UNIVERSITY OF TORONTO
FACULTY OF ARTS AND SCIENCE
BIOCHEMISTRY 210HF

SECOND MID-TERM EXAMINATION: November 14th, 2006
TOTAL DURATION: 1 HOUR

EXAMINER: DR. R. REITHMEIER

Candidates may use simple calculators (supplied by candidates).

This examination is worth 15% of the final grade in the course. There are 15 multiple-choice questions worth ONE mark each for a total of 15 marks.

For the multiple-choice questions you are to choose ONE answer for each question and fill in the appropriate circle on the computer card provided with a soft lead pencil **(not pen!)**. Marks are not deducted for wrong choices.

It is NOT a good idea to leave the entering of your answers on the computer card until the last few minutes of the exam. We cannot help you if you make transcriptional errors.

Please answer all the questions.

When you are not entering answers on your card, please cover the answer card with your question paper.

Please note that the examiner has made every effort to have only one answer per question. However, if you are convinced that a particular question may have two possible answers, it is in your best interest to select the answer that seems MOST appropriate. Do NOT skip the question.

Biochemistry 210 Mid-term Examination

Lipids and Biological Membranes

Dr. Reinhart Reithmeier

Instructions: For each of the following 15 questions, which single statement is <u>NOT</u> correct? (1 mark each, 15 marks total)

1. As we learned in the lectures, lipids are an incredibly diverse set of structures and even relatively small changes can affect their properties.
    a) Fatty acids with longer acyl chains have a higher melting temperature, therefore palmitic acid (C16:0) melts at a lower temperature than stearic acid (C18:0).
    b) Fatty acids with double bonds have a lower melting temperature, therefore oleic acid (C18:1) melts at a lower temperature than stearic acid (C18:0).
    c) Fatty acids typically occurring in nature contain mainly trans, not cis double bonds.
    d) Fatty acids are components of triglycerides, phospholipids and sphingolipids.
    e) Some polyunsaturated fatty acids such as arachidonic acid (C20:4) are required in the diet.

2. Cholesterol has been getting a lot of bad press recently. We know better.
    a) Cholesterol is an important component of biological membranes, where it acts to modulate membrane fluidity.
    b) Cholesterol is a precursor for both steroid and prostaglandins.
    c) Cholesterol is a rigid, planar molecule due to its fused 4-ring structure.
    d) Cholesterol affects the packing of phospholipids in biological membranes.
    e) Cholesterol is mostly synthesized in the body and can also come from our diet.

3. Biological membranes consist of an asymmetric lipid bilayer.
    a) Phospholipids consist of a glycerol backbone, two non-polar fatty acyl chains and a polar headgroup.
    b) Choline has a positive charge, creating the zwitterionic phospholipid, phosphatidylcholine.
    c) Phospholipids can move laterally in the membrane but can also flip-flop spontaneously across the bilayer.
    d) Phospholipids can undergo a temperature-dependent phase transition between a gel and liquid-crystalline state.
    e) Phospholipids can form a lipid bilayer when suspended in water upon sonication.

Cont'd...

4. Membrane proteins are quite different from their soluble cousins.
   a) Membrane proteins can be grouped into integral and peripheral types.
   b) Membrane proteins can contain lipid anchors that attach them to the membrane.
   c) Different membrane proteins found in nature can span lipid bilayers from one to 24 times.
   d) Membrane proteins are found in nature as mainly helical bundles but also as beta-barrels in some bacteria.
   e) Membrane proteins cannot diffuse in the plane of the membrane.

5. Amino acids can be grouped according to their hydrophobicity (Kyte-Doolittle) and also by their secondary structure propensity (Chou/Fasman).
   a) Leucine is hydrophobic and a good helix former.
   b) Lysine is hydrophilic and a good helix former.
   c) Isoleucine and valine are hydrophilic and poor helix formers.
   d) Glycine is neither hydrophobic nor hydrophilic and is a poor helix former.
   e) Proline is hydrophilic and a poor helix former.

6. Integral membrane proteins such as those found in the red blood cell membrane usually contain transmembrane segments with some common features.
   a) Transmembrane segments are hydrophobic.
   b) Transmembrane segments are alpha-helical in conformation.
   c) Transmembrane segments typically contain ~7 amino acid residues.
   d) Transmembrane segments may contain glycine residues that mediate specific interactions between transmembrane segments.
   e) Transmembrane segments can contain polar or even charged residues that usually have an important functional role.

