Investigate the Possibilities

Elementary Chemistry

MATTER

Its Properties & Its Changes

Teacher's Guide

Tom DeRosa
Carolyn Reeves

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Teacher's Manual

Its Properties & Its Changes

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Introduction

The overall goal for each book is to include three components: good science, creation apologetics, and Bible references. This goal underlines the rationale for the design of the workbooks.

Science is a great area to teach, because children have a natural curiosity about the world. They want to know why and how things work, what things are made of, and where they came from. The trick is to tap into their curiosity so they want to find answers.

Many elementary-level science lessons begin with definitions and scientific explanations, followed by an activity. A more effective method is to reverse this order and begin with an activity whenever possible. The lessons found in these workbooks begin with an investigation, followed by scientific explanations and opportunities to apply the knowledge to other situations.

In addition to the investigations, there are sections on creation apologetics, written mostly in narrative forms; connections to Bible references; on-your-own challenges; pause and think questions; projects and contests; and historical stories about scientists and engineers. These sections encourage students to think more critically, to put scientific ideas into perspective, to learn more about how science works, to gain some expertise in a few areas, and to become more grounded in their faith in the Bible.

It is not expected that students will do everything suggested in the workbooks. The variety provides students with choices, both in selection of topics and in learning styles. Some students prefer hands-on activities and building things, while others prefer such things as writing, speaking, drama, or artistic expressions. Once some foundational ideas are in place, having choices is a highly motivating incentive for further learning.

Every effort has been made to provide a resource for good science that is accurate and engaging to young people. Most of the investigations were selected from lessons that have been tested and used in our Discovery classrooms. The science content meets and exceeds the recommendations of the National Science Education Standards.

Format for Individual Lessons:

1. Think about This

The purpose of this section is to introduce something that will spark an interest in the upcoming investigation. Lesson beginnings are a good time to let students make observations on their own; for a demonstration by the teacher; or to include any other kind of engaging introduction that causes the students to want to get answers. Teachers should wait until after students have had an opportunity to do the investigation before answering too many questions. Ideally, lesson beginnings should stimulate the students' curiosity and make them want to know more. Lesson beginnings are also a good time for students to recall what they already know about the lesson topic. Making a connection to prior knowledge makes learning new ideas easier.

2. The Investigative Problem

This section brings a focus to the activity students are about to investigate and states the objectives of the lesson. Students should be encouraged throughout the investigation to ask questions about the things they want to know. It is the students' questions that connect with the students' natural curiosity and makes them want to learn more. Teachers should stress to students at the start of each lesson that the goal is to find possible solutions for the investigative problem.

3. Gather These Materials

All the supplies and materials that are needed for the investigation are listed. The Teacher's Book may contain additional information about substituting more inexpensive or easier to find materials.

4. Procedures and Observations

Instructions are given about how to do the investigation. The Teacher's Book may contain more specifics about the investigations. Students will write their observations as they perform the activity.

5. The Science Stuff

It is much easier for students to add new ideas to a topic in which they already have some knowledge or experience than it is to start from scratch on a topic they know nothing about. This section builds on the experience of the investigation.

6. Making Connections

Lessons learned become more permanent when they are related to other situations and ideas in the world. This section reminds students of concepts and ideas they likely already know. The scientific explanation for what the students observed should be more meaningful if it can be connected to other experiences and/or prior knowledge. The more connections that are made, the greater the students' level of understanding will become.

7. Dig Deeper

This section provides ideas for additional things to do or look up at home. Students will often want to learn more than what was in the lesson. This will give them some choices for further study. Students who show an interest in their own unanswered questions should be allowed to pursue their interests, provided the teacher approves of an alternative project. Students should aim to do at least one project per week from Dig Deeper or other project choices. The minimum requirements from this section should correspond to each student's grade level. Students may want to do more than one project from a lesson and none from other lessons. Remember, this is an opportunity for students to choose topics that they find interesting.

8. What Did You Learn?

This section contains a brief assessment of the content of the lesson in the form of mostly short-answer questions.

9. The Stumpers Corner

The students may write two things they would like to learn more about or they may write two "stumper" questions (with answers) pertaining to the lesson. Stumper questions are short-answer questions to ask to family or classmates, but they should be hard enough to be a challenge.

