Lec.4: Acquired immunity (Adaptive immunity)

Acquired immunity is specific immune response created after an interaction of lymphocytes with particular foreign substances which are recognized specifically by those lymphocytes. This recognition process triggers proliferation and maturation of the lymphocytes which in the case of B lymphocyte results in the secretion of antibodies and the "memorizing" of that particular agent in a process called the primary immune response. On the second contact with the same agent the magnitude of the response is increased as a result of the more rapid and more abundant production of specific antibodies: a process called secondary immune response.

The acquired immune response is a more highly developed system than the innate immune system. It includes not only humoral immunity but also cellular immunity, the production of specific-lymphocytes. As its name implies, acquired immunity is a consequence of an encounter with a foreign substance. The first encounter with a foreign substance that has penetrated the body triggers a chain of events that induces an immune response with specificity against the foreign substance. Although an individual is genetically endowed with the capacity to mount an immune response against a certain substance, acquired immunity is usually exhibited only after an initial encounter with the substance. Thus acquired immunity develops only after exposure to, or immunization with, a given substance. Development of the adaptive immunity requires specific immune responses.

Principles of adaptive immunity

Features of adaptive immunity

The adaptive immune response is characterized by:

1- Specificity: The ability to discriminate between different antigenic epitopes, and respond only to those that necessitate a response rather than making a random response.

2- Memory: The ability to recall (remember) previous contact with a particular antigen, such that subsequent exposure leads to a more rapid and larger immune response.

3- Adaptiveness: The ability to respond to previously unseen antigens, which may never have existed before on earth.

4- Discrimination between "self" and "nonself": The ability to respond to those antigens that are not "self" and to avoid making responses to those antigens that are part of "self".

The most widely accepted theory that best explains these features is the clonal selection theory. The essential features of the clonal selection theory may be summarized as follows:

1- B and T lymphocytes of all antigenic specificities exist prior to contact with antigen.

2- Each lymphocyte carries immunoglobulin or T cell receptor molecules of only a single specificity on its surface.

3- Lymphocytes can be stimulated by antigen under appropriate conditions to give rise to progeny with identical antigenic specificity. In case of B cells, but not T cells, the antigen-specific receptor - immunoglobulin - is secreted as a consequence of stimulation.

4- Lymphocytes potentially reactive with "self" are deleted or in some way inactivated. This ensures that no immune response is mounted against self components.

Acquired (adaptive or specific) immunity is not present at birth. It is learned. As a person's immune system encounters foreign substances (antigens), the components of acquired immunity learn the best way to attack each antigen and begin to develop a memory for that antigen. Acquired immunity is also called specific immunity because it tailors its attack to a specific antigen previously encountered. Its hallmarks are its ability to learn, adapt, and remember.

Acquired immunity takes time to develop after first exposure to a new antigen. However afterward, the antigen is remembered, and subsequent responses to that antigen are quicker and more effective than those that occurred after the first exposure.

The white blood cells responsible for acquired immunity are:

- **Lymphocytes (T cells and B cells)**

Typically, an acquired immune response begins when antibodies, produced by B cells (B lymphocytes), encounter an antigen.

Lymphocytes enable the body to remember antigens and to distinguish self from harmful nonself (including viruses and bacteria). Lymphocytes circulate in the bloodstream and lymphatic system and move into tissues as needed.

The immune system can remember every antigen encountered because after an encounter, some lymphocytes develop into memory cells. These cells live a long time—for years or even decades. When these cells encounter an antigen for the second time, they recognize it immediately and respond quickly, vigorously, and specifically to that particular antigen. This specific immune response is the reason that people do not contract chickenpox or measles more than once and that vaccination can prevent certain disorders.
Surface proteins expressed by immune cells are often referred to the **cluster of differentiations (CD).**
Lymphocytes may be T cells or B cells.

T cells

T cells are produced in the thymus. They can potentially recognize an almost limitless number of different antigens. To avoid attacking the body's own tissues, they need to learn how to distinguish self from nonself antigens. Normally, only the T cells that ignore the body's own antigens (self-antigens) are allowed to mature and leave the thymus.

Mature T cells are stored in secondary lymphoid organs (lymph nodes, spleen, tonsils, appendix, and Peyer patches in the small intestine). These cells circulate in the bloodstream and the lymphatic system. After they first encounter an infected or abnormal cell, they are activated and search for those particular cells.

