BIOL 112: Unit 1 Practice Questions & Answers

This document contains some questions for you to practice. The questions are grouped by topic along with the learning objectives associated with each of the topics. We encourage you to use the learning objectives to guide your studying; ask yourself if you could answer each objective if it was in the form of a question.

There are two types of exam-type questions:

a. **Multiple choice:** these are the types of questions you are likely to see on the exam – various levels of application of the fundamental knowledge and skills for each topic area.
b. **Open response questions (ORQs):** a few examples to give you an idea of the kinds of short answer questions you will see on the exams.

Topic 1: General properties and types of cells

This topic provides a general introduction to cells as the basic unit of life, their structure, diversity and the evolutionary relationship of all living organisms.

Knowledge check questions: you will need this content knowledge to answer exam questions but this style of "recall" question will not be on the exam.

1. What are the key features that define "what is a cell?"
2. What is the function of the plasma membrane?
3. What is the purpose of some cells having internal membranes?
4. What are the three domains on the tree of life?
5. What are the differences between bacterial cells and eukaryotic cells?
6. What is the main chemical form of energy stored inside the cell?

Exam Style Multiple Choice Questions:

1-1. A researcher discovers a strange type of cell in a sample of pond water. What feature of the cell can she use to determine if the cell is bacterial or eukaryotic?
   A. Whether is carries out photosynthesis
   B. The size of the cell
   C. The presence of a cell wall
   D. The presence of internal membranes
   E. The presence of ribosomes

1-2. Which of the following statements about cell evolution is true?
   A. Prokaryotes evolved more than 4 billion years ago, but eukaryotes only evolved 2 billion years ago.
   B. Prokaryotes acquired mitochondria by endosymbiosis with a eukaryote.
   C. The common ancestor cell was archaebacterium.
   D. Eukaryotes arose from eubacteria long after archeabacteria and eubacteria had diverged from each other.

1-3. Why can the results from studies of cellular processes in the bacterium *E. coli* be applied to cellular processes that occur in humans?
   A. It is a single-celled organism and it is easy to culture.
   B. It shares a common ancestor with eukaryotes so many processes are conserved.
   C. It is a model eukaryotic cell that contains a nucleus like human cells.

D. It has a complex cellular metabolism.
E. It is enclosed by a plasma membrane.

Open Response Questions:

1-4. Prokaryotes and eukaryotes have evolved different cellular strategies as cells.

a) Explain how each cell type is addressing cell size-related limitations for dilution, diffusion and surface area to volume ratio.
In prokaryotes, the bacterial cell is typically small in size; in eukaryotes, the cells have lots of smaller compartments (organelles). The shape and size of the cell influences its surface area: volume ratio. In some cases, eukaryotic cells use foldings and projections of the plasma membrane to increase surface area to volume ratio.

b) What are some differences between these types of cells? What characteristics could you use to distinguish between them?
Prokaryotic cells have no membrane bound compartments; Eukaryotic contain a nucleus surrounded by a nuclear envelope, and many membrane-bound compartments, such as mitochondria and (in plants) chloroplasts.

1-6. Which of the following cellular structures or compartments are found in all cells (Make an X beside all that are common to all cells).

A. ____Nucleus.
B. ____Ribosomes.
C. ____Cytosol.
D. ____Plasma Membrane.
E. ____Mitochondria.
F. ____Chloroplasts

Topic 2: Introduction to macromolecules in cells

This topic introduces the four major macromolecules that form the structural and functional components of cells. We will cover specific macromolecules in more detail throughout the course.

- *Refer to Chemistry for Biology Learning objectives, which will be featured throughout the course.*

Knowledge check questions: you will need this content knowledge to answer exam questions but this style of "recall" question will not be on the exam.

1. What are the four main types of biologically important macromolecules? What is the general role of each type? What are the monomers ("building blocks") of each of these macromolecules?
2. What is the general structure of the monomer (building block) of proteins? Describe and draw this structure.
3. What are the names of the termini (ends) of a protein chain?
4. What is the general structure of the monomer (building block) of nucleic acids? Describe and draw this general structure. What are the differences between the DNA monomer and the RNA monomer?
5. Look at Figure 2.18. Predict the types of non-covalent interactions that nucleic acid monomers can participate in.
6. What are the names of the termini (ends) of a nucleic acid?
7. What is the general structure of the monomer (building block) of complex carbohydrates?
8. What are the names of the termini (ends) of a carbohydrate?
9. What types of lipids are found in cell membranes?
10. What is the general structure of the monomer (building block) of phospholipid?
11. By convention how is the directionality of a DNA molecule expressed?
12. What is the directionality observed in a polypeptide?

