Final Exam

UCM010

Introduction into Cell and Molecular Biology

Time and location: Monday, May 27th 2024, 14.00, Campus Johanneberg

Teacher and examiner: Michaela Wenzel, 772 2074, wenzelm@chalmers.se

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

Aids: Dictionary

Exam review: Results will be reported to Ladok within four weeks. Graded exams can be viewed by making an appointment with Gunilla Bankel-Andersson (gunilla.bankel.andersson@chalmers.se). Grading of the exam may be reviewed in agreement with Michaela Wenzel (after consultation with the other teachers, if necessary).

Points breakdown: Total points and point breakdowns are given for each question. The exam gives 100 points in total.

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

10 bonus points can be acquired through the lab report, if it is submitted in time and approved upon first submission (that means that you could pass the course with 40 points on the exam plus 10 points from the lab report).

Read all questions carefully!

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

Questions can be answered in English or Swedish (or even a mix of both).

Please write legibly!!
We will not guess correct answers from unreadable handwriting!

Question 1: Definitions and concepts (1 point per correct answer, max. 10 points)

Below is a short explanation of different expressions and phenomena used in biology. Name the concept that is described.

a) a biomolecule class that occurs in nucleic acids, and serves as both carbon and energy source
b) a method to isolate different cell components and organelles according to their size and density.
c) a regulatory sequence on bacterial DNA that is bound by Sigma factors
d) the theory that DNA replicates by using each of the two DNA single strands as template for a new daughter strand
e) a class of enzymes that helps relieve tension in supercoiled DNA and decatenates circular DNA molecules
f) a group of genes that is transcribed from the same promoter and translated from the same polycistronic mRNA
g) an RNA sequence that changes it structure depending on the presence of a ligand resulting in a change in gene expression
h) the concept that mitochondria and chloroplasts originate from prokaryotes that have been incorporated into eukaryotic cells
i) the mitotic phase, in which the chromosomes are lined up at the middle of the cell
j) a regulated signaling cascade leading to the intended and controlled death of a cell

Question 2: Cells (max. 7 points)

a) Label the missing cell components in the image below. What kind of cell is this and why? 0.5 points per correctly labeled structure, max. 7 points.

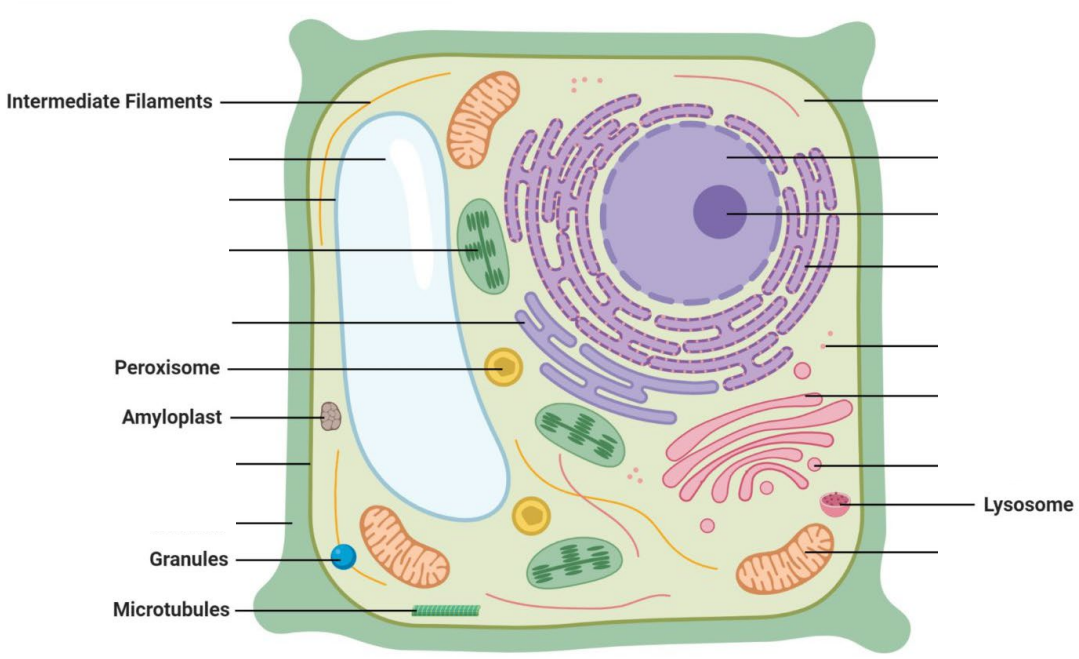
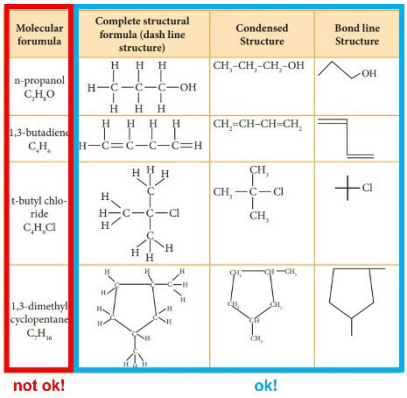


Figure: Plant Cell Structure, Image Copyright © Sagar Aryal, www.microbenotes.com

Question 3: Nucleic acids (max. 5 points)

a) Draw a single nucleotide (in any common structural formula, see image). Three points, no partial points (your nucleotide must exist in nature and occur in fully functional DNA or RNA).



b) Did you draw a nucleotide that would occur in DNA or RNA? Which structural feature(s) determine this? One point.

