

Human Anatomy & Physiology 16

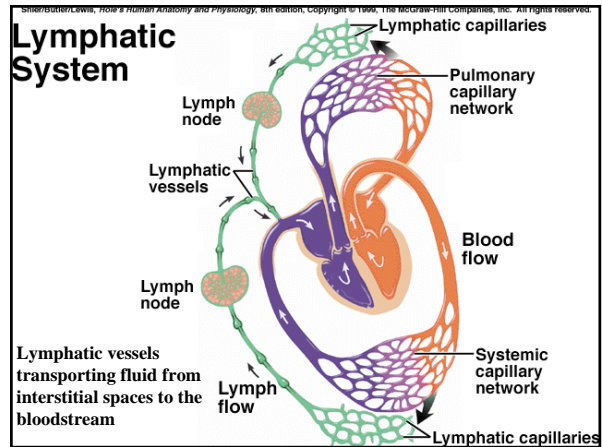
Lymphatic System & Immunity

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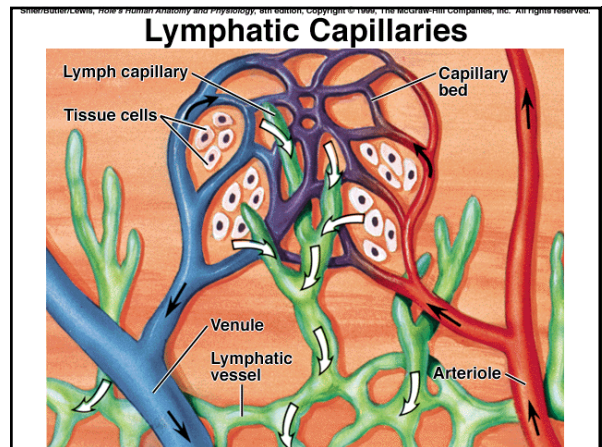
Unit Four

- ### Lymphatic System URLs
- <http://www.howstuffworks.com/immune-system.htm>
 - <http://www.thebody.com/step/immune.html>
 - <http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookIMMUN.html>
 - <http://www.cayuga-cc.edu/about/facultypages/greer/>
 - <http://www.gcm.uic.edu/sigbio/project/updated-lymphatic/lymph1.html>
 - <http://www.pblsh.com/Healthworks/lymphart.html>

- ### Introduction
- The lymphatic system is closely associated with the cardiovascular system and is comprised of a network of vessels that circulate body fluids.
 - Lymphatic vessels transport excess fluid away from interstitial spaces between cells in most tissues & return it to the bloodstream.
 - Lymphatic vessels called lacteals (located in the lining of the small intestine) absorb fats resulting from digestion, & then transport fats to the circulatory system.
 - The organs of the lymphatic system help defend against disease.



- ### Lymphatic Pathways
- Lymphatic pathways start as lymphatic capillaries that merge to form larger vessels that empty into the circulatory system. (This is key to understanding this chapter.)
 - Lymphatic Capillaries**
 - are microscopic, close-ended tubes that extend into interstitial spaces forming networks that parallel the networks of the blood capillaries
 - walls consist of single layer squamous epithelial cells which enables interstitial fluid to enter the lymphatic capillaries
 - lymph – the fluid inside a lymph capillary



