

Examination

Biochemistry and Molecular Biology (KBB032)

Date and place: Monday, August 16-2021, em

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”Grade limits”: 50% = 3; 65% = 4; 80% = 5

Name:

1. Glycolysis is one of the most central metabolic pathways in a cell. (6p)

A) How do you think the rate of glycolysis will be affected by high concentrations of Fructose-1,6-bisphosphate?

B) Which enzyme(s) will be affected?

C) You have measured the concentrations of all intermediates in glycolysis and calculated ΔG for all reactions. To your surprise, according to your measurements and calculation, one reaction seems to have a positive value of ΔG . How would you explain this since you observe a continuous flux from glucose to pyruvate?

2. Formation of ATP via oxidative phosphorylation is an extremely important process in the cell.

A) Describe the process that “liberates energy” and what factors that determines the amount of energy “liberated” (2p)

B) What is the “force” used by ATP:ase for formation of ATP, what are the components constituting this force? (3p)

C) Where in the cell does this process take place, in a eukaryotic cell (1p)

D) How will the process be affected if subjected to cyanide? What complex is the target? (2p)

E) Substrate level phosphorylation is another mechanism used for formation of ATP. Describe this process and mention the main difference compared to oxidative phosphorylation (2p)

3. Acetyl-CoA is a key compound that is involved in the TCA- as well as the glyoxylate cycle.

A) How will Acetyl-CoA be converted in the respective cycle (what end-product will be formed) (2p)

Why is the glyoxylate cycle a necessity for growth on 2-carbon compounds and for the ability to convert fatty acids to carbohydrates? (2p)

4. The pentose phosphate pathway can be divided in an oxidative and non-oxidative part, respectively. Explain how these parts will be regulated and how the end-products from the non-oxidative part will be used if the purpose would be: (6p)

- A) Production of nucleic acids/nucleotides
- B) Formation of reducing power in the form of NADPH
- C) Formation of energy in the form of ATP

5. Photosynthesis and its light reaction in green plants is a very important process for life on earth. (6p)

A) For what reason are there so many different photosynthetic pigments?

B) What end products are formed during non-cyclic and cyclic photosynthesis; respectively?

C) Some photosynthetic bacteria have to rely on reversed electron transport for formation of NAD(P)H. What is meant by reversed electron transport and why is this a necessity for these bacteria?

6. Fermentation of glucose to ethanol is a redox neutral process. Still, ethanol is more reduced than glucose. Explain how this process can still be redox neutral. (3p)

7. Below is a short explanation of different expressions and phenomena used in biology. Indicate with one or two words what is described. (15p)

- a) A molecule such as, *e.g.* cAMP, that will initiate an intracellular response following an external stimulus
- b) Synthesis of carbohydrates from non-carbohydrates sometimes referred to as glycolysis running backwards
- c) Wasteful consumption of ATP. No net change apart from consumption of ATP
- d) The theory that mitochondria and chloroplasts originate from prokaryotes that has been incorporated in eukaryotes
- e) An end-product in a pathway will inhibit an enzyme in the beginning of the same pathway
- f) Bacteria that can obtain energy by oxidising inorganic substrates
- g) Amino acids that we need but can't make ourselves and therefore must be obtained from the diet
- h) Oxidation of fatty acids, two carbons at the time
- i) Transformation of inaccessible N_2 to accessible NH_3 by certain specialized bacteria
- j) Enzymes with binding sites for metabolites (not substrate) that will affect their activity positively or negatively.
- k) A key enzyme during the dark reaction of photosynthesis that will incorporate CO_2 into a 5-carbon compound and produce two molecules of 3-phosphoglycerate.
- l) An enzyme that phosphorylates other enzymes
- m) An enzyme taking part in glycogen biosynthesis where a glucose molecule will bind directly to the enzyme
- n) Enzymes that will catalyze essentially the same reaction but small differences in amino acid composition will result in different kinetics and/or co-enzyme preference
- k) A class of lipids that constitute the majority of biological membranes

8. Name the individual building blocks of DNA and describe their role in DNA structure and function. Which building blocks are different in RNA? How does DNA and RNA differ in their secondary structure?

(5 points)

9. Translate the given sequence into the missing corresponding sequences (genetic code for reference can be found here: https://jgi.doe.gov/wp-content/uploads/2016/03/1035px-Aminoacids_table.png). Note that depending on which sequence is given there could be more than one correct answer. Mind the orientation!

DNA sequence (5'-3'): ATGCGAATTGCAATAAGCGGAGGCGGTACA

Complementary strand (5'-3'):

RNA sequence (5'-3'):

Protein sequence (N-C):

DNA sequence (5'-3'):

Complementary strand (5'-3'):

RNA sequence (5'-3'): AUGACUGAAC AAACCAUUGC ACAUAAACAA

Protein sequence (N-C):

DNA sequence (5'-3'):

Complementary strand (5'-3'):

RNA sequence (5'-3'):

Protein sequence (N-C): MLEQVILFTI LMGFLISVLL

(9 points)

10. Describe or draw bacterial DNA replication. Name each involved enzyme and describe its function and localization in the replication fork. Describe what is happening with both the leading and lagging strand and include strand orientation in your description.

(8 points)

11. Describe what happens during the termination phase of transcription. Which termination factors are involved and what is their function? What would you observe, if one or more termination factors were rendered non-functional by a mutation or chemical treatment?

(5 points)

12. Explain what a sigma factor is. Where does it bind and what is its function? What is the biological role of alternative sigma factors? Give an example for an alternative sigma factor including its function.

(3 points)

13. Describe the principle of the polymerase chain reaction. Which components are needed for the reaction to be successful and what is the role of each component? What are the individual phases and what happens in each phase? What could be a reason for a PCR not yielding any product?

(10 points)

14. With your knowledge about methods to measure gene expression, how would you approach the following research questions? Motivate your answer and explain your experimental setup. Keep in mind that there can be more than one feasible approach.

- a. You want to know at which time during embryonic development a specific (known) gene regulator is active. Your model organism is zebrafish.
- b. You suspect that a genetic predisposition (you don't know which one) causes a higher chance for suffering from long Covid. How would you attempt to identify the involved genetic markers? Funding for Covid research is abundant and have no limitations regarding accessibility or cost of the chosen method.
- c. A low-income country registers an outbreak of an infectious disease among the rural population. You are tasked to identify the causative agent with a simple and cheap approach that is feasible to implement in a mobile low-tech lab. Based on symptoms and epidemiology, you can narrow down the causative agent to a handful of possible culprits. Which method and instrumentation would you recommend to identify the infectious agent in this setting? Once identified, which technique could you use for large-scale diagnostics?

(10 points)