WATER

1. How many hydrogen atoms are in a molecule of water?

How many oxygen atoms are in a molecule of water?

What holds the hydrogen atoms to the oxygen atom?

2. The shading around the molecule represents the relative density of electrons shared by the atoms. What does this indicate about the density of electrons around the oxygen atom as compared to the density of electrons around the hydrogen atoms?

3. Where is the majority of negative charge on the water molecule?

4. Looking at your answers above, tell what atoms are represented by:
   a. The small, unshaded circles.
   b. The larger gray shaded circles.
   c. What do the solid lines between the small and large circles represent?
   d. What is represented by the dotted lines?

5. Describe the cause of the attractions between molecules of water.

6. If another water molecule was added to the group in Model 2 at the upper right side, which of its atoms would be connected to the existing molecule with a dotted line? Describe your reasoning.

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The bonding electrons in some molecules are not equally shared between the atoms. These neutral molecules with a difference of charge across the molecule are called polar molecules. Because of the arrangement of the atoms and electrons in a water molecule, there are two differently charged areas of the molecule even though the molecule is neutral overall. The hydrogen molecules are slightly positive, while the oxygen is slightly negative. The positive area charge (hydrogen) of one water molecule is attracted to the negative area (oxygen) of a different water molecule. This weak attraction is often referred to as hydrogen bonding.

8. Some molecules that are covalently bonded do not have a difference in charge across the molecule. These molecules are referred to as nonpolar. What arrangement of electrons would result in a nonpolar molecule?

9. Some examples of nonpolar molecules include fats, oils, and waxes. How do these substances interact with water?

BIOLOGICAL MOLECULES - The building blocks of life

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From the smallest single-celled organism to the tallest tree, all life depends on the properties and reactions of four classes of organic (carbon-based) compounds—carbohydrates, lipids, proteins, and nucleic acids. These organic molecules are the building blocks of all living things, and are responsible for most of the structure and functions of the body, including energy storage, insulation, growth, repair, communication, and transfer of hereditary information. Simple organic molecules can be joined together to form all the essential biological molecules needed for life.

10. Sketch a monomer for each of the following:

| Carbohydrate | Proteins | Nucleic Acid | Lipids |
BIOLOGICAL MOLECULES

11. Use the diagrams above, your sketches and textbook to show which atoms are present in each type of molecule by listing the symbol for each atom included. Carbohydrate has been done for you.
   a. Carbohydrate— C, H, O
   b. Lipid—
   c. Amino acid—
   d. Nucleic acid—

12. Which type of molecule includes an example with a long-chain carbon backbone? What is the dominant element attached to the carbon backbone?

13. [see 3.5, pg. 54] The fatty acid chain of the lipids is often referred to as a hydrocarbon chain. Discuss with your group why the chain is given this name and write a one-sentence definition for a hydrocarbon.

14. [see 3.4, pg. 46] Which molecule has a central carbon atom with four different components around it? What are the 4 different components?

15. Which molecule has a sugar, nitrogenous base, and phosphate group?

16. Discuss some similarities among all four types of molecules. List as many as you can.

17. What is the chemical formula of the first carbohydrate molecule shown?

18. [see 3.4, pg. 46-47] There are 20 naturally-occurring amino acids, and each one only varies in the structure of the R side chain. Two amino acids are shown in Model 1. What are the R side chains in each?

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During chemical reactions, the bonds in molecules are continually broken and reformed. To break a bond, energy must be absorbed. When bonds are formed, energy is released. If more energy is released than absorbed during a chemical change, the process can be used as a source of energy. A general rule for processes such as respiration is the more carbon atoms there are in a molecule, the more energy that molecule can provide to the organism when it is used as food.

19. Using the information from above, is a carbohydrate or a lipid more likely to be a good source of energy for an organism?

20. What are the reactants of reaction A?
   What are the products of reaction A?

21. Each of the reactants in reaction A is a single sugar molecule, also called a monosaccharide. What prefix before saccharide would you use to describe sucrose?

22. What are examples of polysaccharides in Humans, Plants?
23. What are the reactants of reaction B?

24. When the two molecules in reaction B are joined together, what two molecules are produced?

25. What product do both reactions have in common?

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When sugars are joined together the new bond that forms is a glycosidic bond. When amino acids are joined the new bond that forms is a peptide bond. When fatty acids are joined to a glycerol the bond that holds them is an ester bond.

26. On the diagrams A, B, & C in circle and label the glycosidic, peptide, and ester bonds.

27. These reactions are all referred to as dehydration synthesis or condensation reactions. Develop an explanation for why these terms are used to describe these reactions.

28. These reactions can also be reversed, breaking the large molecule into its individual molecules. What substance would need to be added in order to reverse the reaction?

29. (see 3.1, pg. 37) What word is used to describe the reaction that uses water to break apart a large molecule?

30. Metabolism is the collective term used to describe all the chemical reactions taking place inside living organisms. Why is water so important for metabolic reactions?

31. (see 3.5, pg. 54) Look at the two types of fatty acids, saturated and unsaturated. What is the difference between the two?

32. (see 3.5, pg. 54) Saturated fats are solid fats, like the animal fats lard and butter, whereas unsaturated fats are more fluid and form oils, such as vegetable oil. Trans fats are plant oils that are artificially solidified to make them suitable for baking purposes. In recent years trans fats have been associated with negative health issues and are not as widely used. Explain in simple molecular terms what would have to be done to a plant oil to transform it to a trans fat.

