LECTURE 4: LYMPHATIC SYSTEM AND IMMUNITY

INTRODUCTION
The lymphatic system is closely associated with the cardiovascular system. The primary organs of the lymphatic system are the bone marrow and thymus gland, and the secondary lymphatic organs include the lymph nodes and spleen. These organs work together to transport excess tissue (interstitial) fluid to the blood stream, transport dietary fat, and help defend the body against disease-causing agents (pathogen).

Think of different immune cells as the different units in the organization of military troops. For example, in the Immune Corps there are two divisions: nonspecific immunity and specific immunity (because both divisions are fighting the same war (pathogens = agents causing disease), there is often shared action between the divisions).

Each division is made up of regiments (for example the specific immunity division is made up of T cells regiment and B cells regiment). NK cells are a special unit within the regiment. T cell regiment is divided into battalion, such as helper T cells, cytotoxic T cells, and suppressor T cells; B cells regiment is divided into battalion such as B plasma cells and B memory cells.

Soldiers of cytotoxic T cell battalion (i.e. T cytotoxic cells) are trained specially in hand-to-hand combat like two soldiers in hand-to-hand combat with enemy soldier (T cytotoxic cells are specially trained to make physical contact with the target cell and destroy them i.e. they engage in cell-to-cell combat).

Soldier in B cells battalion are trained in attacking enemy soldiers from distance e.g. using laser to mark enemy target for destruction by macrophages or using poison on enemy troops (B cells produce Antibodies (Ab) that reach far away targets and recognize them and mark them for destruction. Antibodies recognize specific antigens of the surface of foreign cell (mark enemy targets with laser) and activate macrophages to engulf them.

**NOTE:** Antigen is simply a flag or marker (a protein) on a cell's surface, or you could think of an antigen as human face. When you go home or when you visit your friend, they look at your face (antigens located on the surface of the cell) and recognize you as self and let you in. One the other hand if a complete stranger (a pathogen, a bacteria, or cell from another individual) walks into your house (enters the body), you (lymphocytes, macrophages check the surface proteins) do not recognize the face (the antigens located on the surface of foreign cell), thus you (lymphocytes, macrophages) prevent the stranger from entering your house (the body), verbally or if they force their way in then physically.

Remember that lymphocytes are not fixed in one location. Lymphocytes camp out for a while in a node and then move to another location (lymphoid tissue). The troops of each battalion are on constant surveillance, and must frequently change positions as they guard the country against invaders (lymphocytes are on constant surveillance of body and constantly move from node to node and to other lymphoid tissue and they constantly look for foreign cells, and damaged cell that could cause problem and they guard the body against invaders).

Troop travel from fort to fort taking highways and they camp at each fort for a while either to get special training or get order or information. Lymphocytes travel from lymphoid tissues to lymphoid tissue via blood vessels and lymphatic vessels and they spend time at each lymphoid tissue.

The battalion of T cells must reside at “Fort Thymus i.e. spend time at thymus (the T in T cells = thymus)” while they receive special “training” e.g. the hand to hand combat and special ways of detecting and recognizing enemy soldiers (at the thymus t cells get the cell to cell recognition, T cell activation and antigen recognition training). Once they receive their training (antigen recognition and T cell activation), they can sally forth against their specific foes.

The spleen acts like a combination of quality control station and recycling centre, recognizing and destroying rigid or misshapen red cells and then recycling the iron and amino acids they contained.

Phagocytes are special battalions of the white blood cell regiment in the Nonspecific Division. These battalions are made up of platoons of microphages and macrophages. They act as the scouts and are strategically located in areas that are likely to be compromised by the enemy. Microphages are usually short-lived: they are destroyed by a single phagocytic event like kamikaze pilots. Macrophages are larger, so they can survive several encounters with the enemy. Macrophages also help out by cleaning up the debris left from the microphage battles and so deny food to the enemy. Some macrophages are stationed in permanent locations (called fixed
macrophages) and wait for the invaders to arrive; others are allowed to wander around looking for trouble. Fixed macrophages guard the areas of the body that are in direct contact with the environment (i.e. entrances to the body such as respiratory pathway (located in the alveoli), digestive tract).

