MID-TERM EXAM 2 - 10/17/01
C484, Fall 2001 NAME_____

You will have 1 hour to complete this exam. There are **13** pages containing 4 questions worth 100 points and bonus questions worth 15 points. A page of reference material is provided at the end of the exam. Please answer the questions in the space provided. There is a blank page at the back in case you need additional space. Be sure to indicate that you have completed a problem on this page to insure that you receive credit for the work. Please show all of your work, including units, in order to receive full credit. You may use a calculator but you may NOT share a calculator with your neighbor.

READ THE QUESTIONS CAREFULLY! In several cases, you have the choice of which question you want to answer.

Pace yourself. Many of the questions have multiple parts, so do what you can on one question and then move to the next. The exam will most likely take you the full hour to complete.

Please try to be neat. If we cannot read your writing, we cannot award you credit for your answer.

Concerns have been raised about academic misconduct in this course. Please sign below to indicate that you have read and agree to abide by ALL ASPECTS of the Code of Student Rights, Responsibilities and Conduct. (appended)

I agree to uphold the highest levels of ethical conduct for myself and recognize that knowingly letting others cheat off of me constitutes misconduct (See point III.A.6).

_____ _____
signature date

Question 1	_____/15
Question 2	_____/25
Question 3	_____/30
Question 4	_____/30
Bonus	_____/15
TOTAL:	_____/100

1) Define **any 5** the following terms: **(3pts. each/15 pts. total)**

a) terpene

b) homoglycan

c) unilamellar vesicle

d) flippase

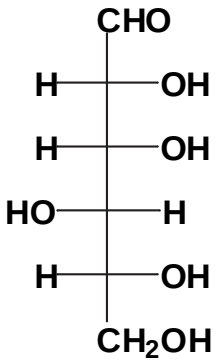
e) glycosidase

f) integral membrane protein

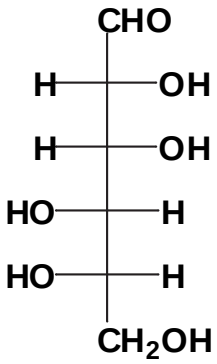
g) phosphatide

h) secondary active transport

2) The structures of L-mannose and D-gulose are shown below in Fischer projection. Answer the following questions about these two sugars. **(25 pts)**



D-gulose



L-mannose

a) Of these two hexoses, you would expect to find only one in a normal *E. coli*. Which one would you find and why would you not find the other one? **(2 pts)**

b) Draw an arrow on the structure above indicating the reaction that occurs to generate α-D-gulopyranose. **(3pts)**

c) Describe in words the difference between the reactions that form the α- and β-anomers of D-gulopyranose. **(3 pts)**

d) Draw the Haworth projection of α-D-gulopyranose formed as a result of the reaction in part b. **(4 pts)**

e) What is the name of the organic functional group generated during the reaction in part b? **(2.5 pts)**

