2 Chemistry Comes Alive

Student Objectives

When you have completed the exercises in this chapter, you will have accomplished the following objectives:

PART 1: BASIC CHEMISTRY

Definition of Concepts: Matter and Energy

1. Differentiate between matter and energy and between potential energy and kinetic energy.
2. Describe the major energy forms.

Composition of Matter: Atoms and Elements

3. Define chemical element and list the four elements that form the bulk of body matter.
4. Define atom. List the subatomic particles, describe their relative masses, charges, and positions in the atom.
5. Define atomic number, atomic mass, atomic weight, isotope, and radioisotope.

How Matter Is Combined: Molecules and Mixtures

6. Define molecule, and distinguish between a compound and a mixture.
7. Compare solutions, colloids, and suspensions.

Chemical Bonds

8. Explain the role of electrons in chemical bonding and in relation to the octet rule.
9. Differentiate among ionic, covalent, and hydrogen bonds.
10. Compare and contrast polar and nonpolar compounds.

Chemical Reactions

11. Define the three major types of chemical reactions: synthesis, decomposition, and exchange. Comment on the nature of oxidation-reduction reactions and their importance.
12. Explain why chemical reactions in the body are often irreversible.
13. Describe factors that affect chemical reaction rates.

PART 2: BIOCHEMISTRY

Inorganic Compounds

14. Explain the importance of water and salts to body homeostasis.
15. Define acid and base, and explain the concept of pH.

Organic Compounds

16. Describe and compare the building blocks, general structures, and biological functions of carbohydrates and lipids.
17. Explain the role of dehydration synthesis and hydrolysis in forming and breaking down organic molecules.
18. Describe the four levels of protein structure.
19. Indicate the function of molecular chaperones.
20. Describe enzyme action.
21. Compare and contrast DNA and RNA.
22. Explain the role of ATP in cell metabolism.

Everything in the universe is composed of one or more elements, the unique building blocks of all matter. Although over 100 elemental substances exist, only four of these (carbon, hydrogen, oxygen, and nitrogen) make up over 96% of all living material.

Activities in Chapter 2 test mastery of the basic concepts of both inorganic and organic chemistry. Chemistry is the science of the composition, properties, and reactions of matter. Inorganic chemistry is the science of nonliving substances such as salts and minerals, which generally do not contain carbon. Organic chemistry is carbon-based chemistry. Biochemistry is the science of living organisms, whether they are plants, animals, or microorganisms.

Student understanding of atomic structure, the bonding behavior of elements, and the structure and activities of the most abundant biochemical molecules (protein, fats, carbohydrates, and nucleic acids) is tested in various ways. Mastering these concepts is necessary to understanding the functions of the body.

BUILDING THE FRAMEWORK

PART 1: BASIC CHEMISTRY

Definition of Concepts: Matter and Energy

1. Select *all* terms that apply to each of the following statements and insert the letters in the answer blanks.

_____ 1. The energy located in the bonds of food molecules:

A. is called thermal energy
B. is a form of potential energy
C. causes molecular movement
D. can be transformed to the bonds of ATP

_____ 2. Heat is:

A. thermal energy
B. infrared radiation
C. directly related to kinetic energy
D. a result of all energy conversions

_____ 3. Whenever energy is transformed:

A. the amount of useful energy decreases
B. some energy is lost as heat
C. some energy is created
D. some energy is destroyed

2. Use the key choices to identify the energy *form* in use in each of the following examples.

Key Choices

A. Chemical B. Electrical C. Mechanical D. Radiant

_____ 1. Chewing food

_____ 2. Vision (two types, please—think!)

_____ 3. Bending your fingers to make a fist

_____ 4. Breaking the bonds of ATP molecules to energize your muscle cells to make that fist

_____ 5. Lying under a sunlamp

Composition of Matter: Atoms and Elements

1. Complete the following table by inserting the missing words.

Particle	Location	Electrical charge	Mass
		+1	
Neutron			
	Orbitals		

2. Insert the *chemical symbol* (the chemist's shorthand) in the answer blanks for each of the following elements.

_____ 1. Oxygen _____ 4. Iodine _____ 7. Calcium _____ 10. Magnesium

_____ 2. Carbon _____ 5. Hydrogen _____ 8. Sodium _____ 11. Chloride

_____ 3. Potassium _____ 6. Nitrogen _____ 9. Phosphorus _____ 12. Iron

3. Using the key choices, select the correct responses to the following descriptive statements. Insert the appropriate answers in the answer blanks.

Key Choices

A. Atom C. Element E. Ion G. Molecule I. Protons

B. Electrons D. Energy F. Matter H. Neutrons J. Valence

_____ 1. An electrically charged atom or group of atoms

_____ 2. Anything that takes up space and has mass (weight)

_____ 3. A unique substance composed of atoms having the same atomic number

_____ 4. Negatively charged particles, forming part of an atom

_____ 5. Subatomic particles that determine an atom's chemical behavior, or bonding ability

_____ 6. The ability to do work

_____ 7. The smallest particle of an element that retains the properties of the element

_____ 8. The smallest particle of a compound, formed when atoms combine chemically

_____ 9. Positively charged particles forming part of an atom

_____ 10. The combining power of an atom

_____ 11. _____ 12. Subatomic particles responsible for most of an atom's mass

4. From the list below, select the element or elements that match the descriptions. Insert their chemical symbols in the answer blanks.

Oxygen	Iodine	Calcium	Magnesium
Carbon	Hydrogen	Sodium	Chloride
Potassium	Nitrogen	Phosphorus	Iron

_____ 1. Found as a salt in bones and teeth

_____ 2. Makes up more than 96% of the mass of a living cell

_____ 3. Essential for transport of oxygen in red blood cells

_____ 4. Essential cations in muscle contraction

_____ 5. Essential for production of thyroid hormones

_____ 6. Present in nucleic acids (in addition to C, H, O, and N)

_____ 7. The most abundant negative ion in extracellular fluids

How Matter Is Combined: Molecules and Mixtures

1. Match the following terms to the appropriate descriptions below:

Mixture Solution Molarity Colloid Suspension

_____ 1. Concentration expressed in moles

_____ 2. Components are physically, not chemically, combined

_____ 3. Homogeneous combination of solvent and solute(s)

_____ 4. Large particles can settle out unless constantly mixed

_____ 5. Large particles will not settle out

_____ 6. Exhibits the sol-gel phenomenon

_____ 7. An example is sand and water

2. Briefly explain how the following pairs of chemical species differ. Identify each substance as a molecule of an element, a molecule of a compound, an atom, or an ion.