Exam Style Multiple Choice Questions:

2-1. Why is water capable of forming hydrogen bonds with the major macromolecules?

A. The hydrogen atoms carry partial positive charges.
B. The oxygen atom carries a partial negative charge.
C. It is a polar molecule.
D. The hydrogen atom is less electronegative than the oxygen atom.
E. All of the above apply.

2-2. Which of the following statements about hydrogen bonds is true?

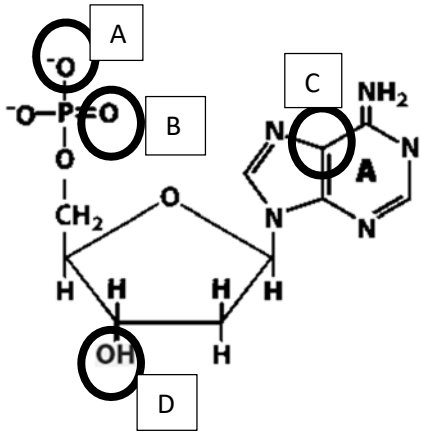
a) They are covalent bonds with water.
b) They are non-covalent bonds formed between hydrocarbons in water.
c) They are non-covalent bonds formed between nonpolar groups.
d) They are non-covalent bonds formed only in the presence of water.
e) They are non-covalent bonds that help maintain the 3-D structure of macromolecules.

2-3. Fill in the blanks: Macromolecular structures are assembled in this order: _____ are joined together by _____ bonds to form biological _____, which associate with each other by _____ bonds, forming larger structures.

a. Monomers, covalent, polymers, noncovalent
b. Polymers, covalent, monomers, noncovalent
c. Monomers, noncovalent, polymers, covalent

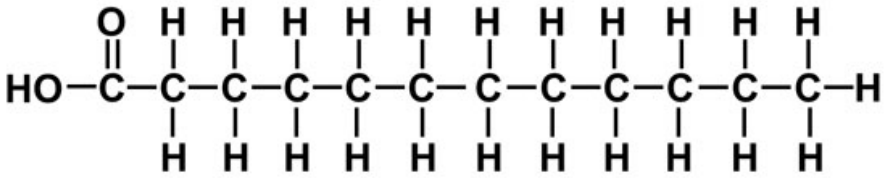
d. Polymers, noncovalent, monomers, covalent

2-4. In this picture showing one of the nitrogenous bases of DNA, which of the circled atom is least likely to hydrogen bonds with water?



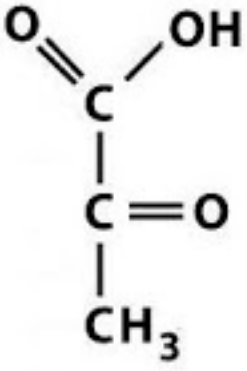
2-5 How many atoms in the pictured molecule can form H-bonds with water molecules?

Saturated Fatty Acid



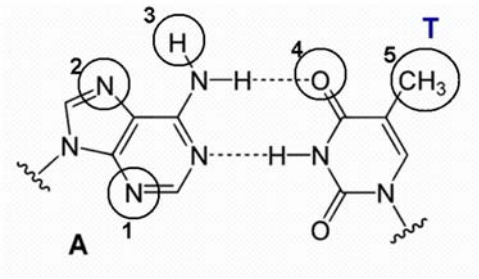
A. 1
B. 2
C. 3*
D. 4
E. 7

2-6 How many atoms in the pictured molecule can form H-bonds with water molecules?



A. 1
B. 2
C. 3
D. 4*
E. 7

2-5. Below is a diagram showing two nucleotides that are H-bonded to each other. An isoleucine in the primary structure of a DNA binding protein was shown to interact with these molecules. Using just this information, which one of the circled atoms/groups shown on the molecules below is likely to have an induced-dipole – induced-dipole interaction with the isoleucine?



