Immune System Review Sheet

If you have questions email me (Jacks01186@aol.com). You may call me also but only as a LAST AND FINAL RESORT (in other words try the email first please). Good luck and study hard!

Body’s 1st Line of Defense
- Is nonspecific
- Works to prevent invaders from entering the body
- Examples:
  - THE SKIN
    - intact skin can not be penetrated by most pathogens
  - SECRETIONS
    - sweat, tears, saliva etc. contain lysozyme which attacks the cell wall of many invaders
  - DIGESTIVE SYSTEM
    - mucous membranes
    - stomach acid kills swallowed bacteria
  - RESPIRATORY SYSTEM
    - nostril hairs filter incoming air
    - mucus in respiratory tubes traps invaders
    - cilia

Body’s 2nd Line of Defense
- Is nonspecific
- Responsible for stopping the spread of bacteria/virus once it enters the body
  1. WHITE BLOOD CELLS – what are the functions of each?
    - Neutrophils and Monocytes
    - Macrophages
    - Natural Killer Cells
  2. Antimicrobial Proteins (Defense Proteins)
    - Interferons –how do these work?
    - Complement Proteins:
      - Can coat surface of microbes making it easier for macrophages to engulf them,
      - Can poke holes in microbes’ membranes causing them to lyse
  3. Inflammatory Response
    - Triggered by tissue damage
    - Damaged tissue releases chemical alarm signals such as HISTAMINE – causes nearby blood vessels to dilate and makes them “leakier” so that blood flow increases to area and blood plasma can leak out into tissue (increases phagocytes in area and clotting proteins and platelets to seal up cut)
Macrophages engulf bacteria and any infected body cells, body cells that were damaged by injury, or other macrophages that may have died in “battling” the invader.

**PUS** may be secreted – consists of dead white blood cells (bodies after the battle) and fluid that leaked from the capillaries to the tissue during the response.

**Systemic Inflammatory Response** – inflammatory response that is widespread (all over the body) such as a FEVER – your body’s way of inhibiting reproduction of invader and stimulating phagocytes.

**Septic Shock** – overwhelming systemic inflammatory response

**Lymphatic System**
- Network made up of vessels, fluid (**LYMPH**), and **LYMPH NODES** – organs filled with macrophages and **LYMPHOCYTES**.
- Includes: tonsils, adenoids, appendix, spleen, bone marrow and thymus
- **FUNCTIONS**
  1. Returns tissue fluid to circulatory system
  2. Key in fighting infection – lymph circulates through vessels and carries microbes from infection sites to lymph nodes where macrophages may engulf pathogen or invader may stimulate lymphocytes to mount specific immune response.

**B Cells vs. T Cells**
- Both B cells and T cells develop in the bone marrow
- T cells are carried via the blood to the thymus where they mature.
- B cells mature in the bone marrow
- The surface receptors on a B cell are many copies of the **SAME antibody** (the antibody that the B cell will secrete many copies of later when it undergoes clonal selection)
- The surface receptors on a T cell are **T cell receptors**. Remember that T cell receptors are *highly, highly specific* because they must recognize and bind to both your body’s “self proteins” and an antigen (when they are bound together in a self-non-self complex).

**Body’s 3rd Line of Defense**
- Specific
- Responsible for fighting off invaders that have entered your blood and body fluids (Humoral immunity) and that have infected your cells (Cell-mediated immunity)

**Antigens and Antibodies**
- **ANTIGEN** – molecule that elicits an immune response. Can be protein or polysacharride on surface of foreign cell or free floating piece of invader (ie. In body fluids)
- **ANTIBODY** – protein found in blood plasma that attaches to a specific antigen and helps counter its harmful effects. Antibodies are secreted by B Cells.
**Antibodies** have **ANTIGEN BINDING SITES** where they bind to specific antigen. Antibodies bind to specific regions on surface of the antigen called **ANTIGENIC DETERMINANTS**. The antibody recognizes and binds to a specific antigen because antigen binding site and antigenic determinant fit together perfectly (like a lock and key).

