Human Physiology I Learning Goals **Spring 2010**

Course Learning Goals:

Students will be able to:

1. Use basic chemical/biochemical, physical, and mathematical principles to describe the functioning of life processes associated with the topics in this course.
    a. Physiology I: Cell physiology, neurophysiology, endocrinology, muscle physiology, and immunology.

2. Demonstrate the use of the scientific method and quantitative reasoning to the field of physiology.

3. Demonstrate the how and why (the mechanistic and teleologic) understanding of the levels of organization composing the human organism.

4. Diagram and identify the regulated homeostatic variable, sensor, integrator and effector in the homeostatically regulated system and predict how a perturbation to the system will be compensated for.

5. Integrate knowledge of the major systems to outline how these systems interact to maintain homeostasis.

6. Relate structure and function in physiology.

7. Demonstrate an understanding of the physiology and basic regulatory concepts relating to the functioning of life processes.

Course Overview

Reading Assignment: Silverthorn Chapters 1 & 2

Other resources: American Physiological Society Powerpoint Presentation - Introduction to Physiology

Main Goals

1. **Describe the discipline of physiology in relation to other biological disciplines and in terms of the types of questions physiologists explore.**
2. **Translate physiological data from graphs to words and vice versa.**

Terminology

Physiology	Extracellular fluid	Homeostasis
Biology	Intracellular fluid	Equilibrium
Cell	Translational research	
Tissue	Control system	
Organ	Dependent variable	
Organ systems	Independent variable	

Learning Goals

Students will be able to:

1. Outline the levels of biological organization from atom to system, define physiology and discuss the relation to biology. (Pages 2-3)
2. Describe how the human organism is arranged into functional levels designed to maintain homeostasis and achieve emergent properties such as thought, emotion, locomotion, and communication.
3. Discuss the significance of maintaining homeostasis to the survival of the whole organism.
   -Faculty emphasis: this theme will be revisited throughout the semester (emphasized in more depth in cellular communication section of cell physiology goals)

Scientific Thinking: to be emphasized throughout semester.

1. Determine the dependent and independent variables on a graph.
2. Predict the change in equation outcome based upon manipulation of equation components.
3. Predict the change in physiological outcome based on change in independent variable when presented with a graph (example professor dependent)

Optional Learning Goals

- Trace the historical path of key current physiological concepts.
- List the recent Nobel laureates and their corresponding achievements.

Cell Physiology

Reading Assignment: Silverthorn Text - Chapters 3, 4 & 5

Main Goals

1. **Describe the cellular components and their associated functions**
2. **Explain how proteins are made from genes.**
3. **Explain how chemical reactions proceed in a biological setting.**
4. **Explain the processes and factors involved in cellular transport within a cell and across a cell membrane.**

Terminology

Chapter 3: Compartments: Cells and Tissue

Epithelia	Cell junctions	Cell membrane
Interstitial fluid	Lipid	Golgi apparatus
Carbohydrate	Proteins	Organ
Endoplasmic reticulum (smooth and rough)		Mitochondria
Nucleus	Cytosol	Ribosomes
Mitochondrial matrix	Intermembrane space	Lysosomes
Peroxisomes	Cell	Tissue
Gap junctions	Tight junctions	Desmosomes
Simple epithelia	Stratified epithelium	Squamous epithelium
Cuboidal epithelium	Columnar epithelium	Organelle
Microfilaments	Intermediate filaments	Microtubule
Motor proteins	Cilia	

Chapter 4: Energy & Cellular Metabolism

Kinetic energy	Potential energy	Entrophy
Reaction rate	Activation energy	Free energy
Endergonic	Exergonic	Reactants
Products	Enzyme	Coenzyme
Energy	Chemical work	Mechanical work
mRNA	tRNA	rRNA
Codons	Transcription	Translation
Gene	Transcription factors	Polymerase
Protein synthesis	Amino acid	Peptide
Polypeptide		

Chapter 5: Membrane Dynamics

Permeability	Diffusion	Gradient
Ligand	Receptor	Enzyme
Membrane transport proteins	Chemically gated channel	Active Transport

Voltage gated channel Hydrophilic Hydrophobic

Learning Goals

Students will be able to…

1. Diagram the structure of the plasma membrane indicating where carbohydrates, fats, and proteins are found within and on the plasma membrane. (Pages 53-55)
2. Explain/differentiate the functions of carbohydrates, fats, and proteins found within and on the plasma membrane. (Pages 55-58)
3. Predict the function of a cell based upon the number/concentration of specific organelles such as the nucleus, Golgi apparatus, endoplasmic reticulum, and mitochondria. (Pages 58-68)

