**Introductory Molecular and Cell Biology Assessment (IMCA)**

J. Shi, W. B. Wood, J. M. Martin, N. A. Guild, Q. Vincens and J. K. Knight

To prolong the utility of this assessment we ask that it not be given to students in a form that they can keep. If administered in class, please collect all copies. We do not recommend administering the assessment online, but if you do so, we recommend putting a time limit on the test (e.g., 30 minutes), restricting the website to your students, and leaving the questions up for a limited time only.

1. Many infectious diseases are becoming difficult to treat because of bacterial resistance to antibiotics. Populations of bacteria can become resistant when they are exposed to an antibiotic. What is the best general explanation for how this occurs?

    a) The antibiotic induces specific mutations in some of the bacteria that make them antibiotic-resistant.
    b) The antibiotic activates bacterial genes encoding enzymes that can destroy the antibiotic.
    c) The antibiotic increases the bacterial mutation rate, so that resistant mutant bacteria are more likely to arise.
    d) Antibiotic-resistant mutant bacteria already present in the population survive and reproduce in the presence of the antibiotic.

2. Which of the following statements comparing bacteria and eukaryotes is true?

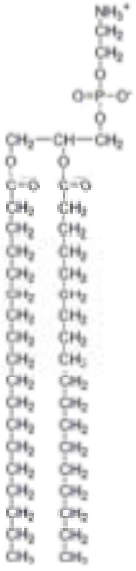
    a) Eukaryotic cells have a nucleus surrounded by a nuclear membrane; bacterial cells don't.
    b) Eukaryotic cells don't have cell walls; many bacterial cells do.
    c) The genetic material of eukaryotic cells is DNA; the genetic material of bacteria can be either RNA or DNA.
    d) Eukaryotic cells use a different code to specify the amino acids in proteins than bacterial cells.

3. Which of the following statements about viruses is <u>FALSE</u>?

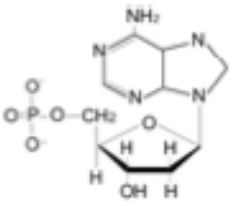
    a) Viruses have a nucleus but no cytoplasm.
    b) Viruses can reproduce only when they are inside a living host cell.
    c) Viruses cannot make proteins on their own.
    d) Some viruses use RNA rather than DNA as their genetic material.

4-8. The molecular structures shown below are representative of five major classes of building-block molecules (monomers) that make up macromolecules and membranes in cells. Match each structure with the name of the correct monomer (a – e).

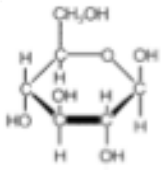
a) fatty acid b) amino acid c) nucleotide d) phospholipid e) monosaccharide



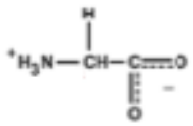
4.



5.



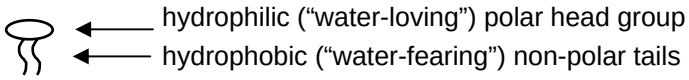
6.

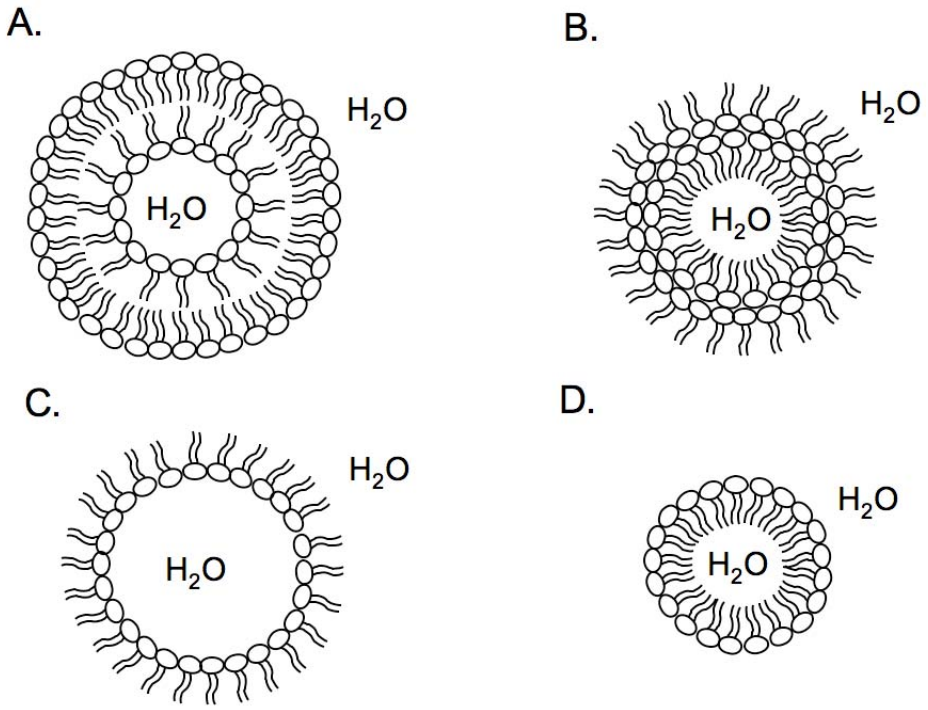


7.

