Name_____Period_____

Chapter 2: The Chemical Context of Life

This chapter covers the basics that you may have learned in your chemistry class. Whether your teacher goes over this chapter, or assigns it for you do review on your own, the questions that follow should help you focus on the most important points.

Concept 2.1 Matter consists of chemical elements in pure form and in combinations called compounds

1. Define and give an example of the following terms:
   matter

   element

   compound

2. What four elements make up 96% of all living matter?

3. What is the difference between an *essential element* and a *trace element*?

   essential element

   trace element

Concept 2.2 An element's properties depend on the structure of its atoms

4. Sketch a model of an atom of helium, showing the electrons, protons, neutrons, and atomic nucleus.

5. What is the atomic number of helium? _____ Its atomic mass? _____

6. Here are some more terms that you should firmly grasp. Define each term.
   neutron

   proton

   electron

   atomic number

atomic mass

isotope

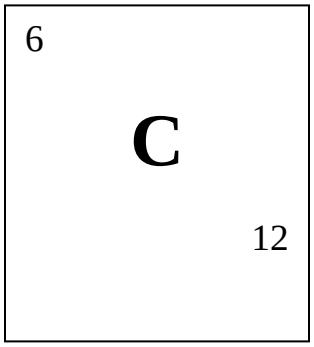
electron shells

energy

7. Consider this entry in the periodic table for carbon.

What is the atomic mass? _____ atomic number? _____

How many electrons does carbon have? _____ neutrons? _____



8. Which is the only subatomic particle that is directly involved in the chemical reactions between atoms?

9. What is *potential energy*?

10. Explain which has more potential energy in each pair:

a. boy at the top of a slide/boy at the bottom

b. electron in the first energy shell/electron in the third energy shell

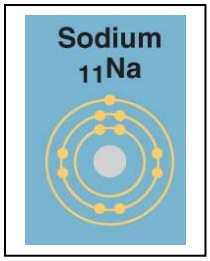
c. water/glucose

11. What determines the chemical behavior of an atom?

12. Here is an electron distribution diagram for sodium:

a. How many valence electrons does it have? _____ Circle the valence electron(s).

b. How many protons does it have? _____



Concept 2.3 The formation and function of molecules depend on chemical bonding between atoms

13. Define *molecule*.

14. Now, refer back to your definition of a *compound* and fill in the following chart:

	Molecule? (y/n)	Compound? (y/n)	Molecular Formula	Structural Formula
Water				
Carbon dioxide				
Methane				
O_2			O_2	

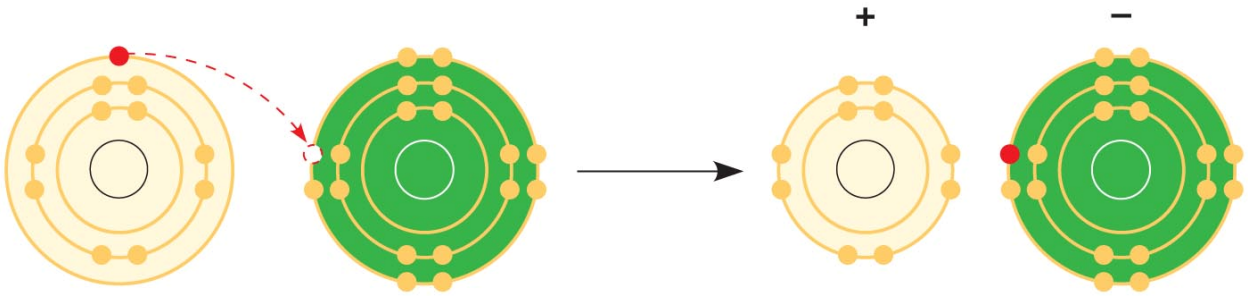
15. What type of bond is seen in O_2? Explain what this means.

16. What is meant by *electronegativity*?

17. Explain the difference between a *nonpolar covalent bond* and a *polar covalent bond*.

18. Make an electron distribution diagram of water. Which element is most electronegative? Why is water considered a *polar* molecule? Label the regions that are more positive or more negative. (This is a very important concept. Spend some time with this one!)

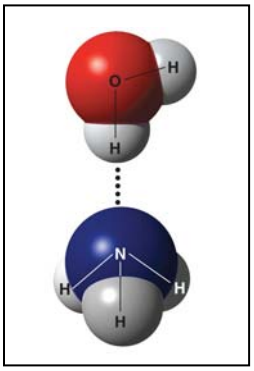
19. Another bond type is the *ionic bond*. Explain what is happening in the figure below (2.14):



20. What two elements are involved above?

21. Define *anion* and *cation*. In the preceding example, which is the anion?

22. What is a *hydrogen bond*? Indicate where the hydrogen bond occurs in this figure.



23. Explain *van der Waals interactions*. Though they represent very weak attractions, when these interactions are numerous they can stick a gecko to the ceiling!

24. Here is a list of the types of bonds and interactions discussed in this section. Place them in order from the strongest to the weakest: hydrogen bonds, van der Waals interactions, covalent bonds, ionic bonds.

