Syllabus

BME 5010, ME 5100, ECE 5100, IE 5100, CHE 5100 - Fall 2011

No: BME 5010, ME 5100, ECE 5100, IE 5100, CHE 5100

Title: Engineering Physiology

Credits: 4

WSU Catalog Description:
Course Prerequisites: BME 5005 or previous college-level human physiology course. Students enrolled in BME 5005 will be removed from the course by the instructor.

Instructor: Weiping Ren, MD, PhD.

Office Hours: M/W 4:30 – 5:30 p.m. or By Appointment (No Walk-Ins).
Office location: 2102 Bioengineering Center
Phone: 313-577-8118 Email: as7606@wayne.edu
Course Meeting Time: Monday and Wednesday 5:30pm- 7:20pm, Sept 6 – Dec 19, 2011.
Course Meeting Location: Room 1507 ENGG

Teaching assistant (TA):
Wei Song
2223 Bioengineering Center
E-mail: ea4029@wayne.edu
Office Hours: M/W 4:30 – 5:30 p.m. or By Appointment (No Walk-Ins).

Goals:

Physiology is the study of the mechanisms by which the body functions. The goal of this course is to provide the basics of human physiology --that is, the mechanisms by which the organ systems of the human body function, with a unique emphasis on the quantitative aspects of the human systems. Another goal of this course is to provide quantitative ways in which biomedical engineering, genetic engineering and cell biology are being used to address problems of health and disease based on the principles of physiology.
Learning Objectives:

Following Completion of the Engineering Physiology Course students will be able to:

- Provide knowledge base and understanding of the physiological processes underlying health and disease in the major organ systems of the body.

- Summarize the major functions of the nervous system, muscular system, cardiovascular system, respiratory system, renal system, gastrointestinal system, and endocrine system.

- Describe the concept of homeostasis as it applies to physiological systems.

- Provide knowledge base and understanding of the molecular and cellular mechanisms of physiological processes, in order to provide a foundation for understanding biomaterial and tissue engineering in subsequent courses.

- Provide sound basis in physiological principles and knowledge in the application of biomedical engineering fields.

Textbook:


Prerequisites by Topic:

BME 5005 or previous college-level human physiology course. Students enrolled in BME 5005 will be removed from the course by the instructor.

Additional learning materials:

The lecture handouts are available on the course Blackboard web site, available through Pipeline. It is the responsibility of the student to obtain the handouts from the course web site. Students should access the notes prior to class.

Some editions to the textbook come with 2 CDs, "Essential Study Primer," which can be used for self-study. We also have ADAM Interactive Physiology CD-ROMs available. These are not required but serve as an additional study aid. They cover the muscular, cardiovascular, nervous, respiratory and urinary systems. There are eight CDs available on each subject. They can be checked out from Mr. Song Wei (Teaching Assistant) on Monday and returned Wednesday of the same week or checked out Wednesday and returned the following Monday. Please return them at these times without exception so that other students can check them out. If they are still available you are free to check them out again. Students who are regularly delinquent in returning CDs will be warned and will then be penalized 5 exam points on the next exam for every day that the CD is not returned. Grades will not be issued to students who do not return CDs at the end of the semester. You can also buy an entire set of seven CDs from Tangent Scientific for ~$149 (phone, 1-800-363-2908). Again, the CD-ROMs are an optional learning tool, and not required for the course.
Distribution of Points:

Grading: Grades for this class will be based on the following components:

- 6 Exams 30 points each
- Assignment Report/Presentation 30 points

The grading scale for graduate students is as follows:

**Graduate Students**

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<tr>
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****THERE ARE NO EXTRA ASSIGNMENTS YOU CAN DO TO INCREASE YOUR GRADE.****

Course Structure:

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*Chapters from Vander et al, 10th/11th edition

**Computer Resources:**

Each student should have access to a computer for blackboard handouts, materials and assignments

**Course Resources:** none.

**Course Policy:**

It is your responsibility to visit the course website at (http://blackboard.wayne.edu) to keep you up to date:

Late submission of homework is not accepted.
Adherence to the University's Code of Ethics will be strictly monitored and enforced. This will be applicable to assignments, projects and examinations.

**Cheating Policy and Penalty for Cheating:**

It is the responsibility of each student to adhere to the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University in matters concerning his or her educational endeavors. Thus, a student should not falsely claim the work of another as his/her own, or misrepresent him/herself so that the measures of his/her academic performance do not reflect his/her own work or personal knowledge. In this regard, cheating will not be tolerated. Cheating includes (but is not limited to) any communication (written or oral) during examinations and sharing of work, such as using the same models or computer programs or copying work. All assignments and projects must be an individual effort unless specifically noted. All written assignments and oral presentations are expected to conform to standards for citation (referencing). Please refer to the “Expectations for Citation in Biomedical Engineering” handout (attached and available on the web) for guidance. STUDENTS WHO CHEAT ON ANY ASSIGNMENT OR DURING ANY EXAMINATION WILL BE ASSIGNED A FAILING GRADE FOR THE COURSE.

**Equipment Handling Policy:** none.

**Schedule:** see course structure for details

- September – Last day to drop a class with a full tuition refund.
- October — Last day to drop a class without a signature from the instructor.
- After October — Withdrawal from any class is possible only with the permission of the Instructor. Such permission is granted only under exceptional circumstances.

**Examination policy:**

This course will have six examinations, which may consist of multiple choice, true/false, short answer, problem solving and/or short essay questions. Your exam grades will be determined by the total number of points obtained. You will have the entire class period to complete each exam. The exams are closed book.