   -Faculty note: Improved student buy in to this section occurs when you start with a clicker question they can't answer instead of a reiteration of organelle function.
4. List the three types of cytoskeletal elements and provide one major function of each. (Pages 60-63; Table 3-2)
5. List the four major categories of tissues and provide one major function of each (Pages 68-80)
6. Differentiate between cell junction types in the organization of specialized tissue and how this affects cell-cell communication. (Pages 69-71)
7. Determine the probability a chemical reaction will proceed when presented with various chemical reactions differing in activation energy levels. (Pages 93-95; Figures 4-2, 4-3, 4-4)
8. Explain why it is necessary that living organisms require a catalyst (an enzyme) present to carry out a reaction. (Page 98; Figures 4-3, 4-4, 4-6, 4-8, 4-9)
9. Using diagrams, describe in general terms how the information in a gene is accessed for expression of a specific protein. (Pages 114-122)
10. Explain the process by which a protein is synthesized, modified, stored/secreted and the organelles involved in this process. (Pages 114-122; Figures 4-24, 4-25, 4-26, 4-27)
    a. Diagram the Central Dogma of Biology (DNA makes RNA makes protein) and the roles of DNA, RNA and protein within the cell. (Figure 4-24)
    b. Identify the different forms of RNA (ribosomal, transfer, messenger) and their function in protein synthesis. (Figure 4-24)
    c. Describe the role and outcome of transcription and translation in the process of making a protein. (Figure 4-25, 4-26)
11. Identify the diverse roles proteins play in the body and predict what structures/processes can and cannot be affected by genetic mutation. (Page 113)
12. Differentiate between the functional units of a protein (amino acid and peptide bond). (Page 30, Figure 2-9)
13. Differentiate between equilibrium and homeostasis. (Pages 130-132)
14. Differentiate the terms passive diffusion, facilitated diffusion, and active transport based on cellular energy requirements. (Pages 132-148; Figure 5-4)
15. Explain why the cell membrane makes such a good barrier to keep out or in polar molecules. (Pages 138-139)

16. Predict movement of a substance across a cell membrane and explain how and what factors contribute to its movement (hydrophobicity, concentration, electrical gradients). (Pages 132-150)
17. Explain how chemical and electrical gradients are established in the cell. (Pages 158-165; Figures 5-30, 5-31, 5-32)

Cellular Communication

Reading Assignment: Silverthorn Chapter 6: Communication, Integration, and Homeostasis

Main Goal

1. Describe how cells receive and integrate information to change/direct cell functions.

Terminology

Electrical signal	Chemical signal	Target cell
Local communication	Long distance communication	Gap junctions
Paracrine	Autocrine	Amplification
Primary messenger	Secondary messenger	Agonist
Antagonist	Specificity	Receptor
Threshold	Afferent	Integrating center
Efferent	Effector	Response
Feedback	Feedforward	

Learning Goals

Students will be able to:

1. Differentiate between paracrine, autocrine, endocrine, and exocrine signaling. (Pages 75 (endocrine and exocrine), 175-176 (paracrine and autocrine))

2. Describe the common features of cellular signaling cascades in the body. (Pages 177-191)
   a. Determine the interaction between the signal molecule (ligand) and receptor. (Figure 6-7)
   b. Differentiate between the categories of cell surface receptors that activate a cascade in the cell (ligand gated, enzyme receptors, G-protein coupled receptors). (Figure 6-5)
   c. Describe the role of a primary messenger, secondary messenger, and protein kinase in a signal transduction cascade initiated by a plasma membrane receptor. (Pages 177-185)
   d. Differentiate physiological outcome to a stimulus based upon receptor specificity, amplification, and desensitization. (Pages 177-191)
   -Faculty emphasis: student thinking is to focus on the message sent vs. receiving cell response.
   e. When presented with a graph of receptor affinity differentiate between a low and high affinity receptor. (Pages189-190 – *topic discussed, but not in graphical form*)
   f. Compare and contrast the role of a ligand versus a receptor in directing a change in cell response.

