This is an open book, open notes exam. Choose any 7 questions (out of 10) to answer. Each question is worth 15 points. Typed answers are encouraged but are not necessary if your handwriting is legible.

Only the first 7 questions answered will be graded. No extra credit will be given. Please mark the questions you are NOT answering with a large X to avoid confusion.

You may make use of any reference material but may not discuss the exam with anyone.

You may take up to 23 hours to complete this test.

PLEASE PUT YOUR NAME ON ALL SHEETS.

The test must be returned to the Biology Department office (77 Klamath) by 1030 am Friday November 30th

(PLEASE NOTE THAT EXAMS TURNED IN AFTER THE DEADLINE WILL NOT BE GRADED AND WILL RECEIVE A FAILING GRADE)

This test will be graded only if the following statement is signed:

"On my honor, I did not collaborate with any other person, including a fellow student, during this exam. I also state I did not plagiarize from any source."

Signature______________________________________________

Under no circumstances should your answers exceed the space given.
1. Many bats use echolocation to identify and localize objects in their environment. They accomplish this by sending out a high frequency signal and measuring the time it takes a reflection of that signal to return to them. Some bats use their echolocation abilities to distinguish between an object that is 49 cm away and one that is 50 cm away. They accomplish this in spite of the fact that the difference between a reflected echo from a 49 cm target and one from a 50 cm target is less than 10 microseconds (10^{-5} sec). How can the nervous system determine this timing difference considering it is two orders of magnitude less than the duration of a single action potential (10^{-3} sec)? Propose a neural mechanism that might be able to accomplish this feat.
2. You are recording from a squid giant neuron whose resting potential is -60 mV. You inject square pulses of hyperpolarizing current (1 nA = 10^{-9} A) into the cell for 20, 40 and 100 ms in duration, respectively. These current injections generate the voltage and current records presented below (left arrow denotes the beginning of the current injection). For all questions, show your calculations.

A) What is the cell’s time constant (Tau; answer should be in msec (5pts)?

B) What is the cell’s membrane resistance (Rm; answer should be in ohms) (5 pts)?

C) What is the cell’s membrane capacitance (Cm; answer should be in farads) (5 pts)?
3. Define the concept of a receptive field as it applies to sensory systems (5 pts). How does this concept apply to olfaction (2.5 pts)? To gustation (2.5 pts)? Describe the receptive fields of an olfactory and a gustatory sensory cell (5 pts).
4. You are recording from a mammalian nerve cell that has never been recorded before. Using patch clamp techniques, you voltage clamp a small patch of membrane that has one or a few of a particular type of channel. The recordings you obtain look like this:

A) Is this channel voltage gated? Why or why not (5 pts)?

B) The experimental solutions used to obtain these recordings were:
   - Extracellular: 150 mM KGluconate (glutamate is an impermeant anion) & 10 mM NaCl
   - Intracellular: 150 mM KCl & 1mM MgCl₂

   What ion(s) carries (carry) the current observed in the figure? Explain your answer (5 pts).

C) Draw the I-V curve for this channel (5 pts).
5. Barnacle photoreceptor cells have a typical neuronal morphology as shown below.

These cells are unusual, however, in that light produces a generator potential in their dendrites which travels all the way to the terminal and activates transmitter release without producing an action potential. Explain how this is possible using your knowledge of passive properties of neurons.
6. A) Describe Hebb’s rule of learning for both strengthening and weakening synapses (5 pts).

B) Discuss Hebb’s rule in terms of possible molecular mechanisms in pre- and post-synaptic cells (5 pts).

C) Explain how the molecular mechanisms responsible for long term potentiation (LTP) are consistent with Hebb’s rule (5 pts).
7. One of the classic methods to depolarize a cell is to increase the extracellular concentration of K+ ions.

A Explain exactly why this works (5 pts).

B Increasing extracellular Na+ concentrations does not have this effect. What effect is seen and why (5 pts)?

C Increasing extracellular K+ levels in the presence of TEA will lead to what effect on the resting potential of the neuron? Why?
8. What insights into neuroscience have you gained from reading *The Man Who Mistook His Wife For A Hat* and viewing the Nova video? Include at least one specific example each from the book and the video in your answer.
9. Vertebrate dorsal root sensory cells have a Na⁺-dependent action potential. Voltage clamp experiments reveal that the inward Na⁺ current is reduced but not eliminated in the presence of TTX. What do you conclude from this results? Describe two experiments to test your conclusion.
10. You undoubtedly studied one aspect of nervous system function you regarded as important but was not covered on this exam. So that all that studying was not a total waste, pose a question that covers a topic from any part of this course not addressed by other questions on this exam, and then answer your own question. You’ll be graded both on the quality of the question (7.5 points) and on the quality of the answer (7.5 points). Your question should not be too trivial (e.g., name two kinds of cells in the nervous system), it should not be a twist on one of the questions already on the exam and ought to reflect your judgment of what a fair yet relatively difficult exam question should be.