

## CREDITS

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### VIDEO

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### TEACHER'S RESOURCE BOOK

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## INTRODUCTION

Stage fright --- fear of failure --- that's basically what happens to many students at the thought of a formula, whether it is mathematics, physics, chemistry or those areas of biology that seek to explain the molecular aspects of the living world. Students immediately assume they won't be able to understand what they are about to encounter, and their minds set up a mental wall.

You, as a teacher, face a double challenge: not only must you present and explain the material students need to know in a manner that is clear and understandable, you first must scale the mental barrier that so many students set up. Learning the significance of organic compounds is one such challenge because it is a topic that students instinctively expect to be difficult. The video program *Organic Compounds in Action* gives you a tool to help break through your students' self-imposed barriers to learning this topic.

The video program combines the engaging style of a visually rich video format with a series of written exercises that review, reinforce and extend the information in the video. The program engages the curiosity of students such that they are learning about the chemistry of living systems *before* they have a chance to put up a wall. This combination of print and video makes the topic accessible. The video opens the door to learning, and the written exercises provide more depth.

*Organic Compounds in Action* demystifies the structure of organic compounds by providing a simple, logical investigation of the significance of structure rather than just a listing of facts to be memorized. Students see that chemical structure is connected to the behavior of these compounds. Although the term "organic compound" can refer to any molecule containing carbon, this program focuses primarily on four major groups of organic compounds found in living systems: lipids, carbohydrates, proteins, and nucleic acids. One key to understanding biological processes (as opposed to just describing them) is to explore the behavior of the chemicals of which living systems are made. For this reason, learning about organic compounds in the context of their function helps students tie together aspects of chemistry and biology in a way that makes sense and is, therefore, knowledge that students can retain and use.

In addition to the written exercises, this program includes accessory material in the form of a CD-ROM that contains molecular models. These models are scientifically accurate and were designed and programmed by scientists and software engineers at Molecular Simulations, Incorporated (MSI). The CD-ROM is provided as a courtesy of MSI to promote education and familiarize teachers and students with high quality molecular models. Some of the molecular images in the video were provided by MSI, offering an effective connection between what students see on the videotape and images they can explore on the computer at their own rate.

## LEARNING OBJECTIVES

After viewing the video *Organic Compounds in Action*, your students should be able to:

- understand that organic compounds are found in living systems, but that they share the same fundamental chemistry as compounds that make up nonliving material.
- explain that carbon has specific advantages for building complex molecules.
- show examples of various ways in which molecular structure can be depicted in written form, diagrams or molecular models.
- describe the relationship between monomers and polymers.
- list four major groups of organic compounds in living systems and describe what they do.
- relate the structure of organic compounds to their function in biological systems.
- recognize the importance of modeling as a tool in scientific research.

## VIDEO SUMMARY

A striking array of molecular images opens the video *Organic Compounds in Action* to capture the attention of students from the start. The program initially introduces the important idea that the chemistry of living systems is not “magic” but instead is subject to the same fundamental principles as found in nonliving material. In this context the video defines the term “organic compound” and explains that this program focuses on four major groups of organic compounds that are important in living systems: **lipids**, **carbohydrates**, **proteins**, and **nucleic acids**.

Students learn that organic compounds are subject to the same chemical principles as any other compounds, but they also share some unique features. Although many organic compounds are very complex, they are primarily composed of just a few elements. The four elements carbon, oxygen, hydrogen and nitrogen make up, by mass, over 96% of the human body.

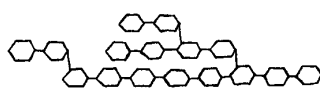
Students also begin to hear about the role of organic compounds, such as the structural protein in a muscle or the carbohydrates that supply energy when the muscle is being exercised.

Throughout the exploration of these four major groups of organic compounds, the video uses a visual table of contents as a reminder of the connection between the terms (lipid, carbohydrate, etc.) and what they have learned about the structure and behavior of compounds from each group. A graphic “shorthand” symbol for each type of organic compound appears next to the name after the video segment has explored that topic.

### **lipids**



### **carbohydrates**



### **proteins**



### **nucleic acids**



The first big question addressed by the video is *What are organic compounds and what are they made of?* The structure of organic compounds is introduced through a dramatic comparison: two molecular models contrast the tiny methane molecule and an enormous organic compound, the protein known as trypsin. This pair reminds students that organic compounds come in a vast range of shapes and sizes. For simplicity, the video begins a detailed look at structure in organic compounds by focusing on methane.

Carbon is the “star of the show” when it comes to organic compounds. Students see that the bonding pattern of carbon makes it ideal to form stable, complex molecules. One reason is that carbon can bond covalently to as many as four other atoms. Extending this initial example of methane, the video shows that a long string of carbons and hydrogens can bond together to form hydrocarbons. When a single carboxylic acid group is added to one end of a long hydrocarbon chain, the result is a simple fatty acid, a component of a lipid.

In addition to answering the large question of what makes up organic compounds, the video also addresses a second important question, *What do organic compounds do?* Throughout the program, these questions are tackled together, making the connection between form and function.

Students need concrete examples to connect what they learn about the structure and behavior of organic compounds with the world around them. To do this, the video provides a live demonstration of one property of organic compounds: their relative insolubility in water. Students see the contrast between the ability of a carbohydrate, common table sugar, with that of lipids, such as olive oil, to dissolve in a glass of water. The sugar easily goes into solution, while the olive oil does not dissolve readily in water. This familiar example provides a solid reference for the contrasting chemical properties of these two major groups of organic compounds.

With solubility behavior in mind, students can more easily understand the action of lipids in living systems. Graphic diagrams show how lipids play a role in cell membranes to form a barrier that restricts the flow of water soluble compounds. Phospholipids are particularly important in this function, because the phosphate-containing “heads” of these molecules are slightly hydrophilic, or water-loving. The hydrophilic part of these molecules faces toward the outer surfaces of the membrane, while the water-repelling or hydrophobic parts line up in the interior of the membrane. Students also see molecular models of complex lipids such as cholesterol and vitamin E, while they learn about the role of some complex lipids in living systems.

The next segment of the video explores carbohydrates. The students’ attention is called to the contrast in general composition of carbohydrates versus lipids. Carbohydrates contain much more oxygen. Usually the ratio of carbon to oxygen is 1:1 and the ratio of hydrogen to oxygen is 2:1. This point is brought home through the visual impact of a comparison of molecular models of sucrose and vitamin E. In these models, oxygen is represented by red atoms, and the carbohydrate obviously has much more red than the lipid. This early visual reference lets students begin to see the molecular basis for the difference in solubility of these two groups of organic compounds.

## VIDEO SUMMARY (CONTINUED)

Graphic demonstrations show that a simple sugar such as glucose can serve as a monomer in enormous polymer molecules such as starch or glycogen. These simple and complex carbohydrates serve an important function as the short and intermediate term energy supplies for living systems.

Other actions of carbohydrates include structural support in plant cells in the form of the polymer known as cellulose, and cell surface identifiers such as the carbohydrate components of cell membrane lipids and proteins that determine blood type.

The third group of organic compounds to be examined, the proteins, presents some very different features than the large carbohydrate polymers. Graphic demonstrations show the structure of the monomers of proteins, the amino acids. Amino acids contain nitrogen in the generic part of their structure, a key feature for forming the covalent peptide bonds that hold together the primary structure of a protein. Animation of the graphic diagrams shows the formation of a peptide bond in a growing chain of amino acids. Once folded, the chain results in a protein, shown in the video as a striking three-dimensional molecular model. Students are reminded that models such as this one are not just artist's depiction of how a molecule might look. They are instead accurate scientific tools that contain information about the spatial relationships of the many atoms that make up the protein.

The importance of the three-dimensional shape of a protein is made clear as students watch what happens when heat unfolds a protein in egg white: we see this denaturation as the cooking of the egg. Students also learn what proteins do: they act as catalysts (enzymes), as structural components of cells, or they bind and carry essential molecules such as oxygen in the blood.

The action of a particular protein depends on its structure which, in turn, is specified by the sequence of amino acids. This sequence is dictated by the genetic program for this particular protein, and this idea leads the video into the final group of organic compounds, the nucleic acids.

