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Perspective

The significance of T-cell receptors in immunological surveillance

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DESCRIPTION

T-cell receptors (TCRs) are fundamental components of the immune system and play a crucial role in adaptive immunity. With their ability to recognize a diverse range of antigens, TCRs are key players in coordinating immune responses and defending the body against infections and diseases. This article will provide an in-depth exploration of T-cell receptors, discussing their structure, diversity generation, antigen recognition, signaling mechanisms, and functional implications.

Structure of T-cell receptors

T-cell receptors are integral membrane proteins primarily expressed on the surface of T cells. Each TCR is composed of two distinct protein chains an α chain and a β chain in the case of αβ TCRs, which are the most common type. Alternatively, γ and δ chains form γδ TCRs, which are found in a smaller subset of T cells. Both αβ and γδ TCRs are responsible for antigen recognition and initiating immune responses.

The α and β chains of TCRs consist of constant and variable regions. The constant regions provide structural stability and anchor the TCR to the cell membrane, while the variable regions contain hypervariable loops that are responsible for antigen recognition. These loops, also known as complementarity-determining regions (CDRs), interact with antigens in a highly specific manner.

Diversity generation

The diversity of TCRs is essential for their ability to recognize a wide range of antigens. TCR diversity is achieved through a process called VDJ recombination, which occurs during T cell development in the thymus. During this process, gene segments called variable (V), diversity (D), and joining (J) segments are rearranged to form a unique *TCR* gene.

The rearrangement of V, D, and J segments introduces random combinations and contributes to the vast repertoire of *TCRs* . Additionally, the addition or deletion of nucleotides at the junctions between these segments further increases TCR diversity. This process ensures that each T cell expresses a unique TCR capable of recognizing different antigens.

Antigen recognition

TCRs recognize antigens in the context of major histocompatibility complex (MHC) molecules. MHC molecules are cell surface proteins that present antigens to T cells. There are two major classes of MHC molecules: MHC class I and MHC class II.

MHC class I molecules: MHC class I molecules are expressed on the surface of nearly all nucleated cells and present antigens derived from intracellular pathogens, such as viruses or intracellular bacteria, to CD8+ T cells. CD8+ T cells, also known as cytotoxic T cells, express αβ TCRs and are responsible for directly killing infected cells.

MHC class II molecules: MHC class II molecules are primarily expressed on the surface of antigen-presenting cells (APCs) such as dendritic cells, macrophages, and B cells. They present antigens derived from extracellular pathogens to CD4+ T cells, also known as helper T cells. CD4+ T cells express αβ TCRs and play a critical role in coordinating immune responses by activating other immune cells and assisting in antibody production.

The interaction between TCRs and antigen-MHC complexes is highly specific. The CDR loops of the TCRs engage with both the antigenic peptide and the MHC molecule, forming a stable complex. This interaction triggers a series of signaling events within the T cell, leading to T cell activation and the initiation of immune responses.

Signaling mechanisms

Upon TCR engagement with the antigen-MHC complex, intracellular signaling pathways are activated within the T cell. These signaling events are initiated by the recruitment and phosphorylation of specific proteins within the TCR complex. The TCR complex includes additional proteins such as CD3ε, CD3γ, CD3δ, and CD3.

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