IPHY 3470 LEARNING GOALS - HUMAN PHYSIOLOGY I

COURSE LEARNING GOALS
(THOSE GOALS WILL BE INCORPORATED IN EACH SECTION OF THE COURSE)

Students will be able to

1. Demonstrate an understanding of the physiology and basic regulatory concepts related to the functioning of life processes. The life processes to be studied in Human Physiology I will include cell physiology, neurophysiology, endocrinology, muscle physiology, and immunology.

2. Describe the functioning of life processes for the human physiological systems using basic chemical/biochemical, physical, and mathematical concepts.

3. Demonstrate a teleologic (why) and mechanistic (how) understanding of the life processes examined in this course.

Determine if the following statements are mechanistic or teleological in nature.

i. “Glucose is transported from blood into cells by transporters in response to insulin.”
ii. “Glucose is transported from blood into cells because cells require glucose to meet their energy needs.”

a. mechanistic, mechanistic  b. mechanistic, teleological
   c. teleological, mechanistic   d. teleological, teleological

What is a mechanistic explanation of mitochondrial function?
  a) cells need a lot of energy to maintain homeostasis
  b) citric acid cycle and electron transport system in the mitochondria produce ATP
  c) both
  d) either

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.
Main Goals

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

Students will be able to: *(these skills will be emphasized and expected throughout semester)*

1. **Outline the levels of biological organization from atom to system, define physiology and discuss the relation to biology.**

   The brain is an example of what level of organization (highest level of organization)?
   a. atom   b. cell   c. molecule   d. organ   e. organ system   f. tissue

   The digestive system contains what levels of organization? Choose any that apply.
   a. atom   b. cell   c. molecule   d. organ   e. organism   f. tissue

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.**

Use the following scenario and answer choices for questions XX

Consider a thermostatic heating system in a home in terms of homeostatic regulation.
You want your home to stay around a nice comfortable temperature of 70°C.

a. furnace   b. opening outside door   c. 70°C   d. room temperature
   e. thermometer   f. thermostat   g. turning on a space heater
What is the thermostatically regulated variable in this scenario?  d
What is the sensor?  e
What is the integrator?  f
What is the set point?  c
What is the effector?  a

Does the temperature in the house remain constant at 70°C or does it vary around 70°C?
   a. remains constant  b. varies

Use the following figure and answer choices for question XX

The next set of questions relate to temperature control in the body.

a. 98.6°F  b. body temperature
c. decrease loss of heat  d. increase heat production
e. monitor external temperature  f. monitor internal temperature
g. produce shivering  h. monitoring cells
i. skeletal muscle  j. temperature control center

What is the homeostatically regulated variable?  b
What is the sensor?  h
What does the sensor need to do?  f
What is the effector?  i
What does the effector need to do?  d
What is the integrator?  j

Which component in the human body is most like the thermometer?

   a. body temperature  b. brain (hypothalamus.
c. nerve receptors  d. muscles

If a disease caused the homeostatic sensor to stop working, what would you expect to happen to body temperature?

   a. decrease below set point
   b. return to normal (to set point)
   c. increase above set point

4. Determine the dependent and independent variables on a graph.
5. Predict the change in equation outcome based upon manipulation of equation components.

6. Predict the change in physiological outcome based on change in independent variable when presented with a graph (example professor dependent)

The graph to the right, shows the average weight (kg. for male and female students in a physiology lab)

What is the dependent variable?  
- sex  
- weight

What is the independent variable?  
- sex  
- weight

Is a bar graph the most appropriate way to present these data?

- Yes
- No, a line graph would be better.
- No, a pie chart would be better.
- No, a scatter plot would be better.

Other Questions

Which of the following are questions a physiologist would be interested in answering (as opposed to a researcher in another field)? Choose any that apply.

- **a. How does the body adapt to extreme elevations?**
- **b. Does speciation occur more quickly in tropical than temperate climates?**
- **c. Why does pollen cause allergies?**
- **d. Under what conditions are certain genes expressed?**
- **e. How can we engineer a more drought-resistant strain of corn?**
- **f. How can we improve DNA sequencing techniques to provide faster sequencing of DNA?**
- **g. How does the structure of the protein, kinesin, influence its function?**
- **h. How does exercise decrease the risk of developing cardiovascular disease?**
Prior to covering this section students should already be able to…

Anatomy
1. List the three types of cytoskeletal elements and provide one major function of each.
2. List the four major categories of tissues and provide one major function of each.
3. Differentiate between cell junction types in the organization of specialized tissue and how this affects cell-cell communication.

Main Goals
- Describe the cellular components and their associated functions
- Explain how proteins are made from genes.
- Explain how chemical reactions proceed in a biological setting.
- Explain the processes and factors involved in cellular transport within a cell and across a cell membrane.

**CHAPTER 3: COMPARTMENTS: CELLS AND TISSUE**

<table>
<thead>
<tr>
<th>Epithelia</th>
<th>Cell junctions</th>
<th>Cell membrane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interstitial fluid</td>
<td>Lipid</td>
<td>Golgi apparatus</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>Proteins</td>
<td>Organ</td>
</tr>
<tr>
<td>Endoplasmic reticulum (smooth and rough)</td>
<td>Intermembrane space</td>
<td>Mitochondria</td>
</tr>
<tr>
<td>Nucleus</td>
<td>Cytosol</td>
<td>Ribosomes</td>
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<tr>
<td>Mitochondrial matrix</td>
<td>Intermembrane space</td>
<td>Lysosomes</td>
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<tr>
<td>Peroxisomes</td>
<td>Cell</td>
<td>Tissue</td>
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<tr>
<td>Gap junctions</td>
<td>Tight junctions</td>
<td>Desmosomes</td>
</tr>
<tr>
<td>Epithelium</td>
<td>Microfilaments</td>
<td>Intermediate filaments</td>
</tr>
<tr>
<td>Microtubule</td>
<td>Motor proteins</td>
<td>Cilia</td>
</tr>
</tbody>
</table>

For this course students should accomplish…

1. **Diagram the structure of the plasma membrane indicating where carbohydrates, fats, and proteins are found within and on the plasma membrane.**

2. **Explain/differentiate the functions of carbohydrates, fats, and proteins found within and on the plasma membrane.**

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.**

Which cell type would you expect to have mitochondria? Circle any that apply.
- a) epithelial cell
- b) kidney cell
- c) neuron
d) skeletal muscle    e) smooth muscle

In which organelle would you expect this molecule to be synthesized?

   a) cytosol     b) nucleus     c) ribosome
   d) rough ER    e) smooth ER

Which organelle would be in higher density for a cell that has a high-energy requirements vs. a cell with lower energy demands?

   a) Golgi      b) **mitochondria**      c) nuclei
   d) proteasome e) rough ER      f) smooth ER

**CHAPTER 4: ENERGY & CELLULAR METABOLISM**

Prior to covering this section students should already be able to…

**Biology and Chemistry Review**

1. Given a chemical reaction, identify and define the major components of a chemical reaction: reactants, substrates, products, and enzymes.
2. Determine how the complexity of a molecule affects the amount of free energy available to do work.
3. Differentiate between an exergonic and endergonic reaction based on the difference in activation energy and net free energy change of the reaction.
4. Describe how and why endergonic and exergonic reactions may be coupled together and explain the role of ATP, NADH, and FADH2 in assisting energy transfer.
5. Determine the probability a chemical reaction will proceed when presented with various chemical reactions differing in activation energy levels.

<table>
<thead>
<tr>
<th>Kinetic energy</th>
<th>Potential energy</th>
<th>Entropy</th>
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<tbody>
<tr>
<td>Reaction rate</td>
<td>Activation energy</td>
<td>Free energy</td>
</tr>
<tr>
<td>Endergonic</td>
<td>Exergonic</td>
<td>Reactants</td>
</tr>
<tr>
<td>Products</td>
<td>Enzyme</td>
<td>Coenzyme</td>
</tr>
<tr>
<td>Energy</td>
<td>Chemical work</td>
<td>Mechanical work</td>
</tr>
<tr>
<td>mRNA</td>
<td>tRNA</td>
<td>rRNA</td>
</tr>
<tr>
<td>Codons</td>
<td>Transcription</td>
<td>Translation</td>
</tr>
<tr>
<td>Gene</td>
<td>Transcription factors</td>
<td>Polymerase</td>
</tr>
</tbody>
</table>
Protein synthesis
Amino acid
Polypeptide
Peptide
Transport work

For this course students should accomplish…

Energy in Biological Systems

1. Describe the general process of how energy is cycled within and between the environment and living organisms.

2. Given a scenario, identify what type of work (chemical, transport, and/or mechanical work) is being described.

Which of the following would be an example of mechanical work? Circle any that apply.

   a. beating of cilia       b. cell changing shape
   c. movement of organelles in cell   d. muscle contraction
   e. ATP donating phosphate group to an enzyme

A compressed spring represents what type of energy? When the spring is allowed to ‘spring’, or decompress, what type of energy does this represent?

   a. kinetic, kinetic       b. kinetic, potential
   c. potential, kinetic    d. potential, potential

In what 2 forms is energy stored in the body?

   a. chemical bonds and concentration gradients
   b. chemical bonds and movement
   c. concentration gradients and entropy
   d. kinetic energy and entropy
   e. kinetic energy and movement

Which of the following molecules do you think has the greatest amount of stored energy?

   a. carbon monoxide      b. fructose      c. glycogen
   e. cholesterol/TG       f. All would have the same amount of free energy.

