Final Exam

**KBB032**

**Biochemistry and Molecular Biology**

**Time and location:** Monday, August 15th, 2022, afternoon session 14.00-16.00

**Teacher and examiner:** Michaela Wenzel 772 2074

Teacher will be available for questions by phone throughout the exam.

**Aids:** All aids are allowed, including laptops and lecture notes. See rules on next page.

**Exam review:** Results will be reported to Ladok within three weeks. Grading of the exam may be reviewed after agreement with Michaela Wenzel.

**Points breakdown:** Points for each question are indicated in parentheses.

Grading: 50% = 3; 65% = 4; 80% = 5

**Read all questions carefully!**

Remember that some questions may have more than one correct answer.

Please write legibly.

**Instructions for using laptops:**

- A computer is allowed.
- You must be certain to turn your sound off
- You must shut down all modes of communication with other people (e.g., chats, push notices, slack, email, twitter etc.). **It is not allowed to communicate with another person** by any means throughout the exam. The only exception is a supervised phone call to the examiner.
- Everything we ask will be possible to answer based on the course contents that are published in Canvas.
- You will not need to use any other source of information. However, it is not prohibited to search the internet.
- If you use web sources for any kind of information, be careful to avoid plagiarizing. Write a reference to the source (so we can look it up). Use your own words to describe the information in the source to show you have understood it; do not copy text from the source.

**Question 1: Definitions and concepts** (10 p total)

Below is a short explanation of different expressions and phenomena used in biology. Name the concept that is described (1 p each).

a) the theory that mitochondria and chloroplasts originate from prokaryotes that has been incorporated in eukaryotes
b) a chemical reaction characterized by the gaining of electrons by an atom
c) a chemical reaction characterized by the loss of electrons from an atom
d) a group of genes that is regulated by the same regulator but not necessarily located close to each other on the chromosome
e) an end-product in a pathway will inhibit an enzyme in the beginning of the same pathway
f) amino acids that a given organism needs but cannot make itself and therefore must be obtained from the diet
g) Transformation of (to most organisms) inaccessible $N_2$ to accessible $NH_3$ by certain specialized bacteria
h) a catalytic step in a metabolic pathway that determines the reaction speed of the whole pathway
i) the transfer of a phosphate group from a substrate to ADP
j) the transfer of a phosphate group to ADP that is driven by the transmembrane proton gradient

**Question 2: Pentose phosphate pathway** (6 p total)

a) Which are the two most important functions of the pentose phosphate pathway? (4 p)

b) Glucose-6 phosphate dehydrogenase is a key enzyme of this pathway, describe the reaction catalysed by this enzyme. (2 p)

**Question 3: Oxidative stress** (12 p total)

Imagine that you are working for a biotechnology company and you are tasked to optimize a bacterium for a process that results in the unwanted formation of reactive oxygen species (ROS). Your goal is to increase the resistance of your bacterium to ROS.

a) Name a metabolic pathway that you could manipulate to reach this goal and explain how it would increase ROS resistance (3 p).
b) Outside from engineering metabolic pathways, could you also reach your goal by modulating the expression of specific enzymes? If so, which ones and how would they contribute to ROS resistance (3 p)?
c) ROS can cause severe damage to DNA. Which type of DNA damage is caused by ROS and which mechanism is involved in repairing that damage (3 p)?
d) If oxidative DNA damage is not repaired, this can have serious consequences. Describe why base oxidation can lead to problems for the cells. Are there different consequences for multicellular and unicellular organisms and, if so, why (3 p)?

**Question 4: Fatty acid metabolism** (8 p total)

Cells can both synthesize fatty acids, e.g. to produce membrane lipids, (fatty acid synthesis) and degrade them (beta oxidation).

a) How many cycles are needed to synthesize a 16 C fatty acid chain (a fatty acid chain that contains a chain of 16 carbon atoms) (2 p)?
b) Name three different end products of beta oxidation. For each one, name a process, in which it can be used (6 p).

**Question 5: Amino acid metabolism** (9 p total)

You are working for a biotechnology company that would like to produce as much as possible of the amino acid glutamate. As a molecular biologist you have the tools to increase and decrease activity of different enzymes.

a) Suggest three different enzymes whose activity you would like to change in order to maximize production of glutamate. (3 p)
b) Motivate your suggestions and indicate whether you want to decrease or increase the activity. (6 p)

**Question 6: Nucleic acids** (6 p total)

Cells have two types of nucleic acids that fulfill distinct roles in storing and using genetic information.

a) Name the individual building blocks of DNA and describe their role in DNA structure and function. (3 p)
b) Which building blocks are different in RNA? (2 p)
c) How do DNA and RNA differ in their secondary structure? (1 p)

**Question 7: Replication** (12 p)

In order to produce fit offspring, DNA must be replicated with high accuracy and distributed equally to the daughter cells upon cell division.

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.

**Question 8: PCR and sequencing** (16 p total)

Polymerase chain reaction and DNA sequencing are based on the same molecular principles. However, there are crucial differences that make the respective reactions possible.

a) 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 (2 p)? What are the individual phases and what happens in each phase (2 p)?
b) What could be a reason for a PCR not yielding any product other than forgetting to add one of the components (2 p)?
c) Describe the principle of Sanger sequencing including components and point out the four major differences to a PCR reaction (5 p).
d) Explain the role of each of these differences that enables sequencing (5 p).

**Question 9: Sequences** (9 p total)

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!

(1 p per translated sequence)

DNA sequence (5'-3'): ATGAGAATAGCTGTAGATGCAATGGGAGGA

Complementary strand (5'-3'):

RNA sequence (5'-3'):

Protein sequence (N-C):

DNA sequence (5'-3'):

Complementary strand (5'-3'):

RNA sequence (5'-3'): AUGUUUAACUUACCAAAUAAAAUCACACUA

Protein sequence (N-C):

DNA sequence (5'-3'):

Complementary strand (5'-3'):

RNA sequence (5'-3'):

Protein sequence (N-C): MSSKLLRGTFVLTLGTYISR

**Question 10: Measuring gene expression** (12 p total)

Two farmers grow crops on adjacent fields. One farmer has issues with his plants frequently being eaten by caterpillars, while the other one has mostly healthy plants. Assume that there are no differences between pesticide or fertilizer usage.

a) What could be possible reasons for the different susceptibilities to the caterpillar infestation? (6 p)
b) Which method for monitoring gene expression would you choose to identify the genetic determinants underlying the different phenotypes and why? (6 p)