1. H_2O_2 and $2OH^-$ _____

_____

2. $2O^{2-}$ and O_2 _____

_____

3. $2H^+$ and H_2 _____

_____

3. Using the periodic table in the appendix of your textbook, determine the molecular weight of each of the following:

_____ 1. Water (H_2O) _____ 2. Ammonia (NH_3) _____ 3. Carbonic acid (H_2CO_3)

4. Circle the term that does *not* belong in each of the following groupings.

1. Cholesterol $C_6H_{12}O_6$ Perspiration H_2O NH_3 Compound

2. Urine $Ca_3(PO_4)_2$ Inhaled air Exhaled air Plasma

3. Scatters light Transparent True solution Saline

4. Blood cells Water Solute Salt (NaCl) Glucose molecules

5. Weight/volume method 5 g NaCl and 100 ml H_2O 5% NaCl One-molar NaCl

6. Heterogeneous mixture Scattering of light Salt water Milky Colloid

Chemical Bonds

1. Figure 2.1 is a diagram of an atom. Select two different colors and use them to color the coding circles and the subatomic structures on the diagram. Identify each valence electron by inserting an X in the correct location on the diagram. Then, respond to the questions that follow, referring to this diagram. Insert your answers in the answer blanks.

◯ Nucleus ◯ Electrons

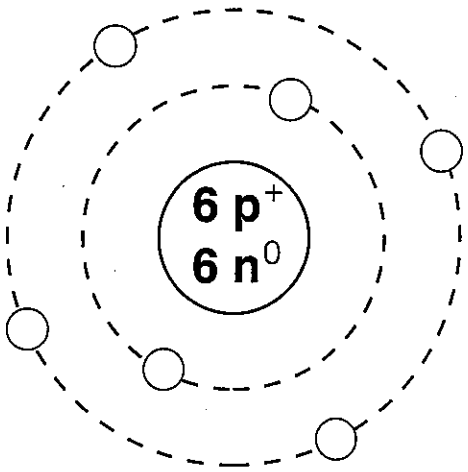


Figure 2.1

_____ 1. What is the atomic number?

_____ 2. Give the atomic mass of this atom.

_____ 3. Name the atom represented here.

_____ 4. How many electrons are needed to fill its outer shell?

_____ 5. What is the valence of this atom?

_____ 6. Is the atom chemically active *or* inert?

_____ 7. Imagine this atom with one additional neutron. What is the name given to this slightly different form of the same element?

_____ 8. Imagine this atom with two additional neutrons and a nucleus that can eject beta particles. What is the name given to this type of atom?

_____ 9. The electrons in the second electron shell are more energetic. True or false?

2. Two types of chemical bonding are shown in Figure 2.2. Select three different colors. Use two colors to color the electrons named at each coding circle. Use the third color to add an arrow to show the direction of transfer of any electron. Then, insert the name of the type of bond and the name of the compound in the blanks provided below the figure.

◯ Electrons shared ◯ Electron(s) transferred

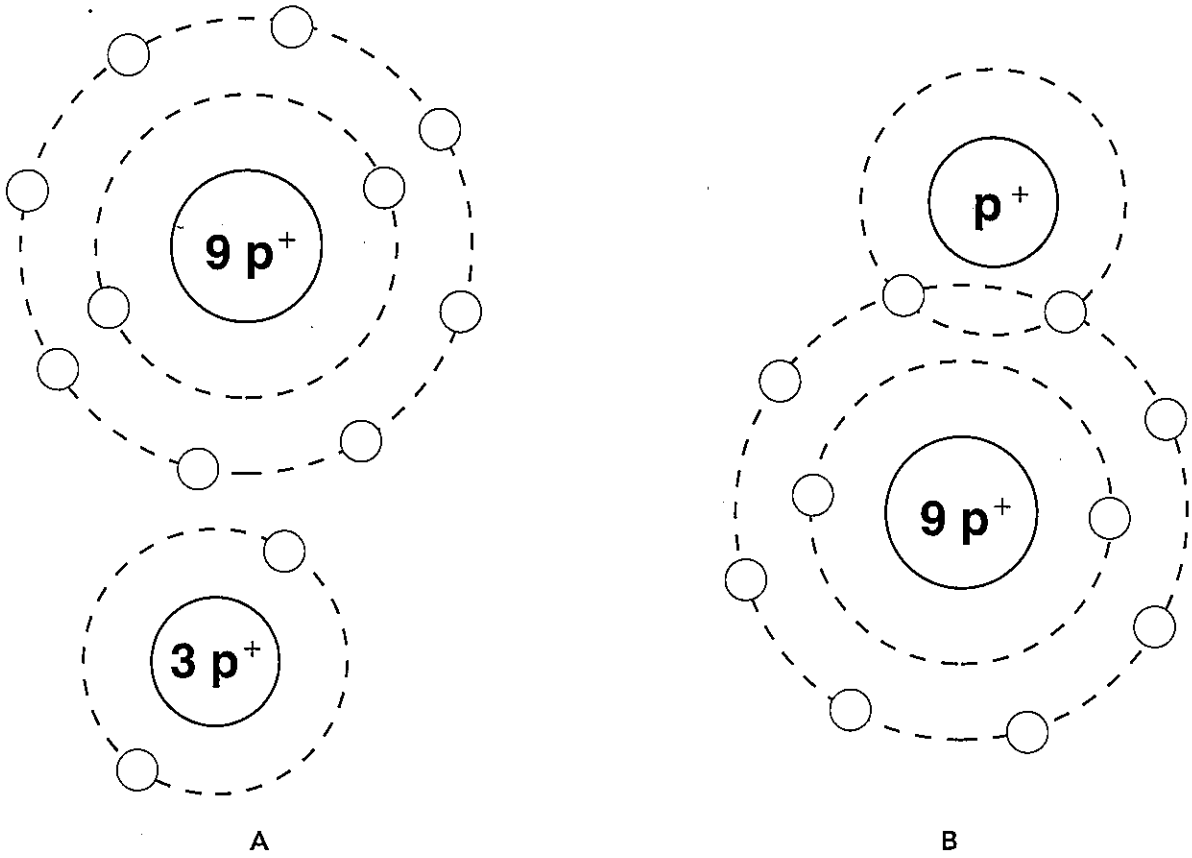


Figure 2.2

A. Type of bond _____

Name of compound _____

B. Type of bond _____

Name of compound _____

3. Complete the following table by filling in the missing parts.

Chemical symbol	Atomic number	Atomic mass	Electron distribution
	1		
		12	
N			
			2, 6, 0
		23	
	12		
			2, 8, 5
S			
	17		
		39	
Ca			

4. Using the information in the table you constructed in Exercise 3, complete the following table, which concerns atoms that form ionic bonds.