**Material covered on the exams:**

You are responsible for all material in the lecture, notes and the assigned reading in the textbook (figures, tables and text). See attached course schedule for dates of all exams. THERE ARE NO MAKE-UP EXAMS.
Assignments:
There is one assignment to complete during the semester. This assignment will be in the form of a written report and class presentation. The due date for each report will be at the same time as your assigned presentation day and will be assigned randomly the first day of class. The written report must be submitted electronically via Blackboard. The PowerPoint presentation must be submitted via email to the Instructor one day before presentation. Late assignments will not be accepted and students will receive a zero for their grade.

Homework policy:
The required reading for this course is shown in the attached schedule. For many students there is much new material covered. Students are strongly encouraged to read the assigned text before the material is covered in class. The end of each chapter or section in the text has (1) a summary of key concepts, (2) a list of key terms and (3) a series of review questions. Reviewing these will be helpful to your understanding of the material. The figures in the text are good, and studying them will help you learn key concepts.

Outcome Coverage:
(a) An ability to apply knowledge of mathematics, science, and engineering. Exams will require students to apply math, science, and engineering concepts to achieve passing grades in this course.

(b) An ability to design and conduct experiments, as well as to analyze and interpret data. Throughout this course students will be presented with analytical and quantitative thinking problems. Their task would be interpreting and analyzing such data and correlate their results to engineering and physiology concepts.

(c) An ability to function on multidisciplinary teams. Students will be given in class problems that require collaborative efforts among the individual groups in class to provide the best engineering solution.

(d) An ability to identify, formulate, and solve engineering problems. This class is the building block of all the fundamentals required to resolve the complicated issues and cases in tissue engineering such as:
(i) Implementing the knowledge of nervous system to the study and skills of engineered nerve repair.
(ii) Understanding that physiology is the study of function of living things and understand how the body is organized? Why Engineers need to study human physiology
(iii) Providing the knowledge base of sensory systems. Distinguishing between sensory information, sensation, and perception. Recognizing the need for, and an ability to repair the damages of hearing and vision.
(iv) Understanding muscle physiology and the mechanism of muscle contraction. Better understand the mechanism of muscle repair.
(v) Providing knowledge base and understanding of the gastrointestinal system, and understand the basic process of food digestion and absorption. Describing the current technologies used for the measurement of gastrointestinal motility.

(vi) Providing knowledge base and understanding of the cardiovascular system. Understand the basic concepts of heart beat, blood pressure, and blood clotting. Learning how to apply such knowledge for the tissue engineering of heart and blood vessels.

(vii) Providing knowledge base of renal physiology. Understanding how the urine is formed. Better understanding the strategies of kidney tissue engineering and functional renal imaging.

(viii) Providing knowledge of endocrine organs. Understanding the importance of hormones in the physiology.

(e) An ability to communicate effectively. Students are required to communicate their understanding to physiology concepts in writing and through class presentation and discussion.

(f) The broad education necessary to understand the impact of engineering solutions in a global, Economic, environmental, and societal context. After this class, students will have broad understanding in physiology concepts and principals related to the following topics: the nervous system, muscular system, cardiovascular system, respiratory system, renal system, gastrointestinal system, and endocrine system. This broad understanding will build their foundation in Biomedical Engineering and future engineering projects.

(g) A recognition of the need for, and an ability to engage in life-long learning. This class is considered a prereq to all science classes at the BME dept. successful completion of this class will permit students the ability to engage in life-long learning.

**Attendance policy:**

Regular attendance of the lectures is strongly encouraged, but attendance is not part of the grade for this course. However, you will need to attend on the days you are scheduled to present your assignment. The instructor may elect to look at strong attendance favorably in a borderline case where the final course grade falls just short of the next higher grade.

**Therefore avoid all appearance of improper behavior!** Students who witness cheating should report the incident to the instructor as soon as possible. (Cheating observed during an Exam should be quietly reported during the Exam period). Students are also welcome to discuss any concerns related to cheating with Dr. John Cavanaugh, Associate Chair of Biomedical Engineering.

**Blackboard:**

Blackboard will be used throughout the course for communication among students and with the instructor. Feel free to post both private and common questions. Written assignments will be turned in and distributed to students via Blackboard. In order to use the system, you must log on through Pipeline. **Please activate your Wayne email address,** forwarding it to your standard email if you wish. This will be the address with which the class communicates with you.
Learning Objectives and outcomes of Coverage Matrices

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(b) An ability to design and conduct experiments, as well as to analyze and interpret data. Throughout this course students will be presented with analytical and quantitative thinking problems. Their task would be interpreting and analyzing such data and correlate their results to engineering and physiology concepts.

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Instructor Course Assessment Report

• Teaches the correct techniques Y N

• Provides appropriate and effective demonstration Y N

• Uses correct terminology appropriate to the level of the students Y N

• Positions themself to the best advantage when instructing a student Y N

• Notices and corrects incorrect performances Y N

• Provides encouragement and feedback Y N

• Students are briefed prior to activity Y N

• Answers questions adequately Y N

• Identifies suitable environment for teaching practices Y N

• Provides viable reason/incentive for learning skill Y N

• Identifies key teaching points Y N
Survey Results

1) Please circle the class you are enrolled in
Respondents: 
   Day: Evening: Distance Learning:

2) What is your intended major?
Respondents:

3) Course content was consistent with the course objectives in the syllabus.
Respondents:
1
2
3
4
5

4) Subject matter was relevant to student’s educational goals.
Respondents:
1
2
3
4
5

5) What were your expectations of this class and were they met effectively?

Time Commitment
1) What was the (average) amount of time you spent on this course per week outside of class?
Respondents:
0-5 hrs:
5-10 hrs:
10-15 hrs:
15-20 hrs:
>20 hrs:

2) Rank the following in order of time spent (1 being the most amount of time spent, 4 the least.)
Respondents:
   ___Textbook ___Blackboard Online Materials ___Other Internet sites ___Other _____
   #1   #1   #1   #1
   #2   #2   #2   #2
   #3   #3   #3   #3
   #4   #4   #4   #4

3) How would you rate your attendance?
Respondents:
a) excellent
b) good
c) could be better

Quizzes

No quizzes are offered throughout this course
Examinations

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Material covered on the exams: You are responsible for all material in the lecture, notes and the assigned reading in the textbook (figures, tables and text). See attached course schedule for dates of all exams. THERE ARE NO MAKE-UP EXAMS.

