**Chapter 15**

**An Overview of the Body’s Defenses**

* Resistance to most plant and animal pathogens
* Resistance due to physiological processes of humans that are incompatible with those of the pathogen (species resistance)
  + Correct chemical receptors not present on human cells
  + Temperature and pH may be incompatible with those necessary for the pathogen’s survival
* Number of pathogens for which humans don’t have innate resistance can cause disease

**The Body’s First Line of Defense**

* Made up of structures, chemicals, and processes that work to prevent pathogens entering the body
* Includes the skin and mucous membranes of the respiratory, digestive, urinary, and reproductive systems

**The Role of Skin in Innate Immunity**

* Skin composed of two major layers
  + Epidermis
    - Multiple layers of tightly packed cells
      * Few pathogens can penetrate these layers
      * Shedding of dead skin cells removes attached microorganisms
    - Epidermal dendritic cells
      * Phagocytize pathogens
  + Dermis
    - Contains protein fibers called collagen
      * Give skin strength and pliability to resist abrasions that could introduce microorganisms
  + Skin has chemicals that defend against pathogens
    - Perspiration secreted by sweat glands
      * Salt – inhibits growth of pathogens by drawing water from their cells
      * Antimicrobial peptides – sweat glands secret dermicidins
      * Lysozyme – destroys cell wall of bacteria
    - Sebum secreted by sebaceous (oil) glands
      * Helps keep skin pliable and less likely to break or tear
      * Lowers the pH of the skin to a level inhibitory to many bacteria

**The Role of Mucous Membranes and the Lacrimal Apparatus in Innate Immunity**

* Mucous membranes line all body cavities open to the outside environment
* Two distinct layers
  + Epithelium
    - Thin, outer covering of the mucous membranes
    - Unlike surface epidermal cells, epithelial cells are living
    - Tightly packed to prevent entry of pathogens
    - Continual shedding of cells carries attached microorganisms away
  + Deeper connective layer that supports the epithelium
* Lacrimal apparatus
  + Produces and drains tears
  + Blinking spreads tears and washes surface of the eye
  + Lysozyme in tears destroys bacteria

**The Role of Normal Microbiota in Innate Immunity**

* Normal microbiota help protect the body by competing with potential pathogens (microbial antagonism)
* Various activities of the normal microbiota make it hard for pathogens to compete
  + Consumption of nutrients makes them unavailable to pathogens
  + Create an environment unfavorable to other microorganisms by changing pH
  + Help stimulate the body’s second line of defense
  + Promote overall health by providing vitamins to host

**Other First-Line Defenses**

* Antimicrobial peptides
  + Present in skin, mucous membranes, neutrophils
* Toll-like receptors (TLRs)
  + Cells produce antimicrobial peptides when microbial chemicals bind to TLRs on host cell
* NOD proteins
  + Intracellular receptors for microbial components such as bacterial cell walls
* Other processes and chemicals

**The Body’s Second Line of Defense**

* Operates when pathogens succeed in penetrating the skin or mucous membranes
* Composed of cells, antimicrobial chemicals, and processes but no physical barriers
  + Many of these components are contained or originate in the blood
* **Defense Components of Blood**
  + Plasma
    - Plasma is mostly water containing electrolytes, dissolved gases, nutrients, and proteins
      * When the clotting factors, a group of plasma proteins, are removed from plasma, the remaining fluid is called serum
      * Includes iron-binding compounds
      * Other plasma proteins include complement proteins and antibodies
  + Defensive blood cells: leukocytes
    - The cells and cell fragments in plasma are called *formed elements*
    - Three types of formed elements
      * Erythrocytes – carry oxygen and carbon dioxide in the blood
      * Platelets – involved in blood clotting
      * Leukocytes – involved in defending the body against invaders
        + Divided into granulocytes and agranulocytes
  + Defensive blood cells: leukocytes
    - Granulocytes
      * Neutrophils and eosinophils can phagocytize pathogens
      * Neutrophils and eosinophils are capable of diapedesis
    - Agranulocytes
      * Two types
        + Lymphocytes – most involved in adaptive immunity
        + Monocytes – leave the blood and mature into phagocytic cells called macrophages
    - Lab analysis of leukocytes
      * The differential white blood cell count test can signal signs of disease
        + Increased eosinophils can indicate allergies or parasitic worm infection
        + Bacterial diseases often show increase in leukocytes and in neutrophils
        + Viral infections show increase in lymphocytes
* **Phagocytosis** 
  + Cells capable of phagocytosis are called phagocytes
  + Phagocytosis is not completely understood
  + Can be divided into five stages
    - Chemotaxis
    - Adherence
    - Ingestion
    - Killing
    - Elimination
* **Nonphagocytic Killing**
  + Killing by eosinophils
    - Mainly attack parasitic helminths (worms) by attaching to their surface
    - Secrete toxins that weaken or kill the helminth
    - Eosinophilia, or elevated eosinophil levels, is often indicative of a helminth infestation
  + Killing by natural killer lymphocytes
    - Secrete toxins onto the surface of virally infected cells and tumors
    - Differentiate normal body cells because they have membrane proteins similar to the NK cells
  + Killing by neutrophils
    - Produce chemicals that kill nearby invaders
    - Generate extracellular fibers called neutrophil extracellular traps (NETs) that bind to and kill bacteria
* **Nonspecific Chemical Defenses Against Pathogens**
  + Complement
    - Set of serum proteins designated numerically according to the order of their discovery
    - Complement activation results in lysis of the foreign cell
    - Complement can be activated in three ways
      * Classical pathway
      * Alternate pathway
      * Lectin pathway
    - Inactivation of complement
      * Body’s own cells withstand complement cascade
        + Membrane-bound proteins on many cells bind with and break down activated complement proteins
  + Interferons
    - Protein molecules released by host cells to nonspecifically inhibit the spread of viral infections
    - Cause many symptoms typically associated with viral infections
    - Two types
      * Types I (alpha and beta)
      * Type II (gamma)
  + **Inflammation**
    - Nonspecific response to tissue damage resulting from various causes
    - Characterized by redness, heat, swelling, and pain
    - Two types
      * Acute
      * Long-lasting (chronic)
    - Acute inflammation
      * Develops quickly and is short lived
      * Is typically beneficial
      * Is important in the second line of defense
        + Dilation and increased permeability of the blood vessels
        + Migration of phagocytes
        + Tissue repair
  + **Fever**
    - A body temperature over 37°C
    - Results when chemicals called pyrogens trigger the hypothalamus to increase the body’s core temperature
    - Various types of pyrogens
      * Bacterial toxins
      * Cytoplasmic contents of bacteria released by lysis
      * Antibody-antigen complexes