1. True or False?
    a. In an α-helix, the backbone carbonyl groups point toward the helix's amino-terminal end.
    b. Similarities in primary or tertiary structure (or both) can reveal that proteins have related functions.
    c. Single chains of collagen and keratin both form right-handed helices.
    d. van der Waals forces are the weakest forces stabilizing a protein's conformation.
    e. β-sheets have a dipole moment because of the direction of their backbone H-bonding groups.
    f. The hydrophobic effect drives protein folding because increases in entropy are favorable.
    g. A protein's entropy increases as it folds.
    h. The strength of a hydrogen bond depends in part on the electronegativities of the atoms bonding to hydrogen.
    i. Water is an amphipathic molecule.
    j. All mutarotatory carbohydrates are reducing sugars.
    k. All reducing sugars are mutarotatory.
    l. Glycosaminoglycan, a structural polysaccharide, provides stability to the bacterial cell wall.
    m. Proteins and polysaccharides adopt the same values of dihedral angles in their favored conformations.

2. Briefly define a 'hydrogen bond.' (25 words or fewer.)

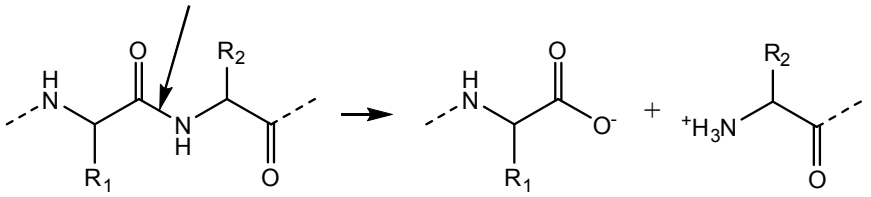
3. The following two sequences are portions of longer protein sequences:
    1. `Gln-Gly-Asn-Glu-Gln-Lys-Ser-Phe-Val-Ile-Ala-Tyr-Ala-Leu`
    2. `His-Gly-Gln-Asp-Thr-Arg-Ser-Phe-Ala-Val-Gly-Trp-Val-Val`
    a. Briefly define the word "amphipathic." (10 words or fewer.)
    b. Which of the above sequences is/are amphipathic?
    c. Would you expect these two sequences to adopt similar structures?

4. For each of the following amino acid pairs, name the most likely interaction that would occur between their side chains:
    a. Asn and Glu
    b. Arg and Glu
    c. Met and Phe
    d. Ala and Ser
    e. Tyr and Thr

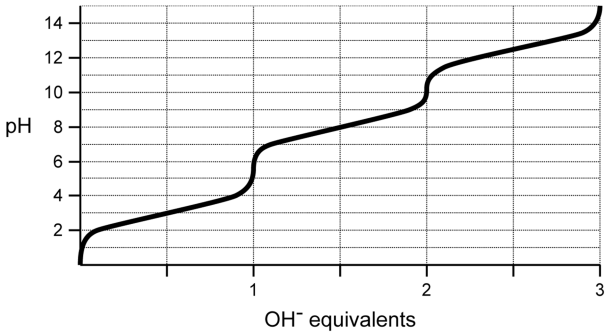
5. The following questions relate to the structural diversity of biomolecules:
    a. How many different disaccharides can be formed from two glucose molecules? Show your reasoning. (Consider disaccharides related by mutarotation to be the same.)
    b. How many different dipeptides can be formed from any two (unmodified) amino acids? Show your reasoning.
    c. Which type of polymer – polypeptide or polysaccharide – has more potential for covalent structural diversity? Explain why in 15 words or fewer.

