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Immunology of Infectious Diseases and Adaptive Immune Response

Isabel Allende*

Department of Biology, University of Medicine and Pharmacy, Bucharest, Romania

Abstract

Immunology is the study of the immune system and its response to various pathogens, including infectious diseases. The immune system is a complex network of cells, tissues and organs that work together to protect the body from harmful microorganisms such as bacteria, viruses, fungi and parasites. When a pathogen enters the body, the immune system recognizes it as foreign and mounts a response to eliminate it. This response involves several key components. The innate immune system provides the first line of defence against pathogens. It includes physical barriers like the skin and mucous membranes, as well as immune cells such as neutrophils, macrophages and natural killer cells. These cells can recognize common features of pathogens, called Pathogen-Associated Molecular Patterns (PAMPs), through Pattern Recognition Receptors (PRRs). The innate immune response aims to contain and eliminate pathogens until the adaptive immune response can be activated.

Keywords: Immunology • Pathogen • Immune system • Specific response

Introduction

The adaptive immune response is a highly specific response that develops over time. It involves specialized immune cells called lymphocytes, which include B cells and T cells. When a pathogen is encountered, B cells produce antibodies that can bind to and neutralize the pathogen. T cells, on the other hand, can directly kill infected cells or help other immune cells in their functions. The adaptive immune response has memory, allowing for a faster and more effective response upon subsequent encounters with the same pathogen.

Literature Review

Antibodies, also known as immunoglobulins, are proteins produced by B cells in response to pathogens. They can recognize and bind to specific molecules on the surface of pathogens, marking them for destruction by other components of the immune system. Antibodies can also activate other immune responses, such as the complement system, which can directly kill pathogens or enhance their recognition by immune cells. This aspect of the immune response involves the activation of T cells, which play a crucial role in recognizing and eliminating infected cells. Cytotoxic T cells can directly kill infected cells, while helper T cells coordinate the immune response by activating other immune cells and producing cytokines, which are signalling molecules that regulate immune responses. Cell-mediated immunity, also known as cellular immunity, is a vital component of the immune system's defence against pathogens, cancer cells and other foreign substances. It involves the activation and coordination of various types of immune cells, primarily T lymphocytes (T cells) [1].

T cells are a type of white blood cell that are produced in the bone marrow and mature in the thymus gland. They play a central role in cell-mediated immunity by recognizing specific antigens displayed on the surface of infected cells or other abnormal cells. There are two main types of T cells involved in cell-mediated immunity: cytotoxic T cells (also called CD8+ T cells) and helper T cells (also called CD4+ T cells). Cytotoxic T cells (CD8+ T cells) are responsible for directly killing infected or abnormal cells. When a cytotoxic T cell recognizes an antigen on the surface of a target cell, it binds to it and releases cytotoxic molecules such as perforin and granzymes. These molecules create pores in the target cell's membrane and initiate apoptosis (cellular self-destruction) in the infected or abnormal cell.

***Address for Correspondence:** Isabel Allende, Department of Biology, University of Medicine and Pharmacy, Bucharest, Romania, E-mail: isabelalleneasn@yahoo.com*

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Discussion

Helper T cells (CD4+ T cells) play a supportive role in cell-mediated immunity. They help coordinate the immune response by secreting signalling molecules called cytokines. These cytokines stimulate other immune cells, such as macrophages and cytotoxic T cells, to enhance their activities. Helper T cells also help B cells produce antibodies, which are important for humoral immunity (another branch of the immune system). In addition to T cells, other immune cells, such as natural killer (NK) cells, macrophages and dendritic cells, contribute to cell-mediated immunity. NK cells are capable of killing infected or abnormal cells without prior sensitization, while macrophages and dendritic cells help in presenting antigens to T cells, initiating the immune response [2].

Cell-mediated immunity is particularly important in defending against intracellular pathogens, such as viruses, certain bacteria and parasites that reside inside host cells. It is also crucial for recognizing and eliminating cancer cells and controlling autoimmune responses. Overall, cell-mediated immunity provides a targeted and specific response against infected or abnormal cells and its coordinated actions with other components of the immune system ensure effective immune surveillance and protection. Infectious diseases occur when pathogens successfully evade or overcome the immune system's defences. This can happen through various mechanisms, such as antigenic variation (changing their surface molecules to avoid recognition), suppression of the immune response, or hiding inside host cells [3].

Some pathogens can also manipulate the immune response to their advantage, leading to chronic infections or immunopathology, where the immune response itself causes damage to the host. Understanding the immunology of infectious diseases is essential for developing effective vaccines, therapies and diagnostic tools. Researchers study the interactions between pathogens and the immune system to identify potential targets for intervention and improve our ability to prevent and treat infectious diseases. The adaptive immune response, also known as acquired or specific immunity, is a complex defence mechanism of the immune system that is activated in response to specific pathogens or foreign substances. It is characterized by its ability to recognize and remember specific antigens, which are molecules on the surface of pathogens or foreign substances that trigger an immune response. The adaptive immune response involves two main types of lymphocytes, or white blood cells: B cells and T cells. These cells are produced in the bone marrow and mature in the thymus gland. When an antigen enters the body, it is taken up by Antigen-Presenting Cells (APCs), such as dendritic cells, macrophages, or B cells [4].

The APCs process the antigen and present fragments of it on their surface

using a molecule called Major Histocompatibility Complex (MHC) class II. These antigen fragments are then recognized by helper T cells, which have specific receptors capable of binding to the antigen-MHC complex. The binding of the T cell receptor to the antigen-MHC complex, along with other co-stimulatory signals, activates the helper T cell. Activated helper T cells release cytokines, chemical messengers that stimulate other immune cells, including B cells and cytotoxic T cells. B cells are responsible for the production of antibodies, which are specialized proteins that can bind to specific antigens. When activated by helper T cells, B cells differentiate into plasma cells, which secrete large quantities of antibodies. These antibodies circulate in the bloodstream and other body fluids, binding to the antigen and marking it for destruction by other immune cells or by activating the complement system. Cytotoxic T cells, also known as killer T cells, directly attack infected cells or cancer cells. They recognize antigen fragments presented on infected cells or cancer cells by MHC class I molecules [5,6].

Conclusion

The cytotoxic T cells release toxic molecules that induce apoptosis, or programmed cell death, in the target cells. One important aspect of the adaptive immune response is immunological memory. After an initial encounter with an antigen, some B and T cells differentiate into long-lived memory cells. These memory cells "remember" the specific antigen and mount a faster and more effective immune response upon re-exposure. This is the basis for vaccination, where a harmless form of the antigen is introduced into the body to stimulate the production of memory cells without causing the full-blown disease. Overall, the adaptive immune response is highly specific, adaptable and long-lasting, providing the body with a powerful defence against a wide range of pathogens and foreign substances.

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Conflict of Interest

The author shows no conflict of interest towards this article.

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