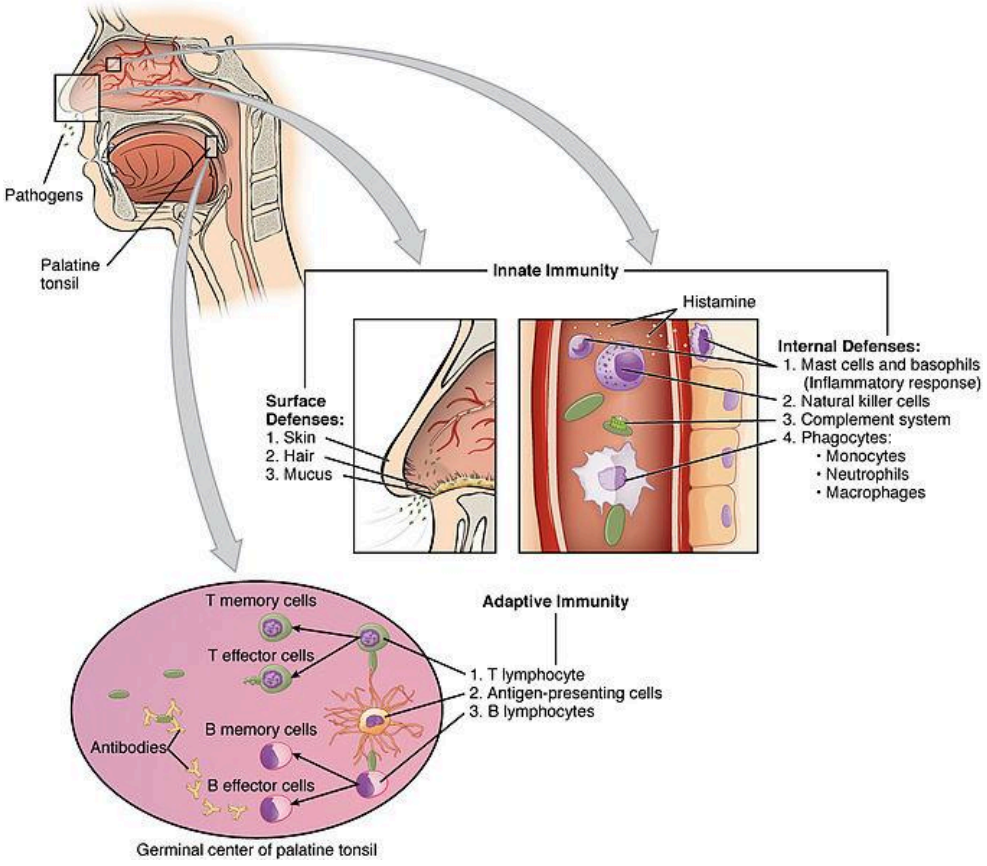
3.2.1

Specific Defenses of the Immune Response

What happens if bacteria or viruses get through the first wall of defense (physical barriers) and are not destroyed by the second wall of defense (inflammation, phagocytes, complement proteins, or fever)? Then it is up to the final wall of defense, the specific defenses or the immune response, to destroy the pathogen and protect our health. The specific defenses are carried out by 3 different cell types: helper T-cells, cytotoxic T-cells, and B-cells. These cells are produced in the bone marrow and are released into the blood in an inactive state. Inactive helper T-cells, cytotoxic T-cells, and B-cells are referred to as being *naïve.* In order to mount a defense against a pathogen, these cells must undergo an activation process. Once activated, the cells will divide rapidly, producing many more activated cells of the same type. These additional cells will then carry out their functions in destroying any bacterial or viral pathogens that have entered the body tissues.



