**Natural Defenses: The Immune System and Its Functions**

**Introduction:**

 The world around us is teeming with microscopic organisms called microbes, some beneficial, some harmless, and some harmful. When the body comes into contact with the harmful types of microbe, it relies on its natural defenses, finely tuned after thousands of years of evolution to detect and neutralize harmful invaders while leaving the surrounding tissues for the most part undamaged. It takes many different types of cells and cellular secretions to do this, and without these cells and the biochemical processes they perform, complex life as humanity presently understands it would’ve likely not developed.

* 1. **Physical Barriers to infection**

The human body has several barriers to infection that occur as a result of the environment that the groups of cell tissues create for it. The two major physical barriers to infection are the **Epidermis** and the **Mucous Membranes**. These two barriers form the first line of defense and are incredibly effective at blocking **Pathogens**, Microbes that infect a host cell in order to multiply and spread.

* + 1. **The Epidermis**

The **Epidermis,** composed of the outermost layers of the skin, is the largest organ in the body, and is a major part of the body’s initial immune defense. The Epidermis is composed of several layers of keratinized, stratified, squamous epithelial cells. These cells are found in uneven layered stipes (stratified) and have no standard definite shape(squamous). The properties of these cells create a harsh environment for would-be invaders. Firstly, keratinized cells are incredibly difficult to penetrate due to the hardness of keratin coating. Secondly, the secretions of glands within the skin make the Epidermis slightly acidic, coming in at a pH of about 5.5. These two properties alone keep most pathogens from entering through the skin, with the exception of an open wound. (OpenStax 2013)

* + 1. **The Mucosal Membranes**

Whereas the Epidermis protects the outside of the body, the **Mucosal Membranes** protect the bodies inner workings. The **Mucosal Membranes** are tissues composed of non-keratinized epithelial cells, and line the mouth, nasal passages, lungs, and gastrointestinal tract. As is made apparent by their name, these cells form a mucus layer that traps pathogens, allowing them to be caught and expelled from the body or sent into the stomach and dissolved. (OpenStax 2013).

* 1. **Innate Immunity**

The second line of defense is an inborn type of immune response dubbed **Innate Immunity**. This form of immunity is nonspecific for most pathogens, but does an excellent job determining self-entities, or things that are a part of the body, from nonself-entities, which are not originally from the body. This line of defense uses several different types of cell to detect and fight off infection. The major cells involved in innate immunity are the macrophages, the neutrophils, the monocytes, and the NK or Natural Killer cells.

* + 1. **Macrophages, Neutrophils, And Monocytes**

The macrophages, neutrophils, and monocytes make up the majority of cells involved in the processes of innate immune response**.** The **macrophages** are **phagocytic cells,** cells that phagocytose, or swallow, harmful substances and break them down into component structures. The macrophages are everywhere in the body and are meant to respond quickly to threats to the body. These cells easily find nonself entities, phagocytose them, and present antigens to T cells to activate the adaptive immune response. The **neutrophils** are granulocytes, cells that contain cytoplasmic granules that release infection fighting compounds into the body like histamines that aid the bodies normal immune function while also helping to kill off pathogens that are invading the body. Finally, the **monocytes** are immature immune cells that can be transported quickly through the body and be differentiated into either a macrophage or dendritic cell depending on the needs of the body during a particular immune response (OpenStax, 2013).

* + 1. **The Natural Killer Cells**

The **Natural Killer cells**, or NK Cells, are another type of phagocytic cell. These cells, however, also perform the function of killing cells in the body that have been infected by pathogens. They do this by initiating a natural process of cell death called **Apoptosis**. When the **natural killer cell** detects a pathogen-infected cell through a process involving its surface sensors, it uses enzymes called **perforins** to perforate the cell wall and send in another enzyme, called **granzymes** to trigger apoptosis (OpenStax 2013). Once this is triggered in an infected cell, the cell wall ruptures and the cell dies, taking the pathogens with it. A natural killer cell can also use this method of triggering the natural apoptotic process of a cell to kill rogue cancerous cells, thus helping to prevent tumors. (Khan Academy, 2014).

* 1. **Adaptive Immunity**

Whereas the **innate immune response** is a fast first responder with no immunological memory, the **adaptive immune response** is a slower, more permanent solution to immunological threats. The adaptive immune response differs from the innate immune response in several key factors. First, the adaptive immune response is much slower than the innate immune response, taking several days, whereas the innate immune response only takes minutes (Kenneth et al., 2017). Second, the adaptive immune response keeps immunological memories of pathogens it has come into contact with before in order to respond more effectively to infections from the same pathogen in the future. Lastly, while the innate immune response is very good at discriminating between self and nonself entities, it is not as good as the innate immune responses near perfect self-discrimination. The major cells in the adaptive immune response are **dendritic cells**, **T cells**, and **B cells**. Interestingly, while all animals have an innate immune response, only vertebrates possess and adaptive immune response. (Kenneth et al., 2017).

* + 1. **Dendritic Cells**

**Dendritic cells** are one of the most vital parts of the whole immune response. They are important because they act as the bridge between the innate immune response and the adaptive immune response. This is because dendritic cells are a type of professional antigen presenting cell, or a cell whose purpose is to detect antigens, bind them, and present the bound antigen to T cells, activating them and triggering the rest of the adaptive immune response (Kenneth et al., 2017).

* + 1. **B Cells**

The purpose of a **B cell** is to produce antibodies when activated. The activation of **B cells** is handled by special T cells called helper T cells in the lymph nodes. In addition to producing antibodies, **B cells** will also proliferate, or create more of themselves. This activation occurs when a **T cell** detects the antigen it is specific for. (OpenStax, 2013)

* + 1. **T Cells**

**T cells** are the memory cells of the adaptive immune response and the main reason why they are so effective at curbing invasions by harmful pathogens. They are named **T cells** due to their origin point, the thymus. **T cells** are initiated when they sense a specific antigen presented by **dendritic cells** in the **T cell zone** of a lymph node. When activated by antigen presentation by a professional antigen presenting cell in a lymph node, the T-Cells will activate **B cells**, who will then produce antibodies. (Kenneth et al. 2017)

* 1. **Immune Diseases**

Now that we’ve discussed how the immune system works, what happens when it doesn’t? The immune can malfunction in 2 main ways, autoimmune disorders and immunodeficiencies. In the case of autoimmune disorders, this means the bodies T cells recognize the body as foreign and begin to activate the immune system to attack the body. Autoimmune diseases such as multiple sclerosis lead to the destruction of body tissue and early death in the individual. Immunodeficiencies are caused by a multitude of different infection and gene related factors, and cause the afflicted individual to be much more susceptible to disease.

* 1. **Summary**

With its physical barriers, innate sentries, and memory acquiring cells, the vertebrate immune system is a highly vigilant and versatile guard against the infectious pathogens that surround us every day. It is fair to say that you wouldn’t be reading this if your skin and mucous membranes weren’t walling pathogens out. If your macrophage “sentries” weren’t guarding against any pathogens that managed to cross that barrier. Even if those two defenses alone aren’t enough to defeat the pathogenic menace, your B and T cells will be there to learn how to better detect and fight the enemy, and then reuse that crucial information again and again in the many microscopic battles to come.

**References**

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