In specific immunity the B and T cells regiment rely on some of the troops in the first division (none specific defence or none specific immunity), but they fight their battles using different weapons, so they need different training. Once they receive their orders (differentiation), they can move around in order to detect infiltrators.

Think of specific and nonspecific defence as the NYPD (New York police department) that patrols New York City. NYPD is on constant surveillance and looking for criminals, gang members and offenders (pathogens, viruses, parasites, abnormal body cells) regardless of their background, race or gender i.e. they are nonspecific defence because they are not looking for specific individual, but they are basically looking for anyone who may break the law. It is like in our body macrophages are on constant surveillance and looking for any abnormal cell, infected cell. So the first line of defence is none specific defence. However if none specific defence failed to detect or prevent the offender, and the offender managed to commits a crime, then the victim calls 911 or reports the crime. When reporting the crime a detailed description of the offender is collected (i.e. gender, race, height, style of hair, any special marks…), and based on that information a detective (antibody is produced by the B cells) is assigned to find that specific offender i.e. antibody (detective) response to an antigen (offender) is like ordering a custom-made shoes (antibodies) that can only fit a specific person (antigen). The defence always begins as none specific and then becomes specific.

When you get an infection for the first time, the response in producing antibodies is taking longer time, but with second exposure to the same antigen, the respond time is much shorter. It is like our custom made shoes; the first order is slow and takes a long time before we get our custom made shoes because a custom form needs to be made to fit your feet. However the next time you order, the response is quick. The shoe form is like a memory cell.

FUNCTION OF LYMPHATIC SYSTEM
1. Protection, maintenance and distribution of lymphocytes (lymphocytes are produced and stored in lymphoid tissues and organs e.g. spleen, thymus, bone marrow)
2. Return of fluid and solutes from peripheral tissue to blood
3. Distribution of hormones, nutrients, and waste product from their tissue of origin to general circulation.

LYMPHATIC PATHWAYS
We learned about Lymphocytes in previous lectures that: Lymphocytes respond to: Invading pathogens; Foreign proteins; and Abnormal cells; Body has several physical and chemical barriers that prevent infection (these physical and chemical barriers are our none specific and specific defenses). All the cells, tissues involved in immunity production are part of immune system.

Lymphatic pathways begin as lymphatic capillaries, which come together to form afferent lymphatic vessels, which lead to lymph nodes. The vessels that leave the lymph nodes are called efferent lymphatic vessels, which come together to form lymphatic trunks, which lead to two collecting ducts, which finally join the subclavian veins, where the lymph enters the cardiovascular system. Lymph and plasma differ in their composition. Plasma has more proteins compared to lymph.
1. **Lymphatic capillaries:**
   a. Lymphatic network begins with lymphatic capillaries
   b. They differ from blood capillaries because they: Originate as blind pockets (closed-ended tubes whereas blood capillaries are open in both direction); Are larger in diameter; Have thinner wall (receive lymph through their thin walls); Have flattened or irregular outline
   c. Lymphatic capillaries are located throughout the body, except in: avascular tissues (e.g. cartilages are avascular tissue); CNS; splenic pulp; and bone marrow.
   d. Include lacteals that are lymphatic capillaries within villi of the small intestine.

2. **Lymphatic vessels (LV):**
   a. Are formed by the merging of lymphatic capillaries
   b. Have walls similar to veins and possess valves that prevent backflow of lymph
   c. Lead to lymph nodes as "afferent" LVs, leave lymph nodes as "efferent" LVs, and then merge into lymphatic trunks i.e. lymphatic vessels enter lymphatic node via afferent pathway and exit the lymph node via efferent pathway.

3. **Lymphatic trunks:**
   a. Drain lymph from relatively large body regions
   b. Pass their lymph into venous blood by joining one of two collecting ducts: **right lymphatic duct** or **thoracic (left lymphatic) duct**
4. **Collecting ducts:**
   a. **Right lymphatic duct** drains the right upper body (25% of total body)
   b. **Thoracic (left lymphatic) duct** drains the remaining 75% of the body's lymph i.e Most of the lymph returns to the venous circulation by way of the thoracic duct.
   c. **Both collecting ducts** join the subclavian veins (right lymphatic ducts join right subclavian veins and thoracic duct joins the left subclavian vein).