STRONG

WEAK

25. Use morphine and endorphins as examples to explain why molecular shape is crucial in biology.

Concept 2.4 Chemical reactions make and break chemical bonds

26. Write the chemical shorthand equation for photosynthesis. Label the *reactants* and the *products*.

27. For the equation you just wrote, how many molecules of carbon dioxide are there? _____

    How many molecules of glucose? _____ How many elements in glucose? _____

28. What is meant by *dynamic equilibrium*? Does this imply equal concentrations of each reactant and product?

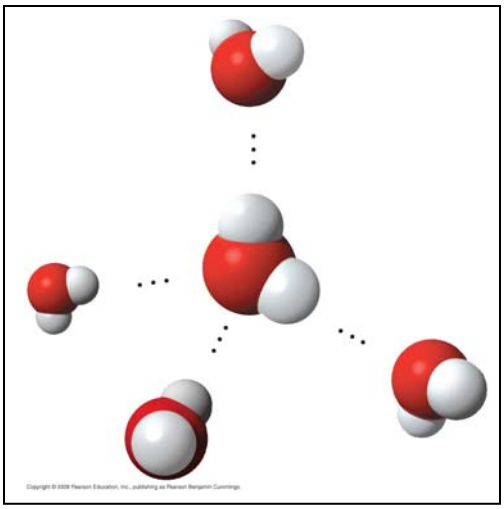
Testing Your Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

1._____ 2._____ 3._____ 4._____ 5._____ 6._____ 7._____ 8._____

Name_____Period_____

Chapter 3: Water and the Fitness of the Environment

Concept 3.1 The polarity of water molecules results in hydrogen bonding



1. Study the water molecules at the right. On the central molecule, label oxygen (O) and hydrogen (H).

2. What is a *polar molecule*? Why is water considered polar?

3. Now, add + and – signs to indicate the charged regions of *each* molecule. Then, indicate the hydrogen bonds.

4. Explain *hydrogen bonding*. How many hydrogen bonds can a single water molecule form?

Concept 3.2 Four emergent properties of water contribute to Earth's fitness for life

Hydrogen bonding accounts for the unique properties of water. Let's look at several.

Cohesion

5. Distinguish between *cohesion* and *adhesion*.

6. What is demonstrated when you see beads of water on a waxed car hood?

7. Which property explains the ability of a water strider to walk on water?

Moderation of Temperature

8. The calorie is a unit of heat. Define *calorie*.

9. Water has high *specific heat*. What does this mean? How does water's specific heat compare to alcohol's?

10. Explain how hydrogen bonding contributes to water's high specific heat.

11. Summarize how water's high specific heat contributes to the moderation of temperature. How is this property important to life?

12. Define *evaporation*. What is *heat of vaporization*? Explain at least three effects of this property on living organisms.

Expansion upon Freezing

13. Ice floats! So what? Consider what would happen if ponds and other bodies of water accumulated ice at the bottom. Describe why this property of water is important.

14. Now, explain *why* ice floats. Why is 4^{o}C the critical temperature in this story?

Solvent of Life

15. Review and define these terms:
    solvent

    solution

    solute

16. Consider coffee to which you have added sugar. Which is the solvent? The solute?

17. Explain why water is such a fine solvent.

18. Define *hydrophobic* and *hydrophilic*.

19. You already know that some materials, such as olive oil, will not dissolve in water. In fact, oil will float on top of water. Explain this property in terms of hydrogen bonding.

20. Now, let's do a little work that will enable you to prepare solutions. Read the section on solute concentrations carefully, and show the calculations here for preparing a 1-molar solution of sucrose. Steps to help you do this follow. The first step is done for you. Fill in the rest.

Steps to prepare a solution:

a. Write the molecular formula. $C_{12}H_{22}O_{11}$

b. Use your periodic table to calculate the mass of each element. Multiply by the number of atoms of the element. (For example, O has a mass of 16. Therefore one mole of O has a mass of 16 x 11 = 176 g/mole.)

c. Add the masses of each element in the molecule.

d. Add this mass of the compound to water to bring it to a volume of 1 liter. This makes 1 liter of a 1-M (1 molar) solution.

21. Can you prepare 1 liter of a 0.5-molar *glucose* solution? Show your work here.

22. Define *molarity.*

Concept 3.3 Acidic and basic conditions affect living organisms

23. What two ions form when water dissociates?

You should have answered "hydronium (H_3O+) and hydroxide ions (OH–)" in the preceding question. However, by convention, we will represent the hydronium ion as H+.

24. What is the concentration of each ion in pure water at 25°C?

25. Water has a pH of 7. *pH* is defined as the negative log of the hydrogen ion concentration [H+]. Can you now see how water is assigned a pH of 7?

26. To go a step further, the product of H+ and OH– concentrations is constant at 10^{-14}.

$$[H+\}[OH-\} = 10^{-14.}$$

Water, which is neutral with a pH of 7, has an equal number of H+ and OH– ions. Now, define

acid

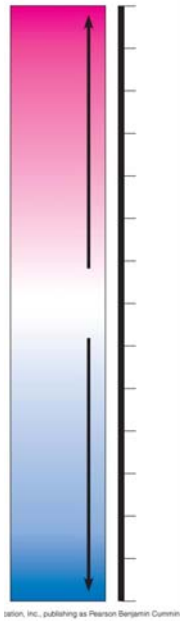
base

27. Because the pH scale is logarithmic, each numerical change represents a 10X change in ion concentration.

    a. So, how many times more acidic is a pH of 3 compared to a pH of 5?

    b. How many times more basic is a pH of 12 compared to a pH of 8?

    c. Explain difference between a pH of 8 and a pH of 12 in terms of H+ concentration.



