Blood Biochemistry
BCH 577

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Part III

- **Immunity And Lymphocytes**

Immunity: the ability of human body to resist all types of organisms or toxins.

1. Phagocytosis invaders by white blood cells and tissue macrophage.

2. Destruction of organisms by the acid of the stomach and the digestive enzymes.

3. Resistance of the skin to invasion by organisms.

4. Presence certain chemical compounds in the blood that.

Some of these compounds are

(1) lysozyme, a mucolytic polysaccharide.

(2) basic polypeptides, which react with and inactivate gram-positive bacteria;

(3) the complement complex, a system of about 20 proteins that can be activated in various ways to destroy bacteria.

(4) natural killer lymphocytes that can recognize and destroy foreign cells, tumor cells, and even some infected cells.

Acquired Immunity

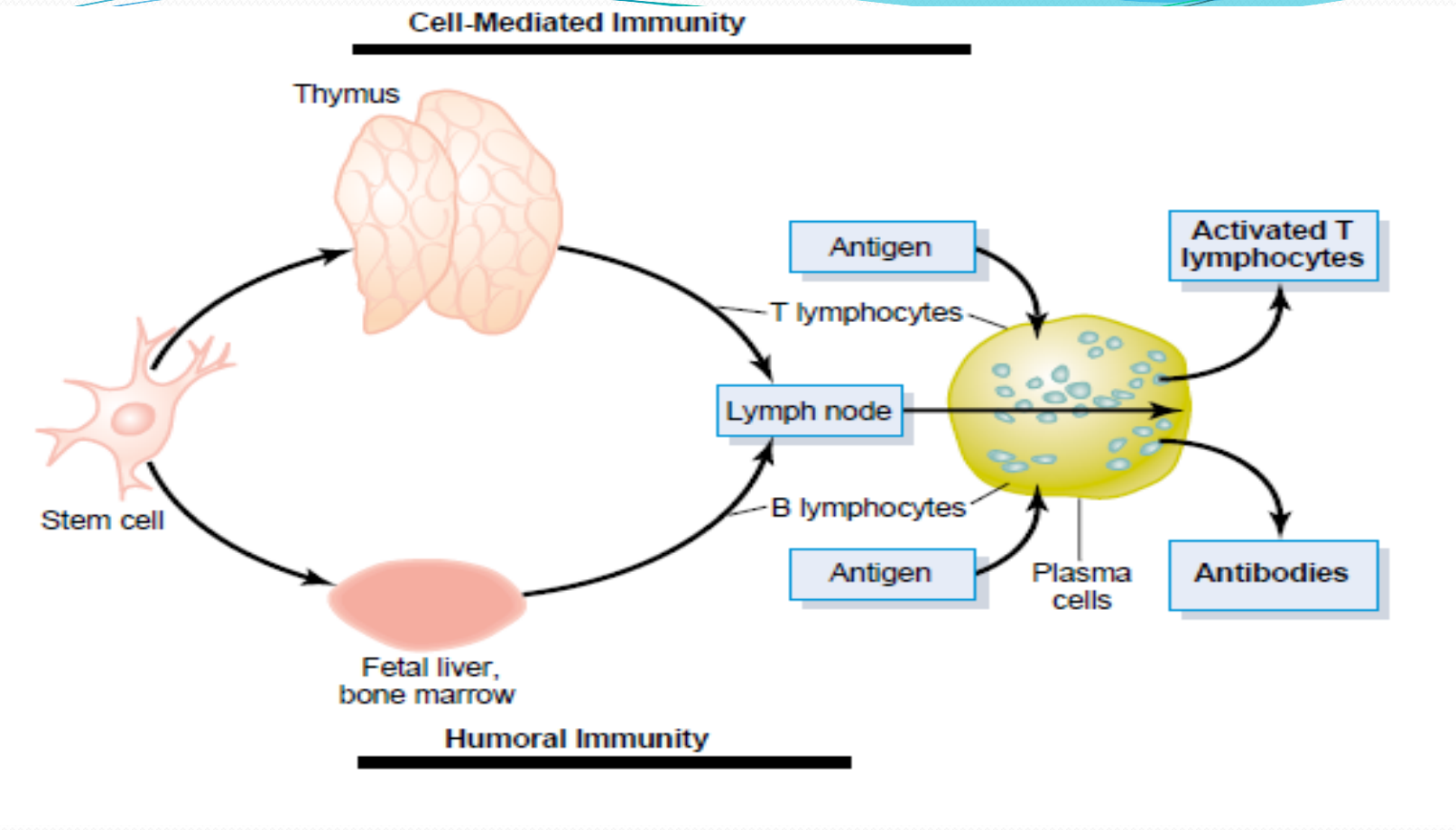
The human body has the ability to develop powerful specific immunity against invading agents (bacteria, viruses, toxins, and foreign tissues from other animals). This is called (*acqu)* Acquired immunity is caused by a special immune system that forms antibodies and/or activated lymphocytes that attack and destroy the specific invading organism or toxin.

