**Chapter 16 Specific Defenses**

**Third Line of Defense**

• Is called specific immunity

• The body’s ability to recognize and defend itself against distinct invaders and their products

• Is a “smart” system whose “memory’ allows it to respond rapidly to a second encounter with a pathogen

**Elements of Specific Immunity**

• Is acquired over time

• Immunologists are scientists who study the cells and chemicals involved in specific immunity

• Antigens trigger specific immune responses

• Various cells, tissues, and organs are part of specific immunity

• Includes B and T lymphocytes

**Antigens**

• Molecules that trigger a specific immune response

• Include components of bacterial cell walls, capsules, pili, and flagella, as well as proteins of viruses, fungi, and protozoa

• Food and dust can also contain antigenic particles

• Enter the body by various methods

• Through breaks in the skin and mucous membranes

• Direct injection, as with a bite or needle

• Through organ transplants and skin grafts

**Lymphatic System**

• Screens the tissues of the body for foreign antigens

• Composed of lymphatic vessels and lymphatic cells

**Lymphatic Vessels**

• Form a one-way system that conducts lymph from local tissues and returns it to the circulatory system

• Lymph is a liquid with similar composition to blood plasma that arises from fluid leaked from blood vessels into surrounding tissues

**Lymphoid Cells**

• Develop from stem cells in the red bone marrow

• Includes lymphocytes, the smallest of the leukocytes

**Lymph Nodes**

• Houses leukocytes that recognize and attack foreign antigens present in the lymph

• Concentrated in the cervical (neck), inguinal (groin), axillary (armpit), and abdominal regions

• Receives lymph from afferent lymphatic vessels and drains lymph into efferent lymphatic vessels

**Other Lymphoid Tissues and Organs**

• Spleen

• Similar in structure and function to the lymph nodes

• Filters bacteria, viruses, toxins, and other foreign matter from the blood

• Tonsils and mucosa-associated lymphoid tissue (MALT)

• Physically trap foreign particles and microbes

• MALT includes the appendix, lymphoid tissue of the respiratory tract, and Peyer’s patches in the wall of the small intestine

**B Lymphocytes**

• Arise and mature in the red bone marrow

• Found primarily in the spleen, lymph nodes, red bone marrow, and Peyer’s patches

• Small percentage of B cells circulate in the blood

• Major function is the secretion of antibodies

**Antibodies**

• Also called immunoglobulins (Ig)

• Soluble, proteinaceous molecules that bind antigen

• Secreted by plasma cells, which are B cells actively fighting exogenous antigen

• Considered part of the humoral immune response since bodily fluids such as lymph and blood were once called humors

**Antibody Function**

• Antigen-binding sites are complementary to antigenic determinants (epitopes)

• Due to the close match can form strong, noncovalent interactions

• Hydrogen bonds and other attractions may also be involved

**Antibody Function**

• Function in several ways

• Activation of complement

• Stimulation of inflammation

• Agglutination

• Neutralization

• Opsonization

**Classes of Antibodies**

• A single type of antibody is not sufficient for the multiple types of invaders to the body

• The class involved in the immune response depends on the type of foreign antigen, the portal of entry, and the antibody function needed

• 5 different classes of antibodies

**B Cell Receptor (BCR)**

• Is an antibody that remains associated with the cytoplasmic membrane

• Each B lymphocyte has multiple copies of a single type of BCR

• Antigen binding site is identical to that of the secreted antibody for that particular cell

• The randomly generated antibody variable region determines the BCR (it is not formed in response to antigens)

• Each BCR is complementary to only one antigenic determinant

• The BCRs on all of an individual’s B cells are capable of recognizing millions of different antigenic determinants

**T Lymphocytes**

• Produced in the red bone marrow and mature in the thymus

• Circulate in the lymph and blood and migrate to the lymph nodes, spleen, and Peyer’s patches

• Part of the cell-mediated immune response because they act directly against various antigens

• Endogenous invaders

• Many of the body’s cells that harbor intracellular pathogens

• Abnormal body cells such as cancer cells that produce abnormal cell surface proteins

**T Lymphocytes**

• 3 types

• Cytotoxic T cells

• 2 types of helper T cells

**Cytotoxic T cells (TC Cells)**

• Distinguished by the CD8 cell-surface glycoprotein

• Directly kill certain cells

• Cells infected with viruses and other intracellular pathogens

• Abnormal cells, such as cancer cells

**Helper T Cells (TH Cells)**

• Distinguished by the CD4 cell-surface glycoprotein

• Function to “help” regulate the activities of B cells and cytotoxic T cells during an immune response

