Name-_______________________________

Chapters 1-5 Questions

1) “Life” is easy to recognize but difficult to define. The dictionary defines life as “the state or quality that distinguishes living beings or organisms from dead ones and from inorganic matter, characterized chiefly by metabolism, growth, and the ability to reproduce and respond to stimuli.” Biology textbooks usually elaborate slightly; for example, according to a popular text, living things:
   a. Are highly organized compared to natural inanimate objects.
   b. Display homeostasis, maintaining a relatively constant internal environment.
   c. Reproduce themselves.
   d. Grow and develop from simple beginnings.
   e. Take energy and matter from the environment and transform it.
   f. Respond to stimuli.
   g. Show adaptation to their environment.
Score yourself, a car, and a cactus with respect to these characteristics. Is there any grey area? In the context of what you just did, why could defining life be an elusive business?

2) In 1944, at the beginning of his book, What is Life, the great physicist Erwin Schrödinger (of cat fame) asked the following question: “How can the events in time and space which take place within the spatial boundary of a living organism be accounted for by physics and chemistry?” What would be your answer today? Do you think there are peculiar properties of living systems that disobey the laws of physics and chemistry? Explain your answer.

3) It seems to be human nature to try and group living things into categories. These groupings have helped philosophers and naturalists better understand the living world around them. A taxon is the name given to any specific level of organization in our current classification system. Identify the taxonomic levels that biologists most frequently use. How are they organized? Can taxonomic systems be used to show phylogeny (aka evolutionary relationships) of organisms?

4) Chapter 1 includes heredity (i.e. DNA and genes) as well as evolution. Discuss the connection between heredity and evolution?

5) What is meant by the term “descent with modification?”

6) Science is often described to work by a set of steps or by a specific method. Why is this not necessarily true?

7) What is the difference between a hypothesis and a theory?

8) What is the arrangement of protons, neutrons and, electrons in an atom? Describe this verbally then diagrammatically.

9) A carbon atom contains six protons and six neutrons.
a. Without looking at a periodic table what is carbons atomic number and atomic weight? How did you know this?
b. How many electrons does it have? How many valence electrons does it have? How did you know this?
c. How many additional electrons must it add to fill its outermost shell? How does this affect carbon’s chemical behavior?
d. Carbon with an atomic weight of 14 is radioactive. How does it differ in structure from nonradioactive carbon? How does this difference affect its chemical behavior?

10) Sketch the electron shell configuration of a sodium atom. According to the octet rule, what would be the simplest way for a sodium atom to achieve electron stability?

11) Many elements have isotopes, which are rare variants of the element with additional neutrons in the nucleus. Deuterium is an isotope of hydrogen that has one neutron. Does the neutron change the chemical reactivity of deuterium, compared with normal hydrogen? Explain why or why not.

12) The concepts of chemical bonding and electronegativity allow us to predict whether a molecule will be polar or nonpolar, and how it will interact with water. Typically, a difference in electronegativity greater than 0.5 will result in polarity. For each of the bonds below indicate:
   a) Whether the bond is polar or nonpolar
   b) If polar which end is $\delta^+$ end
   c) How a molecule with the bond will interact with water (hydrophilic or hydrophobic).

<table>
<thead>
<tr>
<th>N-H</th>
<th>C-H</th>
<th>C=O</th>
<th>C-N</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-H</td>
<td>C-C</td>
<td>H-H</td>
<td>O-P</td>
</tr>
</tbody>
</table>

13) Compare electron behavior in ionic, covalent, and hydrogen bonds. Which is strongest, and why?

14) What is the difference between a covalent and a non-covalent bond?

15) Hydrogen bonds and van der Waals attractions are important in the interactions between molecules in biology. 
   a. Describe the differences and similarities between van der Waals attractions and hydrogen bonds.
   b. Which of the two types of interactions would form (1) between two hydrogens bound to carbon atoms, (2) between a nitrogen atom and a hydrogen bound to a carbon atom, and (3) between a nitrogen atom and a hydrogen bound to an oxygen atom?

16) How do variations in electronegativity result in the unequal sharing of electrons in polar molecules?
17) Consider the molecule carbon dioxide. Are the bonds between the C and the O atoms ionic or covalent? Is this molecule hydrophobic or hydrophilic? Explain your answers.

18) Here is the structure of the molecule glycine:

H \quad H \quad C \quad O
\quad H \quad \quad \quad \quad O-H

a) Is this molecule hydrophilic or hydrophobic? Explain.
b) Draw two glycine molecules and show how they can be linked by dehydration synthesis.

19) What is the difference between a solute and a solvent?

20) What is meant by the terms osmosis and diffusion? Are they the same thing? How are they related to the concepts of hypertonic, isotonic, and hypotonic?

21) Transpiration is the name given to how water travels up a plant, from its roots to its leaves. Discuss how this happens in the context of water's special properties.

