Candidate number ……..…….……
Course code ……..
Page no……...

NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET
INSTITUTT FOR FYSIKK

EXAM IN TFY4260 – CELL BIOLOGY AND CELLULAR BIOPHYSICS

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Date: 8 June 2017
Time: 09.00-13.00

All questions in Exercises 1 to 4 have the same weight (5 pts). Questions in Exercise 5 count with 1 pt each (15 in total). None of the questions require lengthy answers so answer as precisely and concisely as possible.
Good luck!

Exercise 1: Transport across membranes and cell junctions

a) Taking into account that the concentration of glucose is higher inside the epithelial cells that line the gut than in the gut or blood, explain how glucose is transported from the gut to the blood.
b) What type of cell-cell junction is responsible for preventing substances from diffusing between adjacent cells in the epithelium? Make a scheme of how such junctions look like.
c) Besides limiting the flow of substances between cells, the junctions from b) also define compartments in the plasma membrane. Explain how this is relevant in the context of glucose transport (a)).
d) You are given a sample with fluorescently labelled cells to visualize using confocal microscopy. What is the purpose of the pinhole in front of the detector in this technique?

Exercise 2: Cell signaling and cell mobility

The G protein-linked receptor is responsible for many of the signaling cascades present in cells. It consists of a large transmembrane protein that crosses the membrane seven times. It possesses the N-terminus in the extracellular fluid and the C-terminus in the cytosol of the cell.

a) Where are these receptor proteins synthesized? Justify.
b) Make a simple scheme of the primary structure the protein indicating where you would expect to find the start-transfer and stop-transfer sequences. Justify. (*Hint:* do not forget to indicate the N- and C-termini in your representation.)
c) The activation of the G proteins by binding to the G protein-linked receptor is an amplification step, but the activation of adenylyl cyclase for cAMP synthesis is not. Why?
d) Neutrophils are phagocytic cells (part of the immune system), which have G protein-linked receptors all over the surface. When a chemoattractant binds to a receptor it starts two signaling cascades. One induces the activation of Rac (via PIP_3), leading to the polymerization of actin filaments. The other leads to the Rho pathway and induces actin-

Candidate number ……..…….……
Course code ……..
Page no……...

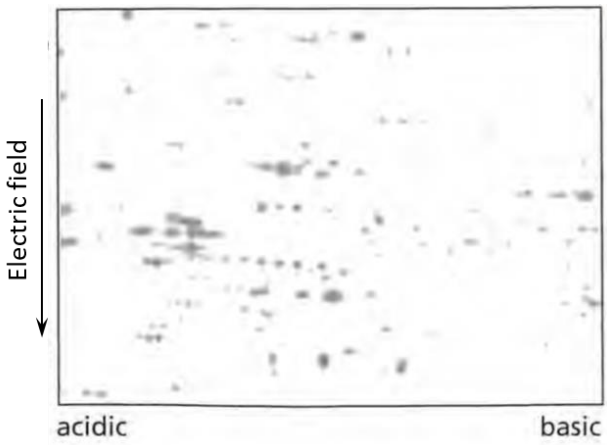
myosin contraction. How do these signal cascades contribute to the unidirectional motion of the cell by chemotaxis? (*Hint:* The PIP_3 second messenger is very short-lived).

Exercise 3: Cancer cells, cytoskeleton and immunology

a) Which cells of the adaptive immune response do you expect to be activated during a viral infection? Justify.
b) Describe, schematically, two different mechanisms in which insertional mutagenesis, the integration of the viral genome into a cell, can lead to the development of cancer?
c) MSH2 is a gene commonly associated with familial nonpolyposis colorectal cancer. This gene encodes a protein that is involved in correcting mismatched nucleotides. Briefly explain why the individuals who possess a mutated MSH2 gene from birth are more likely to develop colon cancer than individuals without a mutated gene.
d) Intermediate filaments can be used in cancer diagnostics. Why?
e) Bending of cilia is driven by the action of axonemal dyneins. What would happen to the cilia if the nexin proteins, which join adjacent microfilament doublets, would be missing?