There are different types of T cells:

- **Killer (cytotoxic) T cells (Tc)**attach to antigens on infected or abnormal (for example, cancerous) cells. Killer T cells then kill these cells by making holes in their cell membrane and injecting enzymes into the cells.
- **Helper T cells (Th)**help other immune cells. Some helper T cells help B cells produce antibodies against foreign antigens. Others help activate killer T cells to kill infected or abnormal cells or help activate macrophages, enabling them to ingest infected or abnormal cells more efficiently.
- **Suppressor (regulatory) T cells (T reg)** produce substances that help end the immune response or sometimes prevent certain harmful responses from occurring.

T cells can distinguished one from another by the presence of membrane of glycoprotein on their surface :

- Th is displaying CD4 and recognized antigen in complex with major histocompatibility class II antigen MHC II.
- Tc is displaying CD8 and recognized antigen in complex with MHCI.
- T reg is identifying by the presence of CD4 and CD25.

The ratio of CD4: CD8 is approximately 2:1 in normal peripheral blood . A change in this ratio is often an indicator of immunodeficiency ,autoimmune diseases and other disorders.

When T cells initially encounter an antigen, most of them perform their designated function, but some of them develop into memory cells, which remember the antigen and respond to it more vigorously when they encounter it again.

Sometimes T cells—for reasons that are not completely understood—do not distinguish self from nonself. This malfunction can result in an autoimmune disorder, in which the body attacks its own tissues .

B cells

B cells are formed in the bone marrow. B cells have particular sites (receptors) on their surface where antigens can attach. B cells can learn to recognize an almost limitless number of different antigens.

Lymphocyte B Cell

The B-cell response to antigens has two stages:

- **Primary immune response:** When B cells first encounter an antigen, the antigen attaches to a receptor, stimulating the B cells. Some B cells change into memory cells, which remember that specific antigen, and others change into plasma cells. Helper T cells help B cells in this process. Plasma cells produce antibodies that are specific to the antigen that stimulated their production. After the first encounter with an antigen, production of enough of the specific antibody takes several days. Thus, the primary immune response is slow.
- **Secondary immune response:** But thereafter, whenever B cells encounter the antigen again, memory B cells very rapidly recognize the antigen, multiply, change into plasma cells, and produce antibodies. This response is quick and very effective.

Although the main function of B cells is to produce antibodies, they can also present antigen to T cells.

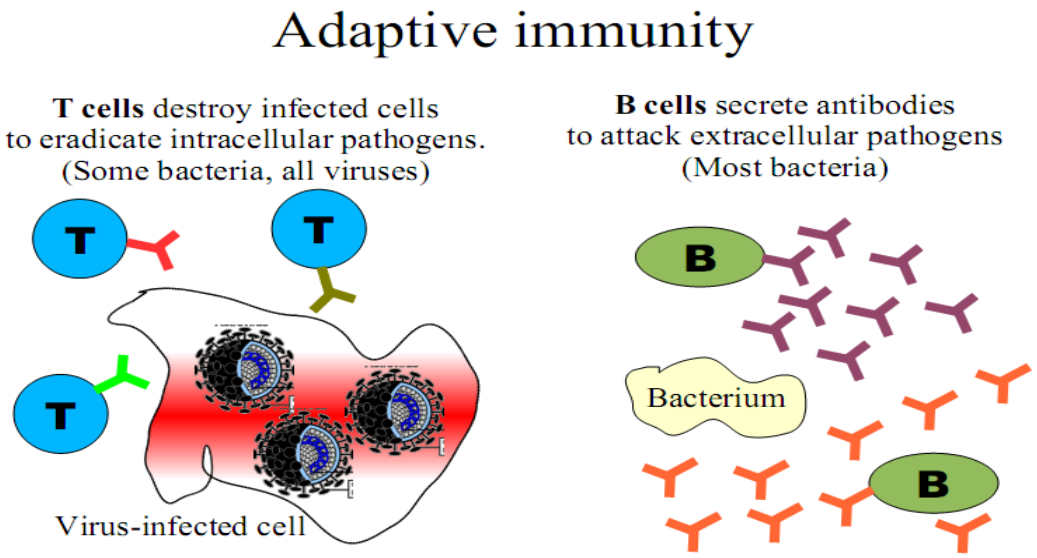
Other participants in acquired immunity are

- Dendritic cells
- Cytokines
- The complement system (which enhances the effectiveness of antibodies

Dendritic Cells

Dendritic cells reside in the skin, lymph nodes, and tissues throughout the body. Most dendritic cells ingest and break antigens into fragments (called antigen processing), enabling helper T cells to recognize the antigen. Dendritic cells present antigen fragments to T cells in the lymph nodes.