3. Explain the physiological relevance of two law of thermodynamics.

Enzymes

1. Explain why it is necessary that living organisms require a catalyst (an enzyme) present to carry out a reaction.
2. Distinguish between reversible and irreversible chemical reactions on the amount of activation energy, release of energy, and whether the reaction is exergonic or endergonic.

3. Explain the equilibrium constant (Keq) and predict what happens to the reaction rate and value of Keq when the reaction is at equilibrium or if equilibrium is disturbed.

Which reaction would benefit most from an enzyme? Graph c
Which would require energy?
How are enzymes typically inactivated? Circle any that apply. (7pts)
   a. changing pH in cytoplasm to 7.4
   b. changing temperature to 37°C
   c. denaturation
   d. interaction with inhibitor
   e. interaction with zymogen

Based on the diagram below, what aspects of this chemical reaction are altered by the enzyme (catalyst)? (7pts)
   a. changes rate of reaction
   b. decreases activation energy
   c. increases activation energy
   d. decreases net free energy
   e. increases net free energy

Metabolism & ATP Production
1. Explain how using the following mechanisms cells can regulate the movement of substrates through metabolic pathways.
   • controlling enzyme concentration, modify enzymes, use of multiple enzymes, compartmentalize enzymes, and regulating the ratio of ATP/ADP

2. Diagram, identify and/or explain the significance of the key/entry components (e.g., rate-limiting steps) of the catabolic pathways for ATP production/generation from carbohydrate, fat, and protein.

3. Compare and contrast aerobic and anaerobic metabolism of glucose (i.e., location of processes, ATP energy yield, oxygen availability, when one state is dominate over the other, similar reactants, products, key enzymes).

**METABOLISM QUESTIONS**

When chemical, transport, or mechanical work is done by an organism, what happens to the heat generated?
   a) It is used to generate ADP from nucleotide precursors
   b) It is transported to specific organs such as the brain
   c) **It is lost to the environment**
   d) It is used to store energy as more ATP

Bagels are composed of starch. After you have eaten a bagel, the starch is broken down into its smaller subunits of glucose, which can be absorbed by the small intestine. Which form of metabolism is exemplified by this reaction?
   a) Anabolism  b) **Catabolism**  c) Both  d) Neither

Your roommate Sara recently came down with the stomach flu, and she is having a hard time keeping food down. A nurse recommended she not eat solid food for 24 hours but she should drink fluids, such as water or Gatorade.

During this 24 hour time period, most of the energy will come from her cellular energy stores. What are two examples of catabolic metabolic reactions that most likely may be occurring in her body at this time?
   a) Protein stores (muscle tissue breakdown)
   b) **Glycogen stores (glycogen → glucose)**
   c) Fat stores (fat → fatty acids + glycerol)
   d) Ketoacidosis

Which stage of aerobic respiration produces the most ATP?
   a) Glycolysis
   b) Conversion of pyruvate to acetyl CoA
   c) Kreb’s Cycle
   d) Electron transport phosphorylation

Why can fats and proteins be used in the cell as fuel?
a) Because they can be converted to glucose by enzymes
b) Because they can be converted to intermediates of glycolysis or the citric acid cycle
c) Because they can pass through the mitochondrial membrane to enter the citric acid cycle
d) Because they contain more energy than glucose

Cyanide is a poison that blocks the passage of electrons along the electron transport chain. What is a metabolic effect of this poison? Choose any that apply.
   a) pH of the intermembrane space becomes lower than normal.
   b) Electrons are passed directly to oxygen, causing cells to undergo apoptosis.
   c) Alcohol (-OH) would build up in the cells
d) NADH supplies would be exhausted and ATP synthesis would cease
e) No proton gradient would be produced and ATP synthesis would cease

Which compound will produce the most ATP when oxidized?
   a) Acetyl CoA
   b) Fatty acid
   c) Glycerol
d) Pyruvate
e) Lactate

You are comparing two cultures of cells. One undergoes cellular respiration (aerobic metabolism) and one ferments (anaerobic metabolism). Both cultures produce ATP at the same rate (for example, 100 ATP/msec). If this is true, what else would you observe about the fermenting culture? Choose all that apply.
   a) It would require more glucose per minute than the respiring culture
   b) It would have a higher rate of glycolysis than the respiring culture
c) It would produce pyruvate at a faster rate than the respiring culture
d) It would require more oxygen than the respiring culture

Central Dogma
1. Using diagrams, describe in general terms how the information in a gene is accessed for expression of a specific protein.

2. Explain the process by which a protein is synthesized, modified, stored/secerted and the organelles involved in this process.
   a. Diagram the Central Dogma of Biology (DNA makes RNA makes protein) and the roles of DNA, RNA and protein within the cell.
   b. Identify the different forms of RNA (ribosomal, transfer, messenger) and their function in protein synthesis.
   c. Describe the role and outcome of transcription and translation in the process of making a protein.

3. Identify the diverse roles proteins play in the body.
4. Differentiate between the functional units of a protein (amino acid and peptide bond).

**CENTRAL DOGMA QUESTIONS**

Consider the following description of a candy factory:

The boss of the candy factory gives a copy of the master recipe to a messenger who leaves the boss’s office through the door to go to the factory floor and deliver the recipe to a workstation. The workers then pick up the ingredients, and combine them according to the recipe. When the candy assembly is finished, the workers eat some and the rest is wrapped for shipment.

Which step would be analogous to a loaded tRNA binding to an mRNA on a ribosome?

- a) boss gives recipe to messenger
- b) candy is wrapped for shipment
- c) messenger brings recipe to factory floor
- d) workers pick up ingredients
- e) workers combine ingredients at workstation

Which of the following would not be affected by a mutation in the nuclear DNA?

(Disregard any enzymes that might be needed to catalyze synthesis.)

- a) lysosome
- b) phospholipid in cell membrane
- c) ribosome
- d) All would be affected
- e) None would be affected

The following are involved in the process of protein synthesis. Identify where in the cell (nucleus, cytoplasm, both) you would expect to find each.

- i. RNA Polymerase (nucleus a)
- ii. Promoter (a: nucleus)
- iii. Codon (c: both)

Answer Options: a) Nucleus b) Cytoplasm c) Both

**Use the following scenario for questions X-X**

Shiga toxin (*Shigella dysenteriae*) inactivates the mammalian ribosome and leads to inhibition of protein synthesis and death of susceptible cells. Where would this toxin act?

- a) Cytosol
- b) Nucleus
- c) Mitochondria
- d) Smooth ER

What specific process within protein synthesis is this toxin directly affecting?

- a) Chromatin remodeling
- b) mRNA processing
- c) Post-translational modification
- d) Translation
- e) *Transcription*
1. Differentiate the terms passive diffusion, facilitated diffusion, and active transport based on cellular energy or physical requirements.

What is a characteristic that distinguishes between simple diffusion and facilitated diffusion?

a) In simple diffusion, active transport is used; in facilitated diffusion, it is not.
b) In simple diffusion, energy is not required; in facilitated diffusion, energy is required.
c) In simple diffusion, hydrophilic molecules cross the membrane; in facilitated diffusion, hydrophobic molecules cross the membrane.
d) In simple diffusion, molecules move up their concentration gradient; in facilitated diffusion, they move down their concentration gradients.
e) In simple diffusion, molecules pass through the lipid bilayer; in facilitated diffusion, they pass through a protein.

Matching. Match the appropriate method of transport to the four images presented that depict each type of transport. (You can use the same answer more than once)

i. Example 1: C    ii. Example 2: A
iii. Example 3: D   iv. Example 4: B

Answer Options:

a. passive diffusion
b. facilitated diffusion
c. primary active transport
d. secondary active transport
Match the data in the graph (A, B, C) to the type of transport occurring.
   a) carrier-mediated, no competition
   b) carrier-mediated, with competition
   c) diffusion

Which types of cellular transport allow molecules to flow from areas of low concentration to areas of high concentration? Choose any that apply.
   a) facilitated diffusion
   b) primary active transport
   c) secondary active transport
   d) simple diffusion

Of the different cellular transport mechanisms, which use ATP directly while transporting molecules? Choose any that apply.
   a) facilitated diffusion
   b) primary active transport
   c) secondary active transport
   d) simple diffusion

Which type of energy is necessary to allow a molecule to begin moving across the cell membrane via facilitated diffusion?
   a) potential
   b) mechanical
   c) chemical
   d) none

Goblet cells are found in the epithelium of the trachea. The function of these cells is to produce and secrete mucus into the lumen of the trachea. Which membrane transport mechanism would you predict they use to accomplish this?
   a) exocytosis
   b) facilitated diffusion
   c) phagocytosis
   d) receptor-mediated endocytosis
   e) transcytosis

For each scenario below, indicate whether the condition will change the rate of transport, and if so how.

