In order to fight off pathogens, which can be anything from bacteria to fungi, your body uses two types of defense mechanisms (Murray, Rosenthal, Pfuller, 2016). The first is the innate immune system. This is a nonspecific primary response that serves as the initial defense mechanism. This mechanism involves physical barriers and internal defenses. The second is the adaptive immune response, which responds to specific diseases. This type of immunity has memory and will be reactivated and elicit a faster response upon a second exposure to the pathogen. The adaptive immune response can be further broken down into humoral and cell mediated responses. In addition, the adaptive and innate immunity have specific cells that are involved with each type of immunity (Murray et al., 2016).

**Physical barriers**

The innate immune system has physical and internal defenses (Murray et al., 2016). The physical barriers serve as the initial anti-pathogen response for the body. The physical barriers include skin, hair, cilia, mucus membranes, chemical secretions, digestive enzymes, and stomach acid. An example of a chemical that is secreted is lysozyme. Lysozyme is in nasal secretions, saliva, and tears. The stomach is not the only organ that has an acidic environment. The kidneys and bladder also have a low pH. An additional physical barrier is urinary flow. Urinary flow prevents harmful bacteria from colonizing. If the pathogen or harmful bacteria gets passed the physical barriers, then a backup plan must be in place. This is when the internal defenses come into play (Murray et al., 2016).

**Inflammatory response**

The internal defenses include inflammatory response, complement proteins, phagocytic cells, and natural killer cells (Murray et al., 2016). While inflammation seems to be a negative thing it is actually beneficial to the body. **Inflammation** is activated if pathogens are detected or if tissue damage is present. There are many signs of inflammation including fever, pain, tissue damage, and vasodilation (Murray et al., 2016). **Vasodilation** is when blood vessels increase in size. These signs are beneficial in fighting off the infection. For example, vasodilation allows for the immune cells to rush to the infection in order to help fight off the pathogen. There are two types of inflammation: acute inflammation and chronic inflammation (Murray et al., 2016). **Acute inflammation** is the first response to an infection. Leukocytes (which we will learn about later) rush to the site of infection and function to try and repair the damaged tissue. **Chronic inflammation** is when inflammation does not subside and continues for long periods of time. This can be severe and may lead to further tissue damage or loss of function of the tissues (Murray et al., 2016).

**Innate Immune Cells**

There are many cells involved in the innate immune response. Many of the cells are known as leukocytes, also known as white blood cells (Murray et al., 2016). A process called hematopoiesis must generate these cells continually. This is done by a series of steps. The process starts with a self-renewing cell, which is turned into a pluripotent stem cell. The pluripotent stem cell is divided into two branches: myeloid progenitor cells or lymphoid progenitor cells (Murray et al., 2016).

**Myeloid Progenitor Cells**

The **myeloid progenitor cells** are made into two types of cells: non-nucleated and nucleated cells (Murray et al., 2016). The non-nucleated cells include erythrocytes and platelets. **Erythrocytes** are red blood cells. The nucleated cells include basophils, eosinophils, neutrophils, and monocytes. **Monocytes** are precursors for macrophages and dendritic cells. **Macrophages** function in phagocytosis. **Phagocytosis** involves the engulfment of a foreign cell, also known as an antigen, ingesting it, and presenting fragments of the digested cell on the surface in order to warn other cells of the intruder. An **antigen** is a pathogen or piece of a foreign substance that should not be in the body and therefore causes an immune response. Each cell has a different function relating to the immune response**. Basophils** and **eosinophils** function in the defense against pathogens and provide a response to allergies. **Neutrophils** function is phagocytosis and the main role for a **dendritic cell** is to present antigens to alert other cells to fight off the infection (Murray et al., 2016).

**Lymphoid Progenitor Cells**

The lymphoid progenitor cells differentiate into three lymphocytes: B-lymphocytes, T-lymphocytes and natural killer cells. **B-lymphocytes** are very important to adaptive immunity. These cells function to produce antibodies (Murray et al., 2016). **Antibodies** are Y-shaped structures that bind to the antigen or foreign cell. **T-lymphocytes** produce substances that function in cell death and help with the growth of B-cells. We will look into these lymphocytes in more detail later. **Natural killer lymphocytes** destroy the cells that have antibodies on their surface from B-cells. They also kill other infected cells such a tumor cells (Murray et al., 2016).

**Complement**

**Complement** is associated with the innate immune system. It is made up of many proteins and components that are located in the serum. These components are initially inactive, and when activated, they function to destroy microorganisms. They do this using three different ways: opsonization, inflammation, and cytolysis (Murray et al., 2016).

Complement can coat the microbes in a component called C3b. This is so that other cells can recognize it, and then that cell can be phagocytized and destroyed. C3b binds to neutrophils and macrophages in order to promote phagocytosis. Opsonization can be promoted in three ways. The phagocytic cell can be bound with an antibody, C3b, or by an antibody and C3b combined (Murray et al., 2016).

In order to induce inflammation, when the proteins of the complement are broken down they are able to attract cells that promote inflammation. The complement also activates a complex known as membrane attack complex (MAC) (Murray et al., 2016). The **MAC complex** causes apoptosis of cells, also known as cell death. It does this by putting a hole in the cell membrane in which the cytoplasm and its contents leak out of the cell. Complement must be activated in order to elicit a response. For now, just know that the **alternative pathway** is used to activate complement. There are other pathways, but we will learn about these in a later chapter. The alternative pathway is nonspecific and is activated by the contact with the cell surface of a microbe. Ultimately, this pathway results in the destroying the pathogen (Murray et al., 2016).

