11.4B: Antigen-presenting Cells - B and T cells

LEARNING OBJECTIVES

- Explain the role played by B and T cells in the adaptive immune system

The adaptive, or acquired, immune response to an initial infection takes days or even weeks to become established, much longer than the innate response. However, adaptive immunity is more specific to an invading pathogen and can fight back much more quickly than the innate response if it has seen the pathogen before. Adaptive immunity occurs after exposure to an antigen either from a pathogen or a vaccination. An antigen is a molecule that binds to a specific antibody, often stimulating a response in the immune system as a result.

The adaptive immune response activates when the innate immune response insufficiently controls an infection. In fact, without information from the innate immune system, the adaptive response could not be mobilized. There are two types of adaptive responses: the cell-mediated immune response, which is controlled by activated T cells, and the humoral immune response, which is controlled by activated B cells and antibodies. Upon infection, activated T and B cells that have surface binding sites with specificity to the molecules on the pathogen greatly increase in number and attack the invading pathogen. Their attack can kill pathogens directly or they can secrete antibodies that enhance the phagocytosis of pathogens and disrupt the infection. Adaptive immunity also involves a memory, which gives the host long-term protection from reinfection by the same type of pathogen; upon re-exposure, this host memory will facilitate a rapid and powerful response.

B and T Cells

Lymphocytes, which are white blood cells, are formed with other blood cells in the red bone marrow found in many flat bones, such as the shoulder or pelvic bones. The two types of lymphocytes of the adaptive immune response are B and
T cells. Whether an immature lymphocyte becomes a B cell or T cell depends on where in the body it matures. The B cells remain in the bone marrow to mature (hence the name “B” for “bone marrow”), while T cells migrate to the thymus, where they mature (hence the name “T” for “thymus”).

Figure: **T cell by SEM**: This scanning electron micrograph shows a T lymphocyte. T and B cells are indistinguishable by light microscopy, but can be differentiated experimentally by probing their surface receptors.

### B Cell Receptors

The maturation of a B or T cell involves becoming immunocompetent, meaning that it can recognize and bind to a specific molecule or antigen. This recognition, which is central to the functioning of the adaptive immune response, results from the presence of highly specific receptors on the surfaces of B and T cells. On B cells, these receptors contain antibodies, which are responsible for antigen binding. An antibody is specific for one particular antigen; typically, it will not bind to anything else. Upon antigen binding to a B cell receptor, a signal is sent into the B cell to turn on an immune response.
B cell receptors: B cell receptors are embedded in the membranes of B cells and bind a variety of antigens through their variable regions, or antibodies. The signal transduction region transfers the signal into the cell.

T Cell Receptors

Meanwhile, T cell receptors are responsible for the recognition of pathogenic antigens by T cells. Unlike B cells, T cells do not directly recognize antigens. Instead, they recognize antigens presented on major histocompatibility complexes (MHCs) that cells use to display which proteins are inside of them. If a cell is infected, it will present antigenic portions of the infecting pathogen on its MHC for recognition by T cells, which will then mount an appropriate immune response. Unlike antibodies, which can typically bind one and only one antigen, T cell receptors have more flexibility in their capacity to recognize antigens presented by MHCs.
Figure: **T cell receptors (TCRs)**: A T cell receptor spans the membrane and projects variable binding regions into the extracellular space to bind processed antigens via MHC molecules on APCs.

It is the specific pathogen recognition (via binding antigens) of B and T cells that allows the adaptive immune response to adapt. During the maturation process, B and T cells that bind too strongly to the body's own cells' antigens are eliminated in order to minimize an immune response against the body's own tissues. Only those cells that react weakly to the body's own cells will remain. This process occurs during fetal development and continues throughout life. Once they are immunocompetent, the T and B cells migrate to the spleen and lymph nodes where they remain until they are called on during an infection. B cells are involved in the humoral immune response, which targets pathogens loose in blood and lymph, while T cells are involved in the cell-mediated immune response, which targets infected cells.

### Key Points

- The adaptive immune response is slower to develop than the innate immune response, but it can act much more powerfully and quickly than the innate immune response against pathogens that it has seen before.
- B and T cells are lymphocytes, or white blood cells, which are able to recognize antigens that distinguish "self" from "other" in the body.
- B and T cells that recognize "self" antigens are destroyed before they can mature; this helps to prevent the immune system from attacking its own body.

### Key Terms

- **B cell**: a lymphocyte, developed in the bursa of birds and the bone marrow of other animals, that produces antibodies and is responsible for the immune system
- **T cell**: a lymphocyte, from the thymus, that can recognize specific antigens and can activate or deactivate other immune cells
- **antigen**: a substance that binds to a specific antibody; may cause an immune response

**LICENSES AND ATTRIBUTIONS**