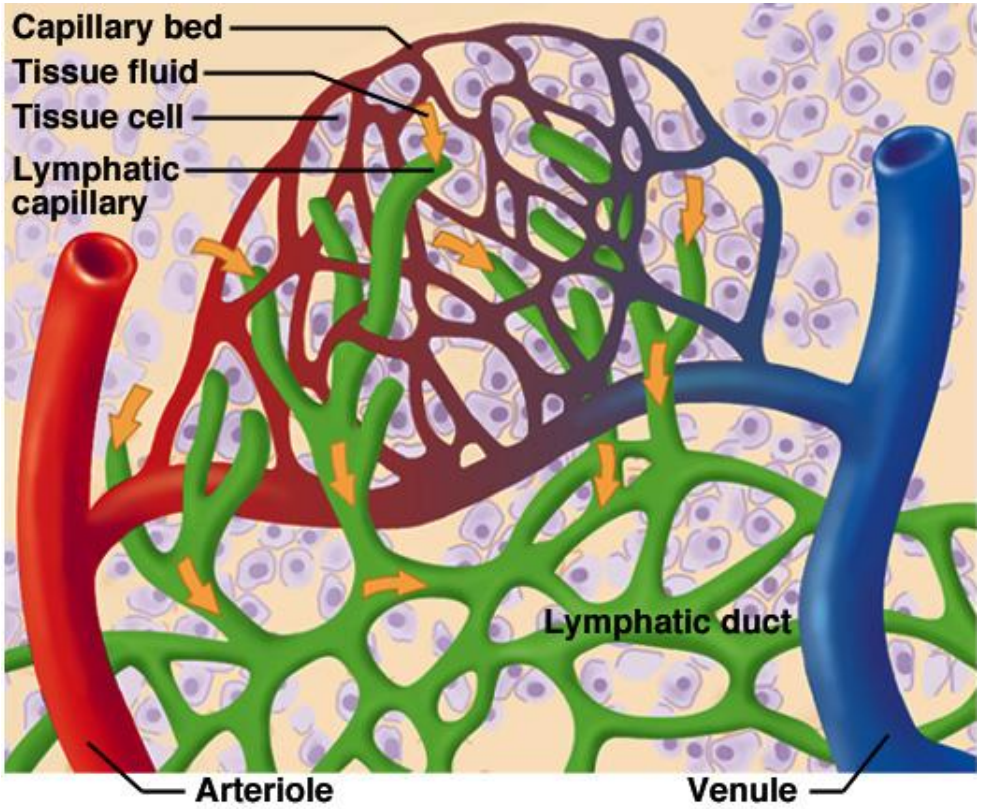
Chapter 21
Lymphatic and Immune Systems



- Maintain fluid balance
- Protect body from infection and disease

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

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, left arm, left side of head, neck and thorax; empties into L subclavian vein

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 bloodstream in subclavian veins, draws lymph into it
- Exercise significantly increases lymphatic return

Lymphatic Cells

- 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)

