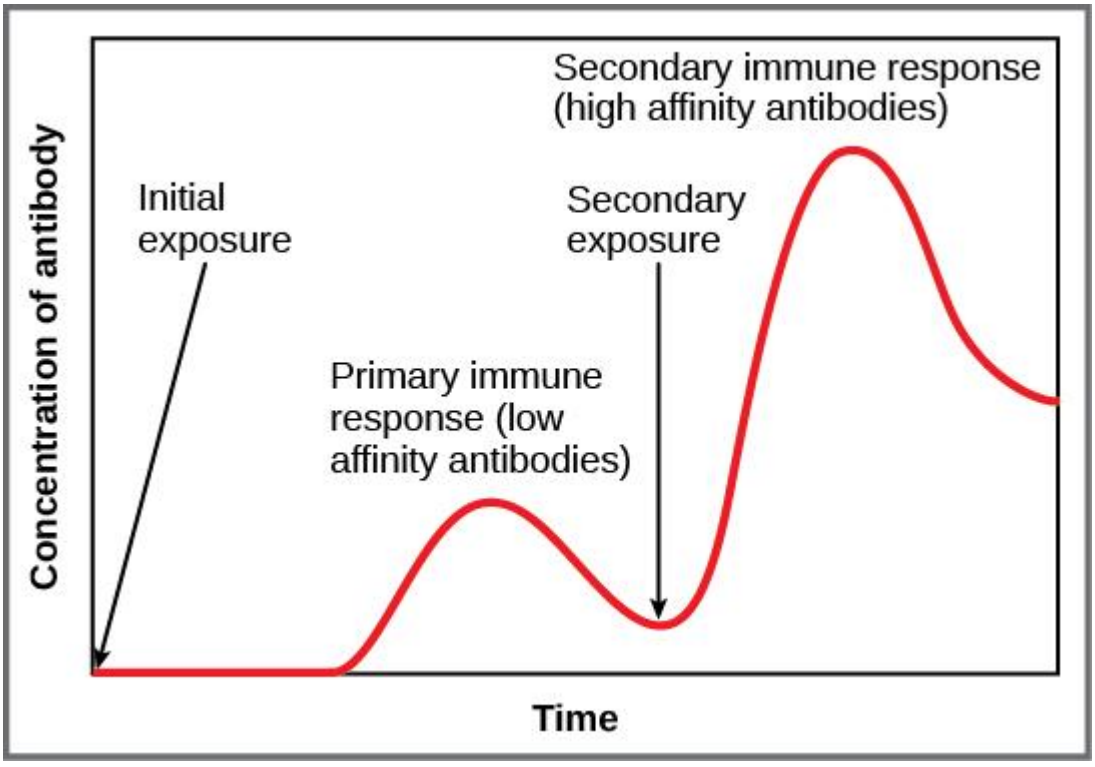
3.2.3

Immunological Memory

In addition to being specific to a particular antigen, the immune response also exhibits a property called **immunological memory.** When a person is exposed to an antigen for the first time, the helper T-cells, cytotoxic T-cells, and B-cells can become activated and mount a defense to destroy the antigen. It normally takes 5-10 days for a detectable response to occur during the first contact with an antigen. The first exposure to an antigen results in a *primary response* to the antigen, but if the person is exposed to the same antigen a second time, a *secondary response* occurs. The secondary response almost always results in a detectable response within 24 hours and is much more effective at destroying the pathogen because many more helper T-cells, cytotoxic T-cells, and B-cells become activated to destroy the antigen. As a result, most healthy individuals will only get sick with a pathogen one time, as long as the pathogen has the same antigens on a subsequent exposure.



