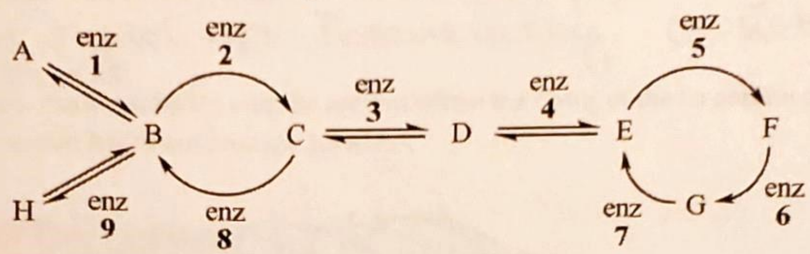
CH/BI 308 Biochemistry   Exam III Spring 2020   Name: Key

Please read the directions carefully. No cell phones or other electronic devices except for calculators are allowed. The use of our course textbook is allowed; however, the use of notes, workbook activities, the internet or peer collaboration is prohibited during the exam and the use of those materials would be a violation of the BSC Honor Code. Students suspected of violating the honor code will be reported to the honor council for review. This exam will be posted on moodle at 8:00 AM on the scheduled day of the exam. Completed exams must be turned in via the TurnItIn link on moodle by 11:59 PM Central on the scheduled day of the exam. No late exams will be accepted. If you have a question, I will be available via Teams during our normal scheduled class time or can be reached via email at khayden@bsc.edu. Good luck, take your time, and read carefully!

Honor code: ______________________________

(25) 1. Answer the questions below about the diagrammed pathway.



a. Would you expect enzyme 1 to be regulated? Briefly explain why or why not.

5

no, it is shown as reversible, ∴ it is probably near equilibrium & those steps are often not regulated

b. If you answered 'yes' to part a, which molecules would you expect to act as positive effectors? Negative effectors?

5

N/A

c. Would you expect enzyme 2 to be regulated? Briefly explain why or why not.

5

yes, it is shown as nonreversible & requires a sep enzyme (8) to Reverse C→B. Often those are regulated

d. If you answered 'yes' to part c, which molecules would you expect to act as positive effectors? Negative effectors?

5

I expect A&B to be (+) effectors where C→G may be negative effectors as they are products

e. For the remaining enzymes (3-9), which do you expect to operate far from equilibrium? List their numbers.

5

5, 6, 7, 8

(5) 2. How would inhibition of glutamate transamination affect the citric acid cycle? Explain.

↓ α ketoglutarate, ↓ TCA under conditions by which we may be metabolizing protein or relying on protein catabolism for energy or gluconeogenesis

(5) 3. What citric acid cycle metabolite(s) would accumulate in the presence of malonate? Explain.

Inhibits succinate dehydrogenase so TCA would slow down @ that step so ~~[illegible]~~ [Succinate] & [Succinyl CoA] would likely build up. Potentially α-ketoglutarate as well.

(20) 4. Calculate how many c-subunits must be present within the C-ring of the Fo portion of ATP synthetase so that NADH can produce 3.5 ATP.

10 ~~3.5 ATP / NADH | NADH / 10 H⁺ | 1 H⁺ / 1 C unit~~

$$\frac{1\ NADH}{3.5\ ATP} \cdot \frac{10\ H^+}{1\ NADH} \cdot \frac{1\ C\ subunit}{1\ H^+} \cdot \frac{3\ ATP}{360^\circ} = \frac{8.57\ C\ subunits}{360^\circ}$$

b/t 8 & 9 subunits

a. Under these conditions, how much ATP would $FADH_2$ produce. Explain why.

10

$$\frac{360^\circ\ turn}{8.57\ C\ subunits} \cdot \frac{1\ C}{1\ H^+} \cdot \frac{6\ H^+}{1\ FADH_2} \cdot \frac{3\ ATP}{360^\circ\ turn} = 2.10\ \frac{ATP}{FADH_2}$$

(15)

5. Using the reduction potential values of the ETC components found in table 18-1, calculate the $\Delta G^{\circ\prime}$ values for the transfer of electrons from Cytochrome C directly to O_2 via complex IV as seen in: ($\Delta G^{\circ\prime} = -nF\Delta E$, F = 96,485 J/V*mol)

   a. 2 cyto. C(red) + ½ O_2 → 2 cyto. C (oxid.) + H_2O(red.)

5

$\Delta E = 0.815 - 0.235 = 0.58$ ✓

$\Delta G = -2\,(96{,}485)\,(0.58)$

$\Delta G = -112$ kJ/mol

   b. How much ATP could be produced from this energy?

5

$\frac{-112 \text{ kJ/mol}}{30.5 \text{ kJ/mol}} = 3.7$ ATP

   c. why do you think the cell is designed to transfer electrons in 5 steps versus one step?

