1. **Introduction**
2. Key attributes of the immune system will ultimately determine the overall acquired immunity of a certain individual. The immune system can be extremely diverse in theory and the subject involving the immune system is especially complex.

1. A general review of the immune system involves many different mechanisms. Factors largely involved in the response of the system include the defenses of the innate and adaptive immunity. The different components of the immune system can be shown as mechanisms. Innate immunity is a natural defense mechanism that is the first line of host defense for an immunocompromised individual. The innate system is a quick response system that can act within hours of exposure to a pathogen. The system includes anatomical barriers such as epithelial surfaces that provide a first barrier against a pathogen. Antimicrobial substances can be used as protection these include: lysozymes, peroxidase, Iron binding proteins, and defensins. The adaptive immune system provides a much less timely response. Although, the adaptive response provides a much stronger response upon recognition of a known foreign pathogen. The system uses a learned mechanism that allows for the immune system to recognize pathogens and eliminate them.
2. The extreme complexity of the immune system forms a difficult understanding of the organization and aspect pertaining to the activity of the system. Broadly, most of the processes involved rely on an antigen presenting cell such as a macrophage. This results in activation of an immune response when it takes place in a lymphoid organ such as a lymph node or the spleen. The antigen presenting cells engulf pathogens and can stimulate a response of helper T cells in the case of adaptive immunity. Helper T cells can provide assistance to effector cells which allow the hyperproduction of plasma cells, producing additional antibodies that can help in immune defense.

**II. General Concepts**

1. **Specific and Nonspecific Defenses.** Some responses of the protective mechanism involved in the immune response include nonspecific defenses, which are generally present in many organisms. Furthermore, specific defenses are unique to the organism they pertain to.
2. **Nonspecific Defenses**, (Innate mechanism) this defense is present at birth in all individuals. This response is highly non-specific to any and all pathogens that enter the body. The defense is quick acting, although no memory is generated within the system. The body’s first response to pathogens is a nonspecific defense.
3. **Mechanical barriers** can physically block pathogens from entering the body. A barrier that falls under these criteria is the skin. The skin provides the most important defense mechanism in the body.
4. **Chemical barriers** create an environment that most pathogens can’t sustain in. The stomach acid creates a certain low pH that destroys pathogens that enter the GI tract in what we eat and drink.
5. **Antibacterial substances** inhibit growth of pathogens and provide defense in areas physical barriers can’t. Some substances that are involved include tears and mucus secretions. Lysosomes are present in tears, whereas they are an enzyme that catalyzes the elimination of the cell walls of some bacteria.
6. **Ingestion and elimination by granulocytes** these are white blood cells that contain proteins that are able to fight off infection. Specific types of granulocytes include neutrophils, eosinophils, and basophils.
7. **Flushing of microbes in bodily fluids** this process excretes pathogens out of the body using different responses. Urination is a response that flushes infectious agents out of the urinary tract.

 2. **Specific Defenses,** this response mechanism is generated throughout the life of an organism. Specific defenses are key to the complex immune response. This defense is highly specific to a certain pathogen that has been processed through the innate response. The system has a slower response mechanism, although the response is stronger with increased exposure. Memory cells are present in this defense.

**B. Attributes of the Immune Response.** The immune systems include two key attributes that elicit an immune response:

1. **Specificity**, the immune response provides a unique action to combat an antigen. If an individual is given immunization for a particular virus, the immune system will elicit a precise response that is certain to the components of the virus treated for. The reason for specificity is because of the particular antigen receptors on lymphocytes. The identification must particularly match the receptor found on the lymphocyte. The receptors that are provided with the necessary criteria for the antigen will generate activation of a response.
2. **Memory,** this mechanism allows for a more timely response in exposure to a pathogen. Immunizations provide a memory background for the immune system to recognize a certain pathogen. This creates a protection system ready for future invaders to the system. The repeated presentation of an antigen, allows for the immune system to generate antigen specific lymphocytes after exposure to a particular invader. The cells produced in response will provide increased protection even after the antigen has been eliminated. If an organism is invaded by a particular pathogen in the future, the system will recognize it. Furthermore, the proliferated specific lymphocytes will provide a response of much greater amplitude.

**C. An Overview of the Immune Response.** The processes of the immune system include 3 critical phases.

1. **Introduction** of a foreign invader presented to a cell causes antigen-presenting cells such as: dendritic cells, macrophages, and lymphocytes to present an antigen. The invader is recognized by receptors on the presented cells. In response, an increased production of T and B cells are generated.

2. **Supplementation** of helper T cells produces an increased abundance of cytokines. These cytokines create an up production of antibodies presented to the affected cell. Proliferation and differentiation of T and B cells are generated.

1. **Effective Responses** such as: the formulation of antibodies, cytotoxic T cells, and macrophages. This response is also known as cell-mediated immunity. This process includes opsonization and phagocytosis. The response neutralizes toxins and viruses.

**III. Cells of the Immune System**

 **A. Lymphocytes and other antigen-presenting cells.** The blood in the body has two main types of cell subsets. Each has a unique physiological role that is important in maintaining proper regulation. Red blood cells sustain favorable oxygenation levels in the blood and tissues. White blood cells act as a protective mechanism, ready to fend off potentially harmful invaders.