C. Lymphatic Vessels

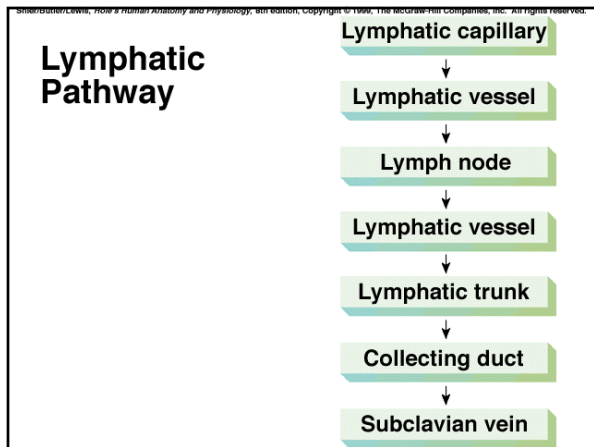
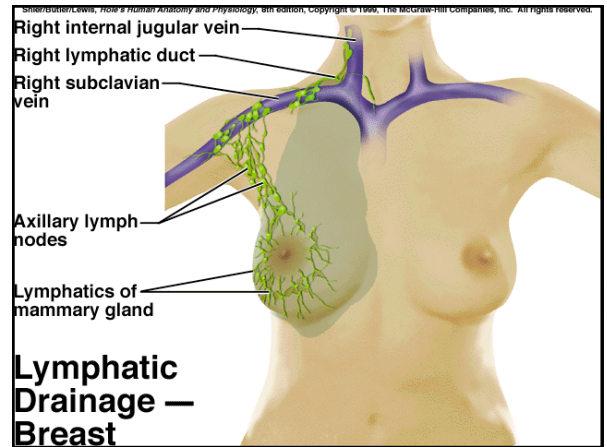
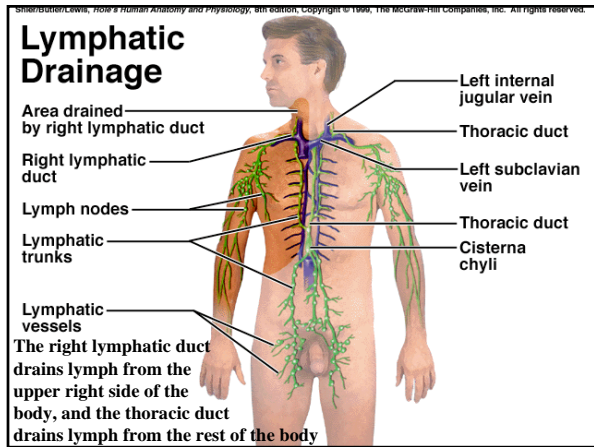
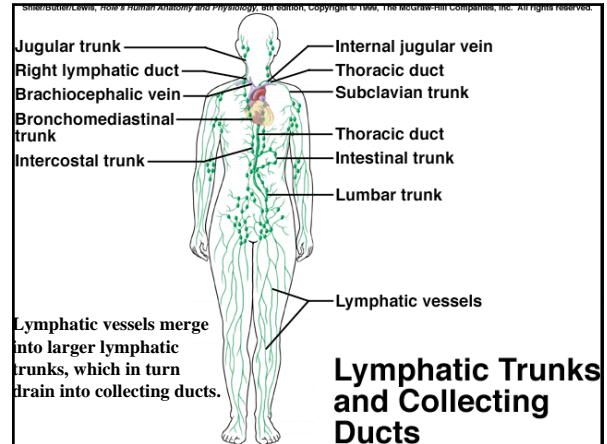
- *walls of lymphatic vessels are thinner than walls of veins
- * have semilunar valves to prevent backflow of lymph
- ***lymph nodes** – specialized lymph organs that are composed of a mass of lymphoid tissue located along the course of a lymphatic vessel

D. Lymphatic Trunks and Collecting Ducts

- *after leaving lymph nodes the vessels merge to form large lymphatic trunks which drain lymph & are named for the region of the body they serve:
- *lumbar, intestinal, intercostal, bronchomediastinal, & subclavian trunks
- *lymphatic trunks join (are drained by) **collecting ducts** – the **thoracic duct** & the **right lymphatic duct**; these ducts join the subclavian veins

LYMPHATIC PATHWAY:

- >lymphatic capillary->lymphatic vessel->lymph node->lymphatic vessel
- >lymphatic trunk->collecting duct->subclavian vein



Tissue Fluid and Lymph

A. Tissue fluid becomes lymph once it has entered a lymphatic capillary; lymph formation depends on tissue fluid formation.

