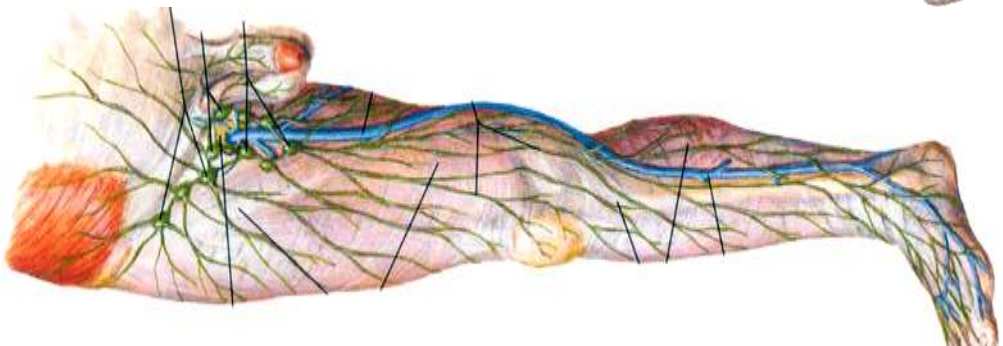
Lymphatic Vessels

Features of structure

- Three layered wall but thinner than vein,
- More numerous valves than in vein
- Interposed by lymph nodes at intervals
- Arranged in superficial and deep sets

- Larger ones composed of 3 layers
  - tunica interna: endothelium and valves
  - tunica media: elastic fibers, smooth muscle
  - tunica externa: thin outer layer





Valve in a Lymphatic Vessel

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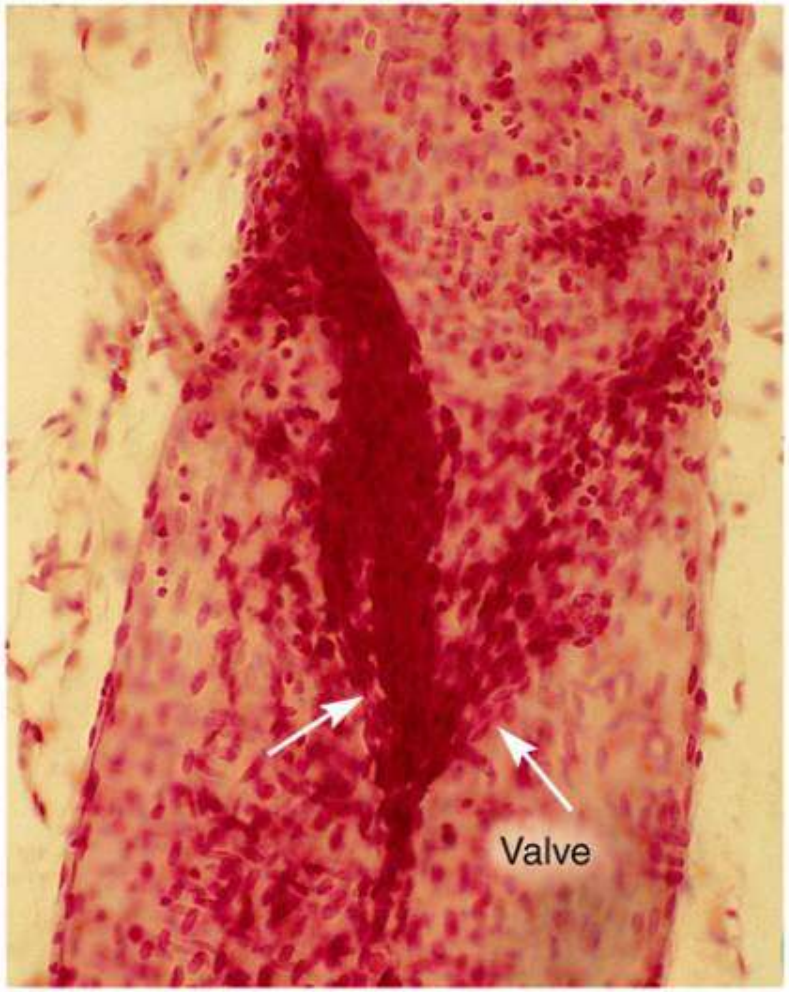

(a)

Route of Lymph Flow

- **Lymphatic capillaries**
- **Collecting vessels: course through many lymph nodes**
- **Lymphatic trunks: drain major portions of body**
- **Collecting ducts :**
  - **right lymphatic duct – receives lymph from R arm, R side of head and thorax; empties into R subclavian vein**
  - **thoracic duct - larger and longer, begins as a prominent sac in abdomen called the cisterna chyli; receives lymph from below diaphragm, L arm, L side of head, neck and thorax; empties into L subclavian vein**

The Fluid Cycle

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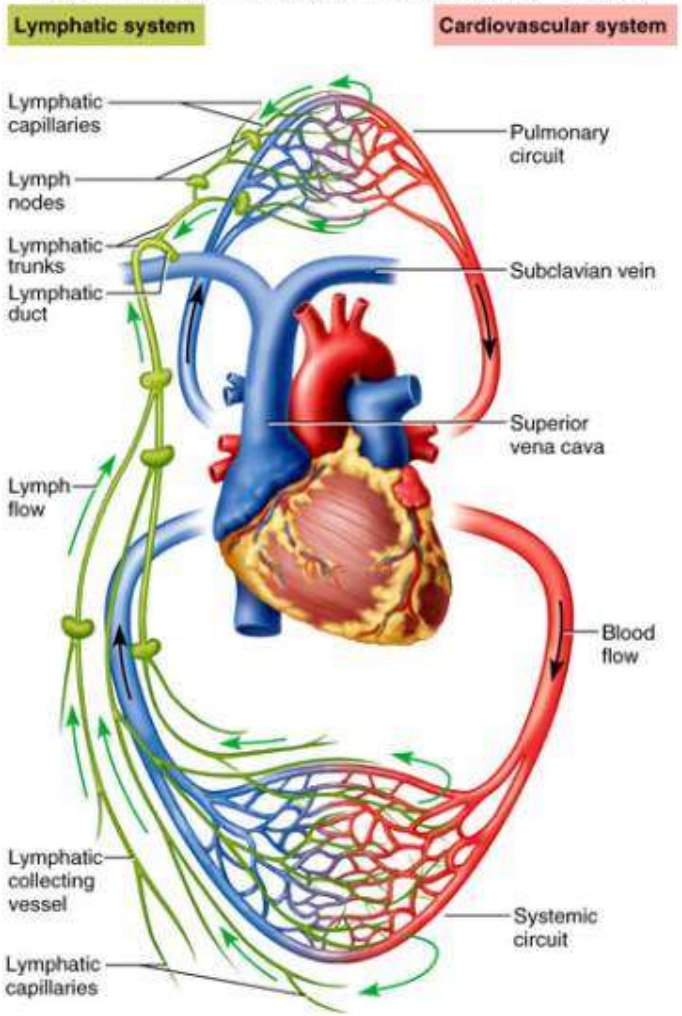

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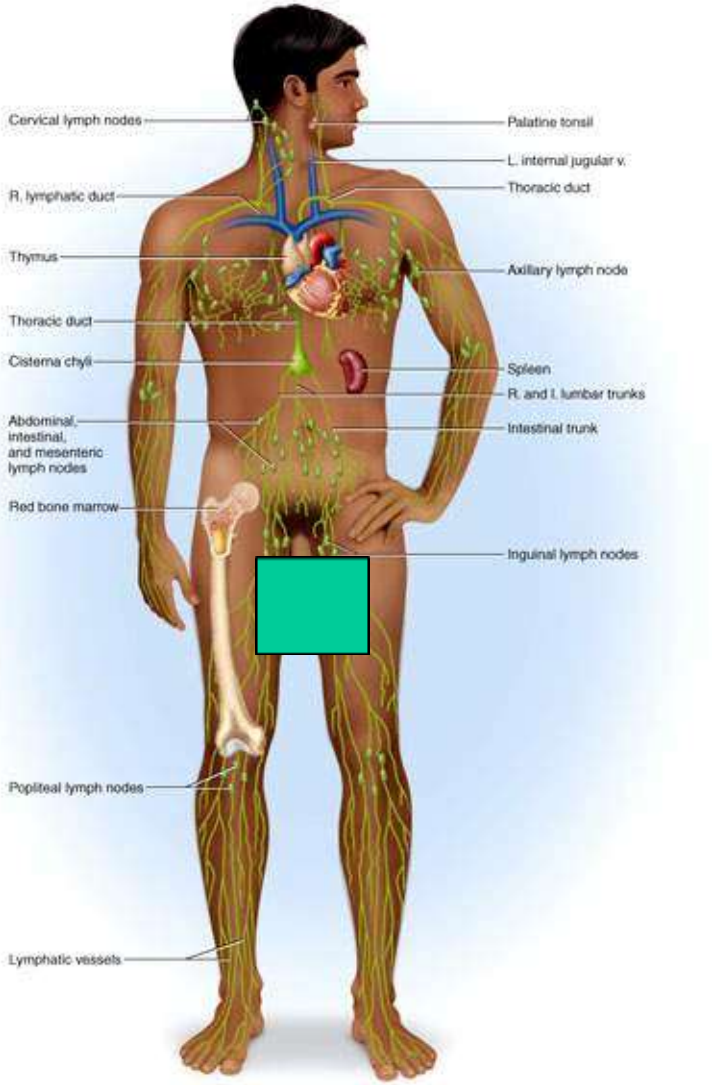
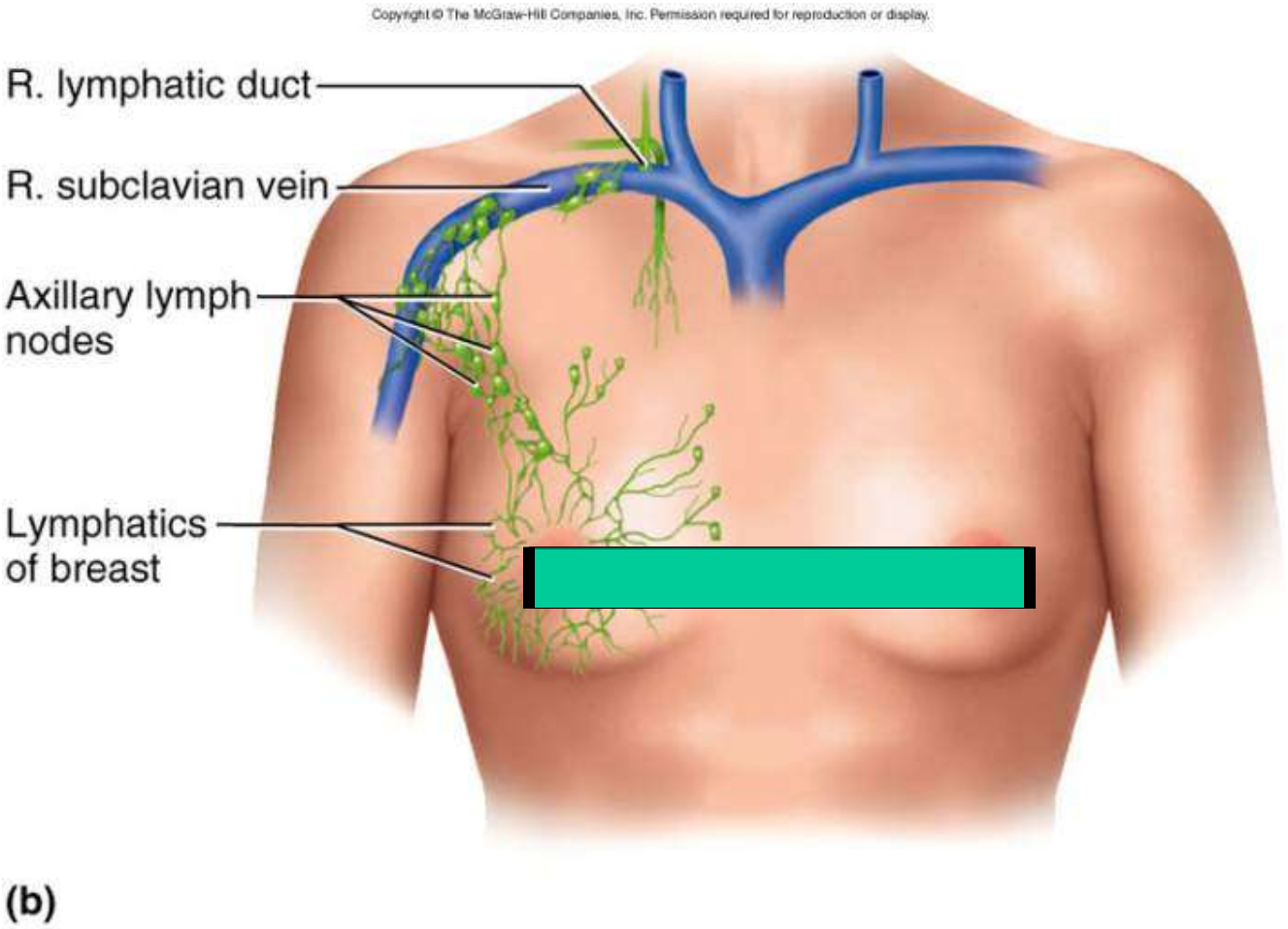
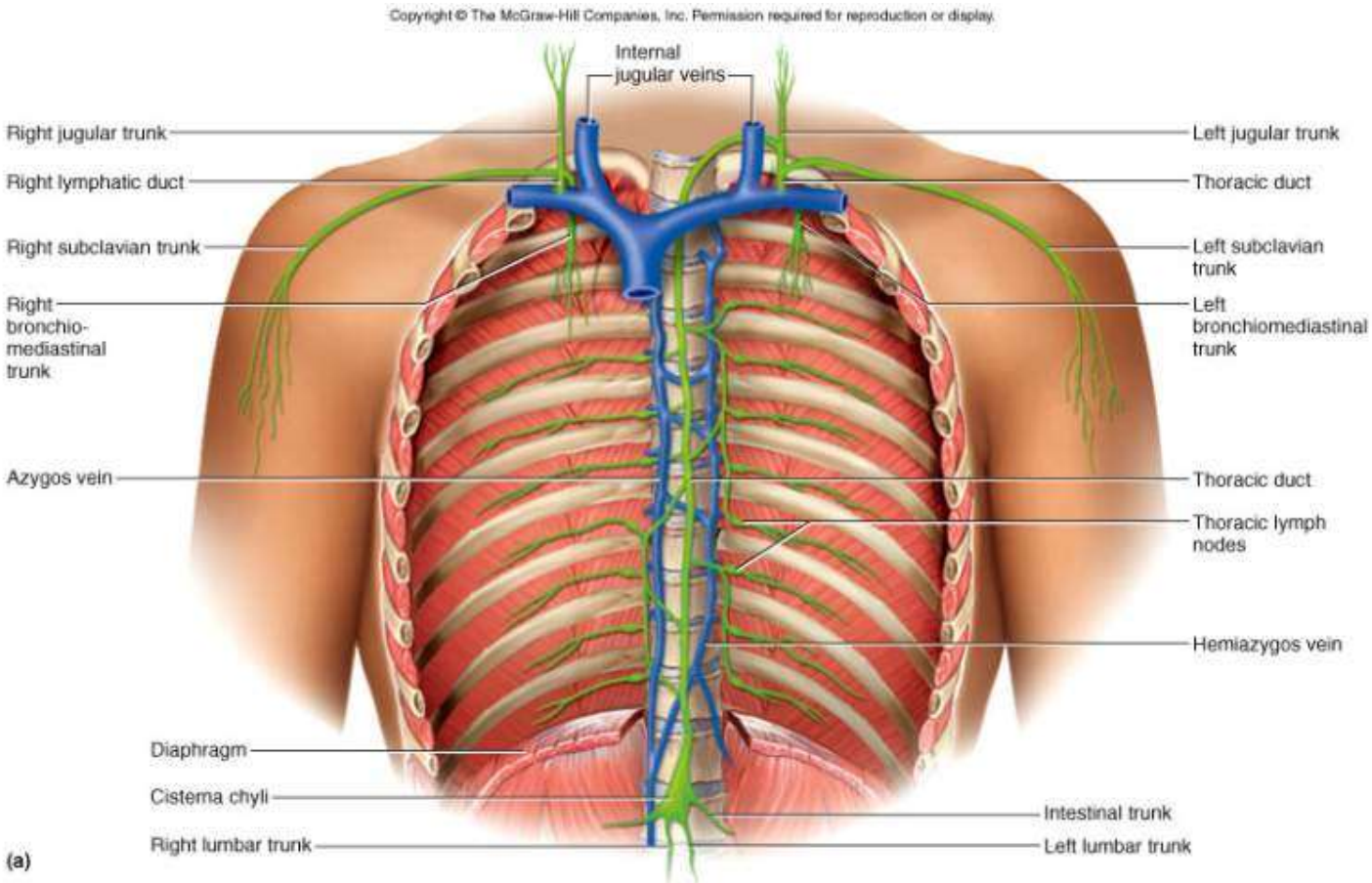


