Chapter 15
Topics - Adaptive Immunity
- Second line of Defense
- B cells
- T cells
System has **Specificity** and **Memory**

**Immune** means free from burden.
The **immune system** consists of a number of organs, tissues, cells, cellular products and mechanisms that are coordinated to protect us from foreign insults.
**Vulnerable** is the opposite of immune and means susceptible to foreign insults.

**Antigens** are large molecules, generally proteins, although antigens may be carbohydrates, nucleic acids, etc.
**Immunogens** are antigens that can stimulate an immune response and are **immunogenic**.

**Receptors**
- Present on B and T cells
  - BCR on B cells - is an **ANTIBODY** - recognizes native antigen
  - TCR on T cells – a heterodimer that recognizes processed antigen that is presented on MHC
- B cell receptors are secreted as antibodies

**Cytokines in Inflammation and Disease**
Low molecular weight proteins secreted by white blood cells and other cells in response to stimuli, including invading pathogens

**Inflammation and Disease**
- **Th1** - type response – **Cell Mediated Immunity**
  - IL-2, IFN-γ, IL-12
- **Th2** - type response – **Humoral Mediated Immunity**
  - IL-4, IL-10, IL-13
Two arms of the adaptive immune system

**Humoral immunity** - B cells mature into mature plasma cells when they encounter foreign antigen.

**Cellular immunity** - certain types of T cells

**Two classes of T cells** - T\textsubscript{H} (T helper cells) and T\textsubscript{C} (cytotoxic T cells)

B cells and T cells can be distinguished by phenotypic markers on their surfaces called cellular differentiation or CD markers.

- **B cells** - CD19, CD20, CD21 - SURFACE ANTIBODY
- **T\textsubscript{H} cells** - CD4
- **T\textsubscript{C} cells** - CD8
- **NK cells** - CD16, CD56

**Properties of antigens**

An antigen is a foreign substance that has the capability to elicit an immune response

The sites on the antigen that are immunogenic are the epitopes

**Characteristics of antigens**

- **Superantigens**
  - Bacterial toxins
  - T cell activation much greater than normal antigens
  - Large release of cytokines
  - Results in toxic shock syndrome and some autoimmune diseases
  - *S. aureus* releases TSST

**Humoral immunity**

Immune response distinguishes foreign from self

**Clonal selection** - An antigen is presented by an APC to a specific B cell that is specific for the antigen. The B cell proliferates into a plasma cell that secretes antibody specific for the epitope presented by the APC. Memory cells also!!
B cells
- Antibody
- Antibody-antigen interaction
- Response

Antibody
- Product of B cell (plasma cell) activation
  - Immunoglobulin (Ig) or antibody
- Structure
- Classes - there are 5

Characteristics of the immunoglobulins

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Isotypes of Antibodies
- Based on the Fc (constant) fragment
  - IgG - peripheral
  - IgA - gut/mucosal
  - IgM - surface & secreted
  - IgD - surface
  - IgE - allergies - worms
Opsonization
- Microbes or particles coated with antibodies - similar to C3b
- Enables macrophages to recognize and phagocytize microbe

Neutralization
- Antibody binds to
  - The microbe or virus receptor
  - Antigenic site of a molecule
  (Eg. Exotoxin)
- Prevents further binding of microbe (no cell entrance for virus) or toxin

Complement fixation
  (activation)
- Antibodies interact with complement proteins - activate complement cascade
  (Eg. Classical pathway)
- Lysis of microbial cell

Summary of antibody functions

Elimination of Foreign Antigens

Primary Response
- First exposure
  - Latent period - initial response to Ag
  - Synthesis of antibodies
    - Slower response - less antibody generated
    - IgM first
    - Followed by IgG
Secondary Response

- Re-exposure to the same immunogen
- Antibody synthesis, titer, and length of antibody persistence is rapid and amplified
  - Due to presence of memory cells

Antigen presenting cells (APC) – 3 total

- Macrophages and dendritic cells
  - Process and present antigen in association with MHC I/II
  - T cell receptor recognize antigen/MHC I/II
  - B - cells are the 3rd major APC

Macrophages

Most antigens are processed by antigen-presenting cells including macrophages such that the antigen fragments are in a state that lymphocytes can be stimulated. Antigen presentation is in the context of the major histocompatibility complex (MHC).

Classes of MHC

- Each individual has a unique MHC genetic profile
- **Class I** – all nucleated cells
- **Class II** – macrophages, dendritic cells, B cells - or - APCs
- CLASS I = CD8 T cell
- CLASS II = CD4 T cell

Cell-mediated immunity (CMI)

CMI is the type of immunity where T cells protect against many viral infections, and reject tumors and transplants -

T cells **do not** make antibody

Good at killing **intracellular** pathogens
**T₇ - THE GENERAL**

- Regulate immune reactions to antigens by releasing cytokines
- CD4 receptor
- Type of cytokine will determine subset of T₇
  - T₇₁ (CMI)
  - T₇₂ (Humoral)
- Cytokines activate macrophages & other cells
- Most prevalent T cell in the blood

**Tₐ - THE KILLER**

- Bind and lyse cells (apoptosis)
  - microbe, viral infected cells, foreign cells, cancer cells
- CD₈ receptor
- Perforins – punch holes in the membrane
- Granzymes – degrade proteins
- Natural killer (NK) cells
  - related to Tₐ
  - attack virus infected cells and cancer cells

Activated T₇ cells produce cytokines that regulate T cells, B cells and other cells of the immune system.

HIV destroys T₇ cells and abrogates both humoral and cell-mediated immunity.

Tₐ kill virus-infected cells and tumor cells by releasing cytotoxins such as perforin (perforates the cells) and granzyme.

NK cells are large lymphocytes that kill tumor cells, virus-infected cells and foreign cells (transplants).
Specific Immunities

- Active
- Passive
- Natural
- Artificial

Active

- Natural or artificial
- Antigen activates B and T cells
  - Memory cells
  - Long-term protection

Passive

- Natural or artificial
- Receive antibodies from another individual or animal
- No memory cells
- No antibody production
- Short-term protection

Natural

- Immunity produced by normal biological exposure, no medical intervention
  - Natural active
    - Eg. Infection
  - Natural passive
    - Eg. Mother to child

Artificial

- Immune protection through medical procedures or intervention
  - Artificial active
    - Eg. Vaccination
  - Artificial passive
    - Eg. Immunotherapy - anti-toxins or anti-venoms (antibodies)

There are many, many, many, very, very, very important terminologies that are very, very, very important in understanding immunology.

Fortunately, there are only a few cells that are important to us in our collective defense against foreign invaders.

All in all, understanding how the immune system interacts with microorganisms is the other half of the infectious disease story.