Note to the Teacher

The books in this series are designed to be applicable mainly for grades 3–8. The National Science Education Standards for levels 5–8 were the basis for much of the content. Recommendations for K–4 were also considered, because basic content builds from one level to another.

However, the built-in flexibility allows younger students to do many of the investigations, provided they have good reading and math skills. Middle school students will be presented the basic concepts for their level, but will benefit from doing more of the optional research and activities

We feel it is best to leave grading up to the discretion of the teacher. However, for those who are not sure what would be a fair way to assess student work, the following is a suggestion.

1. Completion of 20 activities with write-up of observations — ⅓
2. Completion of What Did You Learn Questions + paper and pencil quizzes — ⅓
3. Projects, Contests, and Dig Deeper — ⅓

The teacher must set the standards for the amount of work to be completed. The basic lessons will provide a solid foundation for each unit, but additional research and activities are a part of the learning strategy. The number of required projects should depend on the age, maturity, and grade level of the students. All students should choose and complete at least one project each week or 20 per semester. 5th and 6th graders should complete 25 projects per semester. A minimum guide for 7th and 8th graders would be 30 projects. The projects can be chosen from "Dig Deeper" ideas or from any of the other projects and features. Additional projects would give extra credits. By all means, allow students to pursue their own interests and design their own research projects, as long as you approve first. Encourage older students to do the more difficult projects.

As students complete each investigation and other work, they should record what they did and the date completed in the student journal. A chart is included in the Student Book to do this. You may or may not wish to assign a grade for total points. But a fair evaluation would be three levels, such as: minimum points, more than required, and super work. Remember, the teacher sets the standards for evaluating the work.

Ideally, if students miss one of the investigations, they should find time to make it up. When this is not practical, make sure they understand the questions at the end of the lesson and have them do one of the "Dig Deeper" projects or another project.

You should be able to complete most of the 20 activities in a semester. Suppose you are on an 18-week time frame with science labs held once a week for two or three hours. Most investigations can be completed in an hour or less. Some of the shorter activities can be done on the same day or you may choose to do a teacher demonstration of a couple of the labs.

It is suggested that at least five hours a week be allotted to the investigations, contests, sharing of student projects, discussion of "What Have You Learned" questions, and research time. More time may be needed for some of the research and projects. Count projects, contests, and Dig Deeper activities equally. There are over 70 possible activities from which students may choose.

Any time chemicals are used that might irritate eyes, safety glasses should be required. This is also a requirement for being around flames and other devices used for heating water or other chemicals. They are as important as safety belts are for children in a moving vehicle. Some activities should be done only as demonstrations, but a student helper can assist if the student is wearing safety glasses and covering to protect clothes. Caution students about tasting anything unless they are specifically told to do so.

Refer students to textbooks or other references to help them answer questions, but also encourage them to think of their own explanations. It is not too early to help students understand that science is mostly about finding explanations for things they have observed and about finding patterns in nature. When controlled experiments are done, help them identify the controls and the variable.

Most of the supplies and equipment can be obtained locally. However, these may also be ordered for convenience.

INVESTIGATION #1

The Physical Side of Chemicals

Think about This

A detective collected samples of food from the table where a victim was eating when he collapsed. The detective sent them to a crime lab. A few days later, the lab called to say they had positively identified a poison in the victim's food that was not in anyone else's food. Have you ever wondered how someone in the crime lab could figure out what chemicals are present in food or in someone's blood or in something else?

The Investigative Problems

How can the physical properties of a chemical substance be used to help identify the substance?

Procedure & Observations

Your teacher will show you ten items. Your job is to identify one of the items on the basis of its physical properties. You should eliminate any item that doesn't match the descriptions. These are the physical properties of the item: It is round. It is flat. You would not want to eat it. It would be hard to break. It is shiny. What is the item that has all of these properties?

Your teacher will give you some more substances to investigate, but each of these will be a pure chemical substance. They will be either an element or a compound.

Bring a magnet near each substance and observe if the magnet has an effect on it. Place each substance in a container of water and observe if it floats or sinks. Note if it is soluble (will dissolve) or insoluble (will not dissolve) in the water. Note also the color and whether it is shiny or dull. Put this information in a data table.

