Name: _____ **Exam I, Physiology** **Spring 2000**

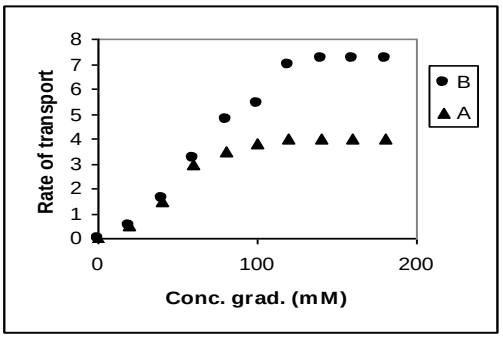
1. Suppose there was a mutation in the voltage-gated K+ channels of a neuron so that they opened at the same time as the Na+ channels.
   A) What effect would this have on the neuron? Explain. (6)
   B) What if they didn't open at all during an action potential? (4)

2. Consider a normal neuron at rest. Suppose there is slightly more Cl- outside than in.
   A) What will happen to the membrane potential if Cl- channels opened? (4)
   B) Under what circumstances, if any, would Cl- not diffuse across the membrane, even if many Cl- channels were open and there was a gradient? (4)
   C) If the Cl- gradient was very weak, is it possible that it would diffuse against the concentration gradient? (2)

3. How does the refractory period keep action potentials from travelling backwards? (6)

4. How would the following affect the likelihood of a post-synaptic neuron firing in response to stimulation from incoming action potentials? (Explain each answer)
   A) having some voltage-gated Na+ channels on the dendrites, halfway between the axon terminals and the axon hillock (4)
   B) having a higher frequency of incoming action potentials (4)
   ***C)What is the advantage of this kind of complexity? (4)

5. Consider the graph showing the rate of transport across an epithelium versus the concentration gradient.
   A) What is the most likely explanation for the difference between curves A and B? (4)
   B) How is the difference significant for synaptic transmission? (4)



6. If a neuron had very slow Na/K pumps (active transporters) how would that affect its function? (8)

7. A) Given what you know of neurons, describe a potential mechanism by which a drug can slow a patient's heart rate. (3)
   B) Describe how another drug could act on the heart but create the opposite effect? (3)

8. Given what you know about the chemical senses, what is the molecular basis for our ability to differentiate between different smells? (4)

9. How can you detect the direction from which a sound comes? (6)

10. Why is low frequency light not detected by the eye? (4)

11. Suppose you found a region on the skin of a snail that you thought may be an ear. How would you test this hypothesis? (There are several possible answers) (6)

12. What is the role of cyclic nucleotides (cAMP and cGMP) in sensory perception? (6)

13. Consider two muscles with different-sized thick filaments. One of the muscles (A) had the myosin heads clustered near the tip of the thick filament. The other muscle (B) had thick filaments with twice as many myosin

heads, but they were spread out along the length of the filament. Sketch a graph showing how the tension produced by the muscle varies with extension in each case (draw them on the same graph). Explain your graph. (8)

14. Some muscles, such as finger muscles, have fine control of the force they produce. Other muscles, such as the hamstrings, have cruder control-- they are incapable of producing a wide variation of gentle forces. What could account for this? (6)

Principles of Physiology **Fall 2001, Exam I**

1. A) Suppose the resting potential of one animal's neurons is -60 mv (inside relative to outside) and a very different species has a resting potential of -90 mv. Describe one possible cause for this difference. (4)

B) The membrane potentials also differ at the peak of their action potentials (+60 mv for one, +50 mv for the other). Describe one possible cause for this difference. (4)

C) The duration of their action potentials also differs (0.75 ms for one, 2 ms for the other). What cellular event must be different to create an action potential that lasts longer? (4)

D) What type of experiment would you do to test the mechanism you propose in C? (you don't have to describe the experiment). (2)

2. Some animals are sensitive to magnetic fields. These animals often contain crystals of magnetite. Magnetite is a mineral that orients in a magnetic field so that it always points north (like a compass needle). Describe a possible mechanism by which changes in the animal's orientation relative to a magnetic field could trigger an action potential. You can make any assumptions you want about where the magnetite is found, and in what kind of arrangement it is found. (8)

4. In chemoreceptors, what is the function of G-protein linked enzymes? (8)

3. A) Why is a single action potential reaching a synapse unlikely to trigger an action potential in a post-synaptic neuron? Explain in detail. (10)

B) Each neuron in the brain may receive input from hundreds of neurons. The effect of the input from each may differ. Specifically, a *single* action potential from one specific neuron may bring the neuron closer to firing than a *single* action potential from another neuron. Describe one possible difference between neurons that could give rise to this difference in effect. (6)