Chemical symbol	Loss/gain of electrons	Electrical charge
H		
Na		
Mg		
Cl		
K		
Ca		

5. Complete the following table relating to atoms that form covalent bonds.

Chemical symbol	Number of electrons shared	Number of bonds made
H		
C		
N		
O		

6. Figure 2.3 illustrates five water molecules held together by hydrogen bonds. First, correctly identify the oxygen and hydrogen atoms both by color and by inserting their atomic symbols on the appropriate circles (atoms). Then, label the following structures in the figure:

◯ Oxygen

◯ Hydrogen

◯ Positive pole

◯ Negative pole

◯ Hydrogen bonds

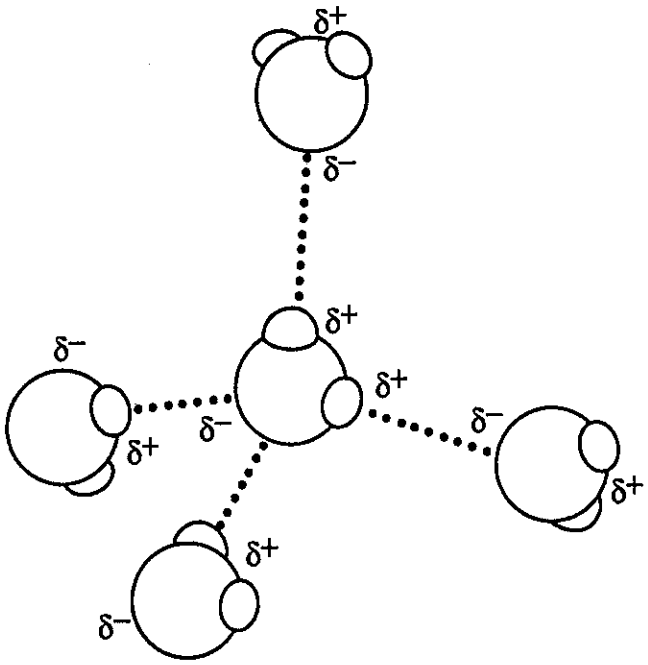
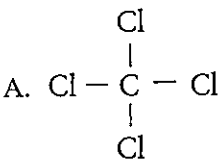
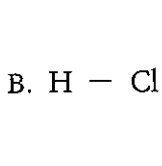
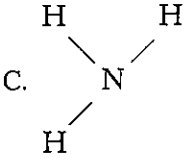


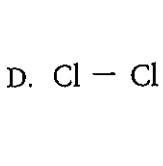
Figure 2.3

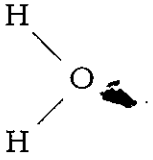
7. Circle each structural formula that is likely to be a polar covalent compound.

A. 

B. 

C. 

D. 

E. 

Chemical Reactions

1. Match the terms in Column B with the equations listed in Column A. Enter the letters of all correct answers in the answer blanks.

	Column A	Column B
_____	1. $A + B \rightarrow AB$	A. Synthesis (combination)
_____	2. $AB + CD \rightarrow AD + CB$	B. Decomposition (dissociation)
_____	3. $XY \rightarrow X + Y$	C. Displacement (exchange)
_____	4. $AB + CD \rightleftarrows AD + CB$	D. Designates chemical equilibrium

2. Circle the term or phrase that does *not* belong with the grouping in each of the following cases.

1. High reaction rate Low product concentration High reactant concentration Low reactant concentration
2. High reaction rate Large particles Small particles Many forceful collisions
3. Catalyst Enzyme Reactant Increase reaction rate
4. Oxidized substrate Electron donor Electron acceptor Loss of hydrogen
5. Catabolic Simple → complex Complex → simple Degradation

PART 2: BIOCHEMISTRY

1. Use an X to designate which of the following are organic compounds.

_____ 1. Carbon dioxide	_____ 3. Fats	_____ 5. Proteins	_____ 7. H_2O
_____ 2. Oxygen	_____ 4. KCl	_____ 6. Glucose	_____ 8. DNA

Inorganic Compounds

1. Complete the following statements concerning the properties and biological importance of water.

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.

The ability of water to maintain a relatively constant temperature and thus prevent sudden changes is because of its high __(1)__. Biochemical reactions in the body must occur in __(2)__. About __(3)__ % of the volume of a living cell is water. Water molecules are bonded to other water molecules because of the presence of __(4)__ bonds. The cooling effect of perspiration as it evaporates from the skin is the result of the high __(5)__ of water. Water, as H^+ and OH^- ions, is essential in biochemical reactions such as __(6)__ and __(7)__ reactions.

2. Circle the term that does *not* belong in each of the following groupings.

1. HCl H_2SO_4 Vinegar Milk of magnesia
2. NaOH Blood (pH 7.4) $Al(OH)_2$ Urine (pH 6.2)
3. KCl NaCl $NaHCO_3$ $MgSO_4$

4. Ionic Organic Salt Inorganic

5. pH 7 pH 4 Neutrality $OH^- = H^+$

6. Basic pH 8 Alkaline pH 2

3. Use the key choices to identify the substances described in the following statements. Insert the appropriate answers in the answer blanks.

Key Choices

A. Acids B. Bases C. Buffers D. Salts

_____ 1. _____ 2. _____ 3. Substances that ionize in water; good electrolytes

_____ 4. Proton (H^+) acceptors

_____ 5. Substances that dissociate in water to release hydrogen ions and a negative ion other than hydroxide (OH^-)

_____ 6. Substances that dissociate in water to release ions other than H^+ and OH^-

_____ 7. Substances formed when an acid and a base are combined

_____ 8. Substances such as lemon juice and vinegar

_____ 9. Substances that prevent rapid or large swings in pH

_____ 10. Substances such as ammonia and milk of magnesia

4. Define *pH*. _____

5. Using the key choices, fully characterize weak and strong acids.

Key Choices

A. Ionize completely in water

B. Ionize incompletely in water

C. Act as part of a buffer system

D. When placed in water, always acts to change the pH

E. Ionize at high pH

F. Ionize at low pH

G. Ionize at pH 7

Weak acid: _____ Strong acid: _____

6. Complete the following statements concerning a particular solution—cola.

_____ 1.
_____ 2.
_____ 3.

A can of cola consists mostly of sugar dissolved in water. It also contains carbon dioxide gas, which makes the cola "fizzy" and makes the solution's pH lower than 7. In chemical terminology, you could say that cola is an aqueous solution in which water is the __(1)__, sugar and carbon dioxide are __(2)__, and the dissolved carbon dioxide makes the solution __(3)__.