Basic Types of Acquired Immunity

Humoral immunity or B-cell immunity (because B lymphocytes produce the antibodies). Circulating antibodies, globulin molecules in the blood plasma that are capable of attacking the invading agent.

Cell-mediated immunity or T-cell immunity (because the activated lymphocytes are T lymphocytes).

Formation of large numbers of activated T lymphocytes that are made in the lymph nodes to destroy the foreign agent.



Formation of antibodies and sensitized lymphocytes by a lymph node in response to antigens. This figure also shows the origin of *thymic (T) and bursal (B) lymphocytes* that respectively are responsible for the cell-mediated and humoral immune processes.

Thymus Gland Preprocesses the T Lymphocytes.

- **The T lymphocytes, after origination in the bone marrow, migrate to the thymus gland.**
- **The T lymphocytes divide rapidly and at the same time develop for reacting against different specific antigens.**
- **One thymic lymphocyte develops specific reactivity against one antigen. Then the next lymphocyte develops specificity against another antigen. This continues until there are thousands of different types of thymic lymphocytes with specific reactivities against many thousands of different antigens.**

- **Different types of preprocessed T lymphocytes leave the thymus and spread by way of the blood throughout the body lymphoid tissue.**
- **The thymus also makes certain that any T lymphocytes leaving the thymus will not react against proteins or other antigens that are present in the body's own tissues.**
- **The thymus selects which T lymphocytes will be released by first mixing them with all the specific "self-antigens" from the body's own tissues.**

- **If a T lymphocyte reacts (90%), it is destroyed and phagocytized instead of being released.**
- **Most of the preprocessing of T lymphocytes in the thymus occurs shortly before birth of a baby and for a few months after birth. Beyond this period, removal of the thymus gland diminishes (but does not eliminate) the T-lymphocytic immune system.**

Liver and Bone Marrow Preprocess the B Lymphocytes.

- **B lymphocytes are known to be preprocessed in the liver and bone marrow during late fetal life and after birth.**
- **B lymphocytes are different from T lymphocytes in two ways: First, instead of the whole cell developing reactivity against the antigen, as occurs for the T lymphocytes, the B lymphocytes actively secrete antibodies that are the reactive agents.**

- **Antibodies are large protein molecules that are capable of combining with and destroying the antigenic substance.**
- **The B lymphocytes forming many millions of types of B-lymphocyte antibodies with different specific reactivates.**
- **After preprocessing, the B lymphocytes, like the T lymphocytes, migrate to lymphoid tissue throughout the body.**

T Lymphocytes and B-Lymphocyte Antibodies React Highly Specifically Against Specific Antigens, Role of Lymphocyte Clones

- **When specific antigens come in contact with T and B lymphocytes in the lymphoid tissue, certain of the T lymphocytes become activated to form activated T cells, and certain of the B lymphocytes become activated to form antibodies.**
- **Millions of different types of preformed B lymphocytes and preformed T lymphocytes that are capable of forming highly specific types of antibodies or T cells have been stored in the lymph tissue**