Lymphatic Drainage of Mammary and Axillary Regions



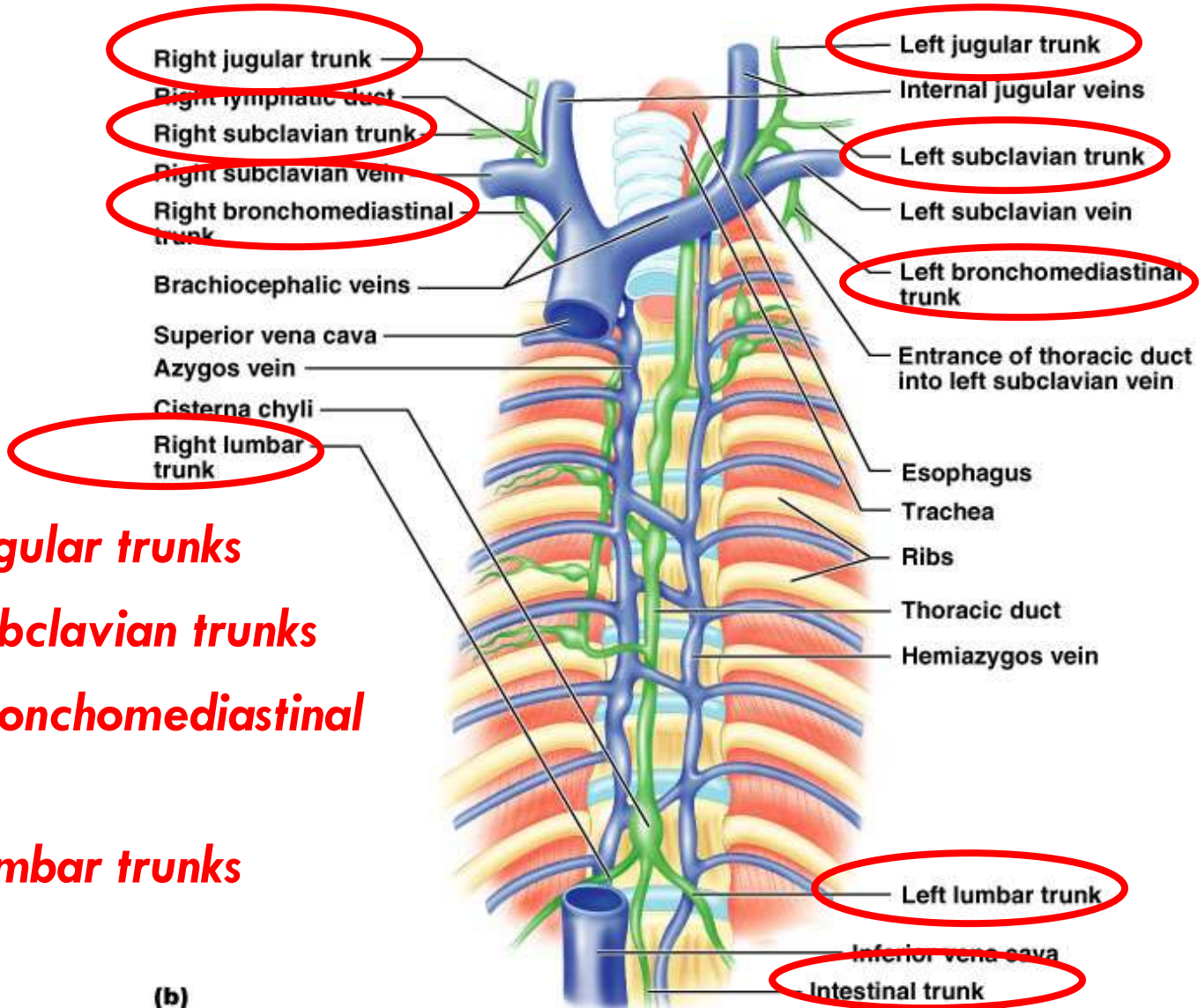
Drainage of Thorax



Mechanisms of Lymph Flow

- Lymph flows at low pressure and speed
- Moved along by rhythmic contractions of lymphatic vessels
  - stretching of vessels stimulates contraction
- Flow aided by skeletal muscle pump
- Thoracic pump aids flow from abdominal to thoracic cavity
- Valves prevent backward flow
- Rapidly flowing blood in subclavian veins, draws lymph into it
- Exercise significantly increases lymphatic return

LYMPH TRUNKS

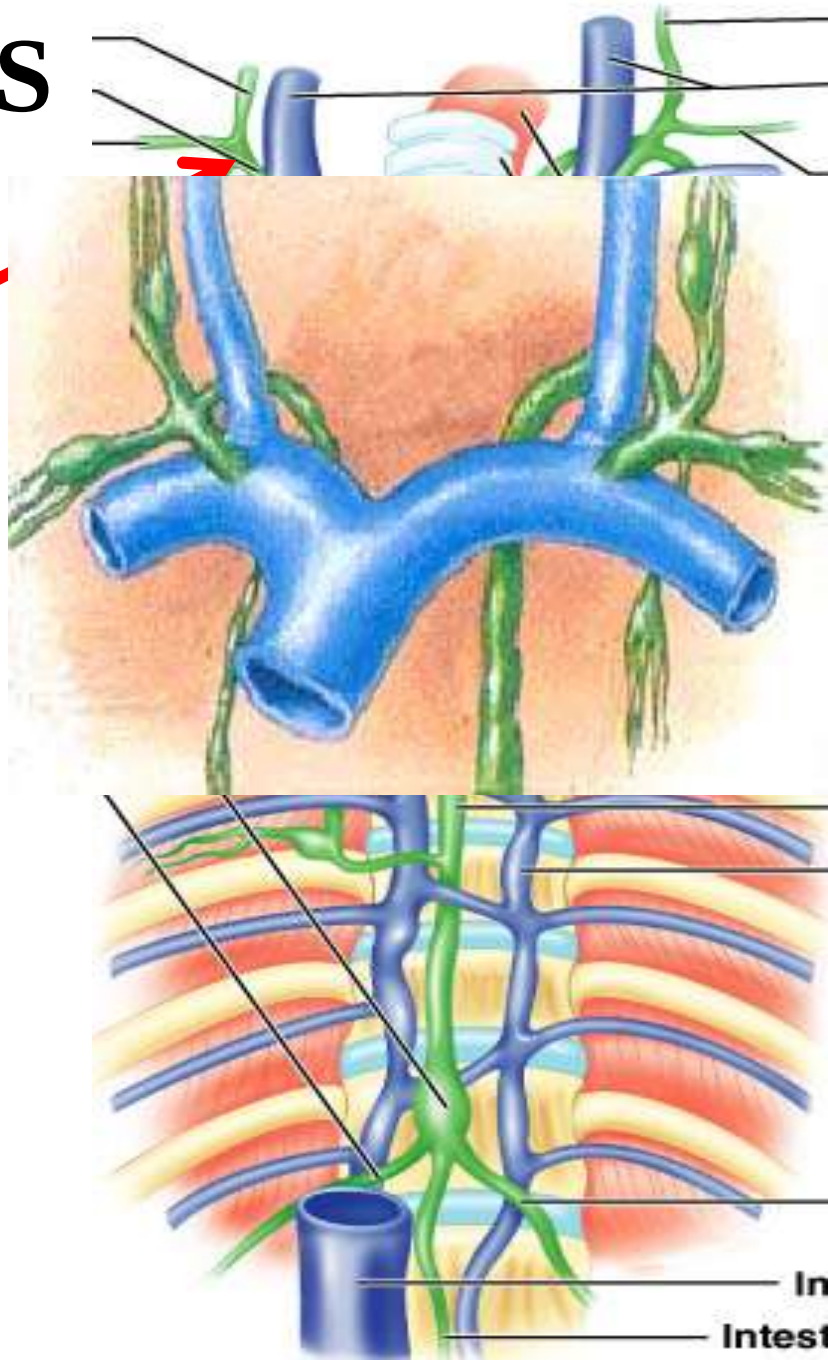


- *right and left jugular trunks*
- *right and left subclavian trunks*
- *right and left bronchomediastinal trunks*
- *right and left lumbar trunks*
- *intestinal trunk*

LYMPHATIC DUCTS

Right lymphatic duct

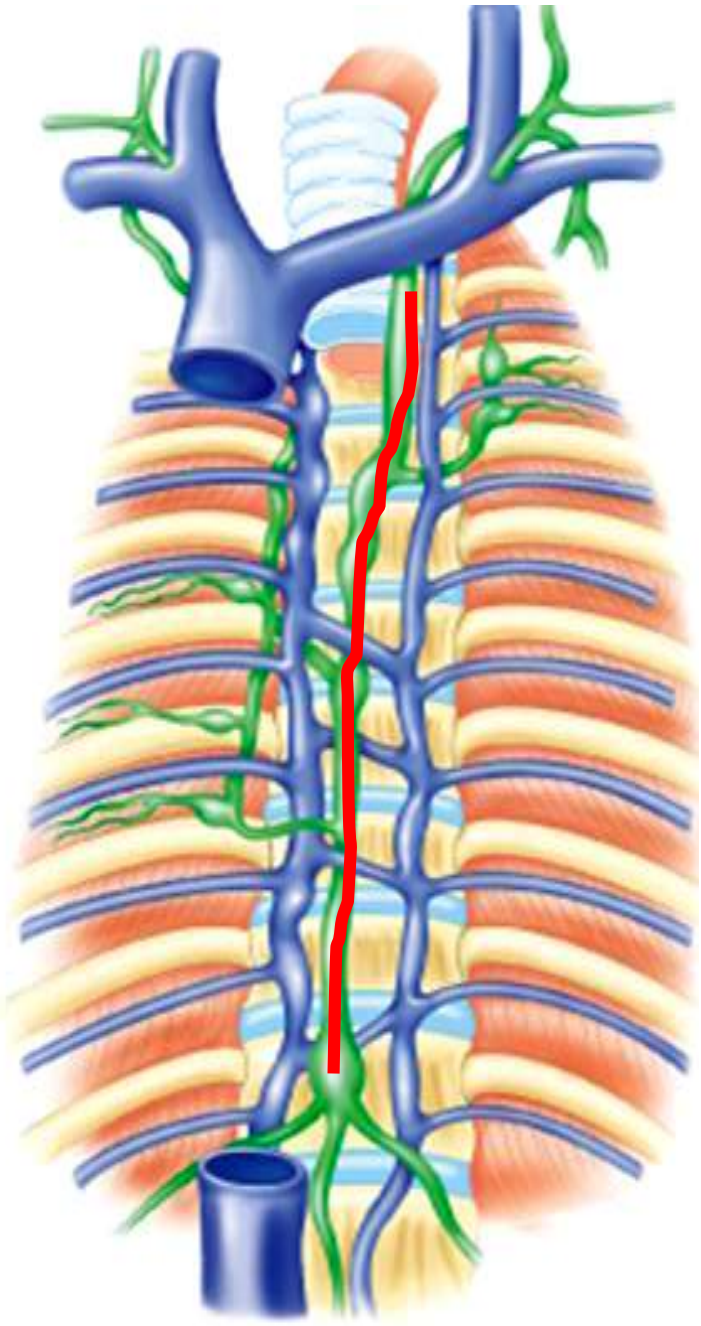
- Formed by union of right jugular, subclavian, and bronchomediastinal trunks
- Ends by entering the right venous angle



LYMPHATIC DUCTS

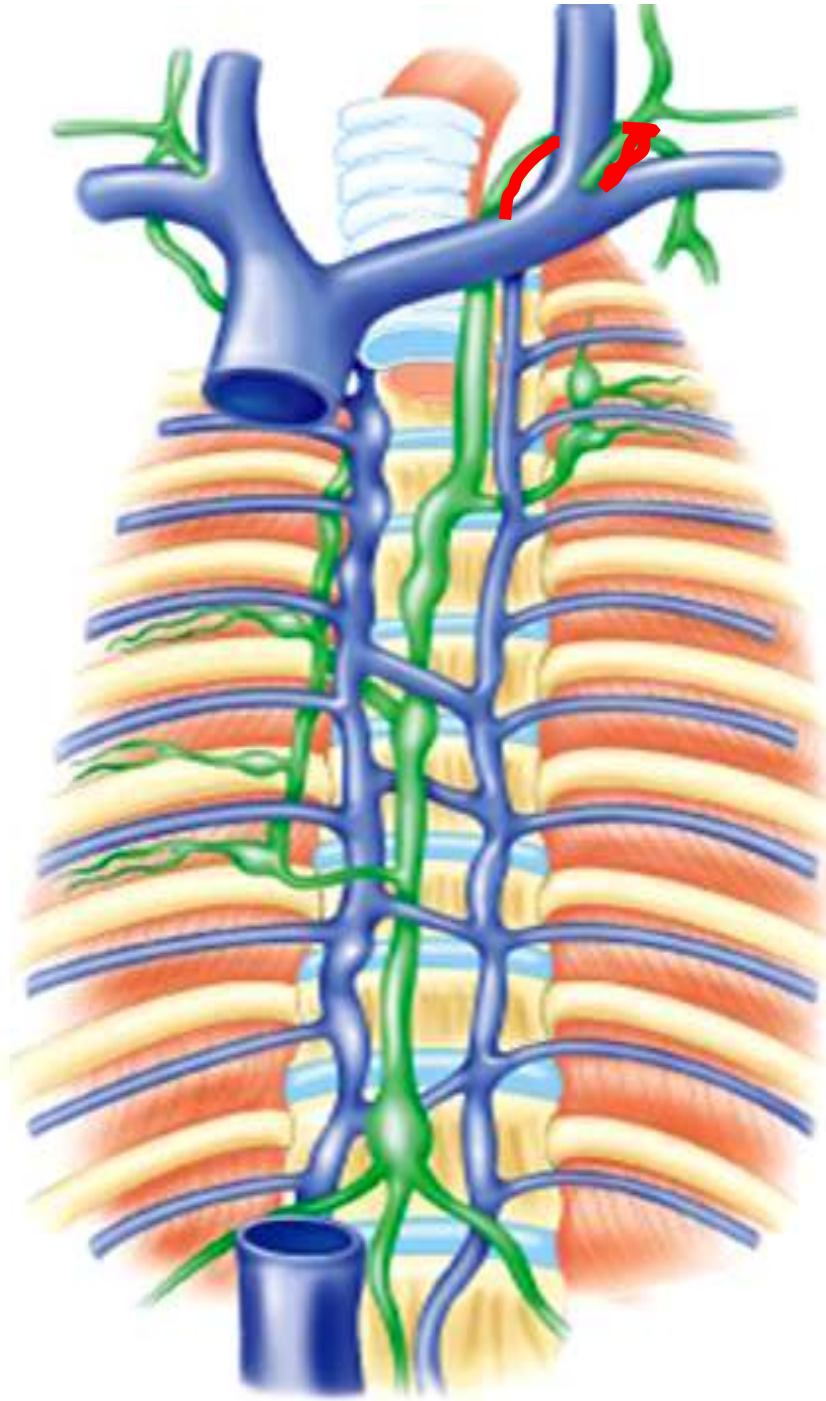
Thoracic duct

- **Begins in front of L1 as a dilated sac, the cisterna chyli,**
- **formed by left and right lumbar trunks and intestinal trunk**
- **Enter thoracic cavity & ascends**
- **Travels upward, veering to the left at the level of T5**



THORACIC DUCT…..

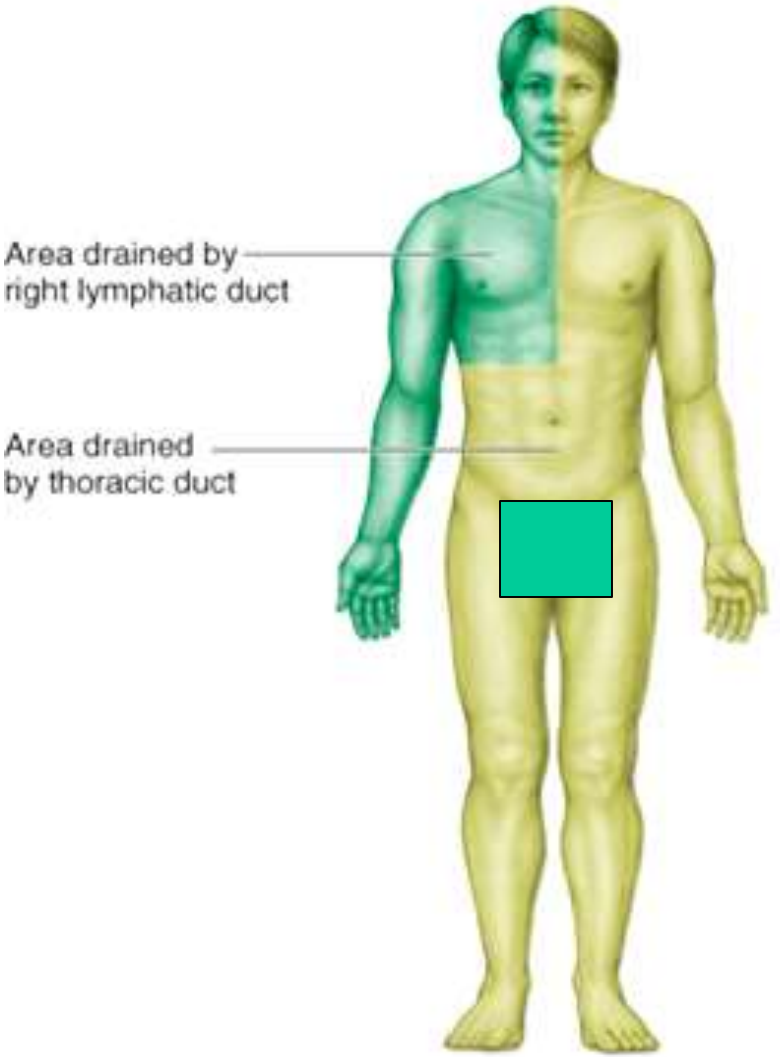
- **At the root of the neck, it turns laterally**
- **arches forwards and descends to enter the left venous angle**
- **before termination, it receives the left jugular, Subclavian and broncho-mediastinal trunk**



DRAINAGE PATTERN

RIGHT LYMPHATIC DUCT - Receives lymph from right half of head, neck, thorax and right upper limb, right lung, right side of heart, right surface of liver

THORACIC DUCT - Drains lymph from lower limbs, pelvic cavity, abdominal cavity, left side of thorax, and left side of the head, neck and left upper limb



(b) Lymph drainage pattern

Lymph Tissue

- 3 types
  - Diffuse lymphatic tissue
    - No capsule present
    - Found in connective tissue of almost all organs
  - Lymphatic nodules
    - No capsule present
    - Oval-shaped masses
    - Found singly or in clusters
  - Lymphatic organs
    - Capsule present
    - Lymph nodes, spleen, thymus gland