B. Tissue Fluid Formation

- ***tissue fluid** originates from blood plasma; it is composed of H₂O & dissolved substances that leave the blood capillaries by filtration & diffusion; it generally lacks proteins-can have some small proteins; as the protein concentration of tissue fluid rises, the osmotic pressure of the fluid rises

C. Lymph Formation

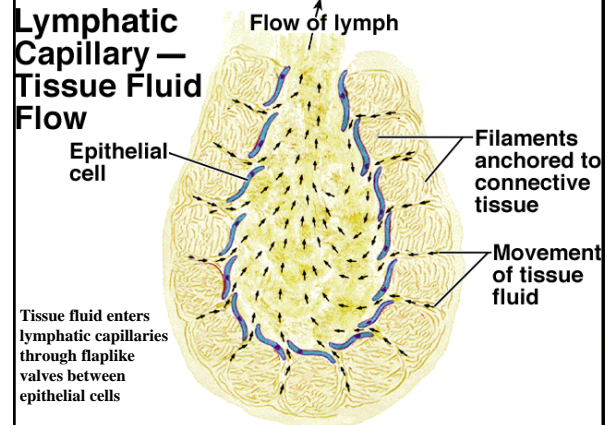
- *rising osmotic pressure in tissue fluid interferes with return of water to the blood capillaries
- *increasing pressure within interstitial spaces forces some tissue fluid into lymphatic capillaries, & this fluid becomes lymph

D. Lymph Function

*lymph returns proteins that leak out of blood capillaries to the bloodstream; it also transports foreign particles, such as bacteria or viruses, to lymph nodes



Lymphatic Capillary — Tissue Fluid Flow



Lymph Movement

A. The hydrostatic pressure of tissue fluid drives the entry of lymph into lymphatic capillaries.

B. Lymph Flow

*lymph needs help to flow through the lymph vessels
 *forces that help the flow are – contraction of the skeletal muscles, pressure changes due to the action of breathing muscles & contraction of smooth muscles in the walls of the larger lymphatic trunks. The flow of lymph peaks during physical exercise.

C. Obstruction of Lymph Flow

*Conditions that interfere with lymph movement cause tissue fluids to accumulate in the interstitial spaces, producing edema.
 *Edema can occur as a result of lymphatic tissue being removed during surgery.

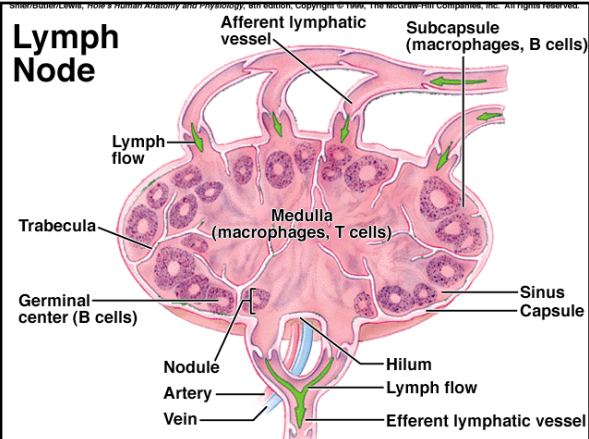
Lymph Nodes

A. Lymph nodes, which contain lymphocytes & macrophages, are located along lymphatic pathways. They fight invading microorganisms.

B. Structure of a Lymph Node (gland)

*vary in size & shape (bean-shaped)
 *hilum – indented region of bean-shaped node, blood vessels & nerves connect at the hilum of the lymph node
 *afferent vessels enter at various points on the convex surface of the node & this is how lymph enters the node
 *efferent vessels (lymphatic vessels) exit at the hilum of the node & lymph leaves the node through these vessels
 *lymph nodules – structural units of the lymph node & are compartments of the node that contain dense masses of actively dividing lymphocytes & macrophages; nodules are associated with the mucous membranes of the respiratory & digestive tracts & found in tonsils, Peyer's patches of ileum of the small intestine
 *lymph sinuses – spaces within the node

Lymph Node

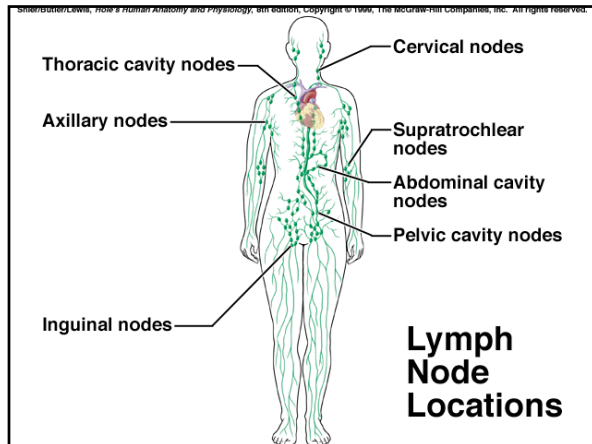


C. Locations of Lymph Nodes

*lymph nodes aggregate in groups or chains along the paths of larger lymphatic vessels; are absent in the central nervous system
 *major locations are: cervical, axillary, inguinal, subtrochlear regions, & within the pelvic, abdominal, & thoracic cavities