Graphic depictions show the arrangement of monomers in the nucleic acid DNA and illustrate the role of RNA as an intermediate step between the stored genetic information and its expression in the synthesis of a protein. Students also see that the structure of DNA permits the important information in its sequence of monomers to be preserved during replication.

The final part of the video provides a more detailed look at the action of organic compounds by contrasting the role of enzymes versus structural proteins (in this case porin).

The most important feature of the video program *Organic Compounds in Action* is that it builds a conceptual framework into which students can add information about biomolecules as they continue their studies. The first step in this continuation is the experience offered in the written exercises. Neither the video nor the written activities are intended to be encyclopedic. They are, instead, designed to arouse curiosity, overcome barriers of anxiety about the material, and provide a meaningful introduction to the ways in which chemical structure is connected to what organic compounds actually do.

The program intentionally takes a new approach to the order of presentation of the four major groups of compounds found in living systems. In order to emphasize the connection of structure with molecular behavior, this program builds sequentially from the simplest of organic compounds, methane. It shows how bonding builds hydrocarbon chains, which are components of fatty acids and lipids. These, in turn, are largely extensions of the original monomer, methane, and consequently are not very soluble in water. Addition of lots of oxygen to the formula of carbon and hydrogen produces a different group, the water-soluble carbohydrates. And so the theme of structure and behavior is built up logically. For this reason, the order of presentation is:

- lipids
- carbohydrates
- proteins (in which the sequence of monomers begins to matter) and finally
- nucleic acids (the underlying basis for the sequence in proteins).

The written exercises can be used immediately after the video or later, as an assessment or review piece. Some of the written exercises directly review what is presented in the video; others build on that knowledge and make connections to new information, such as reading a product label. Many of the exercises lend themselves to group or cooperative work, or a particular exercise can be used to foster class discussion.

## TEACHER'S NOTES (CONTINUED)

In addition to the actual worksheets, we provide you with comments on potential student responses to each exercise as follows.

### **WORKSHEET 1- NOTES**

Students should be able to mention some key features of each group of organic compounds and to list a variety of biological actions for each one. Effective responses could be relatively simple; for your convenience, we provide a fairly comprehensive sample of responses:

#### **LIPIDS:**

##### **CHEMICAL PROPERTIES**

Mainly composed of carbon and hydrogen; generally hydrophobic (not very water soluble); common structures include fats (made up of glycerol plus fatty acids); phospholipids, (which have one end that is slightly hydrophilic); complex lipids such as the multi-ring structure of cholesterol.

##### **ACTION IN LIVING SYSTEMS**

Lipids provide a rich source of energy storage (in fat tissue). They are major components of cell membranes, and some lipids serve as hormones. Some vitamins are lipids, providing essential nutrition needs. In nerve cells, lipids form electrical insulation that allows these cells to conduct nerve impulses. Lipids in fat tissue provide heat insulation in some animals.

#### **CARBOHYDRATES:**

##### **CHEMICAL PROPERTIES**

Carbohydrates are composed primarily of carbon, hydrogen and oxygen, generally in the following ratios (by number of atoms): carbon to oxygen, 1:1; hydrogen to oxygen, 2:1. This high relative amount of oxygen makes them generally more water soluble (hydrophilic) than lipids. Simple sugars (such as glucose or fructose) can be joined as disaccharides, or simple sugar monomers can make up huge branched-chain carbohydrate polymers, such as starch.

##### **ACTION IN LIVING SYSTEMS**

Carbohydrates such as sugars are short term suppliers of energy. Carbohydrate polymers (starch, glycogen) are intermediate stores of energy. For example, glycogen stored in a muscle is broken down to release the glucose monomers as a supply of energy to an exercising muscle. Some polymers, such as cellulose in plant cells, play a structural role. Carbohydrates bound to membrane lipids or proteins on cell surfaces act as important cell signals.

**PROTEINS:****CHEMICAL PROPERTIES**

Proteins are huge polymers composed of monomers known as amino acids. The amino acids are connected through strong covalent bonds called peptide bonds. The basic structure of amino acids contains four kinds of atoms, carbon, oxygen, hydrogen and nitrogen. The side group can vary. There are twenty different amino acids in proteins. The order of amino acids along the chain is different in different proteins, and this sequence determines how the protein will fold up into an active structure.

**ACTION IN LIVING SYSTEMS**

Some proteins are enzymes—chemical catalysts that make chemical reactions go faster and be more specific. Other proteins serve a structural role, in membranes and in tissues such as muscles and organs.

**NUCLEIC ACIDS:****CHEMICAL PROPERTIES**

Nucleic acids are long polymer chains containing monomers known as nucleotides. Each nucleotide monomer contains five types of atoms: carbon, oxygen, hydrogen, nitrogen and phosphorus. Each monomer is made up of a five-carbon sugar (ribose in RNA or deoxyribose in DNA), covalently bonded to the next monomer through a phosphate group. This makes up the backbone of the nucleic acid. Each monomer also contains a nitrogenous base, and the order of bases is the basis for genetic information. DNA contains four bases, adenine (A), guanine (G), thymine (T), and cytosine (C). In RNA, uracil (U) occurs instead of thymine. Two nucleic acid strands can be connected through a series of weak hydrogen bonds between the bases of each strand. Specific pairing occurs: A with T or U and C with G.

**ACTION IN LIVING SYSTEMS**

The main role of nucleic acids is to provide a genetic program for a living system, both for making copies (in offspring) and for producing proteins or special RNA molecules for maintenance of cell functions. For example, the genetic information stored in DNA indicates the order of amino acids in a protein; an RNA copy is made as an intermediate step.

## TEACHER'S NOTES (CONTINUED)

### WORKSHEET 2- NOTES

The purpose of this exercise is for students to review the importance of carbon in building organic compounds.

**Organic compound:** A compound containing carbon; organic compounds are found in living systems although they can be made in the laboratory, too.

**Properties that make carbon useful in living systems:** Carbon forms strong (covalent) stable bonds with as many as four other atoms, making it useful to form a variety of small compounds or to connect many small compounds into giant polymers. Carbon in organic compounds is bonded to a variety of other atoms.

**“Not every molecule in a living system is an organic compound.”** This statement is correct according to the definition of organic compounds as compounds containing carbon. For instance, water is a major component of living systems but is not “organic”.

### WORKSHEET 3- NOTES

Students should recognize that organic compounds behave according to the same principles as inorganic compounds. Organic compounds do not contain a vital force (in other words, vitalism is not a valid theory). The idea of a vital force was dropped when scientists demonstrated several examples of organic compounds that could be synthesized in the laboratory (such as urea, ammonium cyanate and acetic acid.) The specific dates and compounds are less important than the underlying concept. Scientific theories change in the face of multiple lines of scientifically reliable new evidence that show them to be incorrect.

### WORKSHEET 4- NOTES

Sucrose contains much more oxygen relative to the number of carbon atoms than does vitamin E. The many -OH groups form hydrogen bonds with atoms of the solvent, water, making the sucrose soluble.

### WORKSHEET 5- NOTES

Polymers are huge molecules made up of repeating smaller molecules called monomers that are identical or similar.

In the human diet, starch is a useful source of energy in that it can be broken down to glucose, which is in turn metabolized. Because we lack the enzyme necessary to digest cellulose, this polymer provides fiber in our diets.

**WORKSHEET 6- NOTES**

This activity gives students a chance to connect what they have learned to familiar topics in daily life and to use evidence to support their statements.

Have students work in teams of four. They can bring in package labels listing nutrition facts, or you can supply examples that you choose. Students should compare the difference in relative nutritional value and caloric value of different processed foods, noting the now familiar groups of organic compounds present, such as fats (lipids) carbohydrates and protein. It should be evident that fats are higher in caloric value per gram than are carbohydrates and thus provide a rich energy source. Students will also see listings for fiber (which is essentially an indication of cellulose, a complex plant carbohydrate that is indigestible by humans) and vitamins.

**WORKSHEET 7- NOTES**

You may want to supply news articles that mention the transfer of genes from one organism to another. This technology involves molecular cloning in which DNA that encodes a useful protein is copied or synthesized, attached to a vector and transported into foreign cells in order to express the protein in the new environment. A protein produced in this way often is called a "transgenic" protein.