Lymphatic Cells

- **Natural killer (NK) cells**
  - **responsible for immune surveillance**
- **T lymphocytes**
  - **mature in thymus**
- **B lymphocytes**
  - **activation causes proliferation and differentiation into plasma cells that produce antibodies**
- **Antigen Presenting Cells**
  - **macrophages (from monocytes)**
  - **dendritic cells (in epidermis, mucous membranes and lymphatic organs)**
  - **reticular cells (also contribute to stroma of lymph organs)**

Lymphatic Tissue

- **Diffuse lymphatic tissue**
  - **lymphocytes in mucous membranes and CT of many organs**
  - **Mucosa-Associated Lymphatic Tissue (MALT): prevalent in passages open to exterior**
- **Lymphatic nodules**
  - **dense oval masses of lymphocytes, congregate in response to pathogens**
  - **Peyer patches: more permanent congregation, clusters found at junction of small to large intestine**

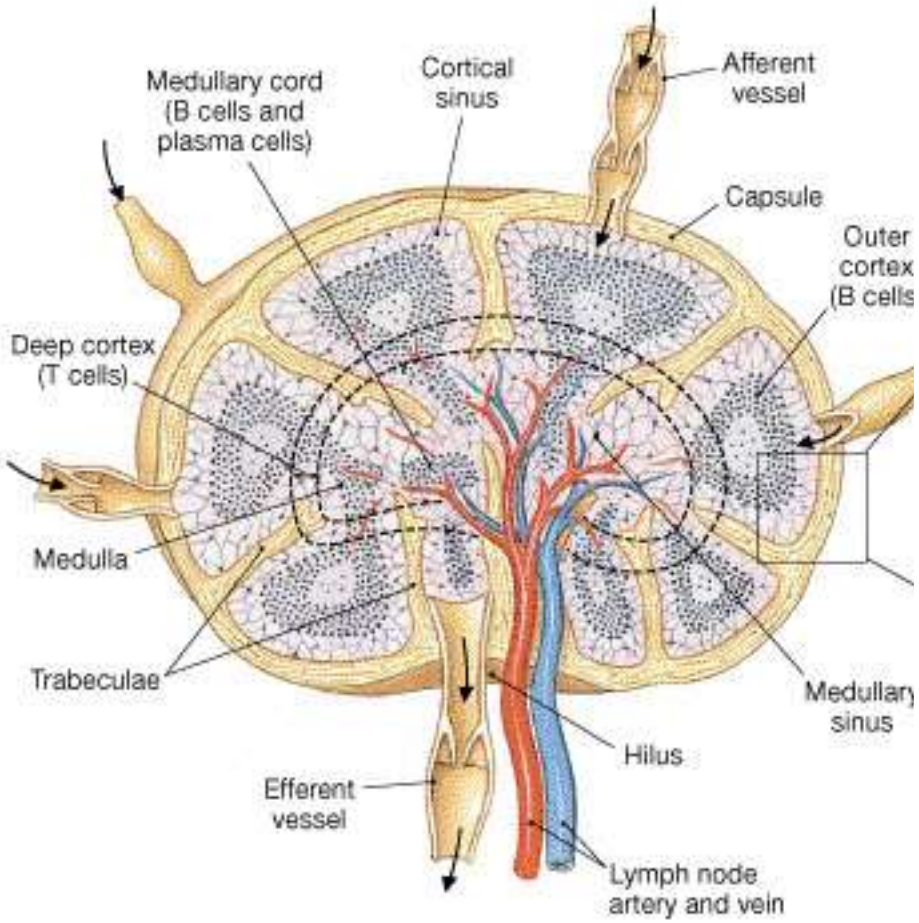
Lymphatic Organs

- At well defined sites; have CT capsules
- Primary lymphatic organs
  - site where T and B cells become immunocompetent
  - red bone marrow and thymus
- Secondary lymphatic organs
  - immunocompetent cells populate these tissues
  - lymph nodes, tonsils, and spleen

Lymph Node

- **Lymph nodes - only organs that filter lymph**
- **Fewer efferent vessels, slows flow through node**
- **Capsule gives off trabeculae, divides node into compartments containing stroma (reticular CT) and parenchyma (lymphocytes and APCs) subdivided into cortex (lymphatic nodules) and medulla**
  - **reticular cells, macrophages phagocytize foreign matter**
  - **lymphocytes respond to antigens**
  - **lymphatic nodules-germinal centers for B cell activation**

Lymph Node



- Oval structures located along lymphatics
- Enclosed by a fibrous capsule
- Cortex = outer portion
  - Germinal centers produce lymphocytes
- Medulla = inner portion
  - Medullary cords
- Lymph enters nodes through afferent lymphatics, flows through sinuses, exits through efferent lymhpatic

Lymphadenopathy

- **Collective term for all lymph node diseases**
- **Lymphadenitis**
  - **swollen, painful node responding to foreign antigen**
- **Lymph nodes are common sites for metastatic cancer**
  - **swollen, firm and usually painless**

Lymph Node

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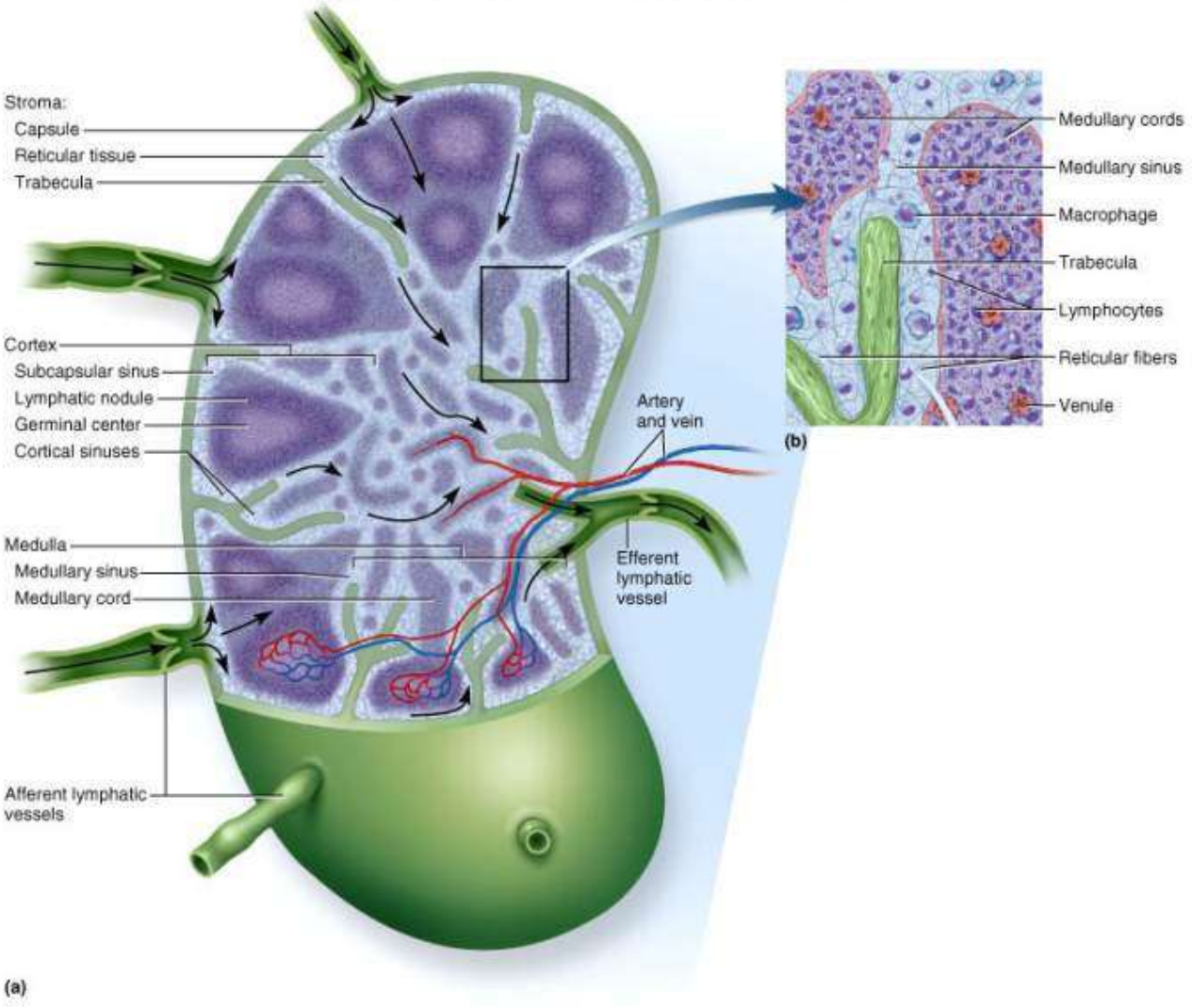

Tonsil

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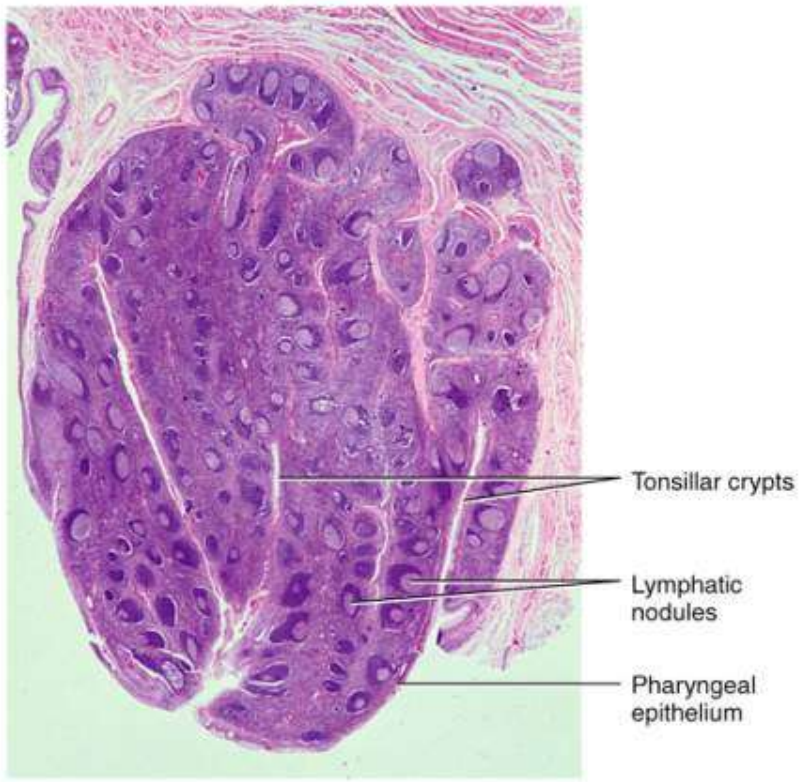
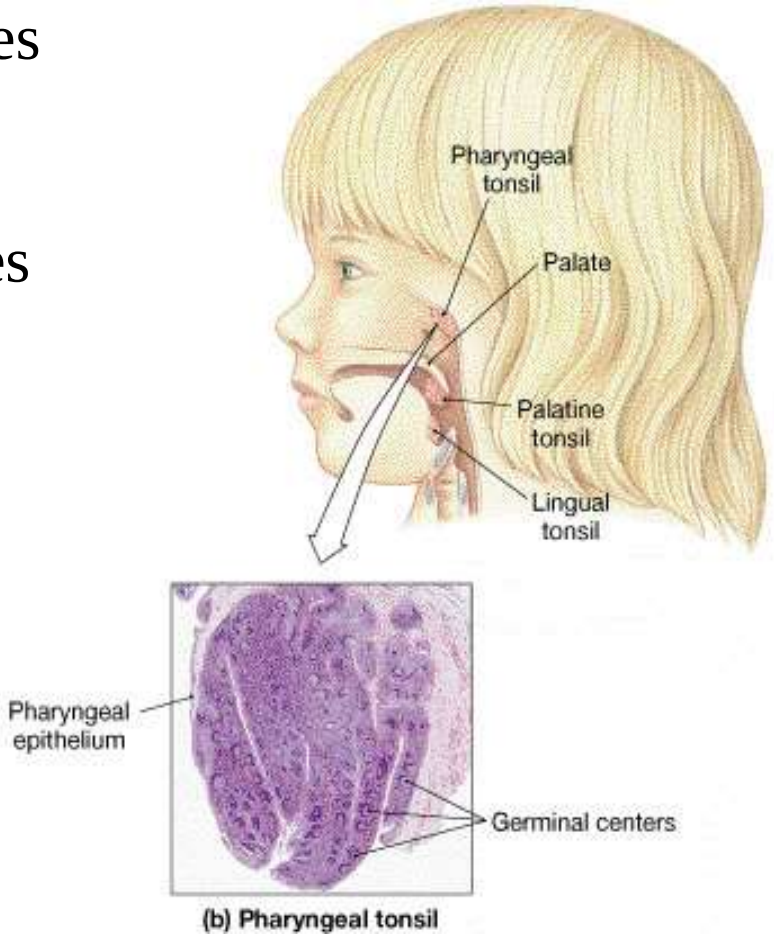


(b)

- **Covered by epithelium**
- **Pathogens get into tonsillar crypts and encounter lymphocytes**

Tonsils

- Multiple groups of large lymphatic nodules
- Location – mucous membrane of the oral and pharyngeal cavities
- Palatine tonsils
  - Posterior-lateral walls of the oropharynx
- Pharyngeal tonsil
  - Posterior wall of nasopharynx
- Lingual tonsils
  - Base of tongue



Location of Tonsils

- **Palatine tonsils**
  - **pair at posterior margin of oral cavity**
  - **most often infected**
- **Lingual tonsils**
  - **pair at root of tongue**
- **Pharyngeal tonsil (adenoid)**
  - **single tonsil on wall of pharynx**

Thymus

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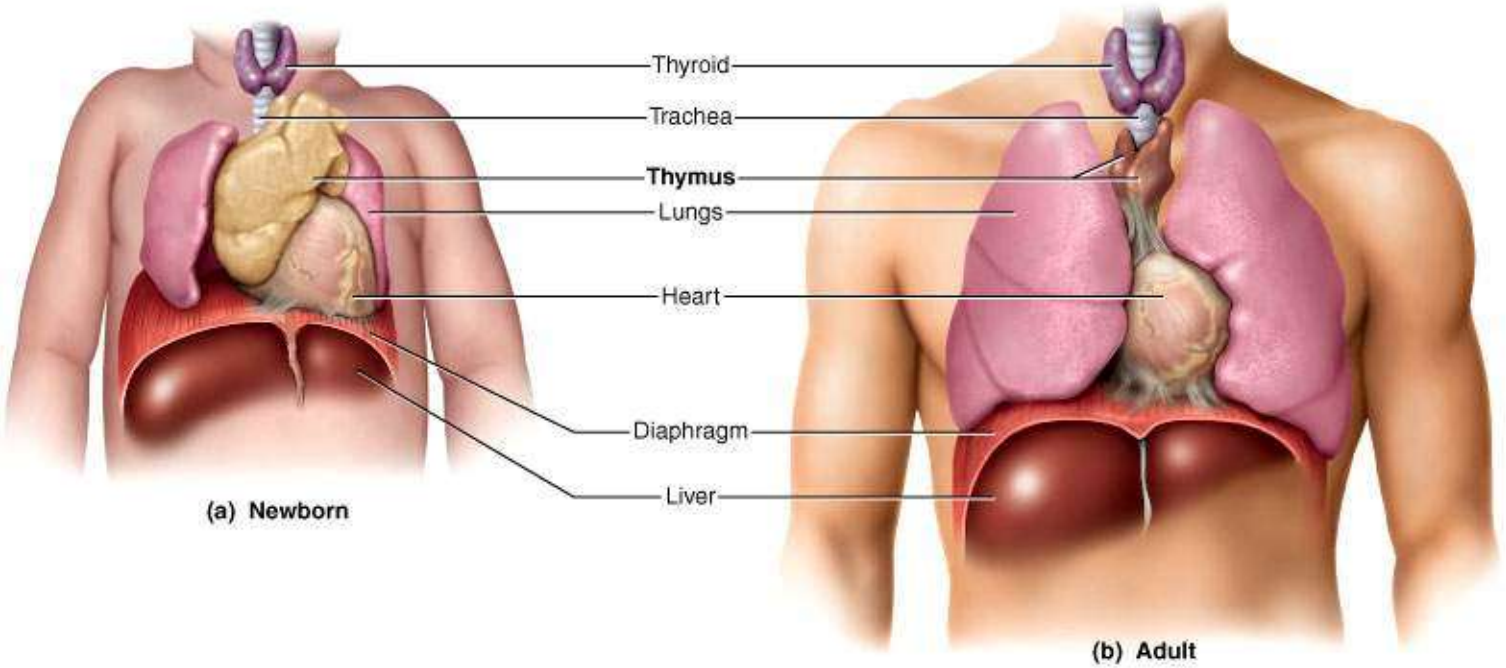

Thymus

- **Capsule gives off trabeculae, divides parenchyma into lobules of cortex and medulla**
- **Reticular epithelial cells**
  - **form blood thymus barrier in cortex**
    - **isolates developing T lymphocytes from foreign antigens**
  - **secretes hormones (thymopoietin, thymulin and thymosins)**
    - **to promote development and action of T lymphocytes**
- **Very large in fetus; after age 14 begins involution**
  - **in elderly mostly fatty and fibrous tissue**