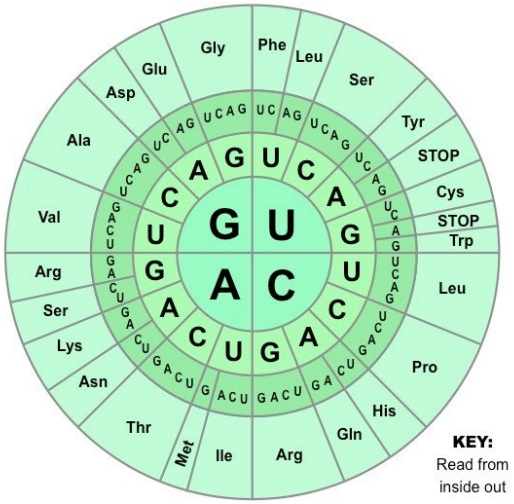
c) Did you draw a monophosphate, diphosphate, or triphosphate version of your nucleotide? Which one of the three would be incorporated into a growing DNA/RNA strand? One point.

Question 4: Sequences (max. 6 points)

Translate the given sequence into the missing corresponding sequences (see genetic code to the right).

Mind the orientation!

One point per translated sequence, max. 6 points.



a)

DNA sequence (5’-3’): ATGATTCAAATCGATCCAAGAAGCTCAACA

Complementary strand (5’-3’):

RNA sequence (5’-3’):

Protein sequence (N-C):

b)

DNA sequence (5’-3’):

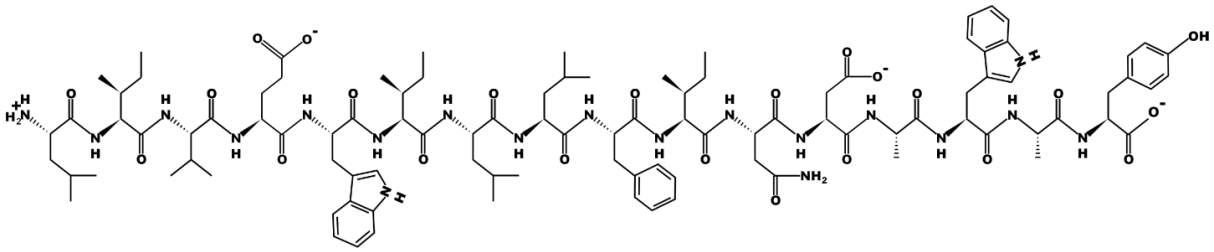
Complementary strand (5’-3’):

RNA sequence (5’-3’): AUGAUUGAACUGCGGCAGCUGUCAAAAGCG

Protein sequence (N-C):

Question 5: Proteins (max. 25 points)

a1) Depicted below is a peptide sequence. Translated into one-letter amino acid codes, it spells a sentence. What does it say? Half a point per correct amino acid, 8 points max.



Tipp: Follow the peptide bonds to mark the peptide backbone and then identify the individual side chains!

a2) Name each individual amino acid (full names). Half a point per unique amino acid, max. 5 points.

b1) Below is a peptide sequence in three-letter codes.

Ile-Arg-Pyr-Asn-Met-Ala-Ile-Asp-Glu-Asn

How would the following amino acid substitutions affect the properties of the peptide? One point each, max. 5 points.
Ile -> Leu
Arg -> Lys
Asn -> Asp
Met -> Ala
Glu -> Lys

b2) Which of these substitutions would have small, moderate, or strong effects? Justify your reasoning! Half a point per answer, max. 2.5 points.

b3) What does the amino acid sequence in b1 spell in one-letter code? 4.5 points.