Exercise 4: Gene regulation and cell cycle

a) A small portion of a two-dimensional display of proteins from human brain is shown in the figure below. These proteins were separated using two-dimensional (SDS-PAGE) gel electrophoresis, that is, they were separated based on their size in one dimension and on their isoelectric point in the other. Not all protein spots in the gels are products of different genes; some represent modified forms of a protein that migrate to different positions. Indicate where in the gels you would expect to find proteins with larger molecular weight. Indicate sets of spots that could represent proteins that differ in the number of phosphates they carry. Explain your choices.



b) Some of the spots present in the electrophoresis gels are due to transcription factors. What are these and what is their function?
c) Describe the different phases the cells undergoes during cell division.
d) A person has been exposed to ionizing radiation and the DNA is damaged. To avoid replication of the damaged DNA, the cells are stopped/arrested in the cell cycle. Describe how this takes place. Some of the proteins involved are: ATM, p53, p21, cyclin, RB protein. What happens to the cells if the DNA is not repaired?

Candidate number ……..…….……
Course code ……..
Page no……...

Exercise 5: Mark the correct alternative with a cross. Deliver these pages together with the answers of the other exercises. Do not forget to write down the candidate number.

a) Protein/Lipid ratio is largest in the
   - myelin sheath of nerve axons
   - rough endoplasmid reticulum
   - outer membrane of mitochondria

b) Transport of HCO_3^- in and out of the erythrocytes (red-blood cells) is driven by
   - simple diffusion.
   - a HCO_3^--pump.
   - a HCO_3^-/Cl- antiport carrier protein

c) ATP synthases can be found in the
   - outer membrane of mitochondria
   - intermembrane space of mitrochondria.
   - inner membrane of mitochondria.

d) Newly synthesized lipids are predominantly transported to the mitochondria via
   - coated vesicles.
   - lipid carriers.
   - translocases.

e) The core oligosaccharide side chain added to glycoproteins in the endoplasmic reticulum is composed of:
   - mannose (Man), galactose (Gal) and N-acetylglucosamine (GlcNAc).
   - mannose (Man), sialic acid (Sia) and N-acetylglucosamine (GlcNAc).
   - mannose (Man), galactose (Gal) and N-acetylneuraminic acid (NANA).

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

g) Lysosomes are characterize by possessing
   - a high pH value.
   - a large concentration of urate oxidase.
   - a large concentration of proteases.

h) An action potential occurs in the following steps:
   - Opening of K^+ voltage-gated channels, membrane depolarization, inactivation of K^+ channels, opening of Na^+ voltage-gated channels, membrane hyperpolarization.
   - Opening of K^+ voltage-gated channels, membrane hyperpolarization, inactivation of K^+ channels, opening of Na^+ voltage-gated channels, membrane depolarization.

Candidate number ……..…….……
Course code ……..
Page no……...

- Opening of Na^+ voltage-gated channels, membrane depolarization, inactivation of Na^+ channels, opening of K^+ voltage-gated channels, membrane hyperpolarization.

i) Nerve transmission in the heart muscle is done via a
   - adhesive junctions.
   - gap junctions.
   - tight junctions.

j) Striated muscle contraction is driven by
   - Microtubules and kinases.
   - Microfilaments and myosin.
   - Intermediate filaments and vimetin.

k) The protein class, whose fibers have a high tensile strength and account for much of the strength of the extracellular matrix is named
   - collagen.
   - elastin.
   - fibronectin.

l) Which class of enzymes has allowed the development of recombinant DNA technology?
   - DNases.
   - Restriction endonucleases.
   - Topoisomerases.

m) RNA splicing in an example of
   - genomic control.
   - post-transcriptional control.
   - translational control.

n) During the screening process of T cells in the thymus, these are presented to cells presenting self-peptides. T cells survive this process if the affinity of their receptor to that of the MHC-bounded self-peptide is
   - strong.
   - weak.
   - none.

o) Lack of cadherins in cancer cells contributes to
   - evading apoptosis and cell immortality.
   - Sustained angiogenesis and uncontrolled growth.
   - enhanced cell mobility and metastases.