7. Membrane proteins carry out many essential functions.
   a) They can act as receptors, channels and transporters.
   b) They are often present in low concentration, but there are some exceptions.
   c) They can be solubilized and purified in the native state using hydrophobic organic solvents.
   d) They can be purified and then crystallized in the presence of detergents.
   e) They can often be expressed to high levels in transfected cells.

8. Sodium dodecyl sulfate (SDS) is a very useful reagent in membrane research.
   a) SDS is a strong, ionic detergent.
   b) SDS denatures proteins causing them to unfold.
   c) SDS disrupts membrane protein-lipid interactions, thereby efficiently solubilizing membranes.
   d) SDS gel electrophoresis can be used to separate proteins based on their intrinsic charge.
   e) SDS dissociates oligomeric proteins into subunits.

Cont'd...

9. Glycophorin A is an abundant glycoprotein found in the plasma membrane of human red blood cells.
    a) Glycophorin A contains a single transmembrane segment.
    b) Glycophorin A contains N- and O-linked sugars in its amino-terminal region that faces the cell interior.
    c) Glycophorin A contains a highly charged carboxyl-terminal tail that is located in the cytoplasm.
    d) Glycophorin A exists as a dimer in the membrane, held together by specific interactions between the transmembrane regions.
    e) Glycophorin A displays negative charges on the cell surface to prevent red blood cells from aggregating.

10. Bacteriorhodopsin is a well-characterized membrane protein.
    a) Bacteriorhodopsin is a light-driven proton pump.
    b) Bacteriorhodopsin is a single polypeptide that spans the membrane 12 times.
    c) Bacteriorhodopsin contains a prosthetic group, retinal that is covalently attached to lysine via a Schiff's base linkage.
    d) Light induces a trans-cis isomerization in retinal that results in a proton being transferred outward to an external site.
    e) Bacteriorhodopsin exists as a "2-dimensional" crystal in the membrane of certain bacteria.

11. Few high-resolution structures are currently available for integral membrane proteins. Some of the reasons for this are:
    a) Natural membrane proteins are often expressed at low levels.
    b) Integral membrane proteins need to be solubilized with detergents, which may alter their structure.
    c) Membrane proteins often require specific lipids for stability and proper function, and these lipids may be lost during purification.
    d) Membrane proteins are difficult to crystallize.
    e) Except for some small beta-barrel membrane proteins, most membrane proteins are too small for high-resolution NMR analysis.

12. The structure of the KscA potassium channel from *S. lividans* has revealed a number of important features:
    a) The channel is a tetramer of four identical subunits, each containing two transmembrane segments.
    b) The transmembrane segments are alpha-helical in conformation.
    c) The channel contains a pore at the centre of the tetramer.
    d) The potassium ion is bound by amino groups donated by exterior polypeptide loops that fold into the pore.
    e) The channel is selective for potassium ions and is unable to efficiently transport sodium ions.

Cont'd...

13. Some membrane proteins such as alpha-hemolysin do not contain transmembrane alpha-helices.
    a) Alpha-hemolysin is a toxin produced by *Staphylococcus aureus*.
    b) Alpha-hemolysin contains a beta-barrel that forms a water-filled channel.
    c) Alpha-hemolysin consists of 7 identical subunits, each contributing 2 beta-strands to the pore.
    d) The pore is too small in diameter to allow leakage of molecules like ions, ATP and amino acids from the cell.
    e) The beta-barrel is long enough (28Å) to span the thickness of the hydrophobic region of a lipid bilayer.

14. Membrane proteins play an important role in the transport of compounds across biological membranes.
    a) The passive diffusion of polar compounds across a lipid bilayer is very fast.
    b) Membrane transport can be classified as active or passive.
    c) Membrane proteins such as the sodium-potassium ATPase use the energy of ATP to pump ions against their concentration gradients.
    d) Secondary active transport systems use a sodium gradient to co-transport sugars and amino acids into cells.
    e) Channels allow the passage of specific ions down their concentration gradients.

15. Membrane proteins play a key role in transmembrane signalling.
    a) Membrane proteins act as receptors for specific hormones or first messengers that enter the cell.
    b) Binding of the hormone induces a conformational change in the receptor.
    c) The signal often affects an enzyme that can create a second messenger.
    d) Some examples of second messengers found inside cells are calcium ions, cAMP and IP_3, whose level is controlled by hormone action.
    e) Certain phospholipids and their breakdown products can act as signaling molecules.

END