**WORKSHEET 8- NOTES**

Students need not list the specific name, just the group with which the compound is associated, along with some explanation of the features that identified each compound.

- ▶ lipid (stearic acid, a fatty acid that is a component of lipids) -- identified by the long hydrocarbon chain and the end carboxyl group
- ▶ carbohydrate (glucose, a simple sugar) --- identified by the ring structure and the ratio of carbon to oxygen and hydrogen to oxygen
- ▶ lipid (methane, a monomer of fatty acids) --- identified by the presence of carbon and hydrogen only
- ▶ protein (two amino acids joined by a peptide bond) --- identified by the presence of carbon, hydrogen, oxygen and nitrogen and by the distinctive peptide bond, the basis for connecting amino acid monomers together to form a protein polymer
- ▶ nucleic acid (a nucleotide, a monomer from which RNA is built) - identified by the presence of five types of atoms, C, H, O, N, P and by the distinctive combination of a five-carbon ribose sugar, phosphate and nitrogen-containing base.

## TEACHER'S NOTES (CONTINUED)

### WORKSHEET 9- NOTES

Student diagrams should show how lipids form a bilayer membrane with a hydrophobic interior that acts as a barrier to the water-based contents of a cell.

### WORKSHEET 10- NOTES

The most likely example of a double bond from the video is the  $C=O$  seen in carboxyl group of a fatty acid or of an amino acid.

Ethane and ethylene have the same number of carbon atoms, but in ethane the two carbons are bonded through single  $C-C$  bonds, while in ethylene they are connected through a double bond,  $C=C$ .

### WORKSHEET 11- NOTES

Students need not draw a detailed structure with every atom but they should be able to show in their diagram that fatty acids bond at the positions of all three carbon atoms in glycerol through the carboxyl group of the fatty acids, leaving the hydrocarbon chain extending away from the backbone.

### WORKSHEET 12- NOTES

When comparing two fatty acids of equal number of carbon atoms in the hydrocarbon chain, the saturated one should have the most hydrogen atoms because each carbon atom is bonded to the maximum possible number of hydrogen atoms.

Butter is higher in saturated fats than are cooking oils from plant sources. This difference in saturation effects the temperature at which these compounds melt, so butter is solid at room temperature but olive oil is not

Some heart patients avoid meat and dairy products to reduce their intake of saturated fats.

### WORKSHEET 13- NOTES

Covalent bonds connect the monomers of a nucleic acid together in a specific sequence to form a strand of DNA or RNA. The sequence of monomers is important because it is the basis for storing genetic information in the structure of a nucleic acid. Hydrogen bonds pair bases of two different strands. This structure is important because it makes it possible to use one strand as a template (pattern) to copy an exact sequence of bases in a new strand being made. This situation is true for replication of a DNA molecule or for making an RNA copy from DNA.

**WORKSHEET 14- NOTES**

An enzyme is a protein that serves as a catalyst in chemical reactions in living systems. The peptide chain that makes up trypsin needs to fold into the appropriate globular structure for it to be active. Trypsin is found in the small intestine because it helps with the digestion of proteins in the diet. Because the enzyme trypsin is itself a protein, it needs to cut only at specific amino acid positions so that it can distinguish other peptides from its own peptide chain and not completely digest itself.

**WORKSHEET 15- NOTES**

Student diagrams should reflect the presentation in the last section of the video. In particular, students should demonstrate that they understand that specificity of enzyme action depends on the substrate fitting exactly to the active site of the enzyme, whether that happens prior to binding (lock-and-key) or the enzyme alters shape to fit (induced fit).

**WORKSHEET 16- NOTES**

RNA and protein both are polymers in which monomers are linked by covalent bonds in a specific sequence. The primary sequence of monomers determines the final three-dimensional structure and function of both organic compounds. Similar to a protein (enzyme), an RNA molecule can be a catalyst. Other RNA molecules store and transmit genetic information, a function that proteins do not carry out.

**WORKSHEET 17- NOTES**

Student responses will vary. Models are useful because they enable scientists to carry out experiments or observe complex systems with many variables. This characteristic is particularly true of computer or mathematical models. Physical models give scientists a way to study or visualize spatial relationships or to communicate ideas to other scientists. Anatomical models are examples of physical models.

**WORKSHEET 18- NOTES**

Encourage students to make a connection between the principles they learned in the video and the organic compounds they chose as the star of their reports.

Researching the topics easily may be divided among members of a team, and the reports can be made as speeches, written articles, tapes, and so on.

You may find useful examples and entertaining reading in a book by University of Cambridge science writer John Emsley, *Molecules at an Exhibition*, published in 1998 by Oxford University Press.

## TEACHER'S NOTES (CONTINUED)

With regard to the examples given on the student worksheet, keep in mind these issues:

- ▶ Caffeine is added to cola drinks, but it occurs naturally in tea and coffee.
- ▶ Oil spills demonstrate the insolubility of oil in water.
- ▶ Carbon dating depends on the presence of a radioactive isotope of carbon, and organic compounds contain carbon.
- ▶ Nicotine does occur naturally in tobacco. Here is an opportunity to think about the fact that “natural” and “healthy” are not synonymous.
- ▶ Ethylene is a plant hormone that can cause leaves to drop from plants. It also occurs in gas leaks.
- ▶ Plastics are manmade polymers that use petroleum products as starting material. There is a limited supply of petroleum (fossil fuels). Perhaps the plastics industry could shift to a renewable resource: alcohol. Plastics are not degraded by the enzymes found in decomposer bacteria, although cellulose is degraded. As a result, plastics present a problem in land fills.
- ▶ Nitrocellulose cloth was the 1884 substitute for silk, and it is flammable. Cotton is a natural cellulose fiber, while rayon and tencel are synthesized industrially using cellulose.

# **STUDENT WORKSHEETS**

**CLASSIFYING ORGANIC COMPOUNDS**

In the video you saw four major groups of organic compounds that are important in living systems: lipids, carbohydrates, proteins and nucleic acids. In the chart below, describe in words or diagrams some of the key chemical features that distinguish each group and indicate what organic compounds in each group do in living systems.

|                            | <b>CHEMICAL<br/>PROPERTIES</b> | <b>ACTION IN<br/>LIVING SYSTEMS</b> |
|----------------------------|--------------------------------|-------------------------------------|
| <b>LIPIDS</b>              |                                |                                     |
| <b>CARBO-<br/>HYDRATES</b> |                                |                                     |
| <b>PROTEINS</b>            |                                |                                     |
| <b>NUCLEIC<br/>ACIDS</b>   |                                |                                     |

**GENERAL KNOWLEDGE OF ORGANIC COMPOUNDS**

What are your responses to these topics?

Define “organic compound”.

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Explain what properties make organic compounds particularly useful in living systems:

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Discuss whether or not this statement is correct: “Not every molecule in a living system is an organic compound.”

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**POLYMERS AND MONOMERS**

Define these terms:

polymer: \_\_\_\_\_

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monomer: \_\_\_\_\_

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Starch is a huge polymer of glucose molecules made by plant cells. To which major group of organic compounds does it belong?

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Another huge plant polymer containing glucose is called cellulose, which consists of long, unbranched chains. Although it contains the same monomers as starch, the bonds between monomers are slightly different. Humans have digestive enzymes that can break apart starch into its component glucose molecules, but humans cannot digest cellulose because they lack the enzymes necessary to release bonds that connect the glucose molecules.

Explain the different actions that these two polymers have as part of the human diet.

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**ORGANIC COMPOUNDS IN FOOD LABELS**

According to your teacher's instructions find the labels for four different processed foods. Compare the relative amounts of the organic compounds (such as carbohydrates, protein, fats) in the different foods. List the four foods you selected and use the nutrition data from the labels to support your answers to the following questions:

Which of your samples supplies the most protein per serving? How much is present (in grams/serving?) \_\_\_\_\_

\_\_\_\_\_

Which of your samples has the highest fat content per serving? How much is present (in grams/serving?) \_\_\_\_\_

\_\_\_\_\_

Which of your samples has the highest carbohydrate content per serving? How much is present (in grams/serving?) \_\_\_\_\_

\_\_\_\_\_

Which of your samples supplies the most calories per serving?

