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NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET
INSTITUTT FOR FYSIKK

EXAM IN TFY4260 – CELL BIOLOGY AND CELLULAR BIOPHYSICS

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Date: 9 June 2016
Time: 09.00-13.00

All questions in Exercises 1 to 5 have the same weight (5 pts). Questions in Exercise 6 count with 1 pt each (15 in total). None of the questions requires lengthy answers so answer as precisely and concisely as possible.
Good luck!

Exercise 1: Lipid membranes and transport across membranes

a) True or false? Transport by transporters can be either active or facilitated, whereas transport by channels is always facilitated. Justify.
b) The intake of glucose into erythrocytes is done via glucose transporter GLUT1. Once inside the cell, the glucose is quickly phosphorylated to glucose-6-phophate. Why? c
c) Order the following membranes in terms of protein/lipid ratio: rough endoplasmic reticulum (ER), smooth ER, inner mitochondrial membrane, and myelin sheath of nerve axon. Justify.
d) You are given a sample with unstained red blood cells in a solution. Which microscopy technique would you use to view the shape of the cells? Explain your choice.

Exercise 2: Cytoskeleton and contractibility

a) True or false? In most animal cells, motor protein dyneins deliver their cargo to the periphery of the cell, whereas kinesins deliver their cargo to the interior of the cell. Justify.
b) Most of the transfer of proteins and lipids is done with the so-called "coated vesicles". Why have the vesicles such name? Name **two** reasons for the presence of such structure.
c) Why is it that intermediate filaments lack polarity whereas actin filaments and microtubules have two distinct ends with a defined polarity?
d) True or false? Motor neurons trigger action potentials in muscle cell membranes that open voltage-sensitive Ca^{2+} channels in T tubules, allowing the extracellular Ca^{2+} to enter the cytosol, bind to troponin C, and initiate muscle contraction. Justify.

Exercise 3: Immunology and membrane-bound compartments

a) Explain the mechanism that regulates the selection of appropriate T-cells in the thymus.
b) After having been presented with antigen, B cells proliferate and differentiate into memory B cells and plasma cells. What are the most distinct structural and functional differences between memory and plasma cells? Justify.

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c) Draw a rough scheme of the synthesis, processing and assembly of the class I MHC (major histocompatibility complex) – peptide (antigen) complex and antigen presentation, highlighting the most important points of this process.

Exercise 4: Cell signaling and cancer cells

Rous sarcoma virus (RSV) carries an oncogene called *Src*, which encodes a continuously activated protein tyrosine kinase (Src) that leads to unchecked cell proliferation. Normally, Src carries an attached fatty acid (hydrocarbon) chain that allows it to bind to the cytoplasmic side of the plasma membrane. A mutant version of Src does not possess the hydrocarbon chain. Infection of cells with RSV encoding either the normal or the mutant Src leads to the same high level of protein kinase activity, but the mutant Src does not cause cell proliferation.

a) What is it meant with continuously activated? Taking into account the general structure of receptor, give an example on how this could be achieved.
b) The target (X) for phosphorylation by Src resides in the membrane. Explain why the mutant Src does not cause cell proliferation.
c) Name **two** characteristics that cancer cells possess which contribute to the invasion and metastases of cancer cells.

Exercise 5: DNA recombination and regulation of gene expression

In the absence of glucose *E. coli* can proliferate on pentose sugar arabinose, using an inducible operon called *ara*. The *araC* gene encodes a gene regulatory protein that binds adjacent to the promoter and coordinates the expression of the genes involved in the arabinose metabolism. To understand the regulatory properties of the AraC protein, you isolate a mutant bacterium with a deletion of the *araC* gene. The table below shows the gene expression of araA protein in the presence and absence of arabinose, for both bacteria phenotypes:

	araA protein	
	- arabinose	+ arabinose
wild type	1	1000
mutant	1	1

a) Do the results in the table indicate that the AraC protein regulates arabinose metabolism by negative control or by positive control? Justify. What would the data in the table indicate if the AraC protein was regulated by the mechanism you did not choose in a)?
b) What is an operon? Why are these less common in eukaryotes?
c) The first step in a DNA cloning procedure using bacteria is to insert the desired piece of DNA into an appropriate cloning vector. *pU*C19 is a popular plasmid cloning vector. It possesses an amp^R gene and 11 different restriction sites clustered in a region containing the *lacZ* gene, which codes for the enzyme β-galactosidase. Why are these features desirable?

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Exercise 6: Mark the correct alternative with a cross. Deliver these pages together with the answers of the other exercises. Do not forget to indicate the candidate number.

a) The Na^+/K^+ pump, responsible for maintaining electrochemical ion gradients is an example of
   - Direct active transport.
   - Indirect active transport.
   - Facilitated diffusion.

b) Transport of enzymes from the Golgi complex to the endosomes is done via
   - Constitutive secretion.
   - Regulated secretion.
   - anterograde transport.

c) Transport of proteases from the ER to the lysosomes relies on the fact that two compartments have different
   - pH.
   - temperature.
   - size.

d) Fusion of vesicles with target membranes is mediated by
   - SNARE proteins.
   - dynamin.
   - actin.

e) KDEL amino acid sequence tags polypeptides for
   - destruction by proteasomes.
   - transport to lysosomes.
   - transport to the ER.

f) The resting membrane potential arises from
   - large differences in ion composition inside and outside of the cell.
   - small differences in the charge distribution inside and outside of the cell.
   - variations of pH inside and outside of the cell.

g) Release of neurotransmitters in the synaptic cleft and binding to receptor on a muscle cell is an example of
   - autocrine signaling.
   - paracrine signaling.
   - endocrine signaling.

h) G protein-linked receptors activate a particular type of G protein (guanosine binding protein) that it turn activates other proteins, initiating a signaling pathway. The G protein is composed of three subunits (α, β, and γ), where subunits G_β and G_γ are permanently bound. Which subunits are able to initiate a signaling pathway?
   - G_α.
   - $G_{\beta\gamma}$.
   - Both.

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i) Microvilli from intestinal mucosa are cells are made of organized arrays of
   - microtubules.
   - microfilaments.
   - intermediate filaments.

j) Integrins indirectly bind the extracellular matrix to
   - microtubules.
   - microfilaments.
   - intermediate filaments.

k) In cell division, metaphase is characterized by the
   - separation of the two sister chromatids of each chromosome.
   - break down of the nuclear envelope.
   - alignment of the chromosomes in the center of the cell.

l) The contractile ring formed during early anaphase, which leads to the cytoplasmic division of the cell is composed of
   - tubulin.
   - actin.
   - dynamin.

m) In the cell cycle, Cdk-Cyclin regulates progression though the restriction point by phosphorylating the
   - p53 protein.
   - Rb protein.
   - E2F transcription factor.

n) The p53 tumor suppressor gene is the most frequently mutated gene in human cancers. Which process is p53 involved in?
   - Apoptosis.
   - Angiogenesis.
   - DNA organization.

o) Telomere integrity in cancer cells is the result of
   - natural cell aging.
   - DNA replication.
   - active telomerase activity.