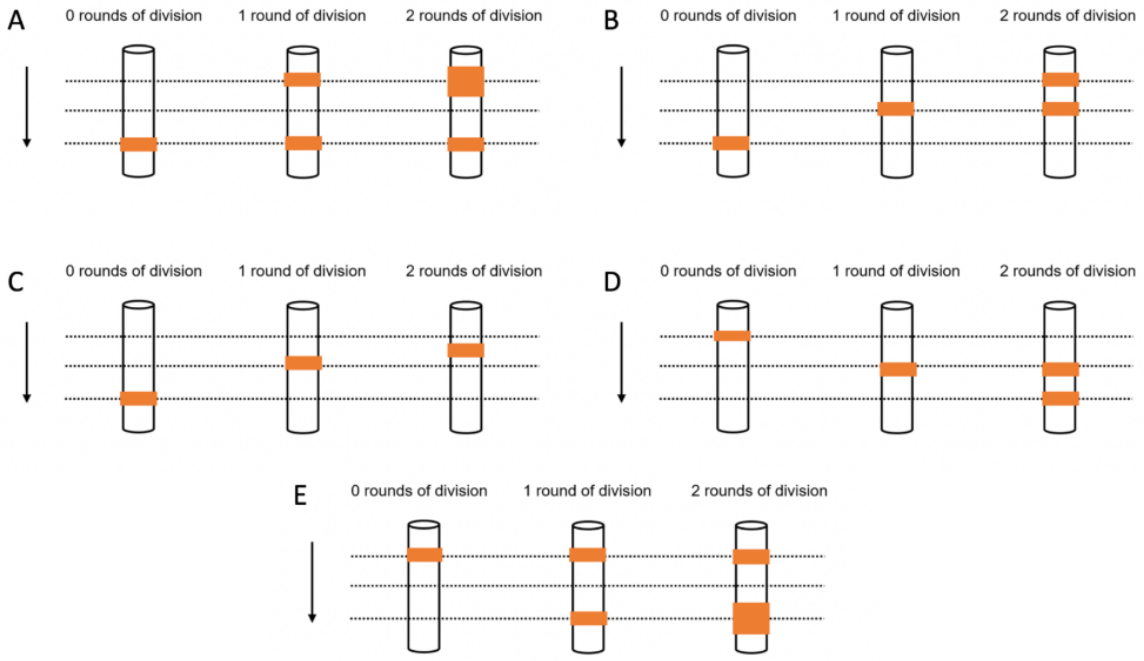
Question 6: DNA replication (max. 12 points)

In 1958, Matthew Meselson and Franklin Stahl conducted a famous experiment that proved the concept of semi-conservative DNA replication.

a) Explain or draw the three hypothetical modes of DNA replication that were tested in this experiment (semi-conservative, conservative, dispersive). 6 points

b) Explain the setup of the Meselson-Stahl experiment. Which 'trick' enabled this experiment? Which method was used? What was the model organism? 3 points

c) The picture below shows theoretical outcomes of the Meselson-Stahl experiment (the arrow indicates increasing density). Which one correctly depicts semi-conservative DNA replication? Motivate your answer. 3 points



Question 7: Membranes (max. 10 points)

a) Name the following types of membrane components that contain: (4 points)

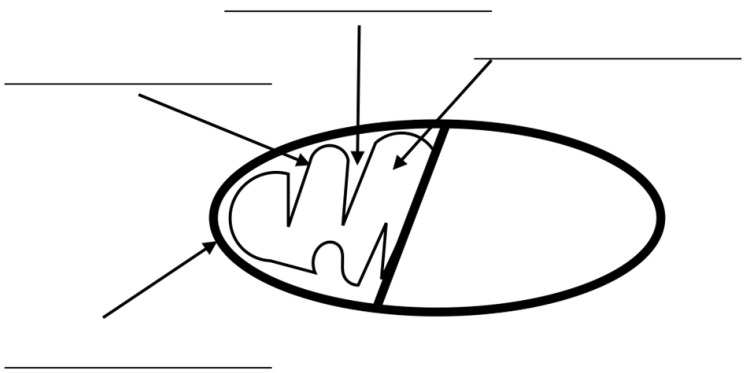
i. A phosphate, glycerol, and two fatty acids
ii. A phosphate, a fatty acid, and a sphingosine
iii. A fatty acid, a sugar, and a sphingosine
iv. A steroid ring structure and a nonpolar hydrocarbon tail

b) What are the three major types of active transporters? Where do these transporters get their energy from? (6 points)

Question 8: Mitochondria (max. 11 points)

a) Use the figure below to: (6 points)

i. Name the marked four components of the mitochondria.
ii. Draw an additional arrow to the part of the mitochondria where the mitochondrial DNA is located.
iii. In which of these components does the electron transport chain and ATP synthesis take place?



b) In the electron transport chain,

i. Which are the three major complexes (the names, not the numbers)? (3 points)
ii. Which are the two important electron mediators that transport electrons between the complexes? (2 points)

Question 9: Cytoskeleton (max. 8 points)

a) What are the two major structural components of ATP synthase? In which one are protons transported? In which one is ATP generated from ADP? (4 points)

b) Below, two of the three major components of the cytoskeleton are listed.

- Actin filaments
- Microtubules

For each of them, indicate:

i. Its overall structure. (2 points)
ii. One process or function in the cell, in which it is important. (2 points)

Question 10: Cell cycle and reproduction (max. 6 points)

In the schematic picture of the cell cycle below…

a) Fill in the names of the different phases of the cell cycle. (3 points)

b) Indicate in what phase:

i. the nuclear DNA is duplicated (1 points)

ii. the cell splits in two daughter cells (1 points)

iii. in which phase the cell commits to cell division, influenced by increased levels of cycline D. (1 points)