\_\_\_\_\_

\_\_\_\_\_

Which do you think has a higher caloric value per serving, fats or carbohydrates (sugars and starch)? Give evidence for your answer.

\_\_\_\_\_

\_\_\_\_\_

Notice the fiber content in your food samples if it is listed. From what major group of organic compounds does fiber come? Is it more likely to be high in foods from plants or animals? Why? \_\_\_\_\_

\_\_\_\_\_

What other patterns do you notice in the nutrition content of your particular food samples? \_\_\_\_\_

\_\_\_\_\_



# IDENTIFYING ORGANIC COMPOUNDS

For each of the following compounds, write the name by the correct structure and identify the major group of organic compounds to which each molecule belongs. For each molecule, describe the features that helped you make your decision.

1. stearic acid

\_\_\_\_\_

2. glucose

\_\_\_\_\_

3. methane

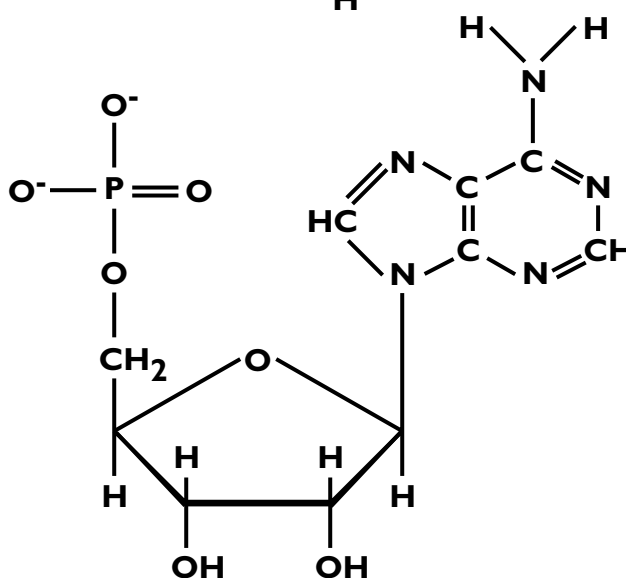
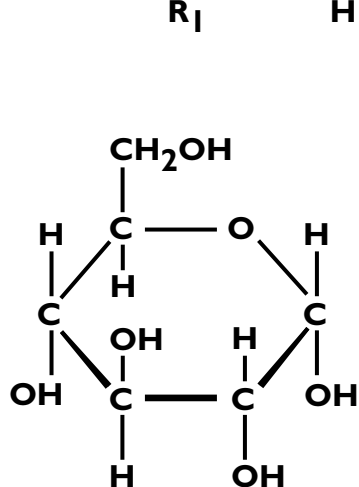
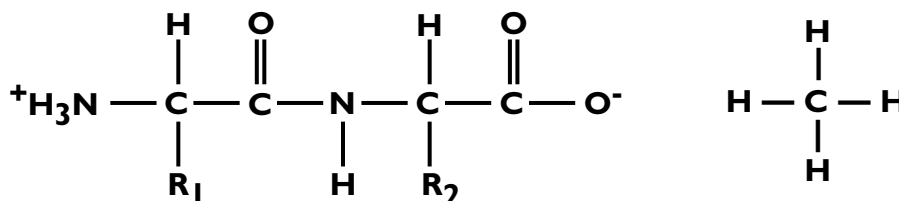
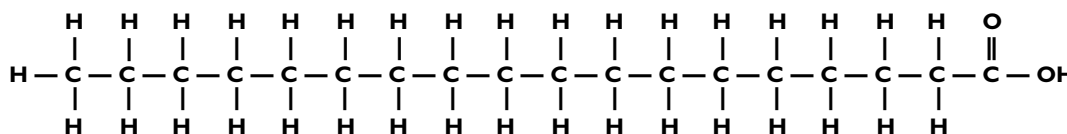
\_\_\_\_\_

4. two generic amino acids with a peptide bond

\_\_\_\_\_

5. a nucleotide

\_\_\_\_\_



**LIPIDS IN CELL MEMBRANES**

Lipids contain long hydrocarbon chains that are hydrophobic (water insoluble). Phospholipids have a slightly hydrophilic (water-soluble) phosphate in one part of the compound in addition to the hydrophobic chains. Draw a diagram to show how this aspect of lipid structure makes lipids useful in forming cell membranes. Write a sentence or two as a legend to explain your diagram.

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## SINGLE AND DOUBLE BONDS

Background: Carbon atoms can form single or double bonds with certain other atoms. For example, carbon can bind to another carbon atom either through a single covalent bond or a double covalent bond:

|             |       |
|-------------|-------|
| Single Bond | $C-C$ |
| Double Bond | $C=C$ |

In the video you saw a double bond between carbon and a different atom. To what other atom have you seen a double bond? What organic compound was it in?

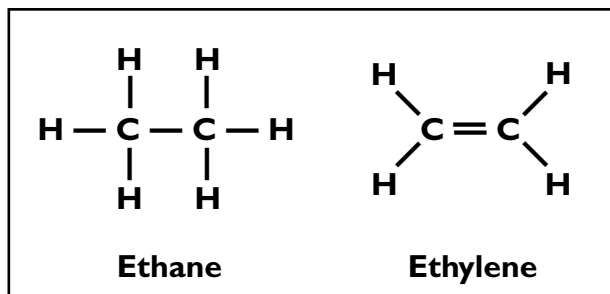
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Compare the organic compounds shown in Figure X, ethane and ethylene. Ethane was shown in the video. Ethylene is produced by fruits to speed the ripening process.

**Figure X:**



In what way is the structure of these organic compounds similar?

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In what way do they differ?

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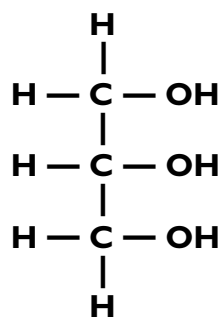


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**DIAGRAM OF A LIPID**

A fat (lipid) containing three fatty acids and glycerol is called a triacylglycerol.

This molecule is glycerol:



**Glycerol**

Draw a diagram to explain how it serves as a backbone for a triacylglycerol.

**SATURATED AND UNSATURATED FATS**

Background: Fatty acid components of lipids can have all the carbons bonded together through single covalent bonds or in some cases one or more double bonds occur. Special terms are used to mark this distinction:

- ▶ **Saturated fat:** lipid in which all the carbon atoms of the fatty acids are bonded to one another by single C—C bonds down the chain.
- ▶ **Unsaturated fat:** lipid in which one or more pairs of carbon atoms in the fatty acid components are connected through double C=C bonds.
- ▶ If the fat has more than one double bond, the fat is said to be polyunsaturated.

Answer this question, justifying your reasoning: If two fatty acids contain the same number of atoms in the hydrocarbon chain, but one fatty acid is unsaturated and the other is saturated, which molecule will have more hydrogen atoms? Explain your answer.

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Background: Some medical studies show evidence to support the idea that a diet rich in saturated fats can increase the risk of heart disease for most people. Unsaturated fats in the diet apparently result in less risk than saturated fats do. Consult the nutrition information for these two lipids: butter and cooking oil (corn oil, olive oil, canola oil or some other vegetable oil). Keep in mind that butter is made from milk, which comes from animals.

Which is higher in saturated fats, butter or cooking oil? Give evidence to support your answer.

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In what important physical property do butter and cooking oil differ at room temperature?

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Why do you think some heart patients reduce the amount of meat, and other animal products in their diets or become vegetarians?

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**DIAGRAMMING AN ENZYME**

The way an enzyme interacts with its substrate is important to its action. Draw diagrams to show the difference in the induced fit model and the lock-and-key model for enzyme action.





## EXTENDED PROJECT

### **Profile:** *Organic Compounds and Society*

Adopt the role of a journalist and report on an organic compound that has a significant impact on society. You may select your compound from examples in the news or use the following statements to give you an idea.