Scenarios
i. increase concentration of molecule that competes for transport

ii. Difference in concentration of an ion across the membrane increases by 25% (A)

iii. Membrane permeability increases (A)

iv. Number of active protein pumps (ATPases) increases (A)

Answer options

a. increase the rate of transport of molecules across a cell membrane
b. decrease the rate of transport of molecules across a cell membrane
c. have no effect on the rate of transport.

Explain why the cell membrane makes such a good barrier to keep out or in polar molecules.

Predict movement of a substance across a cell membrane and explain how and what factors contribute to its movement (hydrophobicity, concentration, electrical gradients).

Which type of amino acid would you expect to find crossing the plasma membrane?

a) hydrophobic 
b) hydrophilic 
c) lipophilic 
d) hydrophobic and hydrophilic 
e) hydrophobic and lipophilic

To the right is a depiction of a liposome. Of the listed molecules, which, if any, would be able to freely move (diffuse) across the membrane? Please circle any that would cross.

a) chloride ion 
b) fatty acid 
c) glucose 
d) nitric oxide 
e) sodium ion

2. Explain how chemical and electrical gradients are established in the cell.

Use the scenario below to determine answer the following questions X-X.

Below is a depiction of a portion of the cell membrane that is positively charged on the intracellular side and negatively charged on the extracellular side. Further in this cell, the concentration of ion X⁺ in the intracellular space is high and in the extracellular space is low.

Does an electrical gradient exist for X⁺? If it exists, what direction is the electrical gradient?

a) No. 
b) Yes, inward. 
c) Yes, outward.
Does a concentration gradient exist for X⁺? If it exists, what direction is the concentration gradient?
   a) No.  b) Yes, inward.  c) Yes, outward.

Imagine an ion channel opens that allows X⁺ to flow. Will X⁺ flow across the membrane through the ion channel? If so, in what direction?

   a) Yes, it will flow from the intracellular to extracellular side
   b) Yes, it will flow from the extracellular to intracellular side
   c) No, it will not flow

What was your reasoning that led you to your determination if the ion would flow?

   a) Chemical gradient favors movement out
   b) Electrical gradient favors movement out
   c) Both the chemical and electrical gradient favors movement out
   d) No gradients acting on X⁺
   e) The two gradients balance each other out

Now consider the same membrane but now with ion Y⁻, instead of X⁺. Ion Y⁻ is similarly distributed as X⁺. Consider the following questions (12-14).

Does an electrical gradient exist? If it exists, what direction is the electrical gradient? (5 pts)
   a) No.  b) Yes, inward.  c) Yes, outward.

Does a concentration gradient exist? If it exists, what direction is the concentration gradient?
   a) No.  b) Yes, inward.  c) Yes, outward.

Imagine an ion channel opens that allows Y⁻ to flow. Will Y⁻ flow across the membrane through the ion channel? If so, in what direction?

   a) Yes, it will flow from the intracellular to extracellular side
   b) Yes, it will flow from the extracellular to intracellular side
   c) No, it will not flow

What was your reasoning that led you to your determination about if the ion would flow?

   a) The chemical gradient favors movement out
   b) Electrical gradient favors movement out
   c) Both the chemical and electrical gradient favors movement out
   d) No gradients acting on X⁺
   e) Two gradients balance each other out
Main Goal

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

<table>
<thead>
<tr>
<th>Electrical signal</th>
<th>Chemical signal</th>
<th>Target cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local communication</td>
<td>Long distance communication</td>
<td>Gap junctions</td>
</tr>
<tr>
<td>Paracrine</td>
<td>Autocrine</td>
<td>Amplification</td>
</tr>
<tr>
<td>Primary messenger</td>
<td>Secondary messenger</td>
<td>Agonist</td>
</tr>
<tr>
<td>Antagonist</td>
<td>Specificity</td>
<td>Receptor</td>
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<td>Response</td>
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<td>Feedback</td>
<td>Feedforward</td>
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For this course students should accomplish…

1. **Differentiate between paracrine, autocrine, endocrine, and exocrine signaling.**

   Some neurons release neurotransmitter that affects neighboring cells, as well as themselves. This is an example of what type of signaling?
   a) autocrine  
   b) paracrine  
   c) **autocrine and paracrine**  
   d) neither

   What type(s) of cell signaling mechanism require(s) a receptor in the target cell for information to be transferred? Choose any that apply.
   a) autocrine  
   b) gap  
   c) **paracrine**  
   d) hormonal

2. **Differentiate the types of cell signaling mechanisms and explain the purpose of each.**
   a. Determine the interaction between the signal molecule (ligand) and receptor.
   b. Differentiate between the categories of cell surface receptors that activate a cascade in the cell (ligand gated, enzyme receptors, G-protein coupled receptors).
   c. Describe the role of a primary messenger, secondary messenger, and protein kinase in a signal transduction cascade initiated by a plasma membrane receptor.

   **Signal Cascade Questions for above 3 goals**
   For the next four questions consider the following: A ligand binds to a receptor and a cellular response is observed, as noted below. In each case decide what type of receptor was most likely activated. Choose the best answer. (5 points each)

   ion channel opens within 1 millisecond
   a) **ligand-gated**  
   b) enzyme receptor  
   c) G-protein coupled receptor  
   d) all three
ion channel opens after a few seconds
   a) ligand-gated       b) enzyme receptor
   c) enzyme receptor or G-protein coupled receptor

cAMP levels rise
   a) ligand-gated
   b) enzyme receptor
   c) G-protein coupled receptor
d) All of the above.
intracellular Ca++ levels rise
   a) ligand-gated
   b) enzyme receptor
   c) G-protein coupled receptor
d) all of the above

By comparison to the cAMP system, what is the role of Ca++ in the figure to the right?
   a) amplifier enzyme
   b) effector
   c) first messenger
d) receptor
   c) second messenger

<table>
<thead>
<tr>
<th>signal (e.g., glutamate)</th>
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<tbody>
<tr>
<td>opening of Ca++ channel (e.g., NMDA glutamate channel)</td>
</tr>
<tr>
<td>increase in intracellular Ca++</td>
</tr>
<tr>
<td>synaptotagmin</td>
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<tr>
<td>exocytosis</td>
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</tbody>
</table>
d. Differentiate physiological outcome to a stimulus based upon receptor specificity, amplification, and desensitization.

Use the following diagrams to answer questions XX-XX

Does the purple receptor ( ) in panel A differ from that in panel B in affinity, saturation and/or specificity? For each, say ‘yes, no or not enough information’.

affinity:  
- a. yes, a is higher in affinity than b  
- b. yes, b is higher in affinity than a  
- c. no, they are the same  
- d. no, there is not enough information

saturation:  
- a. yes, a is higher in saturation than b  
- b. yes, b is higher in saturation than a  
- c. no, they are the same  
- d. no, there is not enough information

specificity:  
- a. yes, a is greater in specificity than b  
- b. yes, b is greater in specificity than a  
- c. no, they are the same  
- d. no, there is not enough information

e. When presented with a graph of receptor affinity differentiate between a low and high affinity receptor.

Both curare and α-bungarotoxin bind to the nicotinic acetylcholine receptor and block its action. Curare binds temporarily to the protein, while α-bungarotoxin binds to it irreversibly. Which shows the most affinity?

- a. acetylcholine  
- b. curare  
- c. α-bungarotoxin  
- d. both acetylcholine and curare  
- e. No difference in affinity

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.

Use the following diagrams for question X-X

What type of feedback is demonstrated in each diagram (positive or negative feedback).

a. both are positive feedback
b. both are negative feedback
c. 1 is positive feedback, 2 is negative feedback
d. 1 is negative feedback, 2 is positive feedback

Based on the control pathway shown in example 1, what is the outcome of the feedback caused by the anterior pituitary releasing the thyroid-stimulating hormone (TSH)?

a. decrease activation of anterior pituitary
b. increase activation of anterior pituitary
c. no change in activation of anterior pituitary

Based on the control pathway shown in example 2, what is the outcome of the feedback caused by the depolarization of cell membrane?

a. decrease depolarization
b. increase depolarization

c. no change in depolarization
CHAPTER 7 - INTRODUCTION TO ENDOCRINE SYSTEM

Main Goals

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

InterActive Physiology CD – 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

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Hypothalamus</th>
<th>Anterior pituitary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior pituitary</td>
<td>Pancreas</td>
<td>Thyroid</td>
</tr>
<tr>
<td>Pineal</td>
<td>Adrenal gland</td>
<td>Hydrophilic</td>
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<tr>
<td>Hydrophobic</td>
<td>Steroid</td>
<td>Cholesterol</td>
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<tr>
<td>Peptide</td>
<td>Amine</td>
<td>Catecholamine</td>
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<tr>
<td>Cortisol</td>
<td>Insulin</td>
<td>Secretion</td>
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Mechanism of action

Students will 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.
   - Faculty note: gonads--leave to Phys II (reproduction section), maybe brief mention as hypothalamus releasing hormones.