 1. **B cells**, also known as plasma cells. **B lymphocytes** are involved in humoral immunity which involves the production of antibodies. B lymphocytes mature into plasma cells in the bone marrow. The human body contains millions of B cells ready to respond to millions of antigens. This allows the body to produce antibodies against an antigen it has never encountered.

 2. **T cells**, or **T lymphocytes** are involved in cell-mediated immunity. Multiple subsets of T lymphocytes are present. Responses of T cells include: activation/regulation of innate cells, activation/regulation of macrophages, recruitment/activation of neutrophils. They promote lymphocyte growth in general.

* 1. **Helper T lymphocytes,** these cells play a significant role in the amplification in the immune responses. Two distinct subsets of helper cells are present in immunity.
		1. TH1 lymphocytes, these cells provide assistance in the differentiation of cytotoxic T cells and can also cause macrophages to act. The cells are known as effectors in the immune response.
		2. TH2 lymphocytes are first and foremost known to be precursors in the upregulation of B lymphocytes.

**\***Additionionally, these responses are mediated by interleukins, which are a certain type of cytokine produced by many cells within the body. They play an essential part in the activation of immune cells.

* 1. **Cytotoxic T lymphocytes,** these cells are one of the main effector cell types. The cells act to directly attack and kill other cells. Activated Cytotoxic T cells circulate within the blood and lymphoid organs in search of antigen presenting cells. They can destroy all infected or abnormal cells.

3. **Antigen-presenting cells,** these cells incorporate an important role in the first stages of immune defense. These cells can trap pathogens and allow recognition by lymphocytes. The most efficient APC is a dendritic cell in a primary response, while macrophages and B cells are highly efficient in a secondary response. These cells can initiate innate and adaptive immune responses which induce a powerful stimulus for antigen presentation.

4. **Phagocytic cells** are another major effector cell mechanism in the immune response. These cells include: monocytes, macrophages, and granulocytes. After the presentation of an antigen or microbe by a plasma cell, phagocytic cells can recognize and ingest infected cells. The expression and representation of phagocytic cells can be influenced by the activation of an effector system known as *complement.* This can help in the dysregulation of microbes by an event such as opsonization. Furthermore, this event causes molecules to coat microbes allowing for an easier act of phagocytosis.

**5. Natural killer cells** use the same key mechanism that is used by cytotoxic T cells in destroying their target cells. The unique component of Natural killer cells is they can act directly on virus infected cells or act on infectious and invasive cells. They can also produce a response in the elimination of antibody coated cells.

**IV. Antigens and Antibodies**

* 1. **Antigens** are foreign molecules that are recognized by the immune system. They can bind to antigen-specific receptors and produce an immune response. Antigens that don’t bind, don’t produce an immune response. Antigens in the body cause the immune system to produce antibodies. Antigens include toxins, chemicals, bacteria, viruses, or other substances that come from outside the body.
	2. **Antibodies** are proteins produced in response to and counteracting against a certain antigen. Antibodies interact chemically with substances throughout the body that are recognized as foreign invaders such as: bacteria, viruses, and foreign substances that might be in the blood. Antibodies are produced and secreted by B cells. They are Y-shaped molecules consisting of two heavy chains and two light chains. An antigen binds to the antigen-binding site at the “tip of the Y”. An important note is that each antibody recognizes a specific antigen.
	3. **Antigen/Antibody Reactions.**

1. **Immunogenicity** is the quality of a molecule to induce an immune response.

2. **Factors Affecting Host Response** is characterized by the age, health, immune system function, route of exposure, exposure strength, and foreignness of invader.

3. **Forces Acting on Reactions**. Antigens and antibodies interact with intermolecular forces such as electrostatic/ionic, hydrogen, van der Waals, and hydrophobic bonds. These can influence the cohesiveness between reactions.

**4. Affinity/Avidity** is the strength of attractive forces within a reaction.

a. **Affinity** is the initial force of attraction between the antigen binding site and the antigen epitope.

b. **Avidity** is the sum of all attractive forces between antigen and antibody. This can measure the stability of the reactions

**V. A Brief Review of Defense Mechanisms**

1. **First Line of Defense**
2. The body’s first response to pathogens involves a variety of mechanisms
3. **Physical Barriers** (Skin/Mucous Membranes). The skin provides a blockage of entry to foreign microbes near the body’s surface. Mucous Membranes generate chemical factors that are made by the body to inhibit microbial growth.
4. **Antimicrobial Substances** (Lysozomes/Transferrins). An enzyme capable of breaking down cell walls, destroying them. Transferrins are iron binding proteins that inhibit the growth of certain bacteria by reducing the availability of iron found in bodily fluids.

**B. Second Line of Defense**

1. This defense operates when pathogens succeed in penetrating the skin or mucous membranes. Composed of cells, antimicrobial chemicals and processes. No physical barriers are present.
2. **Complement Proteins**, circulate in blood plasma. These can coat the surface of microbes making them easier for destruction by macrophages.
3. **Surveillance of White Blood Cells,** these cells act as a monitoring system ready to act on foreign invaders.
4. **Fever,** is the systematic reaction to infections, allergies, and other illnesses.
5. **Inflammation,** is a reaction to injury/infection. Can be characterized by redness, swelling, and/or pain at the site. Causes an increase in blood flow to the area,
6. **Phagocytosis,** certain white blood cells can engulf foreign microbes. Examples include: neutrophils, macrophages, eosinophils.

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