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(2) a list of key terms and

(3) a series of review questions.

Reviewing these will be helpful to your understanding of the material. The figures in the text are good, and studying them will help you learn key concepts.
Review sheet (Chapter 1)

1. Understand the hierarchy of: cells — tissues — organs — organ systems — organism.

2. Describe the levels of cellular organization and state the four types of specialized cells and tissues.

3. Name two fluids that constitute the extracellular fluid. What are their relative proportions in the body, and how do they differ from each other in composition?

4. State the relative volumes of water in the body-fluid compartments.

5. Understand how the various organ systems work together to provide for the needs of all cells.

6. Understand the importance of homeostatic control systems in achieving homeostasis.

7. Understand that homeostasis is achieved by balancing inputs and outputs.

8. Define homeostasis. How is homeostasis important in living systems? Give 5 examples of homeostasis in humans.

9. Please explain the following key words: negative feedback, positive feedback, and feedforward regulation. Describe an example of each. How is each important in homeostasis?

10. Learn the components of the reflex arc—stimulus, receptor, afferent pathway, integrating center, efferent pathway, effectors, response—and how they interact.

11. Understand the concept of balance in the homeostasis of chemicals in the body, and how changing inputs and outputs of the chemicals can induce negative, positive, or stable balance.

12. Define and give the physiological significance (how or why it is important) for the following terms: Matrix (of a tissue); Set point; Autoregulation.

Thought questions:

1. Is the set point for a variable, such as blood pressure, always the same or can it change?
   Explain your answer and give an example.

2. What is the relationship between structure and function in physiological systems? Give some
examples of this relationship.

Chapter 4 review sheet

1. Distinguish between one-way fluxes and net flux. Understand that the net flux of molecules between two compartments is always from the region of higher concentration to the region of lower concentration.

2. Understand why cell membranes are more permeable to nonpolar molecules than to polar molecules and ions. Know the mechanisms by which polar molecules and ions can permeate the cell.

3. What characteristics distinguish diffusion from facilitated diffusion?

4. What characteristics distinguish facilitated diffusion from active transport?

5. Ions diffuse across cell membranes by what pathway?

6. Describe the mechanism by which a transporter of a mediated-transport system moves a solute from one side of a membrane to another.

7. Understand the differences between primary active transport and secondary active transport,

8. Why do sodium and chloride ions in the extracellular fluid and potassium ions in the intracellular fluid behave as if they are nonpenetrating solutes?

9. What is osmosis?

10. What is the osmolarity of the extracellular fluid? Of the intracellular fluid?

11. What change in cell volume will occur when a cell is placed in a hypotonic solution? In a hypertonic solution?

12. Under what conditions will a hyperosmotic solution be isotonic?

A hyperosmotic (to cells) solution will be isotonic if it is 300 mOsm in nonpenetrating solutes, no matter the osmolarity of its penetrating solutes. Penetrating solutes do not affect tonicity.

13. How can the concentration of water in a solution be decreased?
14. If two solutions having different osmolarities are separated by a water-permeable membrane, why will there be a change in the volumes of the two compartments if the membrane is impermeable to the solute, but no change in volume if the membrane is permeable to solute?

15. Understand the importance of regulating the osmolarity of the extracellular fluid.

16. Understand the difference between the osmolarity of a solution and the tonicity of a solution. Appreciate that the osmolarity of only nonpenetrating solutes affects tonicity.

17. Understand that sodium, potassium and chloride ions are effectively nonpenetrating solutes because of membrane transporters.

18. Understand the basic concepts of endocytosis and exocytosis.
Chapter 5 Review Sheet

1. Please explain the following key words: ligands, receptor, second messenger, and binding site.

2. Recognize the structure of typical plasma-membrane receptors.

3. Classify plasma-membrane receptors according to the signal transduction pathways they initiate.

4. What is the first step in the action of a messenger on a cell?

5. Explain why different types of cells may respond differently to the same chemical messenger.

6. What is the specificity and affinity of receptor? Please give examples.

7. Understand how the properties of saturation and competition apply to receptors and their intercellular messengers.

8. Define agonist and antagonist for intercellular messengers, and understand how these competitors, including many drugs, can affect the actions of the messengers.

9. Understand that signal refers to receptor activation, and that transduction refers to the mechanisms (pathways) by which the signal leads to the ultimate response.

10. Describe the signal transduction pathway used by lipid-soluble messengers.

11. Recognize the properties of the four separate types of plasma-membrane receptors. Please give an example for each type.

12. Differentiate between “first messengers” and the “second messengers”.

13. Understand how activating a receptor that is an ion channel can elicit a response in the cell.

15. Know the transduction pathway that leads to production of cyclic AMP as a second messenger, and appreciate the importance of the phenomenon of amplification in this pathway.

16. Understand that activated G proteins can operate ("gate") ion channel proteins directly and indirectly.

17. Appreciate how the various signal transduction pathways can influence each other to bring about the diverse and complex responses of the cell.

18. Describe the manner in which activated plasma-membrane receptors influence gene expression.
Chapter 18 Review Sheet

1. Differentiate between nonspecific immune defenses and specific immune defenses.

2. What are the major cells of the immune system and their general functions?

3. Describe the nature and basic functions of cytokines. Understand why their physiology is complex.

4. Describe the major anatomical and biochemical barriers to infection.

5. What factors influence the body’s resistance to infection?

6. Name the three cell types that function as phagocytes.

7. Describe the sequence of events that constitute the inflammatory response.

8. Understand that lymphocytes are the essential cells in specific immune defenses.

9. Describe the origin of antigen. Know that an antigen can trigger a specific immune response against itself or the cell bearing it.