You will need to collect information from other sources. Use it to write an article or make a presentation. Identify the source of your information. Describe the structure of the organic compound, account for its source and indicate its importance to society.

Here are some statements that might give you an idea, or choose an organic compound that you find on your own.

- Caffeine is found in a variety of popular beverages. For example the approximate amount of caffeine in a cup of coffee, tea or cola is compared in this table:

| Cup of beverage | mg of caffeine |
|-----------------|----------------|
| Cola            | 40             |
| Tea             | 40             |
| Coffee          | 80             |

Based on information in John Emsley, *Molecules at an Exhibition*, published in 1998 by Oxford University Press.

- What effect does caffeine have on the body? Compare the source of caffeine in the popular beverages listed in the table. What is the chemical structure of caffeine?
- Oil spills on the ocean remain intact for long periods of time, endangering wildlife. Why are they persistent? Why could they be a hazard for ocean life? What chemicals are involved in an oil spill?
- In an archeological dig, scientists often rely on a technique known as carbon dating to determine the age of the things they study. What does this technique have to do with organic compounds? How does it work and for what types of determinations is it useful?
- Nicotine is an addictive chemical found in cigarette smoke. Is it “natural”? What health risks does nicotine pose? What other compounds in the smoke pose a risk? Why do people smoke when they know it will damage their bodies?
- Explain this puzzle: Trees along the streets of a city suddenly dropped their leaves in summer, long before the normal leaf fall in autumn. The cause was found to be a leaking gas main. What is the connection?
- Some people oppose the use of plastics because they cause problems in land fill sites and because the world has a limited amount of petroleum. Explain the connection between plastics and petroleum and why plastics behave differently than paper containers in a land fill site.
- A substitute for expensive silk cloth was first made in 1884. It felt silky, but it had a problem: it tended to burst into flames. Clothing can be made from many fibers, such as cotton, rayon, or tencel. Some are natural polymers and some are synthesized industrially. What do these fibers have in common? How are they different? What are their relative advantages and disadvantages?

## GLOSSARY

**AMINO ACID:** One of the nitrogen-containing subunits (monomers) from which protein (a polymer) is formed. Amino acids are covalently linked in the primary structure of a protein in a particular order specified by genetic information. There are twenty different amino acids that commonly comprise proteins.

**CARBOHYDRATE:** Organic molecules composed of carbon, hydrogen and oxygen such that the ratio of carbon to oxygen generally is 1:1 and the ratio of hydrogen to oxygen generally is 2:1. Carbohydrates such as table sugar (sucrose) or glucose are readily soluble in water.

**CARBON:** The defining type of atom found in organic compounds. Carbon is well suited to this role because it forms stable covalent bonds with up to four other atoms.

**CATALYST:** A substance that makes a chemical reaction go faster or be more likely to take place. The catalyst is not itself consumed in the reaction.

**CELLULOSE:** A huge, straight chain polymer of glucose found in plants. The nature of the bonds between glucose monomers make cellulose indigestible by humans, thus forming the fiber in our diets.

**CHOLESTEROL:** A complex, multi-ring lipid that is an example of a steroid. Cholesterol is an important component of animal cell membranes, and it provides the raw material for sex hormones in animals such as humans.

**COVALENT:** This term refers to a type of chemical bond that is strong and stable through the sharing of electrons between the bonded atoms.

**DEOXYRIBOSE:** The five-carbon sugar that is found in DNA (see deoxyribose nucleic acid).

**DEOXYRIBOSE NUCLEIC ACID:** DNA, a huge polymer made of repeating subunits (monomers) known as nucleotides.

**DISACCHARIDE:** A carbohydrate that consists of two simple sugar molecules bound together. Sucrose is an example of a disaccharide containing glucose and fructose.

**ENZYME:** A protein that behaves as a catalyst.

**FAT:** Lipid consisting of fatty acids esterified to a glycerol backbone, as found in adipose tissue of the human body.

**FATTY ACID:** An organic compound that consists of a hydrocarbon chain with a carboxyl group at the end of the molecule.

**GLOSSARY**

**GLUCOSE:** A six-carbon carbohydrate that occurs alone or as a monomer in disaccharides (such as sucrose) or polymer (such as starch, glycogen and cellulose).

**GLYCINE:** An example of an amino acid. Glycine is the simplest amino acid, with hydrogen as the side group.

**GLYCOGEN:** A huge, branched organic compound that is a carbohydrate. Glycogen is a polymer built from glucose monomers. Glycogen occurs in animal tissue such as liver and muscle as an intermediate term storage form for chemical energy.

**HYDROGEN BOND:** A weak bonding association between hydrogen and an electronegative atom. The hydrogen is covalently bonded to some other atom yet forms this weak hydrogen bond with a second atom. Although a single hydrogen bond is weak, a large number of hydrogen bonds such as those found in a protein molecule or within a solution of water can be quite significant when taken collectively.

**HYDROPHILIC:** Refers to the property of attraction to water -- that is, being soluble in water.

**HYDROPHOBIC:** Refers to the property of repelling water -- that is, being insoluble in water.

**LIPID:** Member of group of organic compounds found in living systems and which are largely insoluble in water. Fats, phospholipids and steroids are examples of lipids.

**MONOMER:** A small subunit that is repeated many times in a large molecule known as a polymer.

**MONOSACCHARIDE:** A single, simple sugar molecule such as glucose.

**NITROGENOUS BASE:** The ring-like chemical group that distinguishes different nucleotides as the monomers of nucleic acids. DNA contains nitrogenous bases known as thymine, guanine, cytosine, and adenine. RNA contains uracil instead of thymine.

**NUCLEIC ACID:** Member of a major group of organic compounds that are large polymers made up of nucleotides. DNA and RNA are nucleic acids.

**NUCLEOTIDE:** The monomer component of a nucleic acid.

**GLOSSARY**

**ORGANIC COMPOUND:** Strictly speaking, an organic compound is one containing carbon. Historically organic compounds were thought to be produced only by living systems (although that view now is known to be incorrect) so some people reserve the term for carbon compounds found in living systems.

**PEPTIDE BOND:** A covalent bond between two amino acids. Peptide bonds form the primary structure of a protein, in which the sequence of amino acids is built as a long peptide chain.

**PHOSPHOLIPID:** A lipid that contains phosphate near one end such that one end is slightly hydrophilic while most of the molecule is hydrophobic. This dual behavior makes phospholipids useful in forming membranes.

**POLYMER:** A large molecule made up of repeating smaller units known as monomers.

**POLYSACCHARIDE:** Complex sugar polymer consisting of many small sugar components. Starch is a polysaccharide.

**PORIN:** A class of proteins that line pores in the outer membranes of mitochondria and Gram negative bacteria.

**PROTEIN:** Member of a major group of organic compounds which are large polymers made up of monomers known as amino acids.

**RIBOSE:** A carbohydrate that is a five-carbon sugar. Ribose is a component of nucleotides found in RNA, while the related sugar deoxyribose is found in the nucleotides that comprise DNA.

**STARCH:** A naturally occurring, branched-chain polymer of glucose that is found in plant cells. Starch provides a way for plant cells to store energy. We can digest starch, and it is an important part of our diets.

**STEARIC ACID:** An 18-carbon fatty acid that is a common component of lipids.

**SUCROSE:** A disaccharide, or double sugar, which contains glucose and fructose.

**TRYPSIN:** A large protein that serves as a digestive enzyme, degrading other proteins.

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**GUIDE TO  
USING WEBLAB  
VIEWERLITE  
SOFTWARE ON  
CD-ROM**

## INTRODUCTION

### **Molecular Samples: WebLab ViewerLite Software on CD-ROM**

**Note:** *This CD-ROM contains a professional tool. It is not an educational game or step-by-step simulation.*

The CD-ROM does not contain student exercises. You likely will want to use the suggestions provided in this written material to help you decide how to use the molecular models on the CD-ROM.

**Purpose of the CD-ROM:** The CD provides an opportunity for you and for your students to explore further the structure of sample molecules. It also provides you and your students with a quick glimpse at some of the tools used by professional chemists.