What is the characterizing difference between the chemical released by the Anterior Pituitary (AP) and Poster Pituitary (PP)?

   a) Both release neurohormones
   b) AP: neurohormone; PP: hormone
   c) **AP: hormone; PP: neurohormone**
   d) AP: releases steroid hormones; PP: releases peptide hormones
   e) AP: releases peptide and amine hormones; PP: releases steroid hormones

Blood volume is carefully regulated by vasopressin. When blood volume drops, the hypothalamus signals the posterior pituitary to release vasopressin. What type of chemical is vasopressin?

   a) Autocrine
   b) Hormone
   c) **Neurohormone**
   d) Neurotransmitter
   e) Paracrine
If the connection between the hypothalamus and pituitary were severed, the secretion of which chemical messengers (signals) would be affected?

a) **Releasing hormones**  
b) Tropic hormones  
c) Neurotransmitters

The figures below illustrate the major pathways involved in the homeostatic regulation of blood glucose. The figure on the left demonstrates the response to increased plasma glucose levels, while the figure on the right demonstrates the response to decreased plasma glucose.

Now use the figures above to answer the following questions:

What acts as sensor of glucose levels? (5 points)  
- a) **α and β cells of pancreas**  
- b) insulin & glucagon  
- c) liver  
- d) muscle & adipose tissue  
- e) liver, muscle & adipose tissue  
- f) plasma glucose

What is the integrator? (5 points)  
- a) insulin & glucagon  
- b) liver  
- c) muscle & adipose tissue  
- d) liver, muscle & adipose tissue  
- e) pancreas  
- f) plasma glucose

What is the effector in both instances? (5 points)  
- a) insulin & glucagon  
- b) liver  
- c) muscle & adipose tissue  
- d) pancreas  
- e) plasma glucose

What is the regulated variable? (5 points)  
- a) insulin & glucagon  
- b) liver  
- c) muscle & adipose tissue  
- d) liver, muscle & adipose tissue  
- e) pancreas  
- f) **plasma glucose**
What effect does decreased plasma glucose levels have on α and β cells of pancreas? (5 points)
   a) activates both
   b) inhibits both
c) activates α cells and inhibits β cells
d) inhibits α cells and activates β cells

What happens to insulin and glucagon levels as a result of decreased plasma glucose? (5 points)
   a) both decrease
   b) both increase
c) insulin decreases, glucagon increases
d) insulin increases, glucagon decreases

What is the relationship between the effects of insulin and glucagon? (4 points)
   a) additive  b) agonistic  c) antagonistic
d) permissive  e) synergistic

When blood glucose levels are high, glucose enters liver cells and is converted to glycogen. When blood glucose levels are low, liver cells convert glycogen to glucose (it is the only organ that can do this).

How does glucose get into liver cells from the blood? (4 points)
   a) facilitated diffusion
   b) primary active transport
c) secondary active transport
d) simple diffusion

How does glucose get out the liver cells into the blood? (4 points)
   a) facilitated diffusion
   b) primary active transport
c) secondary active transport
d) simple diffusion

How does increased blood insulin reduce blood glucose levels?

Insulin binds to membrane receptors located on muscle or adipose tissues (1 in figure below). When this occurs, a signal transduction cascade is activated (2) which causes glucose transporter molecules, which are stored in secretory vesicles, to be moved to the cell membrane of these tissues (3). Glucose is then able to enter tissues from the blood (4).
Looking at the figure, what type of receptor would you say the insulin receptor is? (5 points)
   a) channel receptor  b) G-protein coupled receptor  c) receptor enzyme

What type of cellular transport does this glucose transporter (GLUT 4) perform? (4 points)
   a) facilitated diffusion  b) primary active transport  c) secondary active transport  d) simple diffusion

Now, let’s look at control of insulin release in beta cells. Insulin release is regulated. Under resting conditions, insulin is stored in secretory vesicles in the beta cells. Insulin is exocytosed into the extracellular fluid when voltage-gated Ca\(^{++}\) channels open and increase the intracellular concentration of Ca\(^{++}\) in the beta cells (a). What regulates whether the voltage-gated Ca\(^{++}\) channels are open or closed?

Recall that glucose is needed to make ATP (b). As blood glucose levels vary, the rate of transport of glucose into beta cells through the GLUT transporter varies and ATP levels vary. ATP levels influence another type of channel in beta cells, a special type of gated K\(^{+}\) channel (K\(_{ATP}\) channel, c). This channel is open when ATP levels are low, and closed when ATP levels increase.

(5 points each) Now answer the following questions about homeostatic regulation of blood glucose.
When blood glucose levels are high (as compared to low):

If blood glucose levels increased, what would happen?

ATP production in beta cells:  a) decreases  b) increases  c) doesn’t change
K\(_{ATP}\) channel is:  a) open  b) closed
Cell membrane potential:  a) depolarizes  b) hyperpolarizes  c) doesn’t change
insulin is:  a) released  b) not released

GLUT transporters:  a) are upregulated in membrane  
                    b) are downregulated in membrane  
                    c) do not change

glucose is taken up by muscle:  a) yes  a) no

If blood glucose levels increased, what would you expect to happen to glucagon levels?  
  a) decrease  b) increase  c) not change

Recently it has been shown that as much as 50% of insulin secretion is stimulated by glucagon-like peptide-1 (GLP-1). GLP-1 and GIP (gastric inhibitory peptide) are incretins produced by cells of the ileum and jejunum in response to nutrient ingestion. The incretions travel through the circulation to pancreatic beta cells and may reach them even before the first glucose is absorbed. The anticipatory release of insulin in response to these hormones prevents a sudden surge in plasma glucose concentrations when the meal is absorbed.

What type of signaling molecules are the incretins? (5 points)  
  a) autocrine signals  b) paracrine signals  c) juxtacrine signals  d) hormones

What type of control does ‘this’ represent? (5 points)  
  a) feedforward  b) negative feedback  c) positive feedback

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.

For the next four questions, use the following answer choices:  
  A. peptide  B. steroid  C. Both  D. Neither

Which type of hormone is produce in the rough endoplasmic reticulum?  
  A: Peptide

Which type of hormone is produced in the smooth endoplasmic reticulum?  
  B: Steroid

Which type of hormone is exocytosed from the cell via simple diffusion across the bilayer?  
  B: Steroid

Which type of hormone is exocytosed from the cell via secretory vesicles?  
  A: Peptide

3. Differentiate between peptide, steroid and amine hormone synthesis, release, signal reception and action on cell.

Use the following scenario to answer the next two questions.
You have been doing research on the pancreatic endocrine cells that secrete insulin and the adrenal cortex cells that secrete corticosteroids. You prepared tissue for examination under the electron microscope, but the labels fell off the jars when the fixative dissolved the glue. You sent the tissue off anyway and got back the following description for one of the tissues.

“...cells are close to blood capillaries. There are numerous dense, membrane-bound granules throughout the cytoplasm with rough endoplasmic reticulum and free ribosomes.”

Which of the two tissue types is being described?

a) adrenal cortical tissue  

b) pancreatic tissue  

c) both tissues  

d) neither tissue

What is your reasoning for your answer?

a) Because the cells are close to blood capillaries and both steroids and protein travel in the blood.  

b) Because the cells are close to blood capillaries and only proteins travel in the blood.  

c) Because the cells are close to blood capillaries and only steroid proteins travel in the blood.  

d) Because the technician noted a greater number of RER and ribosomes, and these structures are active components in steroid synthesis.  

e) Because the technician noted a greater number of RER and ribosomes, and these structures are active components in protein synthesis.

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).

The concentration of free hormone in the blood depends on which of the following? (4 points)

1. rate of hormone secretion  

2. rate at which the hormone is metabolized  

3. the rate of anaerobic ATP synthesis within the cells  

4. the number of cells in the body with active sodium-potassium pumps  

5. the amount of hormone transported bound to carrier proteins

a) all five  

b) 1, 3, 5  

c) 1, 2, 5  

d) 3, 4, 5  

e) 2, 4, 5
5. Explain the mechanism of how target cells stop responding to the signal when hormone concentration remains high over time (chronically).

6. Explain the role of negative and positive feedback and short loop and long loops in regulating endocrine pathways and identify where the regulation is taking place.

Built in to questions in earlier endocrine goals

7. Given a set of data determine if hormones are acting as synergists, antagonists or permissive hormones.

What characteristic of hormones is depicted by the graph?

![Graph showing different hormones over time]

a. Antagonism
b. Permissiveness
c. Synergism

8. Predict how abnormalities in the hypothalamic-pituitary-adrenal axis will alter hormone secretion and feedback.

Other Endocrine Questions

1. What will influence the magnitude of a target cell’s response to a hormone? (4 points)
   a) concentration of free hormone in the blood
   b) number of receptors on the target cell
   c) whether or not the hormone is a second messenger
   d) a and b
   e) a and c
   f) b and c
Main Goals

• Describe how the anatomy of a neuron does and does not vary with the type of signal it propagates.
• Explain how graded potentials and action potentials are generated and propagated in a neuron.
• Predict whether a signal will continue to be propagated given a set of conditions.
• 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.
• Describe the system level organization of the nervous system in terms of both anatomy and function.

