**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