Chapter 16 The Adaptive Immune Response

Summary Outline

16.1 Strategy of the adaptive immune response
- A. **Adaptive immunity** is acquired throughout life.
- B. **Humoral immunity** is mediated by **B-lymphocytes.**
  1. B-lymphocytes are activated in response to extracelluar antigens.
  2. B-lymphocytes proliferate and differentiate into **plasma cells** that produce **antibodies.**
- C. **Cellular immunity** is mediated by **T-lymphocytes.**
  1. **T-cytotoxic cells** destroy host cells that harbor intracellular agents such as viruses by inducing **apoptosis.**
  2. **T-helper cells** potential cellular and humoral responses.

16.2 Anatomy of the lymphoid system
- A. Lymphatic vessels - Lymph, which may contain antigens that have entered tissues, flows in the lymphatic vessels to the lymph nodes.
- B. Secondary lymphoid organs – Locations where lymphocytes gather to contact antigens.

16.3 The nature of **antigens**
- A. **Antigens** are large, usually **foreign, molecules** with surface **epitopes** that **react specifically** with **antibodies and immune cells**.
- B. Most antigens are immunogens that can induce the production of specific antibodies or immune cells.

16.4 The nature of **antibodies**
- A. **Antibodies** are **proteins (immunoglobulins)** with **two heavy** and **two light polypeptide chains**, which **react specifically** with the antigen that induced their formation.
- B. Properties of antibodies
  1. **Antibody monomers** have a Y shape with an **antigen-binding (Fab) site** at the end of each arm of the Y and an **Fc region**, which accounts for many of the biological functions of the antibody, unique to each class.
  2. **Noncovalent, short-range bonds** hold antigen and antibody together. The reaction is **reversible**.
- C. Outcomes of **antigen-antibody binding**
  1. **Neutralization**
  2. **Immobilization** and **prevention of adherence**
  3. **Agglutination** and **precipitation**
  4. **Opsonization**
  5. **Complement activation**
  6. **Antibody-dependent cytoxicity.**
- D. **Immunoglobulin classes**
  1. **IgG** is a **monomer** that can cause **opsonization, agglutination, precipitation, complement fixation, ADCC** and **neutralization of toxins and viruses**. It is the only class of immunoglobulins that **can cross the placenta**.
  2. **IgM**, usually a **pentamer**, is the **first** class of immunoglobulins **produced during an immune response**. It is very efficient in **agglutination, precipitation, opsonization** and **complement activation**.
  3. **IgA** is abundant as a **dimer in secretions**. It **inhibits adherence of organisms to host cells,** and **protects mucous membrane surfaces**.

4. **IgD** is a **monomer found on B cell surfaces** that acts as a **receptor** for the specific antigen it recognizes.
5. **IgE** is a **monomer** that binds strongly to mast cells and basophils and helps to **protect against some multicellular parasites and contributes to many allergic reactions**.

16.5 **Clonal selection** of lymphocytes

A. Antigens select lymphocytes specific for that antigen, resulting in **proliferation** of expanded clones of **antigen-specific effectors and memory cells**.
B. Lymphocytes recognize antigens based on the antigen receptors on their cell surfaces.
C. Lymphocytes may be **immature, naïve, activated, effector,** or **memory cells.**

16.6 **B-lymphocytes** and the **antibody response**

A. Response to **T-dependent antigens**
   1. When T-dependent antigens bind with B-cell receptors, the antigen is internalized, degraded into peptide fragments and presented to **helper T-cells (antigen presentation)**.
   2. The help T-cell recognizes the antigen and deliver cytokines to the B cell initiating **clonal expansion** that results in the production of **plasma cells** that produce specific **antibodies** to the antigen.
   3. Under the direction of T-helper cells, the expanding B-cell population will undergo affinity maturation and class switching, and formation of **memory cells**.
   4. **Primary response** – A lag period occurs before antibodies can be detected.
   5. **Secondary response** – Memory cells are responsible for a much faster and effective response resulting in the elimination of invaders before they have the opportunity to do much harm.
B. Response to **T-independent antigens**
   1. T-independent antigens include polysaccharides that have multiple identical evenly space epitopes and LPS.
   2. T- independent antigens can induce antibody formation without help from T cells.

16.7 **T lymphocytes**: Antigen recognition and response

A. T-cell receptors recognize antigens presented by the **major histocompatibility (MHC) molecules.**
B. Functions of effector **T-cytotoxic (CD8) cells**
   1. **T-cytotoxic cells** induce **apoptosis** in cells infected with a virus or other intracellular microorganism or cancerous cells.
   2. **T-cytotoxic cells** produce cytokines that cause neighboring cells to become more active against intracellular invaders.
C. Functions of effector **T-helper (CD4) cells**
   1. **T-helper cells** respond to exogenous antigens that are presented by MHC class II molecules.
   2. **Th1 cells** judge antigens presented by macrophages.
   3. A responding **Th1 cell** activated the presenting macrophage and secretes cytokines that help direct the immune response.
   4. **Th2 cells** judge antigens presented by B cells.
   5. A responding **Th2 cell** activated the B cell and supports proliferation and most types of class switching by activated B cells.
D. **Activation of T cells**
   1. **Native T cells** require supporting signals for activation.
   2. Activated T cells stimulate their own proliferation and becomes effective.
   3. **Dendritic cells** sample material in tissues and journey to lymphoid organs to present the antigens to naïve T cells.
   4. **Dendritic cells** that detect molecules that indicate an invading microorganism produce co-stimulatory molecules and activate both subsets of T cells.

5. **Activated macrophages** that have engulfed foreign antigens produce co-stimulatory molecules to activate T-helper cells.

16.8 **Natural killer (NK) cells**

A. **NK cells** mediate **antibody-dependent cellular cytotoxicity (ADCC)**.

B. **NK cells** will kill any cells that do not have **MHC class I molecules** on their cell surfaces

16.9 Lymphocyte development

A. Generation of diversity – Mechanisms include:
   1. **Rearrangement of gene segments**
   2. **Imprecise joining of gene segments**
   3. **Combinations of heavy and light chains**

B. **Negative selection** of self-reactive B cells
   1. Negative selection occurs while B cells develop in the bone marrow.
   2. Negative selection is the process of eliminating B cells that recognize "self" molecules.

C. **Positive and negative selection** of self-reactive cells
   1. Positive selection allows only those T cells that recognize the MHC molecules to develop.
   2. Negative selection results in the elimination of any native T cell that recognizes antigens presented by an antigen-presenting cell that does not have co-stimulatory molecules.