Histology of Thymus

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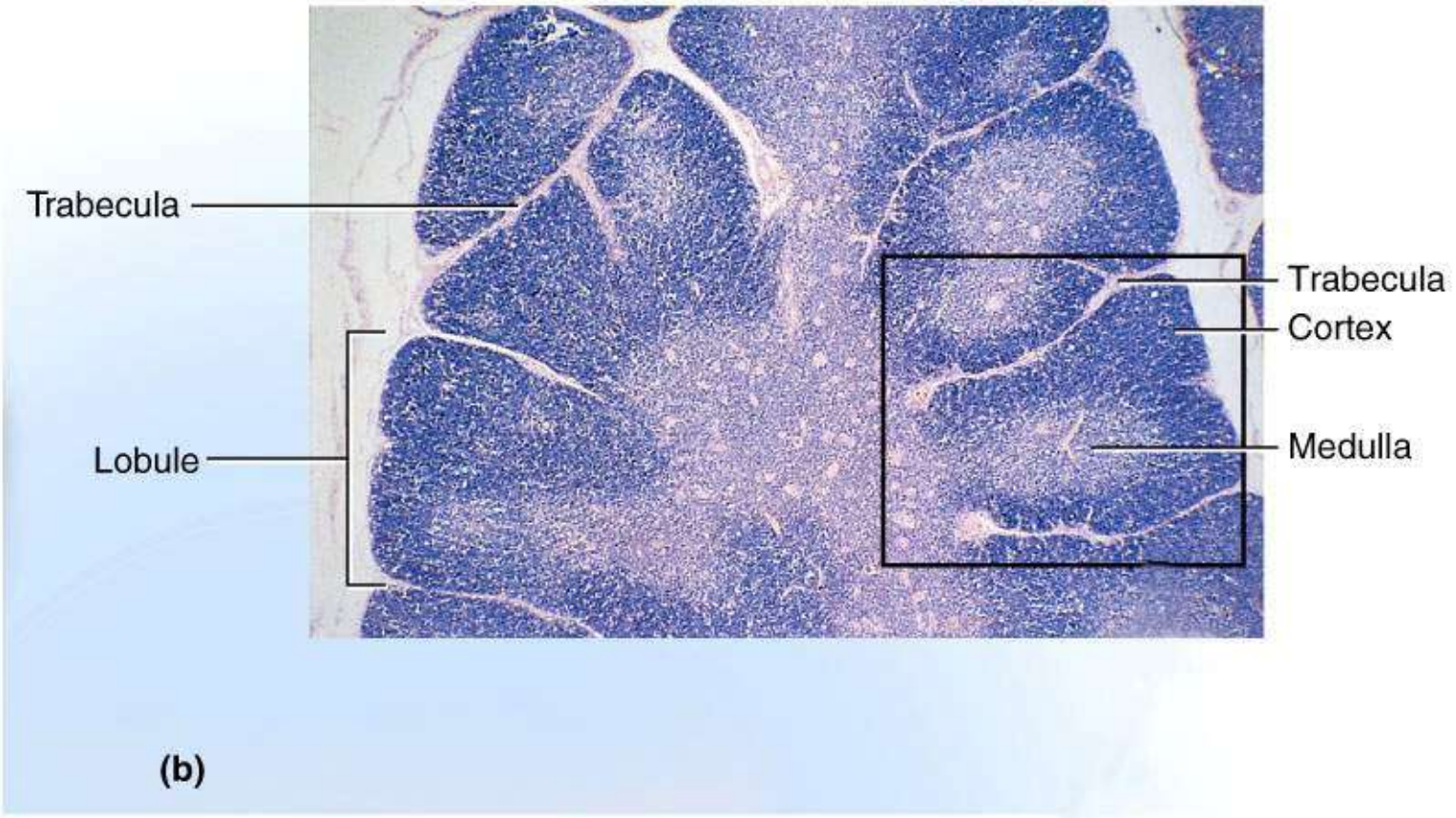
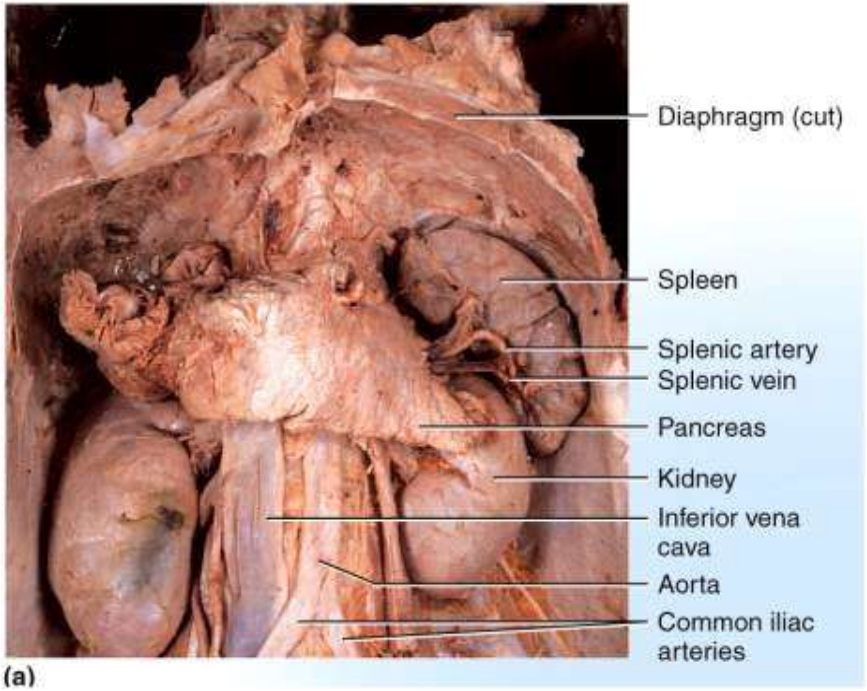
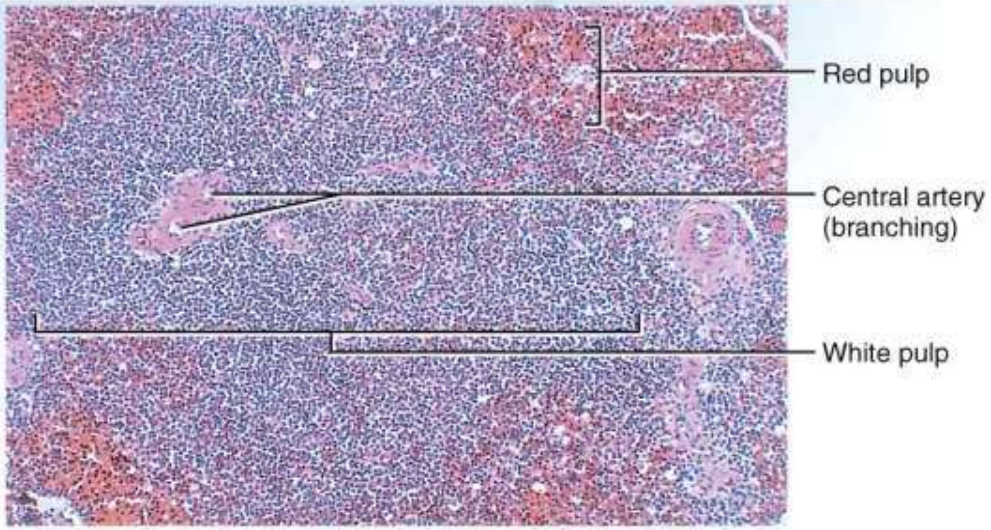


Spleen

- **Parenchyma appears in fresh specimens as**
  - **red pulp: sinuses filled with erythrocytes**
  - **white pulp: lymphocytes, macrophages; surrounds small branches of splenic artery**
- **Functions**
  - **blood production in fetus**
  - **blood reservoir**
  - **RBC disposal**
  - **immune reactions: filters blood, quick to detect antigens**

Spleen


Diaphragm (cut)
Spleen
Splenic artery
Splenic vein
Pancreas
Kidney
Inferior vena cava
Aorta
Common iliac arteries
(a)


Red pulp
Central artery (branching)
White pulp
(c)

Defenses Against Pathogens

- **Nonspecific defenses - broadly effective, no prior exposure**
  - **first line of defense**
    - **external barriers**
  - **second line of defense**
    - **phagocytic cells, antimicrobial proteins, inflammation and fever**
- **Specific defense - results from prior exposure, protects against only a particular pathogen**
  - **third line of defense**
    - **immune system**

External Barriers

- **Skin**
  - **toughness of keratin**
  - **dry and nutrient-poor**
  - **defensins: peptides, from neutrophils attack microbes**
  - **lactic acid (acid mantle) is a component of perspiration**
- **Mucous membranes**
  - **stickiness of mucus**
  - **lysozyme: enzyme destroys bacterial cell walls**
- **Subepithelial areolar tissue**
  - **tissue gel: viscous barrier of hyaluronic acid**
    - **hyaluronidase: enzyme used by pathogens to spread**

Leukocytes and Cutaneous Defenses

- Neutrophils
- Eosinophils
- Basophils
- Monocytes
- Lymphocytes

Neutrophils

- **Phagocytize bacteria**
- **Create a killing zone**
  - **degranulation**
    - **lysosomes discharge into tissue fluid**
  - **respiratory burst**
    - **toxic chemicals are created ($O_2^{\cdot -}$, H_2O_2, HClO)**

Eosinophils

- **Phagocytize antigen-antibody complexes**
- **Antiparasitic effects**
- **Promote action of basophils, mast cells**
- **Enzymes block excess inflammation, limit action of histamine**

Basophils

- **Aid mobility and action of WBC's by release of**
  - **histamine (vasodilator)**
    - **↑ blood flow to infected tissue**
  - **heparin (anticoagulant)**
    - **prevents immobilization of phagocytes**

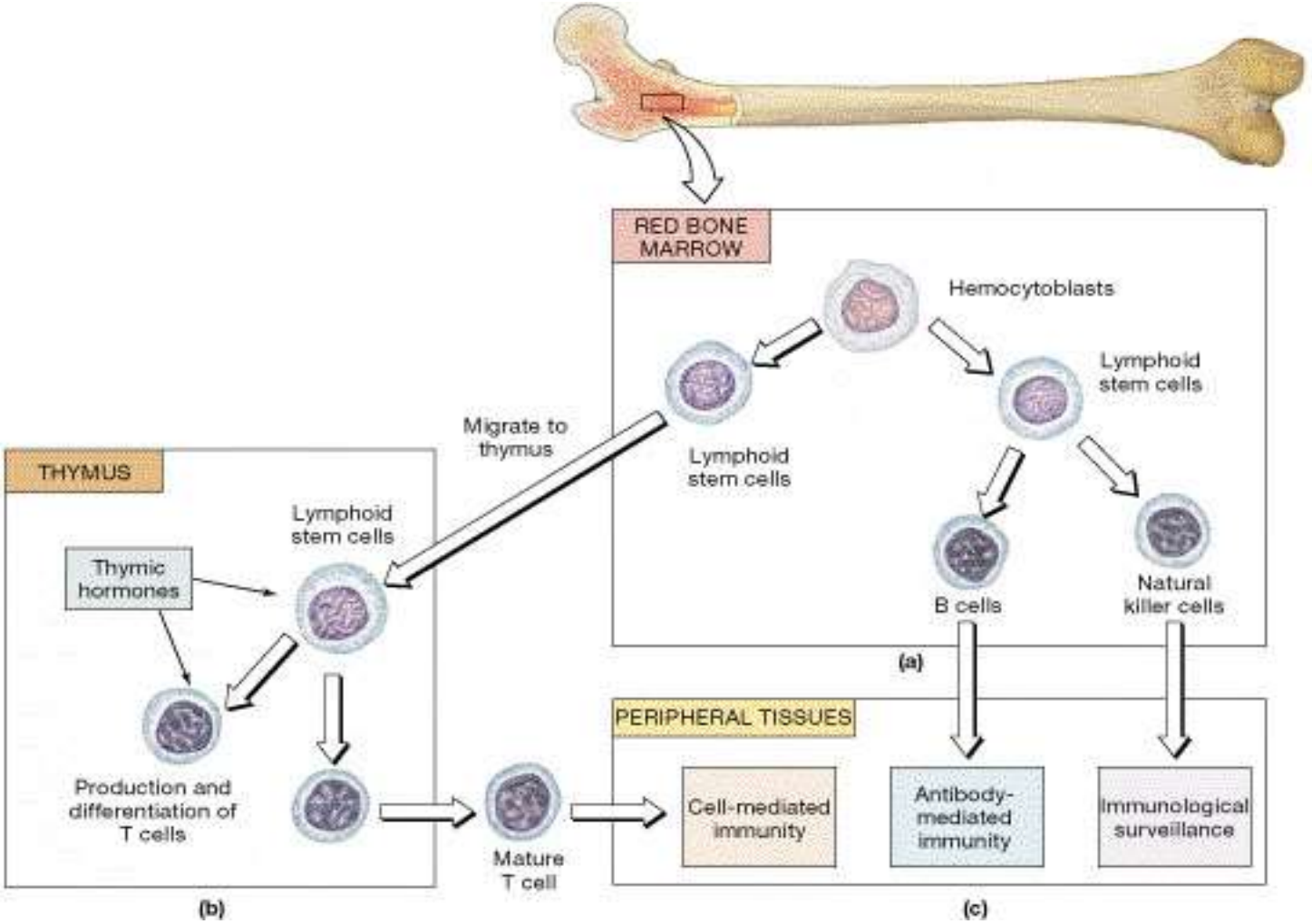
Monocytes

- Circulating precursors to macrophages
- Specialized macrophages found in specific localities
  - dendritic cells
    - epidermis, oral mucosa, esophagus, vagina, and lymphatic organs
  - microglia (CNS)
  - alveolar macrophages (lungs)
  - hepatic macrophages (liver)

Lymphocytes

- **Circulating blood contains**
  - **80% T cells**
  - **15% B cells**
  - **5% NK cells**

Derivation and Distribution of Lymphocytes



Antimicrobial Proteins

- **Interferons**
- **Complement system**

Interferons

- **Secreted by certain cells invaded by viruses**
  - **generalized protection**
  - **diffuse to neighboring cells and stimulate them to produce antiviral proteins**
  - **activate natural killer cells and macrophages**
    - **destroy infected host cells**
    - **stimulate destruction of cancer cells**

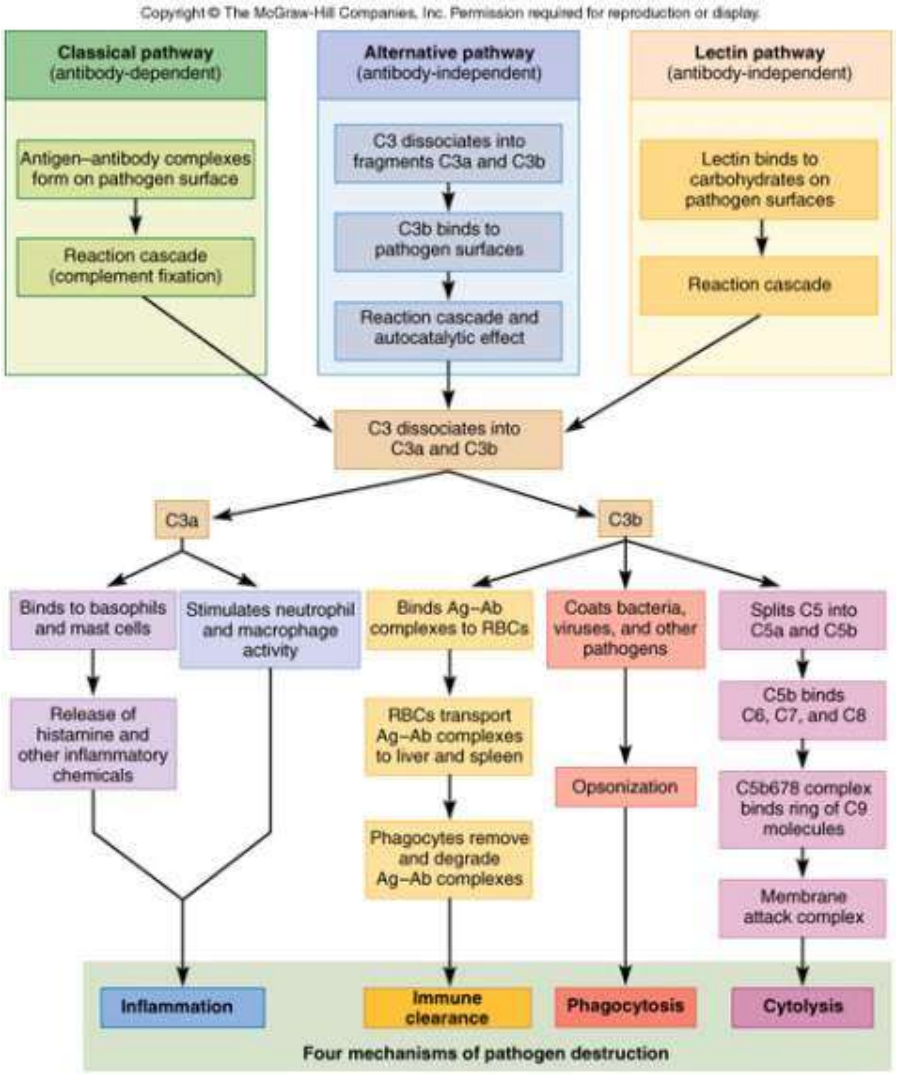
Complement System

- **Complement (C) proteins in blood that must be activated by pathogens**
- **Pathways of complement activation: C3 split into C3a and C3b**
  - **classical pathway**
    - **requires antibody; specific immunity**
  - **alternate pathway**
    - **nonspecific immunity**
  - **lectin pathway**
    - **nonspecific immunity**