28. On the pH chart, label pH 1–14. Label *neutral, acid, base*. Indicate the locations of pure water, urine, gastric juice, and bleach.

29. Even a slight change in pH can be harmful! How do *buffers* moderate pH change?

30. Exercise will result in the production of CO_2, which will acidify the blood. Explain the buffering system that minimizes blood pH changes.

31. *Acid precipitation* is increasing. Explain its sources.

32. Discuss how CO_2 emissions affect marine life and ecosystems.

Testing Your Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

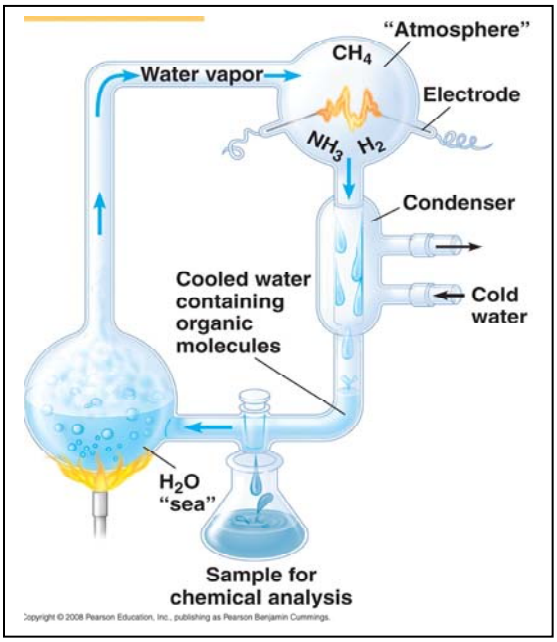
1._____ 2._____ 3._____ 4._____ 5._____ 6._____ 7._____ 8._____

Name_____Period_____

Chapter 4: Carbon and the Molecular Diversity of Life

Concept 4.1 Organic chemistry is the study of carbon compounds

1. Study this figure of Stanley Miller's experiment to simulate conditions thought to have existed on the early Earth. Explain the elements of this experiment, using arrows to indicate what occurs in various parts of the apparatus.



2. What was collected in the sample for chemical analysis? What was concluded from the results of this experiment?

Concept 4.2 Carbon atoms can form diverse molecules by bonding to four other atoms

3. Make an electron distribution diagram of carbon. It is essential that you know the answers to these questions:

   a. How many valence electrons does carbon have?

   b. How many bonds can carbon form?

   b. What type of bonds does it form with other elements?

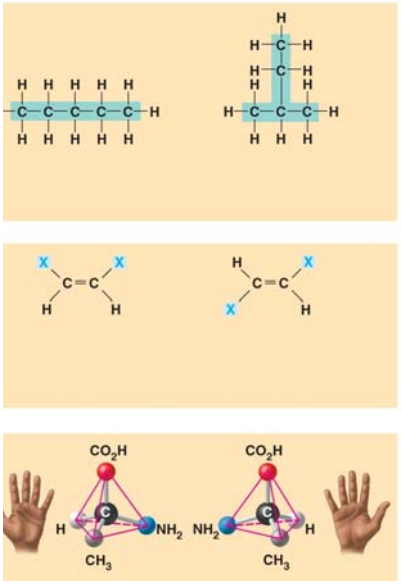
4. Carbon chains form skeletons. List here the types of skeletons that can be formed.

5. What is a *hydrocarbon*? Name two. Are hydrocarbons hydrophobic or hydrophilic?

6. In Chapter 2 you learned what an *isotope* is. Since students often confuse this word with *isomer*, please define each term here and give an example.

	Definition	Example
isotope		
isomer		

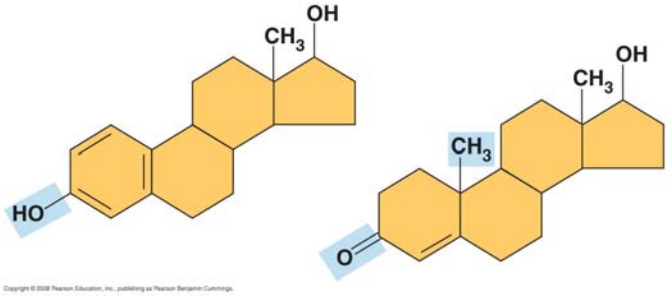
7. Use this figure to identify the three types of isomers. For each type, give a key character and an example.



8. Give one example of enantiomers that vary in their pharmacological effect.

Concept 4.3 A small number of chemical groups are key to the functioning of biological molecules

9. Here is an idea that will recur throughout your study of the function of molecules: Change the structure, change the function. You see this in enantiomers, you will see it in proteins and enzymes, and now we are going to look at testosterone and estradiol. Notice how similar these two molecules are, and yet you know what a vastly different effect each has. Label each molecule in the sketch below, and circle the differences.