1) Recall from the previous lecture that because net inward pressure in venular capillary ends is less than net outward pressure at the arteriolar ends of capillaries, more fluid leaves the capillaries than returns.
2) The difference flows through the tissues and enters lymphatic vessels, that eventually returns the fluid back to the bloodstream.
3) Fluid from the capillaries diffuse out into the tissue. This diffused fluid is called interstitial fluid (fluid that is found in tissue and surrounds cells).
4) Interstitial fluid diffuses into the lymphatic capillaries (fluid that diffused into the lymphatic capillaries is now called lymph).
5) Lymphatic capillaries join together and drain this fluid (lymph) into thoracic duct and lymphatic duct. Note: majority of capillaries (about 75%) drain into thoracic duct
6) Thoracic duct and lymphatic duct will drain into the subclavian veins.

**LYMPH NODES**

Lymphatic nodes are small (size is usually less than 2.5 cm), oval (like red kidney bean) organs of lymphatic system, distributed throughout the body including the armpit (axillary region) and stomach/gut. The lymph nodes of the axillary region receive lymph mainly from the upper limb and mammary gland. Lymph nodes are located along lymphatic pathways, thus they are linked with each other by lymphatic vessels. Lymphatic nodes contain lymphocytes and macrophages, which destroy invading microorganisms. Afferent lymphatic vessels carry lymph into the node and efferent lymphatic vessels carry lymph away from lymphoid nodes toward venous. Several **afferent lymphatic vessels** enter lymphatic nodes at points on the convex surface and a single efferent
lymphatic vessels exits lymphatic node from the hillus. Lymph node consists of compartments that contain masses of lymphocytes and macrophages. Macrophages engulf and destroy damaged cells, foreign substances, and cellular debris.

1. **Outer region = cortex** contains germinal centers of densely packed B cells (+ macrophages) in spaces called lymphatic nodules (or follicles).

2. **Inner region = medulla** contains T cells (+ macrophages and plasma cells) arranged as medullary cords (spaces through which lymph flows).

3. **Flow of Lymph**
   a. One-way direction only
   b. Lymph enters the node through one of several afferent lymphatic vessels on convex surface.
   c. Flows inward through sinuses (between medullary cords), and exits the node via one of two efferent lymphatic vessels at the hilum.

4. **Functions of Lymph Nodes**
   a. Removal and destruction of potentially harmful foreign particles from lymph i.e. Purifies lymph before it reaches venus.
      i. Removal of harmful particles is accomplished through phagocytosis by macrophages.
   b. Centers for the production of lymphocytes that act against foreign particles.

**THYMUS AND SPLEEN**

1. **Thymus**
   a. **Structure:** Thymus is located in mediastinum, just posterior to sternum and has grainy consistency. Reaches its maximum size just before puberty (40g), but decreases in size to 12g by the age of 50. Thymus consists of 2 lobes i.e. it is a bilobed organ. Each lobe consists of lymphatic tissue that is subdivided into lobules of lobules. Each lobules consist of densely packed outer cortex (dark-staining), and central modula (light staining).
   b. **Functions:** Lymphocytes in cortex are dividing, when mature migrate to modula and after 3 weeks enter the blood i.e. immature T cells migrate from the bone marrow to the thymus (via) the blood and in the thymus they mature into T cells and then released into circulation (the thymus is the site of maturation of T cells which will leave the thymus and provide immunity). The epithelial cells secrete a hormone called thymosin, which stimulates further maturation of T cells after they leave the thymus and migrate to other lymphatic tissues.
2. Spleen
   a. Structure: Spleen is the largest collection of lymphatic tissue in the adult body. Spleen is located in the upper left portion of the abdominal cavity (behind stomach). It resembles a large lymph node (i.e. it contains nodules similar to lymphatic nodules) that is encapsulated and subdivided into lobules by connective tissue. Contain may phagocytes. Contains two types of tissue: White pulp and red pulp.
      i. **White pulp** = lymphocytes arranged around central arteries.
      ii. **Red pulp** = blood filled sinuses (venous blood that also serves as blood reservoir).
   b. Functions:
      i. Contain largest collection of lymphoid tissue in adult
      ii. Removal and destruction of foreign particles and worn blood cells from blood (recall that worn out RBC cell are removed from circulation by macrophages located in the spleen). Macrophages remove and destroy bacteria and damaged or worn red blood cells and platelets through phagocytosis.
      iii. Stores and releases blood during hemorrhage.
      iv. In immunity as a site of B cell proliferation into plasma cells i.e. it initiates immune response by B and T Cells