Complement System

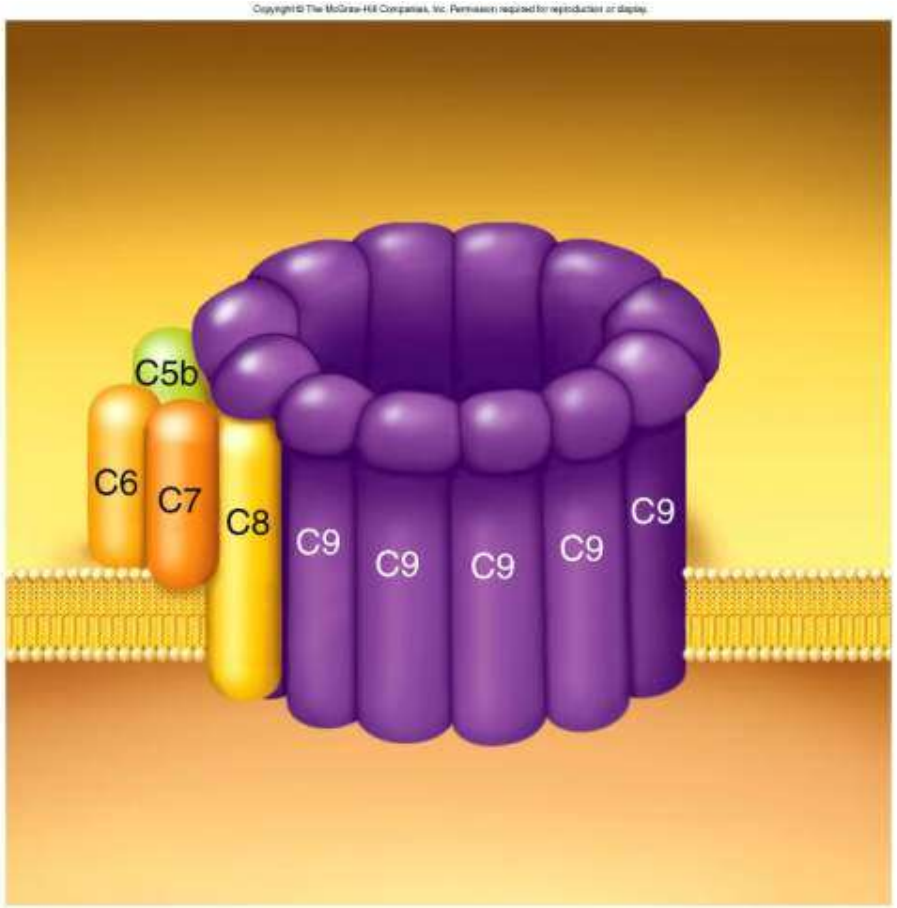
- **Mechanisms of action**
  - **enhanced inflammation**
  - **phagocytosis**
    - **promoted by opsonization**
  - **cytolysis**
    - **membrane attack complex forms on target cell**
  - **immune clearance**
    - **RBCs carry Ag-Ab complexes to macrophages in liver and spleen**

Complement Activation



Membrane Attack Complex

- **Complement proteins form ring in plasma membrane of target cell causing cytolysis**



Immune Surveillance

- **NK cells**
  - **destroy bacteria, transplanted cells, cells infected by viruses, and cancer cells**
    - **release perforins and granzymes**

Action of NK cell

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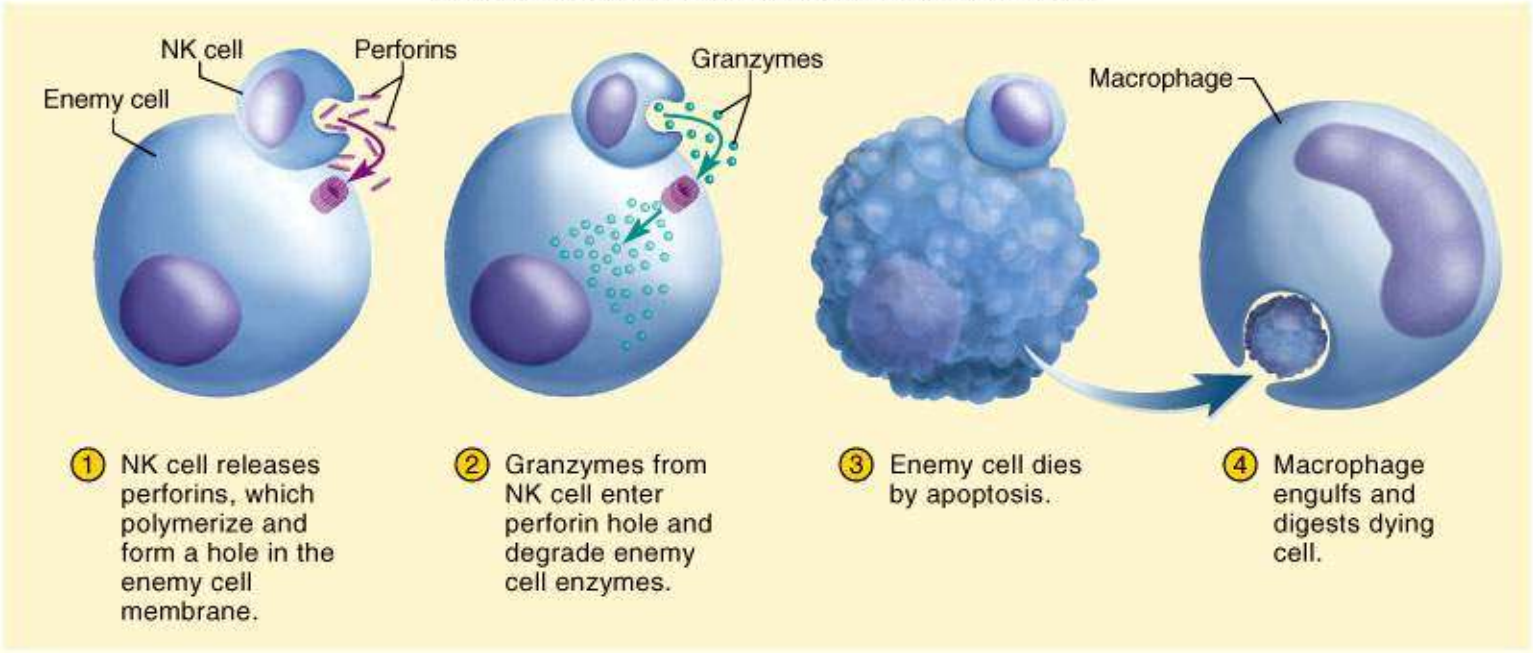

Inflammation

- **Defensive response to tissue injury**
  1. **limits spread of pathogens, then destroys them**
  2. **removes debris**
  3. **initiates tissue repair**
- **Cytokines**
  - **small proteins regulate inflammation and immunity; include**
    - **interferons, interleukins, tumor necrosis factor, and chemotactic factors**

Inflammation

- **Suffix *-itis* denotes inflammation of specific organs**
- **Cardinal signs**
  - **redness (erythema) caused by hyperemia (↑ blood flow)**
  - **swelling (edema) caused by ↑ capillary permeability and filtration**
  - **heat caused by hyperemia**
  - **pain caused by inflammatory chemicals (bradykinin, prostaglandins) secreted by damaged cells, pressure on nerves**

Inflammation

- **Three major processes**
  1. **mobilization of body defenses**
  2. **containment and destruction of pathogens**
  3. **tissue clean-up and repair**

Mobilization of Defenses

- **Kinins, histamine, and leukotrienes are secreted by damaged cells, basophils and mast cells**
  - **stimulates vasodilation that leads to hyperemia**
    - **causes redness and heat**
    - **↑ local metabolic rate, promotes cell multiplication and healing**
    - **dilutes toxins, provides O_2, nutrients, waste removal**
  - **stimulates ↑ permeability of blood capillaries**
    - **allows blood cells, plasma proteins (antibodies, complement proteins, fibrinogen) into tissue**
    - **clotting sequesters bacteria, forms scaffold for tissue repair**

Mobilization of Defenses

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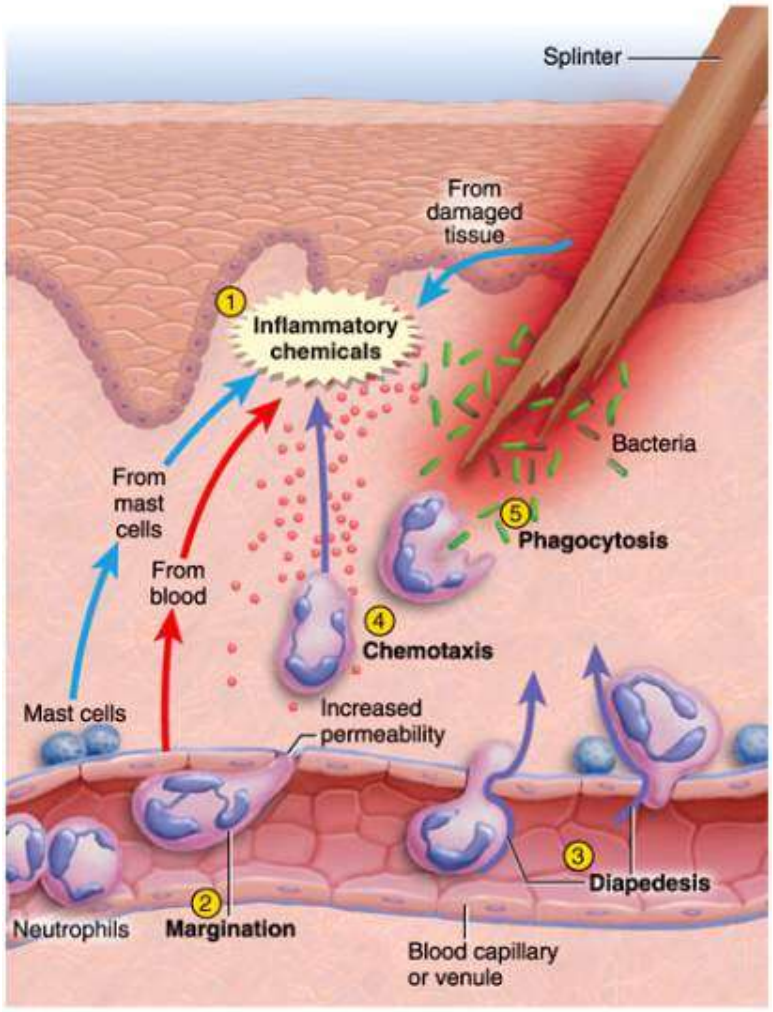


- **Leukocyte Deployment**
  - **margination**
    - **selectins cause leukocytes to adhere to blood vessel walls**
  - **diapedesis (emigration)**
    - **leukocytes squeeze between endothelial cells into tissue space**

Containment and Destruction of Pathogens

- **Fibrinogen** now in tissue clots, trapping pathogens
- **Heparin** prevents clotting at site of injury
  - pathogens are in a fluid pocket surrounded by clot
- **Chemotaxis**
  - leukocytes are attracted to chemotactic chemicals
- Neutrophils are quickest to respond
  - phagocytosis
  - respiratory burst
  - secrete cytokines for recruitment of macrophages and neutrophils
  - macrophages and T cells secrete colony-stimulating factor to stimulate leukopoiesis

Tissue Cleanup

- **Monocytes the primary agents of cleanup arrive in 8 to 12 hours, become macrophages,**
- **Edema ↓ venous flow, ↑ lymphatic flow that favors removal of bacteria and debris**
- **Formation of pus**
  - **mixture of tissue fluid, cellular debris, dying neutrophils and microbes**

Tissue Repair

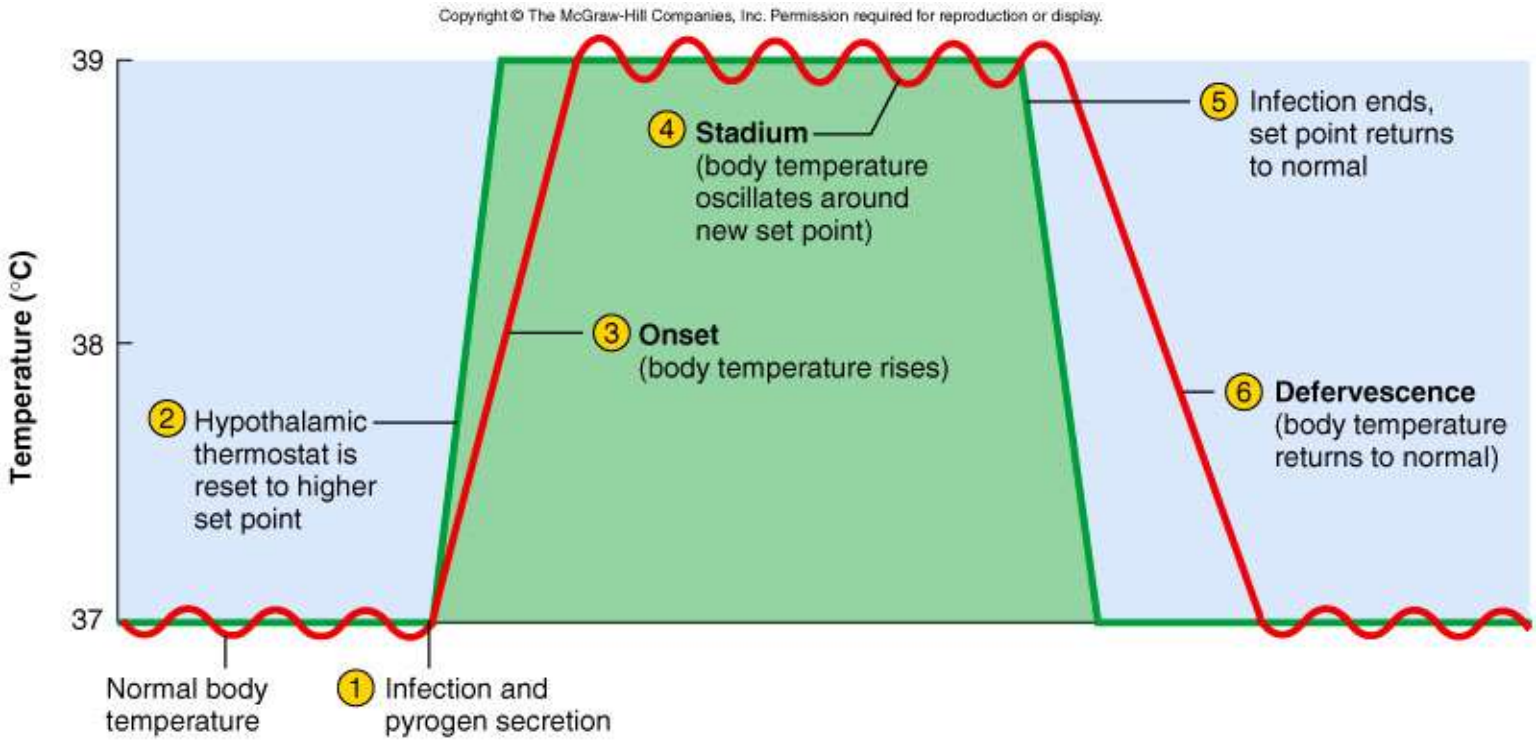
- **Blood platelets and endothelial cells in injured area secrete a cytokine, PDGF, that stimulates fibroblasts to multiply and synthesize collagen**
- **Facilitated by hyperemia that provides materials needed and heat that increases metabolism**
- **Fibrin clot may provide a scaffold for repair**
- **Pain limits use of body part allowing for repair**

Fever

- **Defense mechanism: does more good than harm**
  - **promotes interferon activity**
  - **accelerating metabolic rate and tissue repair**
  - **inhibiting pathogen reproduction**
- **A cytokine, interleukin 1, called a pyrogen**
  - **secreted by macrophages, stimulates anterior hypothalamus to secrete PGE which resets body thermostat higher**

  > 105°F may cause delirium, 111°F- 115°F, coma-death
- **Stages of fever**
  - **onset, stadium, defervescence**

Course of a Fever



Specific Immunity

- **Specificity and memory**
- **Cellular immunity: cell-mediated (T cells)**
- **Humoral immunity: antibody mediated (B cells)**

Passive and Active Immunity

- **Natural active immunity (produces memory cells)**
  - **production of one's own antibodies or T cells as a result of infection or natural exposure to antigen**
- **Artificial active immunity (produces memory cells)**
  - **production of one's own antibodies or T cells as a result of vaccination**
- **Natural passive immunity (through placenta, milk)**
  - **temporary, fetus acquires antibodies from mother**
- **Artificial passive immunity (snakebite, rabies, tetanus)**
  - **temporary, injection of immune serum (antibodies)**

Antigens

- **Trigger an immune response**
- **Complex molecules**
  - **> 10,000 amu, unique structures**
  - **proteins, polysaccharides, glycoproteins, glycolipids**
- **Epitopes (antigenic determinants)**
  - **stimulate immune responses**
- **Haptens**
  - **too small, host macromolecule must bind to them to stimulate initial immune response**

Lymphocytes

- **Specific immunity depends on lymphocytes**

Life Cycle of T cells

- Stem cells in red bone marrow
- Mature in thymus
  - thymosins stimulate maturing T cells to produce antigen receptors
  - immunocompetent T cell has antigen receptors in place
- Deployment
  - naïve T cells colonize lymphatic tissue and organs

Negative Selection of T cells

- Immunocompetent T cells must be able to
  1. bind to RE cell
  2. not react to self antigens
- Failure results in negative selection via
  - clonal deletion: destruction of offending T cells
  - anergy: inactive state, alive but unresponsive
- Leaves body in a state of self-tolerance
- Only 2% of T cells succeed

Positive Selection of T cells

- **Immunocompetent T cells that are able to**
  1. **bind to MHC on RE cell**
  2. **not react to self antigens**

  divide rapidly and form clones of T cells with identical receptors for a specific antigen
  - **these cells have not encountered target antigens, constitute naïve lymphocyte pool**
- **Deployment - cells ready to leave thymus**

B Lymphocytes (B cells)

- **Sites of development**
  - **other fetal stem cells remain in bone marrow**
- **B cell selection**
  - **B cells should not react to self antigens**
    - **or suffer clonal deletion or anergy**
- **Self-tolerant B cells form B cell clones**
  - **synthesize antigen receptors, divide rapidly, produce immunocompetent clones**

Antigen-Presenting Cells (APCs)

- **Function depends on major histocompatability complex (MHC) proteins**
  - **act as cell ID tag**
- **B cells and macrophages, display antigens to T cells**