10. Please describe the names of the various populations and subpopulations of lymphocytes and their roles in specific immune responses.

11. Contrast the general functions of the different antibody classes.

12. Why immunoassay can be used to detect specific molecules? Please give a few examples.

13. Understand the sequence of events that leads to B-cell activation and the secretion of antibodies.

14. Know how activated helper T cells stimulate the killing ability of macrophages and NK cells.

15. What are the differences between B-cell receptors and T-cell receptors?
16. Know the three major types of 

17. What is the major cell type involved in graft rejection?

Analytical and quantitative thinking for Exam 1

1) Using insulin as an example, explain how the secretion of a hormone is controlled by the effects of that hormone’s action.

2) What do you think would happen if most of your physiological regulatory mechanisms were to operate by positive feedback rather than by negative feedback? Would life even be possible?

3) Why are interactions between the body-fluid compartments essential for sustaining life?

4) Suppose a person has collapsed due to a rapid drop in blood pressure. What would you expect to find regarding the rate and strength of this person’s pulse? Explain how this illustrates the principle of negative feedback regulation.

5) Suppose you try to discover a hormone by homogenizing an organ in a fluid, filtering the fluid to eliminate the solid material, and then injecting the extract into an animal to see the effect. If an aqueous (water) extract does not work, but one using benzene as the solvent does have an effect, what might you conclude about the chemical nature of the hormone? Explain.

6) Define apoptosis and explain the physiology significance of this process.

7) Release of lysosomal enzymes from white blood cells during a local immune attack can contribute to the symptoms of inflammation. Suppose, to alleviate inflammation, you develop a drug that destroys all lysosomes. Would this drug have negative side effects? Explain.

8) Describe the conditions required to produce osmosis and explain why osmosis occurs under these conditions.

9) Using the principles of osmosis, explain why movement of Na+ through a plasma membrane is followed by movement of water. Use this concept to explain the rationale on which oral rehydration therapy is based.
10) Mannitol is a sugar that does not pass through the walls of blood capillaries in the brain. It also does not cross the walls of kidney tubule, the structures that transport the blood filtrate to become urine. Explain why Mannitol can be described as osmotically active. How might its clinical administration help to prevent swelling of the brain in head trauma? Also, explain the effect it might have on the water content of urine.

Analytical and quantitative thinking for Exam 1:

1) What factors can alter the opening and closing of protein channels in a membrane?

12) Compare and contrast antigen presentation to helper T cells and cytotoxic T cells.

13) What two processes contribute to immune tolerance?

14) List the systemic responses to infection or injury and the mediators responsible for them.

15) What is the major defect in AIDS, and what causes it?

16) The body of a man contains 49.5 liter of water. He drinks 0.5 liter of water.

Suppose that all this water is absorbed, at first with negligible excretion. What are (a) the percentage decrease in osmotic concentration of the body fluids and (b) (given an initial concentration of 300 mosmol/kg water) the absolute decrease?
Chapter 6 Review Sheet

1. Describe the parts of neurons: cell body, dendrites, axon, and axon terminals. Explain the direction of flow of information in neurons.

2. Understand how myelin is formed and what its general function is.

3. Describe the direction of information flow through a network consisting of afferent neurons, efferent neurons, and interneurons.

4. What is the difference between nerve fiber and nerve?

5. Understand that all interneurons are both postsynaptic cells and presynaptic cells.

6. Describe the physiological roles of glial cells.

7. Are new neurons produced after birth?

8. Understand how current, voltage, and resistance are related (Ohm’s law).

9. What is the driving force for the resting membrane potential?

10. Give the definition of following key words: depolarize, repolarize, and hyperpolarize.

11. Understand why action potentials are said to be “all-or-none.”

12. Explain threshold and the relative and absolute refractory periods in terms of the ionic basis of the action potential.

13. What is the difference between action potential propagation in myelinated axons and in unmyelinated ones?

14. List the differences between graded potentials and action potentials.

15. List three ways in which action potentials can be initiated in neurons.

16. Explain how synapses allow neurons to act as integrators; include the concepts of facilitation, temporal and spatial summation, and convergence in your explanation.
17. Contrast the postsynaptic mechanisms of excitatory and inhibitory synapses.

18. Appreciate that certain diseases and drugs can alter synaptic effectiveness by affecting both pre- and postsynaptic mechanisms.

19. Discuss differences between neurotransmitters and neuromodulators.

20. Understand the basic anatomy of the brain and spinal cord.

21. Describe the following key words: somatic and autonomic nervous systems, parasympathetic and sympathetic divisions of the autonomic nervous system.

22. Compare and contrast the sympathetic and parasympathetic divisions of the autonomic nervous system. Know the differences in neurotransmitter used, differences in anatomy, and functional differences.

23. Understand the importance of the blood-brain barrier in regulating the composition of the brain’s extracellular fluid.

24. Name the neurotransmitter released at each synapse or neuroeffector junction in the somatic and autonomic systems.

25. The chemical composition of the CNS extracellular fluid is different from that of blood. Explain how this difference is achieved.
Chapter 7 Review Sheet

1. Distinguish between a sensation and a perception.

2. Describe the general process of transduction in a receptor that is a cell separate from the afferent neuron. Include in your description the following terms: specificity, stimulus, receptor potential, neurotransmitter, graded potential, and action potential.

3. Describe the factors that can influence the magnitude of a receptor potential.

4. Describe the specific and nonspecific ascending pathways to the cerebral cortex, and the role of divergent and convergent pathways.