10. Define *functional group*.

11. There are seven functional groups. Complete the following chart.

	Hydroxyl	**Carbonyl**	**Carboxyl**	**Amino**	**Sulfhydryl**	**Phosphate**	**Methyl**
Structure							
Example							
Functional Properties							

12. You will need to master the chart and the information in it. Using the functional groups above, see if you can answer the following prompts:

a. $–NH_2$

b. Can form cross-links that stabilize protein structure

c. Key component of ATP

d. Can affect gene expression

e. CH_3

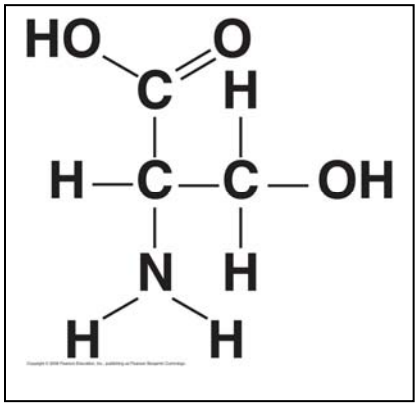
f. Is always polar

g. Determines the two groups of sugars

h. Has acidic properties

i. –COOH

j. Acts as a base



k. Circle and identify three functional groups in the molecule shown above.

Testing Your Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

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

Name_____Period_____

Chapter 5: The Structure and Function of Large Biological Molecules

Concept 5.1 Macromolecules are polymers, built from monomers

1. The large molecules of all living things fall into just four main classes. Name them.

2. Circle the three classes that are called *macromolecules*. Define *macromolecule*.

3. What is a *polymer*?

   a *monomer*?

4. Monomers are connected in what type of reaction? What occurs in this reaction?

5. Large molecules (polymers) are converted to monomers in what type of reaction?

6. The root words of *hydrolysis* will be used many times to form other words you will learn this year. What does each root word mean?

   hydro–

   lysis

7. Consider the following reaction:

   $$C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11}$$

   a. The equation is not balanced; it is missing a molecule of water. Write it in on the correct side of the equation.

   b. So, what kind of reaction is this?

   c. Is $C_6H_{12}O_6$ (glucose) a monomer, or a polymer?

   d. To summarize, when two monomers are joined, a molecule of _____ is always removed.

Concept 5.2 Carbohydrates serve as fuel and building material

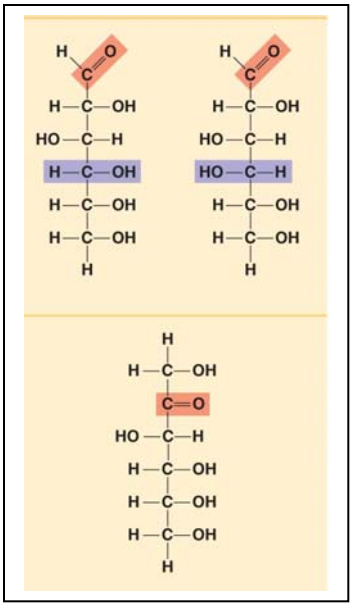
8. Let's look at carbohydrates, which include sugars and starches. First, what are the monomers of all carbohydrates?

9. Most monosaccharides are some multiple of (CH_2O). For example, ribose is a 5-carbon sugar with the formula $C_5H_{10}O_5$. It is a pentose sugar. (From the root *penta–*, meaning 5.) What is the formula of a hexose sugar?

10. Here are the three hexose sugars. Label each of them. Notice that all sugars have the same two functional groups. Name them:

    C=O _____

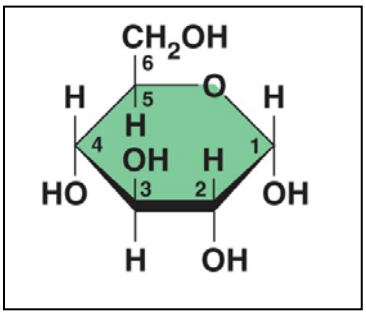
    —OH _____



11. What is the difference between an *aldehyde sugar* and a *ketone sugar*?

12. So, as a quick review, all of these sugars have the same chemical formula: $C_6H_{12}O_6$. What term did you learn in Chapter 3 for compounds that have the same molecular formulas but different structural formulas?

13. Here is the abbreviated ring structure of glucose. Where are all the carbons?



Pay attention to the numbering system. This will be important as we progress in our study. Circle the number 3 carbon. Put a square around the number 5 carbon.

14. Let's look at our reaction in question 7 again: $C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$

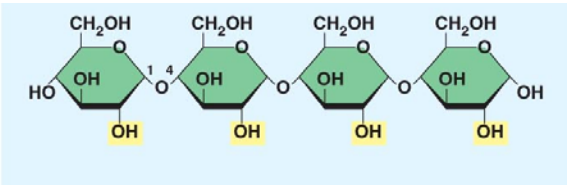
    Notice that two monomers are joined to make a polymer. Since the monomers are monosaccharides, the polymer is a *disaccharide*. Three disaccharides are important to us with the formula $C_{12}H_{22}O_{11}$. Name them below and fill out the chart.

Disaccharide	Formed from which two monosaccharides?	Found where?

15. Have you noticed that all the sugars end in *–ose*? This root word means _____.

16. What is a *glycosidic linkage*?

17. Here is a molecule of starch, which shows 1–4 glycosidic linkages. Translate and explain this terminology in terms of carbon numbering.



