Immune Response

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- 1 - Introduction

When the human body is confronted with foreign molecules like bacteria, viruses, parasites, cancer or antigens, an immune response is triggered. There are two different responses like the innate (unspecific) and the adaptive (specific) immune response.

- 2 - Unspecific Immune Response

The unspecific immune response contains innate mechanisms and defenses that are available immediately. This kind of immune response reacts to foreign molecules. It detects these molecules and fights and removes them. Even cells from the same body can be fought when they contain mutations like in cancer cells. When the immune system wrongly detects body cells as foreign or mutated cells you call this autoimmunity. These so-called autoimmune diseases are for example type 1 diabetes, multiple sclerosis, lupus and rheumatoid arthritis.

- 3 - Specific Immune Response

The unspecific immune response may not be enough to fight a disease and mutated human body cells. In these cases, the specific immune response specifically fights a distinct foreign molecule or antigen. The specific immune response contains the humoral and the cellular immune response.

- 4 - Humoral Immune Response

The humoral (humor: liquids) immune response covers all responses that take place in body liquids like blood or lymph.

The blood contains multiple B-cells that can detect various antigens. Each B-cell has transmembrane receptors that are bound to an antibody. When the antibody can bind a molecule by its B-cell transmembrane receptors, it is activated. Each B-cell contains lysosomes with proteases that digest the protein to small peptides. These small parts of the antigen are presented from the B-cell on the surface with so called MHC class II proteins. T helper cells with their T-cell receptor recognize these small molecules that are presented by the B-cell, which leads to an activation of the B-cell. Some of these activated B-cells

will differentiate or turn into B-Memory-Cells that are able to build new antibodies in the future very fast, when the same foreign molecule is detected.

T-Helper Cell:

T-helper cells can be activated when they bind to an antigen presenting cell (APC) like macrophages or B-cells that presents an antigen on the MHC receptor. In addition to the recognition of the B-cells, the T-helper cell has to bind a CD40 receptor on the B-cell with its own CD40L receptor (when a macrophage is bound, the receptor is called CD28). After activation of the T-helper cells, they can activate naïve B-cells in the lymph nodes, which then will differentiate to a B-plasma cell that produces antibodies. This multiple activation steps lead to a slower response compared to the innate immune system. But it is important to have these mechanisms to avoid false positive reactions.

MHC (major histocompatibility complex)

MHC is a gene cluster that is coding for the MHC proteins. In humans they are also called HLA (human leukocyte antigen). There are two classes of MHC proteins:

MHC Class-I: These proteins are found in body cells with a cell nucleus. If one of these cells presents an antigen with their Class-I protein, a cytotoxic T-cell recognizes it and introduces the destruction of the cell that presents the antigen.

MHC Class-II: These proteins are found in B-cells and macrophages, which uses them to present antigens to T-cells. This leads to the humoral immune response and antibody production.

- 5 - Cellular Immune Response

Besides the humoral immune response that is responsible for foreign molecules in blood, the cellular immune response is responsible for intruders that are inside a cell. This can be viruses for example. If a cell is infected with a virus, it will present this virus particles on the surface of the cell with MHC proteins. T-cells recognize this and introduce the destruction of the cell.

- 6 - Antigen-Antibody Reaction

After the antigen or small pieces of the antigen is presented by a B-cell or a macrophage with the help of the MHC proteins, these kinds of cells transport the antigen pieces to lymph tissues of the immune system. There they present the antigens to the immune system like the B-lymphocytes and the T-lymphocytes and initiate the specific immune response. B-lymphocytes initiate the humoral and T-lymphocytes the cellular immune response. Both responses can work in parallel each other.

Histamin & Cytokine

When cytokines and histamine are released, this usually leads to dilated blood vessels. Whereas the negative signs like swelling, reddening and pain leads to inflammation, it is much easier for the immune system to reach the infected cells, when the blood vessels are dilated. For this reason, the lymph nodes and spleen might grow, when the blood flow increases.

T-Lymphocytes:

After activation of the T-lymphocytes, they split, increase in number and build T-helper cells as well as T-killer cells. Whereas the T-killer cells are directly involved in the destruction of the invasion, the T-helper cells helps the immune system and produces cytokines. Cytokines are important to activate macrophages and cytotoxic T-killer cells.

B-Lymphocytes:

After activation of the B-lymphocytes, antibodies are generated against the small particles of the antigen. These antibodies build an antigen-antibody-complex, which leads to a neutralization of the antibodies. In many cases the phagocytes destroy this complex.

Some of the B-lymphocytes will differentiate to B-plasma cells.

Secondary Immune Response:

Some of the B- and T-lymphocytes will differentiate to memory cells. This immunological memory leads to a faster and more effective immune response when the same antigen is detected by the memory cells. When this new immune response is initiated, it is called secondary immune response. This secondary immune response is much faster compared to the primary immune response. For this reason, many diseases like mumps, measles and rubella only leads to symptoms for the first time. After the first infection, the human body is immune to this disease. This principle is used by vaccinations. The antigen is immunized which leads to memory cells and an immunity.

Active Vaccination

When harmless antigens or attenuated viruses are immunized, it is called an active vaccination.

Passive Vaccination

When antibodies that recognize a specific molecule are immunized, it is called a passive vaccination.

Complement System:

The complement system consists of different plasma proteins, which are activated during the immune response. The complement system stimulates the phagocytes and the digestive system to destroy foreign proteins with enzymes.

The end of the immune response:

When all antigens are removed from the body, no more antibodies are made and the immune response finishes.