Adaptiveimmunity

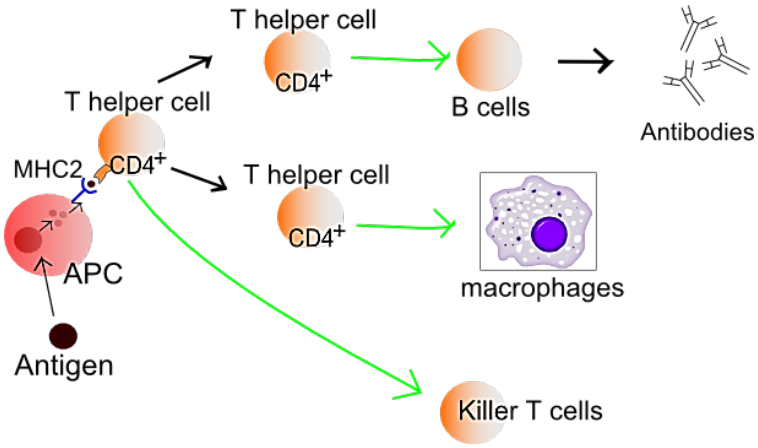
Moumita Pal

Adaptive Immunity

Adaptive system is mainly responsible for more complex reactions. This system activates after innate response is fully activated. Initially, the antigen entered in body is identified by the specific immune cells, then a cascade of reactions is started in the form of antigen antibody reaction to attack the antigen. This immune system also includes generating memory of antigens, which will save their identities in the memory cells so that a specific response will be initiated soon after entry of the same pathogen in future.