18. There are two categories of *polysaccharides*. Name them and give examples.

Type of Polysaccharide	Examples

19. Why can you not digest cellulose? What organisms can?

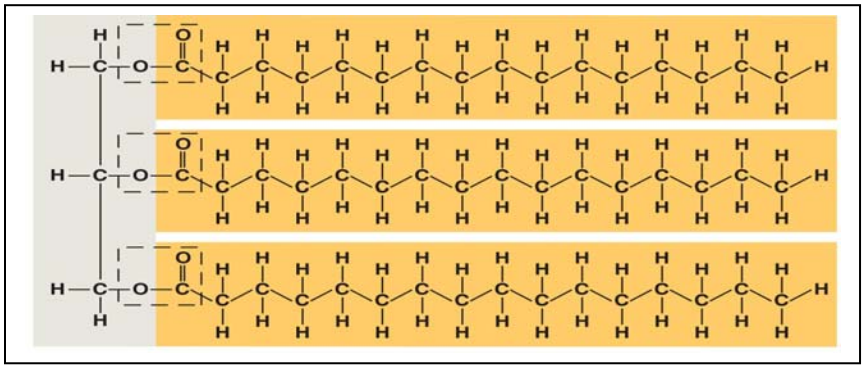
20. Let's review some key points about the carbohydrates. Each prompt below describes a unique carbohydrate. Name the correct carbohydrate for each.

    a. Has 1–4 B glucose linkages
    b. Is a storage polysaccharide produced by vertebrates; stored in your liver
    c. Two monomers of this form maltose
    d. Glucose +_____ form sucrose
    e. Monosaccharide commonly called "fruit sugar"
    f. "Milk sugar"
    g. Structural polysaccharide that gives cockroaches their crunch
    h. Malt sugar; used to brew beer
    i. Structural polysaccharide that comprises plant cell walls

Concept 5.3 Lipids are a diverse group of hydrophobic molecules

21. Lipids include fats, waxes, oils, phospholipids, and steroids. What characteristic do all lipids share?

22. What are the building blocks of *fats*? Label them on this figure.



23. If a fat is composed of 3 fatty acids and 1 glycerol molecule, how many water molecules will be removed to form it? Again, what is this process called?

24. On the figure with question 22, label the ester linkages.

25. Draw a fatty acid chain that is 8 carbons long and is *unsaturated*. Circle the element in your chain that makes it unsaturated, and explain what this means.

26. Name two saturated fats.

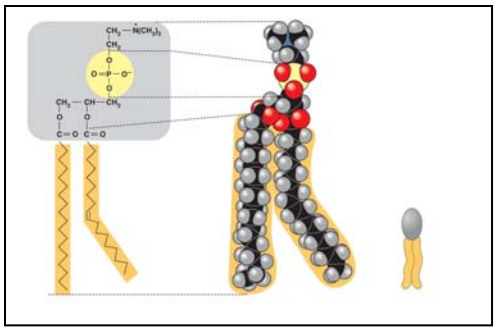
27. Name two unsaturated fats.

28. Why are many unsaturated fats liquid at room temperature?

29. What is a *trans fat*? Why should you limit them in your diet?

30. List four important functions of fats.

31. Here is a figure that shows the structure of a phospholipid. Label the sketch to show the phosphate *group*, the *glycerol*, and the *fatty acid chains*. Also indicate the region that is *hydrophobic* and the region that is *hydrophilic*.



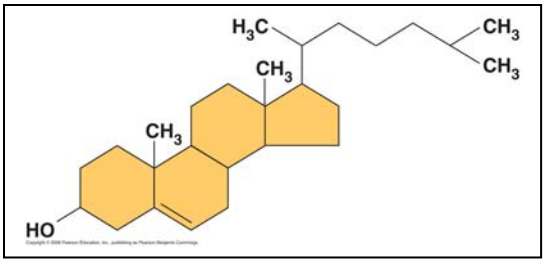
32. Why is the "tail" hydrophobic?

33. Which of the two fatty acid chains in the figure with question 31 is unsaturated? Label it. How do you know it is unsaturated?

34. To summarize, a phospholipid has a glycerol attached to a phosphate group and two fatty acid chains. The head is hydrophilic, and the tail is hydrophobic. Now, sketch the phospholipid bilayer structure of a plasma membrane. Label the hydrophilc heads, hydrophobic tails, and location of water.

35. Study your sketch. Why are the tails all located in the interior?

36. Some people refer to this structure as three hexagons and a doghouse. What is it?



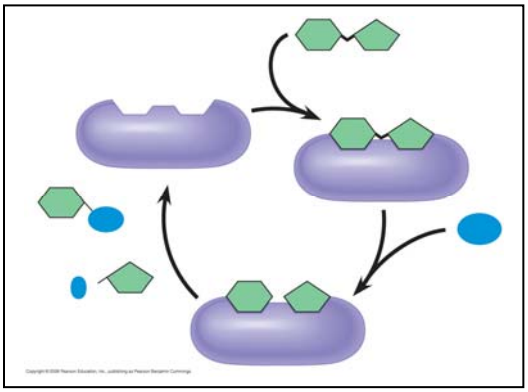
37. What are other examples of steroids?