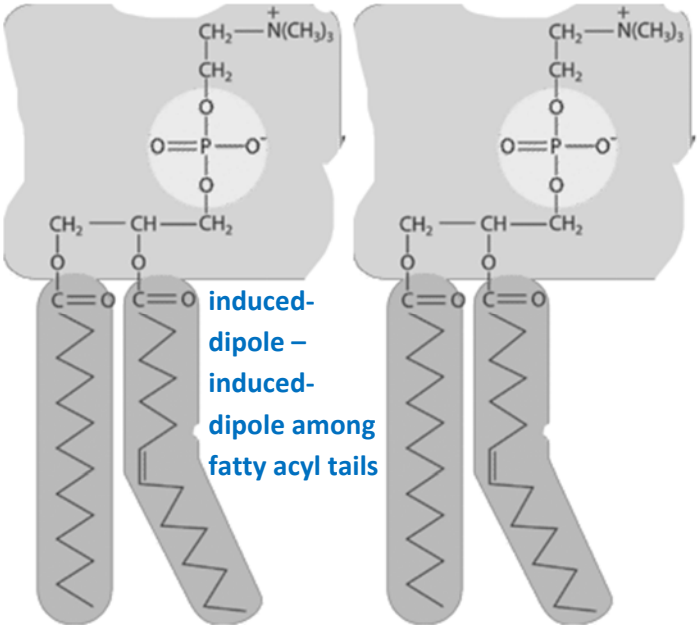
a. group 1
b. group 2
c. group 3
d. group 4
e. group 5

Open Response Questions:

2-6. Conditions of low pH (hydrogen ion, H^+, concentration is increased) will affect amino acids and proteins. For some amino acids, side chains that were negatively charged at neutral pH may become neutral and for other amino acids side chains that were neutral may become positively charged. These effects might contribute to altering the tertiary and quaternary structures of a protein by which of the following mechanisms (choose all that apply)?

1. _____Breaking of peptide bonds.
2. _____Changing the ionic interactions.
3. _____Making new Induced Dipole-Induced Dipole interactions
4. _____Changing the amino acid sequence.
5. _____Causing charge repulsion.

2-7. On the diagram below, label five types of non-covalent interactions that phospholipids can participate in (with water or another phospholipid). Draw water molecules (H-O-H) as required.



Permanent dipole-permanent dipole among any of the electronegative atoms or the H attached to them (see text page 36: "Any H atom covalently bound to an electronegative atom…will have slight pos. charge and can form a H-bond")

Topic 3: Lipids – Phospholipids, membrane structure, and membrane self-assembly

This topic deals with the general biochemical and structural properties of lipids and how they self-assemble into larger structures. Membrane assembly of phospholipids is a specific example to understand thermodynamics and system stability and how this relates to general principles of macromolecular assembly.

Knowledge check questions: you will need this content knowledge to answer exam questions but this style of "recall" question will not be on the exam.

1. Why do phospholipids spontaneously assemble into specific lipid structures? Look at Figure 5.3, why does each of these structures form? What determines whether a micelle, bilayer or liposome forms?
2. What are the different components that make up a phospholipid?
3. What is the fluid mosaic model of membrane structure? Why is it called this?
4. Explain, in your own words, why the formation of a phospholipid bilayer in an aqueous solution is a spontaneous process using the terms delta G, entropy, hydrophobic effect and non-covalent interactions.

Exam Style Multiple Choice Questions:

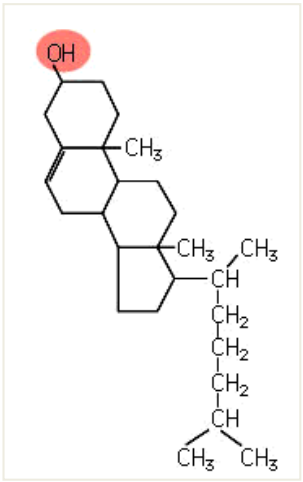
3-1. What is the most important factor explaining the spontaneous assembly of phospholipids into a bilayer in an aqueous solution?

a. Increased entropy of water, and thereby the stability of the system
b. Increased entropy of lipids, and thereby the enthalpy of the system
c. Formation of ionic bonds between the phospholipids, and thereby increased ΔH
d. Stabilization of permanent dipole-induced dipole interactions
e. Increased Induced dipole-induced dipole interactions between the phospholipid head groups
f. Many non-covalent interactions between the hydrocarbon tails of the phospholipids

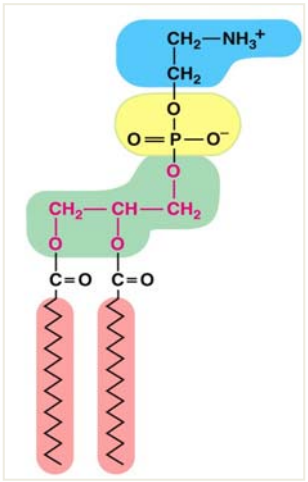
3-2. Based on the structures shown, which of these lipids can form bilayers on their own in an aqueous environment?

a. A only
b. B only
c. Both
d. Neither

Lipid A



Lipid B

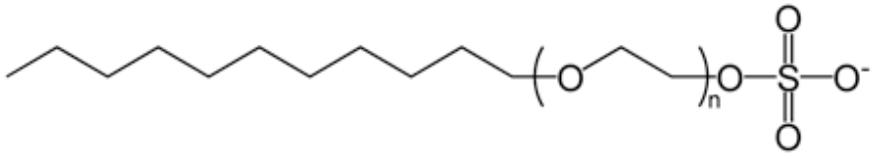


3-3. Why are phospholipids well suited to be the main structural components of membranes?