33. We store excess food in our body either in the form of carbohydrates (in muscles and the liver) or as fat (adipose tissue). When our body needs additional energy it uses the carbohydrate source first as a source of “quick” energy, then the fat. Why do you think carbohydrates are used as a source of quick energy rather than fat? Use complete sentences and scientific terminology in your response.
**Properties of Biological Molecules**

35. In general, the presence of atoms of what element(s) makes a molecule polar? (which elements are usually seen in polar molecules, but not usually in nonpolar?)

36. What about the elements you mentioned above makes the molecules they are a part of polar?

37. In chemistry there is a saying “like dissolves like,” which means things will mix with or dissolve into each other best when their polarities are similar.
   a. Is water polar or nonpolar?
   b. Is oil polar or nonpolar?
   c. Which of the substances in would dissolve well in water? Justify your reasoning.

38. Refer to Model 2.
   a. What is another term for a polar molecule?
   b. What is another term for a nonpolar molecule?
   c. Give the literal translation for the terms you gave in parts a and b above.

**Formation of a Peptide Bond**

<table>
<thead>
<tr>
<th>Amino acid 1</th>
<th>Amino acid 2</th>
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</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
</tr>
</tbody>
</table>

39. Examine the amino acids to the left
   a. Circle an amine group in the diagram.
   b. Draw a triangle around a carboxylic acid (carboxyl) group.

40. How are the amino acids similar to one another?
41. How are the amino acids different from one another?

42. How many amino acids are involved in the reaction to make a dipeptide?
   The original amino acids are combined through a condensation reaction to make the dipeptide.
   a. What does R1 represent in the dipeptide?
   b. What does R2 represent in the dipeptide?
   c. Put a box around the atoms in the amino acids that become the H2O molecule produced by the reaction in molecule.

43. A peptide bond is a covalent bond linking two amino acids together in a peptide.
   a. Circle the peptide bond
   b. Between which two atoms in the dipeptide is the peptide bond located?
   c. Between what two functional groups is the peptide bond located?
44. There are 22 different amino acids found in nature. Additional examples are shown below. With your group, write one or two grammatically correct sentences to describe how these amino acids are similar and how they are different. Use the terms R-group, amine group, and carboxyl group in your description.

Glycine (Gly)

\[\begin{align*}
\text{H}_2\text{N} & - \text{C} - \text{COOH} \\
\end{align*}\]

Cysteine (Cys)

\[\begin{align*}
\text{H}_2\text{N} & - \text{C} - \text{COOH} \\
\end{align*}\]

Asparagine (Asn)

\[\begin{align*}
\text{H}_2\text{N} & - \text{C} - \text{COOH} \\
\end{align*}\]

Phenylalanine (Phe)

\[\begin{align*}
\text{H}_2\text{N} & - \text{C} - \text{COOH} \\
\end{align*}\]

**Primary Structure**

Amino acid sequence: Ser – Tyr – Ala – Phe – Val – Cys – Tyr – Asp – Cys – Gly

Peptide structure:

45. Locate the primary structure of the polypeptide in
a. Draw an arrow to two different peptide bonds in the diagram.
b. Circle three separate amino acids that were joined together to make the polypeptide.

46. The first five amino acids in this polypeptide are serine, tyrosine, alanine, phenylalanine, and valine, in that order (Ser-Tyr-Ala-Phe-Val). If the amino acids were changed or rearranged (i.e., to Val-Phe-Ala-Ser-Tyr), the polypeptide would have a different name and identity. With your group, use this information to write a definition of the primary structure of a protein.

47. Locate the secondary protein structure
a. What types of bonds are holding the secondary structure in place?
b. What groups on the amino acids are always involved in these bonds?

48. Secondary protein structure can take the form of an alpha(α)-helix or a beta(β)-pleated sheet, as illustrated below.

a. Which drawing represents an α-helix, Molecule 1 or Molecule 2? Explain your reasoning.
b. Which drawing represents a β-pleated sheet? Explain your reasoning.
Fill in the chart with the diagram of each Functional (Chemical) group. Carbonyl Group is done for you. In addition, give example molecules where you would see the functional group as part of it. Use Chapter 3 in your book.

<table>
<thead>
<tr>
<th>Chemical Group</th>
<th>Compound Name</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroxyl group (—OH)</td>
<td>Alcohol</td>
<td>(The specific name usually ends in -ol.)</td>
</tr>
<tr>
<td>Carbonyl group (C═O)</td>
<td>Ketone if the carbonyl group is within a carbon skeleton; Aldehyde if the carbonyl group is at the end of a carbon skeleton</td>
<td></td>
</tr>
<tr>
<td>Carboxyl group (—COOH)</td>
<td>Carboxylic acid, or organic acid</td>
<td></td>
</tr>
<tr>
<td>Amino group (—NH₂)</td>
<td>Amine</td>
<td></td>
</tr>
<tr>
<td>Sulphydryl group (—SH)</td>
<td>Thiol</td>
<td></td>
</tr>
<tr>
<td>Phosphate group (—OPO₄²⁻)</td>
<td>Organic phosphate</td>
<td></td>
</tr>
<tr>
<td>Methyl group (—CH₃)</td>
<td>Methylated compound</td>
<td></td>
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