3. Compare and contrast the stimulus and outcomes of positive and negative feedback (Pages 199-200, 222-228)

Endocrinology

Reading Assignment: Silverthorn Chapter 7: Introduction to Endocrine System

Other Resources: InterActive Physiology CD (or online): Endocrinology (Anatomy Review: Endocrine System Review; Biochemistry, Secretion, and Transport of Hormones; The Actions of Hormones on Target Cells, The HPA axis, Response to Stress)

Main Goals

1. **Differentiate between cell signaling and hormonal signaling.**
2. **Compare and contrast the three main types of hormone signaling (synthesis through mechanism of action).**
3. **Describe the conditions under which hormones can or cannot maintain homeostasis.**

Terminology

Hormone	Hypothalamus	Anterior pituitary
Posterior pituitary	Pancreas	Thyroid
Pineal	Adrenal gland	Hydrophilic
Hydrophobic	Steroid	Cholesterol
Peptide	Amine	Catecholamine
Cortisol	Insulin	Hyposecretion
Hypersecretion		

Learning Goals

Students should be able to:

1. Explain the interaction between the organs and glands of the endocrine system, including the hypothalamus, anterior and posterior pituitary, pancreas, thyroid, pineal, and adrenal. (Pages 214-215, 225-226, 229; Figure 7-2)
   -Faculty note: gonads--leave to Phys II (reproduction section), maybe brief mention as hypothalamus releasing hormones.
2. Differentiate between the two main types of secreted factors (lipid soluble and water soluble), including how each leads to a change in cell function. (Pages 217-222)
3. Differentiate between peptide, steroid and amine hormone synthesis, release, signal reception and action on cell. (Pages 217-222; Table 7-1; Figures 7-3, 7-5, 7-6, 7-7, 7-8)
4. Explain why it is important that hormones are broken down (metabolized) and predict consequences on the target cell if high concentrations of hormones are maintained over time (chronically). (Pages 216-218, 220, 232-233)
5. Explain the mechanism of how target cells stop responding to the signal when hormone concentration remains high overtime (chronically). (Pages 216-218, 220, 232-233)
6. For insulin, cortisol, and thyroid hormone, list the metabolic/physiologic action and stimulus for secretion and site of secretion. Explain how negative feedback regulates these pathways and where regulation occurs. (Pages 225-230; Table 7-2 (insulin); Figures 7-9 (insulin), 7-13 (insulin), Figures 7-15 (cortisol), 7-19 (cortisol))

-Can extend knowledge by having students predict pathways and feedback mechanisms with thyroid hormone/ on homework.

7. Given a set of data determine if hormones are acting as synergists, antagonists or permissive hormones. (Pages 230-232; Figure 7-18)
8. Predict how abnormalities in the hypothalamic-pituitary-adrenal axis will alter hormone secretion and feedback. (Pages 234-235; Figures 7-20, 7-21 (Prediction question))

Optional Learning Goals

1. Predict the physiological outcome from disorders such as hypo/ hypercortisolism, Turner syndrome, hypoglycemia, diabetes, obesity (with leptin and ghrelin feedback to brain and appetite, in w/insulin, etc.), thyroid disease-consequences to other systems, and growth hormone deficiencies.
2. In predicting the consequences of abnormalities in hormones secreted from the HPA axis (goal #8), predict the effects of exogenous drugs (pharmacology) that target the HPA axis.

Neurophysiology: General

Reading Assignment: Silverthorn Chapter 8:Neurons: Cellular & Network Properties

Other Resources: InterActive Physiology CD (or online): Nervous I (Anatomy Review)

Main Goals

1. Describe how the anatomy of a neuron does and does not vary with the type of signal it propagates.
2. Explain how graded potentials and action potentials are generated and propagated in a neuron.
3. Predict whether a signal will continue to be propagated given a set of conditions.
4. Explain the mechanism by which neurons can transmit signals from one to another and describe the factors that contribute to efficiency of the signal transfer.
5. Describe the system level organization of the nervous system in terms of both anatomy and function.

