

Fall 2001 Biology 111 Exam #1 - Cellular Communications

There is no time limit on this test, though I have tried to design one that you should be able to complete within 2.5 hours, except for typing. There are four pages for this test, including this cover sheet. You are not allowed to use your notes, old tests, the internet, or any books, nor are you allowed to discuss the test with anyone until all exams are turned in at 11:30 am on Monday September 17. **EXAMS ARE DUE AT CLASS TIME ON MONDAY SEPTEMBER 17.** You may use a calculator and/or ruler. The **answers to the questions must be typed on a separate sheet of paper** unless the question specifically says to write the answer in the space provided. If you do not write your answers in the appropriate location, I may not find them.

Please do not write or type your name on any page other than this cover page. Staple all your pages (INCLUDING THE TEST PAGES) together when finished with the exam.

Name (please print):

Write out the full pledge and sign:

How long did this exam take you to complete (excluding typing)?

Lab Questions:

3 pts.

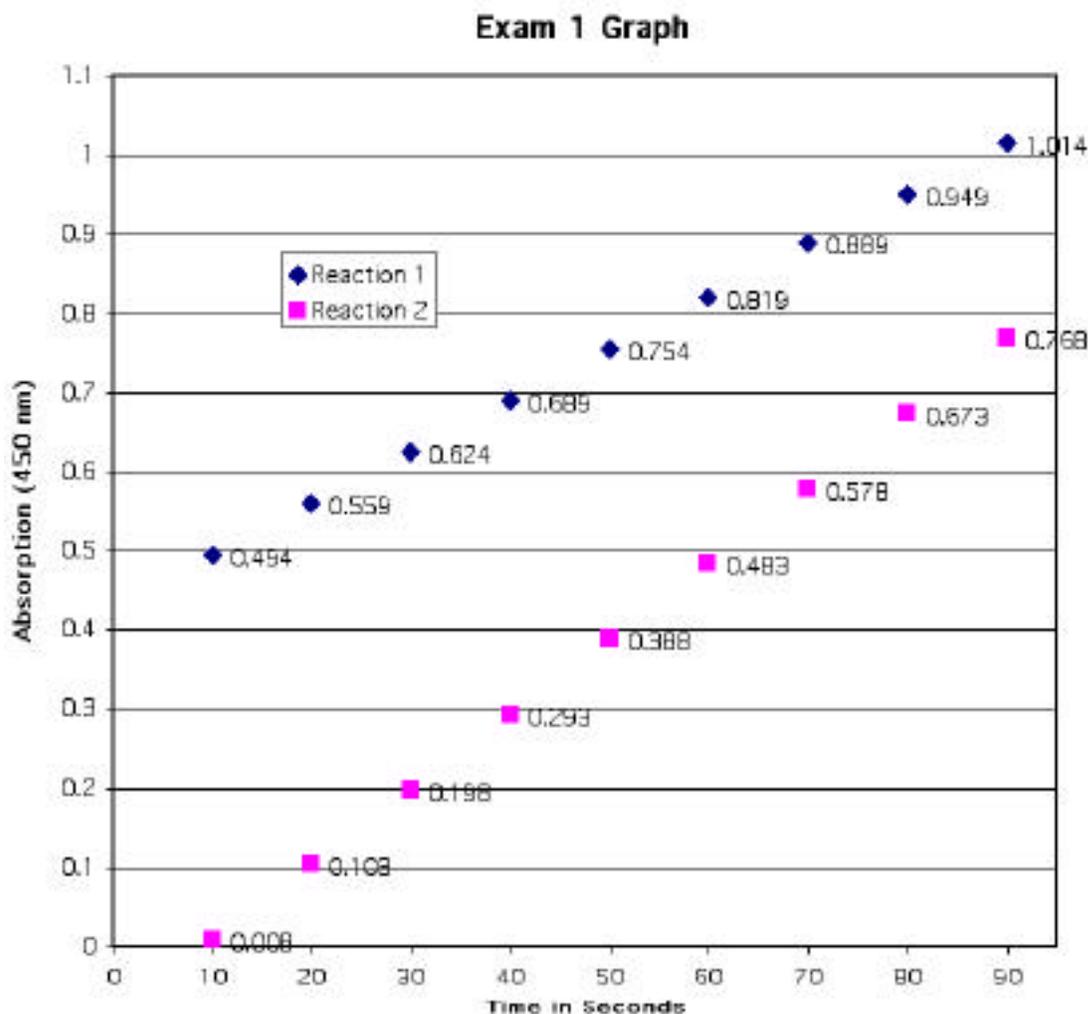
1) Tell me how to make a 200 mL solution that is 1.44 mM NADP⁺, 50 mM isocitrate and 7% v/v IDH if your stock solutions are 28.8 mM NADP⁺, 500 mM isocitrate and 100 mM IDH (to be considered 100% IDH stock solution).