InterActive Physiology CD

• Nervous I (Anatomy Review)

Central nervous system
Peripheral nervous system
Dendrite
Axon hillock (trigger zone)
Afferent
Bipolar neurons
Innervation

Brain
Neuron
Soma (cell body)
Axon terminal
Efferent
Sensory neuron

Spinal cord
Nerve
Axon
Synapse
Unipolar neurons
Motor neuron

Students will be able to:

1. When presented with a representation of a neuron, explain the main function of the dendrites, soma, axon hillock, axon, axon terminal, and synapse.

Which region of a neuron typically serves as the input region?

a) axon  
*b) dendrite  
c) node of Ranvier  
d) presynaptic terminal  
e) soma

Microvilli are present on cells that, because of their function, benefit from an increased membrane surface area. Which structure(s) on a neuron provide a comparable benefit?

a) axon  
b) cell body  
*c) dendrites  
d) trigger zone

For the cell shown to the right, where would you expect an action potential to first be generated?

Answer: E
2. Compare and contrast the function of the three major classes of neurons: afferent, interneuron, and efferent.

3. Describe the direction and function of information flow through the regions of a neuron in response to input from another neuron.

What is the correct sequence of signal transduction in a sensory neuron? (6pts)

viii) sensory stimulus -> v) opening of ligand-gated ion channels ->
      iii) graded potential (receptor potential) -> ix) summation of graded potentials ->
      vii) opening of voltage-gated sodium channels -> i) action potential(s) ->
      ii) action potential propagation -> vi) opening of voltage-gated calcium channels ->
      iv) neurotransmitter release

viii - v - iii - ix - vii - i - ii - vi - iv
InterActive Physiology CD


<table>
<thead>
<tr>
<th>Ions</th>
<th>Ion channels</th>
<th>Leaky channels</th>
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</thead>
<tbody>
<tr>
<td>Concentration gradient</td>
<td>Electrical gradient</td>
<td>Myelin</td>
</tr>
<tr>
<td>Nodes of Ranvier</td>
<td>Permeability</td>
<td>Resting membrane potential</td>
</tr>
<tr>
<td>Electrochemical gradient</td>
<td>Graded potential</td>
<td>Action potential</td>
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<tr>
<td>Gating</td>
<td>Refractory periods</td>
<td>Saltatory conduction</td>
</tr>
<tr>
<td>Oligodendrocytes</td>
<td>Schwann cells</td>
<td>Depolarization</td>
</tr>
<tr>
<td>Repolarization</td>
<td>Hyperpolarization</td>
<td>Threshold</td>
</tr>
<tr>
<td>Activation gate</td>
<td>Inactivation gate</td>
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</tbody>
</table>

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.**

Use the figure below. At which point of the action potential is Na\(^+\) closest to being at electrochemical equilibrium? (5pts)

Answer: C

2. **Identify the structures/factors at the plasma membrane that influence permeability.**

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.**

Use the following scenario for the next two questions.

If the concentration of sodium outside a normal cell were to increase, would you expect there to be any effect on the sodium equilibrium potential or the resting membrane potential?

Equilibrium potential would:
- a) not change  
- b) become more negative  
- c) become more positive

Resting membrane potential would:
- a) not change  
- b) become more negative  
- c) become more positive

If the resting membrane potential is -65mV and the equilibrium potential for chloride is -70mV, would you expect the resting membrane potential to change if the membrane became more permeable to Cl\(^-\)? What if the equilibrium potential for chloride was -60mV?

- a) more negative, more negative  
- b) more negative, more positive  
- c) more positive, more negative  
- d) more positive, more positive
The equilibrium potential for an ion is dependent on what factor(s)?

- **a) Concentration gradient for one ion**
- **b) Concentration gradient for multiple ions**
- **c) Relative ion permeability**
- **d) Concentration gradient for one ion and relative ion permeability**
- **e) Concentration gradient for multiple ions and relative ion permeabilities**

4. **Explain how changes in channel activation/inactivation, chemical and electrical gradients influence the membrane potential and signal propagation.**

Batrachotoxin, a toxin from the poison dart frog, was used historically for hunting on the end of a dart to paralyze prey. This toxin selectively binds sodium (Na\(^+\)) voltage-gated channels causing a conformational change that decreases the voltage required for channel opening, increases the permeability of the channel to sodium and calcium, and prolongs the open state of the channel.

What does “decreasing the voltage required for channel opening” mean about the change in voltage required to cause opening of the channel? Select all that apply. (5pts)

- **a) It takes less depolarization to open and will now open at more positive values**
- **b) It takes more depolarization and will now open at more negative values**
- **c) Threshold has changed.**
- **d) It takes less depolarization to open and will now open at more negative values**
- **e) It takes more depolarization and will now open at more positive values**

You encountered the poison dart frog in the field, accidentally touched it, rubbed your eye and now the toxin has absorbed into your system. Below (left) is a typical action potential under normal conditions. In the table below (right), indicate how the toxin would influence (increase, decrease, not change) the duration, amplitude, and threshold of the action potential.

<table>
<thead>
<tr>
<th></th>
<th>Without Toxin</th>
<th>25) duration of action potential</th>
<th>increase (4pts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>26)</td>
<td>amplitude of action potential</td>
<td>increase (4pts)</td>
<td></td>
</tr>
<tr>
<td>27)</td>
<td>threshold of action potential</td>
<td>decrease (4pts)</td>
<td></td>
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</tbody>
</table>

5. **Compare and contrast the structure and function of the three types of ion channels found in the plasma membrane (mechanical, chemical, voltage gated).**

   In a typical neuron, where would you expect to find voltage-gated Na\(^+\) channels?

- **a) dendrite**
- **b) presynaptic terminal**
- **c) trigger zone**
6. **Compare and contrast graded and action potentials in terms of the relative strength of signal and length of travel in a neuron.**

What would you conclude about transmission of information in the two sensory neurons shown to the right, if the axons are the same diameter? (4pts)

- a) faster in left compared the right
- b) slower in left compared to the right
- c) no difference between the two

Which of the following would NOT influence the time necessary for an action potential to be propagated the length of a particular neuron? (5pts)

- a) absence of nodes of Ranvier
- b) diameter of the axon
- c) length of the axon
- d) presence or absence of a myelin sheath
- e) **type of neuron (e.g., whether axon is sensory or motor)**

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)**

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.**

Use the figure below for questions 13-14

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In a typical neuron, where would you expect to observe a graded potential?

- a) dendrite
- b) presynaptic terminal
- c) trigger zone
- d) a & b
- e) a & c
- f) b & c
- g) All of the above
- h) None of the above.
A dendrite has been injected with a drug that causes the membrane potential to become less negative. Which graph or graphs below depict(s) the effect of this drug? (3pts)
Answer: A & B

A second drug was used on another neuron, causing it to depolarize. Which graph or graphs below depict(s) the effect of this drug? (3pts)
Answer: A & B

If a neurotransmitter caused ion channels to open and Na$^+$ flowed into the cell, the cell would (depolarize, hyperpolarize); if Cl$^-$ flowed out of the cell, the cell would (depolarize, hyperpolarize). (4pts)

- a) depolarize, depolarize
- b) depolarize, hyperpolarize
- c) hyperpolarize, depolarize
- d) hyperpolarize, hyperpolarize

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.

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.

   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.*

Fill in the table provided to answer the following question. During the phases of the action potential what state are each of these channel types?

**Channel State Answer Options**

16) Leakage channels: open or closed
17) Voltage-gated Na$^+$ channels: closed (resting), open, refractory (inactivatable), transitioning from refractory to closed
18) Voltage-gated K$^+$ channels: closed (resting), open, refractory (inactivatable) transitioning from open to closed
### Answer Key:

<table>
<thead>
<tr>
<th>Phases</th>
<th>16) Leakage Channels</th>
<th>17) Voltage-gated Na⁺</th>
<th>18) Voltage-gated K⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) rest (resting membrane potential)</td>
<td>a) <strong>Open</strong> (1pt)</td>
<td>a) <strong>Closed</strong> (1pt)</td>
<td>a) <strong>Closed</strong> (1pt)</td>
</tr>
<tr>
<td>b) depolarizing</td>
<td>b) <strong>Open</strong> (1pt)</td>
<td>b) <strong>Open</strong> (1pt)</td>
<td>b) <strong>Closed</strong> (1pt)</td>
</tr>
<tr>
<td>c) repolarizing</td>
<td>c) <strong>Open</strong> (1pt)</td>
<td>c) <strong>Refractory</strong> (1pt)</td>
<td>c) <strong>Open</strong> (1pt)</td>
</tr>
<tr>
<td>d) afterhyperpolarization</td>
<td>d) <strong>Open</strong> (1pt)</td>
<td>d) <strong>Transitioning from refractory to closed</strong> (1pt)</td>
<td>d) <strong>Transitioning from open to closed</strong> (1pt)</td>
</tr>
<tr>
<td>e) rest (resting membrane potential)</td>
<td>e) <strong>Open</strong> (1pt)</td>
<td>e) <strong>Closed</strong> (1pt)</td>
<td>e) <strong>Closed</strong> (1pt)</td>
</tr>
</tbody>
</table>

Use the table generated in 16-18 to answer the following questions

Which channel type is responsible for establishing and maintaining the resting membrane potential for a typical neuron? (3pts)

a) leakage channels
b) voltage-gated Na⁺ channels
c) voltage-gated K⁺

Which channel type is responsible for the depolarizing phase of the action potential? (3pts)

a) leakage channels
b) **voltage-gated Na⁺ channels**
c) voltage-gated K⁺

Which channel type is responsible for repolarizing phase? (3pts)

a) leakage channels
b) voltage-gated Na⁺ channels
c) **voltage-gated K⁺**

11. Given alterations in the duration or amplitude of an action potential predict the cellular properties that contributed to that change and vice versa.