5. How does the nervous system distinguish between stimuli of different types?

6. List several ways in which sensory information can be distorted.

7. How is information about stimulus intensity coded by the nervous system?

8. Make a diagram showing how a specific ascending pathway relays information from peripheral receptors to the cerebral cortex.

9. Understand the phenomenon of lateral inhibition and how it sharpens acuity.

10. Distinguish between rapidly adapting and slowly adapting receptors.

11. Understand that information in the ascending pathways is subject to control by descending pathways from higher centers of the brain.

12. Understand that the specific pathways for somatic senses cross from the side of the body in which the receptor is located to the other side, in the spinal cord or in the brainstem.

13. Describe the similarities and differences between pain and the other somatic senses.

14. Understand how light waves are focused on the back of the retina. Know the sequence of events that occur during accommodation for viewing distant and near objects.
15. Know the functional anatomy of the photoreceptor cells. Understand the differences between *rods* and *cones*, both in structure and in location on the retina.

16. Understand that the ganglion cells, which form the optic nerve, are the afferent neurons in the visual system. Know the neural pathway from the retina to the thalamus to the primary visual cortex.

17. List the sequence of events that occur between the entry of a sound wave into the external auditory canal and the firing of action potentials in the cochlear nerve.

18. Understand that sound waves are caused by vibrations of molecules (usually in air) and that they have the properties of *frequency* (pitch) and *amplitude* (loudness).

19. Understand the importance of the bones of the middle ear for amplifying the sound wave, and the properties of the basilar membrane that enables a specific part of it to vibrate in response to a sound wave of a particular frequency.

20. Understand how vibration of the basilar membrane affects the stereocilia on the hair cells, and the effect of the bending of the stereocilia against the tectorial membrane on neurotransmitter release by the hair cells.
Chapter 9 Review Sheet

1. List the three types of muscle cells and their locations.

2. Definition of these key words: skeletal muscle fibers, skeletal muscle, and tendons.

3. Describe the structure of the thick and thin filaments and their relationship with each other.

4. Diagram the arrangement of thick and thin filaments in a striated-muscle sarcomere, and label the major bands that give rise to the striated pattern. Know which bands and zones change in length during muscle shortening and which do not.

5. Understand the four steps in the cross-bridge cycle.

6. Describe the roles of tropomyosin, troponin, and calcium ion in regulating skeletal-muscle contraction.

7. Describe the role and source of calcium ions in initiating contraction in skeletal muscle.

8. Describe the events that result in the relaxation of skeletal-muscle fibers.

9. Describe the structure and function of the motor unit.

10. Differentiate among isotonic contractions, isometric contractions, and lengthening contractions.

11. Explain the key words: latent period, contraction time, and velocity of shortening.

12. Describe the load-velocity relation and the length-tension relation.

13. What three events in skeletal-muscle contraction and relaxation are dependent on ATP?

14. What is the difference between fast fibers and slow fibers?

15. Describe the length-tension relationship in striated-muscle fibers.

16. List the factors responsible for skeletal muscle fatigue. Understand the importance of fatigue as a mechanism for preventing the onset of rigor and muscle damage.

17. How the differences in diameter of the different fiber types affect their strength of contraction?
18. Understand that the tension that can be developed in a whole muscle depends upon the tension developed by each individual fiber and the number of active fibers.

19. What are the components of whole muscles? Why the process of motor-unit recruitment controls both the tension and the contraction velocity of the muscle?

20. What happens to skeletal muscle fibers when the motor neuron to the muscle is destroyed?

21. Describe the effects on muscle size and function of denervation, disuse, and long-duration, low-intensity or short-duration, high-intensity exercise training.

22. Understand how muscles must be arranged around joints so that a limb can flex and extend.

23. Appreciate the advantages and disadvantages of the arrangement of the muscles, bones, and joints in the body in a lever system.

24. Describe the structural differences between smooth muscle and striated muscle.

25. Contrast the mechanisms by which cytosolic calcium ion concentration regulates contractile activity in smooth muscle and in skeletal muscle.

26. Contrast the sources for cytosolic calcium in smooth and skeletal muscle.

27. In what ways does the neural control of smooth muscle activity differ from that of skeletal muscle?

28. What effect does a pacemaker potential have on a smooth muscle cell?

29. Describe the differences between single-unit and multiunit smooth muscle.
Chapter 10 Review Sheet

1. Describe motor control in terms of the conceptual motor control hierarchy and using the following terms: highest, middle, and lowest levels; motor program; descending pathways, and motor neuron.

2. Picking up a book, for example, has both voluntary and involuntary components. List the components of this action and indicate whether each is voluntary or involuntary.

3. Identify the types of inputs that the interneurons which synapse with motor neurons receive.

4. Draw a muscle spindle within a muscle, labeling the spindle, intrafusal and extrafusal muscle fibers, stretch receptors, afferent fibers, and alpha and gamma efferent fibers.

5. Describe the major function of alpha-gamma coactivation.

6. What are the components of the stretch reflex? Why the length-monitoring system in muscles is important for control of body movement?

7. Describe the components of the knee jerk (stimulus, receptor, afferent pathway, integrating center, efferent pathway, effector, and response).

8. Distinguish among the following areas of the cerebral cortex: sensorimotor, primary motor, premotor, and supplementary motor.

9. Contrast the two major types of descending pathways in terms of structure and function.

10. Understand the roles of the basal ganglia and the cerebellum in control of motor functioning. Know the effects that impairments to these brain areas have on motor
control.

11. Distinguish *hypertonia* and *hypotonia*. Understand how diseases of the descending pathways and lower motor neurons, respectively, can give rise to these conditions.