- **Each of these preformed lymphocytes is capable of forming only one type of antibody or one type of T cell with a single type of specificity. And only the specific type of antigen with which it can react can activate it.**

- **B lymphocyte progeny will secrete the specific type of antibody that then circulates throughout the body.**
- **T lymphocyte progeny are specific sensitized T cells that are released into the lymph and then carried to the blood and circulated through all the tissue fluids and back into the lymph.**
- **All the different lymphocytes that are capable of forming one specificity of antibody or T cell are called a clone of lymphocytes.**

Origin of the Many Clones of Lymphocytes

The whole gene for forming each type of T cell or B cell is never present in the original stem cells from which the functional immune cells are formed. Instead, there are only "gene segments"—actually, hundreds of such segments—but not whole genes. During preprocessing of the respective T- and B-cell lymphocytes, these gene segments become mixed with one another in random combinations, in this way finally forming whole genes.

Because there are several hundred types of gene segments, as well as millions of different combinations in which the segments can be arranged in single cells, one can understand the millions of different cell gene types that can occur. For each functional T or B lymphocyte that is finally formed, the gene structure codes for only a single antigen specificity. These mature cells then become the highly specific T and B cells that spread to and populate the lymphoid tissue

Mechanism for Activating a Clone of Lymphocytes

- **Each clone of lymphocytes is responsive to only a single type of antigen (or to several similar antigens that have almost exactly the same stereochemical characteristics). The reason for this is the following: In the case of the B lymphocytes, each of these has on the surface of its cell membrane about 100,000 antibody molecules that will react highly specifically with only one specific type of antigen.**

Therefore, when the appropriate antigen comes along, it immediately attaches to the antibody in the cell membrane; this leads to the activation process.

- **In the case of the T lymphocytes, molecules similar to antibodies, called surface receptor proteins (or T-cell markers), are on the surface of the T-cell membrane, and these, too, are highly specific for one specified activating antigen.**

Role of Macrophages in the Activation Process.

- **Most invading organisms are first phagocytized and partially digested by the macrophages, and the antigenic products are liberated into the macrophage cytosol.**
- **The macrophages pass these antigens by cell-to-cell contact directly to the lymphocytes, thus leading to activation of the specified lymphocytic clones. The macrophages, in addition, secrete a special activating substance (interleukin 1) that promotes further growth and reproduction of the specific lymphocytes.**

Role of the T Cells in Activation of the B Lymphocytes.

Most antigens activate both T lymphocytes and B lymphocytes at the same time. Some of the T cells that are formed, called helper cells, secrete specific substances (collectively called lymphokines) that activate the specific B lymphocytes. Indeed, without the aid of these helper T cells, the quantity of antibodies formed by the B lymphocytes is usually slight.

Formation of Antibodies by Plasma Cells.

Before exposure to a specific antigen, the clones of B lymphocytes remain dormant in the lymphoid tissue. On entry of a foreign antigen, macrophages in the lymphoid tissue phagocytize the antigen and then present it to adjacent B lymphocytes. In addition, the antigen is presented to T cells at the same time, and activated helper T cells are formed. These helper cells also contribute to extreme activation of the B lymphocytes. Those B lymphocytes specific for the antigen immediately enlarge and take on the appearance of lymphoblasts.

Some of the lymphoblasts further differentiate to form plasmablasts, which are precursors of plasma cells. In the plasmablasts, the cytoplasm expands and the rough endoplasmic reticulum vastly proliferates. The plasmablasts then begin to divide at a rate of about once every 10 hours for about nine divisions, giving in 4 days a total population of about 500 cells for each original plasmablast. The mature plasma cell then produces gamma globulin antibodies at an extremely rapid rate—about 2000 molecules per second for each plasma cell. In turn, the antibodies are secreted into the lymph and carried to the circulating blood. This process continues for several days or weeks until finally exhaustion and death of the plasma cells occur.