

NAME: _____

STUDENT #: _____

BIO 1140 Introduction to cell biology

MIDTERM #1**February 9th, 2013**

Dr. K.M. Gilmour

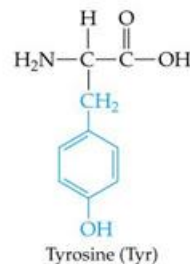
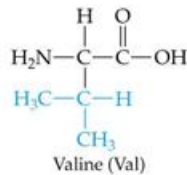
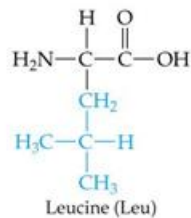
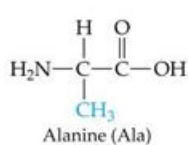
MULTIPLE CHOICE QUESTIONNAIRE KK – MARKING SCHEME**Instructions:**

1. Make sure that you have a complete test package. You should have a set of multiple choice questions with a written-answer questionnaire, and a Scantron. Both components must be returned at the end of the midterm.
2. Fill in the Scantron with your name, student number and course code **BIO 1140 KK**.

Answer the following 20 multiple choice questions **on the Scantron sheet** provided. Choose only one answer from among the choices. (20 marks)

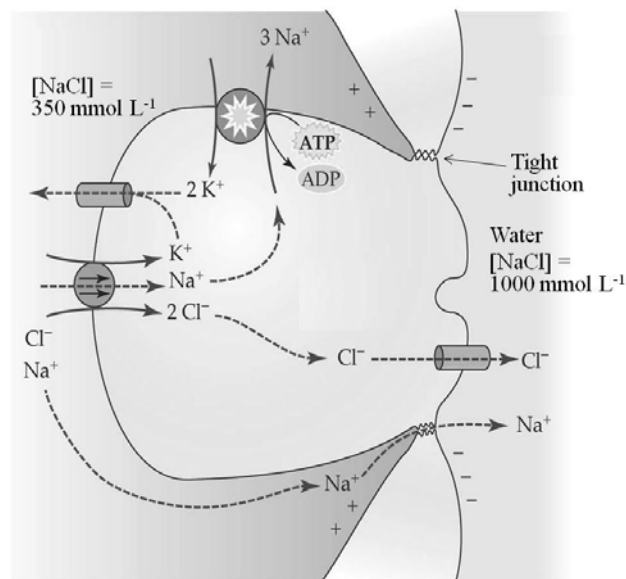
1. Which one of the following is not a model organism?
 - a. *Danio rerio*
 - b. *Saccharomyces cerevisiae*
 - c. *Caenorhabditis elegans*
 - d. *Escherichia coli*
 - e. *Elysia chlorotica*

2. Which one of the amino acids below could be phosphorylated?



- a. Alanine
 - b. Leucine
 - c. Valine
 - d. Tyrosine
3. You are attempting to characterize a novel receptor. You note that the receptor includes seven transmembrane domains. The novel receptor probably belongs to the family of...
 - a. G protein-coupled receptors
 - b. Steroid hormone receptors
 - c. Receptor tyrosine kinases
 - d. None of the above

4. In the schematic at right, Cl^- enters the cell by...
- Simple diffusion
 - Facilitated diffusion
 - Primary active transport
 - Secondary active transport**



5. You have grown a culture of *Arabidopsis thaliana* root cells and discovered that they are heavily contaminated with a mould, a type of fungus. Which one of the following procedures is most likely to eliminate the mould without killing the plant cells?
- Treating the culture with a drug that impairs chlorophyll synthesis.
 - Treating the culture with a drug that dissolves cell walls.
 - Treating the culture with a drug that damages DNA.
 - Treating the culture with a drug that inhibits ergosterol synthesis.**
 - None of a, b, c or d will eliminate the mould without killing the plant cells.
6. In an aerobic bacterium, the proteins of the electron transport chain are located...
- On the inner mitochondrial membrane.
 - In the cytosol.
 - On the plasma membrane.**
 - In the mitochondrial matrix.
 - On the outer mitochondrial membrane.
7. To investigate the nature of a membrane protein, you tag the protein with a fluorescent marker and then measure membrane fluorescence after a variety of treatments designed to detach the protein from the membrane. Treatment with phospholipase C is ineffective, as is changing the solution pH or ionic strength. Membrane fluorescence is eliminated only after the membrane is disrupted by treating it with a detergent. Which of the following conclusions is most consistent with your observations?
- The protein of interest is linked to the membrane by a glycosylphosphatidylinositol (GPI) anchor.
 - The protein of interest is an integral protein.
 - The protein of interest behaves like a peripheral protein.
 - The protein of interest is anchored to the inner (cytosolic) leaflet of the lipid bilayer via a covalent interaction with a membrane fatty acid.
 - Both b and d are consistent with your observations.**