12. Explain the role played by the crossed-extensor reflex in postural stability.

13. Explain the role of the interneuronal networks in walking, incorporating in your discussion the following terms: interneuron, reciprocal innervation, synergist, antagonist, and feedback.
Analytical and quantitative thinking for Exam 3

1) Why is it important to have a large amount of stored high-energy phosphates in the form of creatine phosphate for the function of muscles during exercise? What might happen to a muscle in your body if it ever ran out of ATP?

2) How is electrical excitation of a skeletal muscle fiber coupled to muscle contraction?

3) Organs consisting mostly of highly differentiated cells appear to also contain small populations of multipotent, adult stem cells. Explain the significance of this statement, using skeletal muscles as an example.

4) Explain how the organization of actin and myosin in smooth muscle cells differs from their organization in striated muscle cells, and the advantages of these differences.

5) Define a motor unit and describe its structure.

6). Describe the effect of increasing load on a skeletal-muscle fiber on the velocity of shortening.

7). List the factors responsible for skeletal-muscle fatigue.

8). Summarize the characteristics of the three types of skeletal-muscle fibers.

9) What happens to skeletal-muscle fibers when the motor neuron to the muscle is destroyed?

10) What are the advantages and disadvantages of muscle-bone-joint lever mechanism?

11) What are the two sources of calcium that lead to the increase in cytosolic calcium that triggers contraction in smooth muscle?

12) Picking up a book, for example, has both voluntary and involuntary components. List the components of this action and indicate whether each is voluntary or involuntary.

13) Describe the major function of alpha-gamma coactivation.

14) Describe the roles that the basal ganglia and cerebellum play in motor control.

15) Explain how hypertonia might result from disease of the descending pathways.
16) Explain the role of the interneuronal networks in walking, incorporating in your discussion the following terms: interneuron, reciprocal innervation, synergist, antagonist, and feedback

Analytical and quantitative thinking for Exam 4
1) A man has a blood volume of 5.0 L. Momentarily the output from his right ventricle is 5.00 l/min and his left ventricular output is 4.95 l/min. If this small (1%) discrepancy could persist, and the blood volume was to stay constant, how much extra blood would the pulmonary vessels contain after 20 min?

2) What characteristics of the SA node distinguish it from other possible pacemaker regions and allow it to function as the normal pacemaker? How do action potentials from the SA node reach the atria and the ventricles?

3) Step by step, describe the pressure changes that occur in the ventricles during the cardiac cycle. Explain how these pressure changes relate to the occurrence of the heart sounds.

4) Can a defective valve be detected by an ECG? Can a partially damaged AV node be detected by auscultation (listening) with a stethoscope? Explain.

5) Describe the causes of the P, QRS, and T waves of an ECG, and indicate at which point in the cardiac cycle each of these waves occur. Explain why the first heart sound occurs immediately after the QRS wave and why the second sound occurs at the time of the T wave.

6) Explain how blood moves through arteries, capillaries, and veins. How does exercise affect this movement?

7) Explain how homeostasis of the circulating blood platelet count is maintained. By what mechanism would blood loss increase the platelet count?

8) Using the Frank-Starling law of the heart, explain how the stroke volume is affected by (a) bradycardia and (b) a "missed beat."
9) Which part of the cardiovascular system contains the most blood? Which part provides the greatest resistance to blood flow? Which part provides the greatest cross-sectional area? Explain.

10) A person who is dehydrated drinks more and urinates less. Explain the mechanisms involved.

11) Explain why an anxious person may have cold, clammy skin and why the skin becomes hot and flushed on a hot, humid day.

12) Explain the different ways in which a drug that acts as an inhibitor of angiotensin-converting enzyme (ACE) can lower the blood pressure. Also, explain how diuretics and β1-adrenergic-blocking drugs work to lower the blood pressure.

13) Explain how hypotension may be produced in (a) hypovolemic shock and (b) septic shock. Also, explain the mechanisms whereby people in shock have a rapid but weak pulse, cold and clammy skin, and low urine output. Analytical and quantitative thinking for Exam 4

14) Describe the mechanisms that have been proposed to explain how a diet high in salt could raise the blood pressure.

15) Suppose you feel the pulse of a person in circulatory shock, and find that it is weak and rapid. You are also concerned that the person has a very low urine output. Explain the reasons for these observations. What treatments could be given to raise the blood pressure? Explain.

16) Athletes often have a slower resting cardiac rate than the average (a condition called athlete’s bradycardia). What causes the slower cardiac rate? What cardiovascular adaption allows the person to have athlete’s bradycardia and yet not have a dangerously low blood pressure? What advantages might the slower resting cardiac rate have for the athlete?

17) Draw a ventricular action potential. Describe the changes in membrane permeability that underlies the potential changes.
18) Contrast action potentials in ventricular cells with SA-node action potentials. What is the pacemaker potential due to, and what is its inherent rate? By what mechanism does the SA node function as the pacemaker for the entire heart?

19) Describe the spread of excitation from the SA node through the rest of the heart.

20) Describe the sequence of events leading to excitation-contraction coupling in cardiac muscle.

21) What prevents the heart from undergoing summation of contractions?

22) What are the two major factors influencing force of contraction?

23) What are two major factors that determine pulse pressure?

24) List the chemical factors thought to mediate active hyperemia.

25) What is the only autonomic innervation of most arterioles? What are the major adrenergic receptors influenced by these nerves? How can control of sympathetic nerves to arterioles achieve vasodilation?

26) What is the only solute to have a significant concentration difference across the capillary wall? How does this concentration difference influence water concentration?

27) Identify the receptors, afferent pathways, integrating center, efferent pathways, and effectors in the arterial baroreceptor reflex.

28) How does heart failure lead to edema?
Chapter 13 Review Sheet

1. At rest, how many liters of air and blood flow through the lungs per minute?

2. What are normal values for intrapleural pressure, alveolar pressure, and transpulmonary pressure at the end of an unforced exhalation/expiration?