Organic Compounds

1. Match the terms in Column B with the descriptions in Column A. Enter the correct letters in the answer blanks.

	Column A	Column B
_____	1. Building blocks of carbohydrates	A. Amino acids
_____	2. Building blocks of fat	B. Carbohydrates
_____	3. Building blocks of protein	C. Lipids (fats)
_____	4. Building blocks of nucleic acids	D. Fatty acids
_____	5. Cellular cytoplasm is primarily composed of this substance	E. Glycerol
_____	6. The single most important fuel source for body cells	F. Nucleotides
_____	7. Not soluble in water	G. Monosaccharides
_____	8. Contain C, H, and O in the ratio CH_2O	H. Proteins
_____	9. Contain C, H, and O, but have relatively small amounts of oxygen	
_____	10. _____	11. These building blocks contain N in addition to C, H, and O
_____	12. Contain P in addition to C, H, O, and N	
_____	13. Used to insulate the body and is found in all cell membranes	
_____	14. Primary components of meat and cheese	
_____	15. Primary components of bread and lollipops	
_____	16. Primary components of egg yolk and peanut oil	
_____	17. Include collagen and hemoglobin	
_____	18. Class that usually includes cholesterol	

2. For each of the following statements that is true, insert T in the answer blank. For each false statement, correct the underlined word(s), and insert your correction in the answer blank.

_____ 1. Phospholipids are polarized molecules.

_____ 2. Steroids are the major form in which body fat is stored.

_____ 3. Water is the most abundant compound in the body.

_____ 4. Nonpolar molecules are generally soluble in water.

_____ 5. The bases of RNA are A, G, C, and U.

_____ 6. The universal energy currency of living cells is RNA.

_____ 7. RNA is single stranded.

_____ 8. The bond type linking the subunits of proteins together is commonly called the hydrogen bond.

_____ 9. The external fuel of choice used by cells as a ready source of energy is starch.

_____ 10. The nucleotide base complementary to G is C.

_____ 11. The backbone of a nucleic acid molecule consists of sugar and base units.

3. Five simplified diagrams of the structures of five biochemical molecules are shown in Figure 2.4.

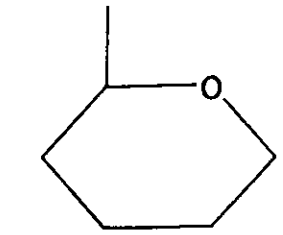
First, identify the molecules and insert their correct names in the answer blanks on the figure (A through E).

Second, select a different color for each type of molecule listed below, and use it to color the coding circle and the corresponding molecular structure in the illustration.

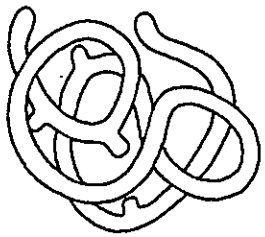
◯ Fat ◯ Nucleotide ◯ Monosaccharide

◯ Functional protein ◯ Polysaccharide

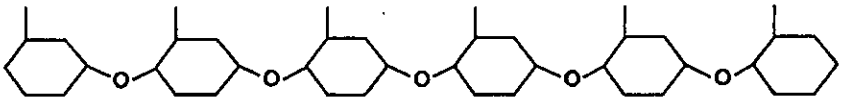
Third, answer the questions relating to these diagrams by inserting your answers in the blanks below the figure.



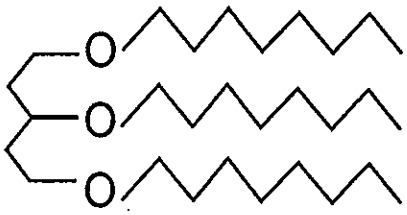
A. _____



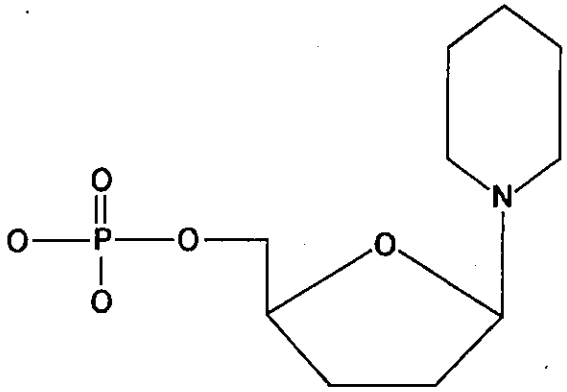
B. _____



C. _____



D. _____



E. _____

Figure 2.4

_____ 1. Give an example of a biochemical having a structure like diagram C.

_____ 2. Which two diagrams illustrate structures of monomers (building blocks)?

_____ 3. Name the level of structure illustrated in diagram B.

_____ 4. Which two diagrams illustrate molecules used for energy storage?

_____ 5. Which diagram shows a structure that most looks like a molecule of ATP?

4. If any of the following statements about enzymes is true, write T in the answer blank. If a statement is false, correct the underlined word and write the correction in the answer blank.

_____ 1. All enzymes are proteins.

_____ 2. The substances on which enzymes act are called cofactors.

_____ 3. The name of an enzyme usually ends in the suffix -ide.

_____ 4. Coenzymes are vitamins that assist the chemical action of enzymes.

_____ 5. Enzymes increase the activation energy of biochemical reactions.

_____ 6. The active site of an enzyme is the location of substrate attachment.

_____ 7. Changes in pH or temperature decrease enzyme activity because bonds break and the enzyme returns to its tertiary structure.

5. The biochemical reaction shown in Figure 2.5 represents the complete digestion of a polymer (as consumed in food) down to its constituent monomers (building blocks). Select two colors, and color the coding circles and the structures. Then, select the one correct answer for each statement below, and insert your answer in the answer blank.