D. Functions of Lymph Nodes

*2 primary functions:
 1) filtering potentially harmful particles from lymph before returning it to the bloodstream & immune surveillance provided by lymphocytes & macrophages
 2) lymph nodes are the centers for production of lymphocytes that act against foreign particles.
 *lymph nodes contain macrophages that remove foreign particles from lymph

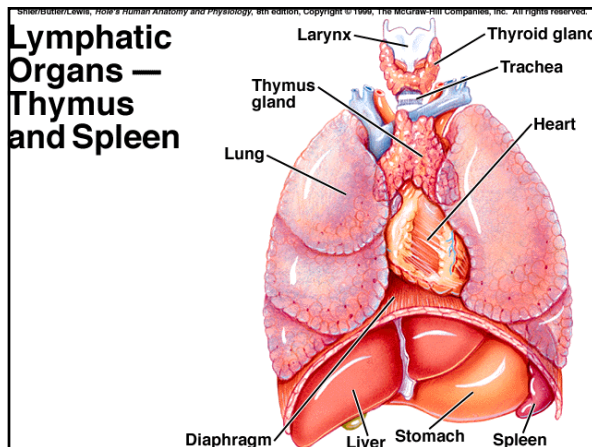


Thymus and Spleen

A. The functions of the thymus and spleen are similar to those of lymph nodes.

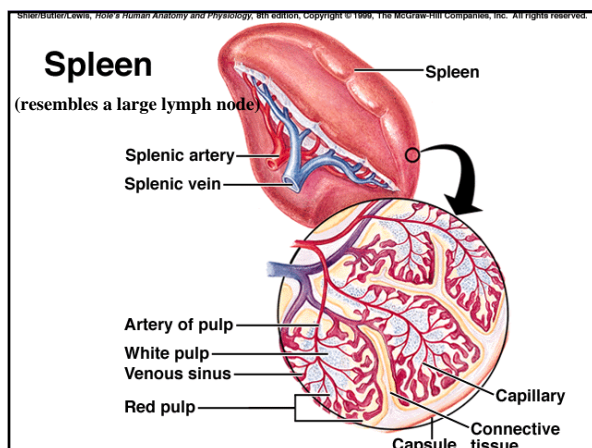
B. Thymus

- *soft bilobed structure enclosed in a connective tissue capsule located within the mediastinum
- *thymus shrinks slowly after puberty
- *it is composed of lymphatic tissue subdivided into lobules
- *lobules contain lymphocytes, most of which are inactive, that develop from precursor cells in bone marrow
- *some lymphocytes mature into T lymphocytes which leave the thymus & provide immunity
- *the thymus secretes **thymosin**, which stimulates the maturation of lymphocytes that have migrated to other lymphatic tissues



C. Spleen

- *largest of lymphatic organs; located just under left portion of diaphragm
- *resembles a large lymph node that is encapsulated & subdivided into lobules by connective tissues
- *spaces within lobules are filled with **blood instead of lymph**
- *2 types of tissues in lobules of spleen:
 - 1) white pulp - tissue containing many lymphocytes
 - 2) red pulp - contains numerous red blood cells plus many lymphocytes & macrophages
- *the spleen contains many macrophages & lymphocytes, which filter foreign particles & damaged red blood cells from the blood
- *the spleen filters blood much as the lymph nodes filter lymph



Body Defenses Against Infection

A. Disease-causing agents, called pathogens, can produce infections within the body.

- *pathogens include bacteria, complex single-celled organisms, fungi, & viruses.
- *An infection may be present without immediately causing symptoms.

B. The body has two lines of defense against pathogens:

- 1) nonspecific defenses that guard against any pathogen (7)
- 2) specific defenses that mount a response against a very specific target.

