

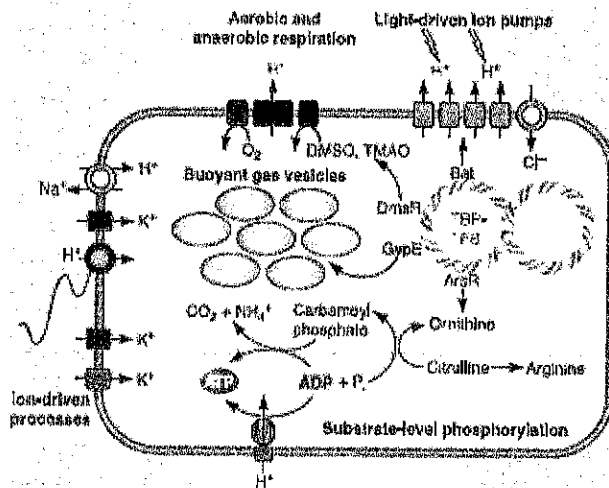
BIOSC 1820, Metabolic Pathways and Regulation
Spring, 2010
Prof. Jeffrey L. Brodsky
Final Exam
April 30, 2010

NAME: _____

Each answer is worth 2 points. GOOD LUCK!!

THE REAL WORLD

1. The following figure is from a paper that appeared in the American Society of Microbiology newsletter in March of this year, and describes what happens in a microbial genus (*Halobacterium*) that can do aerobic and anaerobic respiration, as well as photosynthesis.



It appears that citrulline has two fates in this microbe, depending on the organisms' metabolic needs.

A. What is the name and draw the structure of the intermediate between citrulline and arginine (that is not shown) in the Urea Cycle?

B. What is the name of the enzyme that—as shown here—can catalyze the conversion of citrulline into carbamoyl phosphate and ornithine?

C. On the left side of the figure, why is potassium shown entering the cells? In other words, what is the driving force of potassium entry?

D. What is the name of the protein complex that transports protons via the “light driven ion pumps” at the top of the figure?

E. One member of this microbe family, *Halorubrum lacusprofundi*, was found in an Antarctic lake in which the NaCl concentration is 5 M, which is normally toxic. How can this organism survive in this much salt?

2. Recent evidence indicates that an uncoupling protein (UCP) in the mitochondrial inner membrane is somehow ubiquitinated and then degraded by the 26S proteasome. This UCP acts to decrease the overall proton motive force across the membrane. Interestingly, it was hypothesized that the ubiquitination of the UCP is regulated by the level of reactive oxygen species (ROS).

A. Name one of the three enzymes and write out one of the corresponding reactions that destroys ROS in the cell:

B. What is the name of the specific enzyme family that acts last in the ubiquitination cascade to link ubiquitin onto substrates, such as UCP?

C. If an increase in ROS leads to more UCP ubiquitination, does this make sense? Why?

3. The SREBP-1c transcription factor is activated by insulin. Once activated, the factor increases the synthesis of the genes encoding glucokinase, Acyl-CoA Carboxylase and Fatty Acid synthase. Interestingly, in the inactivated state, the factor is associated with an internal cellular membrane. In order to be activated, it must be released from the membrane. Besides insulin, the transcription factor is also regulated by the levels of fatty acids and cholesterol in the cell.

A. Write the reaction catalyzed by Acyl^{et} CoA-Carboxylase:

B. What is the name of the cofactor/vitamin that is stably bound to this enzyme?

C. If you have just eaten a high fat diet, do you think SREBP-1c will be membrane associated or free in solution?

D. Based on what we have discussed, with which intracellular membrane do you think the transcription factor is associated?

4. Cyanobacteria contain an organelle-like compartment known as the “carboxysome” that houses the enzymes required for carbon fixation in this simple photosynthetic organism.

A. Amongst the many enzymes in the carboxysome is the first enzyme in the carbon fixation pathway. Write out the structures of the reactant(s) and product(s) of this reaction.

B. What is the full name of the enzyme that catalyzes this reaction?

C. Although bacteria do not contain intracellular lipid bilayers, the carboxysome contains a protein protective “sheet”. It has been proposed that this sheet is impermeable to a specific molecule. What molecule do you think this is?

5. The following electron microscope image shows connections between the ER and mitochondrial membranes.



Draw the structure and give the name of the lipid which: (1) is most likely synthesized in the ER and then probably transported via these connections to the mitochondria, (2) is also found in bacteria membranes, and (3) is enriched in the mitochondrial membrane:

MULTIPLE CHOICE—choose the single best answer:

1. If a K^+ ionophore, such as valinomycin, is added to actively respiring mitochondria, what would be the most immediate effect?

- A. There would be no change in either $\Delta\Psi$ or ΔpH
- B. The absolute value of the $\Delta\Psi$ would decrease but the ΔpH would be unaffected
- C. The absolute value of the $\Delta\Psi$ would be unaffected but the ΔpH would decrease
- D. Both the $\Delta\Psi$ and ΔpH would be significantly altered immediately

2. The formation of the following fatty acid would require which of the following?



- A. 6 NADPH, 4 malonyl CoA, and 0 acetyl CoA
- B. 6 NADPH, 3 malonyl CoA, and 1 acetyl CoA
- C. 3 NADPH, 4 malonyl CoA, and 0 acetyl CoA
- D. 4 NADPH, 3 malonyl CoA, and 1 acetyl CoA
- E. None of the above is correct.