1. They are completely insoluble in water.
2. They can self assemble into a bilayer
3. They form a structure in which the hydrophobic portion faces outward.
4. They are made from atoms that are commonly available in foods.
5. They form a single sheet in water.
6. They form a selectively permeable structure.
    a. 1, 4 and 6
    b. 2, 3 and 5
    c. 3 and 5
    d. 2 and 6
    e. 1 and 6

Open Response Questions:

3-4. The structure below is for sodium dodecyl sulfate (SDS), a commonly used laboratory detergent. Put a check beside the statements that are correct regarding the structure and behavior of SDS.



1. ____Many SDS molecules in solution will form a micelle due to the hydrophobic tail and the hydrophilic head.
2. ____The negatively charged oxygen atom would be exposed on the hydrophilic surface of the membrane.
3. ____The amphipathic nature of this molecule can result in SDS inserting into the cell membrane.
4. ____The nonpolar portion of SDS can form Induced Dipole-Induced Dipole interactions with the hydrocarbon chains of phospholipids.

Answer: All statements are true.

Topic 4: Lipids - Membrane selective permeability, transport, diffusion, and osmosis

This topic describes the selective permeability of cellular membranes and the various mechanisms cells use to transport molecules across the lipid bilayer.

Study questions-you will need this background knowledge to answer exam questions but this style of recall question will not be on the exam.

1. What are the different types of passive transport across cell membranes? What are the similarities and differences of each type?

2. What is the definition of diffusion, how does this relate to the different types of passive transport?

3. Look at Figure 5.9. Describe what the green solute particles are doing in each flask. Are they static, or are they moving? If so in what direction?

4. What is osmosis? How is this the same or different from other types of passive transport?

5. Look at Figure 5.11. Compare this figure to Figure 5.9, what is different in this scenario?

6. Look at Figure 5.14, explain why the red blood cell changes shape? Relative to the shown solute concentration, what is the water concentration inside the cell? Outside the cell?

7. How does active transport compare to passive transport?

8. What is an electrochemical gradient?

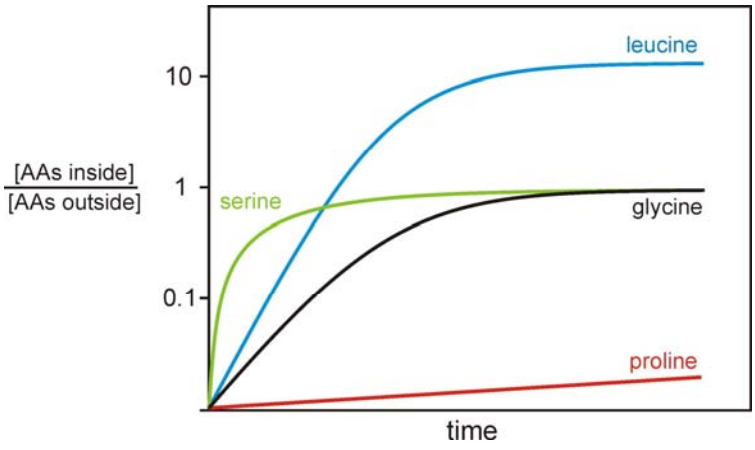
9. Compare the active transport that is shown in Figure 5.12 and 5.13? What are the similarities and differences?

Exam Style Multiple Choice Questions:

4-1. Which of the following statements is true about passive diffusion?