5. How does the myelin sheath speed the transmission of action potentials? (8)

7. Suppose the stone in a balance receptor was larger and heavier (and thus harder to move).

A) Would this have any effect on the sense of static equilibrium (sense of orientation)? Explain. (6)

B) Would it affect dynamic equilibrium (sense of movement)? Explain. (6)

6. Color blindness most likely involves a defect in what type of protein? Explain. (6)

8. If you stimulate a frog's sciatic nerve with increasing stimulus strengths, the force produced increases.

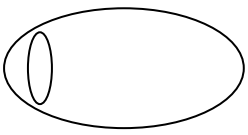
A) Why does force increase? (4)

B) Sometimes when the stimulus increases by a certain amount, the force increases only a small amount, but sometimes it increases by a large amount. Why may there be a difference? (4)

C) Why does the force level off at some point and not get any stronger no matter how high the stimulus goes? (4)

10) Muscles fatigue when lactic acid builds up. The high concentration of hydrogen ions (H+) affects the cellular machinery in the muscle. Specifically, hydrogen ions can bind to proteins and cause shape changes in the protein, rendering them less effective. Give three specific proteins that could be inhibited by hydrogen ions, and describe the effect on the muscle if that protein is impaired. (12)

11) A common cause of poor vision is if the eyes aren't perfectly circular. If it was shaped as in the exaggerated drawing below, how would this affect vision?



Name: _____ Fall 2005, Animal Physiology Exam 1

2. One way of controlling neural activity is pre-synaptic inhibition. In this situation, an axon terminal from one nerve sends a signal to the axon terminal of another nerve, reducing the amount of neurotransmitter it releases per action potential. If, for example, half as much neurotransmitter was released per action potential, how would that affect the likelihood of generating a post-synaptic action potential, and the strength and/or duration of any resulting post-synaptic action potential? Explain in detail. (10)

3. Suppose you inactivated a neuron's Na/K exchange pumps (the active transporters), then immediately stimulated the neuron.

A) Would the action potential fail to occur or be different from usual? Explain briefly. (4)
B) Would repolarization fail to occur or be different from usual? Explain briefly. (4)
C) Would the cell's ability to respond to a second stimulus be changed? Explain briefly. (4)

4. Suppose you've been hired by a drug company to design a therapy for a particular disease. It's known to be caused by excessive firing of neurons in the area of the brain controlling thirst. Describe an approach to correcting this disease that you think would be fruitful. (8)

5. What determines what frequencies we can hear, and what frequencies are too high? Your answer should make clear that you know the basic mechanism by which we sense sound. (8)

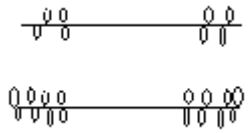
6. List the major similarities in the way an olfactory chemoreceptor cell and a light receptor cell operate. (8)

7. Suppose there are ATP-sensitive potassium channels on the muscle cell membrane. ATP is a ligand that holds these channels closed. How would these channels affect a muscle's response to fatigue? (10)

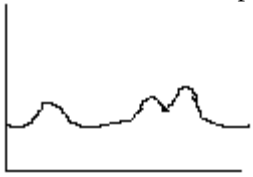
8. Identify two specific processes in a muscle twitch that require ATP. Be specific. (8)

9. What are three adaptations an organism could have that could increase the endurance of a muscle? (6)

10. Consider two muscles, one whose thick filaments are shown above (with fewer heads per myosin molecule), and the other whose thick filaments are shown below (with more heads per myosin). For each muscle, graph what you would expect a single twitch to look like. Assume there is no load on the muscle. Put both graphs on the same figure, for easier comparison. The graph should show tension over time. (6)



11. Consider the following recording of a muscle stimulated three times. Explain what is happening at the cellular level to make the third peak taller than the other two. (6)



12. A) How does the width of a muscle affect the unloaded velocity? (4)

B) How does the width of a muscle affect the loaded velocity? (4)

Principles of Physiology **Fall 2006, Exam I make-up**

1. A) Explain why the action potential is an all-or-nothing event. Your answer should explain why it is either on or off, and why the magnitude is always the same. (6)

B) Explain why the depolarization on the dendrites caused by neurotransmitter crossing a synapse is not all-or-nothing. (6)

C) What is the advantage to the fact that synaptic depolarizations on the dendrites are not all-or-nothing? (6)

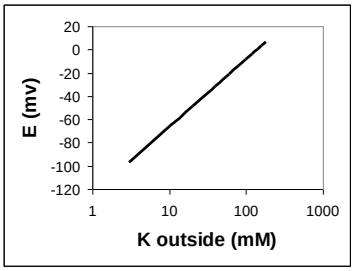
2. A chemosensory receptor cell has ligand-gated and voltage-gated sodium channels. Explain the role of each in creating an action potential. (10)

3. A) Imagine there is a toxin that blocks voltage-gated calcium channels (there probably is). How would this affect synaptic transmission? Explain. (4)

B) How is it possible to have a drug that specifically increases alertness, while another specifically acts on the pleasure centers of the brain? (6)

4. Suppose you are studying the neurons of a garden snail. You measure the resting potential across the membrane while manipulating the concentration of potassium outside the neuron. You get the results shown in the following graph. From this you can tell what the intracellular concentration of potassium is.

