

Chemistry and Biochemistry 153A  
Winter 2011

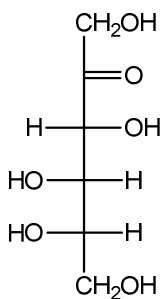
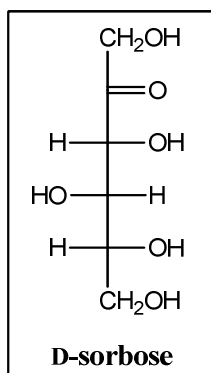
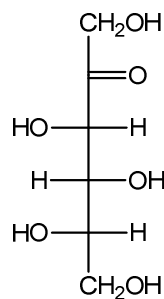
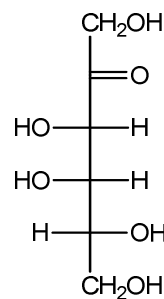
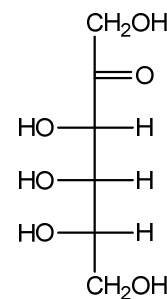
**Exam 1**

Instructions:

- You will have 1 hour 45 minutes to complete the exam.
- You may use a pencil (recommended) or blue or black ink pen to write your answers. Other color inks will not be graded. Your choice of writing utensil will not affect your ability to request a regrade.
- Only answers on the separate answer sheet, in the indicated space, will be graded; writing anywhere else will be ignored. Be sure to write your name on the answer sheet.
- Do not write in the score boxes on your answer sheet; you will be docked points if you do.
- For answers with a word or sentence limit, words beyond this limit will not be read or graded.
- For short- or multi-answer questions, including irrelevant or wrong information or selections in your answer will cause you to lose points.
- Write legibly. If the grader cannot read your answer, you won't get credit.
- Items you may have on your desk:
  - non-programmable scientific calculator, *without its case or cover*
  - writing utensil(s)
  - student ID

**ALL other items** must be placed into a bag, which must be zipped up or closed and pushed *completely* under your chair.
- No hats, hoods, earphones, or cellphones are allowed.
- If you continue to write after 'time' is called, your exam will be taken and docked 10 points.
- **Questions are printed on both sides, as is the colored answer sheet. Be sure you've answered all of the questions!**

- (2) What is the ratio of  $[A^-]:[HA]$  in solution at pH 5 that contains a weak acid with  $pK_a = 5$ ?
  - 1:10
  - 1:2
  - 1:1
  - 2:1
  - 10:1
- (2) Which one of the following amino acids contains an aromatic group?
  - Arginine
  - Phenylalanine
  - Leucine
  - Methionine
  - Glycine
- (2) Which one of the following functional groups does not participate in hydrogen bonding?
  - Amino
  - Amido (amide)
  - Carboxyl
  - Hydroxyl
  - Methyl
- (2) The Fischer projection of D-sorbose is shown. Which of the other structures is L-sorbose?

**a.****b.****c.****d.**

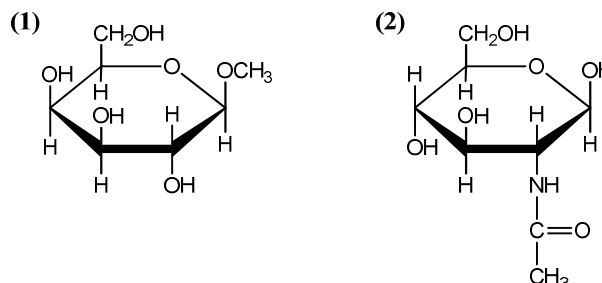
- (1) True or False? D-sorbose is an aldohexose. (See previous problem for structure of D-sorbose.)
- (1) True or False? Water can act as an acid or a base.
- (1) True or False? Steric hindrance prevents a protein from adopting some  $\phi$  and  $\psi$  dihedral angles.
- (1) True or False? A protein's sequence determines its structure.
- (1) True or False? A protein's tertiary structure includes the interactions between separate polypeptide chains.
- (1) True or False? Lipids are more soluble in water than in nonpolar solvents.
- (1) True or False? Biological membranes are mainly composed of lipids and proteins.

12. (4) Given the chart below, choose the **best** explanation for why, in an *E. coli* cell, there are so many different proteins as compared to most other cell components.