**Adaptive immunity**

As mentioned before, the **adaptive immunity** is the response to a specific antigen or infection. This type of immunity has memory and can be divided into two branches: humoral immunity and cellular immunity (Murray et al., 2016). Adaptive immunity relies on T-cells and B-cells, also referred to as lymphocytes. T-cells are made in the bone marrow but mature in the thymus, this is why they are called T-cells. T-cells are the middleman between cell-mediated and humoral immunity. There are three types of T-cells: helper T-cells, cytotoxic T-cells, and memory T-cells. **Helper T-cells** help to activate B-cells and contain the surface antigen CD4. The **cytotoxic T-cells** function in apoptosis (cell death) and contain the surface antigen CD8. **Memory T-cells**, as the name suggests, are able to respond to an antigen initially, and then initiate an immune response even faster upon the next encounter. There are two types of T-antigens. The first is **T-independent antigens**. These antigens have large components such as flagella or capsules that surround the bacteria. The antigen is able to cause a response from the B-cells without the participation of T-cells. The downfall of this is that only IgM antibodies are produced and memory cells are incapable of being produced. This means that there will not be a quicker response upon the next exposure of the antigen. IgM is short for immunoglobulin M, and is referring to a specific type of antibody. **T-dependent antigens** produce not only IgM but also are able to produce all five classes of immunoglobulins and generate memory cells (we will learn about this later). This is because the T and B-cells are able to bind to the antigen (Murray et al., 2016).

The B-cells, as mentioned earlier, produce antibodies, but they also engage in other functions as well. B-cells are made and mature in the bone marrow (Murray et al., 2016). After B-cells are made some will bind to antigens via their receptors. The antigen is then brought within the cell and processed. The B-cell then presents the pathogen fragments on its cell surface so that the helper T-cell can bind to it. This is when the B-cell is activated, and then it can go through clonal expansion. **Clonal expansion** is when the B-cell divides in order to make a large amount of cell copies (Murray et al., 2016). After the cells have been copied, they differentiate into two different types. They either become memory cells so they can elicit a quick response upon the second exposure to the antigen or they become plasma cells. Plasma cells function to produce antibodies (Murray et al., 2016).

As mentioned before, there are five types of immunoglobulins, also known as antibodies, which can be produced by B-cells. The major types are IgG, IgM, and IgA. The other two immunoglobulins are IgD and IgE, and these make up a very small percentage of the immunoglobulins present in the body. The immunoglobulin that is produced the most in blood and tissues is **IgG**. During an immune response **IgM** is detected before any other immunoglobulins. **IgA** is present in secretions, including breast milk and tears. **IgD** is hardly ever found in blood but it is present on B-cells. **IgE** functions to mediate infections and allergy reactions (Murray et al., 2016).

**Primary vs. Secondary response**

The adaptive immune system can be divided into two types of responses. **Primary response** occurs upon exposure to an antigen for the first time and **secondary response** occurs after being exposed to the antigen a second time. The primary antibody response is activated upon vaccination or when contracting a disease. After activation, B-cells make antibodies IgM and IgG. IgM is made first and then it is switched to IgG. These immunoglobulins are made within several days after exposure to the vaccine or disease. Memory cells are also made incase the immune system is exposed to the antigen a second time. These cells are induced if a booster dose of a vaccine is given or if the person is presented with the disease again. This causes the activation secondary antibody response. The antibodies are made within hours and have a more effective response (Murray et al., 2016).

**Humoral & Cellular Immunity**

**Humoral adaptive immunity** is associated with B-cells. This type of immunity involves antibodies and serves as the major defense against extracellular pathogens. Humoral immunity is the same mechanism that was mentioned earlier during the activation of B-cells. On the other hand, T-cells mediate **cellular immunity**. This type of immunity involves contact between cells and produces cytokines. **Cytokines** are the soluble products that cause apoptosis or cell death. The mechanism to activate a T-cell is as follows. The T-cell binds to an antigen-complex known as the MHC located on the cell surface. This activates the T-cell and allows a helper T-cell to secrete cytokines, which causes the T-cell to transform into a cytotoxic T-cell. The cytotoxic T-cell then causes apoptosis of the infected cell (Murray et al., 2016).

**Conclusion**

Overall, the human immune system is vital to live a normal healthy lifestyle. The nonspecific primary response of the innate immune system is important as well as the adaptive immune response that is specific to the antigen. Adaptive immunity can be further broken down in to humoral and cell-mediated immunity. There are many cells of the immune system, primarily known as leukocytes that are imperative to providing a fully functional immune system. In addition, there are other components to the immune system such as inflammation and the complement system. Lastly, the immune system is composed of two types of responses: primary and secondary responses. Primary and secondary responses are both important in making sure our body gets rid of harmful pathogens. The body’s immune system proves to be incredible and a key factor to our survival.

**Reference**

Murray, P. R., Rosenthal, K. S., & Pfaller, M. A. (2016). *Medical microbiology*. Philadelphia, PA: Mosby/Elsevier.