◯ Monomer ◯ Polymer

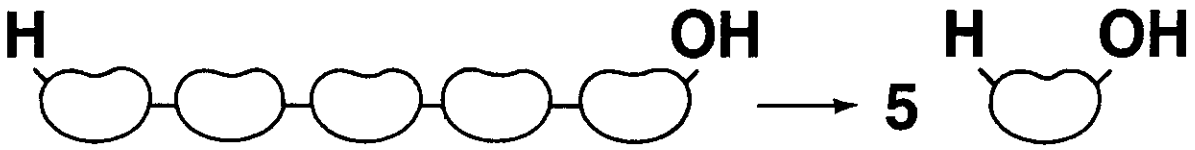


Figure 2.5

_____ 1. If starch is the polymer, the monomer is:

A. glycogen B. amino acid C. glucose D. maltose

_____ 2. During polymer digestion, water as H^+ and OH^- ions would:

A. be a product of the reaction

B. act as a catalyst

C. enter between monomers, bond to them, and keep them separated

D. not be involved in this reaction

_____ 3. Another name for the chemical digestion of polymers is:

A. dehydration B. hydrolysis C. synthesis D. displacement

_____ 4. If the monomers are amino acids, they may differ from each other by their:

A. R group B. amino group C. acid group D. peptide bond

6. Place an X in the blank before each phrase that accurately describes molecular chaperones.

_____ 1. Crucial to correct/normal protein structure

_____ 2. Numbers increase during fever

_____ 3. Numbers decline when proteins are denatured

_____ 4. Originally called heat-shock proteins

_____ 5. Defensive molecules

7. This exercise concerns the way polar molecules—phospholipids, in this example—interact with water. As you can see in Figure 2.6, the phospholipid molecules have arranged themselves to form a hollow sphere within the aqueous environment of the beaker.

First, color all the water-containing areas blue, all areas that exclude water yellow, and the polar heads of the phospholipids gray-black.

Second, draw in a row of phospholipids on the surface of the water in the beaker, showing how they would orient themselves (heads vs. tails) to the water in the beaker.

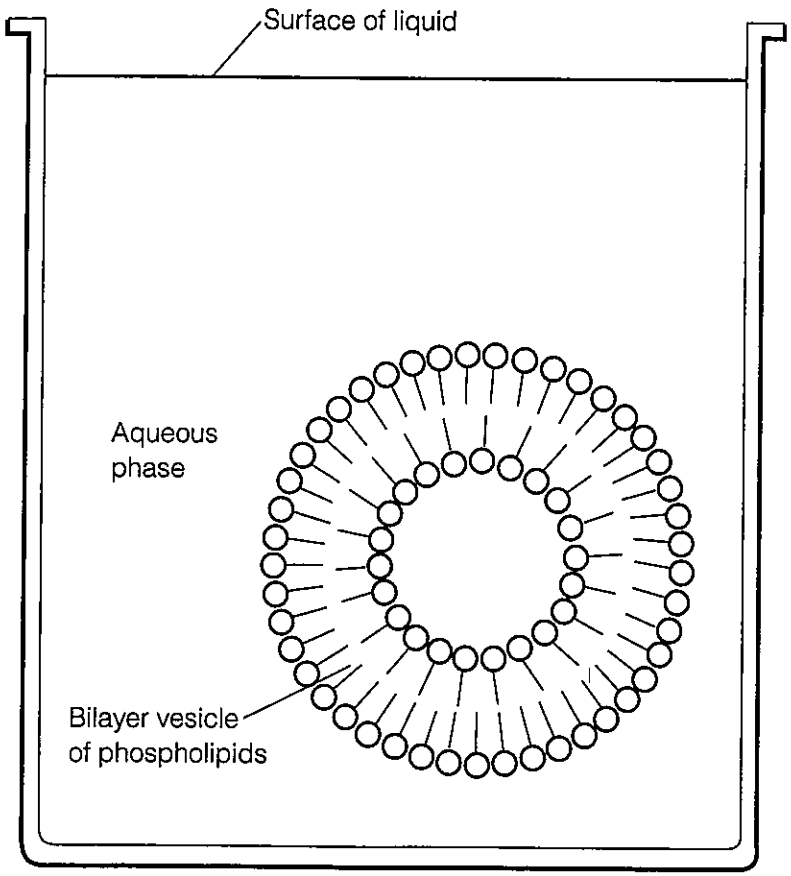


Figure 2.6

8. Figure 2.7 shows the molecular structure of DNA, a nucleic acid.

- ◯ Deoxyribose sugar (d-R)
- ◯ Phosphate unit (P)
- ◯ Adenine (A)
- ◯ Cytosine (C)
- ◯ _____ ( )
- ◯ _____ ( )

A. Identify the two unnamed nitrogen bases, and insert their correct names and symbols in the two blanks beside the color coding.

B. Complete the identification of the bases on the diagram by inserting the correct symbols in the appropriate spaces on the right side of the diagram.

C. Select different colors and color the coding circles and the corresponding parts of the diagram.

D. Label one d-R sugar unit and one P unit of the "backbones" of the DNA structure by inserting leader lines and labels on the diagram.