Antigen Processing

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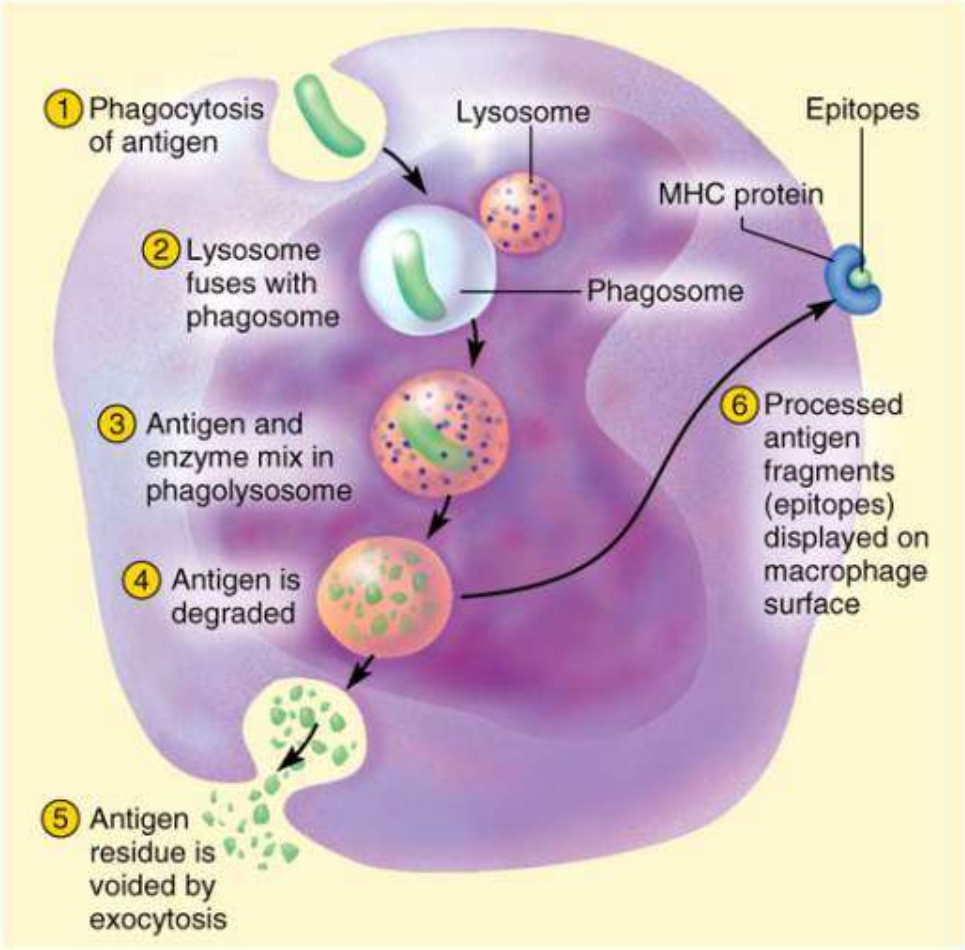

(a)

Interleukins

- **Chemical messengers between leukocytes**
- **Used by lymphocytes and APCs to communicate**

Cellular Immunity

- T cells attack foreign cells and diseased host cells; memory of Ag
- Three classes of T cells

1. Cytotoxic T cells (T_c cells) carry out attack
2. Helper T cells: help promote T_c cell and B cell action and nonspecific defense mechanisms
3. Memory T cells: provide immunity from future exposure to antigen

T_C cell Recognition

- Antigen presentation
  - MHC-I proteins
    - found on nearly all nucleated body cells
    - display peptides produced by host cells
- T_C cell activation
  1. binding of cytotoxic T cells (CD8 cells) to abnormal peptides on MHC-I and
  2. costimulation via a cytokine
  - triggers clonal selection: clone of identical T cells against cells with same epitope

T_H cell Recognition

- **Antigen presentation**
  - **role of MHC-II proteins**
    - **found only on antigen presenting cells**
    - **display only foreign antigens**
    - **stimulate helper T cells (CD4 cells)**

T_H cell Activation

1. binding of helper T cells (CD4 cells) to epitope displayed on MHC-II of APC
2. costimulation via a cytokine
3. triggers clonal selection

T cell Activation

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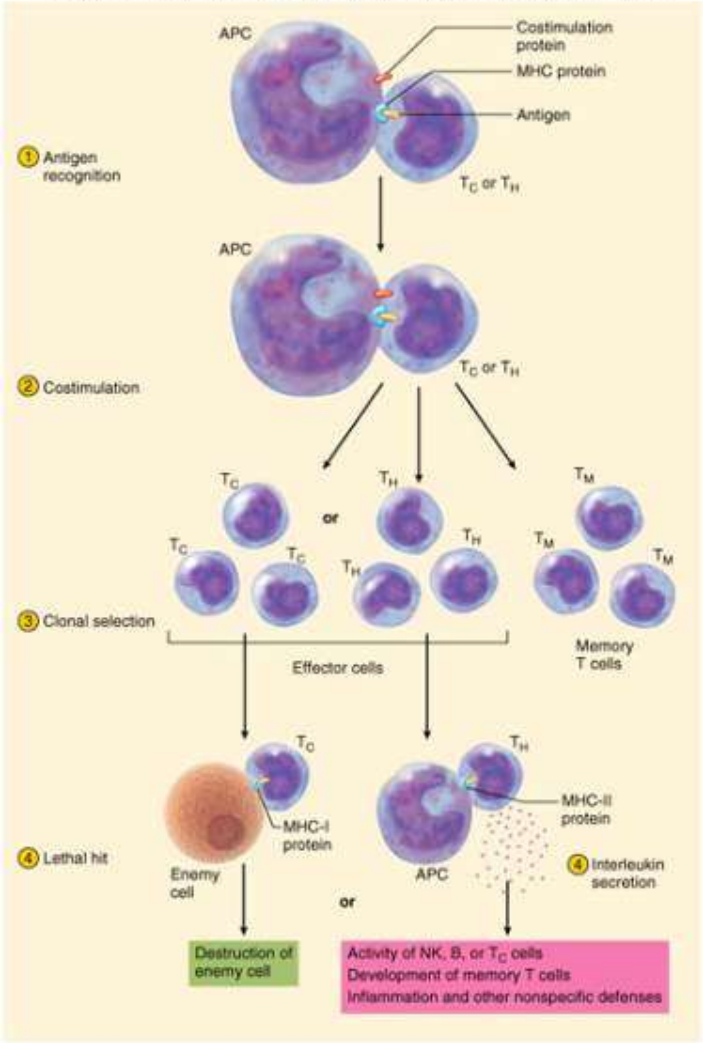
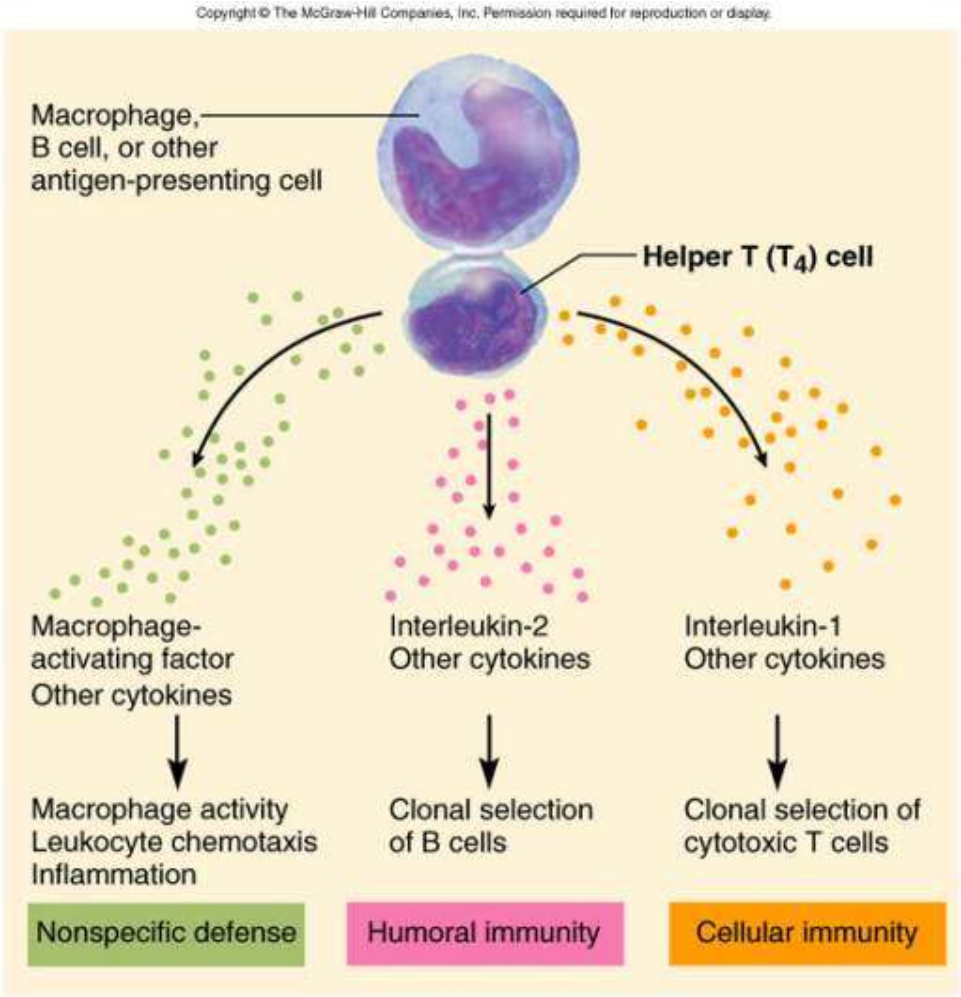


Attack Phase: Role of Helper T Cells



- **Secretes interleukins**
  - **attract neutrophils, NK cells, macrophages**
  - **stimulate phagocytosis**
  - **stimulate T and B cell mitosis and maturation**
- **Coordinate humoral and cellular immunity**

Attack Phase: Cytotoxic T Cells

- **Only T cells directly attack enemy cells**
- **Lethal hit mechanism**
  - **docks on cell with antigen-MHC-I protein complex**
  1. **releases perforin, granzymes - kills target cell**
  2. **interferons - decrease viral replication and activates macrophages**
  3. **tumor necrosis factor: kills cancer cells**

Cytotoxic T Cell Function

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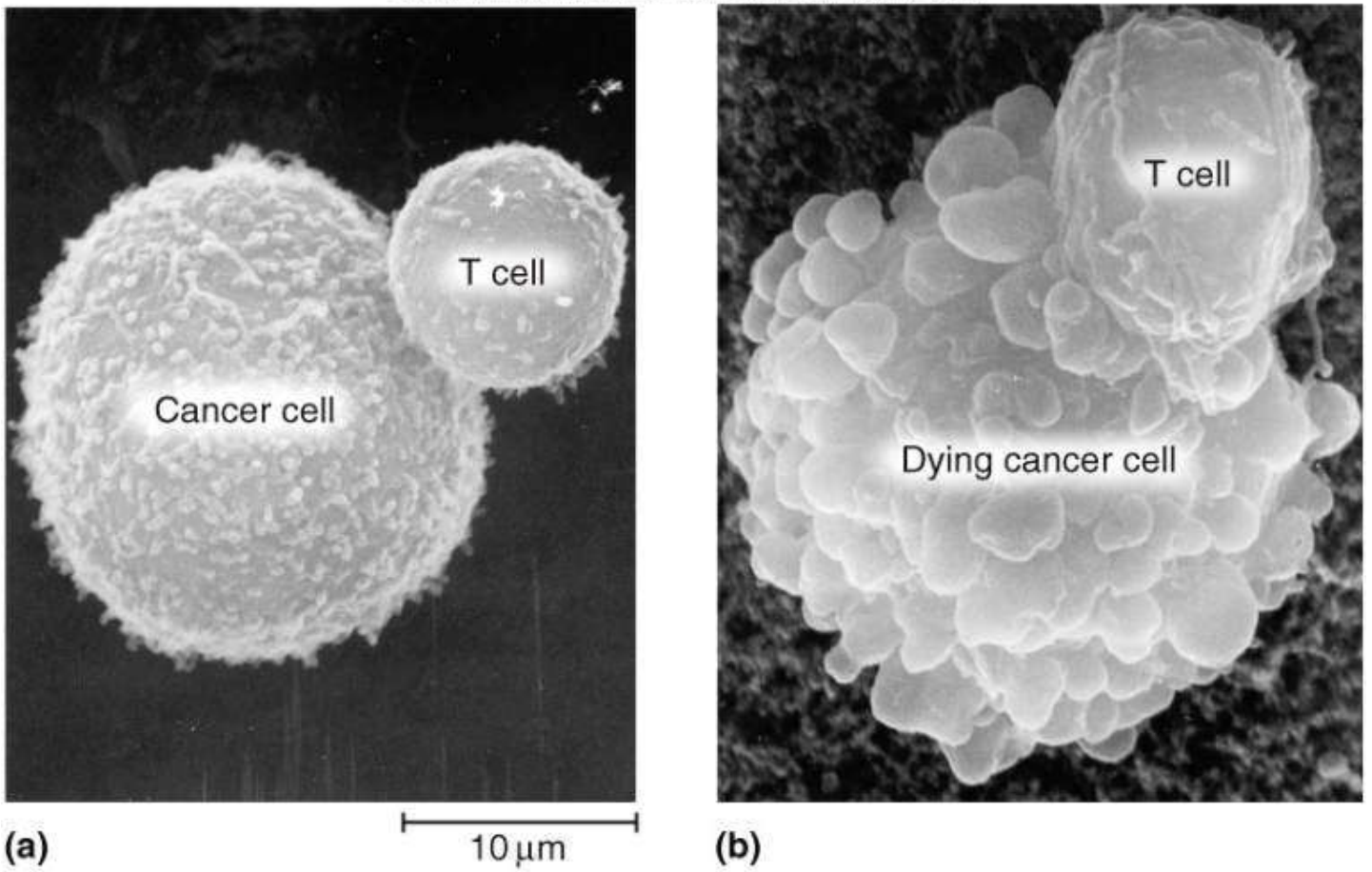

- **Cytotoxic T cell binding to cancer cell**

Destruction of Cancer Cell

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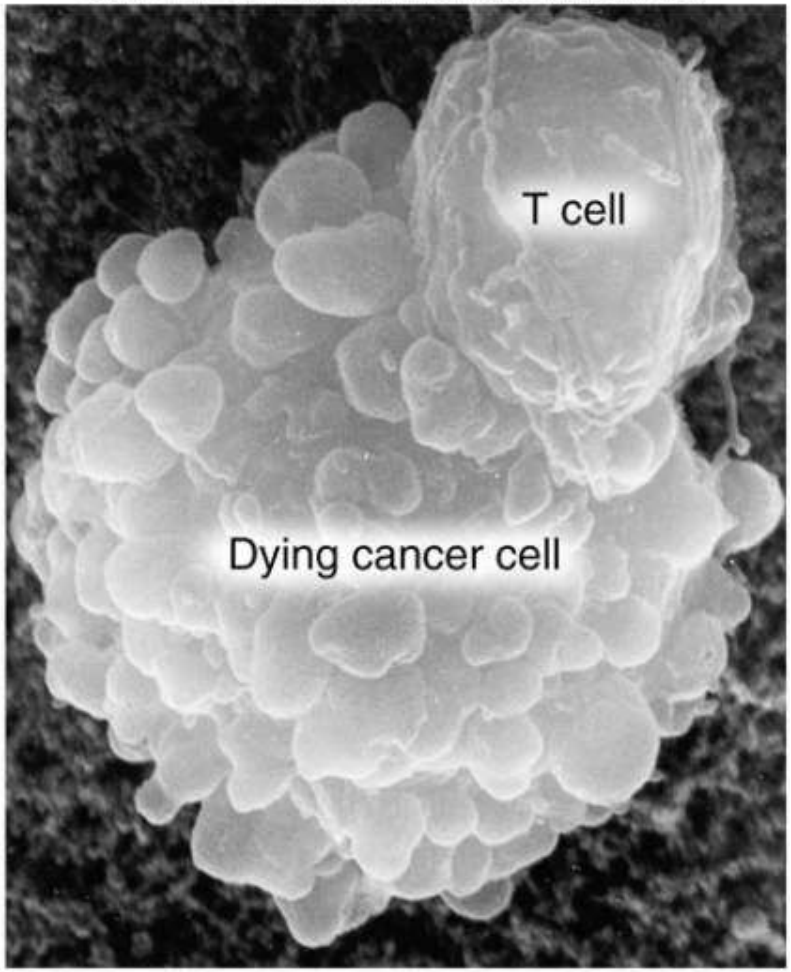

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Memory

- **Memory T cells**
  - **following clonal selection some T cells become memory cells**
  - **long-lived; in higher numbers than naïve cells**
- **T cell recall response**
  - **upon reexposure to same pathogen, memory cells launch a quick attack**

Humoral Immunity

- **Recognition**
  - **B cell receptors bind antigen, take in and digest antigen then display epitopes on its MHC-II protein**
  - **After costimulation by T_H cell, divide repeatedly, differentiate into plasma cells, produce antibodies specific to that antigen**
- **Attack**
  - **antibodies bind to antigen, render it harmless, 'tag it' for destruction**
- **Memory**
  - **some B cells differentiate into memory cells**