Innate (Nonspecific) Defenses

#1 Species Resistance

*Each species is resistant to certain diseases that may affect other species but is susceptible to diseases other species may resist.

#2 Mechanical Barriers

*Includes the skin & mucous membranes lining passageways of the respiratory, digestive, urinary, & reproductive systems that prevent entrance of some infectious agents. Prevention can occur as long as these barriers remain intact.

#3 Chemical Barriers

*enzymes in gastric juice & tears kill some pathogens,
*low (acidic) pH in the stomach prevents growth of some bacteria,

*high salt concentration in perspiration kills some bacteria
*interferons (hormonelike peptides) produced by lymphocytes & fibroblasts stimulate uninfected cells to synthesize antiviral proteins that block proliferation of viruses, stimulate phagocytosis, & enhance activity of cells that help resist infections & stifle tumor growth

*defensins make holes in bacteria cell walls & membranes

*collectins provide broad protection against a wide variety of microbes by grabbing onto them

#4 Fever – offers powerful protection

*viral or bacterial infection stimulates certain lymphocytes to secrete endogenous pyrogen, which temporarily raises body temperature

*higher body temperature & the resulting decrease in blood iron level production by the liver & spleen causes an increase in phagocytic activity that hampers infection

#5 Natural Killer (NK) Cells

*a group of lymphocytes that secrete cytolytic perforins to destroy cells infected by viruses & cancer; perforins destroy the cell membrane & enhance inflammation

#6 Inflammation

*inflammation is a tissue response to damage, injury, or infection; it produces localized redness, swelling, heat, & pain

*chemicals released by damaged tissues attract white blood cells to the site; in bacterial infection, the resulting mass of white blood cells, bacterial cells, & damaged tissue may form a thick fluid called pus

*clotting may occur in body fluids that accumulate in affected tissues

*fibrous connective tissue may form a sac around the injured tissue & thus prevent the spread of pathogens

#7 Phagocytosis

*neutrophils & monocytes are the most active phagocytes in blood

*monocytes give rise to macrophages, which remain in fixed tissues

*phagocytic cells associated with the linings of blood vessels in the bone marrow, liver, spleen, & lymph nodes constitute the mononuclear phagocytic system

*phagocytes remove foreign particles from tissues & body fluids

Read more about this in your textbook.

Adaptive (Specific) Defenses or Immunity

Immunity refers to the response mounted by the body against specific, recognized foreign antigens (non-self molecules). Lymphocytes & macrophages that recognize specific foreign molecules (nonself antigens) carry out immune responses.

*antigen – a chemical that stimulates cells to produce antibodies

*antibody – a protein that B cells of the immune system produce in response to the presence of a nonspecific antigen; it reacts with the antigen

Antigens - *Before birth, body cells inventory the proteins & other large molecules in the body & learn to identify them as "self" molecules.

*The lymphatic system responds to **nonsel**, or **foreign antigens**. It doesn't respond to **self antigens**.

*After inventory, lymphocytes develop **receptors** that allow them to differentiate between **nonsel** (foreign) & **self antigens**.

***Nonsel antigens** combine with the **T cell & B cell surface receptors** & stimulate these cells to cause an immune reaction.

***Antigens** may be proteins, polysaccharides, glycoproteins, or glycolipids.

*Sometimes small molecules (haptens) cannot stimulate an immune response so they combine with a larger one

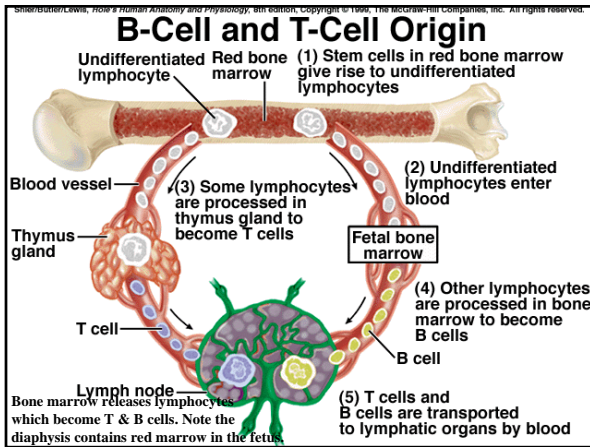
***Haptens** are small molecules that can combine with larger ones, becoming **antigenic**. Haptens are found in penicillin, certain household chemicals, dust, & animal dander