Another type of dendritic cell, the follicular dendritic cell, presents unprocessed (intact) antigen that has been linked with antibody (antibody-antigen complex) to B cells.



Acquired immunity can be active or passive.

- **Active immunity** results from the development of antibodies in response to an antigen, as from exposure to an infectious disease or through vaccination.
- **Passive immunity** results from the transmission ofantibodies, as from mothe r to fetus through the placenta or by the injectionof antiserum

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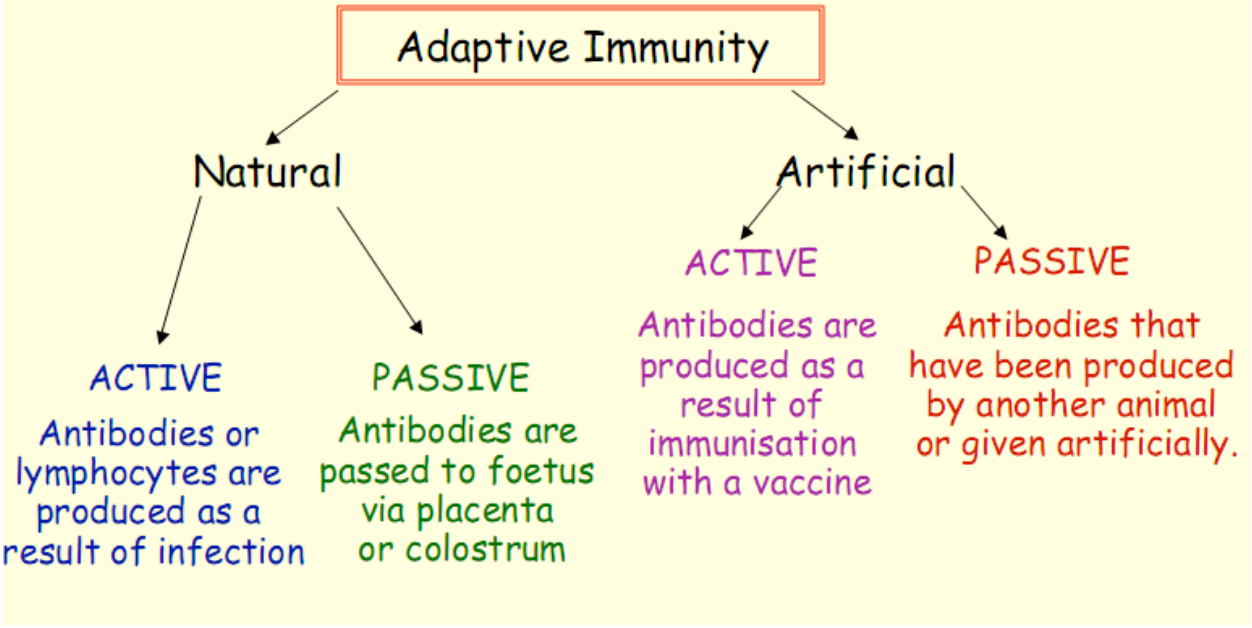
Adaptive Immunity can be NATURAL or ARTIFICIAL



Innate *vs* adaptive immunity

	innate	adaptive
self / non-self discrimination	present, reaction is against foreign	present, reaction is against foreign
lag phase	absent, reponse is immediate	present, response takes at least a few days
specificity	limited, the same response is mounted to a wide variety of agents	high, the response is directed only to the agents that initiated it.
diversity	limited, hence limited specificity	extensive, and resulting in a wide range of antigen receptors.
memory	absent, subsequent exposures to agent generate the same response	present, subsequent exposures to the same agent induce amplified reponses