Terminology

Central nervous system	Brain	Spinal cord
Peripheral nervous system	Neuron	Nerve
Dendrite	Soma (cell body)	Axon
Axon hillock (trigger zone)	Axon terminal	Synapse
Afferent	Efferent	Unipolar neurons
Bipolar neurons	Sensory neuron	Motor neuron
Innervation		

Learning Goals

Students will be able to:

1. Explain the major differences between the central and peripheral nervous systems by the structures and functions of each. (Pages 244-246)
2. When presented with a representation of a neuron, explain the main function of the dendrites, soma, axon hillock, axon, axon terminal, and synapse. (Pages 247-249; Figure 8-3)
3. Compare and contrast the function of the three major classes of neurons: afferent, interneuron, and efferent. (Pages 245-248; Figures 8-1, 8-2, 13-7 (imbedded in patellar tendon reflex)) -*Not well represented in text*.
4. Describe the direction and function of information flow through the regions of a neuron in response to input from another neuron. (Pages 247-249)

Neurophysiology: Electrical Signal Propagation within a Neuron

Reading Assignment: Silverthorn Chapter 6 (page 160-166) & Chapter 8

Other resources: InterActive Physiology CD (or online): Nervous I (Ion Channels, The Membrane Potential, The Action Potential)

Terminology

Ions	Ion channels	Leaky channels
Concentration gradient	Electrical gradient	Myelin
Nodes of Ranvier	Permeability	Resting membrane potential
Electrochemical gradient	Graded potential	Action potential
Gating	Refractory periods	Saltatory conduction
Oligodendrocytes	Schwann cells	Depolarization
Repolarization	Hyperpolarization	Threshold
Activation gate	Inactivation gate	

Learning Goals

Students will be able to:

1. Diagram the factors that are responsible for the resting membrane potential of a neuron, indicating where the concentrations of Na^+, K^+, and Cl^- are high and low, and the direction of the electrical and chemical forces acting on each ion. (Pages 160-166).
2. Identify the structures/factors at the plasma membrane that influence permeability. (Pages 165, 252-254)
3. Explain how the charge separation across the plasma membrane (resting membrane potential) is maintained and what influences the electrical gradient, chemical gradient and permeability have on the resting membrane potential. (Pages 160-165)
4. Explain how changes in channel activation/inactivation, chemical and electrical gradients influence the membrane potential and signal propagation. (Pages 255-261)
5. Compare and contrast the structure and function of the three types of ion channels found in the plasma membrane (mechanical, chemical, voltage gated). (Pages 254-256)
6. Compare and contrast graded and action potentials in terms of the relative strength of signal and length of travel in a neuron. (Pages 255-259; Table 8-3; Figures 8-7, 8-8 (Compare the result of 3rd graph on left and right side of figure))
7. Explain why the cell needs both graded and action potentials in order to integrate information and allow for appropriate cellular communication/neural signaling. (*i.e Why an action potential is not a good integrator of signals and why a graded potential is not a good long distance signal)* (Page 255, *not fully addressed in text)*
8. When presented with a graph of an action potential, indicate when the membrane is being depolarized, repolarized, and hyperpolarized, and identify the major ions contributing to each phase. (Pages 258-260; Figures 8-9, 8-10)

9. Graph an intracellular recording of an action potential as a change in membrane potential over time, indicating zero membrane potential, resting membrane potential, and voltage threshold. (Pages 257-262; Figures 8-9, 8-10)
10. Match membrane events (channel activation/inactivation, ion flow) during a single action potential to changes in membrane polarization as represented by the action potential graph. (Page 258-262; Figures 8-9, 8-10, 8-12)
    a. I.e: When presented with a graph of sodium and potassium permeability, explain how these contribute to the phases of the action potential and how activation/inactivation of the respective ion channels contribute to the shape of these curves. (Figures 8-9, 8-10, 8-12)
11. Given alterations in the duration or amplitude of an action potential predict the cellular properties that contributed to that change and vice versa. (Pages 258-262; Figures 8-10, 8-12)
12. Explain how the phases of the action potential allow for propagation of the signal along an axon uni-directionally in normal conditions. (Pages 262-264; Figures 8-12, 8-15)
13. Explain the influence of myelin and nodes of Ranvier in transmitting an action potential along the axon of a neuron by saltatory conduction. (Pages 266-268)

Student Misconceptions

1. 1.The Na/K ATPase generates the resting membrane potential.
2. Chemical gradients change when electrical gradients change.
3. It takes a lot of ions to change the membrane potential when in fact it's only a few!
4. The ligand/neurotransmitter is the determinant of generating an EPSP or an IPSP. Instead of the receptor being the determinant (i.e. that there are in fact many receptor types for the same chemical).