3. Which of the following statements about the ATP synthase is FALSE?

- A. Within the enzyme, the ADP/ATP ratio is ~2.
- B. The E-ADP intermediate sits at the lowest point in the free energy reaction diagram (i.e., the lowest G° value)
- C. Acidic amino acid side chains serve as H^+ binding sites as protons move through the membrane
- D. The F1 portion—in isolation—is an ATPase
- E. There are 3 reactive sites within the enzyme

4. Each of the following would increase the production of fatty acids in a liver cell except:

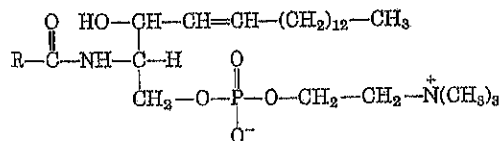
- A. Increased levels of citrate
- B. A decrease in protein kinase A activity
- C. Increased levels of palmitoyl-CoA
- D. Increased secretion of insulin
- E. None of the above—each condition would increase fatty acid levels

5. Several urea cycle components are transported between cells in the body and even within intracellular compartments. Which of the following statements is correct?

- A. Ammonia is the major carrier of nitrogen in the human bloodstream
- B. Carbamoyl phosphate is transported between the mitochondria and cytoplasm
- C. Ornithine is made in the cytoplasm and is then transported into the mitochondria
- D. Most transamination reactions occur within the mitochondria
- E. More than one of the statements above is correct

6. The following molecule is an example of which type of lipid?

- A. cholesterol
- B. phosphatidylserine
- C. sphingomyelin
- D. phosphatidic acid
- E. triacylglycerol

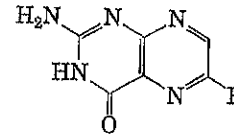


7. Which of the following would lead to an increase in sucrose synthesis in a plant cell?

- A. Increased phosphofructokinase-1 activity
- B. Increased phosphofructokinase-2 activity
- C. Increased levels of phosphate
- D. Increased levels of 3-phosphoglycerate
- E. None of the above—each condition would shut off sucrose synthesis

8. The following cofactor is required for the synthesis of:

- A. cholesterol
- B. malonyl CoA
- C. hydrogen peroxide
- D. tyrosine
- E. phosphoglycolate

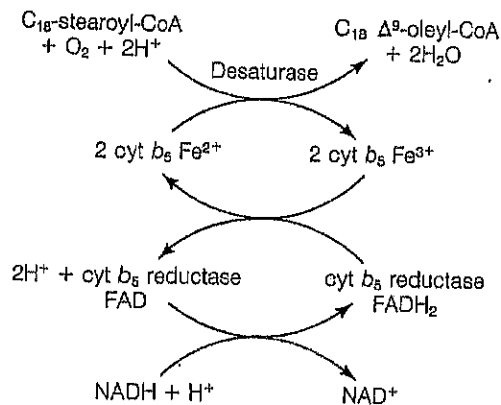


9. Which of the following statements about ribonucleotide reductase is incorrect?

- A. The enzyme contains a stable tyrosine free radical
- B. The enzyme is highly regulated
- C. The enzyme creates a pool of substrates that may be limiting for DNA synthesis
- D. One of the products is dTMP
- E. The enzyme contains iron

SHORT ANSWER (you're getting there!!)

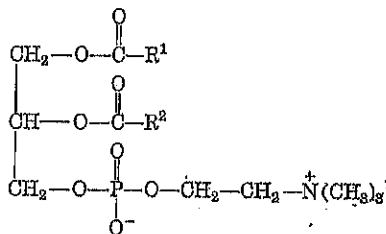
1. The following reaction is an example of what type of reaction?



2. What is the name of the 15-carbon intermediate in cholesterol and sterol biogenesis that is produced from isopentenyl pyrophosphate?

3. What is the name or abbreviation of the “good leaving group” that is required for the synthesis of sucrose from fructose and glucose?

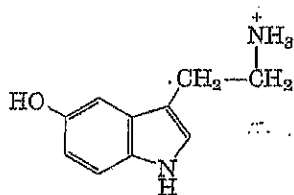
4. What is the name of the following molecule?



5. What is the name of the enzyme that synthesizes NADPH in the chloroplast?

6. What is the name of the enzyme that converts glutamate to α -ketoglutarate concomitant with the conversion of NAD to NADH?

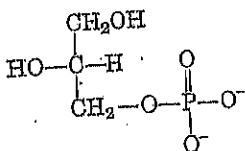
7. What is the name of the following molecule?



10. Suppose that you loaded a mixture of VLDL, LDL, and HDL particles on top of sucrose-containing buffer in a centrifuge tube. Which particle do you think would migrate furthest in the centrifuge tube after spinning the tube for several hours?

STRUCTURES (almost done!!)

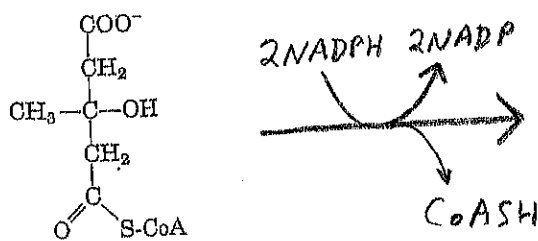
1. There are two immediate ^{metabolic} precursors for the following molecule in the ^{Fat} cell. Draw their structures:



2. Draw the structure of one of the two 4-carbon molecules for which C4 plants are named:

3. What is the structure of the molecule that delivers one of the two nitrogens into the Urea Cycle and whose conjugation is coupled to the hydrolysis of ATP to AMP?

4. Draw the structure of the product of the following reaction:



Have a great summer!