A) Roughly what is the intracellular concentration of potassium? Explain how you know. (6)



B) You find that the resting potential before you start messing with the potassium is -80mv. From this, what is the typical extracellular potassium concentration? (6)

C) What would happen to the resting potential if you changed the sodium concentration outside the neuron? Explain. (6)

5. Explain how our depth perception works. (8)

6. A) High frequency sound attenuates rapidly (the sound is scattered and weakened as it travels). What consequences does this have for determining the location of a sound source? (5)

B) One drawback to echlocation is that animals like bats have to call very loudly. Why does this complicate echolocation? Explain. (5)

7. What is the function of the photopigment rhodopsin (opsin + retinal) in vision? (8)

8. A) If you stretch a vertebrate cross-striated muscle to 170% of its resting length, it will be unable to produce force. Why? (8)

9. A) Why do muscles become rigid if no ATP is present? (5)

B) What is the function of calcium in muscles? (5)

Name: _____ **Exam I, Fall 06**

1. People who suffer from salt imbalances (for ex. through dehydration or some pathological condition) often experience overexcitable nerves that fire too often (causing cramps, random twitches, or difficulty thinking clearly). If the intracellular concentration of potassium was unusually low for example, nerves may begin to fire action potentials more often than they are supposed to. Why would this happen? (10)

2. At a synapse, opening one sodium channel (for the normal duration before closing) causes a small depolarization. Opening a handful of sodium channels may cause a larger depolarization. Opening more channels may lead to an even larger depolarization, up to a point. Then the depolarization would be the same regardless of how many other sodium channels opened. Explain why the number of open channels increases the depolarization, and why it doesn't matter beyond a certain point. (10)

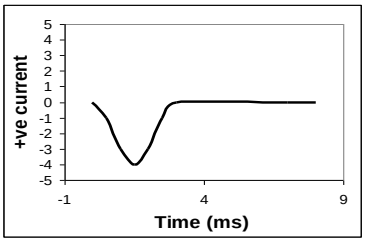
3. A. Axons that are larger in diameter transmit signals faster. This is because the rate of charge leakage is slower than a skinnier axon (note that this refers to the general leakage of ions across the membrane, not movements controlled by specific channels). How does slower leakage lead to increased signal velocity down the axon? (5)

B. If ion leakage from the dendrites was **increased** due to greater general leakiness, how would this affect the firing of the neuron in response to action potentials coming in from a pre-synaptic neuron? (5)

4. Consider the following recording from a voltage clamp experiment. A drug was used to block a channel.

A) Which channel was blocked? (4)

B) On a separate chart, draw what the action potential (voltage vs. time) during this recording would look like. Make sure that events line up on the x-axis where you would expect based on the voltage clamp data. (6)



5. Imagine a drug that blocked reuptake of an excitatory neurotransmitter such as epinephrine by pre-synaptic cells.

A. Explain how this might affect nerve cell firing. (4)

B. Would this affect all nerve cells? Explain. (4)

7. Some animals have excellent night vision. There are a number of things that would provide good night vision.

A. Describe how the fovea (the area in the center of the retina) could be changed, and also possibly the connections to the optic nerve, in order to improve night vision. (6)

B. Describe how changes in the activity of proteins or enzymes on the vesicle membrane of photoreceptor cells could improve night vision. (6)

8. Do balance receptor cells depend on sodium gradients? Explain briefly. (6)

9. In some non-striated muscle cells, like those lining the intestine, calcium levels in the cytoplasm never drop to zero. They stay constant at a low level, and may rise and fall slowly. How would this affect the way the muscle behaved? Explain. (8)

10. Most muscles are neither 100% oxidative, nor 100% glycolytic – they are a mixture of these fiber types. All the fibers in a single motor unit, though, are the same (either glycolytic or oxidative). Explain what this means for the control of muscle performance. (8)

11. Squid tentacles are extremely fast. Two adaptations that they have are the following: they have many more sarcomeres attached end-to-end in each muscle fiber than is typical, and they have very short distances from the sarcoplasmic reticulum to the actin and myosin filaments.

A. Explain how each of these would affect the speed of the tentacle strike. (6)

B. Name one other adaptation that would increase the speed of the strike. (4)