Humoral Immunity - Recognition

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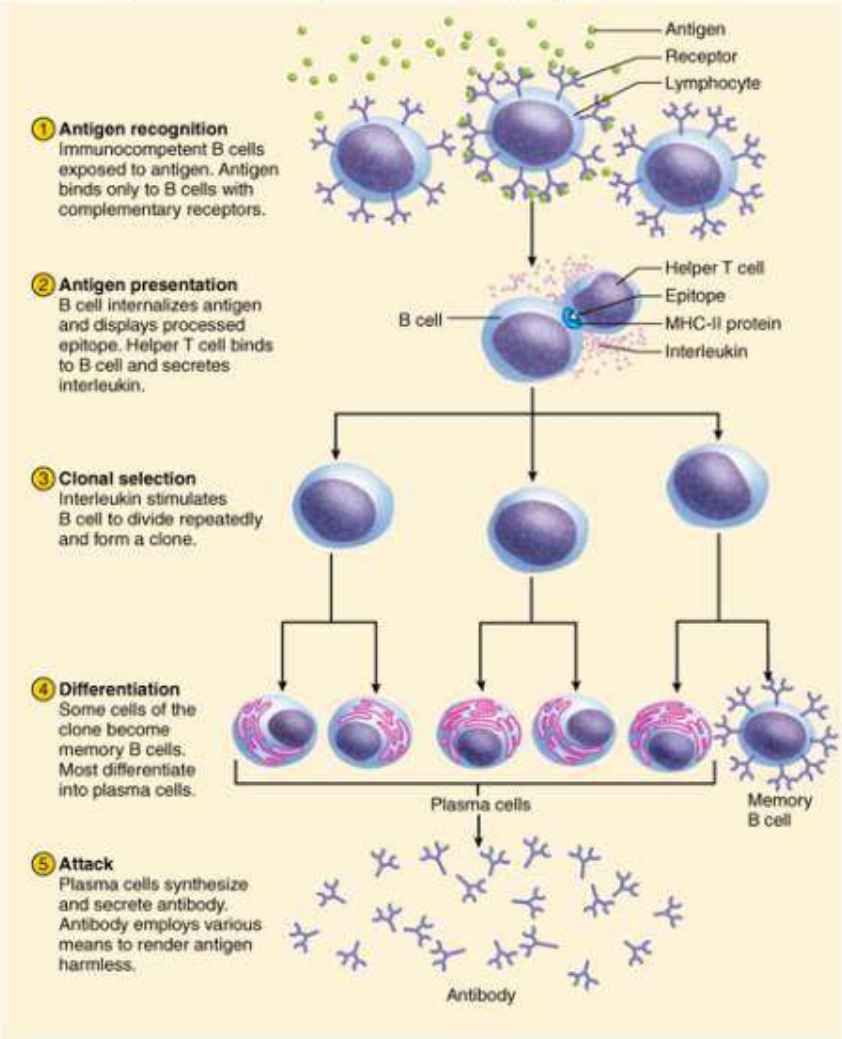

B cells and Plasma cells

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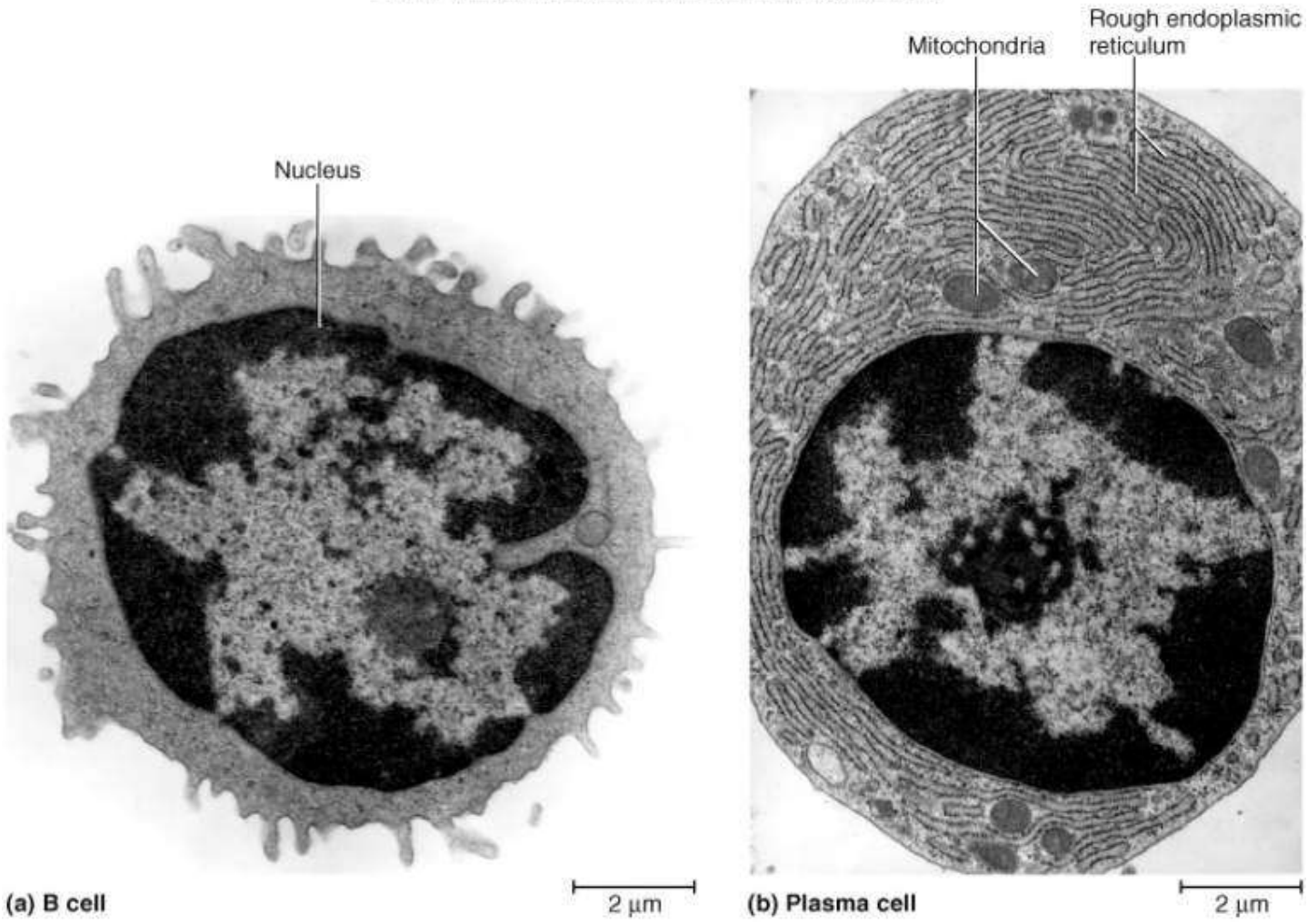

Antibody Structure

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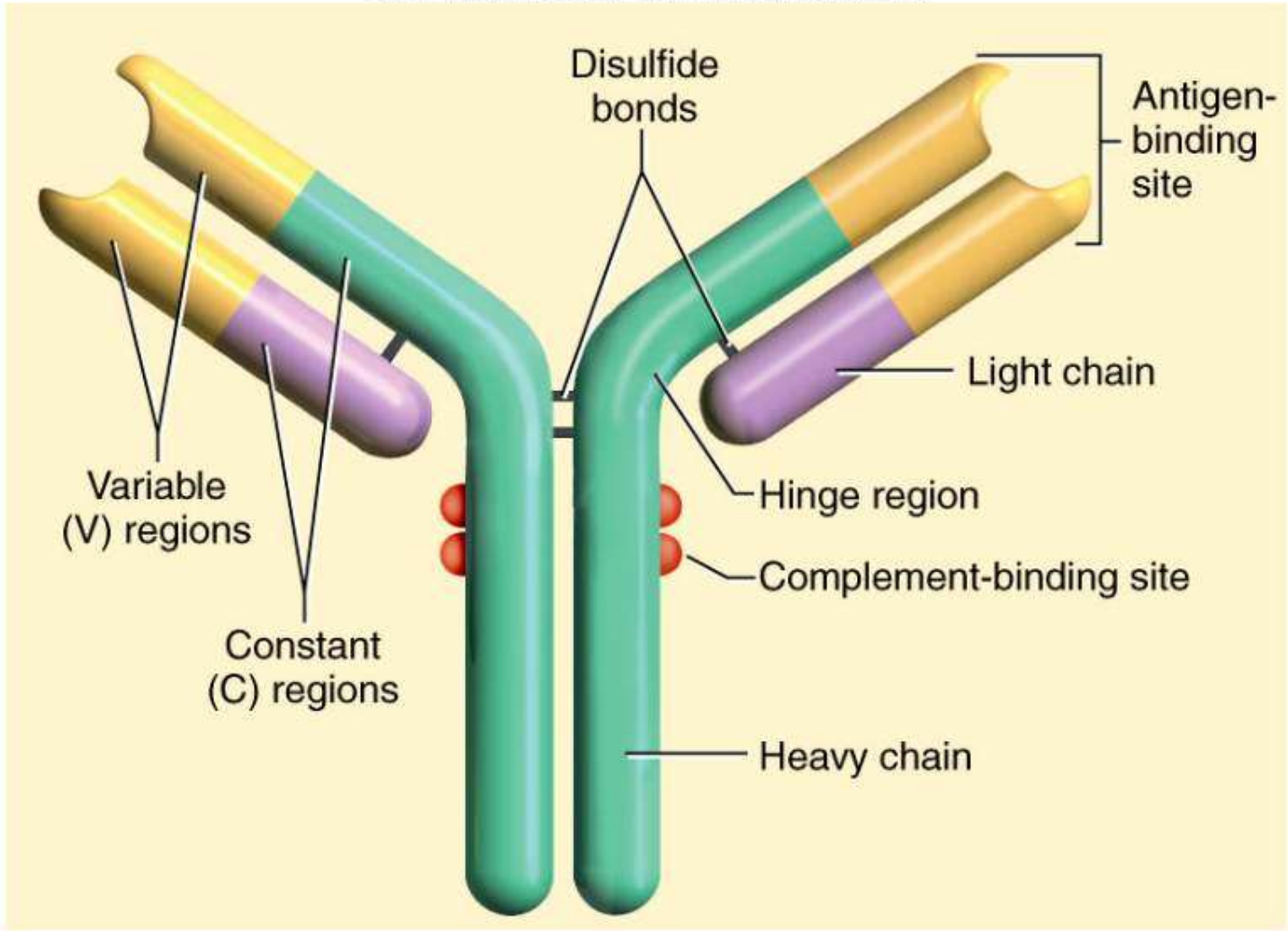

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Antibody Classes

- **By amino acid sequences of C region of antibody**
- **IgA: monomer in plasma; dimer in mucus, saliva, tears, milk, intestinal secretions, prevents adherence to epithelia**
- **IgD: monomer; B cell membrane antigen receptor**
- **IgE: monomer; on mast cells; stimulates release of histamines, attracts eosinophils; immediate hypersensitivity reactions**
- **IgG: monomer; 80% circulating, crosses placenta to fetus, 2° immune response, complement fixation**
- **IgM: pentamer, 10% in plasma, 1° immune response, agglutination, complement fixation**

Antibody Diversity

- **Immune system capable of as many as 1 trillion different antibodies**
- **Somatic recombination**
  - **DNA segments shuffled and form new combinations of base sequences to produce antibody genes**
- **Somatic hypermutation**
  - **B cells in lymph nodules rapidly mutate creating new sequences**

Humoral Immunity - Attack

- **Neutralization**
  - **antibodies mask pathogenic region of antigen**
- **Complement fixation**
  - **antigen binds to IgM or IgG, antibody changes shape, initiates complement binding; primary defense against foreign cells, bacteria**
- **Agglutination**
  - **antibody has 2-10 binding sites; binds to multiple enemy cells immobilizing them**
- **Precipitation**
  - **antibody binds antigen molecules (not cells); creates antigen-antibody complex that precipitates, phagocytized by eosinophil**

Agglutination and Precipitation

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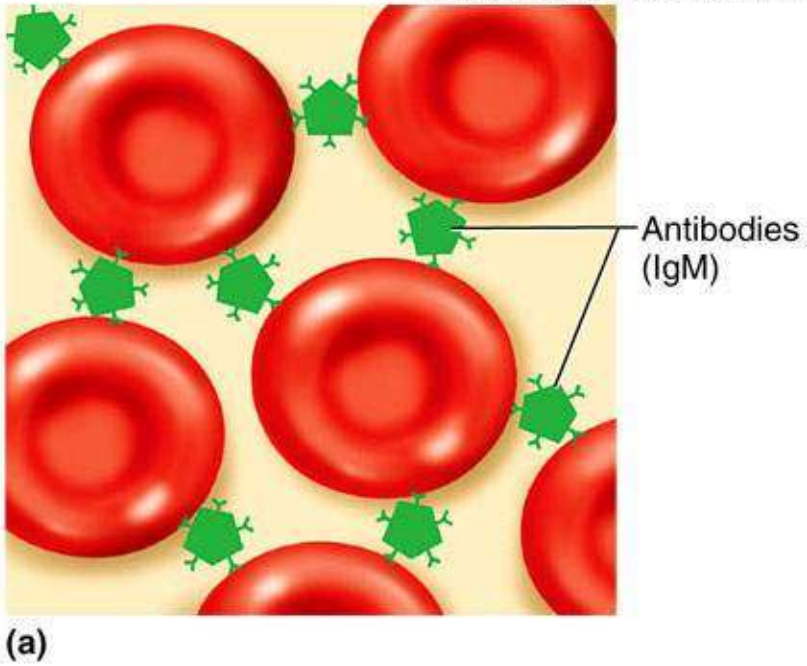

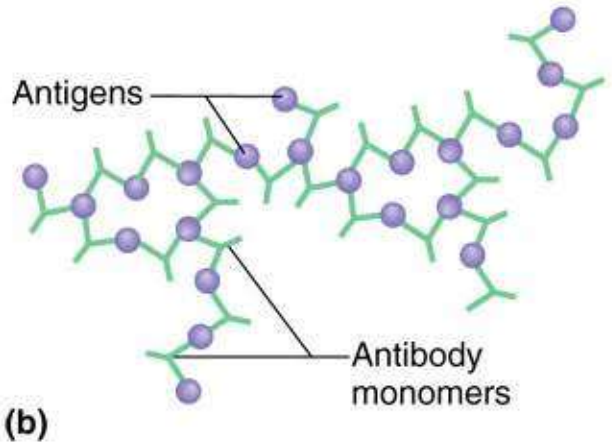

Humoral Immunity Responses

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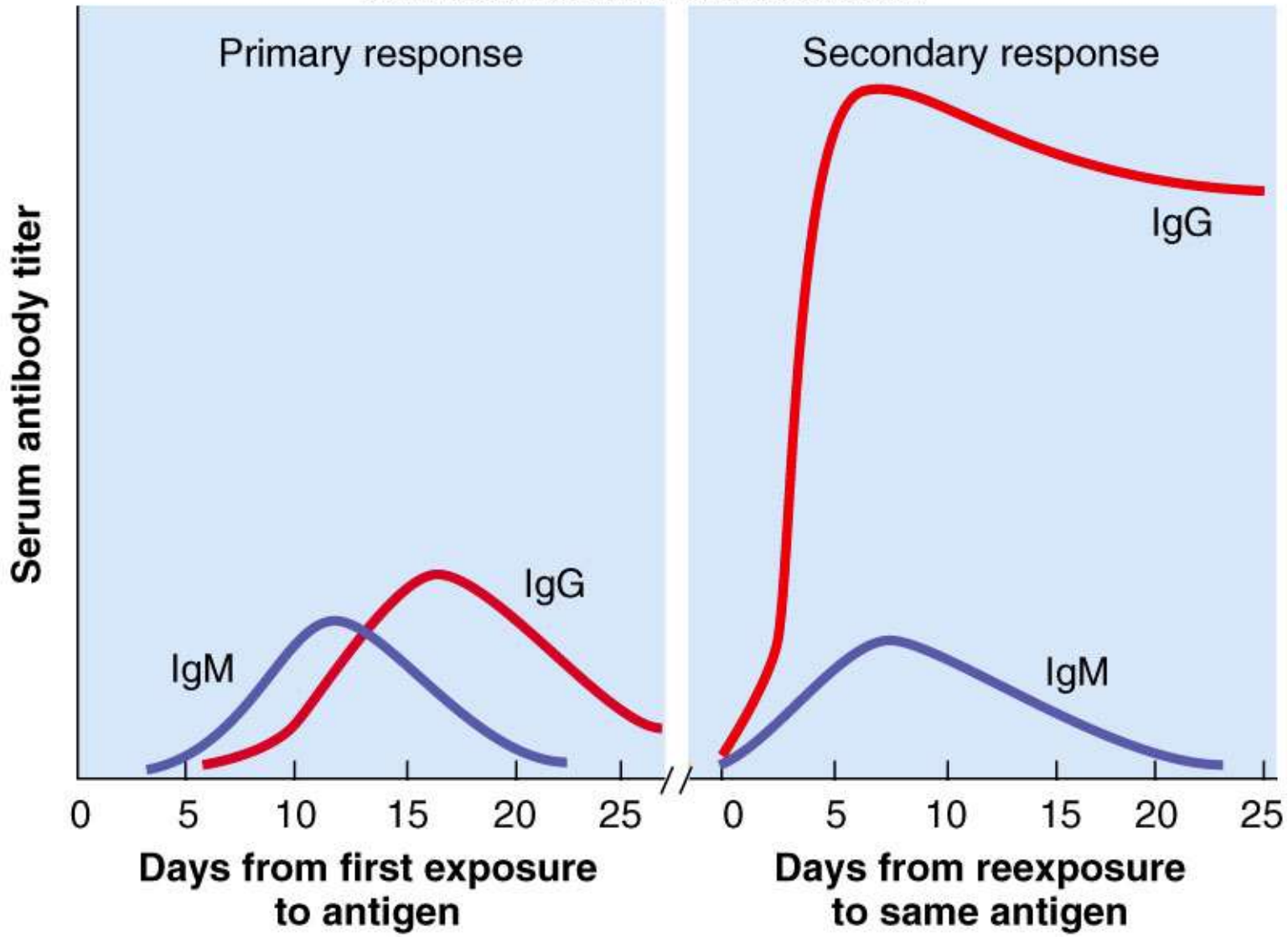

Hypersensitivity (Allergy)

- **Excessive immune reaction against antigens that most people tolerate - allergens**
- **Type I Antibody mediated (IgE), acute reaction**
- **Type II Antibody mediated (IgG, IgM), subacute**
- **Type III Antibody mediated (IgG, IgM), subacute**
- **Type IV Cell mediated, delayed**

Type I (acute) Hypersensitivity

- **Anaphylaxis**
  - **occurs in sensitized people**
  - **allergen caps IgE on mast cells, basophils**
  - **release inflammatory chemicals**
- **Asthma**
  - **most common chronic illness in children**
  - **inhaled allergens, histamines, bronchiole constriction**
- **Anaphylactic shock**
  - **bronchiole constriction, dyspnea, vasodilation, shock, death; treatment- epinephrine**

Type II Hypersensitivity (Antibody-Dependent Cytotoxic)

- **IgG or IgM**
  - **binds to antigens on cells; complement activation and lyses or opsonization**
  - **may bind to cell surface receptors and either interferes with function or over-stimulate cell**