The HRM video program titled *Organic Compounds in Action* displays several 3-dimensional computer models of organic compounds. The models used for these video sequences were supplied as a courtesy by Molecular Simulations Inc. (MSI) a software company which designs and sells computer programs that simulate chemical reactions. MSI has made available a free version of one of their professional software tools and a sample of 3-D molecular models for your observation. These complex models are dramatic visually, and they engage student interest particularly well because the models can be manipulated by the students themselves.

The viewing software and 3-D molecular models are provided as a courtesy of MSI on the CD-ROM distributed free of charge by HRM along with your video program.

#### **Restrictions to the use and distribution of the material on the CD-ROM:**

The molecular models and WebLab ViewerLite software are provided free of charge through permission of Molecular Simulations Inc. **You have permission to use the software and models for educational purposes as described in the license agreement displayed as you install the software.** You must accept this license agreement in order to use the material. Specifically, you are not permitted to reproduce this software or the models or derivatives thereof for commercial use.

**Note:** *This mini-guide is a suggested exercise series. It is not a comprehensive user manual for the molecular viewing software on the CD-ROM.*

There are many aspects of the molecular model software that are not explained in this mini-guide. The collection of sample molecular models is far greater in size than the examples addressed in the suggested exercises.

**Use of the CD-ROM:** The CD contains the software needed to view and manipulate the molecular models designed by MSI. *There are no step-by-step exercises included on the CD.* In order to help you think of ways to engage students with the molecular models, HRM has developed this mini-guide to the use of the CD-ROM.

This complementary mini-guide is provided by HRM to give you an introduction to your options for manipulating the models. This guide also provides a variety of student exercises that focus on organic compounds. Some of these exercises draw directly on information described in the video. Others require that students make connections to outside material, such as concepts and facts from their textbook or lecture.

**Intended audience for the exercises:** The suggested exercises can be used with three different groups of students. You may want to let the more advanced learners work independently with the exercises and the models while you focus attention on teaching mainstream material to the remainder of the class. Alternatively, you may find certain simple exercises in the guide useful to give the slower students extra practice with basic concepts. Or the CD-ROM can be used as a general extension to the student worksheets provided in the Teacher's Resource Guide for the video.

**Educational opportunities:** The suggested exercises included in this mini-guide provide a specific set of experiences that target some key concepts associated with the study of organic compounds. The learning opportunities with the molecular models supplied on the CD-ROM, however, are open-ended.

Keep in mind that simply viewing and manipulating the molecular models gives students a rich, visually based experience that encourages learning through channels other than reading or listening to lecture. Even if students "play" with the models just for the fun of watching them move, some visual reinforcement about molecular structure takes place. Obviously, students learn much more when they have a specific task or goal of their own, such as those built into the student exercises in this guide, and then spend time with the computer models to meet that goal.

You may need to remind students that molecular models accurately display some important characteristics of molecules but they are not "what the molecules look like". We cannot "look" directly at a molecule and see sticks and balls in convenient colors, but the representation in the model accurately displays the spatial relationship of atoms and reminds of the way in which the atoms are bonded together. Student Worksheet 1 is particularly useful in helping students realize the distinction between a scientifically accurate model and a "picture" of a molecule.

## INTRODUCTION (CONTINUED)

**About molecular modeling and MSI:** The models on this CD-ROM are far more than an artist's conception of how molecules would appear if we could see them. *The samples provided by MSI\* reflect the accurate three dimensional geometry of the molecules.*

Computer modeling is a powerful scientific research tool, not only to depict structures but also to simulate complex systems. Computer models enable scientists to conduct careful experiments in systems with many variables, systems in which variables might be impossible to control in the real world. Your students may be surprised to learn that scientific models go far beyond the traditional static models such as plastic representations of skeletal structure.

The WebLab ViewerLite software is a limited version of a professional tool. It is used to view and manipulate pre-existing models, supplied here through courtesy of MSI. If you want to learn more about molecular modeling software, you can visit the MSI website at [http:// www.msi.com](http://www.msi.com).

**Description of the contents of the CD-ROM:** The CD-ROM contains software that allows you to view and manipulate a collection of molecular models also provided on the disc. The software is called WebLab ViewerLite3.1 and is found on the CD-ROM under the name **WLViewerlite31.exe**. You must install this software in order to view the models.

The molecular models are provided on the CD-ROM in a directory called "**Samples.**" Once you have the WebLab ViewerLite software installed, you can open the Samples directory and select 3-D molecular models from a variety listed under ten different topics.

\* Molecular Simulations Inc., a subsidiary of Pharmacopeia, Inc., is a provider of molecular modeling, simulation, and informatics. Using MSI's software, researchers organize and analyze scientific data, share biological and chemical information, and develop novel compounds, materials, and processes.

### MECHANICS:

#### **To install WebLab ViewerLite 3.1 software on Windows 95 or NT:**

Put the CD-ROM in your machine and select (double click) the file "WLViewerlite31.exe". Follow the onscreen instructions to install. For example, your first installation step will be to select (single click) on "set-up" from the menu choices. Remember that selecting "cancel" will cause you to exit installation at any point. Choosing "next" moves you through the installation steps. You will be asked where you want to install the software, so you may want to have a computer location in mind. For example, you could insert a link to the WebLab ViewerLite3.1 software under "Programs" in your computer's general menu (accessed in Windows 95 from the "Start-up" icon).

**To view 3-D molecular models:** Your selection of models is listed in the folder called "Samples." Once the WebLab ViewerLite software is installed and selected, you can view models by opening this folder (double click on "Samples" on the CD-ROM) and selecting the molecule you want. Molecules are listed in these ten categories:

- |                    |                    |
|--------------------|--------------------|
| ➤ DNA              | ➤ Natural Products |
| ➤ Environmental    | ➤ Petroleum        |
| ➤ Fragments        | ➤ Pharmaceuticals  |
| ➤ General Interest | ➤ Proteins         |
| ➤ Inorganics       | ➤ Small Molecules  |
| ➤ Materials        |                    |

For example, try opening the category "Petroleum" and then from the list displayed in this category, open "Methane." You will have the chance to view and manipulate this molecule using the installed software.

When you want to move on to another molecule, you can minimize (or iconify) the window holding the molecule and work on it later. If you exit from the WebLab Viewer, you can save the file by specifying a filename, or you can answer "no" to the query about saving changes in order to keep the original model as delivered.

**Note:** *If you save the current version of methane to a location other than the "Samples" directory (by specifying a new location) you will retain the original version in the "Samples" file for future use.*

*In order to keep an original version of the molecular models for consistency and for convenience of use, we recommend that you make a copy of the "Samples" folder on your hard disc. That way, you can simply open this copy folder and click on the model you wish to view. The installed viewer software will automatically access the model and let you move and display it as you choose.*

## SELECTED COMMANDS TO VIEW MODELS

We recommend that you learn to manipulate models mainly through trial-and-error. On-screen help can be found under the menu item called “Help”. You don’t need to be well versed in all commands in order to do any viewing. You can add to your expertise a little at a time.

One convenient way to familiarize yourself with how to manipulate the models is to do Student Exercise 1. It not only focuses on some important chemical concepts, it also demonstrates some basic commands in the modeling software.

Worried that you might make an error? Don’t worry! You have an “undo” command under the menu item “Edit” plus an “undo” icon.

The following descriptions will give you a shortcut to some of the most important features of the software for the educational exercises provided in this guide. The descriptions will be more helpful if you read them and try out a few commands as you go.

**Hints for manipulating models:** As indicated earlier, the software contains far more options for adjusting and displaying the models than are covered in the student exercises. By exploring the software in a leisurely way on your own, you likely will discover many specific tasks that you would like to have students experience. To expedite your exploration, here are a few hints about manipulating and viewing the models:

- **Side bar icons:** Notice the selection of side bar icons on the left side of your screen. You can let your cursor sit still on the icon and an explanatory caption will appear.

For example, the top icon, an arrow, lets you **select** all or part of a molecule. When you click this icon, your cursor becomes a tool to select the part of the model of interest. When you put the cursor on a part of the molecule, single click and hold down the mouse button, you can drag open a box to enclose the part (or all) of the molecule you wish to select. The selected region becomes yellow when you release the mouse button. The purpose of selecting part of a molecule is to highlight it to call attention, to choose it as the target of some manipulation such as adding a label to the atoms, or to copy it. When you again click the mouse button anywhere, the selection will be undone.