10 mL NADP stock + 20 mL isocitrate + 14 mL IDH + water to a final volume of 200 mL

7 pts.

2) In the graph paper below, graph out the enzyme reaction data in the table on the next page. Be sure to label both of the reactions and the axes. Explain which reaction has the higher reaction rate and support your conclusion with the data you have graphed.

Reaction 2 has the steeper slope which means it has the higher reaction rate.



Raw absorption data in table below. Wavelength of light used was 450 nm.

Time (sec)	Abs. Reaction 1	Abs. Reaction 2	Abs. Blank
10	0.512	0.026	0.018
20	0.577	0.121	0.018
30	0.642	0.216	0.018
40	0.707	0.311	0.018
50	0.772	0.406	0.018
60	0.837	0.501	0.018
70	0.902	0.596	0.018
80	0.967	0.691	0.018
90	1.032	0.786	0.018

Lecture Questions:

6 pts.

3) Eukaryotic cells are full of organelles. Explain why this is an evolutionarily adaptive characteristic. Use an example from one of the four systems we studied in detail.

Organelles allow enzymes that work on related processes to be collected in one area. They may have specialized needs (e.g. ion concentration, pH, etc.) and an organelle can provide this. Finally, organelles can permit a localized concentration of components that can be used to perform a particular task. For example, the ER concentrates calcium ions which are used to produce calcium waves in the egg to initiate the slow block to polyspermy.

8 pts.

4) Explain how enzymes can be turned on or off by covalent modulation. To receive full credit, you must use a real example from one of the four systems we studied in detail.

Protein kinase A (PKA) phosphorylates glycogen synthase in the liver which inactivates the enzyme. By adding a negative charge to the protein, all the amino acids adjust their positions which causes a change in shape. This shape change inactivates glycogen synthase. Conversely, PKA phosphorylates phosphorylase kinase to activate it. This time the negative phosphate causes the amino acids to reposition in a way that stimulates the enzyme to become active.

8 pts.

5) Beta blockers are drugs that block the beta adrenergic receptor so epinephrine cannot bind to its receptor. Explain in molecular terms why these drugs would reduce the blood pressure in a patient.

By blocking the epinephrine receptor on heart cells, the heart cannot respond to epinephrine by contracting more forcefully. A more forceful contraction would lead to higher blood pressure because more blood is pumped into vessels of a fixed diameter per unit time and therefore, the vessels will experience higher pressure.

8 pts.

6) Caffeine gives you a “buzz” because caffeine inactivates phosphodiesterase. Since you understand what role phosphodiesterase plays in your cells, explain why caffeine is a stimulant.

Phosphodiesterases are used to inactivate the stimulation caused by epinephrine. Phosphodiesterase cleaves cAMP into AMP. By blocking this enzyme, caffeine produces a prolonged presence of cAMP which results in a buzz since we cannot inactivate any stimulation inside our cells.

8 pts.

7) What role does calcium play in muscle contraction?

Calcium binds to troponin which changes its shape due to allosteric modulation. This results in tropomyosin being pulled away from the actin fibers and revealing binding sites on the actin. This permits phosphorylated myosin heads to bind and contract the muscle. When calcium is pumped out of the muscle cytoplasm, the binding sites are covered by a reversal of the process outlined above. Therefore, calcium's role is to permit muscle contraction and relaxation.

7 pts.

8) Explain why the Na⁺/K⁺ pump has to pump ions all the time.

This pump has to maintain the Na and K gradients which generate the membrane potential in neurons and muscles. Because some of our ion channels are leaky, there is a constant need to “bail out” our cells and maintain the ion gradients. This is an on going process. In addition to this low-level pumping, any time our neurons or muscles are depolarized by an action potential, the Na/K pump is needed to reestablish the original resting membrane potential.

8 pts.

9) Ligand-gated and voltage-gated ion channels are involved in the generation of an action potential. Describe the role played by both types of channels.

Ligand-gated Na channels initiate the action potential IF a sufficient number of ion channels are opened, then the cell may be depolarized to or above threshold which will result in a full action potential. The generation and propagation of an action potential is caused by voltage-gated Na channels opening and permitting more ions to flow down their concentration gradients. Since an action potential includes repolarization, we must include the K channels in this description and not just Na channels. K channels are responsible for the repolarization wave since K⁺ ions flow out of the cell and reverse the polarity of the membrane potential. Without this step, excitable cells would continue to depolarize themselves since threshold would be exceeded at all times.

