Learning Objectives
1. Describe the basic differences between innate and adaptive immunity
2. List the major components of the innate defense system and examples of each
3. Describe the two major components of the adaptive immune system
4. Explain where antibody comes from, list the different classes of antibody
5. List the different types of T cells and describe how they contribute to a cell mediated immune response
6. Define antigen, antibody, antibiotic, and cytokine

Two Major Components of the Immune System

- **Innate Immunity (natural immunity)**
  - Protects a naïve animal; an animal that has not been previously exposed to the pathogen
  - Protects immediately
  - Not antigen specific
  - Respond to danger signals from microbes or damaged tissues, which are generally referred to as:
    - PAMPs = pathogen associated molecular patterns: molecules produced by microorganisms but not mammalian cells
    - DAMPS = damage associated molecular patterns: molecules found within mammalian cells and released when the cell is damaged or dies
  - Provide important signals to the adaptive immune response (e.g. costimulatory molecules and cytokines)
  - Components include barriers, phagocytic and sentinel cells, complement, cytokines and NK lymphocyte cells

- **Adaptive Immunity (acquired immunity)**
  - Develops after exposure to an antigen, e.g. bacteria, virus, or vaccine agent
  - Requires days to weeks to develop
  - Is antigen specific and expandable
  - Has memory (anamnestic response); on subsequent exposures to an antigen it responds more rapidly
  - Has tolerance (does not target self-antigens)
  - Enhances the innate response through cytokines
  - Components include humoral immunity (B cells/antibody) and cell-mediated immunity (T cell mediated)

Communication between adaptive and innate response is important for a successful response

Major Components of Innate Immunity

- **Barriers to Infection**
  - Intact skin and mucous membranes = epithelial barriers
  - Examples of types of protection at these surfaces:
    - Acid in the stomach
    - Mucus on the surface provides protection

- **Phagocytic and Sentinel Cells**
  - Phagocytic cells
    - Neutrophil
    - Macrophage
  - Sentinel cells – resident tissue cells that detect invasion by recognizing DAMPS and PAMPs and sending signals to initiate a response
    - Macrophage
    - Dendritic cells
    - Mast cells

- **Complement System** - series of 20-30 proteins in blood plasma
  - An antimicrobial enzyme cascade system
• Very rapidly induced
• Helps control microbial infection in a variety of ways
• Potent; if it is induced and not regulated (turned off) the result is death; one of the components of cobra venom can initiate the alternative pathway of complement and is resistant to the normal regulatory mechanisms

• **Innate Defense Cytokines** - (cytokines = protein messenger molecules between cells)
  o Pro-inflammatory cytokines
    ♦ Secreted by sentinel cells (macrophages, dendritic cells, mast cells) in response to DAMPs and PAMPs
    ♦ Cause fever, lethargy, loss of appetite
  o Chemokines – molecules that cause cells to migrate to sites of infection
  o Interferons – interfere with replication of some viruses
    ♦ Produced by virally infected cells within 24 hours of some viral infections
    ♦ Production of interferon by one cell protects nearby cells by in various ways including activating \ proteins that inhibit viral replication

• **NK cells (natural killer)**
  o A type of lymphocyte
  o Important for killing virus infected cells and tumor cells
  o Targeted to cells that do not express normal proteins (MHC1), cells expressing stress proteins, and/or cells with antibody bound to them

• **Antimicrobial Peptides = defensins**
  o Small molecular weight proteins found along epithelial surfaces like skin and mucosal surfaces and in phagocytic cells
  o These proteins can poke holes in some bacteria and kill them

**Two Major Components of the Adaptive Immune System**

• **Humoral Immunity = Antibodies**
  o There are four different classes (isotypes) of antibody that are secreted and each has some unique characteristics that influence where and how they provide protection
    ♦ IgM - the first antibody produced in every primary antibody response and the largest antibody molecule; functions primarily in the blood stream, short half-life
    ♦ IgG - high in serum, important in systemic diseases in general
    ♦ IgA - important on mucosal surfaces as a dimer
    ♦ IgE - important in allergy and parasitic infection; found on mast cells

• **Cell Mediated Immunity (CMI)** - adaptive immunity mediated by T cells
  o T Helper cells = CD4+
    ♦ Function: produce and secrete cytokines (messenger molecules)
    ♦ Different cytokines in different combination result in different effects; for example, IL4, from T_{H2} cells, influences B cells to make IgE
  o Cytotoxic T lymphocyte (CTL) = CD8+
    ♦ Function: attack and kill cells that make foreign proteins, e.g. viral infected cell or tumor cell
  o Gamma delta (γδ T cell)
    ♦ Function: protection at mucosal surfaces; still not well defined

**Types of Blood Cells - originate in the bone marrow**

• Platelets - important in blood clotting – no major role in immune response
• Red blood cells (RBCs) – do not play a role in immune response
• **Five types of white blood cells (WBCs) or leukocytes** – play a major role in the immune system
  o Basophil - 0.5% of WBCs in circulation
    ♦ Contain granules (which stain basophilic) that are filled with inflammatory mediators, very similar to the mediators in mast cell granules, e.g. histamine, serotonin, other vasoactive substances.
      ♦ It is unclear whether these cells become tissue mast cells or not
      ♦ Important in allergy and parasites
  o Eosinophil - 1-3% in the circulation, half-life of 30 minutes
Important Definitions to Know

- **Antigen**: Any foreign substance that can bind to specific lymphocyte receptors and induce an immune response. For example, bacteria, viruses, fungi, and parasites.
- **Antibody**: An immunoglobulin (Ig) molecule is synthesized by B cells after exposure to antigen. The antibody produced binds specifically to the antigen that activated the B cell. The antibody binds to “the body” of the bacteria, etc.
- **Antibiotic**: A chemical compound, usually obtained from microorganisms, that can prevent growth of or kill bacteria.
- **Cytokine**: Protein messenger (communicator) molecules made by cells that influence the immune response by their effects on other cells; they can act on the cell that made them, a neighboring cell or at a distant site. Types of cytokines include interleukins, interferons, chemokines, colony stimulating factors, and growth factors.

Immune System Dysfunction – will be discussed in later lectures
- When the immune system causes damage and is responsible for the disease process
- An inappropriate response of the immune system
- Examples: hypersensitivities, allergies, autoimmune disease, and immunodeficiencies