**Rotation** is another side bar icon. After you click this icon button, your cursor will appear as an arrow with a curved line. The cursor becomes your rotation tool. Click down, hold and drag your cursor anywhere on the screen. The molecule will rotate.

**Hint:** *make small movements initially until you get used to the way the rotation tool causes the molecule to move.*

Another icon button will **translate** the model across the screen. Try it, and the use of this tool will become immediately apparent. A very useful tool is the **zoom**, represented by a side bar icon button with an up/down arrow. When you click on this icon, your cursor becomes a tool to increase or decrease the size of the model on your screen.

- **Top bar icons:** The icons across the top of your screen are your top tool bar. If they are not displayed, pull down menu item “View” and select “Tool bar” from the list. Several of these icons may be familiar to you, such as the “undo” “redo” arrow buttons or the print button.

A particularly useful icon is the small CPK-type molecule icon to the right end of the tool bar. Click this button, and you have choices about the **display style**. “Display style” also is a menu item under “View.”

You can have some fun with the display style, and the choices offer a good learning tool for students to think about why there are different ways to display molecular structure, rather than simply accepting everything as fixed. The display style used in the video is ball-and-stick. The default style for the models is line. Another interesting style is the CPK style.

Try opening the display style card by clicking on the icon in the tool bar, then choose a new style by clicking in the circle next to the choice. Next you must either click on “Apply” and manually close the display card or click on “OK” and the application will be made automatically. To reverse your choice, click on the “undo” button in the top tool bar, or reopen the display card and make another selection.

- **Top Menu Selections:** You will recognize the options under “File” and “Edit” from other programs. Some particularly helpful options specific for the manipulation of molecules are found under some of the other menu items.

- ◆ The menu item “**View**”: Click and drag down the menu item “View.”

You will find one choice is display style, which we already have described. Another useful option under “View” is called Spin. Click on the spin option and you will have the fun of seeing the model rotate on its own. Note that when spin is selected, a small check mark appears next to the choice. Click again on this option to stop the spinning.

The menu item under the “View” menu called **Tool Bar** lets you display or hide the tool bar, tool palette and status bar. Do not confuse this choice with the larger menu item called “Tools.” A check mark indicates which items are on display.

## USING VIEWERLITE (CONTINUED)

A group of useful functions can be found under the “View” menu choice called **Options**. Open this panel of options and try several. You can adjust the quality of graphics to low, medium or high. High will give you the sharpest image, but it is slower. You can click to move the apparent light source that shines on the atoms. This light source is particularly effective for the ball-and-stick display style. Try some choices and see what appeals to you. Another useful selection on the option card can change the background color. Black is particularly dramatic to show off the models; however, if you plan to print a hard copy of a molecule, a choice of white for the background will save a lot of ink on your print cartridge! Simply click on the background color block and make your new selection.

As in other situations, keep in mind that you must either “apply” your new choices or choose “OK.” If you simply close a panel after making your selection, the choice you made will not be applied to your model.

A couple of hints to avoid difficulties: If full screen mode is selected, you should see a very small window in the lower right corner of your screen. This window contains a button that allows you to return to a display that includes your tool bars and icons. If the toggle is missing, hit the F2 key on your keyboard to make the menus and toolbars visible again.

If someone should accidentally select the color option and thereby display all atoms as the same color in your model, you can reverse this step and go back to color-coding of atoms either by using the “Undo” icon button or, later, by pulling down the menu item “Tools”, selecting “Elemental Properties” and closing without applying or changing them. This step resets the color coding on your display.

- ◆ The menu item “**Tools**”: When you drag down the top menu item called “Tools” you are given several helpful choices for changing the aspects of the molecule that are displayed. **Hydrogens** allows you to display or to *suppress* the hydrogen atoms. Organic compounds have so many hydrogens that it can be difficult to see other aspects of structure. For example, in a very complicated molecule such as a protein, it may be instructive to suppress display of the hydrogens to reduce the clutter and allow the viewer to see other details of the molecular structure. As with other options, you can elect to add or to remove the hydrogens; your choice is not permanent.

Another item under “Tools” is **Labels**. This selection is particularly good to use with students. If you click on this option and select “add” you will see written labels to identify atoms appear in your model. We recommend the default condition be to remove labels because they are distracting, but you will see steps in the student exercises that call for limited use of the labels as a teaching tool.

A fun selection under “Tools” is called **Surfaces**. Try it and see what happens! You can change the surface by using the Display Style panel.

A particularly important choice under “Tools” is the item called **Elemental Properties**. This choice displays a color-coded periodic chart of elements. We suggest that you do not alter the color codes in order to keep consistent with what students have viewed in the video program. However, if you need to check on what element is represented by what color, this is a good reference. (You can also do this by using the side bar “select” icon, selecting the atom of interest, and then using the add labels option under the “Tools” menu item described here.)

**Choices about saving work:** The experience of viewing and manipulating 3-D molecular models is a powerful learning tool even if the changes made to the models are transient. You may, however, want to consider saving the results of students’ work. One option is to have the students choose “save to” a file location or floppy disk when they exit a particular model. (You exit by clicking on the small x in the upper right corner of the open window.)

Another option is to print a final version of a molecule and then exit without saving changes. This step can be used for several purposes, such as to check a student’s identification of a particular feature on a molecule (see student exercises). We recommend that you do not have students automatically save changes back to your master file of molecular samples.

## LEARNING OBJECTIVES

### STUDENT EXERCISES

**Classroom Management:** The particular choices for how to set up assignments will depend on the availability of computers, class size, and the purpose for which you are using the molecular models. The exercises provided here lend themselves well to teamwork, but they are not written specifically for teams in order to give you full flexibility.

As mentioned before, the exercises provide focused tasks to engage student activity, but general exploration with the models can be a useful experience as well.

Students generally are more comfortable with and excited about open-ended computer explorations - such as found in some very popular games - than with tightly scripted programs. With this consideration in mind, the exercises focus on the chemical concepts of interest. You may want to provide suggestions or a selected command list to facilitate the mechanics of using the software.

We recommend that all students start with Exercise 1 to get a feel for the software and the various commands.

### LEARNING OBJECTIVES:

- Students using the molecular models will review and reinforce part of what they learned in the video program.
- Students will gain familiarity with different display styles for molecular structures.
- The visual experience of watching molecules turn will increase student awareness of the three-dimensional shape of molecules.
- Students will think about the elements which make up organic compounds as they examine the models with labeled atoms or check the color coding of elements.
- Comparisons of different models will help students compare the relationship between structure and function.
- Most importantly, the engaging nature of the software to manipulate molecular models will help overcome the instinctive fear that many students have about studying organic compounds because the material is “too hard.”

**Notes on Exercise 1:**

The purpose of this exercise is twofold. First, the exercise teaches students some basics in how to use the molecular modeling software. Second, the exercise focuses on some simple but fundamental chemical concepts, particularly helping students to overcome the misconception that a model is what a molecule actually looks like.

**Worksheet 1A:**

- Students learn to open a model file and to rotate the model. They should observe that methane is shaped like a pyramid (tetrahedral).

**Worksheet 1B:**

- The “stick” style of display uses a thickened line to represent atoms and bonds. The atoms are color-coded.
- The “CPK” style uses overlapping spheres to represent interacting atoms.
- The “ball-and-stick” style uses balls for atoms and sticks to show the bonds that connect them. (see number 3)
- The HRM video uses the ball-and-stick display style for molecular models.

**Worksheet 1C:**

- Dark grey atoms are carbon; white atoms are hydrogen.

**Conclusion:**

Carbon is bonded to 4 other atoms (hydrogens), showing that carbon can form the basis for complex molecules.

Molecular models can be displayed in different ways because they represent atoms that bond together to form molecules. Models can show the correct number of atoms and the correct bonding arrangement, but the model is not an actual picture of a molecule, so it can be represented in more than one way.

