LIFEPAC®

# SCIENCE

STUDENT BOOK

**11th Grade** | Unit 8

Alpha Omega
PUBLICATIONS

# SCIENCE 1108
# HYDROCARBONS



**LIFEPAC Test is located in the center of the booklet.** Please remove before starting the unit.

**Author:**
Harold Wengert, Ed.D.

**Editor:**
Alan Christopherson, M.S.

**Media Credits:**
**Page 7:** © Ian Redding, iStock, Thinkstock; **16:** © AntolyM, iStock, Thinkstock; © VvoeVale, iStock, Thinkstock; **24:** © Antonio Scarpi, Hemera, Thinkstock.

Alpha Omega
PUBLICATIONS

**804 N. 2nd Ave. E.**
**Rock Rapids, IA 51246-1759**

# Carbon Chemistry: Hydrocarbons

## Introduction

Our Creator in His wisdom made a universe that is unique. No length of time nor combination of circumstances could have produced such a world as ours. The study of carbon chemistry is truly a study of God's creation. You will learn that the uniqueness of the carbon atom is the basis of all life. The choice of this atom with its designed characteristics is indeed a mark of an omnipotent Creator. No work of chance could have happened upon the combination necessary to produce life. David proclaimed in Psalm 19:1, "The heavens declare the glory of God and the firmament sheweth his handywork."

Science LIFEPACs 1108 and 1109 will be a study of the carbon atom and the chemistry of life. The study of functional groups of organic compounds will help you to see the glory of God in creation. In this LIFEPAC® you will review the atomic nature of carbon and the molecular structure of carbon compounds. You will also learn more about hydrocarbons, their sources, and their chemistry. For anyone interested in medicine, nursing, biology, or chemistry as a career, these two LIFEPACs should be of special interest.

## Objectives

**Read these objectives.** The objectives tell you what you will be able to do when you have successfully completed this LIFEPAC. When you have finished this LIFEPAC, you should be able to:

1. Classify compounds as organic or inorganic.
2. Identify the three major sources of organic compounds.
3. Describe the structure of the carbon atom.
4. Identify and describe the three forms of carbon.
5. Describe carbon bonding.
6. Classify alkanes, alkenes, and alkynes.
7. Describe alkanes, alkenes, and alkynes.

Survey the LIFEPAC. Ask yourself some questions about this study and write your questions here.