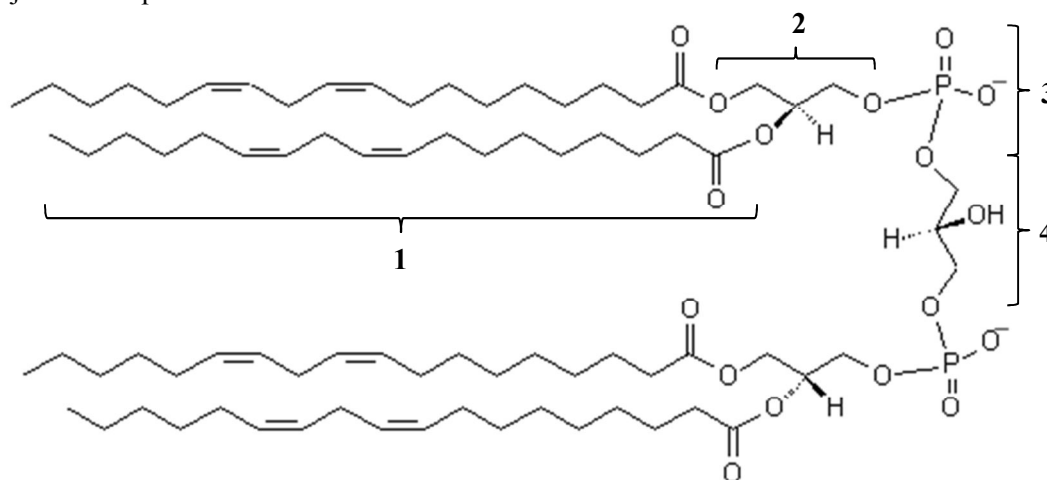
Components of an <i>E. coli</i> cell	Percentage of total cell weight	Number of different
Water	70	1
Proteins	15	3,000
Nucleic acids		
DNA	1	1
RNA	6	>3,000
Polysaccharides	3	5
Lipids	2	20
Subunits & intermediates	2	500
Inorganic ions	1	20

- a. There is only one kind of water molecule.
  - b. Lipids cannot form polymers, so their diversity is limited.
  - c. Proteins have a greater potential for diversity than other types of biomolecules.
  - d. Protein functions are more diverse than the functions of other types of biomolecules.
  - e. Peptide bonds are stronger than bonds in other biomolecules (like glycosidic bonds).
  - f. Although there are only ~1000 different protein folds, proteins with the same fold can differ in sequence.
13. (2) True or False? Water forms more hydrogen bonds in ice than in its liquid form.
14. (2) True or False? The osmotic pressure experienced by a solution enclosed in semipermeable membrane is inversely proportional to the concentration of dissolved solute.
15. (2) True or False? The lower density of solid versus liquid water helps prevent lakes and oceans from completely freezing.
16. (2) True or False? The percentage identity between two sequences can be higher than the percentage similarity.
17. (2) True or False? Adjacent regions of a protein's primary structure are usually adjacent in the protein's tertiary structure.
18. (2) True or False? Denaturing a protein will not affect its ability to function.
19. a. (2) True or False? Changes in pH can disrupt a protein's *secondary* structure.  
 b. (3) Explain your answer to part **a** in 30 words or fewer.

20. (8) Consider the following sugars:

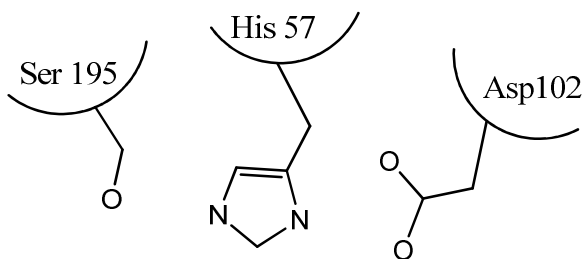


- a. (4) From the following descriptions (A-H), list all that apply to: sugar (1); sugar (2)
- |               |                 |
|---------------|-----------------|
| A. Hemiacetal | E. Mutarotatory |
| B. Hemiketal  | F. Reducing     |
| C. Acetal     | G. Aldose       |
| D. Ketal      | H. Ketose       |
- b. (4) How many different disaccharides may be formed from the condensation of these two sugars? (Assume that mutarotation may occur before and/or after the reaction.) Show your reasoning.
21. (9) Cardiolipin is a membrane lipid found in bacteria and mitochondria, and it is a major component of the inner membranes of heart mitochondria (hence the word 'cardio' in its name). The structure of the major cardiolipin of heart is shown:



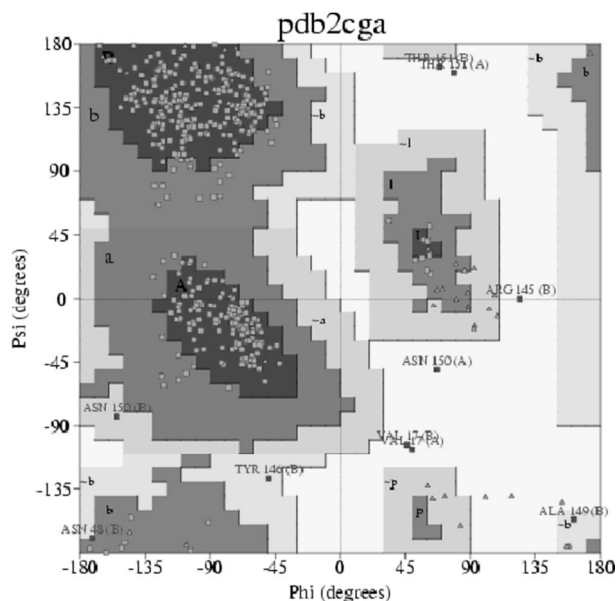
- a. (4) Name the molecular components (1-4) indicated in the structure above.
- b. (2) Cardiolipin is what type of membrane lipid?
- Sterol
  - Sphingomyelin
  - Galactolipid
  - Glycerophospholipid
  - Cerebroside
- c. (3) Based on the general structures of membrane lipids we discussed, would you expect the presence of the above cardiolipin to *increase* or *decrease* the fluidity of the inner mitochondrial membrane?

22. (28) Chymotrypsin is an enzyme (a protein catalyst) that catalyzes the hydrolysis of peptide bonds. In an important region of the structure of chymotrypsin, the side chains of Ser 195, His 57, and Asp 102 interact through hydrogen bonds. (Note that the numbers 195, 57, and 102 indicate the positions of these residues in the protein sequence.)
- (3) List the approximate  $pK_a$  values of these side chains.
  - (3) Over what pH range(s) would this portion of the structure be a good buffer?
  - (4) A depiction of this region of structure is provided to you below and on your answer sheet. Complete the drawing to show the predominant structure at pH 7 by adding any missing hydrogens, double bonds, formal charges, and hydrogen bonds. (Draw dotted lines to represent hydrogen bonds.)



- (4) What fraction of chymotrypsin molecules at pH 7 has a net charge of zero over these three side chains? Show your reasoning.
- (2) True or False? The hydrogen bonds between Ser 195, His 57, and Asp 102 stabilize the secondary structure of chymotrypsin.
- (2) How does the proximity of Asp 102 likely influence the  $pK_a$  of His 57, relative to free His in water?
  - Asp raises the  $pK_a$  of His
  - Asp lowers the  $pK_a$  of His
  - Asp has little or no effect on the  $pK_a$  of His
- (3) Briefly explain your answer to part f (in 20 words or fewer).
- (4) Suggest a conservative substitution for Ser, His, or Asp that would be most likely to preserve the structure and interactions of this essential region. Briefly justify your choice in 20 words or fewer.
- (3) There are many enzymes that catalyze the hydrolysis of peptide bonds. These include trypsin and elastase, whose sequences are similar to that of chymotrypsin. Chymotrypsin, trypsin, and elastase are all digestive enzymes, each specific to peptide bonds in different regions of sequence, and all working together in the intestines of animals to break down ingested proteins. These enzymes are (choose all that apply):
  - Homologs
  - Orthologs
  - Paralogs
  - Analogs
  - Unrelated by evolution

23. (9) The Ramachandran plot below depicts the conformation of chymotrypsin.



- (2) What do the darkest shaded regions on this plot represent? Briefly explain in 12 words or fewer.
  - (2) What do the lightest regions on this plot represent? Briefly explain in 12 words or fewer.
  - (2) What do the individual points on this plot represent? Briefly explain in 12 words or fewer.
  - (3) Based on the information in this plot, what class of fold does chymotrypsin have?
    - $\alpha$
    - $\beta$
    - Either  $\alpha/\beta$  or  $\alpha + \beta$
    - It is not possible to tell from the Ramachandran plot
24. (4) Which of the following types of interactions are used by lectins to recognize specific glycans? Choose all that apply:
- Hydrogen-bonds
  - Salt bridges
  - van der Waals contacts
  - Disulfide bonds
25. (3) The extent of branching in amylopectin is roughly 4%, with branch points occurring every 24-30 residues. For an amylopectin molecule containing  $10^6$  residues, how many reducing ends does it have?
26. (3) The molecule shown below is pyruvate, a breakdown product of glucose and an important intermediate of metabolism. Draw a 3-carbon alkene that has the same oxidation state as pyruvate.