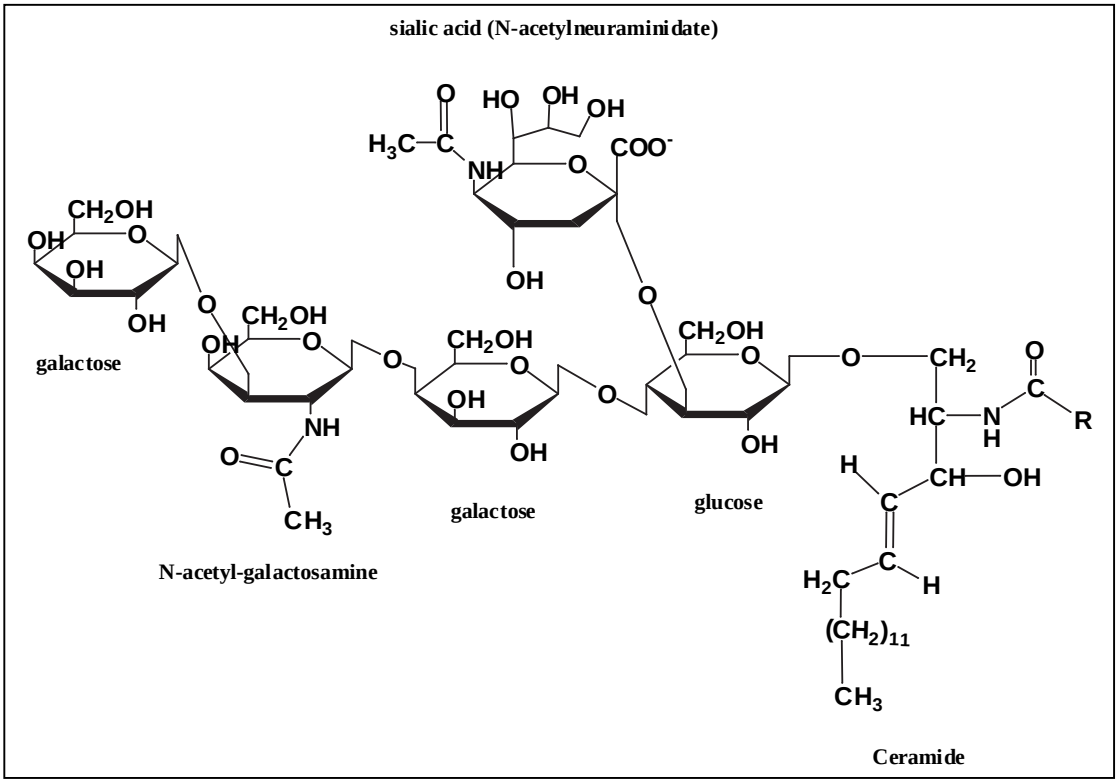
f) Identify the C-2 position by placing a "2" next to the appropriate carbon in your structure in part d. **(2 pts)**

g) Circle all of the chiral carbons on your structure from part d. **(2.5 pts)**

h) How are the two sugars above related to one another stereochemically? **(3 pts)**

I) How is D-gulose related (stereochemically) to D-glucose? **(3 pts)**

3) Shown below is the structure of a ganglioside called G_{M1} found as a component of the membranes in nerve endings. Answer the following questions about this molecule. C-H protons on the sugars have been removed for clarity. **(30 pts)**



a) Fill in the appropriate information to describe the linkages in the ganglioside above. **(8 pts)**

(galactose = Gal, glucose = Glc, N-Acetylgalactosamine = GlcNAc, Sialic acid = Sia)

Gal-_____-(_____→_____) GalNAc

GalNAc-_____-(_____→_____) Gal

Gal-_____-(_____→_____) Glc

Sia-_____-(_____→_____) Glc

b) To what class of lipids does G_{M1} belong? **(2 pts)**

c) In the case of G_{M1} R can be any number of different fatty acid constituents. For the sake of argument, let's say that the R group is the fatty acid linoleic acid, also known as $18{:}2\Delta^{9,12}$. Draw the structure of this fatty acid. **(6 pts)**

d) Lipid bilayers are asymmetric. How would you expect to find G_{M1} oriented in the plasma membrane of a neuron? **(2 pts)**

e) Compare and contrast the G_{M1} to phosphatidylcholine. Things to discuss include: backbone, headgroups, fatty acid components, chemical properties and biological function. **Tabular answers are preferred (and efficient). (12 pts)**

$$\text{-O-CH}_2\text{-CH}_2\text{-N(CH}_3)_3^+.$$

4) One of the primary functions of a membrane is to separate self from not-self and to allow the cell to control the interior environment regardless of the extracellular conditions. Answer the following questions about membranes, transport across membranes and what happens when a toxin targets a membrane as a way to disrupt a host cell. **(30 pts)**

a) The free energy for passive diffusion of a charged molecule is described by the equation below. Define C_1, C_2, Z, *F* and $\Delta\Psi$ and explain the physical origin of the two terms of this equation. **(6 pts)**

$$\Delta G = G_2 - G_1 = RT\ln[C_2]/[C_1] + ZF\Delta\Psi$$

b) How would the equation for the driving force for passive diffusion differ if the solute (the molecule being transported) were neutral? **(4 pts)**