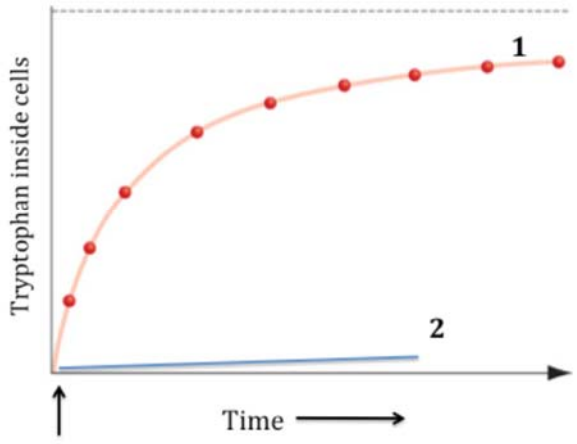
A. Passive diffusion operates independently of concentration.
B. Passive diffusion phenomena can never reach equilibrium.
C. Passive diffusion requires no expenditure of cellular energy.
D. Passive diffusion moves molecules into a cell, but not out of the cell.
E. Passive diffusion does not occur in cells that possess a cell wall.

4-2. This figure shows the uptake of 4 amino acids into cells. Given these data and your knowledge of relative permeability of lipid bilayers to different kinds of molecules, which of the following is correct?



a. Leucine gets in by active transport; serine, glycine and proline get in by passive transport.
b. Serine and leucine get in by active transport; glycine and proline get in by facilitated diffusion.
c. Leucine gets in by active transport; serine, glycine and proline get in by facilitated diffusion
d. All four amino acids get in by facilitated diffusion
e. Leucine, serine, and glycine get in by active transport; proline gets in by facilitated diffusion.

4-3. The figure below shows data from two experiments looking at the uptake of the amino acid tryptophan in *E.coli* cells. At the arrow in the graph, a solution containing tryptophan was added to the media. For experiment 1, tryptophan alone was added. For experiment 2, tryptophan + KCN (potassium cyanide, a known ATP synthesis inhibitor) were added. Which of the following is the most likely explanation for the differences observed in the two uptake curves?

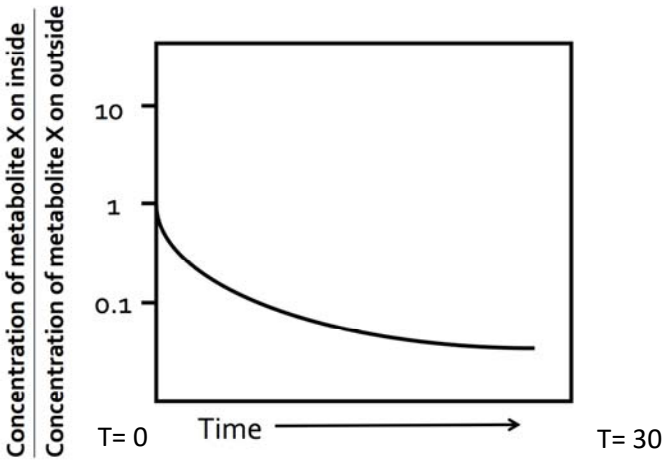


A. KCN binds to the phosphate groups on the phospholipids in the cytoplasmic membrane, reducing the permeability as shown in curve 2
B. Tryptophan is taken up by facilitated diffusion in curve 1 and by active transport in curve 2 with ATP providing the energy for uptake.
C. Tryptophan is taken up by active transport in curve 1 and no uptake occurs in Curve 2 without available ATP.
D. KCN binds to tryptophan making it too big to diffuse through the membrane (curve 2)

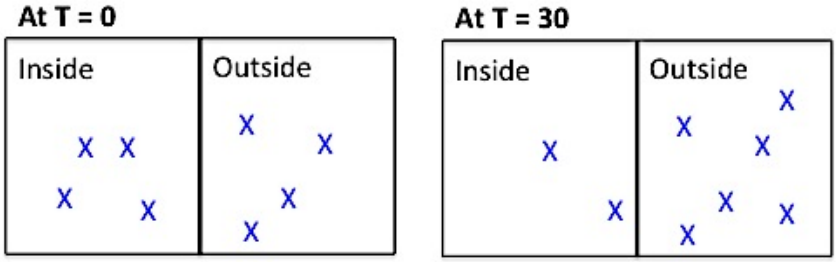
Open Response Questions:

4-4. A protein named PGP can be found in the membrane of kidney cells. PGP is known to be a membrane transporter of Metabolite X – but you don't know what type of transporter it is. To investigate this, kidney cells were placed in growth media containing Metabolite X, and the concentration of this metabolite was measured inside and outside the cells over 30 minutes.

