

The Role of Dendritic Cells in Adaptive Immune Responses and T Cell Activation

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DESCRIPTION

Dendritic Cells (DCs) are integral components of the immune system, renowned for their role in connecting the innate and adaptive immune responses. As professional Antigen-Presenting Cells (APCs), they are instrumental in capturing, processing, and presenting antigens to T cells, thereby initiating and modulating adaptive immunity.

Antigen capture and processing

Dendritic cells are strategically located in tissues that are in constant contact with the external environment, such as the skin, mucosal surfaces, and lymphoid organs. They possess a unique ability to capture a wide array of antigens, including pathogens, dead cells, and tumor antigens. This antigen capture is mediated by a variety of surface receptors, including Pattern Recognition Receptors (PRRs) like Toll-Like Receptors (TLRs), C-type lectin receptors, and others.

Migration to lymphoid organs

Following antigen capture and processing, dendritic cells undergo a maturation process. This maturation involves upregulation of MHC molecules and costimulatory molecules such as CD80, CD86, and CD40 on their surface, which are essential for effective T cell activation. Mature dendritic cells then migrate to secondary lymphoid organs, including lymph nodes, spleen, and mucosa-associated lymphoid tissues. This migration is guided by chemokine gradients, particularly the interaction between CCR7 on dendritic cells and its ligands, CCL19 and CCL21, which are expressed in lymphoid tissues.

Antigen presentation and T cell activation

The core function of dendritic cells in the adaptive immune response is the presentation of processed antigens to T cells. This process involves three critical signals that together ensure the proper activation and differentiation of T cells. These signals collectively ensure that T cells are appropriately activated,

proliferated, and differentiated, equipping the immune system with a tailored response to the encountered antigen.

Induction of immunological memory

Adaptive immunity is the generation of immunological memory, which provides long-lasting protection against previously encountered antigens. Dendritic cells are central to this process by priming both effector and memory T cells. Memory T cells, once generated, persist in the body for extended periods, allowing for a more rapid and robust response upon re-exposure to the same antigen. This ability of dendritic cells to induce immunological memory is fundamental for the effectiveness of vaccines and long-term immunity.

Regulation and tolerance

In addition to initiating immune responses, dendritic cells play a crucial role in maintaining immune homeostasis and tolerance. They are involved in the induction of regulatory T cells (Tregs), which suppress immune responses and prevent autoimmunity. Immature or tolerogenic dendritic cells can present antigens in a manner that does not fully activate T cells, leading to anergy or the generation of Tregs. This mechanism is vital for maintaining tolerance to self-antigens and preventing autoimmune diseases. Dendritic cells also participate in the resolution of immune responses by secreting anti-inflammatory cytokines such as IL-10 and Transforming Growth Factor-Beta (TGF- β), which help dampen the immune response and promote tissue repair and homeostasis.

CONCLUSION

Dendritic cells are indispensable in the adaptive immune response, performing a multitude of functions that ensure a precise and effective immune defense. From capturing and processing antigens to migrating to lymphoid organs, presenting antigens to T cells, and inducing immunological memory, dendritic cells are at the forefront of orchestrating adaptive immunity. Their role in regulating immune responses and

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maintaining tolerance further underscores their importance in immune homeostasis.