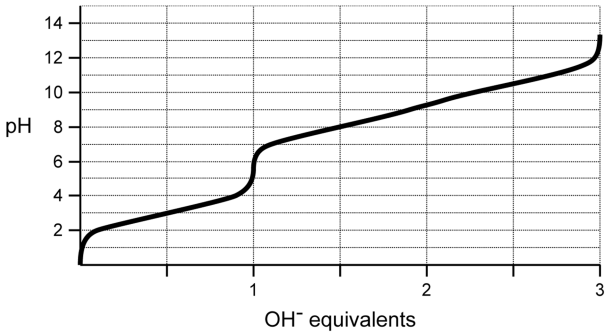
6. You have isolated a tetrapeptide from a longer protein and are trying to determine its sequence.
    a. You find that the C-terminal residue has an N-linked glycosylation. What amino acid(s) could be at the C-terminus?
    b. You treat the peptide with chymotrypsin, an enzyme that hydrolyses peptide bonds that immediately follow aromatic amino acids (except His; see figure). The chymotrypsin cuts the tetrapeptide into two dipeptides. Based on this result, what amino acids could be at position 2?

cleavage by chymotrypsin if R_1 is aromatic, non-His



    c. You perform pH titrations of the two peptides that result from the cleavage with chymotrypsin; the resulting curves are shown below. Based on all of the information you've gotten, what are the possible sequences of the tetrapeptide? Show your reasoning, and give your answer using either 3-letter or 1-letter abbreviations.

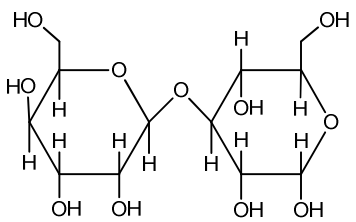




7. Briefly define 'mutarotation.' (15 words or fewer.)

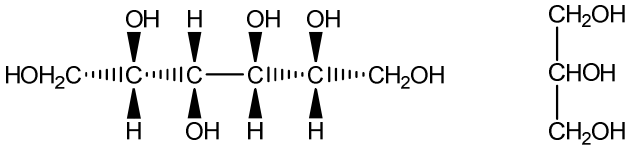
8. What is the relationship between mutarotation and a reducing sugar? How do these features apply to sugars that are hemiacetals, hemiketals, acetals or ketals?

9. Multiple Choice. Which one of the following statements is correct?
    a. A reducing sugar becomes reduced in the presence of Cu^{2+}.
    b. All reducing sugars are mutarotatory.
    c. A polysaccharide can be simultaneously reducing and non-reducing.
    d. The disaccharide shown is a non-reducing sugar:
    e. None of the above.



10. A package of sugarless Bubble Yum bubble gum lists the following ingredients: Sorbitol, Gum Base, Hydrogenated Glucose Syrup, Glycerin, Natural and Artificial Flavor, Sodium Saccharin, Artificial Color. The structures of sorbitol (1) and glycerin (2) are shown below:

1 **2**

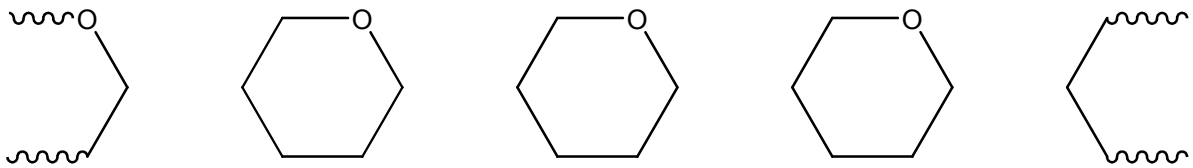


a. Name the class of compounds that includes sorbitol and glycerin. *Be as specific as possible.*
b. Sorbitol can be considered either a D- or L-molecule (in the Fisher naming). Explain why in 30 words or fewer.
c. Although sorbitol is found in nature, it can be synthetically produced from another natural compound. Name this compound and describe the relationship between the two molecules (10 words or fewer).
d. What is another name for glycerin?

