

NAME _____ TA _____ SEC _____

7.012 Problem Set 6 FRIDAY November 19, 2004

Answers to this problem set must be inserted into the box outside

Problem sets will NOT be accepted late. Solutions will be posted on the web.

Question 1

a) Pictured below is a neuron obtained from your TA. Surprisingly, the microscopic structure of your TA's neuron mimics that of a generalized human neuron 😊. Label the neuron components marked with arrows and draw an arrow along the axon to indicate impulse direction of the route traveled by a nerve impulse.

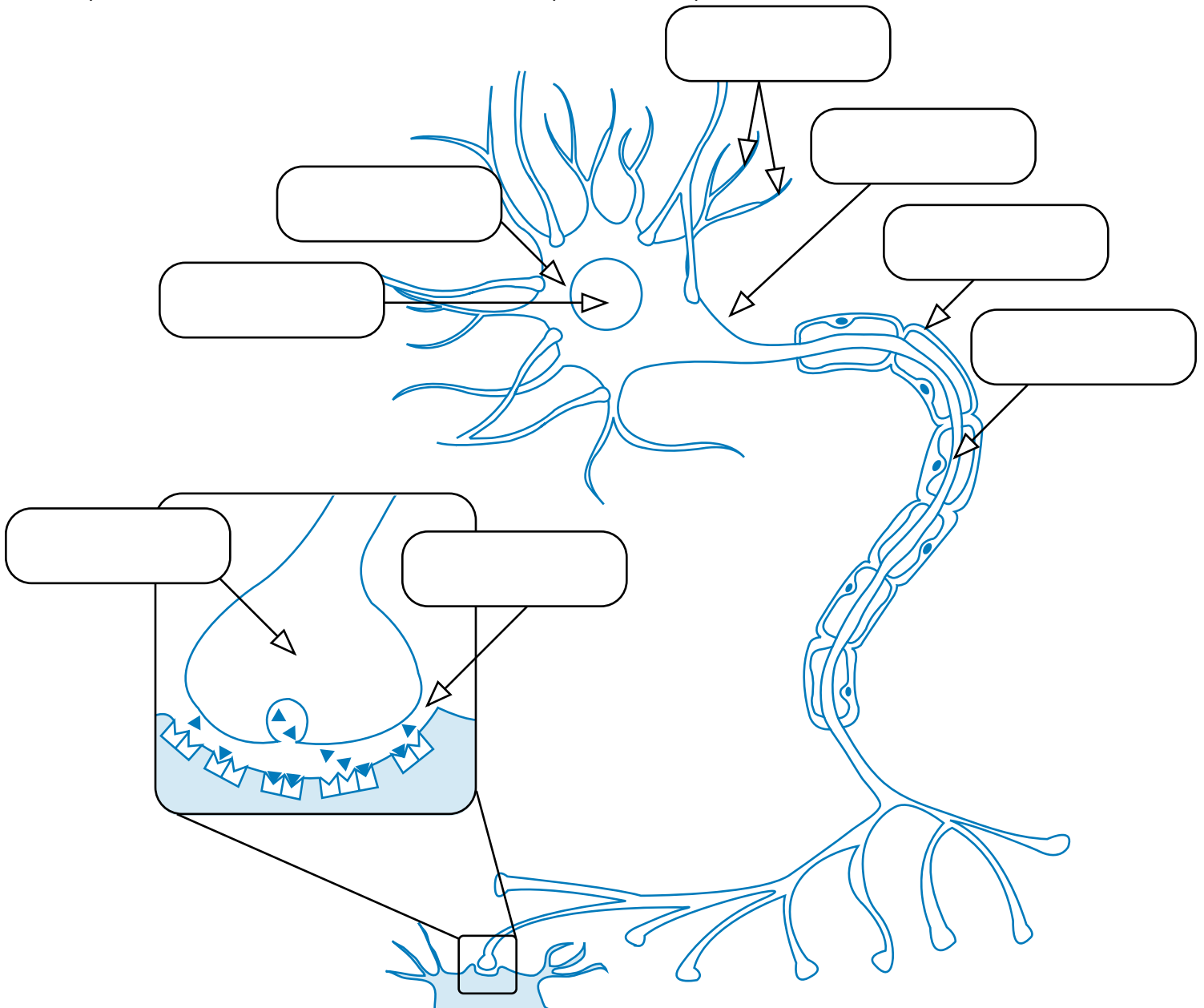


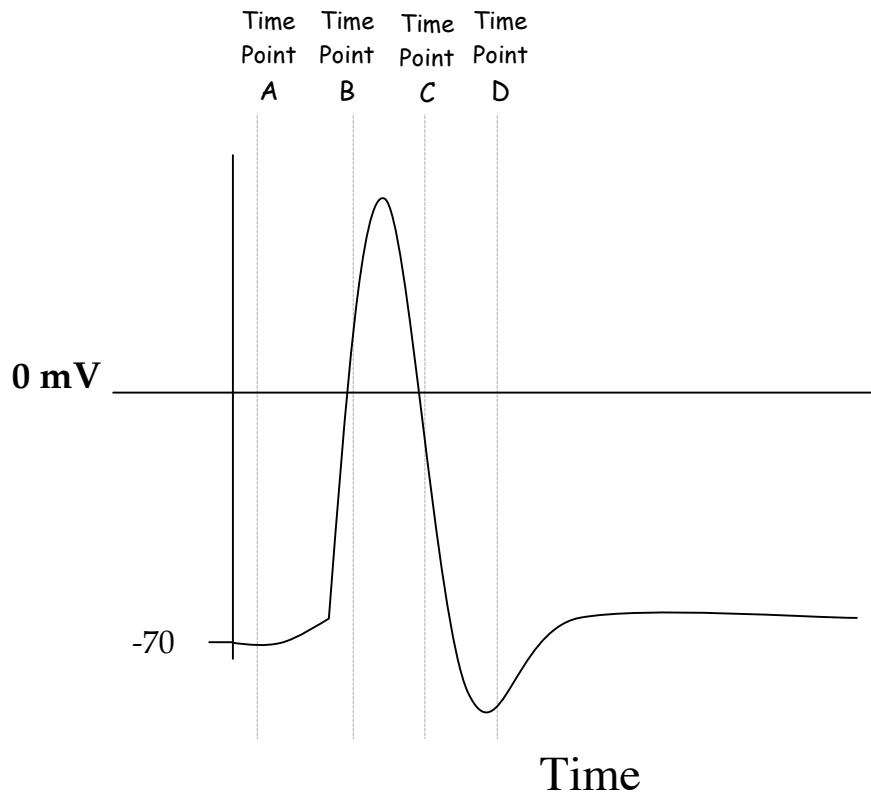
Figure by MIT OCW.

Question 1 continued

b) In a neuron, where do the signals from the excitatory and inhibitory synapses get summed up in the decision to fire an action potential? (Circle the correct one.)

- Cell Body Axon Hillock Myelin Sheath Nerve Terminal Synaptic Vesicle Synaptic Cleft

Shown below is a plot of the membrane potential at a single point on an axon as a function of time as an action potential travels down that axon.



c) For each of the four time points indicated (A-D), fill in the following: the stage of the action potential, the status of the sodium and potassium channels, and the ion flux through each channel at the point along the axon where the potential is being measured. (For the potassium channels give the answers for the voltage-gated type.) Please use the terms provided.

	Time Point			
	A	B	C	D
Stage of action potential				
Voltage-gated Na ⁺ Channel status (Open or Closed/Inactive)				
Voltage-gated K ⁺ Channel status (Closed, Open)				
Na ⁺ Flow through Na ⁺ Channel (Into axon, Zero, Out of axon)				
K ⁺ Flow through K ⁺ Channel (Into axon, Zero, Out of axon)				

d) What role do the Na⁺/K⁺ ATP-driven pumps (present in neuronal cell membranes) play in maintaining the resting potential?

e) Consider an experimental injection of a number of positive ions into the axonal cytoplasm of a neuron. Explain how the voltage-sensitive sodium (Na⁺) channels initiate an action potential in response to this injection.

f) In many cells there are two types of potassium (K⁺) channels present in the axonal membrane. What is the role of each type of K⁺ channel, with regard to the membrane potential?

