

March 7, 2005

Name _____

ID number _____

CH462/562 Exam 2

There are **4** short answer questions worth **8** points each; answer **3** of them.

There are **5** problems worth **24** points each:

If you are a CH462 student, you must answer **3** problems for full credit.

If you are a CH562 student, you must answer **4** problems for full credit.

You may answer one extra problem for extra credit:

For the problem on which you score the lowest, you will get $2/3$ credit.

(If you are a CH462 student and attempt 5 problems, the lowest will be dropped, and the second-lowest will be counted for extra credit.)

The maximum amount of points (not including extra credit) is thus **96** (CH462) or **120** (CH562).

You are advised to look over the problems first before starting to work them. Time should not be a factor, if you are well prepared.

Multiple choice		/24
Problems:	1	/24
	2	/24
	3	/24
	4	/24
	5	/24
Total		

No notes or books of any sort may be used during the exam.

I have neither given nor received aid on this exam.

(signature)

- 3) The enzyme glutamine synthetase is highly regulated via allosteric inhibition by a large number of nitrogen-containing molecules as well as covalent modification. Explain *why* so much energy has been devoted to regulating this enzyme so heavily, and explain how the regulation by covalent modification works.
- 4) Briefly describe 2 different general strategies/mechanisms that cells use to pump ions/molecules *against* an electrochemical gradient. (I want to know *how* they work, not just a name or a specific example.)

Problems

- 1) **Pentose-phosphate pathway & carbohydrate synthesis**
 - a) Show the carbon-shuffling reactions of the oxidative pentose-phosphate pathway. Specifically, show how six ribose-5-phosphates are converted to five fructose-6-phosphates.

- b) Write out the Hatch-Slack pathway used by C₄ plants to fix CO₂.
(Be sure to distinguish which reactions take place in mesophyll cells and which take place in bundle sheath cells.)

- c) Write out the 2 reactions that **Rubisco** can catalyze. You do *not* need to write out the mechanisms – just the overall reactions.

Why is it that tropical plants are more likely to be C4 plants than temperate plants?

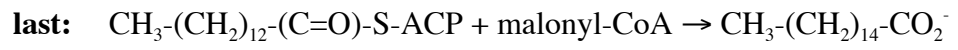
2) Lipid synthesis

a) Show how malonyl-CoA is made. Which coenzyme is crucial to this reaction.

b) Show the first and last “pseudo cycles” of palmitate synthesis by **fatty acid synthase**.

first: acetyl-CoA + malonyl-CoA \rightarrow CH₃-(CH₂)₂-(C=O)-S-ACP

(Note: these “equations” are not balanced for all cofactors, etc.; they are merely intended to indicate the starting and ending points you should use.)



- c) Show how fatty acids are desaturated in mammals. How and why does this differ from the anaerobic pathway in bacteria?

3) Amino acid & nucleotide synthesis

- a) Show how this overall transformation is carried out by **glutamine synthetase** and **glutamate synthase** (no mechanisms necessary):
 α -ketoglutarate + NH₃ → Glu (*not* balanced)

- b) Show how glutamate is converted to arginine

- c) Show how UMP is made, using the following as raw materials:
ribose-5-P_i, Gln, Asp, HCO₃⁻, and whatever cofactors are necessary.

- d) Now show how UMP is converted to dTTP. (No mechanisms are necessary.)

4) Integrated labeling problem

In order to understand how certain biomolecules are synthesized in a simple cyanobacterial cell, which can perform photosynthesis, you could add isotopically labeled molecules and then extract and purify specific biomolecules to see where the label appears. In this problem, you will predict what those results would be, using your knowledge of the biosynthetic pathways. Draw the predicted products and indicate the atoms that could be labeled. **Note:** as intermediates in synthesis, consider only molecules one step away from the added molecule using the common pathways you have already learned (e.g. glycolysis/gluconeogenesis, TCA, amino acid catabolism).

Labeled molecule	Extracted biomolecules	
$\delta[^{15}\text{N}]\text{-glutamine}$ $\text{NH}_2\text{-CH-CO}_2\text{H}$ $\quad $ $\quad \text{CH}_2$ $\quad $ $\quad \text{CH}_2\text{-C=O}$ $\quad $ $\quad ^{15}\text{NH}_2$	Adenine	Proline
$\beta[^{13}\text{C}]\text{-oxaloacetate}$ O=C-CO_2^- $\quad $ $\quad ^{13}\text{CH}_2\text{-CO}_2^-$	Uracil	Asparagine
$^{14}\text{CO}_2$	Sedoheptulose-7- P_i	Serine
	Palmitate	

$[^{13}\text{C}]\text{-acetate}$ $^{13}\text{CH}_3\text{-CO}_2^-$ (assume that this organism uses <i>acetate thiokinase</i> to convert this to acetyl-CoA)	Palmitate	
$\alpha[^{13}\text{C}],\beta[^{14}\text{C}]\text{-serine}$ $\text{H}_2\text{N-}^{13}\text{CH}_2\text{-CO}_2\text{H}$ $\quad \quad \quad $ $\quad \quad \quad ^{14}\text{CH}_2\text{-OH}$	Adenine	Thymine

5) Signal transduction

- a) Take your pick of *one* of the following 2 hormone responses and explain how the signal transduction pathway operates.
- **The β -adrenergic response:** explain how binding of epinephrine to the exterior of a muscle cell results in inhibition of *glycogen synthase* and activation of *glycogen phosphorylase*.
 - **The response to insulin:** explain how binding of insulin to the exterior of a muscle cell results in increased uptake of glucose and activation of *glycogen synthase*.

- b) As mentioned before, there is more than one type of bipolar cell linking rod cells in the retina to ganglions and more than one type of signal transduction pathway operating in them. In this problem, you will use “experimental data” about a new type of bipolar cell (called BP7), along with your knowledge of the signal transduction components, to come up with a hypothesis for how the signal transduction pathway works in this cell. Here is what you know:
- The rod cells work as you have already learned: reception of light by the rod cell results in *lowered* secretion of glutamate onto the bipolar cell.
 - In the dark, the BP7 bipolar cells secrete serotonin onto the ganglion cells, causing them to fire at a high frequency. Upon reception of light in the rod, the level of serotonin secreted from the BP7 cell *drops*, resulting in a lowered frequency of action potentials in the ganglion cell. (Thus, this pair is an example of an OFF bipolar cell and OFF ganglion.)
 - You know that the BP7 bipolar cells express genes for the following proteins:
 - a. A glutamate receptor, a member of the serpentine receptor family
 - b. A “stimulatory” trimeric G protein, G_s
 - Addition of glutamate to BP7 cells results in an *increase* in intracellular cAMP.
 - The BP7 cell has 2 ligand-gated channels that open upon binding intracellular molecules:
 - a. A minor Ca^{2+} channel that *opens* upon binding intracellular cAMP
 - b. A major Na^+ channel that *opens* upon binding Ca^{2+} -calmodulin
 - The cAMP-gated Ca^{2+} channel is a target of Ca^{2+} -calmodulin-dependent protein kinase. Phosphorylation of the channel protein by the kinase results in inactivation of the channel.

Based on these, develop your model of how the signal transduction pathway works in the BP7 cell. Based upon what you know from other systems (and from the last point), also explain *how the signal gets turned off*.

