Immunology

Definition: **immunology** from *Processing Water, Wastewater, Residuals, and Excreta for Health and Environmental Protection: An Encyclopedic Dictionary*

The branch of biology that studies the components of the immune system of higher organisms, immunity from disease, cell-mediated and antibody-mediated responses, and techniques of immunologic analysis.

Summary Article: **Immunology**

*From Encyclopedia of Global Health*

In the late 18th century Dr. Edward Jenner stumbled upon the notion of the immune system following his discovery that cowpox protected him against a human pathogen known as smallpox. This process of immunity by introduction of more mild strains of a disease became known as vaccination. Unfortunately, very little was understood about the etiology of infection and the subsequent induction of the host immune response. Dr. Robert Koch, over 100 years later, established the first relationship between cause and effect as it relates to infection. Out of his work came specific postulates used to understand which pathogens are fundamentally responsible for specific diseases and what components of those pathogens contribute to disease progression. The concept of immunology was born.

Immunology is the study of the immune system, the primary defense mechanism of the body. In humans, the immune system is composed of specific immune cells and produces and utilizes numerous unique, chemical signals. Each component of the immune system works collectively to prevent invasion by foreign substances, or pathogens. Examples of such pathogens include bacteria, viruses, fungi, and parasites. Each utilizes a specific method of transmission such as fecal-oral, airborne, direct inoculation, direct contact, and congenital. To elicit an immune response, these pathogens must not only be foreign to the body, but they must be large enough molecules, chemically complex, and degradable. Still heavily studied area, the human immune system consists of both innate and acquired responses to pathogenic invasion with both types of responses interacting on many complex, biological levels.

Typical components of the innate immune system include normal physiologic and chemical barriers such as the skin, saliva, the pH of the stomach, tears, enzymes, and mucus. During the innate response, the human body utilizes immune cells such as neutrophils, monocytes, NK cells, and tissue macrophages. These cells respond to specific foreign patterns through preexisting pattern recognition receptors. Each type of cell has the ability to kill the invading organism through a nonspecific process known as phagocytosis, a mechanism first discovered by the Russian immunologist Dr. Elie Metchnikoff. This process includes engulfment of the pathogen and fusion with acidic enzymes within the host cell. Innate immune cells can also kill through the complement cascade as well as extracellular mechanisms involving soluble mediators. Complement activation includes first lysing the pathogens, and then coating them with a material targeting them for phagocytosis. Complement involves the following three pathways: classical, alternative, and lectin binding. All converge on a common pathway where a pore is created within the target cell membrane leading to lysis of that cell. In innate immunity, the characteristic immune response includes chemical messages in the form of cytokines, pyrogens (fever producers), interferon, and complement. While innate immunity is an effective means of fighting off foreign bodies,
it is sometimes not enough. Thankfully, our bodies possess another type of immunity known as acquired immunity.

Acquired, or adaptive immunity, can be divided into humoral and cell-mediated immunity. The response time is much slower when compared with innate immunity. Both humoral and cell-mediated responses depend on specific cells known as B and T cells which develop and mature in the primary lymphoid organs of the bone marrow and thymus gland, respectively. Following maturation, these cells leave the primary lymphoid organs and move to secondary lymphoid organs, which include the spleen, lymph nodes, and tonsils. B cells recognize intact pathogen, whereas T cells only recognize pathogen that has been broken down into protein components and presented on the cell surface of another immune cell. B cells communicate with other cells through a specific receptor, whereas T cells must bind using a receptor and an additional cell surface molecule known as the MHC. There are two important types of T cells, CD8 and CD4, and each binds to a specific set of cell surface molecules.

Already armed with a set level of specificity for an invading pathogen, B and T cells are induced to proliferate once they encounter pathogen so that the population of immune cells with identical specificity for a pathogen increases. This increases the potential for specific destruction and containment of the foreign organism. This proliferation, or clonal expansion of cells, in response to the first encounter with pathogen is considered the primary response, and it is soon followed by a more rapid and larger secondary response when the immune system encounters the same pathogen again. This secondary response includes memory B and T cells which contribute to the faster nature of this response.

It is during this secondary response that the different functional capacities of B and T cells are revealed. B cells will differentiate into plasma cells, which will secrete antibodies, or immunoglobulins. There are five different groups of immunoglobulins each with distinct functions and biologic properties: IgG, IgM, IgE, IgD, and IgA. These antibodies are specific for antigens found on the pathogens. Antigens, or any foreign substance recognized by a specific receptor, can include the following: proteins, carbohydrates, lipids, or nucleic acids considered foreign to the body. Once T cells encounter pathogen a second time they also possess the capacity to become memory cells. They function as either helper T cells or cytotoxic T cells both of which play integral roles in pathogenic destruction and induction of the host immune response.

Immunology utilizes many tests to determine the presence or absence or antibodies or antigens. These include radioimmunoassay (RIA), enzyme-linked immunosorbent assay (ELISA), direct immunofluorescence, monoclonal antibody production, and Western blotting.

Our understanding of the process of immunology is crucial, for it allows further exploration into disease prevention, leads to the discovery of vaccines, offers insight into effective and successful methods to fight infection, and uncovers the intricate mechanisms involved in the immune response to pathogenic invasion. Maybe the most important of all of the benefits to our understanding of immunology lies in the ability to improve quality of life and to evade death.

SEE ALSO:
- Acquired Immunity; Immunologist; Innate Immunity.

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