12. Explain how the phases of the action potential allow for propagation of the signal along an axon uni-directionally in normal conditions.
In image shown to right, what type of signal would you expect to see at the indicated location? (5pts)

a)

b)

c)

Answer: C

In image shown to right, what type of signal would you expect to see at the indicated location? (5pts)

a)

b)

c)

13. Explain the influence of myelin and nodes of Ranvier in transmitting an action potential along the axon of a neuron by saltatory conduction.
Chapter 8 - Neuron-Neuron Communication

InterActive Physiology CD

- Nervous II (Anatomy Review, Ion Channels, Synaptic Transmission, Synaptic Potentials and Cellular Integration)

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

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).

   In the depiction below of a mono-synaptic reflex, describe the flow of information by matching the appropriate signal to the location at which it would be measured.

   Question 1: Match I with the appropriate signal (4pts)
   Question 2: Match II with the appropriate signal (4pts)
   Question 3: Match III with the appropriate signal (3pts)

   Signals: a) action potential        b) graded potential        c) end plate potential
            d) pre-synaptic potential   e) post-synaptic potential   f) receptor potential

   Answers:
   a) I: B, a graded potential; & F, receptor potential
   b) II: E, an excitatory post synaptic potential (EPSP); & B, graded potential
   c) III: A, an action potential

Which of the following is a direct result of depolarizing the presynaptic membrane of an axon terminal? (5pts)

   a) an EPSP or IPSP is generated in the postsynaptic cell
   b) ligand-gated channels open, allowing neurotransmitters to enter the synaptic cleft
   c) synaptic vesicles fuse with the membrane
   d) the postsynaptic cell produces an action potential
   e) voltage-gated Ca^{++} channels in the membrane open
2. Describe the three mechanisms (uptake, enzyme clearance, diffusion) used to deactivate neurotransmitters.

Organophosphate insecticides are cholinesterase inhibitors. If this enzyme were to be inhibited, what would you predict to immediately occur at the post-synaptic membrane of a cell containing acetylcholine receptors? (5pts)
   a) decreased amplitude in the graded potential
   b) increased amplitude in the graded potential
   c) inhibition of the post-synaptic potential
   d) prolonged post-synaptic potential

3. 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. Identify basic neurotransmitters involved in eliciting these potentials (ex: acetylcholine, GABA, glycine)

Match the neurotransmitter (acetylcholine, dopamine, epinephrine & norepinephrine, serotonin, none) with the name of its receptor. Each neurotransmitter can be used more than once, and each receptor may match more than one neurotransmitter. (3 points)

   a) dopaminergic
   b) alpha adrenergic receptors
   c) beta adrenergic receptors
   d) cholinergic receptors
   e) muscarinic receptors
   f) nicotinic receptors

Answer: a) DA; b) E & NE; c) E & NE; d) ACh; e) ACh; f) ACh
Students will be able to:

1. **Illustrate the branches of the nervous system; central and peripheral nervous systems, autonomic, sympathetic, parasympathetic, and somatic.**

1. Match the following structures and divisions of the nervous system (3 points):
   1. consists of nerves carrying information between the periphery and central nervous system
   2. consists of the brain and spinal cord
   3. division of the peripheral nervous system that transmits signals to central nervous system
   4. division of the peripheral nervous system that transmits signals from central nervous system
   5. innervates skeletal muscles
   6. innervates smooth muscle, cardiac muscle, and glands

   a) somatic nervous system  
   b) autonomic nervous system  
   c) central nervous system  
   d) peripheral nervous system  
   e) efferent division  
   f) afferent division

   **Answer: 1d, 2c, 3f, 4e, 5a, 6b**

   What are the targets (effectors) of the efferent nervous system? (3 points)
   a) cardiac muscles  
   b) endocrine glands  
   c) skeletal muscles  
   d) smooth muscles  
   e) **All of the above**  
   f) None of the above.

   In the somatic nervous system which type of neurons innervate which type of muscle? (3 points)
   a) postganglionic neurons; skeletal muscles  
   b) preganglionic neurons; cardiac muscle  
   c) **motor neurons; skeletal muscle**  
   d) motor neurons; cardiac and smooth muscle

   Using the answer code on the right, match the description with the autonomic neurotransmitter.
   1) secreted by all preganglionic fibers  
   2) secreted by sympathetic postganglionic fibers  
   3) secreted by parasympathetic postganglionic fibers  
   4) secreted by the adrenal medulla  
   5) secreted by somatic motor neurons
6) binds to muscarinic or nicotinic receptors
7) binds to $\alpha$ or $\beta$ receptors
   
   a) acetylcholine
   b) dopamine
   c) GABA
   d) norepinephrine/epinephrine

Answer: 1a, 2d, 3d, 4d, 5a, 6a, 7d

Norepinephrine is the neurotransmitter released by postganglionic neurons onto smooth muscle cells (epinephrine, predominantly, is released by the adrenal medulla into the bloodstream).
Using the answer code on the right, indicate which type of efferent output is being described. (3 pts)

1) innervates cardiac muscle, smooth muscle, and glands
2) innervates skeletal muscle
3) consists of the axons of somatic motor neurons
4) exerts either an excitatory or an inhibitory effect on its effector organs
5) exerts antagonistic control over effector organs
6) exerts only an excitatory effect on its effector organs

Answer Options:
    a) characteristic of the somatic nervous system
    b) characteristic of the autonomic nervous system
    c) Not characteristic of either
    d) Characteristic of both

Answer: 1b, 2a, 3a, 4b, 5b, 6a

Matching. Using the figure below, answer the following questions (there could be more than one answer).

a) Where would you expect to find nicotinic receptors?
   (skeletal muscle (6), both sympathetic & parasympathetic postganglionic neurons (4,5))

b) Where find muscarinic receptors?
   (effector organs of parasympathetic (7))

c) Where find adrenergic receptors?
   (effector organs of sympathetic (7))

d) Where find directly-gated receptors?
   (skeletal muscle (6), both sympathetic & parasympathetic postganglionic neurons (4,5))

e) Where find indirectly-gated (G-protein coupled) receptors?
   (effector organs of parasympathetic & sympathetic (7))

Which division of the autonomic nervous system prepares the body for intense levels of activity and stress? (4.5 points)
Organophosphate insecticides are acetylcholinesterase inhibitors. A person with organophosphate poisoning would experience what changes to parasympathetic activity? (4 points)

a) parasympathetic hyperactivity  b) parasympathetic hypoactivity
c) no change in parasympathetic activity

2. Explain the brain processes associated with sleep, learning, and memory. Indicate what the homeostatic mechanisms involved. (the stimulus, integrator, effector, and response/output).

An individual has sustained a serious injury that requires life support because they are unable to breathe on their own. Which region of the brain has this injury affected based on their need for life support? (4 points)

a) hypothalamus  b) thalamus  c) cerebellum  d) brain stem

Which structure serves as a direct relay between sensory information and the cerebral cortex? (3pts)

a) basal nuclei  b) epithalamus (pineal gland)  c) hypothalamus
d) limbic system  e) primary motor cortex  f) thalamus

Tim has trouble initiating voluntary motor functions, although his reflex responses are fine. Which lobe of the cerebrum is most likely affected? (5 points)

a) frontal lobe  b) left parietal lobe  c) occipital lobe
d) right parietal lobe  e) temporal lobe

Which areas of the brain are activated regardless of whether someone hears a word or sees a word? Choose any that apply. (6 points)

a) Broca’s area  b) motor cortex  c) primary auditory cortex
d) primary visual cortex  e) thalamus  *) Wernicke’s area
g) none
If someone had a partial transection (incomplete severing) of the spinal cord, so the left side was damaged but not the right side, at the T1-T2 level, what somatosensory perceptual deficits would you expect the patient to exhibit? Choose any that apply. (6 points)

*a) loss of perception of proprioception on the left side
b) loss of perception of proprioception on the right side
*c) loss of perception of vibration on the left side
d) loss of perception of vibration on the right side
e) loss of perception of nociception on the left side
*f) loss of perception of nociception on the right side
g) loss of perception of temperature on the left side
*h) loss of perception of temperature on the right side

General anesthetics keep surgical patients unconscious by reducing activity in what brain structure? (4.5 points)

a) corpus callosum b) hippocampus c) lateral ventricles
d) medullary pyramids e) reticular formation

Methamphetamine (METH) and its derivative 3,4-methylenedioxymethamphetamine (MDMA; ecstasy) are 2 substituted amphetamines with very high abuse liability in the United States. Use of these amphetamine-like stimulants have been associated with loss of multiple markers for dopaminergic and serotonergic terminals in the brain (i.e., there is a loss of these neurons). What symptoms would you expect due to these changes? Choose any that apply. (6 points)

a) anxiety b) balance problems (equilibrium)
c) depression, including anhedonia c) decreased sensitivity of somatic reflex receptors
d) movement problems e) learning and memory
f) violent behavior

During sleep, why don’t we act out our dreams? Relay neurons in the thalamus reduce information reaching the cerebrum by hyperpolarizing neurons, thereby causing less activity in the motor neurons. Release of which neurotransmitter might be involved in reducing the activity in motor neuron? (4.5 pts)

a) glutamate b) acetylcholine c) GABA d) dopamine
3. Determine when the parasympathetic and sympathetic nervous systems will dominate over the other (rest and digest vs. fight or flight responses).
   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.
   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).