g) The voltage-sensitive sodium channel has an inactivated state, in which the channel is not only closed, but also unable to open in response to depolarization. When does the channel shift into this conformation? What effect does this have on the direction of propagation of the action potential?

Question 2

A. You have some drugs that affect neurotransmission, and you wish to determine what steps they are likely to affect.

In a Petri dish culture of neurons, you depolarize a pre-synaptic cell with an electrode and you observe a resulting action potential in that pre-synaptic cell. This step is the same regardless of whether drugs are added. However, the effect on the post-synaptic cell varies.

Additions	What you see in post-synaptic cell...
No drug	You see a slight depolarization in the post-synaptic cell followed by no action potential in the post-synaptic cell.
Drug 1	You see a large depolarization in the post-synaptic cell followed by an action potential in the post-synaptic cell
Drug 2	You see no depolarization in the post-synaptic cell and no action potential in the post-synaptic cell

c) For the following, complete the statement with the letter(s) from the list below.

i) The effect of Drug 1 could be that the... _____

ii) The effect of Drug 2 could be that the..._____

<i>A.</i>	<i>Neurotransmitter is inhibited from degradation.</i>
<i>B.</i>	<i>Neurotransmitter is degraded.</i>
<i>C.</i>	<i>Neurotransmitter's reuptake is accelerated.</i>
<i>D.</i>	<i>Neurotransmitter's reuptake is inhibited.</i>
<i>E.</i>	<i>Neurotransmitter's receptor is blocked.</i>

Question 3

a) You receive a letter in the mail from ACDC (Americans for Cloning Dead Celebrities), asking for a \$10 donation to support the cloning of a famous movie star, Goldie Starlet, who died in a plane crash in 1994 and no remains of her were found. Your friend, who is a huge fan of Goldie, sees the letter and promptly whips out \$10 to send to ACDC. Do you think your friend made a wise decision? Explain your answer.

b) A few months later, you watch a documentary on organ transplants, where a woman named Rosie claims to have received Goldie's left kidney during a kidney transplant in 1993. Briefly outline the steps by which Goldie could be cloned with the help of Rosie.

c) ACDC clones Goldie with some assistance from Rosie. However, the clone has a short stature (typical of a known mitochondrially inherited disorder), whereas Goldie was much taller. Is Rosie a fraud or could there be another explanation?