BODY DEFENSES AGAINST INFECTION
Infection is caused by the presence and multiplication of pathogens. Pathogens are viruses and microorganisms (bacteria, fungi, protozoans, parasites) that cause disease. The body is equipped with two types of defense mechanisms to fight infection: Innate (nonspecific) immunity or resistance and adaptive (specific) immunity. Innate immunity is the 1st and 2nd lines of defense, whereas adaptive immunity is the 3rd line of defense. Those two types of defense, defend the body via mechanical (e.g. skin), chemical (e.g. interferones, cytokines, lysozyme), and cellular (e.g. macrophages, lymphocytes) defenses.

INNATE (NONSPECIFIC) DEFENSES
1. Innate defense is fast and non specific. Innate defense is protection against a wide range of pathogens i.e. innate immunity do not distinguish one type of pathogen from another type, thus destroy all kind of pathogens, and foreign cells that cause damage. Innate immunity is type of immunity that we are born with. In addition that we are born with defense mechanism, each species of organism is resistant to certain diseases that may affect other species, but susceptible to diseases that other species may be able to resist.
2. There are different types of nonspecific defenses: Physical barriers, Phagocytes, Immunological surveillance, chemical barrier (Interferons (cytokines), Complement system), Inflammation, and Fever.
   a. Mechanical barriers or physical barrier (First Line of Defense)
      i. Include the skin and mucous membranes.
      ii. As long as mechanical barriers remain unbroken, they prevent the entrance of some pathogens
   b. Chemical Barriers (First and Second Line of Defense)
      i. Enzymes
         1. The enzyme in gastric juice (i.e. pepsin) is lethal to many pathogens.
         2. The enzyme in tears (i.e. lysozyme) has antibacterial action.
      ii. Acid
         1. Low pH in stomach (hydrochloric acid) prevents growth of some bacteria.
         2. Acidic pH in vagina and urine prevent bacterial growth
      iii. Salt
         1. High salt concentration in perspiration kills some bacteria.
iv. **Interferons**
1. Interferon is a group of hormone-like peptides produced by certain infected cells and lymphocytes in response to the presence of viruses i.e. Interferons are small proteins that act as chemical messengers that coordinate defense and produced in response to presence of viruses.
2. Interferons are released by virally infected cells and activated lymphocytes.
3. These antiviral proteins interfere with the proliferation of viruses, stimulate phagocytosis, and enhance the activity of cells that help resist infections and the growth of tumors.
4. Interferons bind to the surface of abnormal cells and trigger the production of antiviral proteins that prevents virus proliferation.

v. **Complement**
1. There are 11 plasma complement proteins that lyses infected cells. They cause chain of reaction and result attraction and stimulation of phagocytes and also result puncture of bacterial cell = lyses bacterial cell.
2. Also promotion of inflammation and

c. **Natural Killer Cells (NK cells)**
   i. Special lymphocytes that attack foreign material microbes, cancer cells, other abnormal cells.
   ii. They use perforins to rupture cell membranes.
   iii. They also enhance inflammation.

