**THEMES IN THE STUDY OF LIFE**  
  
  
**Inquiring about the World of Life**  
1.    Briefly describe the unifying themes that characterize the biological sciences.  
2.    Diagram the hierarchy of structural levels in biological organization.  
3.    Explain how novel properties of life emerge from complex organization.  
4.    Describe the dilemma of reductionism.  
5.    Describe the two major dynamic processes of any ecosystem.  
6.    Name two characteristics shared by all cells.  
7.    Distinguish between prokaryotic and eukaryotic cells.  
8.    Describe the basic structure and function of DNA.  
9.    Discuss the goals and activities of systems biology.  List the three research developments that have advanced systems biology.   
10.    Explain the importance of regulatory mechanisms in living things.  Distinguish between positive and negative feedback.  
  
**Organizing the Diversity of Life**  
11.    Distinguish among the three domains of life. List and distinguish among the three kingdoms of multicellular, eukaryotic life.  
12.    Explain the phrase: “life’s dual nature of unity and diversity”. Explain how evolution accounts for the unity and diversity of living things.  
13.    Describe the observations and inferences that led Charles Darwin to his theory of evolution by natural selection.  
14.    Explain why diagrams of evolutionary relationships have a treelike form.  
  
**The Process of Science**  
15.    Distinguish between discovery science and hypothesis-based science.  Explain why both types of exploration contribute to our understanding of nature.  
16.    Distinguish between quantitative and qualitative data.   
17.    Distinguish between inductive and deductive reasoning.  
18.    Explain why hypotheses must be testable and falsifiable but are not provable.  
19.    Describe what is meant by a controlled experiment.  
20.    Distinguish between the everyday meaning of the term ‘theory’ and its meaning to scientists.  
21.    Describe an example that illustrates how science may be influenced by social and cultural factors.  
22.    Distinguish between science and technology.  Explain how science and technology are interdependent.

**THE CHEMICAL CONTEXT OF LIFE**  
  
  
**Elements and compounds**  
1.    Distinguish between an element and a compound.  
2.    Identify the four elements that make up 96% of living matter.  
3.    Define the term trace element and give an example.  
  
**Atoms and molecules**  
4.    Draw and label a simplified model of an atom.  Explain how this model misrepresents our understanding of atomic structure.  
5.    Distinguish between each of the following pairs of terms:  
a.    Neutron and proton  
b.    Atomic number and mass number  
c.    Atomic weight and mass number  
6.    Explain how the atomic number and mass number of an atom can be used to determine the number of neutrons.  
7.    Explain how two isotopes of an element are similar.  Explain how they are different.  
8.    Describe a biological application that uses radioactive isotopes.  
  
**Electron distribution and chemical properties**  
9.    Define the terms energy and potential energy.  Explain why electrons in the first electron shell have less potential energy than electrons in higher electron shells.  
10.    Distinguish between nonpolar covalent, polar covalent and ionic bonds.      
11.    Explain why strong covalent bonds and weak bonds are both essential in living organisms.  
12.    Distinguish between hydrogen bonds and van der Waals interactions.  
13.    Give an example that illustrates how a molecule’s shape can determine its biological function.  
14.    Explain what is meant by a chemical equilibrium.

**WATER AND THE FITNESS OF THE ENVIRONMENT**  
**The Properties of Water**  
1.    With the use of a diagram or diagrams, explain why water molecules are:  
              a.    polar  
              b.    capable of hydrogen bonding with 4 neighboring water molecules  
2.    List four characteristics of water that are emergent properties resulting from hydrogen bonding.  
3.    Define cohesion and adhesion.  Explain how water’s cohesion and adhesion contribute to the movement of water from the roots to the leaves of a tree.  
4.    Distinguish between heat and temperature, using examples to clarify your definitions.  
5.    Explain the following observations by referring to the properties of water:  
           •    Coastal areas have milder climates than adjacent inland areas.  
           •    Ocean temperatures fluctuate much less than temperatures on land.  
           •    Insects like water striders can walk on the surface of a pond without breaking the surface.  
           •    If you slightly overfill a water glass, the water will form a convex surface above the top of the glass.  
           •    If you place a paper towel so that it touches spilled water, the towel will draw in the water.  
           •    Ice floats on water.  
           •    Humans sweat and dogs pant to cool themselves on hot days.  
  