Substance	Effect of a magnet	Float or sink in water	Soluble or insoluble in water	Color	Shiny or dull
Iron nail					
Paraffin					
Sugar cube					
Oil					
Copper penny					

Use your chart to identify each substance.

1. Which substance is attracted to a magnet?
2. Which substance is a shiny orange-brown color and sinks in water?
3. Which substance is soluble (dissolves) in water?
4. Which substance is a solid and floats on water?
5. Which substance is not a solid and floats on water?

Objectives

This investigation shows that a pure substance has its own characteristic physical properties. Students investigate several physical properties, including effects of a magnet, color, shininess, solubility in water, and ability to float on water. These properties will be present regardless of the size, shape, and amount of the substance.

Note

Bring ten common items to class for the introductory activity. Include an apple, something made of glass, a rectangular card, and a flat wooden or plastic button. Bring a shiny quarter to be "it," but don't include another item that could fit the description of a round, flat, shiny, inedible object.

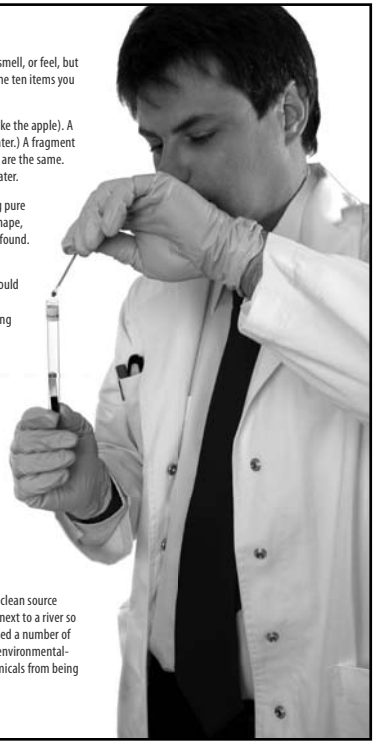
The Science Stuff

Physical properties are often characteristics you can see, hear, taste, smell, or feel, but may include any physical characteristics of a substance. You used some simple physical characteristics to identify one of the ten items you were first shown.

Some of the items you were shown were pure substances (like the glass) and some were a mixture of many substances (like the apple). A pure chemical substance could be either an element or a compound. (We'll learn more about elements and compounds later.) A fragment of a pure substance would have the same properties as the whole substance. All of the basic particles in a pure substance are the same. For example, a piece of pure iron only contains particles of iron and a container of pure water only contains particles of water.

Properties such as size and shape were helpful in identifying the first items, but they are seldom considered in identifying pure chemical substances. The properties of the five pure substances listed in the chart will be present regardless of the size, shape, or amount of the substance. Scientists look for characteristics that will remain the same no matter where the chemical is found. Almost any substance can be made into a round shape, so this would not be helpful in knowing what chemical is present.

We examined physical properties of several pure substances, including the effects of a magnet, whether the substance would float or sink in water, whether the substance was soluble or insoluble in water, its color, and its shininess. There are many other properties we could have considered, such as odor, taste, density, hardness, brittleness, elasticity, melting and boiling temperatures, solubility in other liquids, conductivity of heat and electricity, and viscosity.



Making Connections

There is a huge need for methods, instruments, and trained people to identify chemical substances that are present in things. Identifying unknown chemicals is part of the study of analytical chemistry. This includes what chemicals are present, their characteristics, and how much is present. There are many crime labs that hire people to help solve crimes by identifying such things as drugs, alcohol, poisons, or traces of gunpowder. Medical labs test blood and urine for the presence of many kinds of substances. Other labs help identify pollutants in the air, water, and environment. Industries must constantly monitor their products for impurities. These are only a few of the places where chemicals are analyzed.