22) The organic chemistry of living cells is said to be special for two reasons: it occurs in an aqueous environment and it accomplishes some very complex reactions. But do you suppose it’s really all that much different from the organic chemistry carried out in the top laboratories in the world? Why or why not?

23) What is pH? What does the pH scale represent? How do you calculate pH?

24) Why is pH important to the functioning of biological systems?

25) How are two monomers linked together? Broken down?

26) Draw the chemical structure of a disaccharide formed by two glucose monosaccharides.

27) Examine the glucose molecule shown in your textbook. Identify the functional groups on the molecule.

28) What are the structural differences between alpha-glucose and beta-glucose? How does this difference affect the structure of a string of alpha-glucose molecules in comparison to a string of beta-glucose molecules? Explain why this happens.

29) Some sugars have other functional groups in addition to those typically present. Draw the structure of the amino sugar glucosamine, which has an amino group bonded at
carbon #2 of glucose. Would this molecule be more or less polar than glucose? Explain why.

30) The molecular formula for glucose is C6H12O6. What would be the molecular formula for a polysaccharide made by linking ten glucose molecules together by dehydration reactions?

31) What is the difference between fats and oils?

32) Why are phospholipids amphipathic, and how does this result in a lipid bilayer membrane?

33) If fatty acids are carefully put onto the surface of water, they will form a single molecular layer. If the mixture is then shaken vigorously, the fatty acids will form round structures called micelles. Why does this happen? Explain.

34) List the key differences between DNA and RNA and between purines and pyrimidines.

35) How can DNA molecules be so diverse when they appear to be structurally similar?

36) What attributes of an amino acid’s R group would make it hydrophobic? Hydrophilic?

37) Sketch the bonding of two amino acids, glycine and leucine, by a peptide linkage. Now add a third amino acid, alanine, in the position it would have if added within a biological system. What is the directionality of this process? Does it grow from the N-terminus out or the C-terminus out?

The following questions have some notes with it. Please read through it.

38) What was the first 1° structure of a protein to be determined, and how was it done?

A similar technique based on the overlapping segments is also used to sequence DNA nucleotides which is called “Chromosome Walking”.

The structure of a protein is so important that changing just one amino acid in a chain of over 100 can cause a deadly disease.

2° Structure: In many cases you will see a helix or b pleated sheets. Your textbook doesn’t put the b in front of the pleated sheets, but many references do. The a and b are just there because the helix structure was discovered first.

39) Which is a stronger structure, an a helix or b pleated sheets. Explain your answer.

Disulfide bridges do not just form spontaneously. Note that there is a H attached to the S in Cysteine. Thus a group of enzymes known as Protein Disulfide Isomerases (PDI’s) must catalyze the reaction by removing the H’s in order for the S-S covalent bonds to form. Disulfide
bridges can occur in both 3° and 4° structures. The process is still unknown and it is under investigation because it is very hard to study.

4° Structure: Please note that just because the most commonly used example is hemoglobin with 4 subunits (2 a and 2 b chains), the 4° structure IS NOT the way that 4 polypeptide chains are put together. According to a reader for the AP exam essays, that was a commonly misused example in the 2001 exam Essay #4 part (a).

40) What is denaturation, and how can it occur? You must be able to explain not just the what’s (i.e. temp), but the how’s (how does temperature effect the structure).

41) Examine the structure of sucrase:

![Image of sucrase structure]

You can see many alpha helices and beta-pleated sheets making up the tertiary structure of this enzyme. Where in the protein might you expect to find the following amino acids: valine, proline, glutamic acid, and threonine? Explain your answers.

42) Detergents disrupt hydrophobic interactions by coating hydrophobic molecules with a molecule that has a hydrophilic surface. When hemoglobin is treated with a detergent, the four polypeptide chains separate and become random coils. Explain these observations.

43) The amino acid lysine is at the active site of an enzyme. Normally the enzyme is active at pH 7. At pH 5, the enzyme is inactive. Explain these observations.

44) Biological systems contain “supermolecular complexes,” which are composed of individual molecules of RNA and protein that fit together noncovalently. These complexes can be split apart with detergents that disrupt hydrophobic interactions. Based on your knowledge, fill in the table at the right to indicate which of the observations are characteristic of RNA, which are characteristics of proteins, and which are characteristics of both. Explain your answers.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Protein</th>
<th>RNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has three-dimensional structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monomers connected by N-C bonds</td>
<td>3D structure destroyed by heat</td>
<td>Contains sulfur atoms</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------------------</td>
<td>-----------------------</td>
</tr>
</tbody>
</table>

45) Fill out the following chart:

<table>
<thead>
<tr>
<th></th>
<th>Primarily used for</th>
<th>Examples include</th>
<th>Bonds made to form polymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lipid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nucleic Acid</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>