1. This letter appeared recently in a veterinarian’s advice column. *Dear Dr. Fox: In May, seeing a proliferation of fleas and ticks, I let my guard down and went with my vet’s recommendation of Vectra. We applied it to our small dog in the recommended dose and forgot about it. Within 3 weeks, my healthy 3-year-old dog was dying. More than $10,000 later she survived and came home. She has sort of recovered but her immune system is shot, and she’ll never be the same.*

   a. Do you think the information presented is sufficient scientific evidence to conclude that the dog’s illness is a reaction to Vectra? Why or why not? (2 points)

   b. Suppose you work for the company that makes Vectra. How would you design an experiment to test whether Vectra is harmful to small breeds of dogs? Your answer should summarize your overall strategy; it should also list the independent variable, dependent variable, at least two relevant standardized variables, and your control (8 points).

2. Write a paragraph that describes how the number of protons, neutrons, and electrons in an atom affects its atomic number, mass number, and charge (6 points).

3. The table below contains 10 pairs of terms separated by a slash. Circle the correct terms for each entry in the table (5 points).

<table>
<thead>
<tr>
<th>Photosynthesis</th>
<th>Respiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>Produced / Consumed</td>
</tr>
<tr>
<td>Light</td>
<td>Required / Not Required</td>
</tr>
<tr>
<td>H₂O</td>
<td>Consumed / Released</td>
</tr>
<tr>
<td>CO₂</td>
<td>Consumed / Released</td>
</tr>
<tr>
<td>O₂</td>
<td>Consumed / Released</td>
</tr>
</tbody>
</table>

4. Draw four water molecules as they might interact in a droplet of liquid water. Label a hydrogen bond, a covalent bond, an area with a partial negative charge, and an area with a partial positive charge (4 points).
Part II: 75 points (38 questions; each question is worth 2 points, except the last)

True-false (mark A for true, B for false):

1. Unsaturated fats have more calories per gram than do saturated fats, so saturated fats are considered the healthier choice.
2. Organisms are made of cells, which are made of molecules, which are made of atoms.
3. An atom is “happiest” if the number of protons exactly equals the number of electrons.
4. Cilia and flagella are both structures that help move cells from one location to another.

Multiple choice / matching:

5. The following images depict five possible evolutionary trees, with a root at the bottom and the major categories of life at the tips. Which of these images best summarizes our understanding of the main groups in life’s diversity?

   a.   b.   c.   d.   e.

   Root   Root   Root   Root   Root

6. How many of the items in the following list are smaller than a cell?
   - organ
   - molecule
   - DNA
   - sugar
   - endoplasmic reticulum
   - nucleus
   - isotope
   - organ system
   - tissue
   - biosphere
   - organelle
   - flagellum

   a. 8    b. 7    c. 6    d. 5    e. 4

7. How did the invention of the microscope influence human perceptions about the diversity of life?
   a. Before that time, people thought every life form was either a plant or an animal.
   b. Before that time, people didn’t know life existed at all.
   c. Before that time, people thought fungi were most closely related to animals.
   d. Before that time, people thought protists were prokaryotic.
   e. Before that time, people thought Archaea were eukaryotic.

8. DNA sequencing is a tool used to determine everything from “Who’s the daddy?” to evolutionary relationships. This works because the sequence of ____ in each individual’s DNA is unique.
   a. deoxyribose molecules
   b. ribose molecules
   c. phosphate groups
   d. nitrogenous bases
   e. RNA molecules
In the “Marshmallow test” video, little kids were put alone in a room with a single marshmallow and told that if they didn’t eat the marshmallow before the researcher came back into the room (in 15 minutes), they’d get a second marshmallow. Suppose you wonder whether kids would have more self-control if the reward for waiting were better – say, a cupcake instead of a second marshmallow. In planning that experiment:

9. The dependent variable would be:
   a. the type of reward the kid would get for waiting
   b. the cupcake
   c. the first marshmallow
   d. the second marshmallow
   e. whether the kid ate the marshmallow within 15 minutes