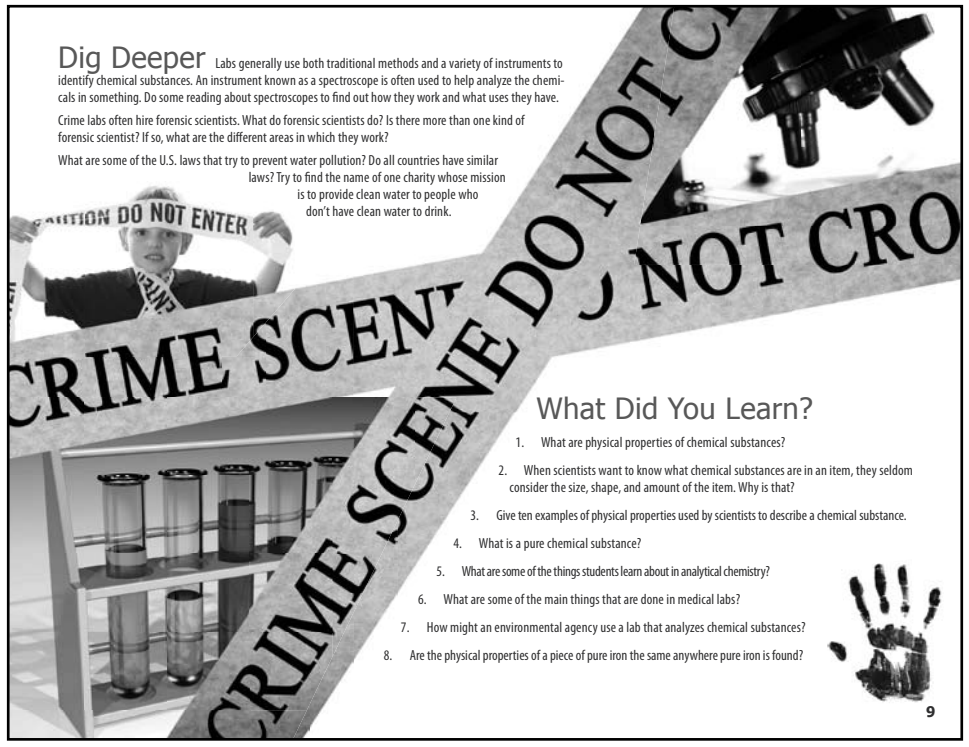
One of the most important things any society can do is to maintain a clean source of water. During the Industrial Revolution, many factories were built next to a river so they could dump their wastes into the river. Congress eventually passed a number of laws to try and keep our water sources free of pollution. Even today, environmentalists look for better ways to prevent pesticides and other harmful chemicals from being washed into rivers and lakes after a rain.

Dig Deeper

Labs generally use both traditional methods and a variety of instruments to identify chemical substances. An instrument known as a spectroscope is often used to help analyze the chemicals in something. Do some reading about spectroscopes to find out how they work and what uses they have.

Crime labs often hire forensic scientists. What do forensic scientists do? Is there more than one kind of forensic scientist? If so, what are the different areas in which they work?

What are some of the U.S. laws that try to prevent water pollution? Do all countries have similar laws? Try to find the name of one charity whose mission is to provide clean water to people who don't have clean water to drink.



What Did You Learn?

1. What are physical properties of chemical substances?
2. When scientists want to know what chemical substances are in an item, they seldom consider the size, shape, and amount of the item. Why is that?
3. Give ten examples of physical properties used by scientists to describe a chemical substance.
4. What is a pure chemical substance?
5. What are some of the things students learn about in analytical chemistry?
6. What are some of the main things that are done in medical labs?
7. How might an environmental agency use a lab that analyzes chemical substances?
8. Are the physical properties of a piece of pure iron the same anywhere pure iron is found?

What Did You Learn?

1. **What are physical properties of chemical substances?** *Physical properties include characteristics you can see, hear, taste, smell, or feel, but could be any physical characteristic of a substance.*
2. **When scientists want to know what chemical substances are in an item, they seldom consider the size, shape, and amount of the item. Why is that?** *A substance's physical properties will be present regardless of the size, shape, or amount of the substance. Scientists look for characteristics that will remain the same no matter where the chemical is found.*
3. **Give ten examples of physical properties used by scientists to describe a chemical substance.** *Density, boiling point, melting point, solubility in water, color, odor, taste, shininess, hardness, magnetic effects, and many other things.*
4. **What is a pure chemical substance?** *An element or a compound; a fragment would have the same properties as the whole substance.*
5. **What are some of the things students learn about in analytical chemistry?** *Analytical chemistry includes what chemicals are present, their characteristics, and how much is present.*
6. **What are some of the main things that are done in medical labs?** *Medical labs might test blood and urine for the presence of many kinds of substances.*
7. **How might an environmental agency use a lab that analyzes chemical substances?** *These labs might help identify pollutants in the air and water and environment.*
8. **Are the physical properties of a piece of pure iron the same anywhere pure iron is found?** *Yes.*

INVESTIGATION #2

Strange Substances and Their Properties

Think about This

Marita challenged her friends to guess what she had inside a plastic container. She called it MX for, Marita's unknown chemical. It moved around the bag like a liquid, but when someone squeezed it, part of it became hard like a solid. Marita asked if she could pour it into a bowl and show everyone some more properties. Her teacher agreed and said she was going to show them another really strange substance that is found in baby diapers.