Lymphocyte Origins

***Lymphocytes** – originate in red bone marrow of fetus; the red bone marrow releases them into the blood before they differentiate

*half of these cells reach the **thymus (thymocytes)** & they remain for a time & they mature into **T cells**; later the blood transports T cells, where they make up 70-80% of circulating lymphocytes; T cells are found in lymphatic organs, nodes, thoracic duct, & white pulp of the spleen

*other lymphocytes remain in the red bone marrow & differentiate into **B cells (B lymphocytes)**; blood distributes B cells; are found in lymphatic organs, lymph nodes, spleen, bone marrow & intestinal lining



T Cells and Cell-Mediated Immunity

*T cells respond to antigens by **cell-to-cell contact**

*T cells **secrete & synthesize polypeptides called cytokines** to enhance other cell responses to antigens

***cytokines** – a type of protein that is secreted by T lymphocytes that attacks viruses, virally infected cells, & cancer cells

***interleukins** are cytokines

T cell types & activation:

*T cells are activated when an **antigen-presenting cell** (accessory cell) displays a foreign antigen

***helper T cells** – become activated when they encounter displayed antigens for which they are specialized to react (HIV cripples these cells)

***memory T cells** provide for a no-delay response to any future exposure to the same antigen

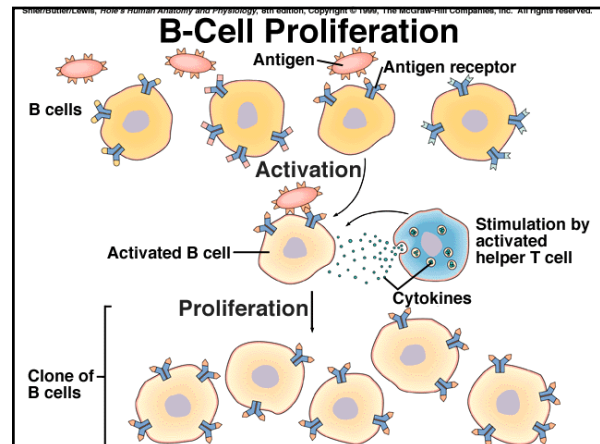
***cytotoxic T cells** recognize foreign antigens on cancerous cells & tumors by releasing the protein **perforin**

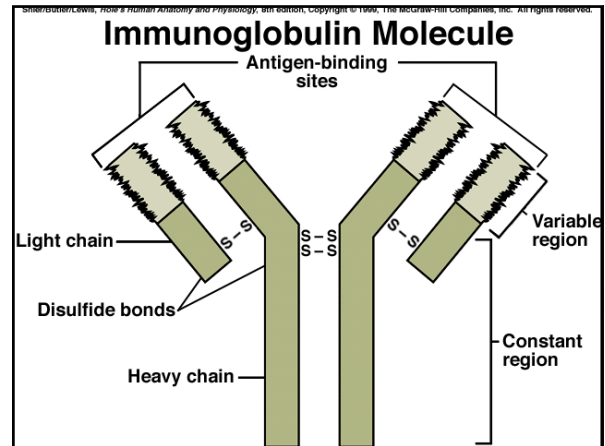
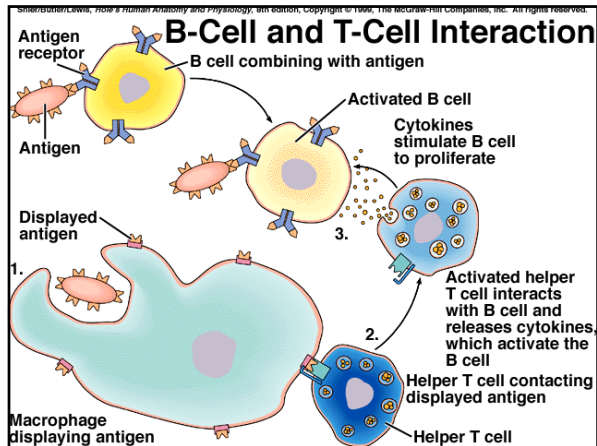
B Cells and Antibody-Mediated Immunity