c) You are unsure whether glucose is absorbed by a particular cell type via a passive diffusion or facilitated transport mechanism. Describe a simple experiment that you can perform that will differentiate between these two modes of uptake. Include a sketch of a plot that depicts the expected result for each case. Label the lines "passive" and "facilitated". **(6 pts)**

d) Insulin works by increasing the number of glucose transporter proteins in the plasma membranes of certain cell types. Assuming you are working with insulin responsive cells, illustrate the effect of insulin exposure on your plot above. Label the plot "+ insulin" and explain the observed differences between data +/- insulin. **(4 pts)**

e) Active transport of sodium and potassium ions uses ATP to drive the motion of the ions against the gradient. Describe how ATP hydrolysis is coupled to the mechanical pumping action catalyzed by the transport protein. **(4 pts)**

f) Glucose uptake by the brush border cells in the intestines is thermodynamically coupled to motion of sodium ions. Sketch a diagram that illustrates the motion of Na^+ and glucose through the transporter and explain how glucose is absorbed by these cells. **(4 pts)**

g) Describe what ultimately is the energy source that drives glucose uptake. **(2 pts)**

BONUS QUESTIONS (Answer one or both as time allows. Each is worth up to 10 pts but there is a maximum of 15 bonus pts.):

A) Bacterial and plant cell walls are essential for survival of their respective cell types. Compare and contrast the structure of the biopolymers that make up these two structures. Be sure to tell me what repeating units make up these macromolecules, how they are connected and what they are called. **Tabular answers are preferred**.

B) Compare and contrast the thermodynamic driving forces for protein folding of globular proteins to those of membrane proteins.

Physical constant and data that might be required for certain problems on this exam.

Concentrations of metabolites

Metabolite	Conc. μM
1,3-bisphosphoglycerate	1.0
2-phosphoglycerate	30
3-phosphoglycerate	120
ADP	140
ATP	1850
Dihydroxyacetone phosphate	140
Fructose-1,6-P	31
Fructose-6-P	14
Glucose	5000
Glucose-6-P	83
Glyceraldehyde-3-P	19
Glycerol-3-phosphate	25
Lactate	2900
NAD^+	540
NADH	50
Phosphoenolpyruvate	23
P_i	1000
Pyruvate	51

Standard Free Energies of hydrolysis for common metabolites

Metabolite	$\Delta G°'_{hyd.}$ kJ mol^{-1}
Phosphoenolpyruvate	-62
1,3-bisphosphoglycerate	-49
Phosphocreatine	-43
Pyrophosphate	-33
Phosphoarginine	-32
ATP → AMP + PP_i	-32
Acetyl-CoA	-32
ATP → ADP + P_i	-30
Glucose-1-Phosphate	-21
Glucose-6-Phosphate	-14
AMP → Adenosine + P_i	-14
Glycerol-3-phosphate	-9

Amino Acid Hydrophathies

Amino Acid Hydropathy	KJ/mol
Alanine	1.0
Arginine	-7.5
Asparagine	-2.7
Aspartic Acid	-3.0
Cysteine	0.17
Glutamic Acid	-2.6
Glutamine	-2.9
Glycine	0.67
Histidine	-1.7
Isoleucine	3.1
Leucine	2.2
Lysine	-4.6
Methionine	1.1
Phenylalanine	2.5
Proline	-0.29
Serine	-1.1
Threonine	-0.75
Tryptophan	1.5
Tyrosine	0.08
Valine	2.3

Constants:

$R = 8.315\ J\ mol^{-1}\ K^{-1}$

$F = 96.48\ kJ\ V^{-1}\ mol^{-1}$

$\mathbf{k} = 1.381 \times 10^{-23}\ J\ K^{-1}$

Conversion Factors:

1 cal = 4.184 J

T in K = °C + 273

Relevant Equations:

$pH = pK_a + \log[A^-]/[HA]$

$\Delta G°' = -RT\ln(K_{eq})$

$\Delta G = \Delta G°' + RT\ln(Q)$

$\Delta G°' = \Delta G° +/- RT\ln[H^+]$