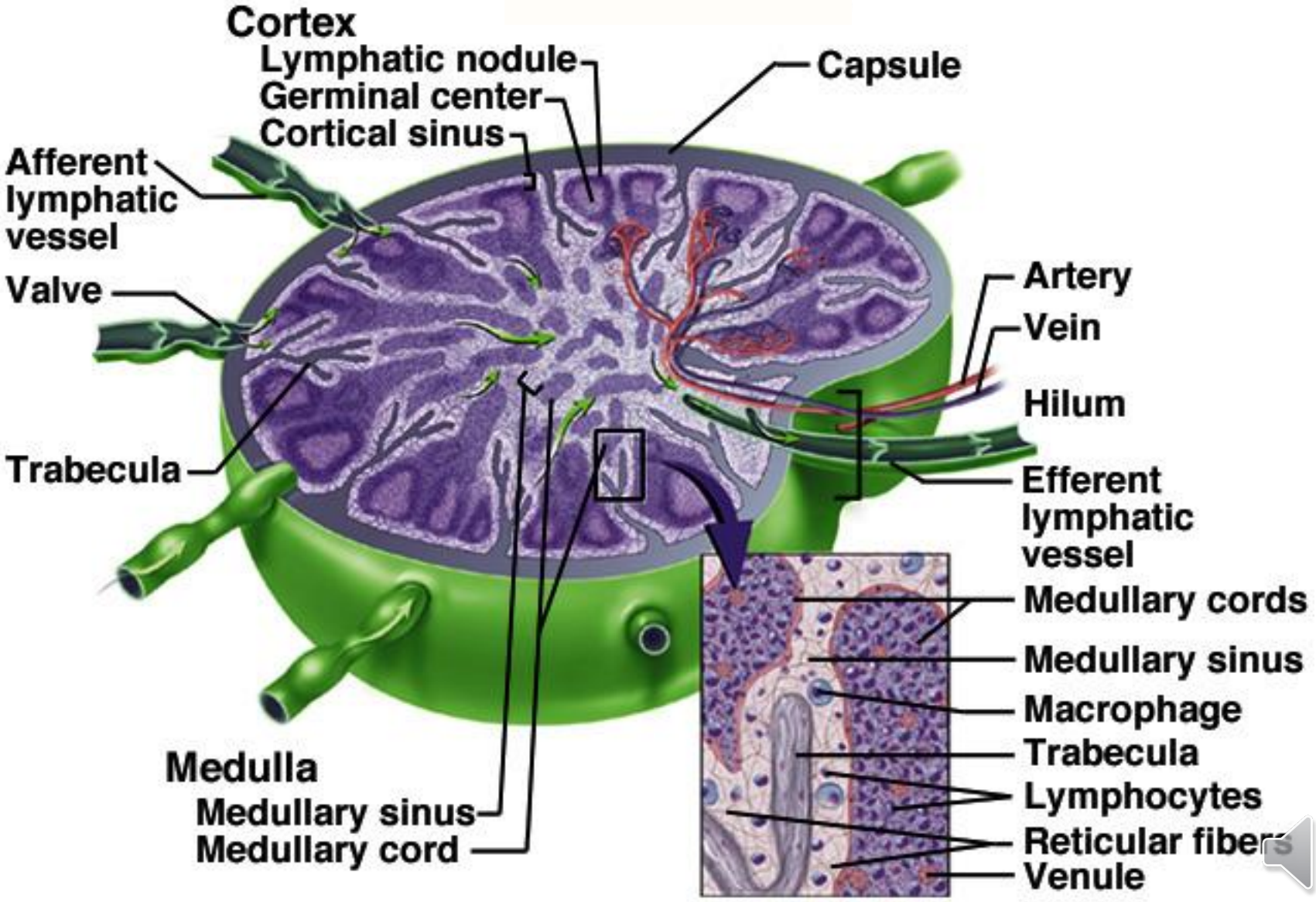
Lymphatic Tissue

- Diffuse lymphatic tissue: lymphocytes in mucous membranes and CT of many organs
  - Mucosa-Associated Lymphatic Tissue: particularly prevalent in passages open to the 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 anatomical sites, have CT capsules
- Lymph nodes
  - cervical, axillary and inguinal regions close to surface
  - thoracic, abdominal and pelvic groups deep in cavities
- Tonsils
  - guard entrance to pharynx
- Thymus
  - between sternum and aortic arch
- Spleen
  - inferior to diaphragm, dorsolateral to stomach

Lymph Node

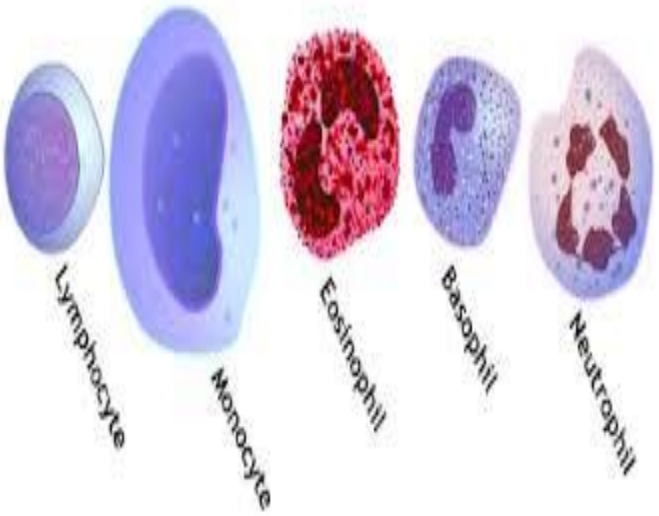

Cortex
Lymphatic nodule
Germinal center
Cortical sinus
Capsule
Afferent lymphatic vessel
Valve
Trabecula
Artery
Vein
Hilum
Efferent lymphatic vessel
Medullary cords
Medullary sinus
Macrophage
Trabecula
Lymphocytes
Reticular fibers
Venule
Medulla
Medullary sinus
Medullary cord

Defenses Against Pathogens

- Nonspecific defenses - broadly effective, no prior exposure
  - external barriers
  - phagocytic cells, antimicrobial proteins, inflammation and fever
- Specific defense - results from prior exposure, protects against only a particular pathogen
  - 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


Lymphocyte
Monocyte
Eosinophil
Basophil
Neutrophil

Leukocytes and Cutaneous Defenses

- Neutrophils
  - phagocytize bacteria
  - create a killing zone
    - degranulation: lysosomes discharge into tissue fluid, triggers
    - respiratory burst: toxic chemicals are created ($O_2^{\cdot -}$, H_2O_2, HClO)
- Eosinophils
  - phagocytize antigen-antibody complexes, allergens, inflammatory chemicals
  - antiparasitic effects: aggregate and release enzymes

Other Leukocytes

- Basophils
  - aid mobility and action of WBC's by the release of
    - histamine (vasodilator) ↑ blood flow to infected tissue
    - heparin (anticoagulant) prevents immobilization of phagocytes
- Monocytes
  - circulating precursors to macrophages
- Lymphocytes
  - natural killer (NK) cells, nonspecific defense, large cells lyse host cells infected with viruses or cancerous by release of perforin proteins

Antimicrobial Proteins

- Interferons: polypeptides secreted by cells invaded by viruses
  - antiviral effect
    - generalized protection
    - interferons diffuse to neighboring cells and stimulate them to produce antiviral proteins
    - activate natural killer cells and macrophages
      - destroy infected host cells
  - anticancer effect
    - stimulate destruction of cancer cells

Complement System

- Group of proteins in blood that must be activated by pathogens to exert their effect
- Pathways of complement activation *(see next slide)*
  - classical pathway
  - alternate pathway
- Mechanisms of action *(see next slide)*
  - enhanced inflammation
  - opsonization (promotes phagocytosis)
  - cytolysis (membrane attack complex)