*B cells attack foreign antigens in a different way than T cells. They **differentiate into plasma cells** which produce & **secrete large globular proteins called antibodies**, also called **immunoglobulins**. **Plasma cells can produce many antibodies**. (2,000 antibody molecules/second)

***antibody-mediated immunity** – antibodies carried by body fluids that react to destroy specific antigens

***Antibodies** are proteins called **immunoglobulins**; are soluble, globular proteins, gamma globular fraction of plasma proteins; each is composed of 4 chains of amino acids that are linked by pairs of sulfur atoms; **light & heavy** chains; variable regions at the ends of these chains are specialized into antigen binding sites to react with antigens



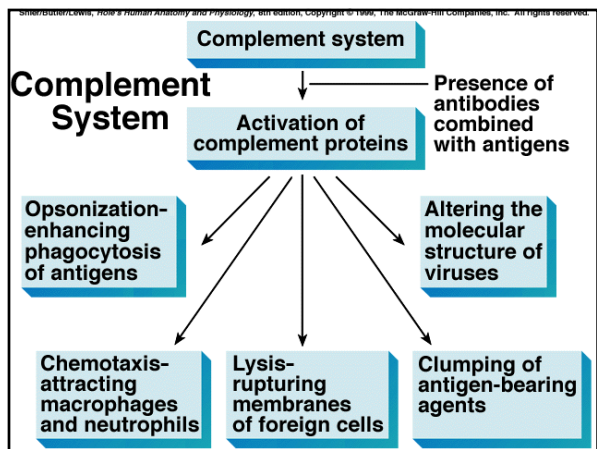


Types of Immunoglobulins – Antibodies
 *5 major types:
 IgG, IgA, IgM, IgD, & IgE = **MADGE**
 *IgG, IgA, & IgM make up most of the circulating antibodies; *IgG is most abundant type

IgD – activates B cells
 IgM – potent agglutinating agent
 IgG – crosses the placenta & confers passive immunity from the mother to the fetus
 IgA – found in body secretions, saliva, sweat, intestinal juice, & milk; helps prevent attachment of pathogens to epithelial cell surfaces
 IgE – causes cells to release histamine & other chemicals that mediate inflammation & an allergic reaction

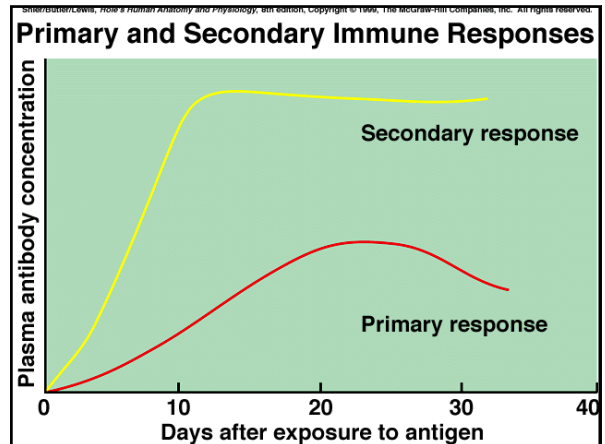
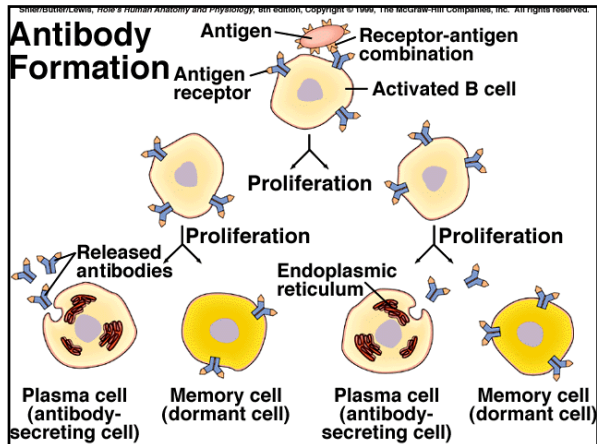
Antibody Action
 *antibodies react to antigens in 3 ways:
 1) direct attack - cause them to clump together or **agglutinate**, or **precipitate**, or **neutralize**
 this allows phagocytic cells to **lyse** the antigens
 2) activate enzymes to attack
 3) stimulate changes in local areas that help prevent the spread of the antigens