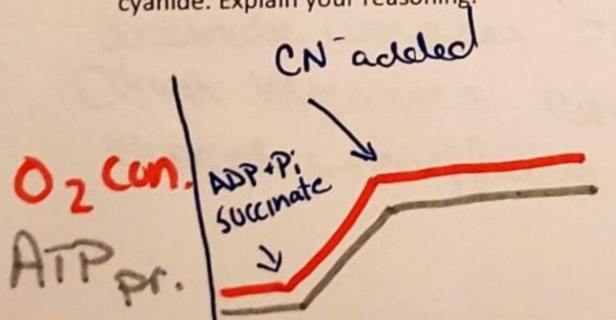
5

Designed for efficiency. Energy is harnessed in steps so as to not loss as much E as heat if all done @ once

6. Dr. Mitchell is playing around with some experiments in his laboratory:

   a. In his first experiment, he incubates isolated, intact mitochondria in a buffered solution containing succinate and ADP + Pi. Demonstrate graphically the effect on oxygen consumption and ATP production over the course of two hours following the addition of cyanide. Explain your reasoning.

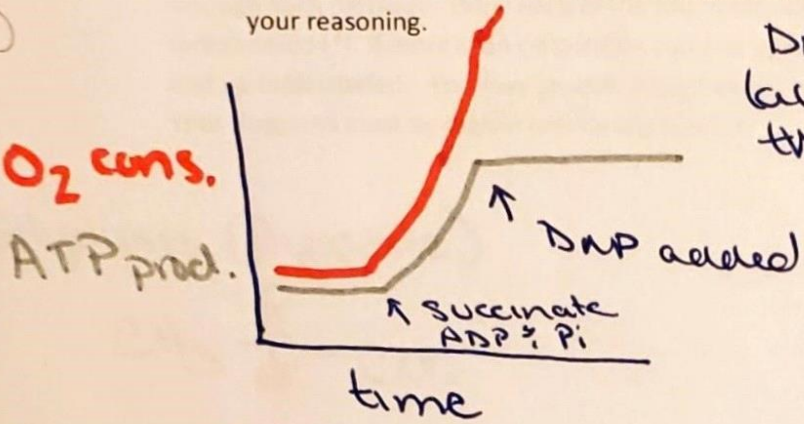
10



CN⁻ inhibits complex 4 of ETC, so all electrons will stop flowing, if e⁻ stop then H+ is no longer pumping ∴ nothing to drive ATP synthetase so ATP production also stops.

b. In his second experiment, Dr. Mitchell incubates intact mitochondria in a buffered solution with succinate and ADP + Pi. Demonstrate graphically the effect on oxygen consumption and ATP production over time following the addition of 2,4-dinitrophenol (DNP). Explain your reasoning.

10



DNP is an uncoupler (allows H+ to pass through the membrane w/o ATP synthase). So electrons can keep flowing however no ATP is made

c. Based on the results of these experiments, Dr. Peter Mitchell proposed the "Chemiosmotic Theory". In your own words, summarize this theory.

Variety of answers

5

d. Would the use of amytol instead of cyanide have the same effect on Dr. Mitchell's experiment in part a? Why or why not?

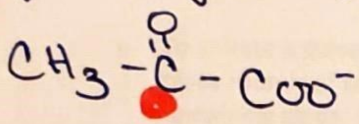
amytol blocks complex I, since succinate makes $FADH_2$ ~~[illegible]~~ and that bypasses complex I, then I would expect no effect.

5

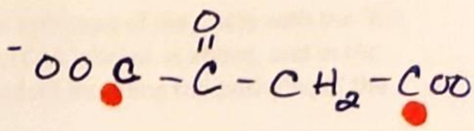
20

7. Cells are fed glucose radiolabeled at carbon #2. Identify where in each molecule the ^{14}C will end up in the terminal molecules (listed in parentheses) for glycolysis (pyruvate), Citric Acid cycle (OAA), glycogenesis (glycogen) and PPP (ribose-5-P). Assume the glucose passes just once through each pathway. Draw each of the four molecules below, with the appropriate carbon radiolabeled (*). If more than on position can end up radiolabeled, mark all positions that can end up radiolabeled. You may provide a brief verbal explanation for each molecule if needed. Your diagrams must be legible and clearly labeled.

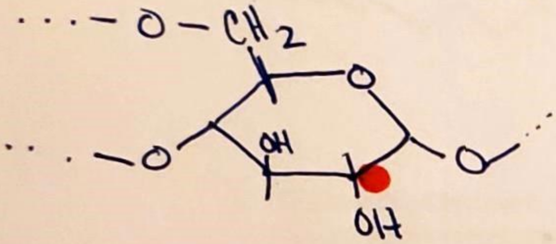
Gilyolysis (Pyruvate)



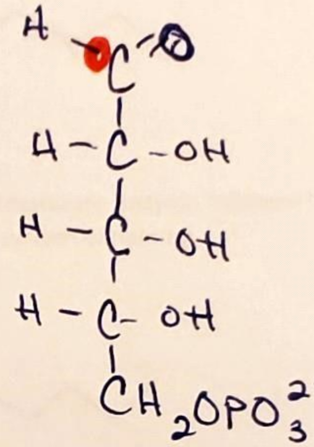
TCA (OAA)



glycogenesis (glycogen)



PPP (Ribose-5-Pi)



(20) 8. Dr. Adipose has asked you to construct some fatty acids that he needs for some future experiments. He has asked you to:

a. Beginning with a supply of ^{14}C acetyl CoA labeled only in the methyl carbon show the structure of the synthesized 18 carbon fatty acid, oleic acid, with all the labels clearly indicated.

