Multiple Choice
Identify the choice that best completes the statement or answers the question.

1. All of the following are found in a DNA nucleotide except
a. adenine.
b. phosphate.
c. ribose
d. deoxyribose.

2. Refer to the table below.

<table>
<thead>
<tr>
<th>% A</th>
<th>% C</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

DNA from a fruit fly species was isolated, and the number of adenine bases was counted and expressed as a percentage of the total number of nucleotides in the DNA. What value should go in the table under the % C heading?

a. 18
b. 32
c. 36
d. 41

3. A molecule of RNA is found to contain 60 hydrogen bonds linking complementary bases, while a molecule of DNA of the same length contains 105 hydrogen bonds linking complementary bases. Which information about nucleic acid structure is essential for someone to understand in order to explain this observation?

a. The pentose sugar in RNA is ribose, while the pentose sugar in DNA is deoxyribose.
b. RNA contains the nitrogenous base, uracil, in place of thymine, which is found in DNA.
c. RNA can fold back on itself to form a stable structure, while DNA forms a stable double-stranded structure.
d. Hydrogen bonds in nucleic acids involve attractive interactions between carbonyl and amino groups in nitrogenous base pairs.

4. What is the sequence of the complementary strand of RNA made from the template DNA sequence below?

5'-CAGCGGTTCGCTGAAAGTC-3'
a. 5'-GUCGCAAGCGACUUCA-5'
b. 5'-GTGCAGCGAGGACTTCA-3'
c. 3'-GTGCAGCGAGGACTTCA-3'
d. 3'-GUCGCAAGCGACUUCA-5'

5. Refer to the table below.

<table>
<thead>
<tr>
<th>Polynucleotide group</th>
<th>Percent of $^3$H label</th>
<th>Percent of $^{14}$C label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortest length</td>
<td>0</td>
<td>87.8</td>
</tr>
<tr>
<td>Midrange length</td>
<td>0.3</td>
<td>12.1</td>
</tr>
<tr>
<td>Longest length</td>
<td>99.7</td>
<td>0</td>
</tr>
</tbody>
</table>

A biologist used the radioisotope tritium ($^3$H) to label thymine and the radioisotope carbon-14 ($^{14}$C) to label uracil. She then incubated a growing bacterial culture with both labeled bases. After five hours of incubation, the biologist extracted polynucleotides from the cells and separated them into three groups, each containing a range of different polynucleotide lengths. The first group contained the shortest polynucleotides. The second group contained polynucleotides of midrange length, and the third group contained the longest polynucleotides. Then she determined the percentage of each radiolabel in each fraction. Her data are summarized in the table above. Which statement represents a reasonable hypothesis that could explain these results?

a. Uptake of $^3$H label and uptake of $^{14}$C label both resulted from DNA replication.
b. Uptake of $^3$H label and uptake of $^{14}$C label both resulted from transcription.
c. Uptake of $^3$H label resulted from DNA replication, and uptake of $^{14}$C label resulted from transcription.
d. Uptake of $^3$H label resulted from transcription, and uptake of $^{14}$C label resulted from DNA replication.
6. Refer to the table below.

<table>
<thead>
<tr>
<th></th>
<th>Species A</th>
<th>Species B</th>
<th>Species C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species A</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species B</td>
<td>79%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Species C</td>
<td>84%</td>
<td>92%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Genomes of three different species were compared to determine the extent of similarity between their base sequences. The results are summarized in the table above. What can be inferred from these data?

a. Species A and C share a closer evolutionary relationship than Species A and B.
b. Species A and B have very little biochemistry in common.
c. Species B is related to Species C, but not to Species A.
d. All three species have genomes of different sizes.

7. The R groups of amino acids have certain properties and allow for amino acids to be organized into all of the groups below except:

a. positively charged and hydrophilic.
b. negatively charged and hydrophilic.
c. uncharged hydrophilic.
d. positively charged and hydrophobic.

8. In an alpha helix, the coiling is stabilized by:

a. the hydrophobic nature of the R chains, which causes the chain to coil with the R groups inward.
b. hydrogen bonding of the N—H groups on one amino acid and the C=O groups on another.
c. repulsion of the R chains from each other, causing the coil to form with the R groups on the outside.
d. disulfide bond formation between cysteines that are regularly spaced along peptide chains.

9. All of the following contribute to or influence the three-dimensional shape of a protein except:

a. temperature.
b. ester linkages.
c. pH.
d. R groups.