The Investigative Problems

What are the physical properties of MX and the chemical in baby diapers?

Procedure & Observations

Part I.

1. Your teacher will give you some MX in a zip bag. Look at the MX mixture through a clear zip plastic bag. Hold the bag by the different corners. Does it have properties of a liquid?
2. Hit the bag of MX (not too hard). Does it feel like a solid?
3. Pour the contents of the bag into a plastic bowl. Pick up some MX in a spoon and let it fall back into the bowl. Does the substance act like a liquid or a solid as it falls? Describe how it falls.
4. Now slowly push your finger into the MX until your finger is touching the bottom of the pan. Pull your finger out slowly. What happened?
5. Slowly push your finger into the MX again. When it is touching the bottom of the pan, try to pull your hand out quickly. What happened?
6. Now try to quickly jab the surface of the MX with your fingers. What happened?
7. Try pushing the back of a spoon through a container of MX. Move the spoon as fast as you can. Describe what happens. Now move the spoon through the MX very slowly. Is there a difference in how hard it is to push the spoon?

Part II.

1. You will need two people to do this activity. Hold a baby diaper over a pan or sink and pour 50 mL of warm water into the inside center of the diaper. Predict how much warm water you think the diaper can hold before it begins leaking. Add another 50 mL of warm water and tilt the diaper back and forth so the water can be exposed to dry areas. Continue to add 50 mL of warm water until the diaper can no longer hold any more water and it steadily leaks. Record the total amount of water you added before it began to leak. Set the diaper aside to examine later.
2. Take another diaper and separate the outer and inner lining from the middle layer. Throw away the outer stuffing and all the linings. Tear the middle layer of the diaper into small pieces. Measure the volume of these pieces of the diaper in a dry graduated cylinder or measuring cup, and record this amount. Put the pieces of the middle layer of the diaper into a gallon plastic zip bag. Add 50 mL of warm water to the bag. What do you see?
3. Continue to add 50 mL of warm water to the bag until the bag is full or the water separates from the diaper material. Keep up with the total amount of water you added.
4. Place the first diaper in a plastic bowl and pull it apart. Compare the inner contents of this diaper to the material in the gallon zip bag.
5. Estimate how much water was added for every 100 mL of dry diaper material. This doesn't need to be exact — just an estimate.
6. List some of the physical properties of the substance in the baby diaper that you observed.

OBJECTIVES

This investigation encourages students to examine some less familiar physical properties and to make careful observations of these properties.

NOTE

Combine cornstarch and water in a large mixing bowl before class. Use a ratio of two parts water to three parts cornstarch, but add more water and cornstarch as needed. It may take several minutes to get all the powder stirred in. It's a little hard to get just the right ratio, but something with the consistency of a thick pancake dough is about right. Test it with your fingertips to see if it feels hard when you push quickly and fluid when you push slowly. It should be easy to pull your finger out slowly and hard to pull it out quickly. Pour a cup or two of the mixture into quart-size plastic zip bags. We will refer to this as MX for the rest of the lesson.

As much as possible, encourage students to use metric units when measuring the prescribed volumes for this and other lessons. If a graduated cylinder is not available, you may use a measuring cup that is marked in milliliters. The more students use metric units, the more familiar these units will become.

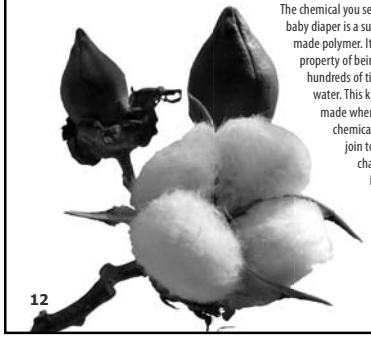
The polymer compound is not harmful, although students should not eat it. No special precautions are needed to dispose of the hydrated chemicals or the MX mixture.