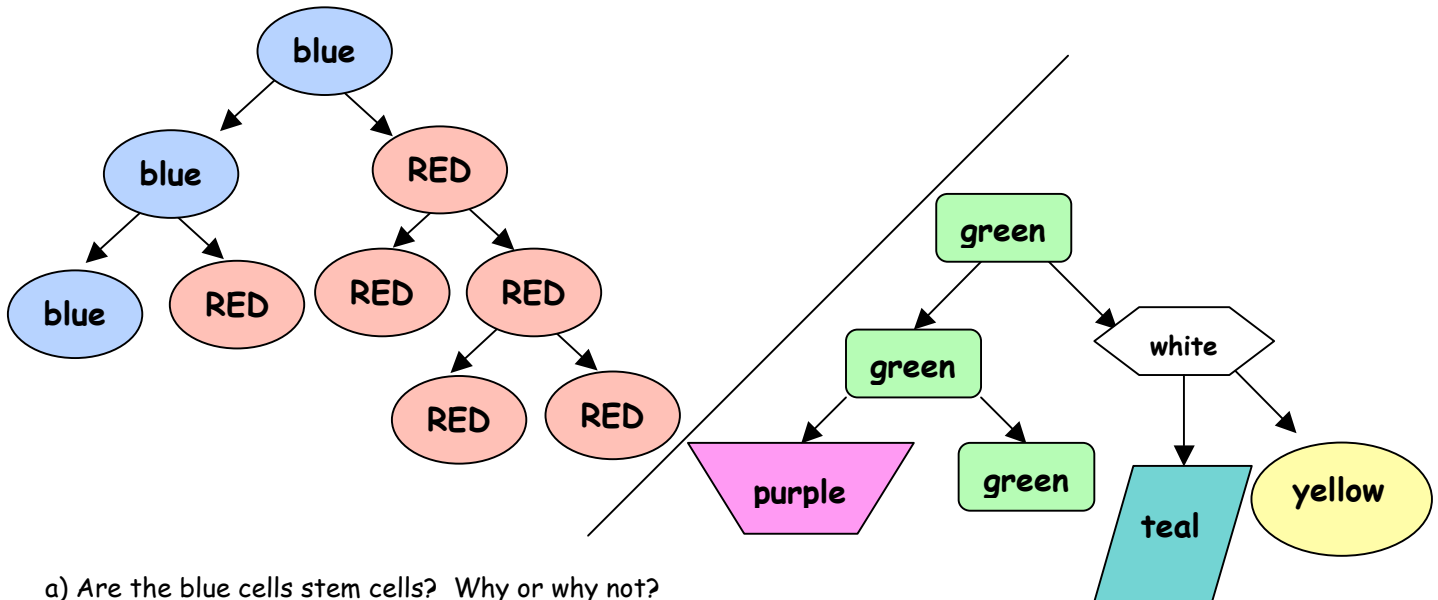
d) The ACDC finds out that Goldie had some of her eggs frozen in a fertilization clinic. Could the nucleus of one of these unfertilized eggs be used to clone Goldie Starlet? Why or why not?

e) Your friend thinks that ACDC should give Rosie a second chance. What steps could one take so that this time the clone has the same stature as Goldie's?

f) After including your suggestions from part e), can you feel confident that the clone will be 100% identical to Goldie in every way. Explain your answer.

Question 4

Divya finds a new brightly colored mammalian species, which he names *Magnificus colores*. She isolates blue and green cells from different parts of this organism, and cultures each cell individually.



a) Are the blue cells stem cells? Why or why not?

b) Given that the green cell is a stem cell, can Divya tell whether it is pluripotent or unipotent? Explain your answer.

c) Divya finds out that development in *M. colores* is similar to human development. She wants to obtain a single cell that can give rise to an individual *M. colores*. Do you have any suggestions? What is the property that this cell possesses?

d) She now wants to isolate embryonic stem cells from an *M. colores* embryo. Where exactly in a developing embryo can she find such cells?

e) *M. colores* have coats with multi-colored spots, which are produced by the *speckle* gene. One functional copy of *speckle* is sufficient to give multi-colored spots. While studying different embryos, Divya detects that one 8-cell stage embryo has both copies of *speckle* mutated. Suggest a strategy using stem cells by which Divya could try to rescue this defect in the embryo.

f) One of the *M. colores* has a weak heart that has only 10% of the normal functioning capacity. If technology were advanced enough, how could ES cells from this animal potentially be used to save it from heart failure? Why would this be preferred over a heart transplant from another individual of this species?