The Immune System: An Overview

On a daily basis the human body is exposed to millions of different microorganisms, while a majority of them are not harmful to us, there are those that do cause illness. While it is unquestionable that we come into contact with these harmful microorganisms in our life, our body has a very unique and complex way of trying to protect us from them. It is the strength and ability of our body to fight off these potentially dangerous organisms that determines whether or not we get sick from them. The name of this defense system in our body is called the immune system, which is a network of cells, tissues, and organs that work together to protect the body (Durani). The resulting actions of this network when exposed to these infectious germs is better known as the immune response. This response is often broken into two different sections, the innate response, and the adaptive response; while it is to note that these two responses are different, it is important to keep in mind they work together often simultaneously in order to fight off the intruder.

The Innate Immune Response

The innate immune response is characterized by physical, chemical, and microbiological barriers that work to prevent infiltration, as well as provide an immediate protective response (Parkin & Cohen). This consists of the mucous membranes in our nose and mouth, our tears, earwax, oils on our skin, as well as some cellular responses within the body. This form of defense is present from birth and elicits a much broader immune response. If a pathogen, a microorganism that can cause disease, makes it past these external barriers and into our body, the fight begins inside the body. A major difference between the innate and adaptive response is that the innate response is not specific. Meaning that when its defense system is employed, it does not look for or attack any specific pathogen. It will defend against any foreign intruder that it comes into contact with. With that being said, these responses are non-self-specific, being that they naturally do not attack their own kind exhibiting a tolerance for them. It knows when a foreign intruder is present because they all contain antigens, which are anything on the cell that elicits the immune response. These are mostly proteins but can also be nucleic acids or other biomolecules. It is these antigens that our body recognizes as potentially dangerous and begins the protective response. Another important difference in the two responses is that the innate immunity cannot produce any type of memory of the pathogens it comes into contact with. So, each time it is compromised, it must go through the steps of recognizing it, and then producing specific cells to fight it all over again.

In order to come into contact with these pathogens, white blood cells, also called leukocytes, are constantly circulating throughout the body searching. Leukocytes can come in many different forms, each having a slightly different job within the response. The response of many leukocytes to the area of infection is what results in the symptom inflammation. This increases blood flow to the area in order to increase the number of immune cells in the area to help. One major type of leukocyte is phagocytes, which circulate only through the bloodstream, and upon sensing an antigen, engulf the cells through a process called phagocytosis. Phagocytosis is the process through which the cell “eats” the intruder in order to kill it. Another major type of leukocyte is macrophages, which like phagocytes engulf pathogens, they differ in their ability to leave the circulatory system giving it less restricted range. After engulfing, macrophages take the immune response one step further by releasing cytokines, which are responsible for recruiting other surrounding immune cells. This alerting also tells cells to be on the lookout for other intruders, basically sounding the defense bells of the body. The last type of leukocyte we will cover are dendritic cells which are often located in mucous membranes or on tissues. Being so close to the usual points of entry for pathogens, these cells are very important in early detection and defense. They utilize phagocytosis as well, the only difference being when they engulf the pathogen they are capable of taking the antigen presented on it and actually presenting it on the outside of itself. When dendritic cells present this antigen material, it triggers cells in the adaptive immunity to begin working. This is very important, and a great example of how innate and adaptive immunity are linked.

Adaptive Immunity

The cells of the adaptive immunity, while present before exposure, are able to fight off the intruder as soon as it enters; they must go through a sort of training in order to prepare for the specific pathogen. It is like watching film before a football game, you must prepare and learn about your specific target and get the troops in line before the game. The film in this analogy being antigen. The adaptive immunity is a much slower immune response and is also specific. The defense cells in this immunity must be instructed to attack a very specific antigen presenting pathogen. If there are two pathogens and an adaptive defense cell is specific for one, it is unable to protect against the other one. The two main types of cells implored in the adaptive immunity are T cells and B cells. T cells are produced in the thymus and are activated upon antigen recognition. Dendritic cells as mentioned in the innate immunity, are capable of presenting antigen material on their surface which is often identified by the T cells. Once they have been activated, the T cell will proliferate into one of three differentiations (Parkin & Cohen). One possibility is a cytotoxic T cell. Its job is to search down and kill the pathogen bearing the same antigen it was shown. When it finds this specific pathogen, it pokes holes in the cell membrane and inserts granzymes into the target cell, which causes apoptosis or cell death (Parkin & Cohen). Another differentiation of the T cell is T helper cells. These play an important role in releasing more cytokines into the area, bringing in even more backup and furthering the immune response. The third possibility is a T effector cell. These cells are responsible for activating B cells, the cells that allow the body to both produce antibodies as well as a memory.

When a T effector cell tells the B cell about an intruding antigen, it then differentiates into one of two cells. It can change into a plasma cell, from which it then in turn produces many antibodies. These antibodies are specifically designed to lock onto the antigens, either completely neutralizing it, or tagging it for phagocytes to come engulf. Antibodies are extremely specific, with even the slightest variation of an antigen making it become completely unidentifiable. The second option is changing into a memory cell. These cells allow for long term protection against this pathogen. It does this by remembering the antigen, and upon a secondary exposure it can immediately begin the pathways of antibody production, skipping the innate response and speeding up reaction time. This allows for a faster and hopefully successful illness prevention. Forcing exposure to a dead/inactive pathogen allows the body to create memory cells; which is how scientists engineer vaccinations.

Conclusion

When thinking about the immune system all together, it is critical to keep in mind how all the different aspects work together to defeat a pathogen. While they are responsible for carrying out their own independent jobs in the response they also might trigger another response or be involved in a pathway. When thinking about the big picture of general immune responses, it is important to remember these things. The innate immune response is elicited first in response to a microorganism that makes it past the first lines of defense. It is an unspecific response that tries to kill the intruder if it can, but more importantly spreading the news of the intruder. It does not know who it is or what it is doing, it just knows it needs to get rid of it and call for backup. It also has no memories of the exposure as it cannot remember the antigen. As part of the innate response telling the rest of the body, it triggers the adaptive immune response; while this can be activated independently it at least strengthened if not started by the innate response. Some results of these reactions can cause symptoms such as inflammation and allergies, both designed to get rid of the pathogen. The adaptive immunity is specific to certain antigens, and often takes much longer to begin. It’s overall goals being antibody production and future memory; memory being the fundamental theory behind vaccinations. Both of these components work together as a team to eliminate the current pathogen, as well as protect against future secondary exposure.

References

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