PLAN = precipitate, lyse, agglutinate, and neutralize
OTHER attack mechanisms:
 ***complement** – a group of proteins in plasma/body fluids that along with IgG or IgM which combine with the antigens & trigger a series of reactions that activate the complement to coat the antigen-antibody complex & make them susceptible to phagocytosis (opsonization); also attract macrophages & neutrophils into the region (chemotaxis)



Specific Defenses (Immunity)

Immune Responses
 ***primary immune response** – when B cells or T cells become activated as a result of encountering the antigens for which they are specialized to react; as a result antibodies are produced for several weeks
 *after a primary immune response some B cells serve as **memory cells** & react to the identical antigen if it appears in the future = **immunity**
 ***secondary immune response** – occurs as a result of memory cell response if the same antigen is encountered later

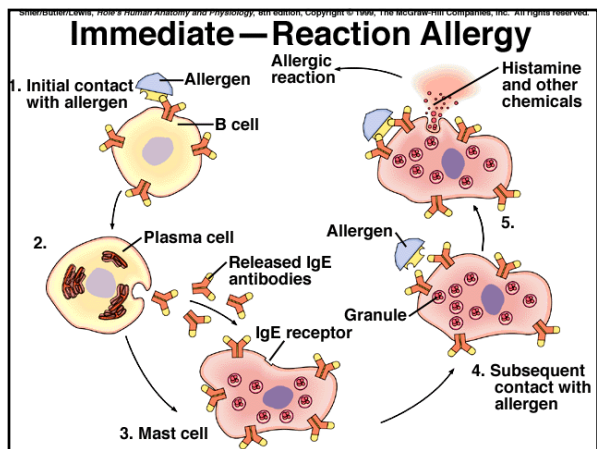


Types of Immunity

- ***naturally acquired active immunity** – occurs after a person develops a primary immune response
- ***artificially acquired active immunity** - vaccines contain a dead or weakened pathogen, or part of it, & develops this type of immunity
- ***naturally acquired passive immunity** - fetus develops this when antibodies pass through a placental membrane from a pregnant woman (mother)
- ***artificially acquired passive immunity** – developed when a person receives an injection of antibodies
- *active immunity lasts much longer than passive immunity

Allergic Reactions

- *an immune attack against a nonharmful substance, & can damage tissues; also called a **hypersensitive reaction**
- ***allergens** – antigens that trigger allergic responses
- ***autoimmunity** – an immune response against a person's own tissues; autoallergy
- ***anaphylactic shock** – a severe form of immediate reaction allergy in which mast cells release allergy mediators throughout the body; can feel apprehension, itching from a breakout of hives, vomiting, & diarrhea. The face, tongue, & larynx may swell restricting breathing. An immediate shot of epinephrine or a tracheotomy. This kind of shock is caused most often by insect stings or penicillin. Peanut allergies can cause similar symptoms.



Transplantation and Tissue Rejection

- *a transplant recipient's immune system may react against the donated tissue in a **tissue rejection reaction**
- *matching donor & recipient tissues & using immunosuppressive drugs can minimize tissue rejection; these drugs can increase susceptibility to infection, however
- *transplants can be successful between identical twins, from one body part to another, between unrelated individuals of the same species, or even between individuals of different species

4 major varieties of grafts (transplant tissue)

1. Isograft – tissue from genetically identical twin
2. Autograft – tissue taken from same individual
3. Allograft – tissue taken from same species
4. Xenograft – tissue taken from different species

Autoimmunity

- * immune system can fail to recognize self from nonself & bring on an immune response against a person's own tissues called autoimmunity
- * in autoimmune disorders, the immune system manufactures autoantibodies that attack one's own body tissues
- *autoimmune disorders may result from a previous viral infection, faulty T cell development, or reaction to a nonself antigen that resembles a self antigen

FINALE!

Remember – At the end of the chapter is a Chapter Summary that is your Study Guide for the Chapter 16 test.

Take a Bow!