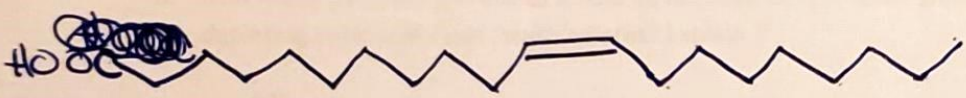
5

b. To imitate a pulse chase experiment, complete the synthesis of oleic acid with the first three rounds of fatty acid synthesis using ^{14}C acetyl CoA labeled as above, and in the remaining steps, use ^{12}C acetyl CoA. Draw your product including the positions of the labels.

5

c. Begin with a C16:0 fatty acid. Draw the products of a Δ9 desaturase enzyme followed by two elongation reactions. Name the product using the ω system of naming.

5



C20:1 ω9

d. Would it be possible to synthesize a Δ12 fatty acid in mammalian cells starting from a C-16 or C-18 carbon fatty acid? Explain?

5.

no b/c mammalian cells lack that enzyme.

(20)

9. The net number of ATP produced from the activation and complete oxidation of haydionic acid (21:1) is (show all of your work for complete credit)

Activation = −2 ATP
Boxid= 9 (NADH + FADH2) = 36 ATP
acetyl CoA= 9 (3 NADH + FADH2 + GTP) = 90 ATP
Succinyl CoA = 1 (NADH + FADH2 + GTP) − 1 ATP = 4 ATP

15

128 ATP

a. How does this compare to the amount of ATP per carbon that glucose can generate?

5

21:1 = 6.1 ATP/C
glucose = 5.33 ATP/C

fat yields more ATP per carbon than glucose

(15)

10. We can synthesize the amino acid glutamate from pyruvate via the citric acid cycle.

a. Which intermediate is used to make glutamate?

5

a-Ketoglutarate

b. How many pyruvate molecules would be required to synthesize glutamate without depleting citric acid cycle intermediates? Explain

5

5 → 3 to make α-Ketoglutarate, 2 to regenerate OAA.

c. If pyruvate was labeled at methyl carbon, where would the label show up in glutamate? Draw the structure and show the position(s) where the label from pyruvate would show up.

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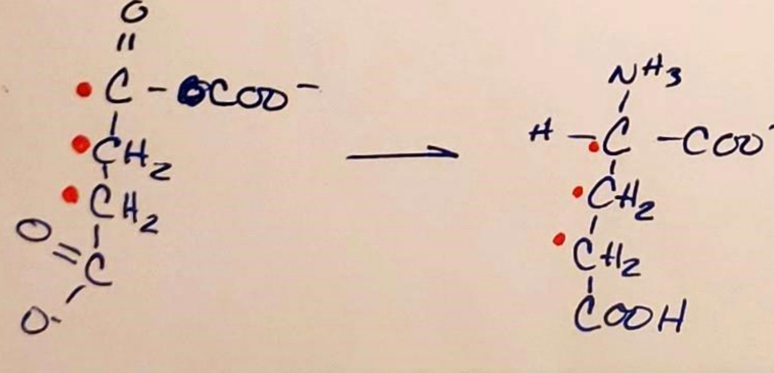

11. On September 6th, 1992, the body of Christopher McCandless and his diary was found inside an abandoned bus in Alaska. His diary inspired the non-fiction book *Into the Wild* written by Jon Krakauer, which was later adapted to a movie. In both the movie and the book, Chris died after surviving for 119 days in the Alaskan wilderness supposedly due to mistakenly eating a poisonous plant. However, results from analytical testing on the plants Chris supposedly ate by the American Chemical Society are reported to be inconclusive for any toxins, and post-mortem reports indicated no presence of toxins in Chris' body. Currently, biochemists and scientist postulate that Chris, instead, may have died from rabbit starvation, which is a form of malnutrition caused by excess consumption of lean protein. The symptoms of rabbit starvation include hyperammonemia, hyperinsulinemia, diarrhea, fatigue, and in prolonged cases, death. Thoroughly explain how a person can starve to death by eating only lean protein such as rabbit meat, and what evidence could a scientist use to support this hypothesis.

15

Variety of answers

(10) 12. Throughout the term we worked in groups. Each group was named after a real biochemist/chemist.

5 a. Who is the scientist that your group was named after?

5 b. Spend a little time researching your scientist and share one thing that you found interesting about that scientist.

Variety of answers