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Chapter 3: The Chemistry of Organic Molecules

Exercise 1 – Diversity of Carbon-Based Molecules (3.1)

The great variety of organic compounds results from the ability of carbon atoms to bond with four other atoms, forming branching chains of different lengths. Several hydrocarbon molecules, consisting only of carbon and hydrogen, are shown in Module 3.1. Practice seeing the versatility of carbon by sketching some hydrocarbon molecules of your own, as suggested below.

1. Sketch a hydrocarbon molecule that is a straight chain, containing five carbon atoms and twelve hydrogen atoms, molecular formula C_5H_{12}:

   Question: Why does each carbon bond to four other atoms?

2. Now sketch a shorter hydrocarbon chain, with only four carbon atoms?

   Question: What is the molelcular formula ($C_?H_?$) of the above molecule?

3. Sketch another five-carbon hydrocarbon, but this time include one double bond:

   Question: What is the molecular formula of this molecule?

4. Sketch a five-carbon hydrocarbon molecule that is branched (and contains no double bonds):

   Question: What is the molecular formula of this molecule? What is the term for its relationship to molecule 1 (in this exercise)?

5. Sketch two five-carbon hydrocarbon molecules in the form of rings, one without double bonds and one with one double bond.

   Question: How many hydrogen atoms are in each of these molecules?

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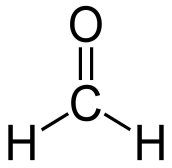
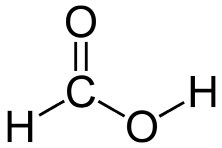
Exercise 2 – Functional Groups (3.1)

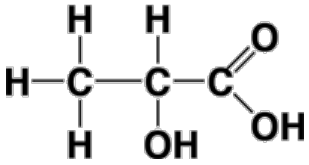
Functional groups participate in chemical changes and give each molecule unique properties. Circle the functional groups that are discussed in this module in the molecules below. Label an example of each of the following: **hydroxyl group, carbonyl group, carboxyl group, amino group,** and **phosphate group.**



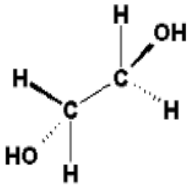
Formaldehyde is the starting point for making many chemicals.

Formic acid gives ant venom its sting.

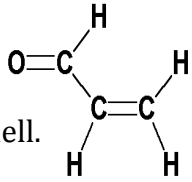




Lactic acid builds up a waste product in exercising muscles and makes them feel tired.

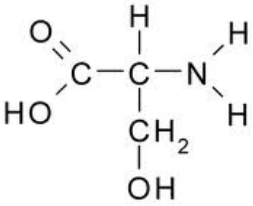


Ethylene glycol is in automobile antifreeze

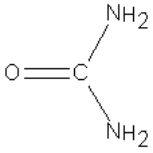


Acrolein is produced when meat is heated; it is the barbecue smell.

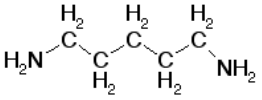
Serine is part of many protein molecules.



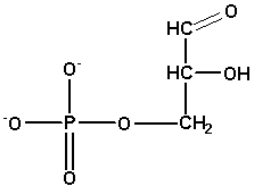
Urea is a waste produced in urine.



Putrescene's name is descriptive; it is produced in rotting flesh.



G3P is an intermediate step in plants' production of sugar.



There are a total of _____ hydroxyl groups, _____ carbonyl groups, _____ carboxyl groups, _____ amino groups, and _____ phosphate groups.

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Exercise 3 – Making and Breaking Polymers (3.1)

There are four main classes of macromolecules. Most are polymers, assembled from smaller monomers in a process called a dehydration reaction. Hydrolysis breaks polymers back down to monomers. State whether each of the following relates to dehydration (D) or hydrolysis (H).

_____ 1. Connects monomers to form a polymer.

_____ 2. Produces water as a by-product.

_____ 3. Breaks up polymers, forming monomers.

_____ 4. Water is used to break bonds between monomers.

_____ 5. Joins amino acids to form a protein.

_____ 6. Glycerol and fatty acids combine this way to form a fat.

_____ 7. Occurs when polysaccharides are digested to form monosaccharides.

_____ 8. –H and –OH groups form water.

_____ 9. Nucleic acid breaks up to form nucleotides.

_____ 10. Water breaks up, forming –H and –OH groups on separate monomers.

Exercise 4 – Polymers, Glucose, and Carbohydrates (3.2)

Carbohydrates are a class of molecules ranging from the simplest sugars, called [1]_____, to giant molecules called [2] _____, built of many sugars. Carbohydrates are the main fuel molecules for cellular work.