Concept 5.4 Proteins have many structures, resulting in a wide range of functions

38. Table 5.1 is loaded with important information. Select any five types of proteins and summarize each type here.

Type of Protein	**Function**	**Example**

39. *Enzymes* are an important type of protein. They will be studied in Chapter 8. For now, use this sketch to review what you know about enzymes. Label the *active site*, the *substrate*, and the *products*. Show what happens to water.

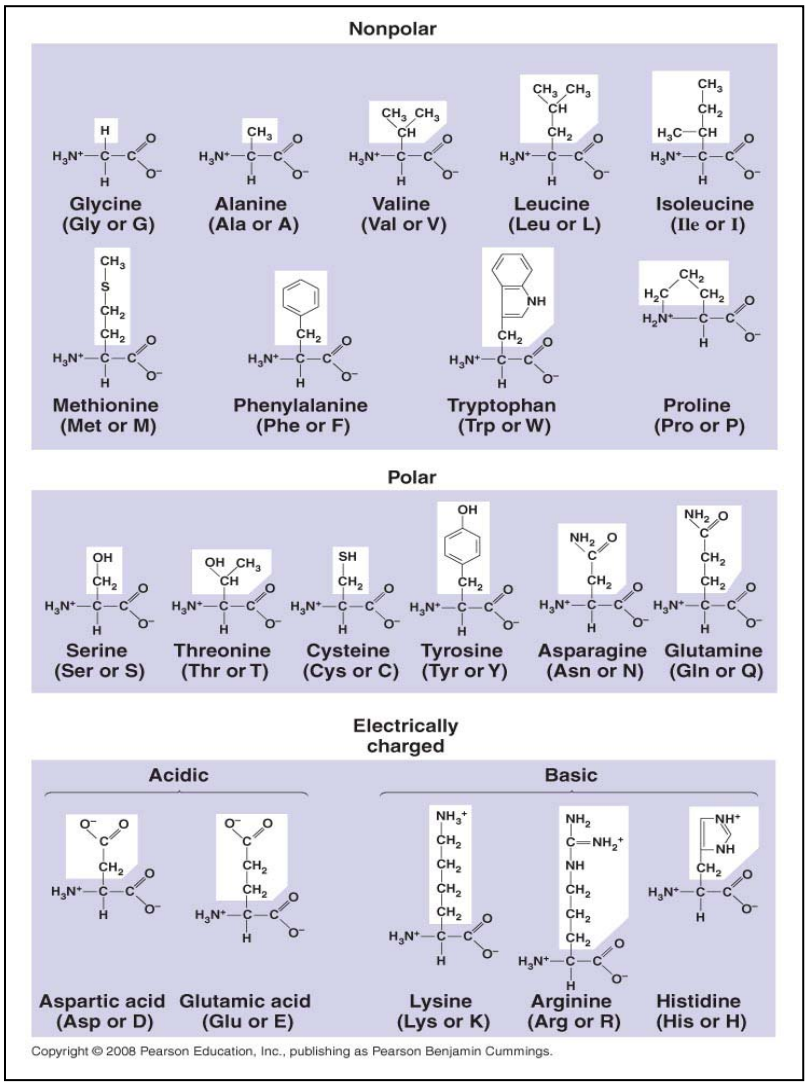


40. Is this reaction dehydration synthesis or hydrolysis?

41. The monomers of proteins are *amino acids*. Sketch an amino acid here. Label the *alpha* or *central carbon*, *amino group*, *carboxyl group*, and *R group*.

42. What is represented by *R*? How many are there?

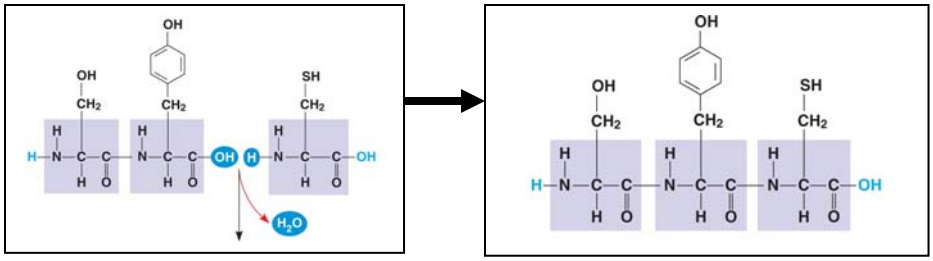
43. Study the figure. See if you can understand why some R groups are nonpolar, some polar, and others electrically charged (acidic or basic). If you were given an R group, could you place it in the correct group? Work on the R groups until you can see common elements in each category.



44. Define these terms:

dipeptide

polypeptide



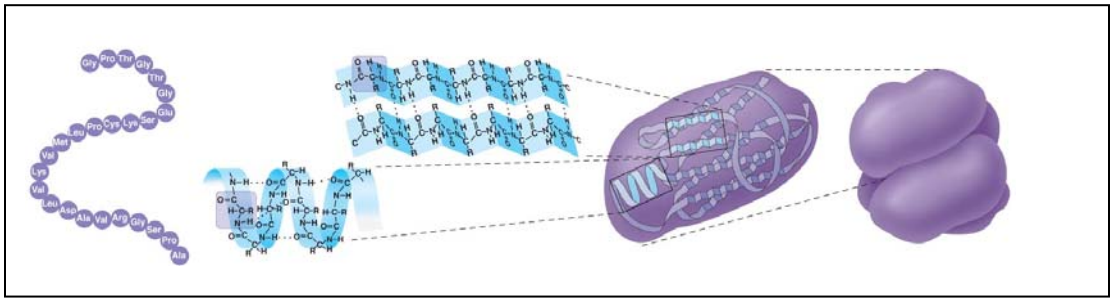
peptide bond

Label each of these terms on the diagrams.