3. Between breaths at the end of an unforced exhalation/expiration, in what directions are the lungs and chest wall tending to move? What prevents them from doing so?

4. Write the equation relating airflow into or out of the lungs to atmospheric pressure, alveolar pressure, and airway resistance.

   \[ F = \frac{(P_{\text{atm}} - P_{\text{alv}})}{R}, \text{ where } F = \text{ airflow, } P_{\text{atm}} = \text{ atmospheric pressure, } P_{\text{alv}} = \text{ alveolar pressure, and } R = \text{ airway resistance.} \]

5. Describe the sequence of events that cause air to move into the lungs during inhalation/inspiration and out of the lungs during exhalation/expiration. Diagram the changes in intrapleural pressure and alveolar pressure.

6. What factors determine lung compliance? Which is more important?

7. How does surfactant increase lung compliance?

8. How is airway resistance influenced by airway radii?

9. Describe the causes of increased airway resistance in asthma.

10. State the formula relating minute ventilation, tidal volume, and respiratory rate. Give representative values for each at rest.
11. State the formula for calculating alveolar ventilation. What is an average value for alveolar ventilation?

\[ \text{Alveolar ventilation (ml/min)} = (\text{Tidal volume} - \text{Dead space volume}) \times \text{Respiratory rate}. \]

12. The partial pressure of a gas is dependent upon what two factors?

13. State the alveolar partial pressures for oxygen and carbon dioxide in a normal person at rest. What factors determine alveolar partial pressures?

\[ \text{Alveolar PO}_2 \text{ is normally 105 mmHg at rest. Alveolar PCO}_2 \text{ is normally 40 mmHg.} \]

14. What is the mechanism of gas exchange between alveoli and pulmonary capillaries? In a normal person at rest, what are the gas pressures at the end of the pulmonary capillaries, relative to those in the alveoli?

15. Why does thickening of alveolar membranes impair oxygen movement but have little effect on carbon dioxide exchange?

16. What is the major result of ventilation-perfusion inequalities throughout the lungs? Describe one homeostatic response that minimizes mismatching.

17. In what two forms is oxygen carried in the blood? What are the normal quantities (in milliliters per liter) for each form in arterial blood?

18. Draw an oxygen-hemoglobin dissociation curve. Put in the points that represent systemic venous and systemic arterial blood. (Ignore the rightward shift in systemic venous blood.)

19. Would breathing pure oxygen cause a large increase in oxygen transport by the blood in a normal person? In a person with a low alveolar \( P \text{O}_2 \)?

20. Describe the effects of increased \( P \text{CO}_2 \), H+ concentration, and temperature on the oxygen-hemoglobin dissociation curve. How are these effects adaptive for oxygen unloading in the tissues?

21. Draw figures showing the reactions carbon dioxide undergoes entering the blood in the tissue capillaries and leaving the blood in the alveoli. What fractions are contributed by dissolved carbon dioxide, bicarbonate, and carbamino?
22. What changes stimulate the peripheral chemoreceptors? The central chemoreceptors?
23. Is respiratory control more sensitive to small changes in arterial $P_{O2}$ or in arterial $P_{CO2}$?
24. Describe the pathways by which increased arterial $P_{CO2}$ stimulates ventilation. What pathway is more important?
25. What happens to arterial $P_{O2}$, $P_{CO2}$, and H+ concentration during moderate and severe exercise? List other factors that may stimulate ventilation during exercise.

**Chapter 14 Review Sheet**

1. What three physiologically active substances do the kidneys secrete?
2. What are the three basic renal processes that lead to the formation of urine?
3. How does the composition of the glomerular filtrate compare with that of plasma?
4. Describe the forces that determine the magnitude of the GFR. What is a normal GFR?
5. What are the sources of water gain and loss in the body? What are the sources of sodium gain and loss?
6. What is the mechanism of sodium reabsorption, and how is the reabsorption of other solutes coupled to it?
7. What is the mechanism of water reabsorption, and how is it coupled to sodium reabsorption?
8. What is the effect of vasopressin on the renal tubules, and what are the sites affected?
9. Diagram the sequence of events by which a decrease in blood pressure leads to a decreased GFR.
10. List the sequence of events leading from increased renin secretion to increased aldosterone secretion.
11. Diagram the sequence of events leading from decreased cardiovascular pressures or from an increased plasma osmolarity to an increased secretion of vasopressin.
12. What are the stimuli for thirst?
13. Diagram the steps leading from increased plasma potassium to increased potassium secretion.

14. What are the two major controls of aldosterone secretion, and what are this hormone’s major actions?

15. Describe the handling of calcium by the kidneys.

16. Describe the formation and action of 1,25-(OH)2D. How does parathyroid hormone influence the production of this hormone?

17. What are the sources of gain and loss of hydrogen ions in the body?

18. List the body’s major buffer systems.

The major extracellular buffering system is the CO2/HCO3⁻ system, and the major intracellular buffers are proteins and phosphates.

19. How do the kidneys respond to the presence of an acidosis or alkalosis?

20. Classify the four types of acid-base disorders according to plasma hydrogen-ion concentration, bicarbonate concentration, and $P$ CO2.
Chapter 11 (Endocrine System) Review Sheet

1. What are the three general chemical classes of hormones?

2. What essential nutrient is needed for the synthesis of thyroid hormones?

3. Which classes of hormones are carried in the blood mainly as unbound, dissolved hormone? Mainly bound to plasma proteins?

4. Do protein-bound hormones cross capillary walls?

5. How do the rates of metabolism and excretion differ for the various classes of hormones?

6. Contrast the locations of receptors for the various classes of hormones.

7. How do hormones influence the concentrations of their own receptors and those of other hormones? How does this explain permissiveness in hormone action?