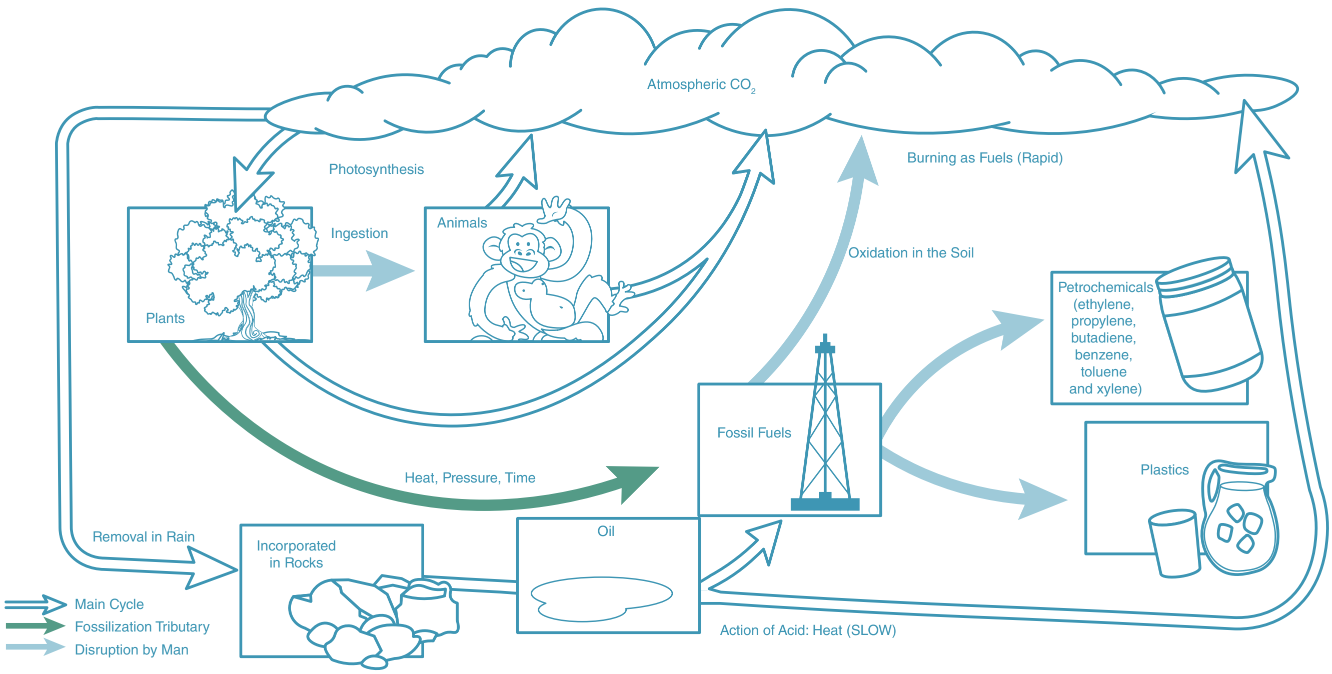
# 1. CARBON COMPOUNDS

Carbon compounds are a part of the familiar carbon cycle. The carbon cycle was part of God's natural balancing of nature. At the time of the Flood, nearly all of our coal and petroleum resources were buried and formed. These carbon compounds are the basis of all the synthetic plastics and petrochemicals man has made for his comfort, as well as his main source of fuel. In this section you will study the sources and classification of carbon compounds.

## Section Objectives

**Review these objectives.** When you have completed this section, you should be able to:

1. Classify compounds as organic or inorganic.
2. Identify the three major sources of organic compounds.



# CLASSIFICATION OF ORGANIC COMPOUNDS

All substances can be classified into either of two categories, *organic* and *inorganic*. This classification scheme was used by the early chemists in a slightly different manner than it is being used today.

Originally, the term *organic* was used in its general sense in that rocks and minerals are inorganic; but plants, animals, and the substances they produce are organic. In this sense, the adjective *organic* tells you that a substance is, or has at one time been, a part of a living organism. An organic substance according to this classification scheme is derived from things that are, or have been, alive.

**Early definition.** This system of classification was set up because prior to the year 1800, organic substances were believed to contain a "vital spirit." Since no chemist possessed, nor could ever hope to attain, a "bottle of vital spirit," laboratory production (except by living things) of organic compounds was believed to be impossible. Thus two separate and distinct types of substances were thought to exist: organic substances, which were impossible to synthesize, and inorganic substances, which could be synthesized. Therefore, originally organic chemistry was founded as the study of compounds from living things that contained a "vital spirit" (quintessence). Historians of science refer to this theory as the *Theory of Vitalism*.

Considerable doubt had begun to cloud this theory when in 1928, the German chemist Friedrich Wohler synthesized urea, a compound normally produced by animal metabolism. While working with the inorganic compound ammonium cyanate, he surprisingly discovered crystals of urea in his beakers. Since then, thousands of organic compounds have been synthesized, and the *Theory of Vitalism* has passed into oblivion.

**Modern definition.** The terms *organic chemistry* or *organic compound* have a slightly different meaning in chemistry today. To illustrate, study the following exercises with special attention to the products of these reactions. A student did the following experiment to collect the data for your study.

> One sugar cube (sucrose) was added to a 100 ml beaker. Enough concentrated $H_2SO_4$ (HIGHLY CAUSTIC) was added to soak the cube completely (about 2 ml). The mixture was allowed to set for several minutes. One of the products of the reaction was a gas which he was able to detect by condensing it on the surface of a cool watch glass set on top of the beaker. The liquid was tested with cobalt chloride paper (detects $H_2O$) and the paper turned colors. A solid residue product of the reaction resembled charred wood or carbon. The reaction became hot.

**Do these activities.**

**1.1** On the basis of the student's data and observations, complete these activities.

a. What does concentrated $H_2SO_4$ do to sucrose? Complete the equation for this reaction.

$$C_{12}H_{22}O_{11} + 11\ H_2SO_4 \longrightarrow 12\ \_\_\_\_\_\_ + 11\ H_2SO_4 + 11\ \_\_\_\_\_\_$$

b. Is the concentrated $H_2SO_4$ a catalyst in this reaction? __________

c. Explain your answer in b. ________________________________________

________________________________________

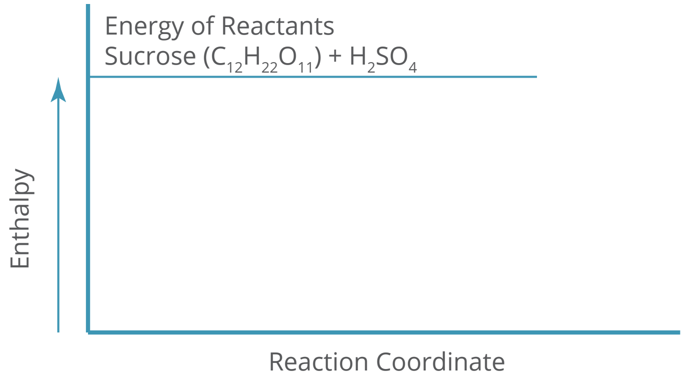
d. What was the gaseous product of this reaction? __________________

e. Did the reactants give off energy when they formed the products? __________________

f. Is the reaction exothermic or endothermic? __________________

g. Do the products or the reactants have more enthalpy? __________________

h. On the basis of these observations, complete the following diagram.