10. Refer to the table below.

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Single-letter abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alanine</td>
<td>A</td>
</tr>
<tr>
<td>Cysteine</td>
<td>C</td>
</tr>
<tr>
<td>Aspartic acid</td>
<td>D</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>E</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>F</td>
</tr>
<tr>
<td>Glycine</td>
<td>G</td>
</tr>
<tr>
<td>Histidine</td>
<td>H</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>I</td>
</tr>
<tr>
<td>Lysine</td>
<td>K</td>
</tr>
<tr>
<td>Leucine</td>
<td>L</td>
</tr>
<tr>
<td>Methionine</td>
<td>M</td>
</tr>
<tr>
<td>Asparagine</td>
<td>N</td>
</tr>
<tr>
<td>Proline</td>
<td>P</td>
</tr>
<tr>
<td>Glutamine</td>
<td>Q</td>
</tr>
<tr>
<td>Arginine</td>
<td>R</td>
</tr>
<tr>
<td>Serine</td>
<td>S</td>
</tr>
<tr>
<td>Threonine</td>
<td>T</td>
</tr>
<tr>
<td>Valine</td>
<td>V</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>W</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>Y</td>
</tr>
</tbody>
</table>

Which peptide could be found inside a phospholipid bilayer membrane due to its hydrophobic properties?

a. RKE
b. HGD
c. GTC
d. LMV

11. Which statement about the structure of a protein is true?

a. Once all hydrogen bonding in a protein is disrupted, the only remaining stable aspect of the protein’s structure is its primary structure.
b. If the van der Waals forces in a protein are disturbed, only the quaternary structure will be affected.
c. Tertiary and quaternary structures of a protein are stabilized by different types of interactions.
d. A gene mutation that causes a single amino acid substitution in the primary sequence of a protein can cause significant change in the protein’s tertiary structure.
12. If heat speeds chemical reactions in a lab, why can’t cells use heat to drive their chemical reactions?
   a. The high energy costs involved would be prohibitive for the cell.
   b. Excess heat would speed up all chemical reactions in a nonspecific way and denature proteins.
   c. Organisms with self-regulated body temperature would actively inhibit increased temperatures.
   d. Chemical reactions inside cells are much different from chemical reactions in a lab and would not respond to heat in the same way.

13. Which statement accurately describes features of the active site of an enzyme?
   a. The active site shape is specific for the substrates.
   b. The active site shape is specific for the products.
   c. The active site is highly versatile and can bind a wide variety of molecules.
   d. The active site is buried deep within a hydrophobic region of the enzyme.

14. The conversion of glucose to glucose 6-phosphate is an enzyme catalyzed reaction, during which the enzyme hexokinase folds around the substrates (glucose and ATP) to exclude water molecules from the reaction site. This change in hexokinase is an example of
   a. substrate specificity.
   b. substrate saturation.
   c. induced fit.
   d. hydrophilic interactions.

15. Refer to the table below.

<table>
<thead>
<tr>
<th></th>
<th>Substrate</th>
<th>Turnover number (at 25°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild-type enzyme</td>
<td>pyruvate</td>
<td>15,000 molecules/sec</td>
</tr>
<tr>
<td></td>
<td>malate</td>
<td>200 molecules/sec</td>
</tr>
<tr>
<td></td>
<td>oxalate</td>
<td>130 molecules/sec</td>
</tr>
<tr>
<td>Mutant enzyme</td>
<td>pyruvate</td>
<td>900 molecules/sec</td>
</tr>
<tr>
<td></td>
<td>malate</td>
<td>750 molecules/sec</td>
</tr>
<tr>
<td></td>
<td>oxalate</td>
<td>680 molecules/sec</td>
</tr>
</tbody>
</table>

Pyruvate dehydrogenase is an enzyme that catalyzes the conversion of pyruvate to acetyl-CoA. This enzyme was isolated from a wild-type strain of bacteria and from a strain that had been subjected to mutation. Both wild-type and mutant forms of the enzyme were then characterized using the normal substrate, pyruvate, and using other compounds similar to pyruvate. Which conclusion is supported by these results?
   a. The wild-type enzyme is able to recognize only one substrate, whereas the mutant enzyme recognizes several substrates.
   b. Change in the protein structure during mutation led to decreases in both substrate specificity and catalytic efficiency in this enzyme.
   c. The active site of the mutant form of the enzyme reacts with a greater range of substrates but at lower efficiencies than the wild-type active site.
   d. Mutation of the enzyme decreased catalytic activity with the normal substrate but broadened the range of substrates with which it can react.
16. Refer to the figure below.

A constant amount of enzyme was exposed to increasing amounts of substrate, and the reaction rate was measured at each substrate concentration. The data were plotted in the graph above. How will the data change if the amount of enzyme present in solution was doubled and the measurements repeated?

a. The data will form a curve indicating higher reaction rates at low substrate concentrations but eventually reaching the same maximum rate as the one shown.
b. The data will form a curve indicating lower reaction rates at low substrate concentrations but eventually reaching the same maximum rate as the one shown.
c. The data will form a curve similar to the one shown but leveling off at a maximum rate twice as high.
d. The data will form a curve similar to the one shown but leveling off at a maximum rate half as high.