10. The best control group would be
   a. the kids who were told they would get a second marshmallow for waiting
   b. the kids who ate the marshmallow within 15 minutes
   c. the kids who never ate any marshmallow
   d. the amount of time the kids had to wait
   e. the number of distractions in the room the kids were in

11. The independent variable would be
   a. the type of reward the kid would get for waiting
   b. the cupcake
   c. whether the kid ate the marshmallow within 15 minutes
   d. the first marshmallow
   e. the second marshmallow

The following can be compared in a quantitative sense. Use the choices below to describe the paired statements.

   a. The first is greater than the second
   b. The second is greater than the first
   c. The two are essentially equal

12. The number of species that do respiration … the number of species that do photosynthesis
13. The number of electrons in the isotope $^{13}\text{C}$ … the number of electrons in the isotope $^{14}\text{C}$
14. The number of water molecules produced in the formation of a triglyceride … the number of water molecules produced in the formation of a chain of four amino acids

15. I ate some fresh grapes as a snack earlier today. If I had crushed some of the grape tissue under a light microscope in the lab classroom, I could probably have seen:
   a. cells containing nuclei
   b. prokaryotic cells
   c. individual water molecules
   d. cell membranes, but not cell walls
   e. flagella

16. After I chewed and swallowed the grapes, they eventually went to my small intestine to be digested. There, digestive enzymes used the ___ reaction to dismantle the polymers in the grapes.
   a. hydrolysis
   b. photosynthesis
   c. secretion
   d. dehydration synthesis
   e. monomer synthesis
The image at right shows a protein embedded in, and extending from, a portion of a membrane.

17. Which amino acid is most likely to be part of the portion labeled “X”?

![Amino acids]

a. Leucine  

b. Isoleucine  

c. Phenylalanine  

d. Glutamine

18. The portion marked “Y” is probably dominated by ____ amino acids.
   a. hydrophilic  
   b. hydrophobic

19. The molecule marked Z is:
   a. a water molecule  
   b. an enzyme  
   c. a steroid  
   d. a monosaccharide  
   e. a phospholipid

20. Without evolution, there wouldn’t have been:
   a. the Big Bang  
   b. the origin of life  
   c. atoms  
   d. the diversity of species we see today  
   e. all of the above are true

21. Which of the following statements is true?
   a. A chemical bond joins two types of cells together.
   b. Three types of bonds are ionic, covalent, and polar.
   c. Two atoms have to have opposite charges if they are going to form a covalent bond.
   d. If one atom “hogs” the other one’s protons, the bond will be polar.
   e. If a sodium atom (Na) has one more proton than electrons, its symbol is written as Na⁺.

22. The objectives on our lab’s light microscopes magnify objects by 4x, 10x, 40x, and 100x. Is it possible to use these microscopes to look at an object magnified by 400x?
   a. Yes, if you switch directly from the 4x to the 100x, the total magnification is 400x.
   b. Yes, if the eyepiece has a magnification of 10x and you use the 40x objective.
   c. No, we don’t have an objective for 400x.
   d. No, it is not possible to magnify an object higher than 100x.
23. Which of the following condition is least likely to cause an enzyme to become denatured?
   a. refrigeration  b. a very salty solution  c. boiling  d. a very acidic solution

24. On a molecular scale, what is happening when an enzyme becomes denatured?
   a. The sequence of the DNA that encodes the enzyme changes.
   b. The polarity of the covalent bonds switches, so nonpolar bonds become polar and vice versa.
   c. The monomers that make up the enzyme all come apart from each other.
   d. The hydrogen bonds that maintain the enzyme’s shape become too strong for it to do its job.
   e. The enzyme’s overall shape is destroyed, so it can no longer function.

25. What is the relationship between food and ATP?
   a. ATP is a polymer that plant cells produce as their food in photosynthesis.
   b. Animal cells, but not plant cells, use food molecules (like glucose) as an energy source to produce ATP.
   c. Animal cells use ATP as an energy source to produce their food in respiration.
   d. Animals and plants need food to make ATP, but prokaryotes don’t need food or ATP.
   e. All types of cells use food molecules (like glucose) as an energy source to produce ATP.