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<th>STEP 1: Recognition and adhesion</th>
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<th>INFLAMMATORY RESPONSE</th>
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<td>i. Inflammation is a localized tissue response to damage, injury, or infection.</td>
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<td>ii. Blood vessels dilate, increasing capillary permeability.</td>
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<td>iii. The response includes localized tissue <strong>redness, swelling, heat, and pain.</strong></td>
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<td>iv. Chemicals released by damaged tissues attract various white blood cells to the site of injury.</td>
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Phagocytosis: Second Line of Defense
i. Phagocytosis is the process by which specialized cells engulf and ingest foreign particles in order to destroy them. Note: Recall function of lysosomes. Lysosomes are organelles that contain digestive enzyme to break down waste materials and cellular debris. In macrophages when bacteria or infected cell is engulfed, lysosomes release their digestive enzyme and break them down.
ii. The most active phagocytes in the blood are neutrophils and monocytes.
iii. Monocytes give rise to macrophages that migrate to various body tissues.
iv. Phagocytic cells associated with the linings of blood vessels in the bone marrow, liver, spleen, and lymph nodes constitute the reticuloendothelial tissue.
v. Phagocytes remove and destroy foreign particles from tissues and body fluids.

Fever
i. Infection (by bacteria and viruses) causes some lymphocytes to produce Interleukin I, which increases body temperature i.e. secretion of Interleukin I causes fever.
ii. Increased body temperature decreases blood iron levels, which increases phagocytic activity.
iii. High temperature may inhibit some viruses and bacterial activities.
iv. It increases metabolism (1°C increase in temperature would increase metabolism by 10%)

Adaptive (Specific) Defenses or Immunity
An adaptive immune response is slower, but more specific. Adaptive (Specific) Defenses or Immunity is protection against particular disease-causing agents i.e. protect body against one particular threats. Specific defense depend upon the activation of lymphocytes (B cells and T cells). It is our third line of defense against infection. Characteristics of specific defense include: tolerance (your B cells and T cells do not attack your own cells); versatility (your body is capable of producing millions of different Ab against any type of Ag); memory (the response to second exposure to the same infection will be much quicker); specificity (one type of Ab recognizes and attacks only one type of Ag). Defense of the body against a particular bacteria or virus is provided by specific immunity.
1. Antigens (Ag's)
a. An antigen is a protein on the surface of cells. This protein on the surface of the cell can be self (a protein that is recognized by the immune system as self) or non self (a protein that is recognized by the immune system as foreign e.g. bacterial protein or a protein from different person (for example during transplant or craft our immune system attacks the transplanted organ))
b. An antigen (a non-self-antigen) triggers the formation of an antibody and reacts specifically with that antibody.
c. How does this process occur?
   i. Before birth, body cells inventory the proteins and other large molecules present in the body (i.e. “self” proteins).
ii. After the inventory, lymphocytes develop receptors that allow them to differentiate between foreign (non-self) antigens and self-antigens.

iii. When non-self or foreign antigens (Ag's) enter human tissues, they combine with T cell and B cell surface receptors, and stimulate these cells to cause an immune response/reaction against them.

d. T-Cells are responsible for cell mediated immunity (cellular immunity) – defense against abnormal cells and pathogens inside cells

e. B-cells provide Ab-mediated immunity (also called humoral immunity) – defense against Ags and pathogens in body fluid

2. Lymphocyte Origins:
   a. Lymphocytes originate in red bone marrow and are released into the blood i.e. Stem cells that will form B cells, T cells and NK cells are found in the bone marrow.
   b. Lymphocytes (B cells, T cells and NK cells) circulate the blood and fight the infection. Note: lymphocytes donot cross blood brain barrier i.e. lymphocytes are not found in CNS. CNS have glial cells called microglia that plays defense role in CNS.
   c. About half of these lymphocytes are released into the blood before they become differentiated. These undifferentiated lymphocytes reach the thymus where they mature and differentiate into T cells.
   d. About half of the undifferentiated lymphocytes stay in bone marrow and they are differentiated and some become B cells and some become NK cells.
   e. Both T cells (70%-80% of circulating lymphocytes) and B (20%-30%) cells are transported through the blood to the lymphatic organs (lymph nodes, spleen, thymus) where they reside and act in immune responses against foreign antigens.

