Description

Cell-mediated immunity (CMI) involves the activation of T cells (T lymphocytes) by a speci antigen. In total, the body contains millions of different T cells—each able to respond to one specific antigen.

Development of T cells

T cells are a special type of lymphocyte. Immature lymphocytes are produced from stem cells in the red bone marrow. Some of these cells are processed within the thymus gland—hence, T cell—during embryological development, then released into the blood. These mature T cells are located in the blood, lymph, and lymphoid organs such as the lymph nodes and spleen.

Common T Cells and Their Functions

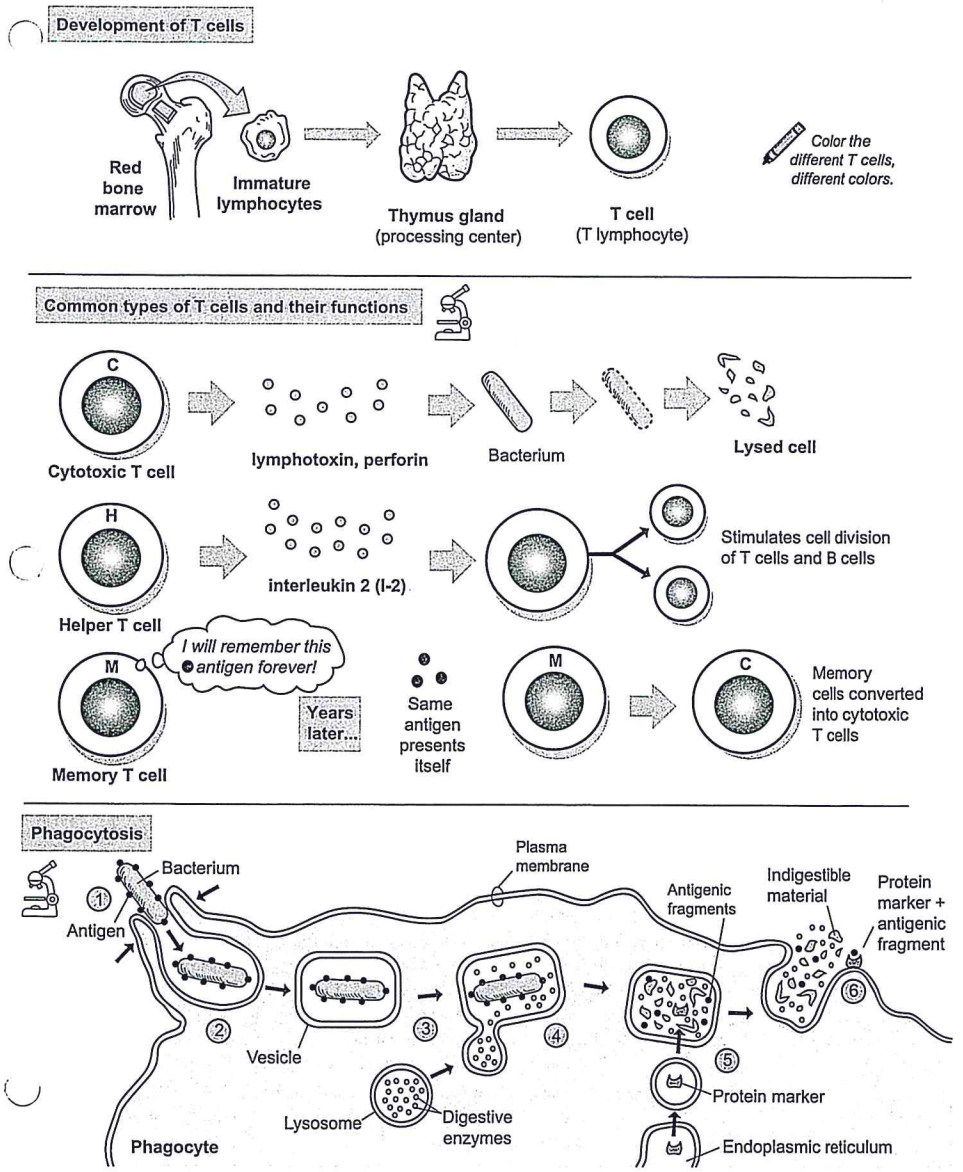
The three major types of T cells are as follows:

- Cytotoxic T cells secrete lymphotoxin and perforin. The former trigger destruction of the pathogen's DNA, and the latter create holes in the pathogen's plasma membrane, resulting in a lysed cell.
- Helper T cells secrete interleukin 2 (I-2), which stimulates cell division of T cells and B cells. This can be thought of as recruiting more soldiers for the fight.
- Memory T cells remain dormant after the initial exposure to an antigen. If the same antigen presents itself again—even years later—the memory cells are stimulated to convert themselves into cytotoxic T cells and enter the fight.