10 pts.

10) Explain how calcium controls exocytosis.

Calcium rushes into the cytoplasm either from the ER (in fertilized eggs) or the extracellular environment (neurons). In neurons, calcium binds to synaptotagmin which causes a change in shape through allosteric modulation. Synaptotagmin causes the adjacent protein called VAMP to change its shape which enables VAMP to bind to syntaxin, located on the cytoplasmic side of the presynaptic plasma membrane. When VAMP and syntaxin interact, the membrane of the secretory vesicle fuses with the plasma membrane and the contents of the vesicle are exocytosed into the synaptic cleft. ATP is consumed in this process. A similar process happens in other examples of exocytosis such as cortical granules in fertilized eggs.

11 pts.

11) a. What is the substrate for phospholipase-C?

Phosphatidylinositol bisphosphate (PIP₂)

b. What are the products?

Inositol triphosphate (IP₃) and diacylglycerol (DAG)

c. What is triggered by each of these products?

IP₃ causes the release of calcium from the ER and DAG causes a rise in cytoplasmic pH (via protein kinase C activation)

10 pts.

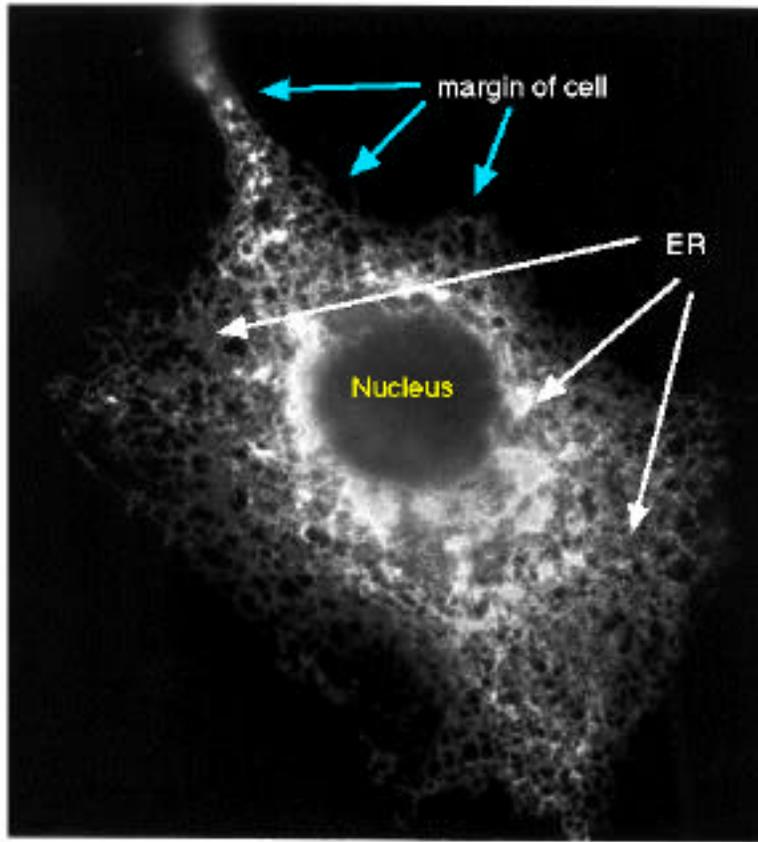
12) Using specific examples we have covered, describe how different cells can respond differently to a common stimulus. You only need to provide two examples.

Neurons respond to depolarization by opening their plasma membrane voltage-gated calcium channels. This rise in cytoplasmic calcium initiates exocytosis as described in the answer to question #10.

Muscles respond to depolarization by flooding their cytoplasm with calcium as well, but the calcium came from the SR instead of outside the cell. This calcium causes the muscles to contract as outlined in the answer to question #7.

6 pts.

13) Below is a photograph of a chicken cell that has been labeled with a fluorescent antibody that binds to the calcium pump. Explain how the antibody could have been produced.



To produce an antibody against a chicken calcium pump, it must have been injected into another animal, such as a mouse. The mouse would respond to the foreign protein by making anti-chicken calcium pump proteins. Spleen cells from the mouse would have been isolated and used to generate hybridomas which are immortal cells grown in culture that secrete many copies of a single antibody, called a monoclonal antibody, that could be used as shown in this photomicrograph.