8.

9. A phospholipid molecule is diagrammed at the right, and the four diagrams A-D below represent cross sections of spherical structures composed of phospholipids. Which of these structures is most likely to form when a phospholipid is vigorously dispersed in water?

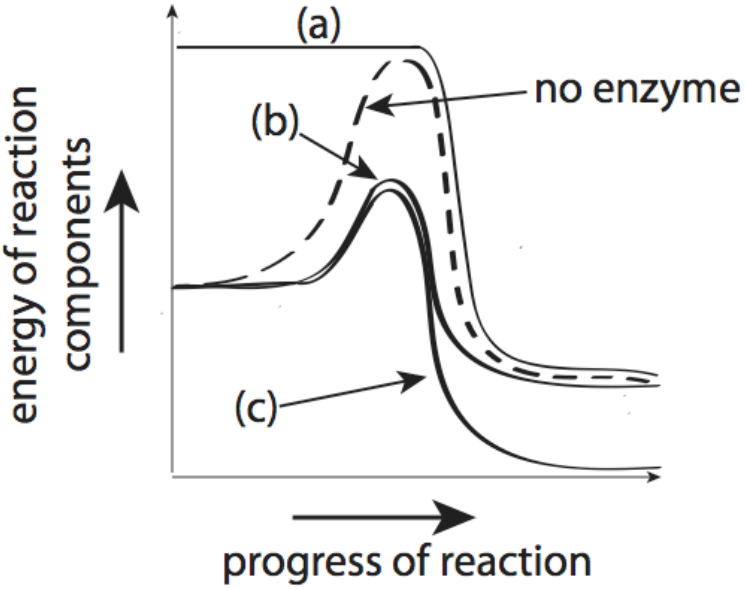



10. Consider a short polar charged region and a short non-polar region in a long polypeptide chain. When dissolved in water, the polypeptide will most likely fold to form a protein in which:

a) The non-polar region is exposed on its surface and the polar region is interior.
b) The polar region is exposed on its surface and the non-polar region is interior.
c) both the non-polar and the polar region are exposed on its surface.
d) both the non-polar region and the polar region are interior.

11. Consider the following chemical reaction: A + B ⇆ C.
In the diagram below, the dashed line represents the energetics of this reaction WITHOUT an enzyme. Which of the solid lines (a, b, c) in the diagram best represents the way the curve would look in the presence of an enzyme catalyst that increases the reaction rate?




12. If the intracellular reaction A + B → C proceeds in the presence of a specific enzyme and no other components, you can conclude that:

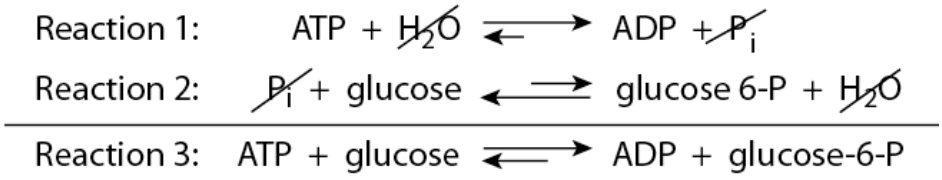
a) the reaction would not proceed in the absence of the enzyme.
b) the reaction would proceed in the absence of the enzyme but at a slower rate.
c) the reverse reaction A + B ← C would not proceed in the presence of the enzyme.
d) the reaction in the presence of the enzyme will not proceed any faster if the temperature is raised a few degrees.

13. If the chemical reaction below is at equilibrium, which of the following statements is FALSE?

$$A + B \leftrightarrows C$$

a) The concentration of reactants and products will remain the same over time.
b) During a 1-minute interval, many molecules of A and B may be converted to C, while about the same number of A and B molecules are produced by the breakdown of C.
c) The rates of both the forward and reverse reactions are zero.
d) The free energy available from the reaction is zero.

14. The reaction catalyzed by the enzyme hexokinase (Reaction 3 below) can be thought of as the sum of Reactions 1 and 2. Reaction 1 is the breakdown of ATP to ADP, which releases energy. Reaction 2, in which glucose is phosphorylated, requires energy.



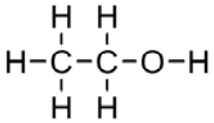

When Reactions 1 and 2 are coupled in the enzyme active site, Reaction 3 will occur spontaneously because:

a) the energy required to form glucose-6-P in Reaction 2 is less than the energy released by ATP breakdown in Reaction 1.
b) the energy required to form glucose-6-P in Reaction 2 is greater than the energy released by ATP breakdown in Reaction 1.
c) both Reactions 1 and 2 can occur spontaneously.
d) neither Reaction 1 or 2 can occur spontaneously alone, but both can occur spontaneously when coupled in the active site of the enzyme.