From the following graph, interpret the data by answering the following questions**.**

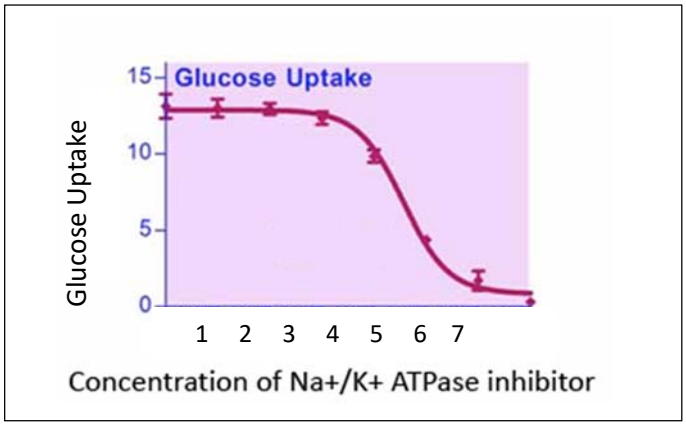


a. Using the letter X to represent metabolite X, draw the relative concentrations of the metabolite at the initial time and later time:



b. Based on the data, what type of transporter is PGP? Active transporter

4-5. The graph below shows the effect of an inhibitor of the Na+/K+ ATPase on glucose uptake in a mammalian cell. Explain what mechanism of transport can account for the fact that inhibition of Na+/K+ transporter can lead to decreased transport of another solute.



This is example of secondary transport. Glucose uptake against a concentration gradient into a cell is driven by coupling to the Na+ concentration gradient by a co-transporter. Inhibition of the Na+/K+ ATPase transporter leads to loss of the Na+ gradient, and decreased Glc uptake

Topic 5: Proteins - Structure and self-assembly

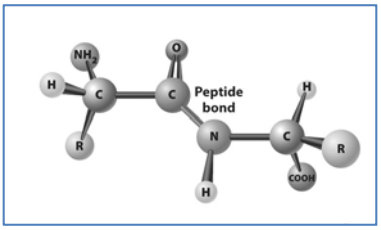
This topic focuses on one of the major macromolecules that function in a cellular environment, proteins. Here we discuss the biochemical and thermodynamic principles that underlie protein structural assembly.

Exam Style Multiple Choice Questions:

5-1. What is the strongest type of non-covalent bond that the polar amino acid side chains can participate in with each other? (The table on Canvas "Chemical bonds for biology" may be helpful here.)

A. Ionic bonds
B. Ion – Permanent-dipole
C. Permanent-dipole – Permanent-dipole
D. Permanent-dipole – Induced-dipole
E. Induced-dipole – Induced-dipole

5-2. What is the best description of this figure?



A. Peptide bonds are formed by the carboxyl group of amino acids being covalently linked by sharing electrons.
B. Peptide bonds are formed by the carboxyl group of one amino acid being covalently linked to the amino group of another amino acid.
C. Peptide bonds are formed by the carbon attached to R-group being covalently linked to the next R-group.
D. Peptide bonds are formed by the central carbon atom in an amino acid being covalently linked to 4 groups.
E. Peptide bonds are formed by a nitrogen and a carbon within one amino acid being covalently linked.

5-3. Imagine that leucine is in the hydrophobic region of a particular protein. By mutation, this leucine is substituted with another amino acid. Which substitution would have the least effect on the protein? *(See the chart of amino acids in your textbook – amino acid structures will be provided on exam)*.

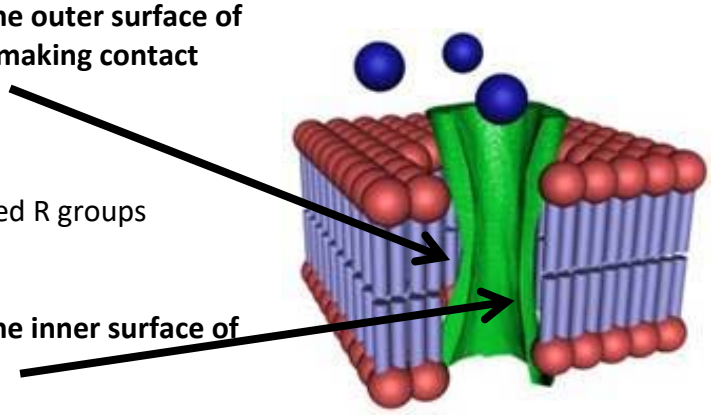
a. Asparagine
b. Valine
c. Aspartic acid
d. Glutamic acid
e. Lysine

5-4. The central green pore structure in the picture shown represents an outer membrane protein called a porin found in some bacteria. Porins are water channels that allow the transport of small ions or charged molecules.