8. Which one of the following statements about G proteins is correct?
- G proteins are heterotrimeric fatty acid-anchored membrane proteins.
 - G proteins function as molecular switches – they are active when GTP is bound to the α subunit and inactive when this GTP is hydrolyzed to GDP.
 - When activated by a cell surface receptor, a G protein dissociates into an α subunit and a $\beta\gamma$ complex.
 - All of a, b and c are true of G proteins.
 - None of a, b or c is true of G proteins.
9. To whom are the first two tenets of the Cell Theory, i.e. that all organisms are composed of one or more cells and that the cell is the structural unit of life, attributed?
- Virchow
 - Schwann and Schleiden
 - Gorter and Grendel
 - Singer and Nicolson
 - Ediden
10. A ligand-gated ion channel...
- Opens or closes in response to changes in the membrane potential of the cell.
 - Is an integral membrane protein receptor.
 - Regulates gene transcription when activated by the binding of a lipid-soluble messenger molecule.
 - Is opened or closed by the binding of a water-soluble messenger molecule.
 - Both b and d are true of ligand-gated ion channels.
11. Which one of the following macromolecules is **least** likely to be found in the cytosolic leaflet of the cell membrane?
- Sterols
 - Phosphoglycerides
 - Glycolipids
 - Proteins
 - All of the above macromolecules are equally likely to be found in the cytosolic leaflet of the cell membrane.
12. You are investigating the mechanism through which a solute (we'll call it X), exits a plant cell across the plasma membrane. You observe that the transport of X exhibits saturation kinetics, depends on the presence of both H^+ ions and ATP, and occurs even when a high concentration of X is present in the extracellular solution. The transport of X most likely occurs by:
- Simple diffusion
 - Facilitated diffusion
 - Primary active transport
 - Secondary active transport
13. The transmembrane domain of an integral membrane protein often consists of an alpha-helix sequence of nucleotides.
- True
 - False

14. A typical prokaryotic cell is...
- 0.03 mm long
 - 3×10^{-6} m long
 - 30 nm long
 - 3×10^6 μ m long
 - None of the above
15. Lactate fermentation...
- Occurs in the skeletal muscle of anoxic goldfish.
 - Regenerates NAD^+ by transferring electrons from NADH to pyruvate.
 - Results in CO_2 production as the 3-C pyruvate is decarboxylated to a 2-C molecule of acetyl-CoA.
 - All of a, b and c are true of lactate fermentation.
 - None of a, b or c is true of lactate fermentation.
16. Amphipathic refers to...
- The adjustment of membrane composition to maintain membrane fluidity at different environmental temperatures.
 - A molecule that includes both hydrophobic and hydrophilic regions.
 - The unique, three-dimensional, stable structure adopted by a polypeptide chain that allows it to acquire biological activity.
 - A membrane that allows selected molecules to pass while preventing or impeding the passage of other molecules.
17. The endosymbiont theory...
- Is supported by the fossil record, which indicates that protists evolved before eukaryotes.
 - Suggests that mitochondria may have originated as anaerobic bacteria and chloroplasts as photosynthetic bacteria that established stable, symbiotic relationships with a prokaryotic host cell.
 - Is supported by similarities between mitochondria/chloroplasts and bacteria, including the use of binary fission for reproduction.
 - Is supported by the absence of phosphoglycerides from the inner membrane of mitochondria and chloroplasts, a trait shared with the plasma membrane of bacteria.
18. Which one of the following adjustments would **not** be used by a soybean plant to maintain the same level of membrane fluidity when the temperature in the greenhouse in which the plant is growing is adjusted from 10°C to 28°C ?
- Increase the length of the hydrocarbon tails in its membrane phosphoglycerides.
 - Increase the proportion of saturated hydrocarbon tails in its membrane phosphoglycerides.
 - Increase the amount of cholesterol in the membrane.
 - Increase the proportion of phosphatidylcholine relative to phosphatidylethanolamine.
 - All of a, b, c and d would be employed by a soybean plant following a temperature change from 10°C to 28°C .

19. Adenylyl cyclase...

- a. Is a membrane-associated enzyme that produces the second messenger cAMP.
- b. Is an enzyme that catalyzes the transfer of a phosphate group from ATP to a protein.
- c. Is a cytosolic enzyme that catalyzes the breakdown of the second messenger cAMP.
- d. Is the kinase activated by cAMP.
- e. None of a, b, c or d is true of adenylyl cyclase.

20. Which one of the following statements about cell membranes is **not** correct?

- a. The two layers of the bilayer differ in protein and lipid composition, a phenomenon termed membrane asymmetry.
- b. The phospholipid bilayer constitutes a permeability barrier that can be overcome by transport proteins such as channels and pumps.
- c. Membrane glycolipids play a key role in regulating membrane fluidity.
- d. Membrane proteins serve numerous functions including cell-to-cell attachment and the detection of extracellular signals.

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WRITTEN-ANSWER QUESTIONNAIRE KK – MARKING SCHEME

Answer the following questions **on the questionnaire in the space** provided. (20 marks)

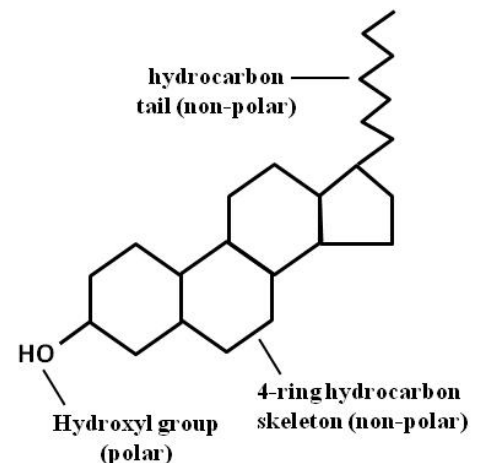
- Complete the following statements. (1 mark per answer)
 - The signalling molecule binds to the **ligand-binding domain (binding domain or binding site, 0.5 marks)** of a receptor.
 - A transport protein that carries two different solutes across the membrane in opposite directions is termed **an exchanger OR antiporter**.
 - The Na⁺,K⁺-ATPase is considered to be a **P-type (phosphorylation is fine)** pump because it is reversibly phosphorylated as part of its pumping mechanism.
 - In the process of **glycolysis**, a 6-C glucose molecule is split into two 3-C pyruvate molecules with the production of ATP and NADH.
 - To maintain membrane fluidity as temperature changes, organisms alter the chemical composition of cell membranes, a phenomenon termed **homeoviscous adaptation**.
 - NADH is **oxidized** OR reduced (**choose one**) to NAD⁺ by the loss of two electrons and a proton, with the release of energy.
- Sketch and label a sterol. Use your sketch to explain the orientation of the molecule within the cell membrane. (3 marks)

Most of the molecule is non-polar or hydrophobic and therefore is embedded in the hydrophobic region of the membrane, among the fatty acid chains of the phospholipids. (0.5 marks)

The polar or hydrophilic hydroxyl group is oriented towards the polar head groups of the phospholipids. (0.5 marks)

(1 mark for a sketch showing a 4-ring structure with a hydroxyl group at one end and a hydrocarbon chain at the other end)

(1 mark for labeling the hydroxyl group, 4-ring structure and hydrocarbon tail)



3. Distinguish between a membrane channel and a porin. (2 marks)

Membrane channels are found in the cell membrane (and intracellular membranes) of eukaryotic cells, whereas porins are found only in the outer mitochondrial membrane. (1 mark)

Porins are fairly non-selective, allowing essentially any solute to pass that is small enough to fit through the pore, whereas membrane channels are highly selective for a particular solute (or water molecules). (1 mark; note that use of “non-selective” and “selective” only, without explaining the meaning of these terms is worth only 0.5 marks)

The transmembrane domain of membrane channels consists of an alpha-helix of hydrophobic amino acid residues, whereas the transmembrane domain of porins consists of a beta-pleated sheet of hydrophobic amino acid residues. (1 mark)

Membrane channels may be gated (opened or closed), whereas porins cannot be gated. (1 mark)

Maximum 2 marks. For full marks, a clear contrast between channels and porins must be drawn.

4. You hypothesize that the increase in heart rate that occurs during a “fight-or-flight” response is mediated by a G protein-coupled receptor that uses cAMP as its second messenger. Design an experiment to test this hypothesis. Briefly describe the experimental approach that would be taken, the rationale for this experimental approach, and the expected results. (4 marks)

The experimental approach would involve measuring heart rate (1 mark) while using experimental treatments that manipulate a G protein-coupled receptor pathway that uses cAMP as a second messenger. If the experimental treatment affects heart rate, then it is likely that the signalling pathway involves a G protein-coupled receptor and cAMP.

In this signalling pathway, the activated receptor activates a G protein that in turn activates the enzyme adenylyl cyclase (AC). Adenylyl cyclase catalyzes the production of cAMP from ATP, and cAMP then binds to protein kinase A (PKA) to activate it. Protein kinase A then activates other pathways in the cell causing heart rate to increase. Phosphodiesterase catalyzes the breakdown of cAMP to AMP. (1 mark for details of the signalling pathway relevant to the experimental treatment chosen)

Possible experimental treatments could include:

- Use of a non-hydrolyzable analogue of GTP (0.5 marks). This treatment would be expected to increase heart rate by turning on the G protein in a permanent fashion. (1 mark)
 - o This approach is not ideal because it would affect any G protein-coupled receptor pathway, not just those using cAMP as the second messenger.
- Addition of a cAMP analogue (1 mark). This treatment would be expected to increase heart rate (1 mark).
- Use of an AC activator (1 mark). This treatment would be expected to increase heart rate by increasing the production of cAMP. (1 mark)
- Use of an AC inhibitor (1 mark). This treatment would be expected to decrease heart rate by reducing the production of cAMP. (1 mark)
- Addition of phosphodiesterase (or an activator of phosphodiesterase) (1 mark). This treatment would be expected to decrease heart rate by increasing the rate of cAMP removal. (1 mark)

- Addition of a phosphodiesterase inhibitor (such as caffeine) (1 mark). This treatment would be expected to increase heart rate by reducing the rate of cAMP removal. (1 mark)
- Addition of a PKA activator (1 mark). This treatment would be expected to increase heart rate. (1 mark)
- Addition of a PKA inhibitor (1 mark). This treatment would be expected to decrease heart rate. (1 mark)

Maximum 4 marks. For full marks, an experimental approach linked to a rationale (i.e. we will do this experiment because it will allow us to get this information) and expected results are needed.

5. Discuss the structure of the plasma membrane with respect to its function as a permeability barrier that selectively regulates the entry and exit of solutes. (5 marks)

The plasma membrane consists of a fluid lipid bilayer containing a mosaic of proteins.

The lipid bilayer consists of amphipathic phosphoglycerides and sphingolipids (or phospholipids as a general term for both) (1 mark) oriented so that their hydrophilic head groups face the aqueous medium on either side of the membrane, while their hydrophobic tail regions form the core of the membrane (1 mark). Sterols and/or glycolipids may also be present; again, these are amphipathic molecules that are oriented in the membrane in the same fashion as phospholipids (1 mark).

Thus, hydrophilic molecules have to penetrate the hydrophobic core of the membrane to cross it. This is not favoured thermodynamically and allows the bilayer to act as a permeability barrier. (1 mark)

The plasma membrane is a selectively permeable barrier owing to the presence of transport proteins (integral transmembrane proteins) that allow the passage of specific hydrophilic molecules across the membrane (1 mark), with or without the expenditure of energy (i.e. up or down diffusion gradients).

They include channel proteins that provide a hydrophilic channel through the membrane through which water molecules or selected ions can move down their diffusion gradient (1 mark). They also include carrier proteins that bind specific solutes and move them across the membrane down their diffusion gradient (1 mark). They also include pumps that bind specific solutes and move them across the membrane against the diffusion gradient by hydrolyzing ATP to provide the necessary energy (1 mark). Pumps and carriers may also work together in secondary active transport mechanisms.

Changes in temperature can affect membrane fluidity; increases in membrane fluidity result in increases in permeability (1 mark). Similarly, changes in membrane composition (e.g. fatty acid chain length or saturation, or type of head group on phospholipids) can affect membrane fluidity; changes that tend to increase membrane fluidity will result in increases in permeability (1 mark).

Maximum 5 marks. For full marks, structure (e.g. lipid bilayer, transport proteins) must be linked to function (e.g. permeability barrier, selective permeability, respectively).