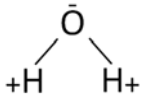
15. Which of the following substances will be least likely to diffuse through a pure phosopholipid bilayer membrane that contains no proteins?

a) $Na^+$

b)



c)



d) O=O

16. If green algae cells in a buffer solution containing only inorganic salts are placed in a sealed container at room temperature with excess carbon dioxide gas and exposed to light, the cells will:

a) live for many hours and multiply.
b) live for several hours, but fail to multiply because there is no source of carbon in the buffer solution.
c) live for several hours, but fail to multiply because no oxygen is present.
d) die rapidly, because no oxygen is present.

17. The oxygen atoms in the $H_2O$ broken down during photosynthesis end up in:

a) ATP molecules generated by photosynthesis.
b) carbohydrates generated by photosynthesis.
c) molecular $O_2$ released during photosynthesis.
d) new $H_2O$ molecules that are produced by respiration.

18. In the presence of oxygen, cells oxidize glucose completely to carbon dioxide and water according to the chemical equation:

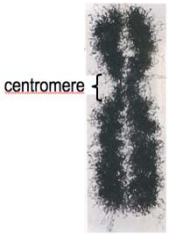
$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

In the process, about 35 molecules of ATP are generated per molecule of glucose oxidized, so that some of the energy released by oxidation is recovered as usable chemical energy. The principal role of $O_2$ in this process is to:

a) accept electrons released by glucose oxidation, forming $H_2O$.
b) supply the oxygen for $CO_2$ production.
c) react with glucose to cleave it into smaller fragments for further oxidation.
d) participate as a reactant in generation of ATP from ADP and $P_i$.

19. The photograph below shows a single replicated chromosome (consisting of two sister chromatids) just before mitosis. This chromosome contains:

a) two single-stranded DNA molecules.
b) one double-stranded DNA molecule.
c) two double-stranded DNA molecules.
d) many double-stranded DNA molecules.



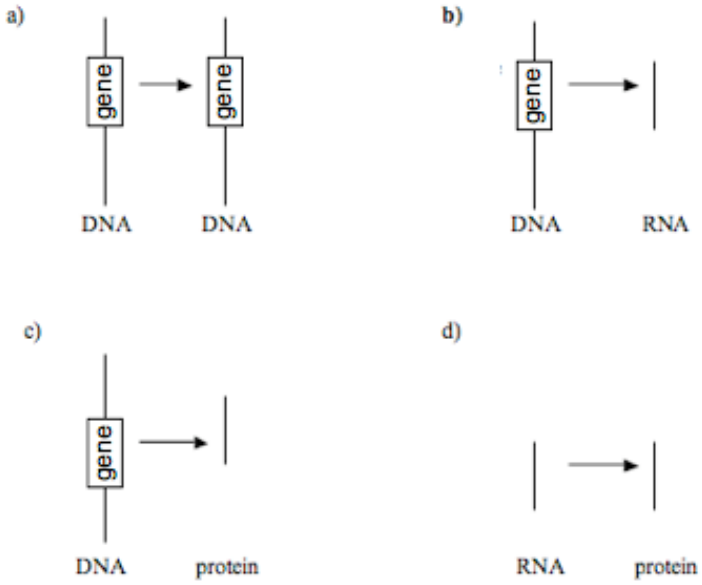

20. The replicated chromosome shown in Question 19 contains:

a) DNA from one of your parents in the sister chromatid on the left and DNA from the other parent in the sister chromatid on the right.
b) DNA contributions from both parents, resulting from recombination (crossing over).
c) DNA from only one of your parents.

21. Which of the following statements about DNA synthesis at the replication fork of a replicating DNA molecule is FALSE?

a) Nucleotides are added at the 3' ends of all the new strands in a replicating DNA molecule.
b) Double-stranded DNA synthesis requires both deoxyribonucleotides and ribonucleotides.
c) The sequence of each newly synthesized single strand is identical to that of the parental single strand that served as its template.
d) One of the two new strands must be synthesized in fragments because the two strands have opposite directionality.

22. Transcription is best represented by which of the following diagrams?




23. The human hexokinase enzyme has the same function as the bacterial hexokinase enzyme but is somewhat different in its amino acid sequence. You have obtained a mutant bacterial strain in which the gene for hexokinase and its promoter are missing. If you introduce into your mutant strain a DNA plasmid engineered to contain the coding sequence of the human hexokinase gene, driven by the normal bacterial promoter, the resulting bacteria will now produce:

a) the bacterial form of hexokinase.
b) the human form of hexokinase.
c) a hybrid enzyme that is partly human, partly bacterial.
d) both forms of the enzyme.

24. In a certain mutant strain of bacteria, the enzyme leucyl-tRNA synthetase mistakenly attaches isoleucine to leucyl-tRNA 10% of the time instead of attaching leucine. These bacteria will synthesize:

a) proteins in which leucine is inserted at some positions normally occupied by isoleucine.
b) proteins in which isoleucine is inserted at some positions normally occupied by leucine.
c) no abnormal proteins, because the ribosomal translation machinery will recognize the inappropriately activated tRNAs and exclude them from the translation process.
d) no proteins, because the inappropriately activated tRNAs will block translation.