• Secrete various soluble protein messengers, called cytokines, that determine which immune response will be activated

• 2 types

• Type 1 helper T cell (TH 1)

• Assist cytotoxic T cells

• Express CD26 and a cytokine receptor named CCR5

• Type 2 helper T cell (TH 2)

• Assist B cells

• Have cytokine receptors CCR3 and CCR4

**Cytokines**

• Soluble regulatory proteins that act as intercellular signals when released from certain body cells

• Immune system cytokines signal among various leukocytes

• The complex web of signals among all the cell types of the immune system is referred to as the cytokine network

**Cytokines of the Immune System**

• Interleukins (ILs)- signal among leukocytes

• Interferons (IFNs)- antiviral proteins that may act as cytokines

• Growth factors- proteins that stimulate stem cells to divide, maintaining a adequate supply of leukocytes

• Tumor necrosis factors (TNFs)- Secreted by macrophages and T cells to kill tumor cells and regulate immune responses and inflammation

• Chemokines- signal leukocytes to go to a site of inflammation or infection and stimulate other leukocytes

**Lymphocyte Editing by Clonal Deletion**

• Vital that immune responses not be directed against autoantigens

• Body “edits” lymphocytes to eliminate any self-reactive cells

**Major Histocompatibility Complex (MHC)**

• Group of antigens first identified in graft patients

• Important in determining the compatibility of tissues in successful grafting

• Major histocompatibility antigens are glycoproteins found in the membranes of most cells of vertebrate animals

• Function to hold and position antigenic determinants for presentation to T cells

• Antigens bind in the antigen-binding groove of MHC molecules

• 2 classes of MHC proteins

• MHC class I

• MHC class II

**Antigen Processing**

• T-independent antigen

• Large antigen molecules with readily accessible, repeating antigenic determinants

• B cells can bind these directly without being processed

• Stimulates B cells to differentiate into a plasma cell and produce antibodies

• T-dependent antigens

• Smaller antigens with less accessible antigenic determinants

• B cells require involvement from helper T cells to target these antigens

• Helper T cells are assisted by leukocytes that process the antigen to make the antigenic determinants more accessible

• Processing is different based on whether the antigen is exogenous or endogenous

**Processing of Exogenous Antigens**

• APC internalizes the invading pathogen and enzymatically digests it into smaller antigenic fragments which are contained within a phagolysosome

• Phagolysosome fuses with a vesicle containing MHCII molecules

• Each fragment binds to the antigen-binding groove of a complementary MHCII molecule

• The fused vesicle then inserts the MHCII-antigen complex into the cytoplasmic membrane so the antigen is presented on the outside of the cell

• The intracellular pathogens are also digested into smaller antigenic determinants

• Each fragment binds to a MHCI molecule located in the endoplasmic reticulum membrane

• The membrane is packaged into a vesicle by a Golgi body which is inserted into the cytoplasmic membrane so the antigen is displayed on the cell’s surface

**Humoral Immune Response**

• Body mounts humoral immune responses against exogenous pathogens

• Components of a humoral immune response

• B cell activation and clonal selection

• Memory B cells and the establishment of immunological memory

**Plasma Cells**

• Make up the majority of cells produced during B cell proliferation

• Each plasma cell secretes only antibody molecules complementary to the specific antigenic determinant

• Are short-lived cells that die within a few days of activation, though their antibodies and progeny can persist

**Memory B Cells**

• Cells produced by B cell proliferation that do not secrete antibodies

• Cells that have BCRs complementary to the specific antigenic determinant that triggered their production

• Long-lived cells that divide only a few times and then persist in the lymphoid tissue

• Are available to initiate antibody production if the same antigen is encountered again

**Cell-Mediated Immune Response**

• Responds to intracellular pathogens and abnormal body cells

• The most common intracellular pathogens are viruses but the response is also effective against intracellular bacteria

• Triggered when antigenic determinants of the pathogen are displayed on the host cell’s surface

**T Cell Regulation**

• Careful regulation of cell-mediated immune response to prevent T cells from responding to autoantigens

• T cells require additional signals from an antigen presenting cell

• Interaction of the T cell and antigen presenting cell at an immunological synapse stimulates the T cell to respond to the antigen

**Acquired Immunity**

• Specific immunity acquired during an individuals life

• 2 types

• Naturally acquired- immune response against antigens encountered in daily life

• Artificially acquired- response to antigens introduced via a vaccine

• Further distinguished as either active or passive

• Active- active response to antigens via humoral or cell-mediated responses

• Passive- passively receive antibodies from another individual