Phagocytosis

Phagocytes ("eater cells") use the process of phagocytosis ("cell eating") to ingest forei pathogens. An example is a macrophage ("big eater"), which is derived from the largest white blood cells—monocytes. Macrophages leave the bloodstream and enter body tissues to patrol for pathogens. As some phagocytic cells engage in phagocytosis, they present antigenic fragments on their plasma membrane surface, thereby stimulating the activation of T cells. Consequently, they are an important part of the CMI. A summary of the phagocytosis process shown in the illustration is:

1. Microbe attaches to phagocyte.
2. Phagocyte's plasma membrane forms arm-like extensions that surround and engulf the microbe. The encapsulated microbe pinches off from the plasma membrane to form a vesicle.
3. The vesicle merges with a lysosome, which contains digestive enzymes.
4. The digestive enzymes begin to break down the microbe. The phagocyte extracts the nutrients it can use, leaving the indigestible material and antigenic fragments within the vesicle.
5. The phagocyte makes protein markers, and they enter the vesicle.
6. The indigestible material is removed by exocytosis. The antigenic fragments bind to the protein marker and are displayed on the plasma membrane surface. This serves to activate T cells.



Description

Antibody-mediated immunity (AMI) involves the activation of B cells (B lymphocytes) by specific antigen. This triggers the B cells to transform into plasma cells, which are able to secrete special proteins called antibodies. The antibodies are transported through the blood and the lymph to the pathogenic invasion site. In total, the body contains millions of different B cells—each able to respond to one specific antigen. Amazing!

Development of B Cells

B cells are a special type of lymphocyte. Immature B cells are produced from stem cells in the red bone marrow. These immature cells are later processed within the red bone marrow—hence, B cell—during embryological development to become mature B cells, then are released into the blood. The mature B cells are located in the blood, lymph, and lymphoid organs such as the lymph nodes and spleen.

Antibody Production

B cells can be stimulated to divide, forming two types of numerous cells: (1) plasma cells, which secrete antibodies, and (2) B memory cells which exist in the body for many years, ensuring a quick response to the same antigen. Antibodies (immunoglobulin, or Ig) are Y-shaped proteins that are subdivided into five classes: IgG, IgM, IgA, IgE, IgD. These are listed in order from the *most* common to the *least* common.

Study Tip: Mnemonic: *Get Me Another Excellent Donut!*

The basic structure on an antibody consists of four polypeptide chains—two heavy chains and two light chains. Both heavy chains and both light chains are identical to the other, and each contains a constant region and a variable region. The constant region forms the "trunk" of the molecule, and the variable region forms the antigen-binding site on the antibody. Note that each antibody has two of these antigen-binding sites. Think of these like claws on a lobster used to "grab" its specific antigen.

How do Antibodies Work?

Antibodies work through many different mechanisms, of which the following are major ones:

1. **Neutralizing antigen:** the antibody can bind to an antigen, forming an antigen–antibody complex. This forms a shield around the antigen, preventing its normal function. In this way, a toxin from a bacterium may be neutralized or a viral antigen may not be able to bind to a body cell thereby preventing infection.
2. **Activating complement:** "complement" refers to a group of plasma proteins made by the liver that normally are inactive in the blood. An antigen-antibody complex triggers a cascade reaction that activates these proteins to induce beneficial responses. For example, some of these activated proteins can cluster together to form a pore or channel that inserts into a microbial plasma membrane. This results in a lysed cell. Other responses include chemotaxis and inflammation. Both of these mechanisms serve to increase the number of white blood cells at the site of invasion.
3. **Precipitating antigens:** numerous antibodies can bind to the same free antigens in solution to cross-link them. This cross-linked mass then precipitates out of solution, making it easier for phagocytic cells to ingest them by phagocytosis.

   Similarly, microbes (such as bacteria) can be clumped together by a process called *agglutination* (not illustrated). The antigens within the cell walls of the bacteria are what are cross-linked. As with precipitation, this is followed by phagocytosis.
4. **Facilitating phagocytosis:** an antigen-antibody complex acts like a warning sign to signal phagocytic cells to attack. In fact, the complex also binds to the surface of macrophages to further facilitate phagocytosis.