- Single antigen will have many different antigenic determinants (can stimulate many antibodies)

**Clonal Selection (remember: Grow, Divide, and Differentiate)**

- You have millions of different types of B cells and T cells (each type has a DIFFERENT receptor on its surface) so you can produce an immune response to millions of different antigens. But you only have a few of each type of B or T cell.
- **Clonal selection** is a way for your body to produce more of a certain type of B or T cell that has receptors that bind to a specific antigen that has infected your body.
- Make sure you know how to walk through the whole process of clonal selection (What causes a B or T cell to be “selected”? What does an activated or “selected” B or T cell do?)
- Clonal selection results in different kinds of cells depending what type of cell was originally activated. If the activated cell was a
  - *B cell* – the clones differentiate into Effector B Cells (plasma cells which secrete antibodies. These antibodies are just many copies of the antibody receptor on the surface of the original “selected” B cell) and Memory B Cells
  - *Cytotoxic T Cell* – the clones differentiate into Activated Cytotoxic T cells and Memory T Cells
  - *Helper T Cell* – the clones differentiate into Activated Helper T Cells and Memory Helper T Cells

**Primary and Secondary Immune Responses**

*Primary Response*

- **A primary immune response** occurs when your body is exposed to an antigen for the first time.
- Why do you get sick when you mount a primary immune response?

*Secondary Response*

- **A secondary immune response** occurs when your body is exposed to the SAME antigen for the second time. Remember that it must be the same antigen because the antibody receptors on the surface of memory B cells will only bind to the specific antigen that stimulated their production during the primary immune response.
- **Memory cells** are responsible for mounting the secondary immune response. How do they do it?
- The secondary immune response is:
  - More immediate
  - Stronger (the antibodies secreted are more effective and more of them are secreted)
  - Last longer
Passive Immunity vs. Active Immunity

- **In Active immunity** the body is stimulated to mount its OWN response to an invader. The invader may be introduced naturally (by actually being infected by a pathogen) or artificially (a vaccine).
- Active immunity lasts long-term because, since your body was stimulated to mount a response, you produced memory cells that will mount a secondary immune response if they encounter the same antigen again.
- **In Passive immunity** the body is NOT stimulated to mount its own response to an invader. The individual receives antibodies from another source (such as through an injection, or fetuses can receive antibodies from their mother through the placenta).
- Passive immunity is only temporary because, since your body was not stimulated to mount an immune response to an invader, you do not produce memory cells and the antibodies that you received from another source die off after a few weeks.

**Vaccine**

- A vaccine is composed of a harmless variant of a disease-causing microbe. (Remember this why vaccines don’t make you sick, because they are harmless variants.)
- Make sure you can explain how a vaccine works to make you immune to a disease. (When you are first injected with a vaccine, how does your body respond? What type of response will your body mount when it later comes into contact with the disease you were vaccinated against and why?)
- If you are vaccinated against a pathogen you acquire active immunity to that pathogen.

**Antibody Structure**

- Antibodies are Y-shaped proteins made up of four polypeptide chains.
- Each antibody consists of two heavy polypeptide chains and two light polypeptide chains.
- Why are the heavy chains called “heavy”? Why are the light chains called “light”?
- Each chain has a variable and constant region
- The amino acid sequence of the constant region, which makes up the tail of the Y-shaped antibody, varies only slightly from one antibody to the next. It helps mediate in which way antigens attached to the antibody will be disposed.
- The amino acid sequence of the variable region, which makes up the antigen-binding site, varies greatly from one antibody to the next. (Remember amino acids sequences determine the 3D conformation of a protein, so if you have a huge variety of amino acid sequences, you will have a huge variety of 3D structures) How is the location of the variable region an example of the antibody’s form fitting its function?
- Draw a diagram of an antibody include heavy and light chains, variable and constant regions and antigen binding sites.
Antibody Function

- Antibodies recognize and bind to an antigen and in doing so to mark the antigen for destruction by a macrophage. (Notice how here the nonspecific defenses (macrophage) and the specific defenses (antibodies) work together to destroy the antigen.)
- When an antibody recognizes and binds to an antigen an **antigen-antibody complex** is formed. The formation of this complex marks the antigens for destruction by triggering an **effector mechanism**.
- Make sure that you can explain the four effector mechanisms: Neutralization, Agglutination, Precipitation and Complement Activation (Complement proteins) (which is responsible for destroying foreign red blood cells in the body?)