Neurophysiology: Neuron-Neuron Communication

Reading Assignment: Silverthorn Chapter 8

Other Resources: InterActive Physiology CD (or online): Nervous II (Anatomy Review, Ion Channels, Synaptic Transmission, Synaptic Potentials and Cellular Integration)

Terminology

Synapse	Presynaptic cell	Postsynaptic cell
Neurotransmitter	Synaptic cleft	Interneuron
Post-synaptic potential	Excitation	Inhibition
Receptor	Exocytosis	

Learning Goals

Students will be able to:

1. Explain how neurotransmitters communicate information across chemical synapses from the axon terminal to a post-synaptic neuron (one neuron to the next). (Pages 271-276)
2. Describe the three mechanisms (uptake, enzyme clearance, diffusion) used to deactivate neurotransmitters. (Pages 277-278)
3. List some basic neurotransmitters (acetylcholine, norepinehphrine, dopamine, serotonin, GABA and glutamate; Optional: histamine and orexin) and the types of receptors to which they bind. (Pages 272-275; Table 8-4)
4. Graph an excitatory post-synaptic potential (EPSP) and an inhibitory post-synaptic potential (IPSP) as a change in membrane potential over time and explain how these potentials sum to influence the membrane potential. (Pages 277-281)

Neurophysiology: System Level

Reading Assignment: Silverthorn
Chapter 9: The Central Nervous System (Pages 312-320)
Chapter 11: Efferent Division: Autonomic and Somatic Motor Control (Pages 377-380, 385-389)

Terminology

Sympathetic	Parasympathetic	Central nervous system
Peripheral nervous system	Autonomic	Somatic
Fight-or-flight	Rest-and-digest	Muscarinic
Nicotinic	Adrenergic	

Learning Goals

Students will be able to:

1. Illustrate the branches of the nervous system; central and peripheral nervous systems, autonomic, sympathetic, parasympathetic, and somatic. (Pages 245; Figure 8-1)
2. Explain the brain processes associated with sleep, learning, and memory. Indicate what structures match the appropriate functions in a general mechanism (the stimulus, integrator, effector, and response/output). (Pages 312-320; Figures 9-20-22)
3. Determine when the parasympathetic and sympathetic nervous systems will dominate over the other (rest and digest vs. fight or flight responses). (Pages 377-380; Figure 11-1)
    a. Differentiate the type of receptors (muscarinic, nicotinic, adrenergic) and neurotransmitter (norepinephrine (NE) and acetylcholine (Ach)) involved in activating the pre and post-ganglionic fibers of the parasympathetic and sympathetic nervous system. (Pages 382, 385-386; Figures 11-7 and 11-11)
    b. Determine how activation of these receptors will differentially affect the response of the same target tissue (e.g., constriction vs. dilation of the pupil, increased or decreased heart rate, breathing rate, digestion, bladder control, insulin release). (Pages 378-380, 387-389; Figures 11-5, 11-11

Sensory Systems

1. Diagram and describe the structures and mechanisms involved in the flow of information that allows for sound and sight (okay to select two other sensory systems, these are the two Steve chose).

Muscle Physiology

Reading Assignment: Silverthorn
Chapters 11: Efferent Division: Autonomic and Somatic Motor Control
Chapter 12: Muscles

Other Resources: InterActive Physiology CD (or online): Muscle Physiology (Anatomy Review: Skeletal Muscle Tissue, Neuromuscular Junction, Sliding Filament Theory, Contraction of Motor Units, Contraction of Whole Muscle)

Main Goals

1. **Relate structure to function involved in the mechanisms of muscle contraction at both the molecular and organ levels of organization.**
2. **Predict changes in muscle contraction based on changes to molecular structure and/or nervous input.**

Terminology

Neuromuscular junction	Motor end plate	Motor neuron
Acetylcholine	Acetylcholinesterase	Nicotinic receptor
Calcium channel	Excitation-contraction coupling	
Sliding filament theory	Myosin	Actin
ATP hydrolysis	Power stroke	Tropomyosin
Troponin	Rigor	End plate potential
Sarcoplasmic reticulum	T-tubules	Action potential
DHP receptor	Twitch	Contraction
Relaxation	Motor unit	Gross motor action
Fine motor action	Isotonic	Concentric action
Eccentric action	Isometric	Spatial summation
Temporal summation	Tetanus	Fast-twitch (II) fibers
Slow twitch (I) fibers	Myoglobin	Oxidative
Glycolytic	Atrophy	Hypertrophy
Monosynaptic reflex	Polysynaptic reflex	Afferent
Efferent	Interneuron	Agonist
Antagonist	Inhibition	Excitation
Central nervous system	Peripheral nervous system	