All Lines of Defense: Cooperation between Innate and Adaptive Immune Response

Author: OpenStax College. License: Creative Commons Attribution 3.0 Unported license Link: https://books.byui.edu/-bWMR

The specific defenses are called “specific” because they are directed against very specific targets. The elements of the first two walls of defense are general defenses that can be effective against any type of pathogen. For example, the physical barriers are effective in preventing E. coli bacterial infections, as well as infections caused by the flu virus. Similarly, the same phagocyte could carry out phagocytosis on the bacteria that cause tuberculosis and the viruses that cause rabies. The first two walls of defense are commonly referred to as “non-specific” defenses because they can be effective against any type of pathogen. When looking at the effect of helper T-cells, cytotoxic T-cells, and B-cells; each cell will only be effective in helping defend against one specific type of pathogen. For example, if a certain B-cell is helping defend the body from the bacteria that causes strep throat, it would be totally useless in helping fight off an infection caused by the cold virus. What is the basis of their ability to be so specific? It is due to their ability to recognize foreign antigens. Most antigens are proteins found on the surface of bacterial cells and viruses, but other molecules, such as carbohydrates, can also function as antigens. Each specific B-cell or T-cell can only recognize and become activated by a single type of antigen, making them “specific” for the particular pathogen containing that antigen.

Helper T-cells.

Once activated, helper T-cells “help” cytotoxic T-cells and B-cells become activated to fight infections. When macrophages carry out phagocytosis, they process some of the proteins from the pathogen and present them on the outer surface of their plasma membrane. Naïve helper T-cells can then come in contact with the antigens to become activated. When a helper T-cell is activated by an antigen on the surface of a macrophage, the helper T-cell will begin to divide rapidly and produce many new cells that are also in an activated state. Most of these activated helper T-cells will move throughout the body to help activate cytotoxic T-cells and B-cells to destroy the antigen. If the helper T-cells are not able to “help” the cytotoxic T-cells and B-cells, these cells will not become activated to fight most types of infections. This is actually what happens when a person becomes infected with the human immunodeficiency virus (HIV). This virus infects the helper T-cells. When the population of functional helper T-cells becomes too low, the patient suffers from Acquired Immunodeficiency Syndrome (AIDS). In other words, their immune system is deficient in providing their body with protection because the helper T-cells are not able to help the cytotoxic T-cells and B-cells become activated to fight other infections. The ultimate cause of death in AIDS patients is usually a pathogen that wouldn’t even make a person with a healthy immune system sick, but since the cytotoxic T-cells and B-cells won’t respond, the pathogen can survive in the body long enough to cause death.