1. **The R-groups of the amino acids lining the outer surface of the porin spanning the lipid bilayer and making contact with the lipid tails, are likely to be:**

   a. mainly polar and charged R groups
   b. an equal mix of charged and uncharged R groups
   c. mainly non-polar R groups

2. **The R-groups of the amino acids lining the inner surface of the porin water channel are likely to be:**
   a. mainly uncharged R groups
   b. an equal mix of charged and uncharged R groups
   c. mainly polar R groups

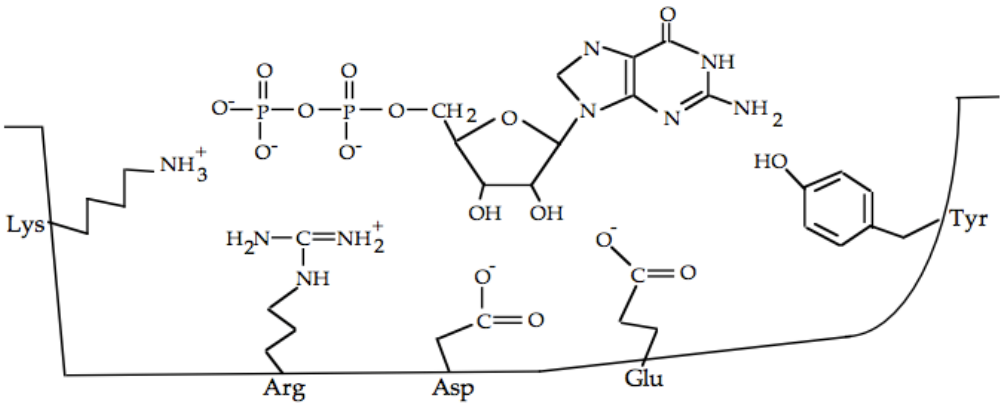


Open Response Questions:

5-5. You are given the amino acid sequence of a protein. All 20 of the common amino acids are present in the protein. When you know the amino acid sequence, what can you predict about the final conformation this protein will assume (choose all that apply)?

1. ____If this protein will form a quaternary structure
2. _ X__Whether secondary structures like alpha helices will form within the protein.
3. ____If, in the 2^o structure, a disulphide (S-S) bond will form between 2 cysteine residues.
4. __ X _If this protein contains transmembrane domains through the lipid bilayer.

5-6. Regulatory proteins called G proteins contain a GDP-binding pocket that is important for their activity. The figure below shows the nucleotide GDP interacting with the protein's amino acid side chains. The amino acids are labeled with their three-letter codes.



For each pair given below, draw (using dashed lines) the strongest type of non-covalent bond on the diagram. (If there is a 'tie' choose the closest interaction.)

a. The interaction between the side chain of Lys, and the phosphate group of the nucleotide. What type of non-covalent interaction is this? Ionic.

b. The interaction between the side chain of Glu, and the ribose group of the nucleotide. What type of non-covalent interaction is this? Ionic-PD

c. The interaction between the side chain of Tyr and the base of the nucleotide. What type of non-covalent interaction is this? PD-PD.

5-7. You make single amino acid changes in the GDP-binding pocket of the G protein shown in the figure above, and examine their effects on the binding of GDP. Consider the nature (e.g. charge, polarity, hydrophilicity, hydrophobicity) of the amino acid side chains and give the **most likely** reason **why** each of the amino acid change has the stated effect.
Consider each amino acid change independently.

a. Arg is changed to a Lys, resulting in a G protein that still binds GDP.

Any statement that indicates the following explanation is acceptable:

Lys is +vely charged (just like Arg) and likely did not change the interactions in the region much.

b. Lys is changed to a Glu, resulting in a G protein that cannot bind GDP.

Glu is –vely charged and this would lead to charge repulsion with Phosphate of GDP – which is likely preventing GDP from binding to G-protein.

5-8. Which statement(s) are true about protein secondary structure? (Choose any/all that apply)

1. They form as a result of repetitive H-bonds between two carbonyl groups of the peptide bond.
2. They form as a result of repetitive H-bonds between the carbonyl oxygen of one amino acyl residue and the hydrogen on the amide group of another.
3. They form as a result of repetitive H-bonds between the peptide bond groups and the adjacent R-groups.
4. They form as a result of repetitive H-bonds between R-groups.
5. One type is an α – helix
6. One type is a β-pleated sheet

5-9. Tertiary structures of proteins results from which of the following interactions? (Choose any/all that apply)

1. Non-covalent interactions between the backbone and the R-groups
2. Non-covalent interactions between the R-groups
3. Covalent bonds between the backbone and S-containing R-groups

Topic 6: Proteins: Enzymes as reaction catalysts

Proteins can have many different functions in cells. This topic focuses on a subset of proteins that can function as enzymes.