Learning Goals

Students will be able to:

1. Explain the anatomy and function of the motor end-plate. (Pages 390-391; Figures 11-12, 11-13)

2. Diagram the sequence of events involved in muscle contraction, from neuronal action potential through cell signaling to force output. (Pages 403-409; Figures 12-7, 12-9, 12-10, 12-11, 12-12)
3. Explain the molecular basis of a muscle contraction based on the sliding filament theory. (Pages 403-407; Figures 12-9, 12-10)
4. Differentiate between muscle fiber types, based on size, fuel source, contraction velocity, fatigue resistance, and mitochondria. *Myoglobin and capillarity – (optional)*. (Pages 412-414; Table 12-2)
5. Graph and explain the length-tension relation with corresponding sarcomere alignment. (Pages 413-414)
6. Compare the processes of temporal and spatial summation in generating force in the muscle to temporal and spatial summation of graded potentials in the neuron. (Pages 278-281, 413, 415; Figure 8-28, 12-16, 12-17)
7. Differentiate between fused and unfused tetanus. (Page 415; Figures 12-17c, 12-17d)
8. Define motor unit and explain how the type and number of motor units influences muscle force. (Pages 415-417; Figure 12-18)
9. Describe the different types of muscle contraction-isotonic, isometric, eccentric, concentric. (Pages 417-420; Figures 12-19, 12-20)
10. Predict a change in force according to the force-velocity relation. (Pages 419 and 421; Figure 12-23) (*Note: Text uses load in lieu of force*.)
11. Differentiate between atrophy and hypertrophy. (*Not discussed in depth in text*) (Pages 67, 233, 420, 528)
12. Compare and contrast the morphological and contractile properties of smooth and cardiac muscle to skeletal muscle. Faculty note: tie cell phys in here including both cell adhesions and organelle concentration. (Pages 397, 421-429; Figure 12-1; Table 12-3)

Optional Learning Goals:

1. Diagram origin of muscle during embryonic development (ecto/endo/mesoderm).
2. Describe the effects of aging on muscle tissue. (*Not discussed in text*)
3. Describe the special sensory receptors affecting motion sickness.
4. Differentiate between muscle fiber types on myoglobin and capillarity.

Student Misconceptions

- Myosin and actin can change length during contraction.

Immunology

Reading Assignment: Silverthorn Chapter 24: The Immune System (pg. 776 – 793)

Other Resources: InterActive Physiology CD (or online): Immune System (Immune System Overview, Anatomy Review)

Main Goals

- **Differentiate between the functions, anatomy, and cell types of the two major branches of the immune system.**

Terminology

Acquired immunity	Antibody	Antigen
B lymphocyte	Basophil	Bone marrow
Basophil	Cytotoxic T cell	Dendritic cell
Eosinophil	Granulocyte	Helper T cell
Immune response	Immunity	Inflammation
Innate immunity	Lymph node	Macrophage
Mast cell	Monocyte	Natural killer cell
Neutrophil	Pathogen	Spleen
Thymus gland	Tonsils	T lymphocyte

Learning Goals

Students will be able to:

1. Describe in general the three major functions of the immune system: how the body protects itself from invaders (pathogens), how it removes dead or damaged cells, and how it removes abnormal cells. (Page 777)
2. Explain the differences between a virus and a bacteria in terms of structure, living conditions, and susceptibility to drugs. (Page 778; Table 24-1)
3. Identify the two major branches of the immune system (acquired, innate), and describe how each of these branches differs in the specificity of a response, the timing of a response, and the effector cells used to eliminate a potential pathogen. (Page 779)
4. Identify primary vs. secondary lymphoid organs. (Pages 780-782; Figure 24-2)
5. Compare and contrast the functions of the six major cell types of the immune system. (Pages 782-785, 787-788, 791-793; Figure 24-4)

Optional Learning Goals

1. Diagram the steps in the process of fighting viral infections. (Page 795-796; Figure 24-18)
2. Diagram the steps in the process of an allergic reaction. (Page 797; Figure 24-19)
3. Compare and contrast the antigens and antibody characteristic of each blood type. (Page 798; Figure 24-20; Table 24-3)
4. Autoimmune diseases (Page 799-800; Table 24-4)
5. Describe how stress alters immune system function. (Page 802)