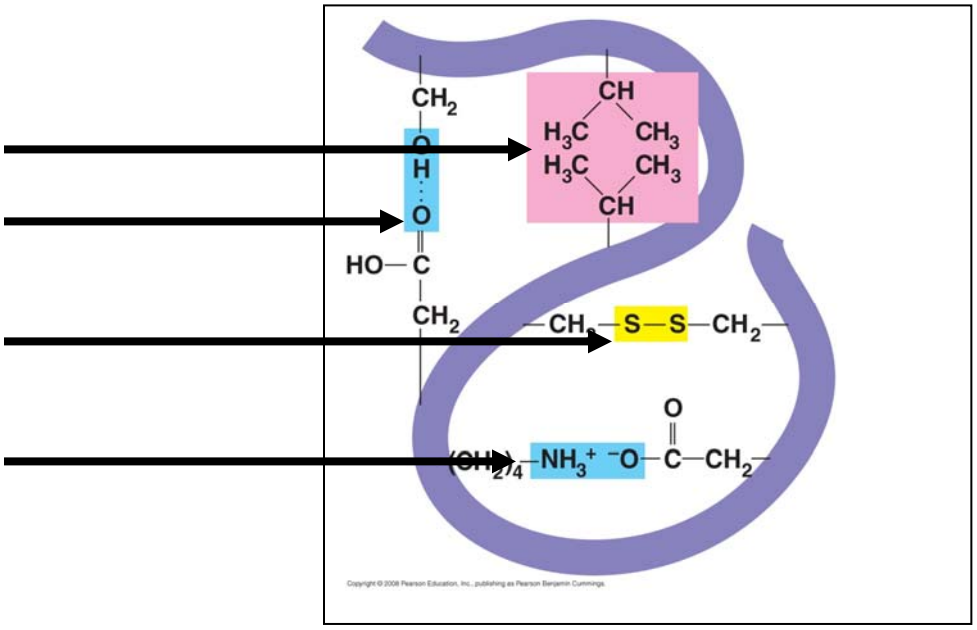
45. There are four levels of protein structure. Refer to Figure 5.21, and summarize each level in the following table.

Level of Protein Structure	**Explanation**	**Example**
Primary (I^o)		
Secondary (II^o) *Alpha helix* *Beta pleated sheet*		
Tertiary (III^o)		
Quaternary (IV^o)		

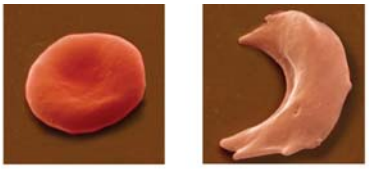
46. Label each of the levels of protein structure on this figure.



47. Enzymes are globular proteins that exhibit at least tertiary structure. On this figure, identify and explain each interaction that folds this portion.

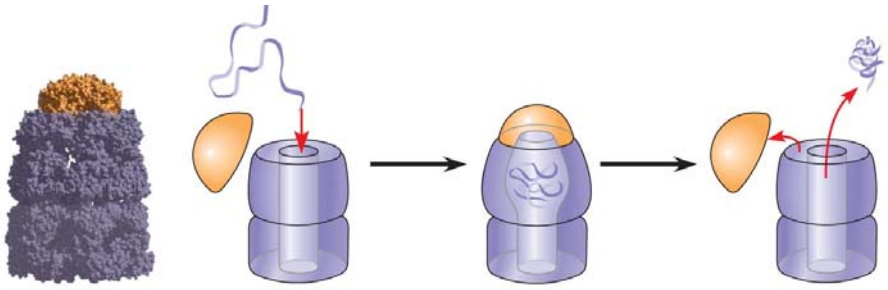


48. Do you remember when, in Chapter 4, we said, "Change the structure, change the function"? Explain how that principle applies to sickle-cell disease. Why is the structure changed?



49. Besides mutation, which changes the primary structure of a protein, protein structure can be changed by denaturation. Define *denaturation*, and give at least three ways a protein may become denatured.

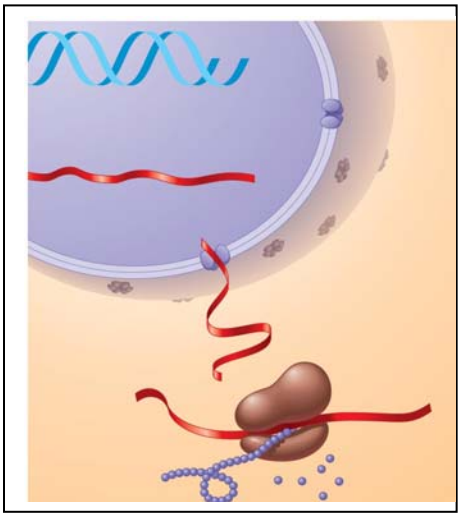
50. *Chaperone proteins* or *chaperonins* assist in the proper folding of proteins. Annotate this figure to explain the process.