Type III Hypersensitivity (Immune Complex)

- IgG or IgM form widespread antigen-antibody complexes
- Complexes precipitate and trigger intense inflammation
  - involved in acute glomerulonephritis and in systemic lupus erythematosus

Type IV Hypersensitivity (Delayed)

- 12 to 72 hour delay
- APC's in lymph nodes display antigens to helper T cells, which secrete interferon and cytokines that activate cytotoxic T cells and macrophages
- Cosmetic and poison ivy allergies - haptens
- TB skin test

Autoimmune Diseases

- **Failure of self tolerance**
  - **cross-reactivity**
  - **abnormal exposure of self-antigens**
  - **changes in structure of self-antigens**
- **Production of autoantibodies**

Immunodeficiency Diseases

- **Severe Combined Immunodeficiency Disease**
  - **hereditary lack of T and B cells**
  - **vulnerability to opportunistic infection**

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Immunodeficiency Diseases

- **AIDS**
  - **HIV structure *(next slide)***
  - **invades helper T cells, macrophages and dendritic cells by "tricking" them to internalize viruses by receptor mediated endocytosis**
  - ***re*verse *tra*nscriptase (*retro*virus), uses viral RNA as template to synthesize DNA, new DNA inserted into host cell DNA, may be dormant for months to years**

HIV Structure

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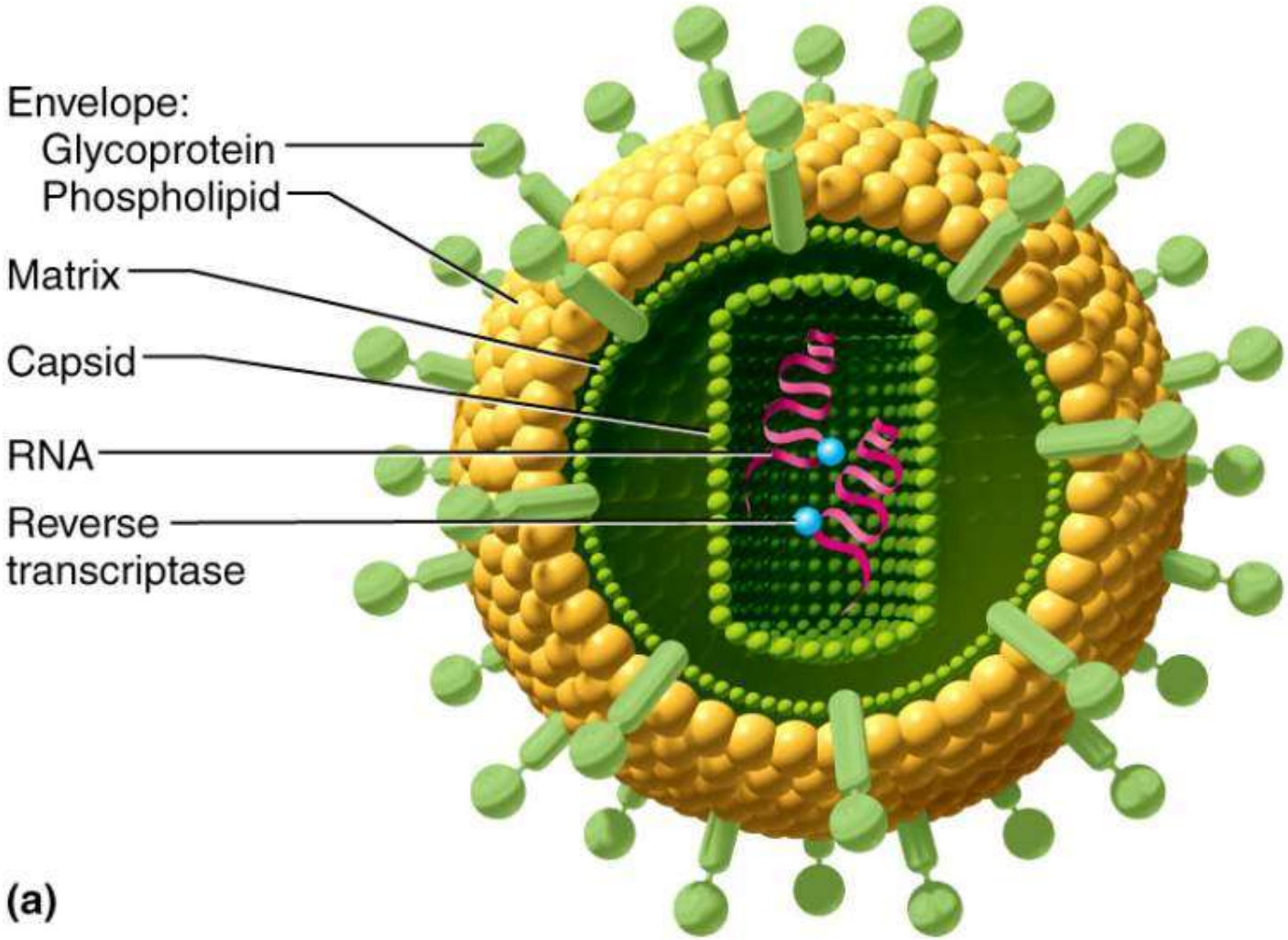

AIDS

- **Signs and symptoms**
  - **early symptoms: flulike chills and fever**
  - **progresses to night sweats, fatigue, headache, extreme weight loss, lymphadenitis**
  - **normal T_H count is 600 to 1,200 cells/μL of blood but in AIDS it is < 200 cells/μL**
    - **person susceptible to opportunistic infections (*Toxoplasma*, *Pneumocystitis*, herpes simplex virus, CMV or TB)**
  - **thrush: white patches on mucous membranes**
  - **Kaposi sarcoma: cancer originates in endothelial cells of blood vessels causes purple lesions in skin**

Kaposi Sarcoma

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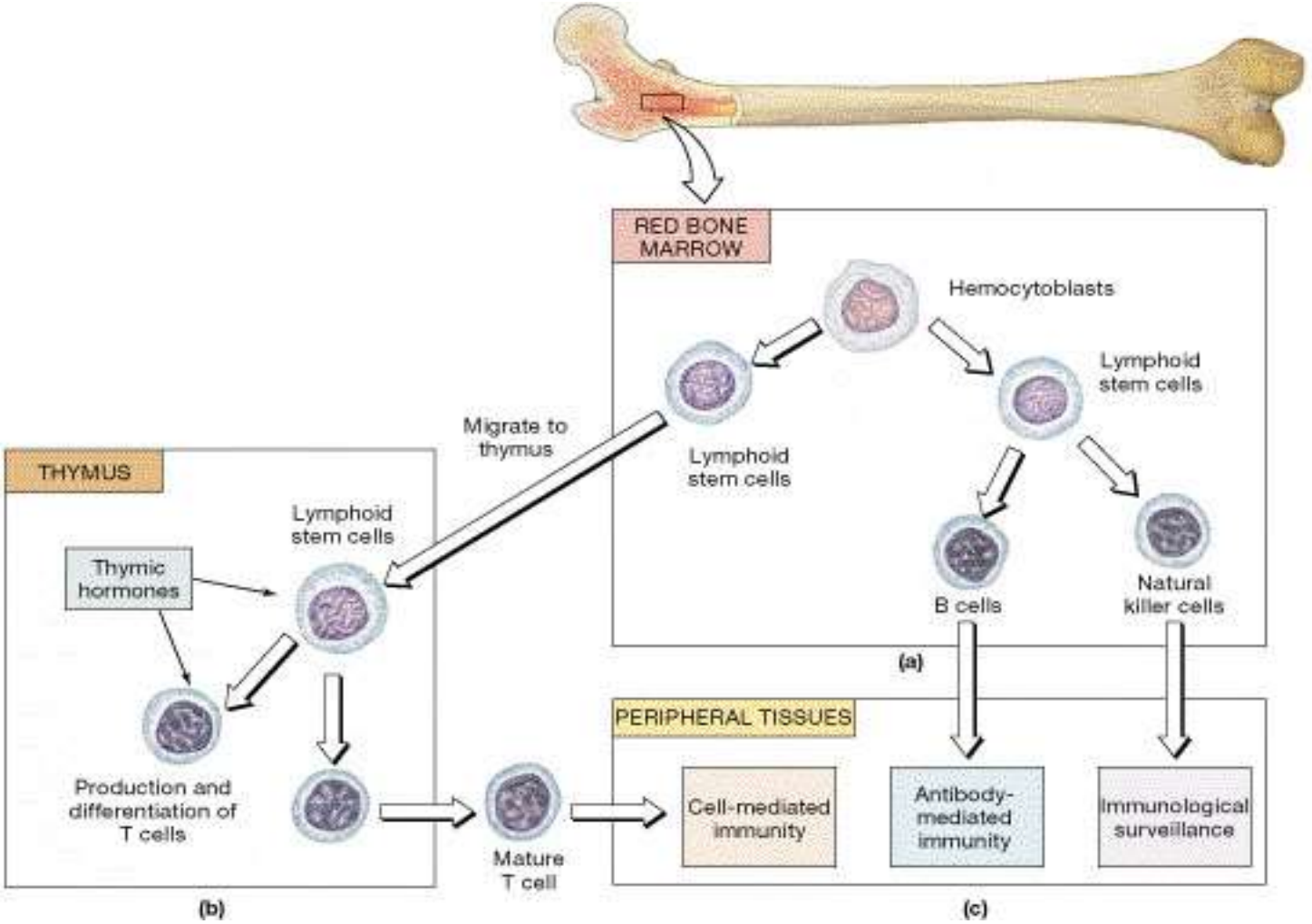
Derivation and Distribution of Lymphocytes



LYMPHEDEMA

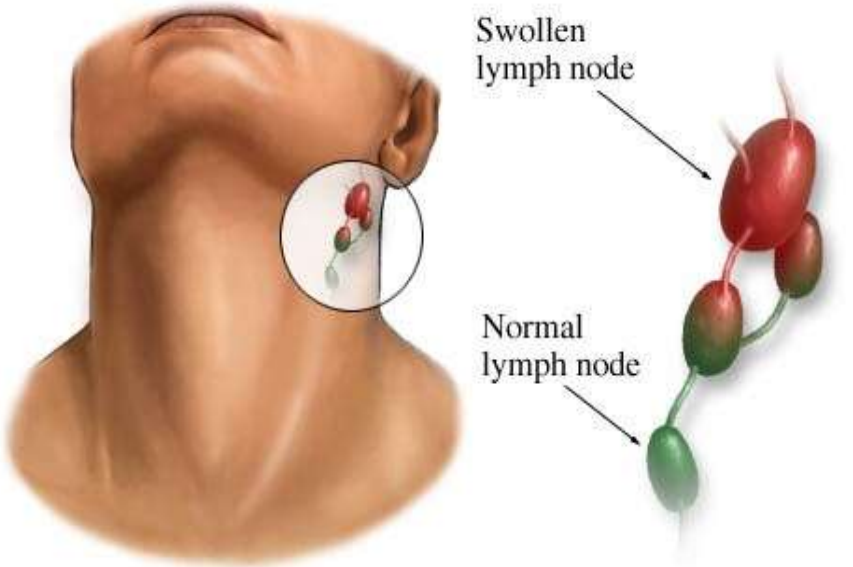
- **Occurs due to accumulation of lymphatic fluid in the interstitial tissue**

- **Sometimes can be appreciated after wearing tight clothing or jewellary on affected limb**

LYMPHADENOPATHY

- **Means a disease of the lymph nodes**

- **Lymph nodes become swollen/ enlarged and may be painful to touch**



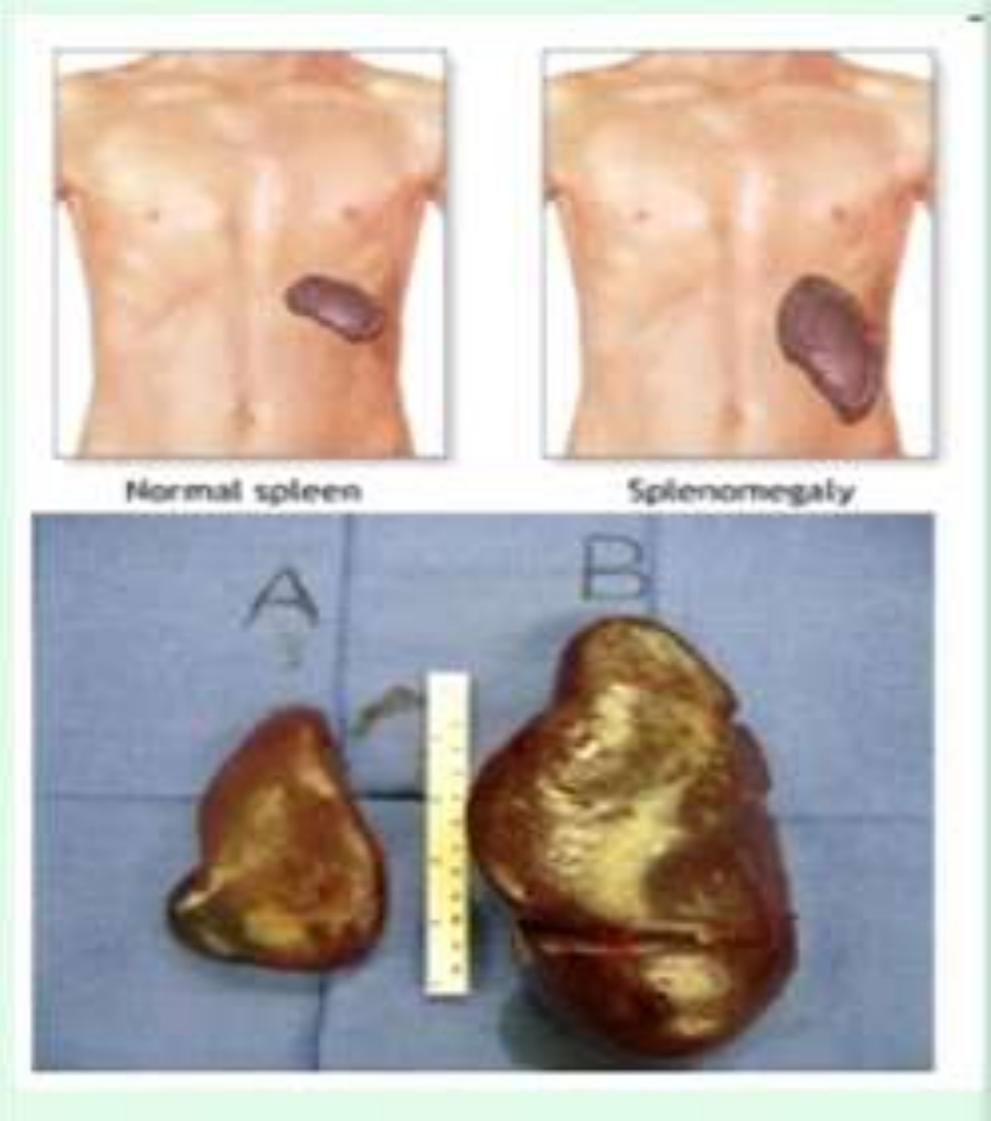
LYMPHOMAS

- **Cancers originating either from the lymphocytes in the lymph nodes or the lymphatic tissue in organs**

- **Risk factors -- HIV, HEPATITIS, EBV infections**

SPLENOMEGALY

- **Enlarged Spleen**
- **Various causes**



HIV Transmission

- Through blood, semen, vaginal secretions, breast milk, or across the placenta
- Most common means of transmission
  - sexual intercourse (vaginal, anal, oral)
  - contaminated blood products
  - contaminated needles
- Not transmitted by casual contact
- Undamaged latex condom is an effective barrier to HIV, especially with spermicide nonoxynol-9

Treatment Strategies

- Prevent binding to CD4 proteins of T_H cells
- Disrupt reverse transcriptase, inhibit assembly of new viruses or their release from host cells
- Medications
  - none can eliminate HIV, all have serious side-effects
  - HIV develops resistance, meds used in combination
  - AZT azidothymidine
    - first anti-HIV drug, inhibits reverse transcriptase
  - Protease inhibitors
    - inhibit enzymes HIV needs to replicate
  - now more than 16 anti-HIV drugs

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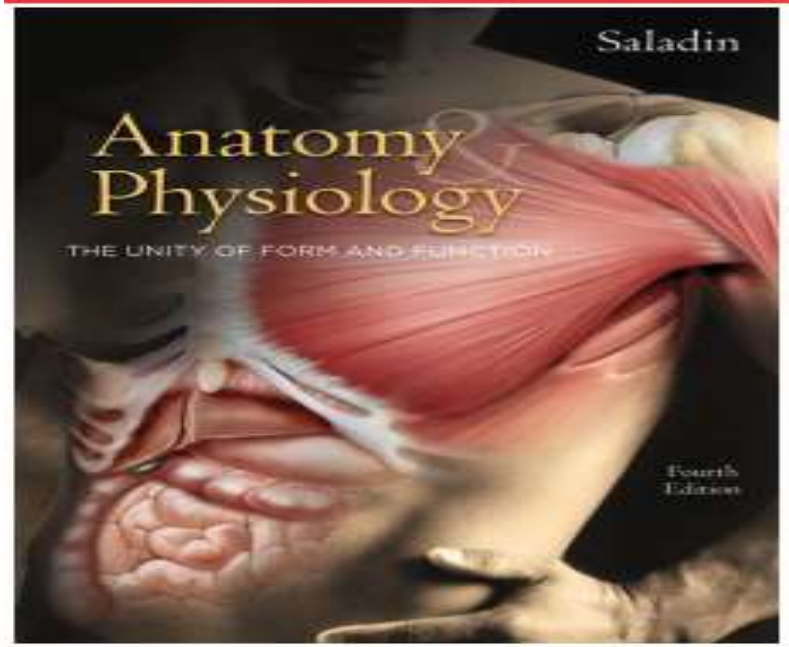

Chapter 21 Lecture Outline

See PowerPoint Image Slides for all figures and tables pre-inserted into PowerPoint without notes.

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