The Science Stuff

MX is actually a mixture of cornstarch and water, but it acquires its own set of interesting physical properties. At times it has properties of a liquid and other times it has properties more like a solid. The water can move in and out of the cornstarch. If you press your fingers into it quickly, the water and cornstarch remains firmly in place. If you press it slowly, the mixture is very fluid. Once your fingers are in the mixture, you will have no trouble removing them slowly. It will be hard to remove them quickly.

The viscosity of MX changes under different conditions. Viscosity is a property of liquids that is related to how slowly they pour from a container or how hard it is to push something through the liquid. Molasses, for example, has a high viscosity because it pours slowly. If it is difficult to push an object through a liquid, the liquid is also said to have a high viscosity. You should have noted that you could push the spoon through the mixture slowly, but it was much more difficult to push it quickly.

Many liquids become less viscous (have less viscosity) when the temperature increases. MX may change viscosity as you apply pressure.



The chemical you separated from the baby diaper is a superabsorbent man-made polymer. It has the unusual property of being able to soak up hundreds of times its weight in water. This kind of polymer is made when many similar small chemicals (called monomers) join together to form long chains of molecules. It is similar to cotton, which is a natural polymer.

Making Connections

Having the proper viscosity is important in choosing motor oils to lubricate cars and trucks. Summer-weight and winter-weight oils allow for changes in summer and winter temperatures. Winter-weight oils are less viscous in cold weather. Summer-weight oils are more viscous in hot weather.

Temperatures reach -40° to –60° F in some places in Alaska during the winter. At these temperatures, residents must use very thin and runny motor oil (low viscosity). They must also keep a heater in the oil pan when vehicles are not in use to keep the oil warm.

The addition of water-absorbing polymers is the secret for no-leak baby diapers. Water-absorbing crystals have other exciting uses. For example, they can be placed in the soil when they are full of water (hydrated), and they will slowly release water to plant roots over a long period of time.

Dig Deeper

Talk with someone who works in a car shop that changes oil in cars. Find out more about the differences in summer-weight and winter-weight oils and why they need to be different.

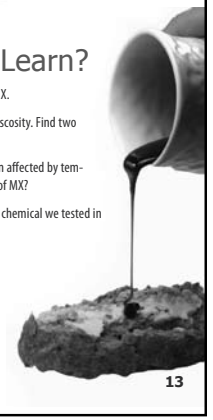
Talk with someone who has lived in Alaska or another area that has long periods of freezing weather. Find out more about how they were able to keep their cars running during those very cold months.

Not too many years ago, baby diapers were made of cloth and were reusable. Today, most American parents use disposable diapers for their babies. Some environmentalists fear that these disposable diapers are creating an environmental problem. Do some research to see why they are concerned about disposable diapers.

Do an experiment by planting two groups of radish seeds. Purchase some water-absorbing polymer crystals from a lawn and garden center. (Commercial products are available under several trade names.) Let the crystals absorb a large amount of water, mix them with an equal amount of moist soil, and plant ten radish seeds in this mixture. Plant ten radish seeds in soil that does not contain the hydrated crystals. Do not water either group. For two weeks, keep a daily record of how the plants are growing.

What Did You Learn?

1. Give several physical properties of MX.
2. There are several ways to describe viscosity. Find two or more ways to describe viscosity.
3. Viscosity of oils and molasses is often affected by temperature. What affects the viscosity of MX?
4. What is one unusual property of the chemical we tested in the baby diaper?
5. What are polymers?



What Did You Learn?

1. **Give several physical properties of MX.** *It is a dull white color. It can flow like a liquid when poured from a container. When pressure is applied quickly, it will have properties like a solid. Its viscosity varies with pressure.*
2. **There are several ways to describe viscosity. Find two or more ways to describe viscosity.** *How slowly a liquid pours from a container or how hard it is to push something through the liquid.*
3. **Viscosity of oils and molasses is often affected by temperature. What affects the viscosity of MX?** *Pressure (and temperature).*
4. **What is one unusual property of the chemical we tested in the baby diaper?** *It has the unusual property of being able to absorb enormous amounts of liquids.*
5. **What are polymers?** *They are made of many similar small chemicals (called monomers) that were joined together to form long chains of molecules.*