**1.2** What is urea? ______________________________________________

______________________________________________

**1.3** Describe the *Theory of Vitalism*. ______________________________________________

______________________________________________

______________________________________________

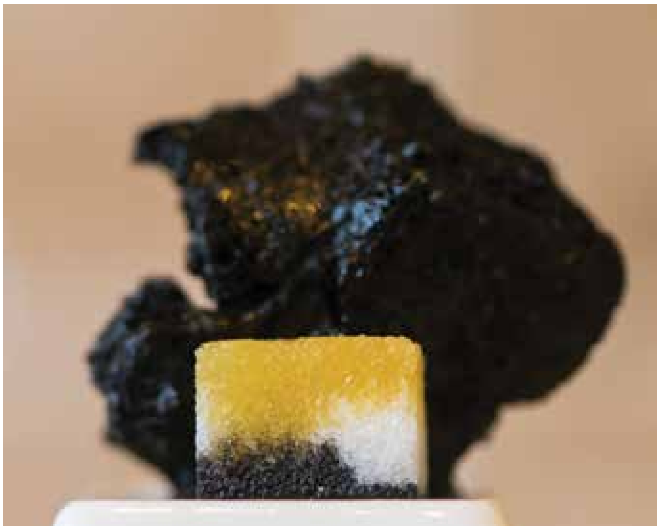
**1.4** Describe Friedrich Wohler's contribution to science. ______________________________________________

______________________________________________

______________________________________________

______________________________________________

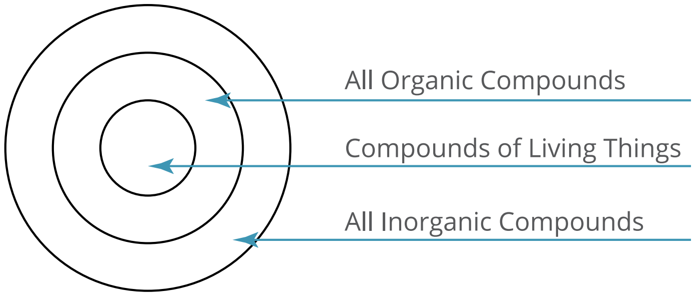
Many plastic materials burn and leave a charred, black residue like that of the $H_2SO_4$–sugar reaction. The products of the preceding reaction are similar to the results of leaving bread in the toaster or meat and potatoes in the oven too long. A hot flatiron left on a piece of cloth yields the same charred products. Sugar, plastics, food, and cloth are part of a large group of substances which have two things in common: (a) they all contain organic compounds and (b) they all contain the element carbon. Examination of the compounds from living things shows an abundance of this element. Organic chemistry is the study of compounds made of carbon. Many compounds of this element, although *not products of living things*, are classified as organic compounds. Exceptions to the rule are oxides of carbon (CO and $CO_2$), metal carbonates, and metal cyanides. All of these exceptions are considered to be inorganic compounds.



| Reaction between sucrose and concentrated sulphuric acid

**Do this activity.**

**1.5** The following circle represents all chemical compounds. Crosshatch organic compounds vertically and inorganic compounds horizontally on the drawing.




**Answer** *true* **or** *false*.

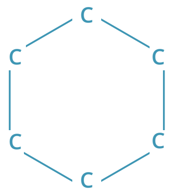
**1.6** ____________ Compounds of carbon are organic.

**1.7** ____________ Organic compounds can not be synthesized.

## SOURCES OF ORGANIC COMPOUNDS

Since Vitalism is dead, what is so special about compounds of carbon that they should be studied separately from the compounds of the other hundred or so elements? In part, the answer seems to be that so many carbon compounds exist. About 50,000 compounds of all the elements other than carbon are known to exist. Well over a million organic compounds are known, and every year more than 100,000 new organic compounds are produced.

