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NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET
 INSTITUTT FOR FYSIKK



EXAM IN TFY4260 – CELL BIOLOGY AND CELLULAR BIOPHYSICS

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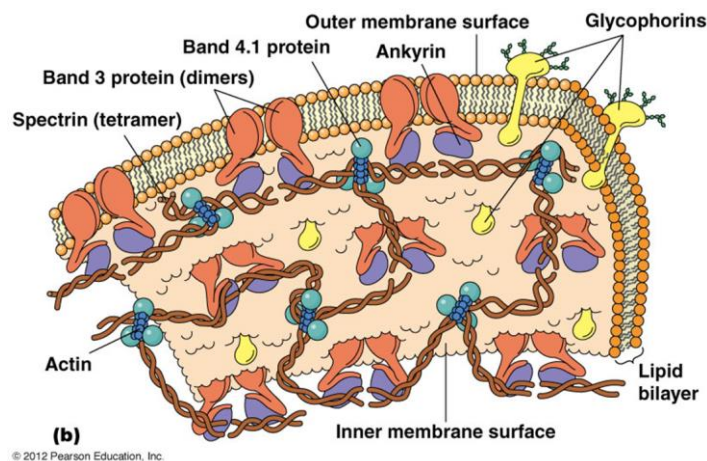
Date: 6 June 2018
 Time: 09.00-13.00

All questions in Exercises 1 to 3 have the same weight (5 pts). Questions in Exercise 4 count with 1 pt each (20 in total). None of the questions require lengthy answers so answer as precisely and concisely as possible.
 Good luck!

Exercise 1: Membranes and transport across membranes

In the capillaries of body tissue, O_2 is released by hemoglobin within the erythrocytes (red blood cells) and leaves the cell. CO_2 enters the cell and is converted to bicarbonate (H_2CO_3). Bicarbonate ions (HCO_3^-) are then transported out of the cell.

- By which processes are CO_2 transported in and HCO_3^- transported out?
- Why is HCO_3^- transported out of the cell?
- How will an erythrocyte respond when placed in a hypotonic solution?
- Below is a schematic representation of the erythrocyte lipid membrane and some associated proteins. Discuss two (general) functions of spectrin in this cell.



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Exercise 2: Cell signaling, regulation of gene expression and cancer cells

- a) Ras is a monomeric G protein that plays an important role as a second messenger in cell signaling initiated by receptor tyrosine kinases (RTK). Explain the role of such G proteins in cell signaling events.
- b) Besides the activation of Ras, RTKs can also activate phospholipase C_γ. Make a scheme of the signaling pathway, which also involves IP₃ (inositol-1,4,5 triphosphate) and DAG (diacylglycerol) as second messengers. Each of these can lead to the activation of other second messengers. One of these processes is a key event in many signaling events. Which? Include it in your scheme.
- c) Even when the transcription of a gene is said to be “off”, there is usually a low, basal level of transcription. Why is this important in relation to the synthesis of galactoside permease (carrier protein) in the lactose catabolism?
- d) DNA methylation is said to be a mechanism that reinforces the cell memory regarding gene expression patterns. Explain why.
- e) To which of the hallmarks of cancer is the lower expression of cadherins by the cancer cell related to? Justify.
- f) A major goal in cancer therapy is to identify anticancer drugs that can be used to inhibit products of specific cancer-critical genes. Should such inhibitors target the products of oncogenes or the products of tumor suppressor genes? Justify.
- g) Briefly explain primary and secondary cell culturing.

Exercise 3: Immunology, the endomembrane system, and cellular motility

- a) Macrophage motility is essential for normal development and immune function. Briefly describe the steps of cell crawling, pointing out the main players in the process.
- b) While most cells have the ability to present antigens at their cell membrane, macrophages and dendritic cells are called **professional** antigen presenting cells. Why?
- c) In the process of presenting an antigen from an intracellular pathogen to the surface, the antigen is transported from the cytosol to the lumen of the endoplasmic reticulum. Why?
- d) How are the major histocompatibility complex protein and antigen transported to the surface of the cell?
- e) Extracellular pathogens are ingested and degraded in the lysosomes of antigen presenting cells. How are lysosomes formed?

Exercise 4: 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) Bacteria cultures that are grown at low temperature are likely to produce membrane lipids with
 - a larger number of carbon atoms in the hydrocarbon chain.
 - a larger number of double bonds.
 - longer headgroups.
- b) Membrane receptors involved in signal transduction belong to the class of
 - integral membrane proteins.
 - peripheral membrane proteins.
 - lipid-anchored membrane proteins.

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- c) Active transport of substances against their electrochemical gradient can be driven by
- ATPases.
 - carrier proteins.
 - both ATPases and carrier proteins.
- d) Most proteins found in mitochondria
- are synthesized in the cytosol and post-translationally imported.
 - are synthesized in the ER and transported in coated vesicles.
 - possess a KREL tag.
- e) The intermembrane space of mitochondria is characterized by the
- large concentration of protons.
 - large concentration of ATP synthases.
 - large concentration of proteases.
- f) The function of the smooth ER includes the synthesis of
- neurotransmitters.
 - cholesterol.
 - messenger RNA.
- g) Peroxisomes are characterized by possessing
- a low pH value.
 - a large concentration of urate oxidase.
 - a large concentration of proteases.
- h) Inactivation of the Na^+ channels is important in the context of nerve transmission because
- it prevents subthreshold depolarization to initiate an action potential.
 - it allows the opening of K^+ channels and membrane repolarization.
 - it keeps the Na^+ channels closed long enough to assure the directionality of the action potential.
- i) The plasma membrane of neurons is
- equally permeable to all ions.
 - more permeable to potassium ions.
 - more permeable to sodium ions.
- j) The nodes of Ranvier are rich in
- myelin sheath.
 - voltage-gated ion channels.
 - neurotransmitters.
- k) Flagella motility is driven by
- Microtubules and dyneins.
 - Microfilaments and myosin.
 - Intermediate filaments and vimentin.
- l) Proteins enter the nucleus

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- via the nuclear pores.
- if they possess a nuclear export signal.
- via the nuclear lamina.

m) The nucleolus

- is surrounded by a thin nucleolar membrane.
- is the site for synthesizes of ribosomal proteins.
- concentrates the rRNA genes.

n) Contact between the microtubules and chromosomal kinetochores occurs

- when the nuclear envelope disintegrates.
- in the anaphase.
- when the DNA is replicated.

o) Cytokinesis begins

- in the metaphase.
- in the anaphase.
- after the telophase.

p) Apoptosis is activated by

- the binding of a growth factor to the respective receptor.
- damages to the DNA.
- the binding of antibodies to antigen

q) Tight junctions

- connect the cytoplasm of two neighbouring cells.
- seals the connection between two neighboring cells in the epithelium cell layer.
- anchors the cells to basal lamina.

r) Resistance against compression forces in tissues is due to:

- collagen.
- elastin.
- proteoglycans.

s) In some cancer cells it is observed an abnormal amplification of genes encoding proteins involved in cell signalling. Which level of gene regulation does it refer to?

- Genetic control.
- Transcriptional control.
- Translational control.

t) When a gene is under negative regulation, the effectors (ligands)

- act as inducers.
- act as repressors.
- can act both as inducers and repressors.