17. An inhibitor that binds to the active site of an enzyme is termed a(n) _____ inhibitor, whereas an inhibitor that binds to a site distinct from the active site is termed a(n) _____ inhibitor. These are examples of ________ inhibition.

a. competitive; noncompetitive; allosteric
b. competitive; uncompetitive; allosteric
c. uncompetitive; competitive; reversible
d. competitive; noncompetitive; reversible

18. Alcohol dehydrogenase (ADH) catalyzes the oxidation of ethanol (CH₃CH₂OH) to acetaldehyde, which is then fed into pathways to make fatty acids or to be used as a fuel source. The human body can therefore tolerate a certain amount of ethanol. However, the body cannot tolerate methanol (CH₃OH). When methanol is ingested, ADH acts on it, breaking it down to formaldehyde, which is toxic to the human body. Emergency medical treatment for methanol poisoning includes intravenous injection of ethanol. Which statement provides the simplest, most likely explanation for how ethanol acts to prevent harm from methanol ingestion?

a. Ethanol acts as an irreversible inhibitor of ADH to shut down its ability to carry out methanol oxidation.
b. Ethanol acts as a competitive inhibitor of methanol to decrease the rate of methanol oxidation by ADH.
c. Ethanol acts as a noncompetitive inhibitor of methanol to decrease the rate of methanol oxidation by ADH.
d. Ethanol acts to protect ADH from irreversible denaturation by methanol.

19. Which statement regarding allosteric regulation is true?

a. Allosteric regulation involves noncovalent binding but not covalent binding of regulator molecules to an enzyme.
b. Shape changes in proteins cannot be transmitted across long distances, which means that allosteric sites must overlap with active sites.
c. An allosteric regulatory site is distinct from the active site, which means that the two sites could be located on separate subunits.
d. Allosteric regulator molecules compete with substrate molecules as they bind to the active site.

20. In a cell, a particular enzyme is inhibited by the action of a kinase and activated by the action of a phosphatase. What does this mean?

a. The kinase adds a phosphate group to an allosteric site on the enzyme that inhibits the enzyme’s catalytic activity; the phosphatase removes the phosphate group and releases this inhibition.
b. The phosphatase adds a phosphate group to an allosteric site on the enzyme that inhibits the enzyme’s catalytic activity; the kinase removes the phosphate group and releases this inhibition.
c. The kinase generates phosphate that binds to the active site of the enzyme, inhibiting its catalytic activity; the phosphatase decomposes phosphate, thereby removing it and its inhibitory effect.
d. The phosphatase generates phosphate that binds to the active site of the enzyme inhibiting its catalytic activity; the kinase decomposes phosphate, thereby removing it and its inhibitory effect.
21. As the end product of a particular metabolic pathway builds up in concentration, it binds to the enzyme that catalyzes the first reaction in the pathway, reducing its catalytic activity. This process is called
   a. cofactor regulation.
   b. feedback inhibition.
   c. metabolic engineering.
   d. systems processing.

22. A biologist studying a metabolic pathway in a fungus species hypothesizes that the pathway is regulated through feedback inhibition. The pathway involves the steps A → B → C → D → E. To test his hypothesis, the biologist could test to see whether _______ inhibits the enzyme catalyzing the reaction of _______.
   a. E; D → E
   b. A; D → E
   c. E; A → B
   d. B; A → B

23. Of the enzymes given below, the most likely to maintain catalytic activity during increasing temperature changes from 22°C to 75°C are those isolated from
   a. bacteria that colonize geyser basins.
   b. the guts of fish that live in temperate lakes.
   c. the intestines of mammals.
   d. a shrimp species that lives in the Arctic Ocean.

24. Refer to the table below.

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Number of subunits</th>
<th>Molecular weight</th>
<th>pH optimum</th>
<th>Temperature optimum</th>
<th>Number of disulfide bonds</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>140,000</td>
<td>2.7</td>
<td>32°C</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>350,000</td>
<td>4.5</td>
<td>15°C</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>52,000</td>
<td>5.3</td>
<td>62°C</td>
<td>5</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>150,000</td>
<td>7.2</td>
<td>38°C</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>60,000</td>
<td>3.2</td>
<td>5°C</td>
<td>0</td>
</tr>
</tbody>
</table>

The table summarizes properties of several enzymes that catalyze different reactions. In addition, each enzyme was purified from a different organism. Which enzyme was most likely purified from a rat stomach?
   a. Enzyme A
   b. Enzyme B
   c. Enzyme C
   d. Enzyme D
   e. Enzyme E

25. Every year, a crab species migrates between tropical and northern Atlantic Ocean waters. How likely would it be that this species produces isozymes that catalyze an essential metabolic reaction?
   a. Very unlikely, because a single metabolic reaction needs only one enzyme, and the production of isozymes would be energetically wasteful
   b. Very unlikely, because an essential metabolic reaction requires a single enzyme with robust properties that make it durable, even when stressed
   c. Very likely, because catalysis of an essential reaction could be optimized all year by switching between isozymes
   d. Very likely, because essential metabolic reactions are so important that organisms need multiple copies of enzymes that catalyze them