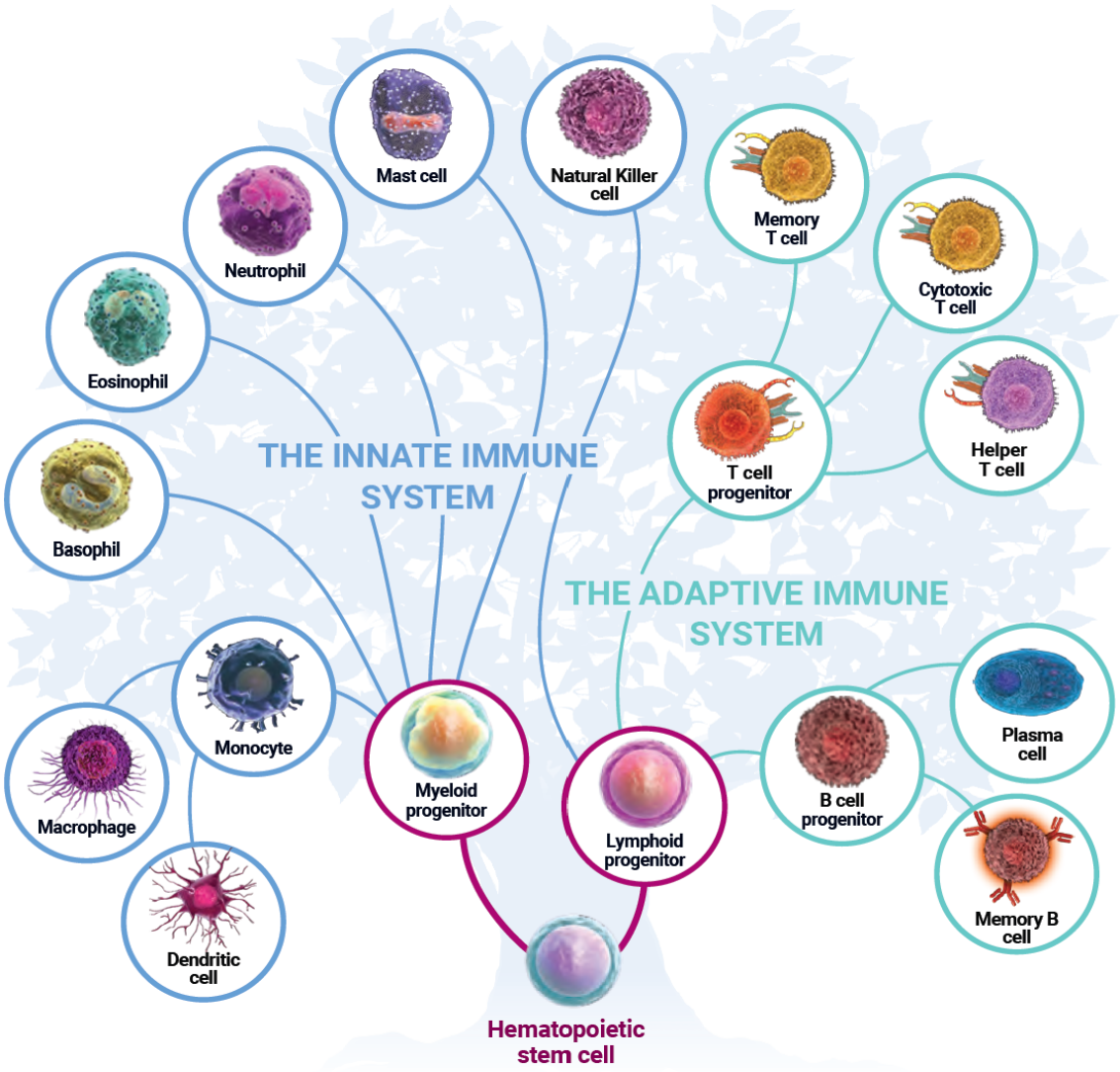
Cells of the adaptive immune system

Unlike the innate immune system, the adaptive immune system relies on fewer types of cells to carry out its tasks: *B cells* and *T cells*.
Both B cells and T cells are lymphocytes that are derived from specific types of stem cells, called multipotent hematopoietic stem cells, in the bone marrow. After they are made in the bone marrow, they need to mature and become activated. Each type of cell follows different paths to their final, mature forms.



B cells

After formation and maturation in the bone marrow (hence the name “B cell”), the naive *B cells* move into the lymphatic system to circulate throughout the body. In the lymphatic system, naive B cells encounter an antigen, which starts the maturation process for the B cell. B cells each have one of millions of distinctive surface antigen-specific receptors that are inherent to the organism’s DNA. For example, naive B cells express antibodies on their cell surface, which can also be called *membrane-bound antibodies*.
When a naive B cell encounters an antigen that fits or matches its membrane-bound antibody, it quickly divides in order to become either a *memory B cell* or an *effector B cell*, which is also called a *plasma cell*. Antibodies can bind to antigens directly. The antigen must effectively bind with a naive B cell’s membrane-bound antibody in order to set off *differentiation*, or the process of becoming one of the new forms of a B cell. Memory B cells express the same membrane-bound antibody as the original naive B cell, or the “parent B cell”. Plasma B cells produce the same antibody as the parent B cell, but they aren’t membrane bound. Instead, plasma B cells can secrete antibodies. Secreted antibodies work to identify free pathogens that are circulating throughout the body. When the naive B cell divides and differentiates, both plasma cells and memory B cells are made.
B cells also express a specialized receptor, called the *B cell receptor (BCR)*. B cell receptors assist with antigen binding, as well as internalization and processing of the antigen. B cell receptors also play an important role in signaling pathways. After the antigen is internalized and processed, the B cell can initiate signaling pathways, such as cytokine release, to communicate with other cells of the immune system.



T cells

Once formed in the bone marrow, *T progenitor cells* migrate to the thymus (hence the name “T cell”) to mature and become T cells. While in the thymus, the developing T cells start to express *T cell receptors (TCRs)* and other receptors called *CD4* and *CD8* receptors. All T cells express T cell receptors, and either CD4 or CD8, not both. So, some T cells will express CD4, and others will express CD8.

Unlike antibodies, which can bind to antigens directly, T cell receptors can only recognize antigens that are bound to certain receptor molecules, called *Major Histocompatibility Complex class 1 (MHCI)* and *class 2 (MHCII)*. These MHC molecules are membrane-bound surface receptors on *antigen-presenting cells*, like dendritic cells and macrophages. CD4 and CD8 play a role in T cell recognition and activation by binding to either MHCI or MHCII.

T cell receptors have to undergo a process called rearrangement, causing the nearly limitless recombination of a gene that expresses T cell receptors. The process of rearrangement allows for a lot of binding diversity. This diversity could potentially lead to accidental attacks against self cells and molecules because some rearrangement configurations can accidentally mimic a person’s self molecules and proteins. Mature T cells

should recognize only foreign antigens combined with self-MHC molecules in order to mount an appropriate immune response.
In order to make sure T cells will perform properly once they have matured and have been released from the thymus, they undergo two selection processes:

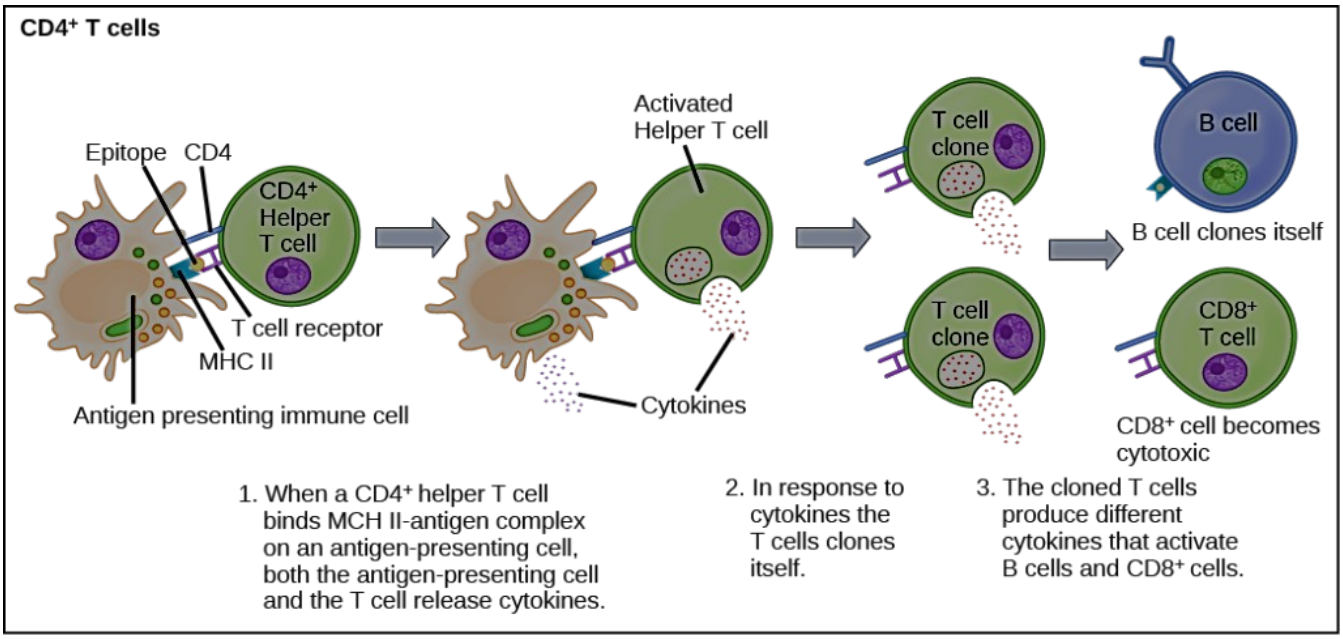
1. *Positive* selection ensures MHC restriction by testing the ability of MHCI and MHCII to distinguish between self and nonself proteins. In order to pass the positive selection process, cells must be capable of binding only self-MHC molecules. If these cells bind nonself molecules instead of self-MHC molecules, they fail the positive selection process and are eliminated by apoptosis.
2. *Negative* selection tests for self tolerance. Negative selection tests the binding capabilities of CD4 and CD8 specifically. The ideal example of self tolerance is when a T cell will only bind to self-MHC molecules presenting a foreign antigen. If a T cell binds, via CD4 or CD8, a self-MHC molecule that isn't presenting an antigen, or a self-MHC molecule that presenting a self-antigen, it will fail negative selection and be eliminated by apoptosis.

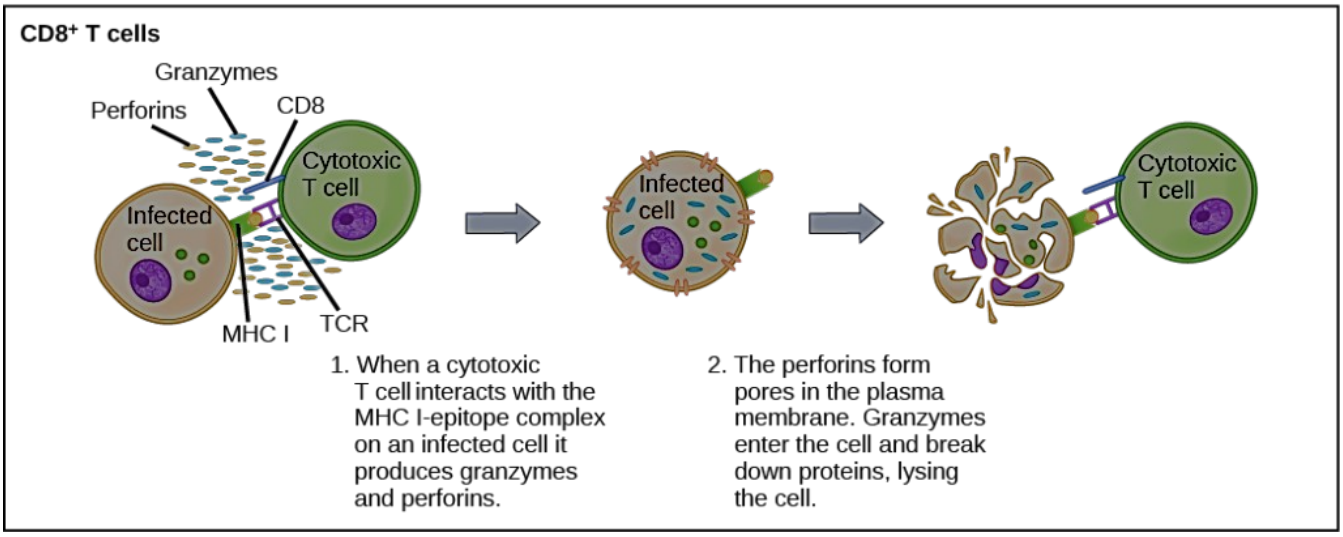
These two selection processes are put into place to protect your own cells and tissues against your own immune response. Without these selection processes, autoimmune diseases would be much more common.
T cell positive selection and negative selection process. After positive and negative selection, we are left with three types of mature T cells: *Helper T cells*, *Cytotoxi T cells* and *T regulatory cells.*

1. *Helper T* cells express CD4, and help with the activation of T_C cells, B cells, and other immune cells.
2. *Cytotoxic T* cells express CD8, and are responsible for removing pathogens and infected host cells.
3. *T* regulatory cells express CD4 and another receptor, called CD25. T regulatory cells help distinguish between self and nonself molecules, and by doing so, reduce the risk of autoimmune diseases.

Humoral vs. Cell Mediated Immunity

Immunity refers to the ability of your immune system to defend against infection and disease. There are two types of immunity that the adaptive immune system provides, and they are dependent on the functions of B and T cells, as described above.
Humoral immunity is immunity from serum antibodies produced by plasma cells. More specifically, someone who has never been exposed to a specific disease can gain humoral immunity through administration of antibodies from someone who has been exposed, and survived the same disease. "Humoral" refers to the bodily fluids where these free-floating serum antibodies bind to antigens and assist with elimination.
Cell-mediated immunity can be acquired through T cells from someone who is immune to the target disease or infection. "Cell-mediated" refers to the fact that the response is carried out by cytotoxic cells. Much like humoral immunity, someone who has not been exposed to a specific disease can gain cell-mediated immunity through the administration of TH and TC cells from someone that has been exposed, and survived the same disease. The TH cells act to activate other immune cells, while the TC cells assist with the elimination of pathogens and infected host cells.





Immunological memory

Because the adaptive immune system can learn and remember specific pathogens, it can provide long-lasting defense and protection against recurrent infections. When the adaptive immune system is exposed to a new threat, the specifics of the antigen are memorized so we are prevented from getting the disease again. The concept of immune memory is due to the body's ability to make antibodies against different pathogens.

A good example of immunological memory is shown in vaccinations. A vaccination against a virus can be made using either active, but weakened or attenuated virus, or using specific parts of the virus that are not active. Both attenuated whole virus and virus particles cannot actually cause an active infection. Instead, they mimic the presence of an active virus in order to cause an immune response, even though there are no real threats present. By getting a vaccination, you are exposing your body to the antigen required to produce antibodies specific to that virus, and acquire a memory of the virus, without experiencing illness.

Some breakdowns in the immunological memory system can lead to autoimmune diseases. Molecular mimicry of a self-antigen by an infectious pathogen, such as bacteria and viruses, may trigger autoimmune disease due to a cross-reactive immune response against the infection. One example of an organism that uses molecular mimicry to hide from immunological defenses is *Streptococcus* infection.

Innate Immunity vs. Adaptive Immunity:

The following chart compares and summarizes all of the important parts of each immune system:

Attribute	Innate Immunity	Adaptive Immunity
Response Time	Fast: minutes or hours	Slow: days
Specificity	Only specific for molecules and molecular patterns associated with general pathogens or foreign particles	Highly specific! Can discriminate between pathogen vs. non-pathogen structures, and miniscule differences in molecular structures
Major Cell Types	Macrophages, Neutrophils, Natural Killer Cells, Dendritic Cells, Basophils, Eosinophils	T cells, B cells, and other antigen presenting cells
Key Components	Antimicrobial peptides and proteins, such as toxic granules	Antibodies
Self vs. Nonself Discrimination	Innate immunity is based on self vs. nonself discrimination, so it has to be perfect	Not as good as the innate immune system, but still pretty good at determining which is which. Problems in self vs. nonself discrimination result in autoimmune diseases
Immunological Memory	None	Memory used can lead to faster response to recurrent or subsequent infections
Diversity and Customization	Limited: Receptors used are standard and only recognize antigen patterns. No new receptors are made to adapt the immune response	Highly diverse: can be customized by genetic recombination to recognize epitopes and antigenic determinants.