Exam Style Multiple Choice Questions:

6-1. What is a transition state in an enzyme-catalyzed reaction?

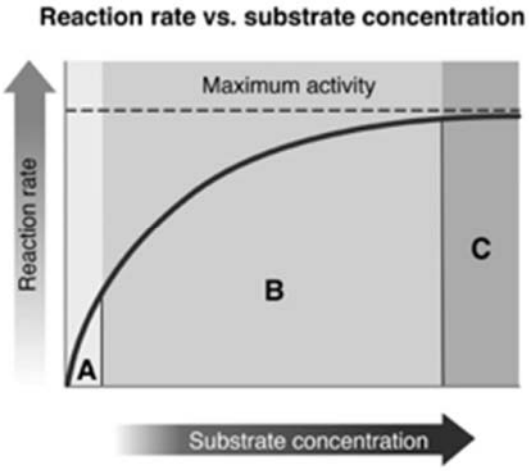
A. An interaction between reactants with high kinetic energy, due to high temperature.
B. **The complex formed as covalent bonds are being broken and re-formed during the reaction**.
C. The place where an allosteric regulatory molecule binds to an enzyme.
D. The shape adopted by an enzyme that has an inhibitory molecule bound at its active site.
E. The state that has the most stable delta G value compared to the reactants and products.

6-2. How does the presence of an enzyme affect whether a reaction is spontaneous or not?

A. It makes the reaction more spontaneous
B. It makes the reaction less spontaneous
C. It increases the reaction free energy change
D. It decreases the reaction free energy change
E. **None of the above**

6-3. In the graph on the right, in which region (A, B, or C) is the enzyme saturated with substrate?

C



6-4. Enzymes work by _____.

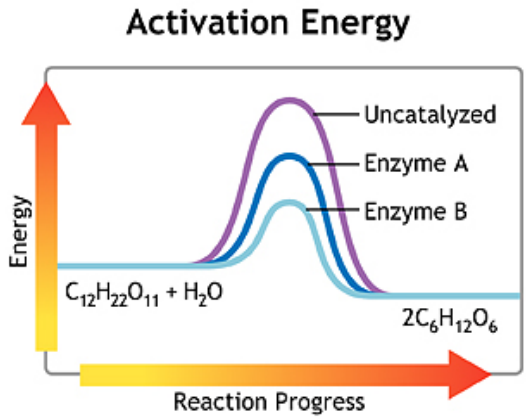
A. increasing the potential energy difference between reactant and product.
B. decreasing the potential energy difference between reactant and product.
C. decreasing the overall delta G of the reaction.
D. **decreasing activation energy**.
E. increasing the stability of the products.

6-5. A(n) _____ inhibitor has a structure similar to the substrate of an enzyme, where as a(n)

_____ inhibitor does not need to have a structure similar to the substrate.

A. competitive; reversible
B. **competitive; non-competitive**
C. non-competitive; irreversible
D. reversible; irreversible

6-6. The graph below presents three activation energy profiles for a chemical reaction (the hydrolysis of sucrose): an uncatalyzed reaction, and the same reaction catalyzed by two different enzymes.



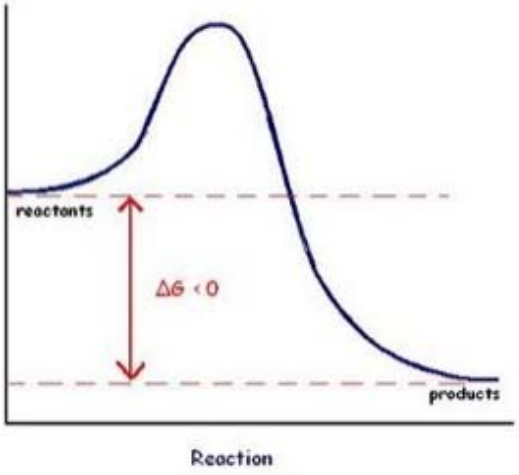
Explain how the activation energy shown here relates to the reaction rates (rate of product formation per unit time), and predict which will have the lowest and highest reaction rates.

6-7. The two reaction curves shown below represent two different un-catalyzed reactions.

Part 1. On each, draw the curve for the enzyme catalyzed reaction.

Part 2. For each curve, is the reaction spontaneous or non-spontaneous? Explain

Reaction 1:



Reaction 2: