NAME: _____ **STUDENT #:** _____

BIO 1140 Introduction to cell biology

MIDTERM #1

February 9th, 2013

Dr. K.M. Gilmour

MULTIPLE CHOICE QUESTIONNAIRE GG

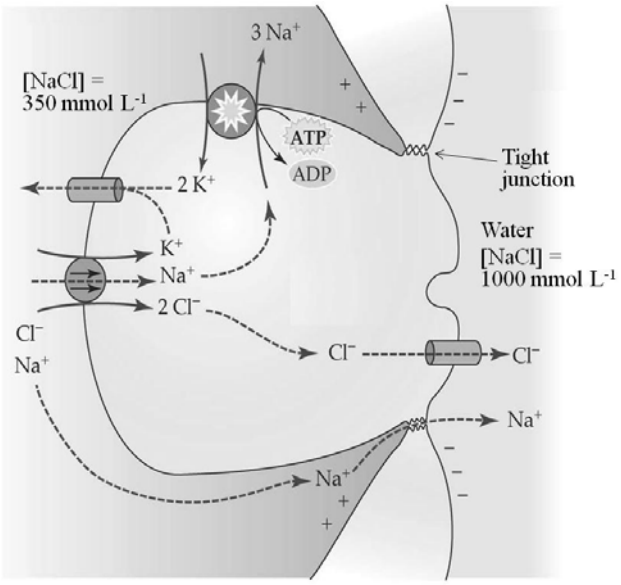
Instructions:

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 GG**.

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

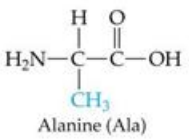
1. Which one of the following is not a model organism?
   a. *Drosophila melanogaster*
   b. *Mus musculus*
   c. *Ambystoma maculatum*
   d. *Arabidopsis thaliana*
   e. *Escherichia coli*

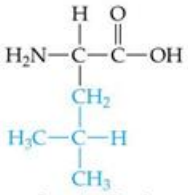
2. In the schematic at right, Cl^- enters the cell by means of…
   a. A channel
   b. An exchanger
   c. A co-transporter
   d. A uniporter

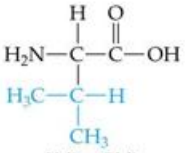


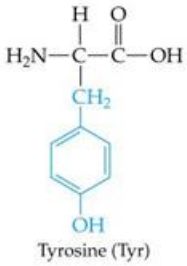
3. A voltage-gated ion channel...
   a. Opens or closes in response to changes in the membrane potential of the cell.
   b. Is an integral membrane protein receptor.
   c. Contains one or more transmembrane domains rich in hydrophobic amino acid residues.
   d. Is opened or closed by the binding of a water-soluble messenger molecule.
   e. Both a and c are true of voltage-gated ion channels.

4. Which one of the amino acids below would you **not** expect to find in the transmembrane domain of an integral membrane protein?


Alanine (Ala)


Leucine (Leu)


Valine (Val)


Tyrosine (Tyr)

   a. Alanine
   b. Leucine
   c. Valine
   d. Tyrosine

5. Which one of the following statements about G proteins is correct?
   a. G proteins are heterotrimeric peripheral membrane proteins.
   b. G proteins function as molecular switches – they are active when ATP is bound to the α subunit and inactive when this ATP is hydrolyzed to ADP.
   c. When activated by a cell surface receptor, a G protein dissociates into an αβ complex and a γ subunit.
   d. All of a, b and c are true of G proteins.
   e. None of a, b or c is true of G proteins.

6. In an aerobic bacterium, the enzymes that catalyze pyruvate oxidation and the citric acid cycle are located…
   a. On the inner mitochondrial membrane.
   b. In the cytosol.
   c. On the plasma membrane.
   d. In the mitochondrial matrix.
   e. On the outer mitochondrial membrane.

7. To investigate the nature of a membrane protein, you treat an isolated membrane with the enzyme phospholipase C and then probe the membrane with a fluorescent marker for the protein of interest. No fluorescence is detected. By contrast, membranes probed with the fluorescent marker after changes in solution pH or ionic strength show a strong fluorescent signal. Which one of the following conclusions is consistent with your observations?
   a. The protein of interest behaves like a peripheral protein.
   b. The protein of interest is linked to the membrane by a glycosylphosphatidylinositol (GPI) anchor.
   c. The protein of interest is anchored to the inner (cytosolic) leaflet of the lipid bilayer via a covalent interaction with a membrane fatty acid.
   d. The protein of interest is an integral protein.
   e. Both b and d are consistent with your observations.

8. The fluid mosaic model of the cell membrane was proposed by:
   a. Virchow
   b. Schwann and Schleiden
   c. Gorter and Grendel
   d. Singer and Nicolson
   e. Ediden

9. You are attempting to characterize a novel receptor. You note that the receptor includes a ligand-binding domain and a single transmembrane domain, and that dimerization occurs when the receptor is activated. 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

10. Alcoholic fermentation…
   a. Occurs in the skeletal muscle of anoxic goldfish.
   b. Regenerates NAD^+ by transferring electrons from NADH to pyruvate.
   c. Results in CO_2 production as the 3-C pyruvate is decarboxylated to a 2-C molecule of acetyl-CoA.
   d. All of a, b and c are true of alcoholic fermentation.
   e. None of a, b or c is true of alcoholic fermentation.

11. Which one of the following molecules would be equally distributed between the two leaflets of the cell membrane?
   a. Cholesterol
   b. Phosphatidylcholine
   c. Glycolipids
   d. Sphingomyelin
   e. All of the above would be equally distributed between the two leaflets of the cell membrane.

12. Phosphodiesterase…
   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 phosphodiesterase.

13. You have grown a culture of *Danio rerio* gill cells and discover that they are heavily contaminated with bacteria. Which one of the following procedures is most likely to eliminate the bacteria without killing the fish cells?
   a. Treating the culture with a drug that damages DNA.
   b. Treating the culture with a drug that dissolves cell walls.
   c. Treating the culture with a detergent that destroys cell membranes.
   d. Treating the culture with a drug that causes the cytoskeleton to disassemble (break down)
   e. None of a, b, c or d will eliminate the bacteria without killing the fish cells.

14. The fluid-mosaic model describes the plasma membrane as…
    a. A lipid bilayer coated on both sides with thin sheets of protein
    b. A cholesterol-rich lipid-protein assembly held together by covalent bonds
    c. A lipid bilayer studded with a unique complement of proteins
    d. A fluid protein layer encased in a mosaic of lipids
    e. None of the above describes the fluid-mosaic model

15. A typical eukaryotic cell is...
    a. 30 nm in diameter
    b. 3×10^{6} µm in diameter
    c. 0.03 mm in diameter
    d. 3×10^{-6} m in diameter
    e. None of the above

16. Homeoviscous adaptation refers to...
    a. The adjustment of membrane composition to maintain membrane fluidity at different environmental temperatures.
    b. A molecule that includes both hydrophobic and hydrophilic regions.
    c. The unique, three-dimensional, stable structure adopted by a polypeptide chain that allows it to acquire biological activity.
    d. A membrane that allows selected molecules to pass while preventing or impeding the passage of other molecules.

17. Which one of the following statements about cell membranes is **not** correct?
    a. Membrane proteins serve numerous functions including cell-to-cell attachment and the detection of extracellular signals.
    b. The chemical composition of membranes differs between organelles, between cells, and even between the two layers of the bilayer.
    c. The fluidity of the membrane is determined by the extent of covalent bonding among membrane components as well as the length and degree of saturation of fatty acid chains in phospholipids.
    d. The lipid bilayer functions as a permeability barrier because it is difficult for hydrophilic molecules to traverse its hydrophobic core.

18. The ligand-binding domain of a membrane receptor often consists of an alpha-helix sequence of hydrophobic amino acid residues.
    a. True
    b. False

19. Which one of the following adjustments would **not** be used by a rainbow trout to maintain the same level of membrane fluidity following transfer from water of 20°C to water of 5°C?
    a. Increase the glycolipid content of the membrane.
    b. Increase the proportion of unsaturated hydrocarbon tails in its membrane phosphoglycerides.
    c. Increase the cholesterol:phosphoglyceride ratio.
    d. Increase the proportion of phosphatidylethanolamine relative to phosphatidylcholine.
    e. All of a, b, c and d would be employed by a rainbow trout transferred from 20°C to 5°C.

20. Following transfer to an unknown solution, a human red blood cell rapidly shrivels and shrinks. The cytoplasm of the red blood cell...
    a. Was more concentrated than the unknown solution.
    b. Was hypotonic relative to the unknown solution.
    c. Contained a solute concentration that was higher than that of the unknown solution.
    d. Was isotonic with the unknown solution.
    e. None of the above adequately describes the cytoplasm of the red blood cell

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WRITTEN-ANSWER QUESTIONNAIRE GG

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

1. Complete the following statements. (1 mark per answer)
   a. Binding of the signal molecule to the receptor is followed by **signal transduction (transduction is fine)**, the process of translating the signal into a cellular response.
   b. A **protein kinase (kinase is fine)(tyrosine kinase or protein kinase A, 0.5 marks)** phosphorylates a protein by catalyzing the transfer of Pi from ATP to the protein.
   c. Receptors activated by **hydrophobic OR lipid-soluble** signalling molecules bind to specific response elements within DNA to regulate gene transcription.
   d. In the process of **photosynthesis**, light energy is transformed into chemical energy.
   e. A molecule that has both hydrophobic and hydrophilic regions is said to be **amphipathic**.
   f. NAD^+ is oxidized OR reduced (**choose one**) to NADH by the gain of two electrons and a proton, with the input of energy.

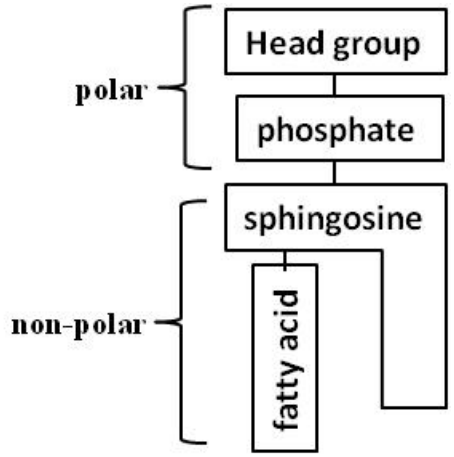
2. Sketch and label a sphingolipid. Use your sketch to explain the orientation of the molecule within the cell membrane. (3 marks)

The non-polar or hydrophobic regions of the molecule (the sphingosine backbone and the single fatty acid) contribute to the hydrophobic interior of the membrane. (0.5 marks)

The polar or hydrophilic head group/phosphate is oriented so that it faces towards the aqueous medium on one side or the other of the membrane. (0.5 marks)

(1 mark for head group and phosphate group, labeled appropriately)

(1 mark for the sphingosine backbone and single fatty acid, labeled appropriately)



3. Distinguish between ATP and cAMP. (2 marks)

Whereas in ATP, three phosphate groups are attached to the ribose sugar, in cAMP only one phosphate group is attached to the ribose, but it is attached to two different carbons. (1 mark)

Whereas ATP functions primarily as the energy currency of the cell, cAMP functions as an intracellular signaling molecule or second messenger. (1 mark)

Whereas cAMP can be broken down by phosphodiesterase, ATP cannot. (1 mark)

Maximum 2 marks. For full marks, a clear contrast between ATP and cAMP must be drawn.

4. You hypothesize that glucose enters active muscle cells by means of a facilitated diffusion mechanism. 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 glucose movement (1 mark) under conditions designed to differentiate between simple diffusion and facilitated diffusion, and facilitated diffusion and active transport.

Transport by facilitated diffusion or active transport involves a transport protein, whereas no transport protein is required for simple diffusion. Thus, a first step would be to gather evidence to determine whether a transport protein is involved. (1 mark)

Transport using a transport protein exhibits saturation kinetics whereas a linear relationship between rate of movement and diffusion gradient is observed for simple diffusion. Measuring the rate of movement at different concentrations of glucose to generate a plot of rate of transport vs concentration gradient would indicate whether a transport protein is involved. (1 mark)

Transport using a transport protein can be inhibited whereas simple diffusion cannot. Measuring the rate of movement of glucose in the presence/absence of a known inhibitor of glucose transporters would indicate whether a transport protein is involved. (1 mark; note that removal of the transport protein from the membrane is not an acceptable strategy because it would require destruction of the membrane)

If a transport protein is involved, then it is necessary to distinguish between facilitated diffusion and active transport.

Active transport requires ATP whereas facilitated diffusion does not. Measuring the rate of movement of glucose in the presence of a non-hydrolyzable analogue of ATP, or following inhibition of ATP synthesis (e.g. with sodium cyanide) would allow facilitated diffusion to be distinguished from active transport (1 mark; removal of ATP 0.5 marks). Transport by facilitated diffusion would continue, whereas transport by active transport would stop. (1 mark)

Whereas facilitated diffusion occurs with the diffusion gradient and the direction of movement can be reversed by reversing the diffusion gradient, active transport occurs against the diffusion gradient and cannot be reversed. Measuring the rate of movement of glucose following the addition or removal of glucose from the extracellular environment (to reverse the diffusion gradient) would allow facilitated diffusion to be distinguished from active transport (1 mark). Transport by active transport would be unaffected by these treatments, whereas the direction of movement would be reversed if transport was by facilitated diffusion. (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. Also, for full marks it is necessary to distinguish between simple diffusion and movement that involves a carrier protein, and between facilitated diffusion and active transport.

5. Contrast and compare kleptoplasty and the endosymbiotic origin of chloroplasts. (5 marks)

Kleptoplasty refers to the acquisition by the sea slug *Elysia chlorotica* of chloroplasts from the algae it eats (1 mark). The relationship is endosymbiotic because the chloroplasts become established in the cells of the intestine of the sea slug and function in photosynthesis. (1 mark)

Similarly, chloroplasts are thought to have originated as cyanobacteria that were engulfed by a larger, "prokaryotic" (neither fully prokaryotic nor fully eukaryotic; either is fine) cell and rather than being degraded, established an endosymbiotic relationship. (1 mark)

Despite this basic similarity, there are a number of differences between kleptoplasty and the endosymbiotic origin of chloroplasts.

Whereas the cyanobacteria that became chloroplasts were passed down to subsequent generations, each generation of sea slugs must acquire its own chloroplasts from the algae it eats. (1 mark)

Also, whereas the cyanobacteria that became chloroplasts divide within the cell (by binary fission) to give additional chloroplasts, the chloroplasts acquired by sea slugs do not divide. (1 mark)

In kleptoplasty, animal cells acquire a fully functional organelle, whereas the endosymbiotic origin of chloroplasts involved a prokaryotic cell acquiring another prokaryotic cell that gradually morphed into an organelle. (1 mark)

In kleptoplasty, a multicellular organism acquires organelles from another cell; the algal cells have to be broken down to extract the chloroplasts. By contrast, the origin of chloroplasts involved a single cell engulfing another single cell (1 mark). This difference is perhaps less marked at the level of the intestinal cells of the sea slug, where individual intestinal cells gain chloroplasts that have already been extracted from the algal cells. (1 mark)

Maximum 5 marks. For full marks, direct comparisons (similarities or differences) must be made between kleptoplasty and the origin of chloroplasts, i.e. it is not sufficient to simply describe one phenomenon and then the other.