Sensory Systems

1. Diagram and describe the structures and mechanisms involved in the flow of information for vision, sound & equilibrium, smell & taste, or somatic senses. Instructors choice of two systems.

Curare was once used as the sole anesthetic for surgery until it was realized that the patients sense of feeling was unaffected. Patients experienced the pain of surgery, but could not react until the curare “wore off”. Predict how curare could block patients from reacting to pain but not from feeling pain. (5pts)

   a) Curare affects transmission of information between sensory neurons and their postsynaptic cells, but not between motor neurons and their postsynaptic cells
   b) Curare affects transmission of information between motor neurons and their postsynaptic cells, but not between sensory neurons and their postsynaptic cells
   c) Curare affects transmission of information between both sensory neurons and their postsynaptic cells, and motor neurons and their postsynaptic cells

You tap the tendon behind the knee that is attached to the hamstring muscle. Which pathway is the monosynaptic pathway, and which the polysynaptic?

   a. pathway from tendon (muscle spindle) to hamstring, pathway from tendon (muscle spindle) to quadriceps
   b. pathway from tendon (muscle spindle) to quadriceps, pathway from tendon (muscle spindle) to hamstring
   c. pathway from tendon (muscle spindle) to hamstring is both
   d. pathway from tendon (muscle spindle) to quadriceps is both

In response to this stimulus, which muscle would contract and which would relax?

   a. hamstring contracts, quadriceps relaxes
   b. quadriceps contracts, hamstring relaxes
c. both would contract

Questions 5, 6: You are pushing as hard as you can against a wall, and suddenly your biceps muscle relaxes.

What is the sensor imbedded in the biceps muscle that responds to the stimulus which causes your biceps to relax? (4 points)
- a) biceps muscle
- b) dendrites
- c) Golgi tendon organ
- d) muscle spindle
- e) sarcolemma
- f) triceps muscle

What is the effector? (4 points)
- a) biceps muscle
- b) dendrites
- c) Golgi tendon organ
- d) muscle spindle
- e) sarcolemma
- f) triceps muscle

Questions 7,8: Arrange the following neurons in the correct sequence for information flow for the monosynaptic and polysynaptic circuits, respectively, during the knee-jerk reflex: interneuron, motor neuron, muscle, sensory neuron.

Answer options: 1, 2, 3, 4, not involved

monosynaptic circuit (4 points):
1=sensory neuron, 2=motor neuron, 3=muscle, interneuron = not involved

polysynaptic circuit (4 points):
1= sensory neuron, 2= interneuron, 3=motor neuron, 4=muscle

Questions 9,10: Match the location (sensory neuron, interneuron, motor neuron, muscle) with the graded potential (EPSP, IPSP, not in circuit) you would expect to see in the input region of that cell when the monosynaptic or polysynaptic pathway, respectively, of the stretch reflex is activated by stretch of the muscle.

monosynaptic pathway (6 points):
- sensory neuron=EPSP, motor neuron=EPSP, muscle=EPSP, interneuron = not involved

polysynaptic pathway (6 points):
- sensory neuron=EPSP, interneuron=EPSP, motor neuron=IPSP, muscle=EPSP

If the receptive field increased in an area of skin, how would the sensitivity of that region be affected, if at all? (4 points)
- a) decrease
- b) increase
- c) not change

Neurons A and B both receive information about sensation on the skin and relay it to the brain. If neuron A has more information converge onto it than neuron B, how would the ability to discriminate the location of two different points on the skin compare in the pathway with neuron A, compared to neuron B? (4 points)
a) worse (less sensitive) in A
b) better (more sensitive) in A
c) not different

Match the receptor type with the sensory receptor. (5.25 points)
1) bitter taste receptor
2) Golgi tendon receptor
3) muscle spindle receptor
4) salt taste receptor
5) sour taste receptor
6) sweet taste receptor
7) umami taste receptor

a) G-protein coupled receptor
b) ligand-gated channel
c) mechanically-gated channel

Answer: 1a, 2c, 3c, 4b, 5b, 6a, 7a
Chapter 11 & 12 - Muscle Physiology

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

Main Goals:
• Relate structure to function involved in the mechanisms of muscle contraction at both the molecular and organ levels of organization.
• Predict changes in muscle contraction based on changes to molecular structure and/or nervous input.

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

Students will be able to…

1. Explain the structure and functions of the motor end-plate.
   The agonist motor neuron to muscle connection is ______; the antagonist motor neuron to muscle connection is ______.
   a) excitatory, excitatory   b) excitatory, inhibitory
   c) inhibitory, excitatory   d) inhibitory, inhibitory

2. Diagram the sequence of events involved in muscle contraction, from neuronal action potential through cell signaling to force output.
   What type of potential is measured at the neuromuscular junction (NMJ)?
a. EPSP (Excitatory Post-Synaptic Potential)
b. IPSP (Inhibitory Post-Synaptic Potential)
c. Receptor Potential (RP)
d. End Plate Potential (EPP)

In this monosynaptic pathway, the sensory neuron synapses on the somatic motor neuron and excites the muscle tissue it innervates. At each appropriate location, identify the location and type of the signal that would be recorded to allow the muscle to be excited and contract. (EPSP, IPSP, EPP, AP)

![Monosynaptic Reflex Diagram]

sensory neuron:
somatic motor neuron:

In this polysynaptic pathway, the interneuron releases a NT that upon binding to it’s receptor elicits an IPSP. Identify the location of the signal, draw the IPSP and state if the muscle (the effector organ) has increased or decreased activation compared to at rest.

![Polysynaptic Reflex Diagram]
At the muscle what type of potential is measured?

a. **Synaptic (EPP)**  
b. Is it excitatory or inhibitory? **Always excitatory (we can increase or decrease activity, but it’s always excitatory)**  
c. What neurotransmitter is released from the agonist motor neuron? **(Ach)**  
d. What neurotransmitter is released from the antagonist motor neuron? **(Ach)**  
e. What is the action at the muscle of each? **(excitatory)**  
f. Is it always excitatory? **Yes.**  
g. In the knee jerk reflex we can’t have antagonist muscles all firing together, is the opposing muscle inhibited or is **excitation decreased** instead?

The tendon attached to the triceps muscle is tapped with a hammer. In response to this stimulus, which muscle(s) would contract and which muscle(s) would relax?

a. biceps brachii contracts, triceps relaxes  
b. **triceps contracts, biceps brachii relaxes**  
c. both would contract  
d. both would relax

What neural pathway is responsible for the pattern of activation seen in the above question (Q20)?

a. Monosynaptic pathways to both muscles  
b. Polysynaptic pathways to both muscles  
c. Monosynaptic pathway to the bicep; polysynaptic pathway to the tricep  
d. **Monosynaptic pathway to the tricep; polysynaptic pathway to the bicep**

3. **Explain the molecular basis of a muscle contraction based on the sliding filament theory.**

For a concentric contraction put the following list of statements related to myosin-actin interaction in the proper order.

a. the myosin head binds to the active site on the actin  
b. ATP is split and the myosin head cocks  
c. The myosin head unbinds from actin  
d. The myosin head has a power stroke, pulling the actin filament

Before performing a dental procedure on you, your dentist administered a general anesthetic. Unfortunately you have a negative response to this anesthetic and begin to experience excessive twitching. It turns out that this anesthetic works by acting on the dihydropyridine receptors (DHP receptor) and leads to maintained calcium release from the sarcoplasmic reticulum (SR). Your dentist administers an antidote to calm the twitching. How could the antidote reverse the effects of the anesthetic?
a. Promotes relaxation by increasing SR ATPase activity, which decreases calcium

b. **Promotes relaxation by decreasing SR ATPase activity, which increases calcium**

c. Promotes relaxation by decreasing calcium release into the intracellular space and thus decreasing the interaction of myosin and actin.

d. Promotes relaxation by decreasing sodium release into the muscle cell, which decreases the rate of action potentials firing at the cell membrane.