26. Which of the following statements about the digestion lab is false?
   a. The amount of starch decreased as the reaction proceeded.
   b. The solution’s pH became more acidic as the vegetable oil was digested.
   c. Omitting the bile (the emulsifier) meant the vegetable oil could not be digested.
   d. Adding acid slowed down the digestion of starch.
   e. If you had used Olestra instead of vegetable oil, the lipase enzymes would still have been able to do their job.

27. Which of the following statements about the molecule at right is true?
   a. It is considered a polymer because it consists of multiple chains.
   b. It contains more calories per gram than any of the other major food molecules.
   c. It is unsaturated.
   d. It can be made into a phospholipid by deleting two of the fatty acid tails.
   e. It is highly soluble in water.

28. Which of the following statements is true?
   a. Hydrogen bonds hold together the glucose molecules in a polysaccharide chain.
   b. Plant cells make starch and glycogen, whereas animal cells make cellulose.
   c. Both monosaccharides and polysaccharides contain C, H, and O in a ratio of 1:2:1.
   d. Sugars and fats are collectively known as carbohydrates.
   e. Lipids and carbohydrates consist of so much C and H that they are insoluble in water.

29. If a cell cannot produce ribosomes, it will:
   a. not have any enzymes
   b. not have any membrane proteins
   c. not be able to transport hydrophilic substances across its membrane
   d. not be able to generate ATP
   e. die because it will not be able to do any of the above essential activities
30. Suppose that in the “condom lab,” your group decided to see whether ultrathin, ribbed, or regular condoms are the stretchiest. Your group picks two types of condoms from each category and measures how many marbles each condom can hold before breaking. The graph of the data should be:
   a. a bar graph, because the number of marbles is a continuous variable
   b. a bar graph, because the type of condom is a discrete variable
   c. a line graph, because the number of marbles is a continuous variable
   d. a line graph, because the type of condom is a discrete variable
   e. any type of graph you like, because scientists depict their data however they think it looks best

31. Cells in the human pancreas secrete digestive enzymes into a duct that leads to the small intestine, where digestion occurs. Which of the following is NOT matched correctly with its role in the process of producing and secreting the enzymes?
   a. ATP – provides the energy needed for making the enzymes
   b. chloroplast – produces sugar inside the cells of the pancreas
   c. Golgi apparatus – packages the digestive enzymes to get them ready to be exported
   d. nucleus – contains the “recipes” for the digestive enzymes
   e. amino acids – monomers that make up the enzymes

Matching! Use the image above and the choices below to answer the next two questions.
   a. a protein       b. a polysaccharide    c. a steroid    d. DNA    e. a nucleotide

32. What is the molecule marked X?
33. What is the molecule marked Y?

34. What do amino acids have in common with nucleotides?
   a. They are both a type of monomer.
   b. They both function as enzymes in cells.
   c. They both include phosphorus.
   d. They both make up DNA.
   e. All of the above are true.

35. What type of molecule is shown at right?
   a. It’s a protein; you can tell because it has nitrogen.
   b. It’s a nucleic acid; you can tell because it has both nitrogen and phosphorus.
   c. It’s a polysaccharide; you can tell because it has rings.
   d. It’s a fat; you can tell because it has double bonds.
   e. It’s water; you can tell because it’s held together with hydrogen bonds.
36. In the image above, do atoms 1 and 2 have partial charges?
   a. Yes, they both have partial negative charges.
   b. Yes, they both have partial positive charges.
   c. Yes, atom 1 has a partial negative charge, and atom 2 has a partial positive charge.
   d. Yes, atom 1 has a partial positive charge, and atom 2 has a partial negative charge.
   e. Atom 1 has a partial positive charge, but atom 2 is neutral.

37. For how many of the covalent bonds in the image above are the electrons shared EXACTLY equally?
   a. all of them  b. seven  c. four  d. three  e. none of them

38. Which test form do you have? (1 point)
   a. Form 1 (green)  b. Form 2 (pink)