E. Circle the associated nucleotide.

F. Answer the following questions by writing your answers in the answer blanks.

1. Name the bonds that help hold the two DNA strands together. _____

2. Name the three-dimensional shape of the DNA molecule. _____

3. How many base pairs are present in this segment of a DNA model? _____

4. What is the term that means "base pairing"?

_____

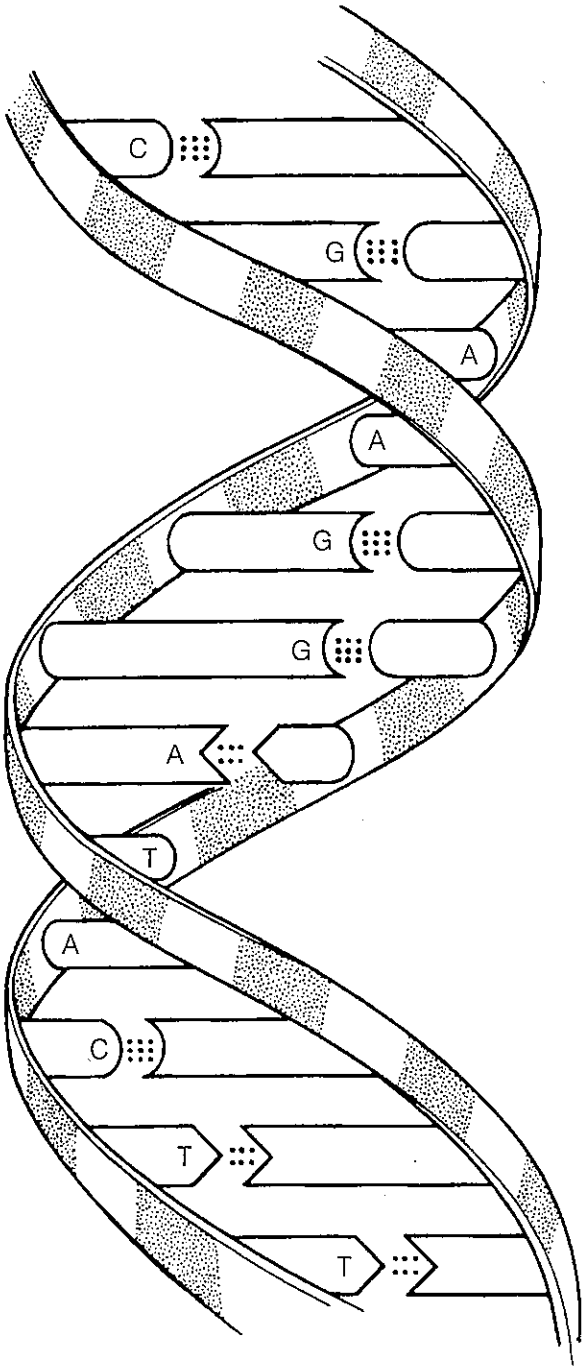


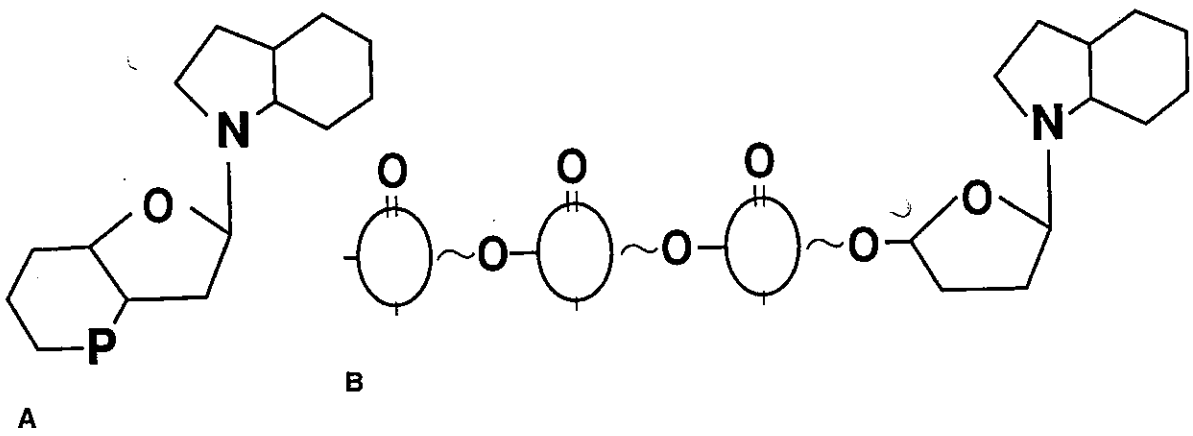
Figure 2.7
Part of a DNA molecule (coiled)

9. Circle the term that does *not* belong in each of the following groupings.

1. Adenine Guanine Glucose Thymine
2. DNA Ribose Phosphate Deoxyribose
3. Galactose Glycogen Fructose Glucose
4. Amino acid Polypeptide Glycerol Protein
5. Glucose Sucrose Lactose Maltose
6. Synthesis Dehydration Hydrolysis Water removal
7. Amino acid Compound Fatty acid Carbon
8. Enzyme activity Body temperature Denaturation Favorable pH

10. Two diagrams, A and B, are shown in Figure 2.8. These represent the stylized structures of ATP and cyclic AMP. Select a different color for each term with a color-coding circle, and color the structures. Identify each biochemical by inserting its name in blanks A. and B. below. Label all high-energy bonds with corresponding colored arrows on the diagrams.

◯ Phosphate ◯ Ribose ◯ Adenine ◯ High-energy bond

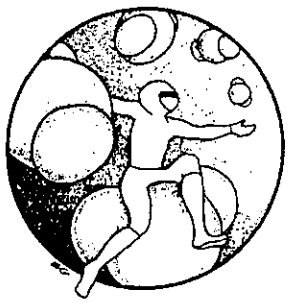


A. _____ B. _____

Figure 2.8

11. Complete the following chart on proteins by responding to the questions that are printed in the headings of the chart. Note the clues that are given! Insert your answers in the spaces provided.

Name of protein?	Secondary or tertiary structure?	Molecular shape: fibrous or globular?	Water-soluble or insoluble?	Function of protein?	Location in body?
Collagen					Cartilage and bone
Proteinase					Stomach
	Quaternary			Carries O_2	Red blood cells
Keratin	Secondary		Insoluble		



THE INCREDIBLE JOURNEY

A Visualization Exercise for Biochemistry

... you are suddenly up-ended and are carried along in a sea of water molecules at almost unbelievable speed.

1. Complete the narrative by inserting the missing words in the answer blanks.

_____ 1.
_____ 2.
_____ 3.
_____ 4.

For this journey, you are miniaturized to the size of a very small molecule by colleagues who will remain in contact with you by radio. Your instructions are to play the role of a water molecule and to record any reactions that involve water molecules. Since water molecules are dipoles, you are outfitted with an insulated rubber wet suit with one __(1)__ charge at your helmet and two __(2)__ charges, one at the end of each leg.

As soon as you are injected into your host's bloodstream, you feel as though you are being pulled apart. Some large, attractive forces are pulling at your legs from different directions! You look about but can see only water molecules. After a moment's thought, you remember the dipole construction of your wet suit. You record that these forces must be the __(3)__ in water that are easily formed and easily broken.

After this initial surprise, you are suddenly up-ended and carried along in a sea of water molecules at almost unbelievable speed. You measure and record this speed as 1000 miles/sec. You are about to watch some huge, red, disk-shaped structures (probably __(4)__) taking up O_2 molecules, when you are swept into a very turbulent

environment. Your colleagues radio that you are in the small intestine. With difficulty, because of numerous collisions with other molecules, you begin to record the various types of molecules you see.

In particular, you notice a very long helical molecule made of units with distinctive R groups. You identify and record this type of molecule as a __(5)__, made of units called __(6)__ that are joined together by __(7)__ bonds. As you move too close to the helix during your observations, you are nearly pulled apart to form two ions, __(8)__, but you breathe a sigh of relief as two ions of another water molecule take your place. You watch as these two ions move between two units of the long helical molecule. Then, in a fraction of a second, the bond between the two units is broken. As you record the occurrence of this chemical reaction, called __(9)__, you are jolted into another direction by an enormous globular protein, the very same __(10)__ that controls and speeds up this chemical reaction.