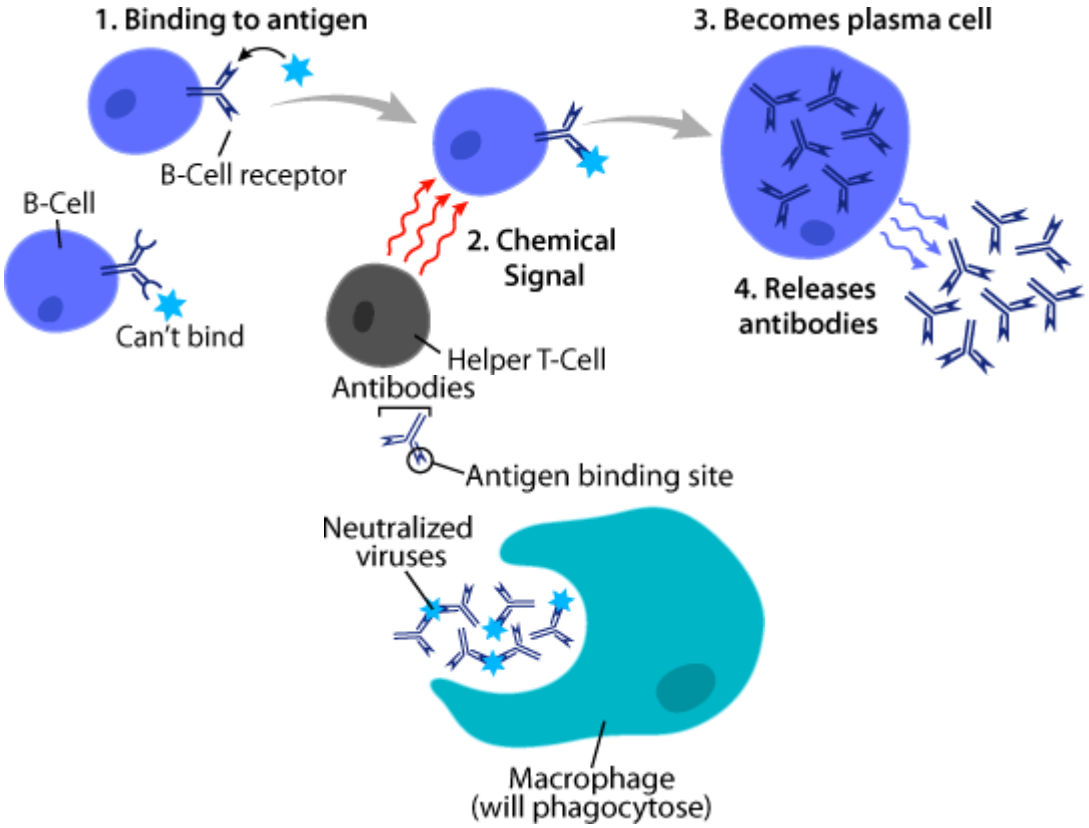
Cytotoxic T-cells

Cytotoxic T-cells can also recognize antigens bound to the surface of other cells, but in order to become activated, an activated helper T-cell must give them a *second signal* by releasing special communication chemicals called cytokines. (The antigen is the *first signal* for activation). When a cytotoxic T-cell recognizes an antigen, and receives the second signal from a helper T-cell, the cell will become activated and divide rapidly to produce many new cells. Most of these new cells will then begin to circulate through the body looking for body cells that have been infected with viruses. When any of our body cells become infected with a virus, the cell will take antigens from the virus and place them on the surface of the cell. This will allow the cytotoxic T-cells to discover which cells are infected. When a cytotoxic T-cell finds an infected cell, it will release substances that will kill the infected cell. That is why these cells are called “cytotoxic”, they are literally “toxic” to cells that are infected with viruses. In a similar fashion, cytotoxic T-cells can also recognize and destroy cells that have become cancerous. Therefore, cytotoxic T-cells give us protection from viruses and cancer.

B-cells

B-cells function to produce antibodies that can bind to antigens, but each B-cell can only produce antibodies that will bind to a single type of antigen. Naïve B-cells are coated with the type of antibody produced by that particular cell. If they encounter the antigen that their antibodies can recognize, the B-cells will bind to the antigen and carry out endocytosis. After destroying the pathogen, antigens will be presented on the surface of the B-cell allowing helper T-cells to “see” what antigen the B-cell recognizes. If an activated helper T-cell recognizes the antigen on the B-cell, the helper T-cell will give the *second signal* for activation by releasing cytokines. Once the second signal has been received, the B-cell will divide rapidly and produce many new B-cells. Most of these cells will begin producing antibodies and release them into the blood stream at a rate of approximately 2000 antibodies per second! These antibodies can then

bind to the antigen they recognize. Once bound to an antigen, antibodies have 3 main effects: enhancing phagocytosis, activating complement, and neutralizing the antigen.



B- Cells Function.

Author: Arizona Board of Regents/ASU Ask a Biologist, Link: https://books.byui.edu/-eVfL License: Creative Commons Attribution-Share Alike 3.0 Unported License CC BYU-SA 3.0

As previously described, phagocytosis can occur without antibodies, but when an antigen is coated with antibodies, macrophages are much more effective and efficient at destroying antigens via phagocytosis. The complement system (normally nonspecific) can also be further activated by the presence of antibodies. Finally, antibodies can coat an antigen, rendering it harmless to the body, a process called neutralization. Neutralization is very beneficial in providing protection from viruses and from poisons or toxins produced by bacteria or from other sources. It is actually possible for a human to gain total protection from rattlesnake venom if they have antibodies that can neutralize the venom and not allow it to cause the tissue damage that would normally result from exposure to the poison. This is achieved by administering small doses of poison over a long period, or alternatively, you could just avoid rattlesnakes!

On the next page you will find a full-page image that shows the "big picture" story of what is happening with the principles of specific immunity.

You may also CLICK HERE to watch a video that goes through this next picture