Concept 5.5 Nucleic acids store and transmit hereditary information

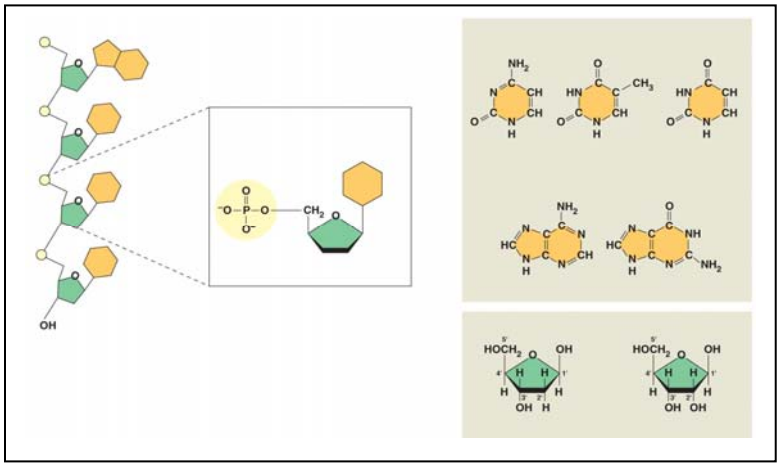
DNA and RNA will be the core topics of Chapter 17. For now, you should just review the general functions and know the components.

51. The flow of genetic information is from DNA → RNA→ protein. Use this figure to explain the process. Label the *nucleus*, *DNA*, *mRNA*, *ribosome*, and *amino acids*.



52. The components of a nucleic acid are a *sugar*, a *nitrogenous base*, and a *phosphate group*. Label each on the figure below.

53. You may recall that early in this chapter we looked at the numbering system for the carbons of a sugar. Label the end of the strand on the left side of the figure below that has the number 5 sugar **5'** and the other end of the chain **3'**.



54. Notice that there are five nitrogen bases. Which four are found in DNA?

55. Which four are found in RNA?

56. How do ribose and deoxyribose sugars differ?

57. To summarize, what are the three components of a nucleotide?

58. Here is a model of DNA, which was proposed by James Watson and Francis Crick. What is this shape called?

59. Why are the strands said to be *antiparallel*?

60. What two molecules make up the "uprights"?

61. What molecules make up the rungs?

62. For the two nucleotides of DNA below, provide the complementary base.
    A —
    C —

63. In a DNA double helix, a region along one DNA strand has this sequence of nitrogenous bases:

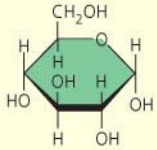
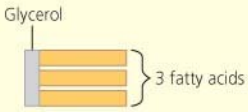
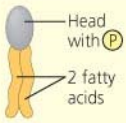
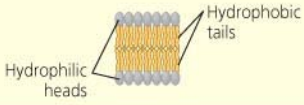
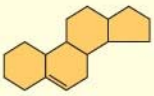
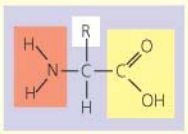
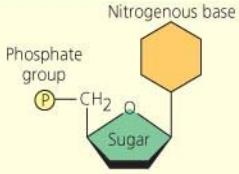
    5'-T A G G C C T-3'

Write the complementary strand. Indicate the 5' and 3' ends of the new strand.

Testing Your Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

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

This summary table from the Chapter 5 Review is an excellent study tool. Use it to organize material from this chapter in your mind.

Large Biological Molecules	Components	Examples	Functions
Concept 5.2 **Carbohydrates** serve as fuel and building material	 Monosaccharide monomer	Monosaccharides: glucose, fructose	Fuel; carbon sources that can be converted to other molecules or combined into polymers
		Disaccharides: lactose, sucrose	
		Polysaccharides: • Cellulose (plants) • Starch (plants) • Glycogen (animals) • Chitin (animals and fungi)	• Strengthens plant cell walls • Stores glucose for energy • Stores glucose for energy • Strengthens exoskeletons and fungal cell walls
Concept 5.3 **Lipids** are a diverse group of hydrophobic molecules and are not macromolecules		Triacylglycerols (fats or oils): glycerol + 3 fatty acids	Important energy source 
		Phospholipids: phosphate group + 2 fatty acids	Lipid bilayers of membranes 
	 Steroid backbone	Steroids: four fused rings with attached chemical groups	• Component of cell membranes (cholesterol) • Signals that travel through the body (hormones)
Concept 5.4 **Proteins** have many structures, resulting in a wide range of functions	 Amino acid monomer (20 types)	• Enzymes • Structural proteins • Storage proteins • Transport proteins • Hormones • Receptor proteins • Motor proteins • Defensive proteins	• Catalyze chemical reactions • Provide structural support • Store amino acids • Transport substances • Coordinate organismal responses • Receive signals from outside cell • Function in cell movement • Protect against disease
Concept 5.5 Nucleic acids store and transmit hereditary information	 Nucleotide monomer	DNA: • Sugar = deoxyribose • Nitrogenous bases = C, G, A, T • Usually double-stranded	Stores all hereditary information
		RNA: • Sugar = ribose • Nitrogenous bases = C, G, A, U • Usually single-stranded	Carries protein-coding instructions from DNA to protein-synthesizing machinery