Once again you find yourself in the bloodstream, heading into an organ identified by your colleagues as the liver. Inside a liver cell, you observe many small monomers, made up only of C, H, and O atoms. You identify these units as __(11)__ molecules because they are being bonded to form very long, branched polymers called __(12)__ by the liver cells. You record that this type of chemical reaction is called __(13)__, and you happily note that this reaction also produces __(14)__ molecules like you!

Once more in the bloodstream, you are ferried, according to your colleagues, into the cartilage of the knee. What an environment you have found! Long, glistening, parallel white fibrous structures indicate that this protein must be __(15)__. Before you fully appreciate and record your observations, you are immobilized along with thousands of other water molecules by this long twisting protein. Like them, you are trapped, all dipoles in the same orientation, in layers of __(16)__ around this protein. Your colleagues are quick to advise that movement of your host's knee will press water out of the cartilage and you will be released. And so you are with a great "woosh."

Via another speedy journey through the bloodstream, you next reach the skin. You move deep into the skin and finally gain access to a sweat gland. In the sweat gland, you collide with millions of water molecules and some ionized salt molecules that are continually attracted to your positive and negative charges. Suddenly, the internal temperature rises, and molecular collisions __(17)__ at an alarming rate, propelling you through the pore of the sweat gland onto the surface of the skin. As you watch, other water molecules on the surface begin to __(18)__, using __(19)__ energy from the body. You record that the cooling effect just observed is the result of a property of water called high heat of __(20)__. Saved from the fate of evaporating into thin air, you are speedily rescued by your colleagues.

CHALLENGING YOURSELF

At the Clinic

1. It is determined that a patient is in acidosis. What does this mean, and would you treat the condition with a chemical that would *raise* or *lower* the pH?

2. Carbon dioxide concentration influences blood pH in the following manner: High levels of CO_2 increase the rate of formation of carbonic acid. If a patient has difficulty ventilating the lungs (particularly in exhaling, as in emphysema), would you expect the patient to be in acidosis or alkalosis?

3. Hugo, a patient with kidney disease, is unable to excrete sufficient amounts of hydrogen ions. Would you expect Hugo to hyperventilate or hypoventilate?

4. Vitamin D is essential for absorption of calcium, which contributes to the hardness of bones. What would most likely correlate with a softening of the bones: an inability to absorb fat, or excess fat absorption?

5. A newborn is diagnosed with sickle-cell anemia, a genetic disease in which an amino acid substitution results in abnormal hemoglobin. Explain to the parents how the substitution can have such a drastic effect on the structure of the protein.

6. Chris has just dissolved pepsinogen in a test tube containing distilled water and albumin protein. When he checks for protein digestion later, he finds that none has occurred. What substance (inorganic) should he have added to the test tube to mimic conditions of protein digestion in the body? What exactly does this needed substance do to promote protein digestion?

7. Johnny's body temperature is spiking upward. When it reaches 104°F, his mother puts in a call to the pediatrician. She is advised to give Johnny children's aspirin and sponge his body with cool to tepid water to prevent a further rise in temperature. How might a fever (excessively high body temperature) be detrimental to Johnny's welfare?

8. Stanley has acute indigestion and is doubled over with pain. How could an antacid reduce his stomach discomfort?

9. Explain the effect of mineral and vitamin deficiency on enzyme activity.

Stop and Think

1. Explain why the formation of ATP from ADP and P_i requires more energy than the amount released for cellular use when ATP is broken down.

2. Can all molecular structures be explained by the concepts of chemical bonding presented in this chapter? What about ozone (O_3) and carbon monoxide (CO)?

3. Using the octet rule, predict the atomic number of the next two inert gases after helium (atomic number 2).

4. Proteins within a cell commonly have negative surface charges. Indicate whether aqueous mixtures containing proteins form colloids or suspensions, and explain why.

5. Explain why a one-molar solution of sodium chloride has twice as many solute particles as a one-molar solution of glucose. How many particles would a one-molar solution of *calcium chloride* have compared to a one-molar glucose solution?

6. Combining carbonic acid, H_2CO_3, and calcium hydroxide, $Ca(OH)_2$, results in the formation of two water molecules and what salt?

7. Draw the following molecules, showing the bonds as lines between the chemical symbols: N_2H_4, H_2CO_3, CH_3COOH.

8. Hydrogen bonding determines the spacing between water molecules in ice crystals. What would happen to lakes in the winter if water molecules were packed more tightly in the solid form than in the liquid form?

9. Explain, in terms of chemical bonding, how ammonia functions as a base.

10. What happens to the pH of water when its temperature is raised to 38°C? What does this imply about our definition of neutral pH?

11. What is "special" about valence shell electrons?

12. Triglycerides float on water. How does this explain the use of triglycerides as the main form of reserve body fuel?

13. Dissect the word *atom*.

14. Can chlorine make covalent bonds? If so, how many will each chlorine atom make?

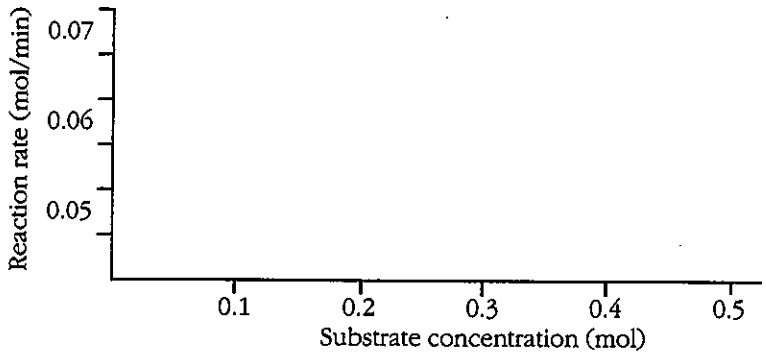
15. What can a cell do to actively control the direction of a reversible reaction?

16. Justify classifying water as both an acid and a base.

17. Given a hydrogen ion concentration [H^+] of 0.000001 mol/liter, what is the pH? How does the relative acidity of this solution compare to that of a solution of pH 7?

18. Graph the following data relating to an enzyme-catalyzed reaction. Then, answer the associated questions.

Substrate concentration (mol)	0.1	0.2	0.3	0.4	0.5
Reaction rate (mol product/min)	0.05	0.06	0.068	0.069	0.069



1. Why is there a plateau in the graph?

2. How would an alteration of the enzyme's active site, such as might occur in competitive or noncompetitive inhibition, affect the reaction rate?