**Notes on Exercise 2:**

The remainder of the exercises provide less step-by-step details about using the software and more focus on chemical concepts, although new commands for manipulating models will be gradually introduced. You may find that students need some time just to experiment with the models, or you may want to use the hints for teachers to help guide students through the software. Generally students like the responsibility of exploring virtual terrain (in this case, the models) on their own, in an open-ended fashion.

Exercise 2 gives students a chance to practice their experiences from Exercise 1 and to think about the way carbon chains are built. Students should recall from the video that hydrocarbons are not very soluble in water.

**Notes on Exercise 3:**

Exercise 3 focuses on a different class of organic compounds, carbohydrates. It is a review of material presented in the video. Students should recognize that sucrose is made of carbon, hydrogen and oxygen, and that it has about equal amounts of carbon and hydrogen.

Students learn to use a new feature of the software, the select tool. This step lends itself well to team work. You may want to directly check each student's ability to highlight glucose, or if you have sufficient space, instruct students to save their highlighted molecule so that you can check later. If you have a color printer, the team can print a copy of its highlighted model. Glucose should appear as yellow.

An oxygen atom lies between the two component sugars in sucrose. The large amount of oxygen makes sugar water soluble.

**Notes on Exercise 4:**

The chemical concepts dealt with in this exercise are a review of those taught in the video, *Organic Compounds in Action*. Vitamin A is an oily substance, containing a hydrocarbon component and a small amount of oxygen. It is fat soluble and is a lipid.

**Notes on Exercise 5:**

This exercise gives students a chance to observe the model for a very complex organic compound, the protein known as cobra toxin. Students use the model to identify sulfur in certain amino acids in this protein. An advanced question challenges students to connect this observation with what they have learned elsewhere about disulfide bonds that stabilize secondary and tertiary structure in some proteins.

**Notes on Exercise 6:**

This exercise provides an opportunity to manipulate a model of a tiny stretch of DNA double helix. Four base pair interactions can be seen. Students can use the color coding of atoms (explained under “Tools” item “Elemental properties”) or label atoms (shown by “View” item “Labels/Add”) to locate nitrogen and help themselves find base components. Students will require outside knowledge to distinguish the smaller pyrimidine bases from the larger purine bases in each pair.

## NOTE TO THE STUDENT

### **Students**

Here is your chance to use 3-D molecular models like the ones you saw in the video *Organic Compounds in Action*. You will be using a professional scientific tool to view, move, and generally explore computer-generated molecular models.

Researchers use software like this to organize and analyze scientific data, share biological and chemical information, and develop novel compounds, materials, and processes.

Computer modeling is a powerful scientific research tool, not only to depict structures but also to simulate complex systems. Computer models enable scientists to conduct careful experiments in systems with many variables, systems in which variables might be impossible to control in the real world. You may be surprised to learn that scientific models go far beyond the traditional static models such as plastic representations of skeletal structure.

To learn more about molecular models,  
you may want to visit the website at  
**[http:// www.msi.com](http://www.msi.com)**.

### **WebLab ViewerLite**

This software is not a game. It has no specific start and finish. To learn some basic commands, do the first exercise, described on Worksheet 1. The rest of the worksheets challenge you with specific tasks to carry out using the 3-D molecular models.

**Good luck!**

# **STUDENT WORKSHEETS**



**EXPLORING WITH VIEWERLITE**

Change the display style.

The default style is called “line.” To change to another display style, click the icon on the far right of the top bar, one that looks like a small molecule. This icon is called “display style.” A window will open that gives you some choices. Click on the tiny circle next to the option called “stick.” Then click “OK” to put your choice into action.

Describe how the model looks when you use the display style called “stick”:

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Repeat step 1, choosing display style “CPK.”

Describe how the model looks when you use the display style called “CPK”:

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Repeat step 1, choosing display style “ball and stick.”

Describe how the model looks when you use the display style called “ball and stick”:

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What does the ball stand for?

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What does the stick stand for?

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What display style was used in the HRM video titled *Organic Compounds in Action*?

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**EXPLORING WITH VIEWERLITE**

What elements are contained in methane? You can find out two ways.

**Label atoms.**

Pull down menu item “Tools”, select option “Labels” and click on “Add.”  
What elements are found in methane?

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How many atoms of each element are found in methane?

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**Read color code.**

Record the colors used to represent atoms in the methane model:

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Next, read the color code for these atoms. To do this, pull down menu item “Tools” and choose the last topic, “Elemental Properties.” You should see a color-coded periodic table of the elements. Find the color that matches each atom in the methane model and next to that color in your previous notes, record the element for which it stands.

Do you get the same answers as you did when you labeled the atoms?

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**YOUR OBSERVATIONS**

You have learned to open the files containing molecular models and to display and manipulate those models. Now based on what you observed about methane, answer these questions:

Describe one feature of methane that shows why carbon is so useful in organic compounds:

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Explain why there is more than one way to show a molecule when you use a molecular model:

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**HYDROCARBONS**

Compare the models for three different molecules contained in the “Petroleum” category: methane (done in Exercise 1), ethane and butane.

What similarities do they share?

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What are the differences?

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What would you predict about the solubility of these organic compounds in water? Explain your response.

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**INVESTIGATING SUCROSE**

**Your task:** Investigate the model for table sugar (sucrose).

- Open the file for the molecule called sucrose.
- Display the model as ball-and-stick.
- Rotate the molecule to see the shape.
- Find out what elements make up sucrose.

Record these observations here:

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For fun, try to set the model into motion. Pull down the “View” menu and select “Spin.” (When you want to stop the model, repeat these steps and click again on “Spin.” The model will stop.)

What do you observe about the ratio carbon to oxygen in sucrose?

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Sucrose is a double-sugar composed of glucose and fructose. Consult an outside source, such as your text, to determine the formula for sucrose. Compare the written formula to the model. Locate the glucose part of the model and highlight it by using the select tool.

To highlight, click on the top icon in the side bar. It looks like a black arrow. This icon is the select tool. It makes your cursor a tool to select one part of a model. Put the cursor just outside the region you want to select. Hold down the mouse button and drag the cursor to make a rectangle that covers the part of the molecule you want to select. (If you get the wrong part, use the “Undo” icon or the “Undo” command under the “Edit” menu.)

Click again and you have highlighted the part of the molecule in the rectangle. The highlighted part will turn yellow. Let your teacher or teammate check to see that you have located the glucose component of sugar correctly.

Through what atom do bonds connect the two sugars in sucrose? Based on what you observe about sucrose in this investigation, what would you predict about its solubility in water?

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**INVESTIGATING VITAMIN A**

**Your task:** Investigate the model for “Vitamin A.”

- Find the file containing the model for vitamin A under the category called “General.”
- Open the model file.
- Examine the model.
- Choose whatever display style you prefer.

Write a short description of your observations:

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What do you predict about the solubility of vitamin A? Explain.

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To which of the four major groups of organic compounds found in living systems does vitamin A belong? Give reasons for your response.

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**INVESTIGATING DNA**

**Your task:** Find a pyrimidine in DNA.

- ▶ Locate the file for a model called DNA1.pdp under the category “DNA.” Open the file for this model. Display either as “line” or as “ball-and-stick.”
- ▶ Rotate the model until you can clearly see the sugar-phosphate backbone for each DNA strand. Now look for 4 base pairs. **Hint:** *The bases contain the element nitrogen. (You have two ways to use the modeling software to identify an element. If you’ve forgotten how, look back at Exercise 1.)*
- ▶ Fix the model in a position that makes it easy to see at least one pyrimidine. (You may need to review material from other sources to remind yourself about which of the bases are pyrimidines and how their general structure differs from the other type of bases, the purines.)
- ▶ Use the select tool (first icon on the left side bar) to highlight the pyrimidine. (If you’ve forgotten how to use the select tool, look at the directions in Exercise 3.)

Based on what you learned in the video *Organic Compounds in Action*, to which of the four major groups of organic compounds does DNA belong?

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**MORE TO INVESTIGATE**

You may find it interesting to observe the models for these familiar molecules:

- **Porin** ( a protein you observed in the video)
- **Cholesterol** (found in the General Interest category)
- **Benzene** (a Petroleum product)
- **Chlorophyll** (a pigment found in green plants)
- **Caffeine**