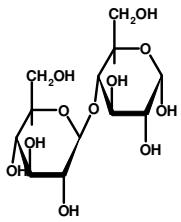
This exam consists of 100 points on five pages. Note: the last question is worth 16 points.

1. (4 pts) What is an "electron density map" and what is its role in structure determination by X-ray diffraction?

2. (5 pts) What is the difference between an aldose and a ketose? Provide **one** example.

3. (5 pts) The structure of a disaccharide is shown on the right;
   i) identify both anomeric carbons by circling them.
   ii) Which is the correct name for this compound? Briefly justify your answer.
   β-glucopyranosyl (1-4) α-glucopyranose
   α-glucopyranosyl (1-4) β-glucopyranose
   β-glucopyranosyl (1-4) α-glucopyranoside
   β-glucofuranosyl (1-4) β-glucopyranose
   β-glucopyranosyl (6-3) α-glucopyranose



4. (6 pts) Please do **one** of the following choices:
   Choice A: Is it possible to obtain the disaccharide shown in the above question (#3) from the hydrolysis of glycogen (or starch)? Why or why not?
   Choice B: Briefly compare and contrast cellulose to the protein-carbohydrate (peptidoglycan) component of bacterial cell walls.

5. (9 pts) Please do **one** of the following two choices:

Choice A: Which thermodynamic "force" or interaction is responsible for the self assembly of micelles and lipid bilayers? How does this interaction affect the critical micelle concentration (CMC) of fatty acids? Your answer should include a description/drawing of the structure of a fatty acid or a phospholipid.

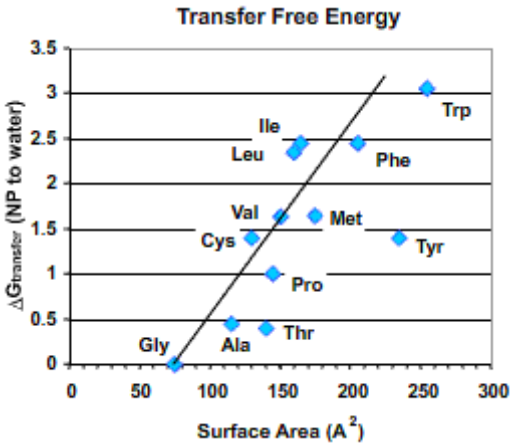
Choice B: What thermodynamic "force" or interaction is responsible for the physical properties (liquid or solid, fluid or gel) of triglycerides or membranes? Illustrate your answer with an example.

6. (9 pts) Please do **one** of the following choices:

Choice A: Why is it difficult for ions such as Na^+ and K^+ to cross a pure phospholipid membrane? Briefly describe the mechanism by which ion channels move these ions across a membrane.

Choice B: Why must the secondary structure of all integral membrane proteins be either α-helix or β-barrel?

Choice C: Briefly explain why a peptide composed of all alanine residues will not partition into membranes while a peptide composed of phenylalanine residues partitions almost entirely into membranes. The diagram on the right may be useful.



7. (10 pts) Compare and contrast direct and indirect coupling and briefly discuss how these mechanisms are used to insure that a metabolic pathway is spontaneous in the forward direction. Provide **one** example.

8. (6 pts)

i) Which metabolic pathway can produce ATP (energy) in the absence of oxygen? (circle correct answer):

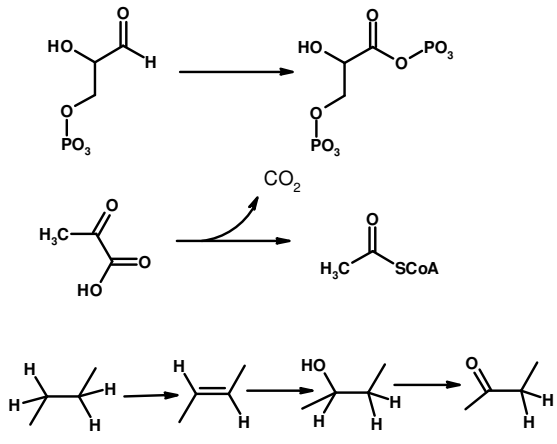
threonine synthesis gluconeogenesis TCA cycle glycolysis fatty acid oxidation

ii) What is the role of lactate (lactic acid) or ethanol in this process?

9. (8 pts)

i) Using *any* oxidation reaction from *any* pathway, illustrate how the energy that is released by the oxidation is captured instead of being lost as heat [The diagram on the right may be helpful.] (6 pts).

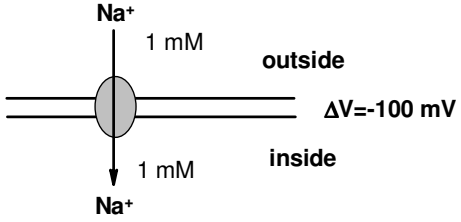
ii) Which is the generic name of an enzyme that typically catalyzes reactions of this type (2 pts)?



10. (5 pts) Please do **one** of the following choices:
    Choice A: Compare and contrast a kinase to a phosphatase. Give **one** example.
    Choice B: Compare and contrast a feedback inhibitor to a product inhibitor. Give **one** example.

11. (12 pts) Please do **one** of the following choices (a well labeled diagram is a suitable answer):
    Choice A: How does the oxidation of NADH in electron transport differ from the oxidation of $FADH_2$ in electron transport? Which complexes/processes are similar, which are different.
    Choice B: Briefly discuss how ATP is synthesized by ATP synthase. Describe the source of energy and the key features of the mechanism of the enzyme.

12. (5 pts) A transmembrane enzyme catalyzes the movement of Na^+ ions from outside the cell to inside the cell. Assume that the concentration of Na^+ ions outside the cell is maintained at 1 mM, the concentration inside is 1 mM, and the membrane potential is -100 mV (inside negative). How many sodium ions would have to be transported to generate sufficient energy to convert ADP + P_i to ATP, assuming that this enzyme could couple sodium transport to ATP synthesis. *[Please use the back of the previous page for calculations if necessary.]*



13. (16 pts) You are running in the Pittsburgh marathon next week and the morning of the race you have a pancake breakfast, a meal rich in carbohydrates. Please answer **all** parts *i – iv*. Note that *part iii* has choices.

i) Describe changes in the levels of ATP, AMP and glycogen in the liver that would occur as you are running the race. Do the levels of these compounds increase, decrease, or remain relatively constant (3 pts)?

ii) Which hormone would be released by the pancreas during the race? Why? (2 pts).

iii) Please do **one** of the following three choices. Be sure to indicate your choice (8 pts).

Choice A: How would this hormone affect the regulation of glycogen synthesis/degradation. You should name the enzymes involved and clearly state how they are regulated and why they are regulated in this manner.

Choice B: How would this hormone affect the regulation of glucose oxidation (glycolysis) or glucose synthesis (gluconeogenesis)? You should name the enzymes involved and clearly state how they are regulated and why they are regulated in this manner.

Choice C: In what way are the pathways of glucose oxidation (glycolysis) or glucose synthesis (gluconeogenesis) sensitive to the energy levels of the liver cell? You should name the enzymes involved and clearly state how they are regulated and why they are regulated in this manner.

iv) Sometime during the marathon you "hit the wall" and have very little energy available and can't keep up your former pace (for me, this would be after about 1/2 mile). What types of compounds (e.g. carbohydrates, triglycerides, aminoacids) are now providing energy and what metabolic pathways are being used to generate this energy? (3 pts)

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