Plants make their own carbohydrates, but humans, like all animals, must obtain them from plants or animals. Imagine eating a piece of whole-wheat bread spread with strawberry jam. It contains a mixture of carbohydrates, along with other macromolecules like [3]_____ and [4]_____. Much of the carbohydrate in bread itself is in the form of a polysaccharide called [5]_____, which is simply a chain of [6]_____ monomers. The monomers were linked together in the wheat plant in a process called a [7]_____ reaction. As the glucose units joined, [8]_____ was produced as a by-product. When you swallow a bite of bread, digestive juices in the intestine separate the monomers in the opposite reaction, called [9]_____. In the intestine, this is actually a two-step process. Secretions from the pancreas first break the starch down to maltose, a type of carbohydrate called a [10]_____, which consists of two glucose monomers. Secretions from the walls of the intestine complete the process, breaking each maltose molecule down to two individual glucose molecules. Each glucose is a [11]_____-shaped molecule, containing [12]_____carbon atoms.

There are other carbohydrates in the bread and jam. Whole-wheat flour contains the tough coats of the wheat seeds. These contain a lot of [13]_____, the fibrous polysaccharide that makes up plant cell walls. Like starch, it is made of glucose monomers,

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but these monomers are [14]_____ in a different orientation. The human digestive tract is not capable of [15]_____ cellulose, so it passes through the digestive tract unchanged, in the form of [16]_____. Sucrose, a [17]-_____ refined from sugar cane or sugar beets, may be used to sweeten the strawberry jam. Each sucrose molecule is hydrolyzed in the small intestine to form one molecule of [18]_____ and on molecule of [19]_____. The jam naturally also contains a small amount of fructose, a [20]_____ that is produced by strawberries and is considerably sweeter than sucrose. (If the jam is artificially sweetened, it might contain other molecules whose [21] _____ are similar to natural sugars. These molecules bind to "sweet" [22]_____ on the tongue, producing the sensation of sweetness.)

Once all the carbohydrates have been hydrolyzed to small monosaccharides, they can be absorbed by the body. Glucose and fructose pass through the wall of the intestine and into the bloodstream, which carries them to the liver. Like all carbohydrate molecules, these sugars are [23]_____, so they easily dissolve in the water of blood plasma. In the liver, the fructose is converted to glucose. This process is relatively easy because glucose and fructose are [24]_____, having the same molecular formula, [25]_____, but slightly different structures. Glucose circulates around the body as "blood sugar" and is taken up by the cells for fuel as needed. Extra glucose molecules are taken up by the liver and muscle cells and linked together by [26]-_____ synthesis to form a polysaccharide called [27]__-_____. This molecule is similar to [28]_____, except it is more branched. Later the glycogen can by hydrolyzed to release [29]_____ into the blood.

Exercise 4 – Protein Functions (3.4)

Everything a cell does involves proteins. Seven classes of proteins are discussed in 3.4 or the lecture. Match each of the classes with one of the descriptions below.
Metabolism, support, transport, defense, regulation, motion, and storage proteins.
Storage proteins are not in the text, but in your notes.

_____ 1. Hemoglobin carries oxygen in the blood.

_____ 2. A protein in muscle cells enables them to move.

_____ 3. Antibodies fight disease-causing bacteria.

_____ 4. Collagen gives bone strength and flexibility.

_____ 5. Insulin signals cells to take in and use sugar.

_____ 6. Proteins in seeds provide food for plant embryos.

_____ 7. A protein called sucrase promotes the chemical conversion of sucrose into monosaccharides.

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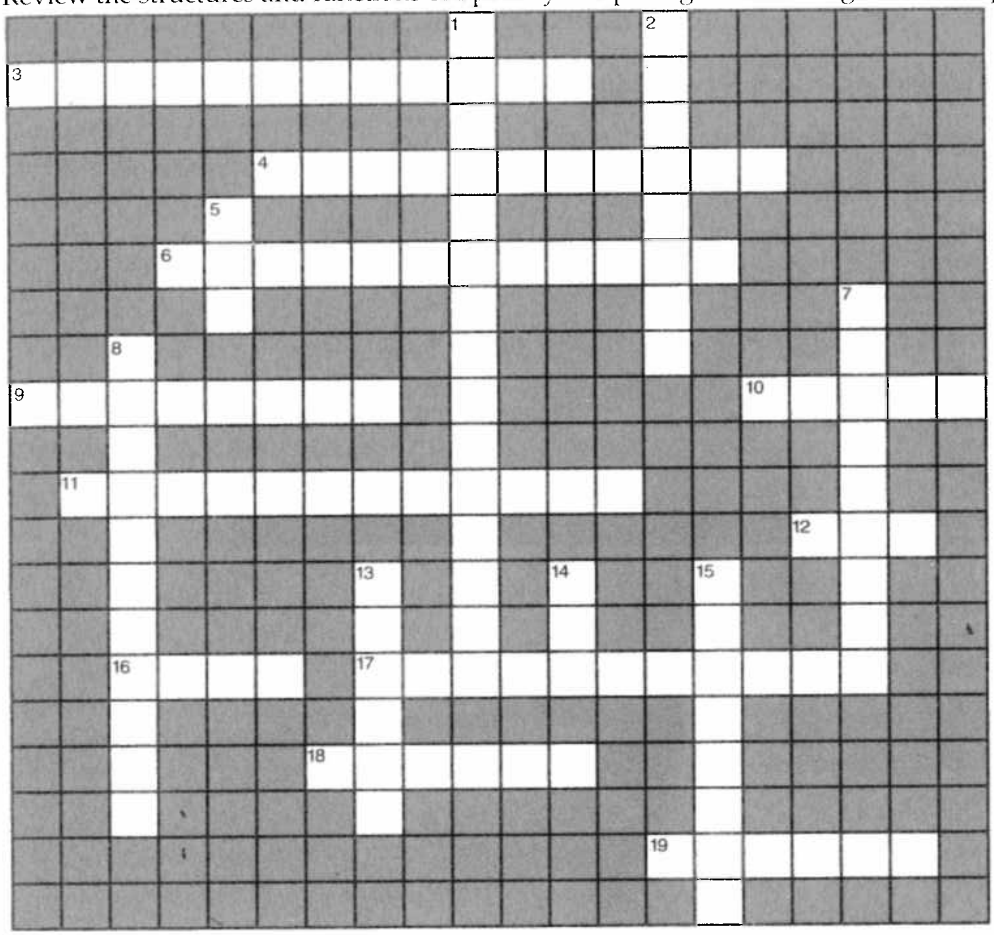
Exercise 6 – Lipids (3.3)

Review the structures and functions of lipids by completing the following crossword puzzle.



Across

3. _____ means that hydrogen has been added to unsaturated fats.
4. _____ is a steroid common in cell membranes.
6. A _____ is similar to a fat; found in cell membranes.
9. A fat molecule is composed of _____ and three fatty acids.
10. Glycerol and 3 _____ acids make a triglyceride.
11. _____ is another name for "fat."
12. A _____ forms a waterproof coat that keeps a fruit or insect from drying out.
16. Olive and corn _____ are examples of unsaturated fats.
17. Fats with double bonds are said to be _____.
18. A _____ is a lipid-containing deposit in a blood vessel.
19. _____ are grouped together because they do not dissolve in water.

Down

1. _____ is when lipid-containing deposits block blood vessels.
2. Female and male sex hormones are examples of _____.
5. _____ is an illegal steroid recently banned by the International Olympic committee and professional sports.
7. Animal fats are said to be _____.
8. Lipids are water-avoiding, or _____ substances.
13. Unsaturated fats contain more _____ bonds than saturated fats.
14. A _____ is a large molecule whose main function is energy storage.
15. _____ steroids are dangerous variants of testosterone.

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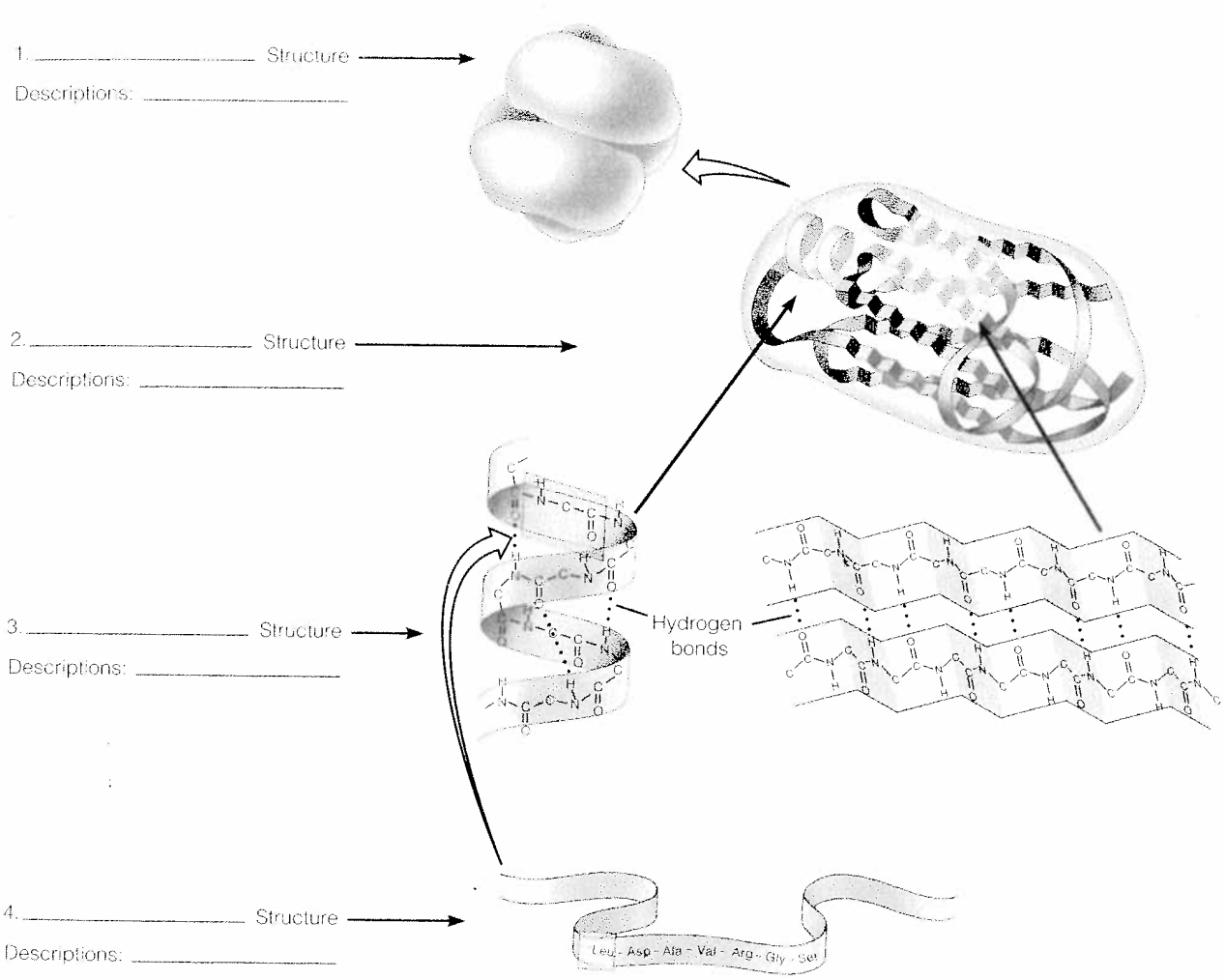
Exercise 7 – Protein Structure (3.4)

Identify each of the levels of protein structure in the diagrams. Then choose the descriptions from the list below that go with each of the levels.



Choose from these descriptions:

A. Overall three-dimensional shape
B. Amino acid sequence
C. Even a slight change in this can alter tertiary structure.
D. This level occurs in proteins with more than one polypeptide subunit.
E. Coiling and folding produced by hydrogen bonds between —NH and C=O groups
F. Not present in all proteins
G. Level of structure that is held together by peptide bonds
H. Alpha helix and pleated sheet
I. Stabilized by clustering of hydrophobic R groups, hydrogen bonds, ionic bonds, and sometimes even covalent bonds
J. "Globular" or "fibrous" might describe this level of structure.

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Exercise 8 – Nucleic Acid Functions and Structure (3.5)

Nucleic acids are the fourth group of macromolecules discussed in this chapter. Review their structures and functions by matching each of the phrases on the right with a word or phrase from the list on the left. Answers may be used more than once.

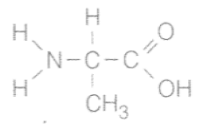
A. Phosphate Group
B. Deoxyribose
C. A, T, C, G
D. DNA
E. Nucleotide
F. A, U, C, G
G. Double Helix
H. Ribose
I. Nitrogenous base
J. RNA

_____ 1. Sugar in RNA
_____ 2. Overall structure of DNA
_____ 3. Short for ribonucleic acid
_____ 4. Passed on from parent to offspring
_____ 5. Nitrogenous bases of RNA
_____ 6. Sugar in DNA
_____ 7. Nitrogenous bases of DNA
_____ 8. Short for deoxyribonucleic acid
_____ 9. DNA works through this intermediary
_____ 10. Nucleotide is sugar, phosphate, and this
_____ 11. Sugar of one nucleotide bonds to this of the next nucleotide
_____ 12. Monomer of nucleic acids

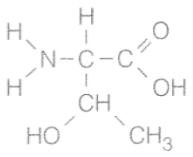
Exercise 9 – Amino Acids (Modules 3.4)

Three amino acids not shown in the modules are diagrammed below.

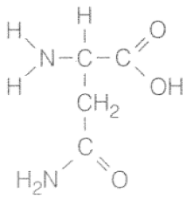
1. Draw a box around the unique R group of each, and label it **R group**.
2. Draw a red circle around the amino group of each, and label it **amino group**.
3. Draw a blue triangle around the acid group of each, and label it **acid group**.



Alanine



Threonine



Asparagine

4. In the space below, sketch the three amino acids to show how they would join to form a tripeptide. What is this chemical reaction called? How many molecules of water would be formed? Show where the water would come from.