

Chapter 17
Adaptive Immunity: Specific Defenses of the Host

Immunity

- **Innate immunity:** Defenses against any pathogen
- **Adaptive immunity:** Induced resistance to a specific pathogen

Dual Nature of Adaptive Immunity

- T and B cells develop from stem cells in red bone marrow
- **Humoral immunity**
 - **B cells** mature in the bone marrow
- **Cellular immunity**
 - **T cells** mature in the thymus

Antigens

- **Antigen (Ag):** A substance that causes the body to produce specific antibodies or sensitized T cells
 - Antibodies (Ab) interact with **epitopes** or **antigenic determinants**
- **Hapten:** A small molecule that acts antigenic once it has been combined with carrier molecules (to form a hapten-carrier conjugate)

Antibodies

- Globular proteins called **immunoglobulins**
- The number of **antigen-binding sites** determines **valence**
 - Most antibodies have two binding sites, and are called bivalent (two binding sites) **monomers**
 - Some antibodies have 2 subunits (**dimers**) or 5 subunits (**pentamers**)

B Cells and Humoral Immunity

- B cell surface immunoglobulin binds with an antigen
 - Antigen is internalized and processed
 - Antigen fragment combines with a **Major Histocompatibility Complex (MHC)**
 - MHC with Ag fragment is displayed on cell surface
- **T-dependent antigens** bind to MHC/Ag fragment

- T_H cell produces cytokines that activate the B cell
- **T-independent antigens**
 - Stimulate the B cell to proliferate as plasma cells that make Abs

Activation of B Cells

- B cells differentiate into
 - Antibody-producing **plasma cells**
 - **Memory cells**
- **Clonal deletion** eliminates harmful B cells
- Humoral response is useful against viruses and bacteria that are circulating freely in the body

T Cells and Cellular Immunity

- T cells mature in the thymus
 - Thymic selection eliminates many immature T cells
- T cells respond to Ag by **T-cell receptors (TCRs)**
- T cells require **antigen-presenting cells (APCs)** to be able to recognize Ag
 - B cells and macrophages often act as APCs
- Many pathogens that enter the gastrointestinal or respiratory tracts pass through epithelial cell gateways
 - **M (microfold) cells** in the intestines
 - **Peyer's patches**, which contain APCs

T Cells

T Helper cells ($CD4^+$ or T_H cells)

- Help B cells that are acting as APCs produce antibodies
- Activate macrophages that are acting as APCs
- T_H cells produce cytokines and differentiate into
 - T_H1
 - T_H2
 - Memory cells

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T Cytotoxic Cells (CD8⁺ or T_C cells)

- Target cells are self cells carrying **endogenous antigens**
- Activated into **cytotoxic T lymphocytes (CTLs)**
 - Require T_H, dendritic cell, and stimulatory signals
 - CTLs recognize Ag + MHC I
 - Induce **apoptosis** in target cell
- CTL releases **perforin** and **granzymes**

T Regulatory Cells (T_{reg} cells)

- CD4 and CD25 on surface
- Suppress T cells against self

Antigen-Presenting Cells

- Digest antigen
- Ag fragments on APC surface with MHC
 - B cells
 - **Dendritic cells**
 - **Activated macrophages**

Natural Killer (NK) Cells

- Granular leukocytes destroy cells that don't express MHC I
- Kill virus-infected and tumor cells
- Attack parasites

ADCC

- **Antibody-dependent cell-mediated cytotoxicity**

Cytokines

- Chemical messengers
- Overproduction leads to **cytokine storm**

Immunological Memory

- **Antibody titer** is the amount of Ab in serum
- **Primary response** occurs after initial contact with Ag
- **Secondary (memory or anamnestic) response** occurs after second exposure

Types of Adaptive Immunity

- **Naturally acquired active immunity**
 - Resulting from infection
- **Naturally acquired passive immunity**
 - Transplacental or via colostrum
- **Artificially acquired active immunity**
 - Injection of Ag (vaccination)
- **Artificially acquired passive immunity**
 - Injection of Ab

Terminology of Adaptive Immunity

- **Serology**: The study of reactions between antibodies and antigens
- **Antiserum**: The generic term for serum because it contains Ab
- **Globulins**: Serum proteins
- **Immunoglobulins**: Antibodies
- **Gamma (γ) globulin**: Serum fraction containing Ab