**The Solvent of Life**  
6.    Distinguish between a solute, a solvent and a solution.  
7.    Distinguish between hydrophobic and hydrophilic substances.  
8.    Explain how you would make up a one molar (1M) solution of ethyl alcohol.  
  
**The Dissociation of Water Molecules**  
9.    Name the products of the dissociation of water and give their concentration in pure water.  
10.    Define acid, base, and pH.  
11.    Explain how acids and bases may directly or indirectly alter the hydrogen ion concentration of a solution.  
12.    Using the bicarbonate buffer system as an example, explain how buffers work.  
13.    Briefly explain how the burning of fossil fuels may affect:  
               a.    Acid precipitation  
               b.    Ocean acidification

**CARBON AND THE MOLECULAR DIVERSITY OF LIFE**

**The Importance of Carbon**  
1.    Explain how carbon’s electron configuration explains its ability to form large, complex and diverse organic molecules.  
2.    Describe how carbon skeletons may vary, and explain how this variation contributes to the diversity and complexity of organic molecules.  
3.    Describe the basic structure of a hydrocarbon and explain why these molecules are hydrophobic.  
4.    Distinguish among the three types of isomers: structural, geometric, and enantiomer.  
  
**Chemical Groups**  
5.    Name the major chemical groups found in organic molecules.  Describe the basic structure of each chemical group and outline the chemical properties of the organic molecules in which they occur.   
  
**ATP**  
6.    Explain how ATP functions as the primary energy transfer molecule in living cells.

**CHAPTER 5  
THE STRUCTURE AND FUNCTION OF LARGE BIOLOGICAL MACROMOLECULES**  
  
The Molecules of Life  
1.    List the four major classes of macromolecules.  
2.    Distinguish between monomers and polymers.  
3.    Draw diagrams to illustrate condensation and hydrolysis reactions.  
  
Carbohydrates Serve as Fuel and Building Material  
4.    Distinguish between monosaccharides, disaccharides, and polysaccharides.  
5.    Describe the formation of a glycosidic linkage.  
6.    Distinguish between the glycosidic linkages found in starch and cellulose.  Explain why the difference is biologically important.  
7.    Describe the role of symbiosis in cellulose digestion by animals.  
  
Lipids are a Diverse Group of Hydrophobic Molecules   
8.    Describe the building-block molecules, structure, and biological importance of fats, phospholipids, and steroids.  
9.    Identify an ester linkage and describe how it is formed.  
10.     Distinguish between saturated and unsaturated fats.   
11.     Distinguish between cis and trans fat molecules.  
12.     Name the principal energy storage molecules of plants and animals.  
   
Proteins have Many Structures, Resulting in a Wide Range of Functions  
13.     Distinguish between a protein and a polypeptide.  
14.     Explain how a peptide bond forms between two amino acids.  
15.     List and describe the four major components of an amino acid. Explain how amino acids may be grouped according to the physical and chemical properties of the R group.  
16.     Explain what determines protein structure and why it is important.  
17.     Explain how the primary structure of a protein is determined.  
18.     Name two types of secondary protein structure. Explain the role of hydrogen bonds in maintaining secondary structure.  
19.     Explain how weak interactions and disulfide bridges contribute to tertiary protein structure.  
20.     List four conditions under which proteins may be denatured.  
21.     Explain how chaperonins may assist in proper folding of proteins.  
22.     List and briefly describe three complementary approaches to determining protein structure.   
  
Nucleic Acids Store and Transmit Hereditary Information   
23.     List the major components of a nucleotide, and describe how these monomers are  linked to form a nucleic acid.  
24.     Distinguish between:  
              a.    pyrimidine and purine  
              b.    nucleotide and nucleoside  
              c.    ribose and deoxyribose  
              d.    5′ end and 3′ end of a nucleotide  
25.     Briefly describe the three-dimensional structure of DNA.  
26.     Explain how DNA or protein comparisons may allow us to assess evolutionary relationships between species.