Primary versus Secondary Immune Response.
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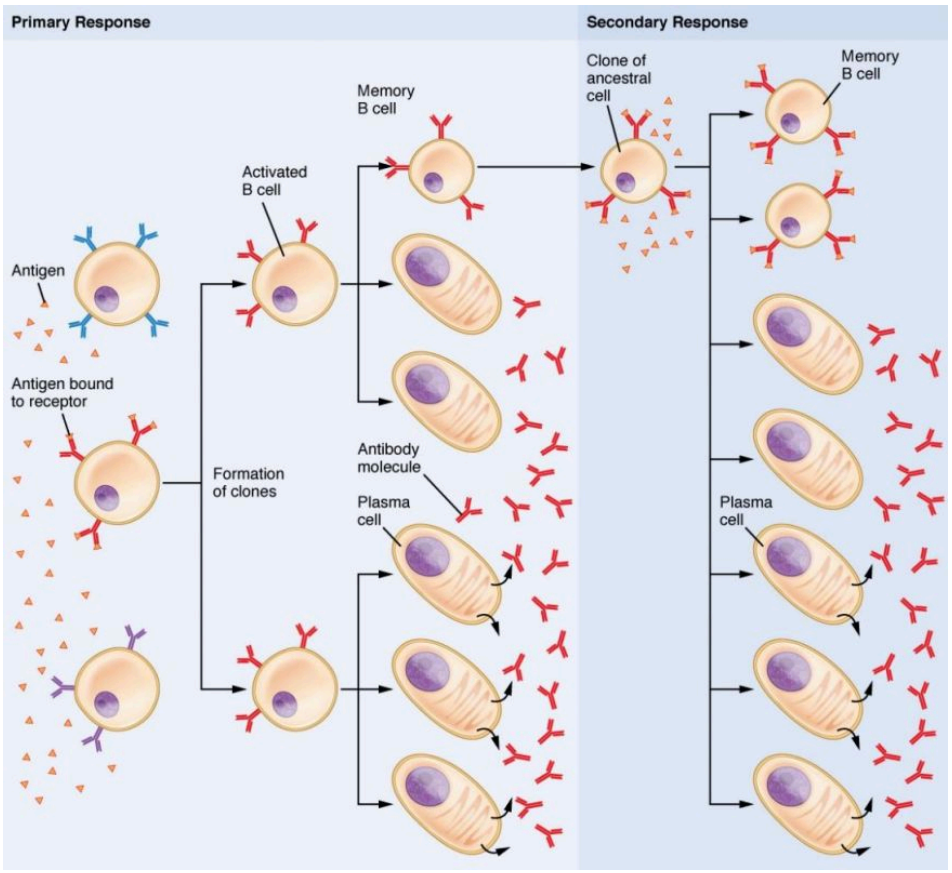
For example, before immunizations for chickenpox were available, most children would get infected with the virus at some point in their childhood, but it is very rare for a child to get chickenpox twice. Why? When the child is exposed to the chickenpox virus for the first time, helper T-cells, cytotoxic T-cells, and B-cells can become activated and give a

primary response to the viral antigens. However, this primary response takes between 5-10 days for the number of activated white blood cells to build up enough to elicit an effective counter attack. As a result of this delay in activation and lower number of activated helper T-cells, cytotoxic T-cells, and B-cells, the virus will stay in the body long enough to do damage and cause the signs and symptoms associated with the chickenpox infection. Eventually the immune response will lead to the destruction of the viruses and the child will be able to get over the infection. If the child were infected with the chickenpox virus a second time (even many years later), the immune response will be much faster and will produce many more activated helper T-cells, cytotoxic T-cells, and B-cells to fight the infection. As a result, the virus will usually be controlled within a few hours after it enters the body and it won't have time to cause the damage that we would normally associate with a chickenpox infection. Early physicians and scientists recognized that if a person had an infection, like smallpox, and survived, they would never get the same infection again. In essence they become "immune" to the effects of subsequent exposures to the pathogens, hence the name immune system.

Why is there a different response on a second exposure to the antigen? As previously described, when helper T-cells, cytotoxic T-cells, and B-cells become activated, they divide rapidly to produce many new cells. B-cells divide into either plasma cells or memory cells. The plasma cells secrete large volumes of antibodies that bind onto target antigen of the foreign substance and mark it for destruction by the cytotoxic T-cell. Most of the new cells, such as the plasma cells, that are produced will carry out that cell's particular function in the immune system, but a few of the new cells will not participate in fighting the current infection. Rather, they will stay in the body in a partially activated state. These partially activated cells are referred to as **memory cells.** If memory cells are exposed to the antigen at a later time, they will become fully activated, dividing and producing many more cells. From these new cells, most will help to fight the infection, but some will become memory cells to provide protection on any subsequent exposure to the antigen. Since the cells have a "memory" of the antigen they can create a much faster defense reaching full strength in less than 24 hours rather than 5 to 10 days.



Memory and Plasma B Cells.

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More specifically, because there are relatively few naïve helper T-cells, cytotoxic T-cells, and B-cells in the body that can respond to a specific antigen, it can take several days for the antigen to be noticed by the right cell. Also, the cytotoxic T-cells and B-cells must have helper T-cell assistance to become activated for the first time. It also takes time for the correct helper T-cell to find the cytotoxic T-cells or B-cells that recognize the same antigen. As a result, it takes 5-10 days for the activation process to occur and the immune response to start removing the antigens from the body during the first exposure to an antigen. However, once the primary immune response is activated and functions, the resultant memory cells are very abundant and they do not require any helper T-cell assistance to become fully activated. Thus, when a person gets exposed to that antigen a second time, the response is much faster. Additionally, memory cells are much better at producing plasma cells so that the antibody response is much greater. The end effect is that the secondary response can eliminate the antigen before it has time to cause damage to the body.

If immunological memory is so effective, why do people continue to get some infections, like strep throat, the common cold, and the flu, over and over throughout their lives? In some cases, there are many different pathogens with different types of antigens that cause the same type of infection. For example, there are over 100 different types of viruses that cause the disease we call the common cold. Therefore, a person would have to get the cold over 100 times before they would have total immunity to that infection. Strep throat is similar in that there are over 80 different antigen types found on the different types of bacteria that cause the infection. The flu is a little different. Flu viruses have very high mutation rates, so the antigens of the virus literally change from year to year. So, if you get the flu this year, you would develop memory cells to this year's antigens, but next year the flu viruses will most likely have different antigens, so you could keep getting the flu year after year.