f. Lymphocyte Function
   i. Antigen-Presenting Cells (e.g. macrophages) Begin the Immune Response
   ii. A macrophage is typically the first cell to respond to an antigen, when bacteria first enter the body. As macrophages fight the invaders (bacteria), at the same time it alerts (activates) lymphocytes.
   iii. After digestion of the antigen (by the macrophage), a self-protein attaches a copy of the foreign antigen to the cell membrane of the macrophage i.e. macrophage destroys the infected cell or bacterial cell and present a piece of destroyed bacteria’s protein to other cells (lymphocytes) as an evidence and also to give them information about the structure and shape of antigen (foreign protein).
   iv. A lymphocyte now recognizes and binds to the antigen-presenting cell.
      1. T cells and B cells are activated and begin a chain of reactions that ultimately destroy/neutralize the invading antigen.

3. T cells and the Cellular Immune Response (CMI):
   a. Play key role in inhibition, maintenance and control of immune response.
   b. T cells respond to antigens directly (by cell-to-cell contact).
   c. T cells secrete cytokines (lymphokines) to enhance other immune responses to antigens.
   d. Colony stimulating factors stimulate bone marrow to produce lymphocytes.
   e. Types of T cells:
      i. Helper T cells (CD4) become activated when they encounter a displayed antigen (on macrophage) for which it is specialized to react. Once activated, helper T cells stimulate B cells to produce antibodies (i.e. they activate B cells when there is infection). They are important because B-cells have to be activated before they could produce Ab.
         1. CD4 Helper T cells stimulate Antibody Mediated Immunity (AMI) and secrete cytokines (CMI).
      ii. Suppressor T cells inhibit the activation of T and B cells when infection is eliminated.
NOTE: because T helper cell stimulate and T suppressor cell inhibits immune response, together they regulate the immune response.

iii. **Cytotoxic T cells** (CD8) recognize foreign antigens on tumor cells and virus-infected cells. They enter peripheral tissue and directly attack Ags (physical and chemical)

1. Stimulated cytotoxic T cells proliferate into a large clone of cells that secrete perforin to destroy target cells.

f. **T cell activation**
   i. They recognize Ag-glycoprotein complex in cell membrane
   ii. Glycoproteins are synthesized by chromosome 6 in the region called Major Histocompatibility Complex (MHC)- so they are known as MHC proteins
   iii. Each individual have different MHC proteins
   iv. There are 2 classes of MHC proteins

1. **MHC Class I**: Present in membrane of all cells. They are synthesized, and transported to membrane by vesicles of Golgi apparatus. As they are formed, they pick up small peptides from cytoplasm and take them to membrane. If the peptide are self, T-cells will ignore them, but none self-peptides will activate T-cell and T-cell will destroy abnormal cell. Think of this as when an infected cell flags the macrophage that “I am infected, destroy me”

2. **MHC Class II**: Present only in the membrane of Ag presenting cells (monocyte, macrophages, kupffer cells of liver, denteric cells of lymph) and phagocytes. Phagocytic cells engulf, break down infected cells and bacterial cells. Ag fragments of digested bacteria will bind to MHC II proteins. MHC proteins will be transported to the cell membrane of macrophage and the Ag (piece of bacterial protein) will be presented on the cell membrane to activate lymphocytes. Think of this as macrophage telling the T cells that we are infected, I (Macrophage) just destroyed an infected cell, and here is the evidence (Ag fragment = picture of the invader) go and look for him and help me eliminate it.

4. **Natural Killer Cells also** use perforins to destroy tumor cells.
   a. Both cytotoxic T cells and natural killer cells can lyse antigens in other ways also.
5. **B cells and the Humoral Immune Response (Antibody mediated immunity, AMI):**
a. **B cells** interact with antigen-bearing agents **indirectly**, by secreting proteins called **antibodies**.
b. There are two types of B cells: plasma B cells and memory B cells. Plasma B cells produce Ab.
c. **B Cell Activation**
   i. B cell becomes activated when it binds to an activated T cell.
   ii. Once activated, a B cell proliferates, enlarging into its clone.
   iii. Activated B cells specialize into plasma cells that secrete antibodies.
   iv. Antibodies react against the specific antigen-bearing agent that stimulated its production.
   v. A diverse population of B cells defends one against a large number of pathogens.