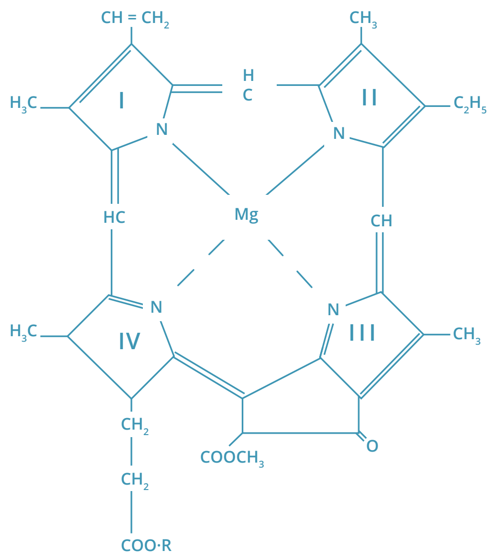
*What is significant about carbon that it forms so many compounds?*




Carbon atoms can attach themselves to one another to an extent not possible for atoms of any other element. Carbon atoms can form chains thousands of atoms long or rings of all sizes, such as chains made of paper clips or strings of popcorn. The chains and rings can have branches and cross-links with atoms of other elements (chiefly hydrogen) attached to the carbon atoms. Each different arrangement of atoms corresponds to a different compound, and each compound has its own physical and chemical properties.

Therefore, the order in which atoms are attached to each other and the electrons which hold them together are very important in accounting for the properties of compounds. Structural formulas and wood models representing molecules can be used to account for the physical and chemical properties of compounds.

*Man himself is a walking organic chemical machine.*




| Chlorophyll a: A green pigment in plants

The intricate balance between life and death, learning and forgetting, growing or not growing, fighting disease or becoming sick is organic in nature. Any student of medicine or nursing will certainly need to understand and appreciate the beauty of this branch of chemistry. The delicate balance of nature has its foundation in the study of organic chemistry. Much of our modern day technology and pollution, especially ecological, is organic in nature.

Not only is organic chemistry contemporary, but it is also a clue to the past. Much of the history of the earth and the study of petrology involves the study of the world of carbon. For example, natural gas, petroleum, and coal are the largest sources of carbon compounds. Although many of these materials are used as they are, many compounds from these sources are used as raw materials for synthesizing new compounds. Coal, for example, has become such an important source of medicines that some are advocating developing atomic energy more rapidly and saving our coal reserves.

**Petroleum.** Natural gas is about 90 percent methane ($CH_4$) with some ethane ($C_2H_6$) and propane ($C_3H_8$) in it. Natural gas is found in certain porous rock formations. Natural gas is used for heating buildings, for cooking food, and for a starting compound to produce other organic substances. Methane, ethane, and propane are colorless and are practically odorless. By law, a sulfur-containing

| Alkanes | | | Boiling Point |
|---|---|---|---|
| natural gas (mostly) | methane | $CH_4$ | -162° C |
| | ethane | $C_2H_6$ | -88° C |
| bottled gas (mostly) | propane | $C_3H_8$ | -42° C |
| | butane | $C_2H_{10}$ | 0° C |
| gasoline | pentane | $C_5H_{12}$ | 36° C |
| | hexane | $C_6H_{14}$ | 69° C |
| | heptane | $C_7H_{16}$ | 98° C |
| | octane | $C_8H_{18}$ | 126° C |
| | nonane | $C_9H_{20}$ | 151° C |
| | decane | $C_{10}H_{22}$ | 174° C |
| | | $C_{11}H_{24}$ | |
| | | $C_{12}H_{26}$ | |

**Table 1: Fractions of Petroleum**

| Fraction | Distillation Temperature C° | Carbon Number | Percent Crude Oil |
|---|---|---|---|
| natural gas | below 20° | $C_1$ - $C_4$ | 2% |
| petroleum ether | 20 - 60° | $C_5$ - $C_6$ | |
| ligroin | 60 - 100° | $C_6$ - $C_7$ | 2% |
| gasoline | 40 - 206° | $C_5$ - $C_{10}$ | 32% |
| kerosene | 175 - 325° | $C_{12}$ - $C_{18}$ | 18% |
| fuel oil | above 275° | $C_{12}$ and higher | 20% |
| lubricating oil | nonvolatile liquids | long chains | |
| asphalt | nonvolatile solids | polycyclic structures | |

Alpha Omega
PUBLICATIONS

804 N. 2nd Ave. E.
Rock Rapids, IA 51246-1759

**800-622-3070**
**www.aop.com**

SCI1108 – Feb '18 Printing

ISBN 978-1-58095-588-1

9 781580 955881