19. Matter *occupies space* and *has mass*. Describe how energy *must* be described in terms of these two criteria. Then, list the criteria usually used to define or describe energy.

20. How do saturated and unsaturated fats differ in molecular structure and gross appearance?

21. Relative to the chemical equation $X + YC \rightarrow XC + Y$, the reactants are _____; the products are _____. If interpreting this reaction in terms of mole quantities, how many moles of each (reactants and products) are indicated by the equation? _____

22. It is said that all chemical reactions reach equilibrium if certain conditions are met. What is the effect of continually adding more reactants to the system?

23. Describe several uses of radioisotopes in biological research or medicine.

24. Evelyn is quite proud of her slender, model-like figure and boasts that she doesn't have an "ounce of excess body fat." Barbara, on the other hand, is grossly overweight. She complains of being "hot" most of the time, and on a hot day, she is miserable. Evelyn generally feels chilled except on very hot days. Explain the relative sensitivity to environmental temperature of these two women on the basis of information you have been given.

COVERING ALL YOUR BASES

Multiple Choice

Select the best answer or answers from the choices given.

1. Energy:

A. has mass
B. does work
C. has weight
D. takes up space
E. causes motion

2. Energy contained in molecular bonds is:

A. electrical
B. mechanical
C. chemical
D. radiant
E. kinetic

3. Which of the following are among the four major elements in the body?

A. Iron
B. Carbon
C. Oxygen
D. Copper
E. Sulfur

4. Which of the following is (are) true concerning the atomic nucleus?

A. Contains the mass of the atom
B. The negatively charged particles are here
C. Particles can be ejected
D. Contains particles that determine atomic number
E. Contains particles that interact with other atoms

5. Which of the following would indicate an isotope of oxygen?

A. Atomic number 7
B. Atomic number 8
C. Atomic mass 16
D. Atomic mass 18
E. Gain of 2 electrons

6. An example of a suspension is:

A. sugar in tea
B. cornstarch in water
C. proteins in plasma
D. carbon dioxide in soda water
E. oil in water

7. Pick out the correct match(es) of element and valence number.

A. Oxygen-6
B. Chlorine-8
C. Calcium-2
D. Nitrogen-3
E. Carbon-4

8. In which mixtures would you expect to find hydrogen bonds?

A. Sugar in water
B. Oil in water
C. Oil in gasoline
D. Salt in water

9. Which of the following is (are) a synthesis reaction?

A. Glucose to glycogen
B. Glucose + fructose to sucrose
C. Starch to glucose
D. Polypeptide to dipeptides
E. Amino acids to dipeptide

10. Which of the following will have the greatest reaction rate, assuming the same temperature, concentration, and catalyst activity?

A. Carbon dioxide and water combining to form carbonic acid
B. Glucose and fructose forming sucrose
C. Amino acids combining to form dipeptides
D. Fatty acids combining with glycerol
E. All of these will have the same reaction rate with the listed factors being equal.

11. Organic compounds include:

A. water
B. carbon dioxide
C. oxygen
D. carbonic acid
E. glycerol

12. Important functions of water include:

A. cushioning
B. transport medium
C. participation in chemical reactions
D. solvent for sugars, salts, and other solutes
E. reduces temperature fluctuations

13. Which of the following molecules does not have at least one double covalent bond?

A. Carbon dioxide
B. Formaldehyde (H_2CO)
C. Oxygen gas
D. Hydrogen cyanide (HCN)
E. Ethanol (CH_3CH_2OH)

14. Which of the elements listed is the most abundant extracellular anion?

A. Phosphorus
B. Sulfur
C. Potassium
D. Chloride
E. Calcium

15. The element essential for normal thyroid function is:

A. Iodine
B. Iron
C. Copper
D. Selenium
E. Zinc

16. To prepare a 15% salt solution such as potassium chloride (KCl) by the weight-volume method, you would:

A. weigh out 15 g of KCl and add water to obtain 100 g of solution
B. weigh out 15 g of KCl and add water to obtain 100 ml of solution
C. weigh out the number of grams equal to the molecular weight of KCl and add water to obtain 1 liter of solution
D. weigh out 15 g of KCl and add 15 ml of water
E. measure out 15 ml of KCl and add water to obtain 100 ml of solution

17. Alkaline substances include:

A. gastric juice
B. water
C. blood
D. orange juice
E. ammonia

18. Which of the following is (are) not a monosaccharide?

A. Glucose
B. Fructose
C. Sucrose
D. Glycogen
E. Deoxyribose

19. Which is a building block of neutral fats?

A. Ribose
B. Guanine
C. Glycerol
D. Glycine
E. Glucose

20. What lipid type is the foundation of the cell membrane?

A. Triglyceride
B. Steroid
C. Vitamin D
D. Phospholipid
E. Prostaglandin

21. Which of the following is (are) not derived from cholesterol?

A. Vitamin A
B. Vitamin D
C. Steroid hormones
D. Bile salts
E. Prostaglandins

22. Which of the following is primarily responsible for the helical structure of a polypeptide chain?

A. Hydrogen bonding
B. Tertiary folding
C. Peptide bonding
D. Quaternary associations
E. Complementary base pairing

23. Absence of which of the following nitrogen bases would prevent protein synthesis?

A. Adenine
B. Cytosine
C. Guanine
D. Thymine
E. Uracil

24. Which of the following is (are) not true of RNA?

A. Double stranded
B. Contains cytosine
C. Directs protein synthesis
D. Found primarily in the nucleus
E. Can act as an enzyme

25. DNA:

A. contains uracil
B. is a helix
C. is the "genes"
D. contains ribose

26. ATP is not associated with:

A. a basic nucleotide structure
B. high-energy phosphate bonds
C. deoxyribose
D. inorganic phosphate
E. reversible reaction

27. Compared to a solution with a pH of 6, a solution with a pH of 8 has:

A. 4 times less H^+
B. 2 times more H^+
C. 100 times more H^+
D. 100 times less H^+
E. 2 times less H^+

28. Glucose is to starch as:

A. a steroid is to a lipid
B. a nucleotide is to nucleic acid
C. an amino acid is to a protein
D. a polypeptide is to an amino acid

Word Dissection

For each of the following word roots, fill in the literal meaning and give an example, using a word found in this chapter.

Word root	Translation	Example
1. ana		
2. cata		
3. di		
4. en		
5. ex		
6. glyco		
7. hydr		
8. iso		
9. kin		
10. lysis		
11. mono		
12. poly		
13. syn		
14. tri		