6. **Antibody molecules:**
   a. Antibodies are proteins called **immunoglobulin**.
   b. Each immunoglobulin molecule consists of four chains of amino acids linked together: Two heavy chains and two light chains.
   c. Variable regions at the ends of these chains are specialized to react with antigens i.e. Region of antibodies that bind to a specific Ag.
   d. The **five major types** of immunoglobulins are IgG, IgA, IgM, IgD, and IgE.
      i. IgG – are single molecules and are mainly responsible for resistance against many viruses, bacteria and bacterial toxins; most abundant circulating antibody (80% of total)
      ii. IgE – accelerates local inflammation and responsible for allergic reaction because they attach to mast cell and basophils and cause the release of histamine from mast cells (basophils), occurs in exocrine gland secretions.
      iii. IgD – found on the surface of B cells, involved in activation of B-cells.
      iv. IgM – first type secreted after antigen arrives
      v. IgA – primarily found in glandular sec i.e. occurs in exocrine gland secretions (i.e. tears, saliva, breast milk, etc.)
   e. **Antibody Actions:**
      i. Antibodies **attack antigens directly**, activate complement, and stimulate local tissue changes that hinder antigen-bearing agents.

**FORMS OF IMMUNITY**
Immunity may be either innate or acquired. Innate immunity is present at birth and has no basis to prior exposure to the antigen involved. Certain innate immunity is species-specific. For example, humans are not susceptible to diseases of cats and dogs i.e. species are genetically different and they do not get certain types of infection for example when you have flue or pneumonia the infection can be passed to other people, but you will not pass the infection to your pets because they are genetically different. Acquired immunity is not present at birth, but rather is acquired following exposure to a particular antigen.

1. **Innate immunity**
   a. Genetically determined
   b. Present at birth

2. **Acquired immunity**
   a. Not present at birth
   b. Achieved by exposure to antigen (active) or received passively
   c. Acquired immunity can be: active or passive
      i. **Active immunity**
         1. Active immunity can be: natural or induced
         2. A person who encounters a live pathogen, which stimulates a primary immune response, and suffers symptoms of a disease, develops **naturally acquired active immunity** i.e. after the disease he/she will develop immunity against that disease
(this type of immunity results from the natural exposure to an antigen in the environment).

3. A person who receives a vaccine containing a dead or weakened pathogen (is induced). The weakened pathogen will stimulate immune response and causes the person to develop artificially (induced) acquired active immunity.

ii. Passive immunity
1. Passive immunity can be natural or induced
2. A person who receives an injection of gamma globulin that contain ready-made antibodies has artificially (induced) acquired passive immunity. In this instance, the patient does not have time to develop active immunity, no immune response occurs, and the immunity provided is only short-term. For example after a snake bite the patient is injected with anti-venom.
3. When antibodies (IgG) pass through a placental membrane from a pregnant woman to her fetus, the fetus develops naturally acquired passive immunity. Or when mother breastfeeds the baby and passes Ab via milk to the babies.

IMMUNE SYSTEM ABNORMALITIES
1. Allergic Reactions or Hypersensitivity (Immune Response gone awry)
   a. Allergic reactions involve antigens combining with antibodies (IgE) The resulting IR is likely to be excessive or violent and may cause tissue damage.
2. Transplantation and Tissue Rejection
   a. A transplant recipient’s immune system may react with donated (non-self) tissue in a tissue rejection reaction i.e. A transplant recipient's body rejects a transplanted organ because her major histocompatibility complex (MHC) does not match that of the donor closely enough.
   b. Matching cell surface molecules of donor and recipient tissues (MHC) and using
immunosuppressive drugs can minimize tissue rejection.
c. Immunosuppressive drugs increase the recipient’s susceptibility to infection (decreases resistance)

3. Autoimmunity
   a. In autoimmune disorders, the body produces antibodies against “self” antigens, resulting in an attack on one’s own tissues.

LIFE SPAN CHANGES
1. The immune system declines early in life, partially due to the decreasing size of the thymus
2. The activity level of T cells and B cells declines as we age.
3. The proportions of the five types of immunoglobulins shift as we age.