8. Describe the sequence of events when steroid or thyroid hormones bind to their receptors.

9. What are the direct inputs to endocrine glands controlling hormone secretion?

10. How does control of hormone secretion by plasma mineral ions and nutrients achieve negative-feedback control of these substances?

11. What roles does the autonomic nervous system play in controlling hormone secretion?
12. What groups of hormones receive input from neurons located in the brain rather than in the autonomic nervous system?

13. Describe the anatomical relationships between the hypothalamus and the pituitary.

14. List all six well-established anterior pituitary hormones and their functions.

15. Diagram the CRH-ACTH-cortisol system.

16. What is the difference between long-loop negative feedback and short-loop negative feedback in the hypothalamo-anterior pituitary system?

17. How would you distinguish between primary and secondary hyposecretion of a hormone? Between hyposecretion and hyporesponsiveness?

Chapter 15 Review Sheet

1. List the four processes that accomplish the functions of the gastrointestinal system.

2. List the primary functions performed by each of the organs in the gastrointestinal system.

3. What structures are responsible for the large surface area of the small intestine?

4. List three ways in which proteins or their digestion products can be absorbed from the small intestine.

5. Describe the process of carbohydrate absorption.

6. Describe the process of fat emulsification.

7. What is the role of micelles in fat absorption?

8. List the cephalic, gastric, and intestinal phase stimuli that stimulate or inhibit acid secretion by the stomach.

9. How does the absorption of fat-soluble vitamins differ from that of water-soluble vitamins?

10. What is "Dumping Syndrome"?

11. Describe the esophageal phase of swallowing. Please explain the function of the upper esophageal sphincter and the lower esophageal sphincter.
12. Describe the cause of gastroesophageal reflux?

13. Describe the clinical use of esophageal manometry.

13. Describe the factors that control gastric emptying.

14. What is the pathophysiology of gastroparesis?

15. Describe the type of intestinal motility found during and shortly after a meal and the type found several hours after a meal.

16. Describe the factors that initiate and control defecation.

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**Chapter 16 Review Sheet (Metabolism and Energy)**

1. In what two organs does major glycogen storage occur?

2. How do the liver and adipose tissue metabolize glucose during the absorptive period?

3. What happens to most of the absorbed amino acids when a high-protein meal is ingested?

4. Using a diagram summarize the events of the postabsorptive period; include the four sources of bloodglucose and the pathways leading to ketone formation.

5. List the overall responses of muscle, adipose tissue, and liver to insulin. What effects occur when plasmainsulin concentration decreases?

6. List five inputs controlling insulin secretion, and state the physiological significance of each.

7. List the effects of glucagon on the liver and their consequences.

8. List two inputs controlling glucagon secretion, and state the physiological significance of each.

9. List four metabolic effects of epinephrine and the sympathetic nerves to the liver and adipose tissue, and state the net results of each.

10. List three effects of growth hormone on carbohydrate and lipid metabolism.

12. Describe how plasma glucose, insulin, glucagon, and epinephrine levels change during exercise and stress. What causes the changes in the concentrations of the hormones?

13. How does obesity contribute to noninsulin-dependent diabetes?

14. Using a diagram, describe the sources of cholesterol gain and loss. Include three roles of the liver in cholesterol metabolism, and state the controls over these processes.

15. What is the significance of the ratio of LDL cholesterol to HDL cholesterol?

16. State the formula relating total energy expenditure, heat produced, external work, and energy storage.

\[ \text{Total energy expenditure} = \text{Internal heat produced} + \text{External work} + \text{Energy stored} \]

17. Which two hormones alter the basal metabolic rate?

18. Describe the control of skin blood vessels during exposure to cold or heat.

19. With a diagram, summarize the reflex responses to heat or cold. What are the dominant mechanisms for temperature regulation in the thermoneutral zone and in temperatures below and above this range?

20. Summarize the sequence of events leading to a fever and contrast this to the sequence leading to hyperthermia during exercise.
Projects

There is one assignment to complete during the semester. This assignment will be in the form of a written report and class presentation. The due date for each report will be at the same time as your assigned presentation day and will be assigned randomly the first day of class. The written report must be submitted electronically via Blackboard. The PowerPoint presentation must be submitted via email to the Instructor one day before presentation. Late assignments will not be accepted and students will receive a zero for their grade.

Each student will be required to investigate a specific topic of interest related to the subject being studied, and to present the material in the form of a written report and a PowerPoint presentation. The written report should be limited to 15 pages or less (references not included in page limit). Please use size 12 fonts with double spacing. The report is to be submitted to the “Safe Assignment box” TWO DAYS before the day of your presentation date. The
The presentation should be limited to **12 minutes**, leaving 3 minutes for discussion. **You will be penalized if you go over the allotted time of 15 minutes!**

The instructor has randomly assigned dates for all students to present (*See attached schedule*). Each student should know his or her presentation date, via the schedule posted on the blackboard site. Two weeks before the assigned presentation date, the instructor will post several topics on the discussion board. Choose a topic from the list by adding your name as a thread under the topic. Limit of two students per topic, so choose which is of interest to you.

**Suggested Plan for Presentation:**

1. Background (General review of concepts)
2. Current research or knowledge of the subject
3. Conclusion/Future Directions

*Organization and conciseness are keys in short presentations*: plan to spend 2-3 minutes on the introduction, 6-8 minutes on the topic and 3-4 minutes on the conclusion/future directions.

*Since the presentation is limited to 15 minutes, your PowerPoint lecture should be around 12-18 slides.*

* * Submit your PowerPoint lecture file to the Instructor one day before your presentation.*
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Fecal incontinence in the elderly

Weight loss and your lifespan

Design components

Basic principles of human physiology presented from the engineering perspective. Bodily functions, their regulation and control discussed in quantitative terms and illustrated by simple mathematical models where feasible.