Cell-Mediated Immunity

- Is responsible for fighting off invaders who have infected the cells of your body.
- Is mounted by **T Cells**
  - **Helper T Cells**
    - Helper T Cells are responsible for **stimulating or amplifying** their own clonal selection, humoral immunity and cell-mediated immunity. (Remember that helper T Cells can **stimulate or amplify** the humoral and cell-mediated responses because B cells or the Cytotoxic T cells may have or may not have already mounted a response to the invader on their own)
    - Make sure you can walk through the role of a Helper T Cell in the immune response (from the macrophage engulfing a bacterium and “eating” it up to the release of interleukin-2 and the effects that it has. Don’t forget APCs, self proteins, non-self molecules, self-non-self complex and interleukins-1 and interleukin-2!)
  - **Cytotoxic T Cells**
    - Cytotoxic T Cells are responsible for attacking and killing infected body cells.
    - Make sure you can walk through the role of a Cytotoxic T Cell in the immune system (from an antigen infecting a body cell to the infected cell’s death by lysis. Don’t forget APCs, self proteins, non-self molecules, self-non-self complex and perforin. Also recall that the activation of a Cytotoxic T Cell does not just result in the release of perforin but also stimulates the Cytotoxic T Cell to undergo clonal selection.)

Allergies

- An allergy is an abnormal sensitivity to an antigen in our surroundings.
- An allergen is an antigen that causes allergies
- An allergic reaction:
  - can occur in response to even the tiniest amount of allergen
  - occurs very rapidly
  - can occur in many parts of the body (eyes/nose/bronchi etc.)
- **Mast Cell** – body cell that produces histamine and other chemicals that trigger the inflammatory response.
• A allergic reaction occurs in a two stage process, make sure that you can explain what happens in both:
  1. SENSITIZATION – occurs when an individual is FIRST EXPOSED to an allergen
  2. SECOND EXPOSURE – occurs when an individual is exposed to the SAME ALLERGEN a second time. (Why is it so important that it is the same allergen?)
• Antihistamines – drugs that interfere with histamine’s action and give relief from an allergy temporarily.
• Anaphylactic Shock – a dangerous type of allergic reaction that occurs when a person is EXTREMELY sensitive to an allergen.
  An individual enters anaphylactic shock because:
  ▪ When exposed to the allergen the mast cells release histamine and other inflammatory chemicals very suddenly and rapidly
  ▪ Histamine causes the individual’s blood vessels to dilate abruptly which results in a huge drop in blood pressure (remember all that resistance that was generating blood pressure suddenly disappears!)
  ▪ This drop in blood pressure can be fatal
• Anaphylactic shock can be countered with EPINEPHRINE (adrenaline).

Autoimmune Diseases
• An autoimmune disease is the result of an individual’s immune system malfunctioning and turning against the body’s own molecules
• Can be antibody-mediated (your B cells make antibodies against your own body molecules) or it can be when your T cells attack cells of your own body.
• Now that you know about autoimmune diseases, explain the importance of the self protein that the APC produces during the cell-mediated immune response.

Immunodeficiency Diseases
• An immunodeficiency disease occurs when an individual lacks one or more components of their immune system and, as a result, are susceptible to infections that usually don’t cause problems.
• AIDS (Acquired Immunodeficiency Disease) – caused by infection with the HIV virus. The HIV virus is deadly because it destroys the immune system leaving the victim defenseless against most invaders.
• HIV can attack many different kinds of cells but favors Helper T Cells. Why does this cause a particularly large problem for the immune system?
• HIV is difficult to treat because it is constantly mutating to new forms.
• PHYSICAL or EMOTIONAL STRESS can also depress your both your specific and nonspecific immune responses.

The Big Picture
• You may find it helpful to trace the path of an invader from its entering the body to its destruction by the specific defenses (3rd line of defense). Think about what defenses it has to get past to get to the 3rd line of defense (for example, it has to
enter the skin or get past your acidic gastric juices; it has to pass interferons etc.)
Then consider how the specific defenses will respond (the diagram below may be helpful). What about if the SAME antigen were to enter your body again? Please do not have a heart attack - I will **not** ask you to do this on the test, but it is important to remember the big picture in the midst of all the little details!

Figure 43.10 An overview of the immune responses (Layer 3)