4. **Differentiate between muscle fiber types, based on size, fuel source, contraction velocity, fatigue resistance, and mitochondria.**

   Why do Type IIx muscle fibers fatigue more quickly than Type I? Check any that apply.

   a. higher capillary density
   b. increased oxidative capacity
   c. higher mitochondrial density
   d. **lower mitochondrial density**
   e. lower capillary density

Below are data indicating the percentage of muscle fibers (Type I or Type II) for three different muscles.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>% Type 1 Fibers</th>
<th>% Type 2 Fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>B</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

Use the data in the chart to answer the following questions, and use the following answer choices:

a) Muscle A     b) Muscle B     c) Muscle C     d) All three muscles.

**During an rapid, explosive movement, such as a vertical jump, which muscle(s) would primarily contribute to this activity?**  
*Answer: A*

**Which muscle(s) would describe the make up of the fibers from the dark, thigh meat from thanksgiving dinner?**  
*Answer: C*

**What are the fuel sources and primary pathway of ATP synthesis used for each of the following activities:**

a. first ten seconds of a 100 meter sprint (CP)
b. bench pressing 250 lbs. for 30 seconds (Glycolysis)

i. Creatine Phosphate
ii. Glycolysis
iii. Oxidative phosphorylation

Below are data indicating the percentage of muscle fibers (Type I or Type IIb) for three different muscles (A, B, C). Use the data in the chart to answer question 43.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>% Type 1 Fibers</th>
<th>% Type 2b Fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>B</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

Which muscle(s) would be best suited to stand on one leg?

a. Muscle a
b. Muscle b
c. **Muscle c**
d. Would not differ

Before heading to the Tour de France a cyclist had a muscle biopsy in his leg. The tests revealed that the dominant muscle fibers were low in myosin ATPase activity and anaerobic enzymes, high in capillary density and myoglobin content. What muscle fiber is dominant in this athlete?

a. **Type I**
b. Type IIa
c. Type II b or d

What is the primary source of ATP generation in this muscle for the athlete as he steadily climbs the mountains of France?

a. ATP
b. Creatine Phosphate
c. Glycolysis
d. **Oxidative Phosphorylation**
At the last 500 meters of the day’s race, the athlete was nose to nose with another athlete to cross the finish line and turned up the intensity of peddling. Immediately after the race, high lactate levels were measured in his blood. Was there a shift in catabolic pathways to produce ATP? If so what pathway dominated?

a. Yes, to creatine phosphate pathways

b. **Yes, to glycolytic pathways**

c. Yes, to oxidative phosphorylation pathways
d. No shift of metabolic pathways took place

For this athlete to maintain force production, what change to cytosolic ion concentrations must occur in the muscle cell?

a. Decrease in intracellular sodium concentration

b. Decrease in extracellular potassium concentration
c. Increase in intracellular potassium concentration
d. Decrease in intracellular calcium concentration
e. **Increase in intracellular calcium concentration**

4. **Graph and explain the length-tension relation for various sarcomere alignments.**

Which of the muscle force relationships is influenced by the inability of myosin heads and actin filaments to overlap?

a. force-length

b. force-velocity
c. force-frequency

When a muscle creates tension, but does not shorten, what type of contraction is this considered?

a. tetanus

b. summation
c. **isometric**
d. concentric
e. eccentric

5. **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.**

When a second EPSP from the activating the same synapse arrives at the trigger zone before the effects of a first have disappeared, what occurs? (4pts)

a) decrease in speed of impulse transmission

b) extinction of the impulse
c) hyperpolarization
d) spatial summation
e) temporal summation

6. Differentiate between fused and unfused tetanus.

7. Define motor unit and explain how the type and number of motor units influences muscle force.

In some diseases there is a decrease in the number of motor units for a given muscle. If the skeletal muscle fibers still exist but the innervating neuron dies, reinnervation of the existing muscle fibers can occur. In general, how has the innervation ratio changed for the surviving motor units?

a. Innervation ratio has decreased
b. Innervation ratio has increased
c. Innervation ratio has not changed

In the above scenario (Q22), how would the force of contraction change for a given motor unit compared to pre-disease?

e. Increased
f. Decreased
g. Not changed

8. Describe the different types of muscle contraction-isotonic, isometric, eccentric, concentric.

What is the difference between a concentric and eccentric contraction at the level of the sarcomere?

a. Both contractions the sarcomere shorten
b. Both contractions the sarcomere lengthen
c. Concentric, sarcomere lengthen; eccentric sarcomere shorten
d. Concentric, sarcomere shortens; eccentric, sarcomere lengthen
e. Both contractions result in no change in the length of sarcomeres

Consider the sarcomeres shown to the right. Would they differ in how much force they are producing?

a. Yes, A > B
b. Yes, B > A
c. No, they would be the same.
9. Predict a change in force according to the force-velocity relation.

10. Differentiate between atrophy and hypertrophy.

11. Compare and contrast the morphological and contractile properties of smooth and cardiac muscle to skeletal muscle.
Aspects of Chapter 24 - The Immune System

Main Goals

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

Interactive Physiology CD

- Immune System (Immune System Overview, Anatomy Review)

<table>
<thead>
<tr>
<th>Acquired immunity</th>
<th>Antibody</th>
<th>Antigen</th>
</tr>
</thead>
<tbody>
<tr>
<td>B lymphocyte</td>
<td>Basophil</td>
<td>Bone marrow</td>
</tr>
<tr>
<td>Basophil</td>
<td>Cytotoxic T cell</td>
<td>Dendritic cell</td>
</tr>
<tr>
<td>Eosinophil</td>
<td>Granulocyte</td>
<td>Helper T cell</td>
</tr>
<tr>
<td>Immune response</td>
<td>Immunity</td>
<td>Inflammation</td>
</tr>
<tr>
<td>Innate immunity</td>
<td>Lymph node</td>
<td>Macrophage</td>
</tr>
<tr>
<td>Mast cell</td>
<td>Monocyte</td>
<td>Natural killer cell</td>
</tr>
<tr>
<td>Neutrophil</td>
<td>Pathogen</td>
<td>Spleen</td>
</tr>
<tr>
<td>Thymus gland</td>
<td>Tonsils</td>
<td>T lymphocyte</td>
</tr>
</tbody>
</table>

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.

   Swelling and soreness of the lymph nodes indicate that:
   a. **Immune cells are fighting infection**
   b. The immune system is incapable of working
   c. Too much or improper exercise has been undertaken
   d. Dangerous cancerous changes are occurring in the immune system
   e. None of the above

   Leslie has a bad sore throat and the lymph nodes in her neck are swollen. This indicates:
   a. The focus of the infection is in the lymph nodes
   b. Lymph is not flowing through these lymph nodes
   c. The lymph gland has increased its secretion of thymosin
   d. **The affected lymph nodes contain an increased number of lymphocytes**

   At what two locations do most immune responses occur?
   a. in the blood; in the thymus
   b. at local sites of infection; in the blood
   c. in draining lymph nodes; in the thoracic duct
2. Explain the differences between a virus and a bacteria in terms of structure, living conditions, and susceptibility to drugs.

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.

   Which of the following is part of the inflammatory response? Check all that apply.
   a. Migration of neutrophils and macrophage to involved area
   b. Localized vasodilation
   c. Formation of interstitial-fluid clots in the injured region
   d. Both migration of neutrophils and macrophage to the involved area and localized vasodilation

   What is a secondary response to an invading microorganism that has invaded a previous time? Check all that apply.
   a. Launched by memory cells
   b. Slower and weaker than the primary response
   c. More rapid, more potent, and longer-lasting than the primary response

   What is true of the specific immune response?
   a. Require helper T cell activation
   b. Are under the control of the acquired immune system
   c. Could not occur if the thymus gland did not develop
   d. A & B
   e. All of the above

   What is true of the nonspecific immune response?
   a. Come into play whether or not there had been prior experience with the offending agent
   b. Are triggered by invasion of infectious microorganisms, chemical injury, mechanical trauma, or burns
   c. Are mediated by lymphocytes
   d. A & B
   e. All of the above

4. Identify primary vs. secondary lymphoid organs.

5. Compare and contrast the functions of the six major cell types of the immune system.

   What kind of white blood cell secretes chemicals that destroy parasitic worms?
a. Basophil
b. **Eosinophils**
c. Lymphocyte
d. Monocytes
e. Neutrophils

Neutrophils engulf foreign particles by what process?
   a. Opsonization
   b. Diapedesis
   c. Chemotaxis
d. **Phagocytosis**
e. Aglutination

What type of cell are dendritic cells?
   a. Are neurons
   b. Participate in the inflammation response
c. Are specialized for phagocytosis of worms
d. **Are specialized antigen-presenting cells**
e. None of the above

Optional Learning Goals
- Diagram the steps in the process of fighting viral infections.
- Diagram the steps in the process of an allergic reaction.
- Compare and contrast the antigens and antibody characteristic of each blood type.
- Autoimmune diseases
- Describe how stress alters immune system function.