11. Consider the following polysaccharides: glycogen, amylose, amylopectin, cellulose, chitin, and heparin. For each, select all of the following properties that describe its 3-dimensional structure:

A. branched
B. granular
C. helical
D. extended
E. fibrous
F. highly hydrated
G. loose intermolecular packing
H. extensive hydrogen bonding
I. limited hydrogen bonding
J. rigid
K. flexible
L. rings in chair conformation

12. You are a biochemist studying unusual carbohydrates found in rare rainforest plants. You extract a polysaccharide from your latest plant sample. On treatment with an enzyme that cleaves β(1→3) glycosidic linkages, the polysaccharide completely breaks down into lactose molecules.
    a. Draw a segment of the polysaccharide on the provided backbones:

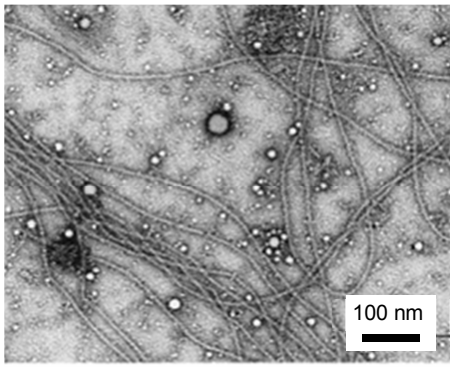


    b. Based on the type of linkages in this polysaccharide, what is this polysaccharide's likely biological role?

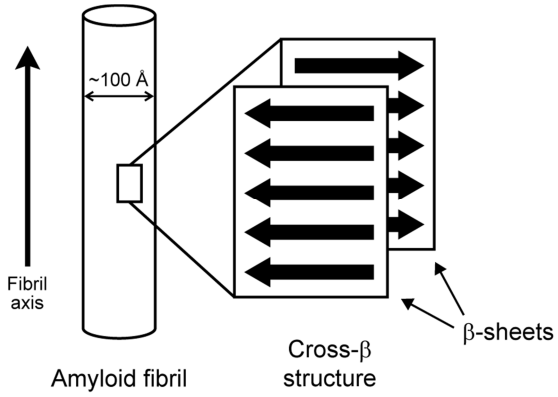
13. Multiple Choice. Which one of the following statements is *incorrect*?
    a. The degree of branching is important to the function of glycogen as a short-term energy-storage molecule.
    b. Branched polysaccharides can have just one non-reducing end.
    c. Although sugars may be linked to peptides via glycosidic bonds, peptidoglycan has amide bonds linking its sugar and peptide components.
    d. Structural polysaccharides often have β-glycosidic linkages and linear, rigid structures.
    e. None of the above.

14. Amyloid fibrils are elongated protein aggregates that form when certain proteins don't fold properly, and instead, they stick together in an ordered way. They form deposits in the body in a number of human diseases, and each disease is associated with a different type of protein.

    The portion of the fibril structure that is common to all amyloid fibrils is called the 'cross-β' structure. 'β' comes from the fact that the proteins of the fibril form intermolecular *β*-sheets that extend along the length of the fibril. 'Cross' comes from the fact that the β-strands of the β-sheets lie perpendicular to (or a*cross*) the long axis of the fibril. (Note that, although parallel β-sheets are depicted in the figure, the sheets may also be anti-parallel.)



Amyloid fibrils from a human patient
Serpell et al. *J Mol Biol* (1995) **254**:113



    a. What is the main type of interaction between protein chains that causes the elongated shape of amyloid fibrils? Choose from the following:

    A. hydrophobic interactions
    B. hydrogen bonds between backbone atoms
    C. hydrogen bonds between side chain atoms
    D. hydrogen bonds between side chain and backbone atoms
    E. ion pairs (electrostatic attraction)
    F. electrostatic repulsion
    G. steric hindrance
    H. ion-polar bonds
    I. van der Waals interactions
    J. covalent bonds

    Studies in the Eisenberg Lab at UCLA have focused on short protein sequences that form cross-β structures. Using X-ray crystallography, researchers determined the cross-β structure of the peptide with sequence Gly-Asn-Asn-Gln-Gln-Asn-Tyr. Although they had already guessed that the peptides would form parallel β-sheets, they were surprised by the interactions that formed between the sheets – mainly van der Waals interactions.

    b. Why were the researchers surprised by their finding? What interactions had they expected to see? Briefly explain in 25 words or fewer.