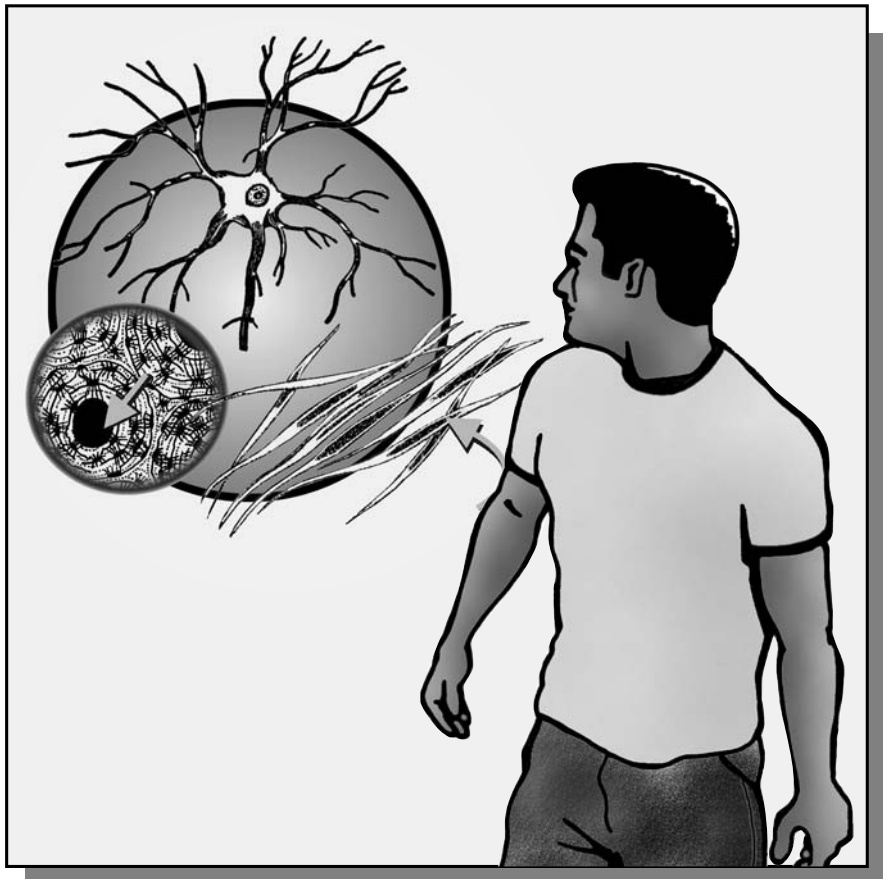
Natural Science Mysteries



Chapter 1

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CHAPTER 1
TABLE OF CONTENTS

PAGE

SECTION 1

1. DESCRIBING MATTER 3-5
States of Matter and Animal Kingdom Overview

2. PHYSICAL PROPERTIES OF MATTER 7-10
Liquid and Linear Measurements, Weight/Mass Measurements

3. CHEMICAL PROPERTIES OF MATTER 11-13
How Substances React With Each Other

4. PHYSICAL AND CHEMICAL CHANGES 15-17
How to Tell the Difference

5. IMPORTANT DISCOVERIES . .19-21
How "White Out" Came About

SECTION 2

6. ATOMS—EARLY DISCOVERIES 23-25
Protons, Electrons, Neutrons, Atomic Theory

7. STRUCTURE AND FUNCTION OF THE ATOM 27-30
Bohr Model, Planetary Model

8. ELEMENTS 31-34
Natural and Artificial, Using Symbols

PAGE

9. ORGANIZING THE PERIODIC TABLE OF THE ELEMENTS . .35-38
Mendeleev, Element Families and Periods

10. INTERPRETING THE PERIODIC TABLE OF THE ELEMENTS . .39-41
Atomic Number and Mass, Metal, Alkali Metal and Noble Gas Families

SECTION 3

11. KINDS OF CHEMICAL BONDS 43-46
Covalent and Ionic

12. ADHESIVES 47-49
Adhesion and Cohesion

13. CHEMICAL FORMULAS 51-53
Meaning and Use of Element Symbols and Numbers

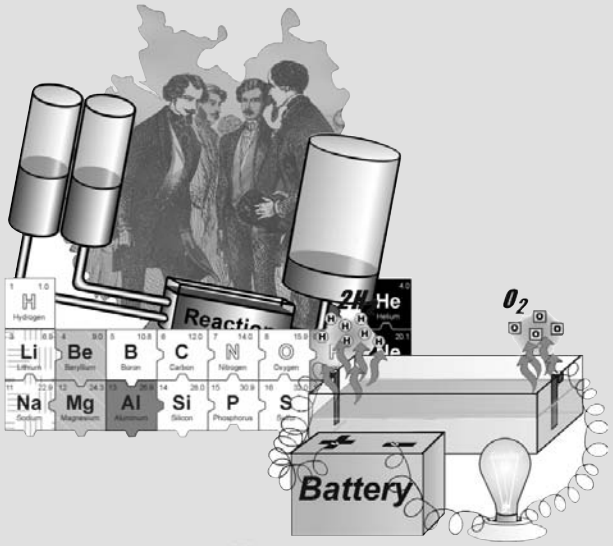
14. CHEMICALS THAT CLEAN . . .55-57
Acids, Bases and Litmus Paper

15. THINGS THAT MATTER 59-61
Artificially Produced Substances for Everyday Use



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"By knowledge, understanding and wisdom the true mysteries of life unfold as they are studied line by line and precept upon precept." —Ronald E. Johnson, C.Ph.D.



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Lesson 1
Biology

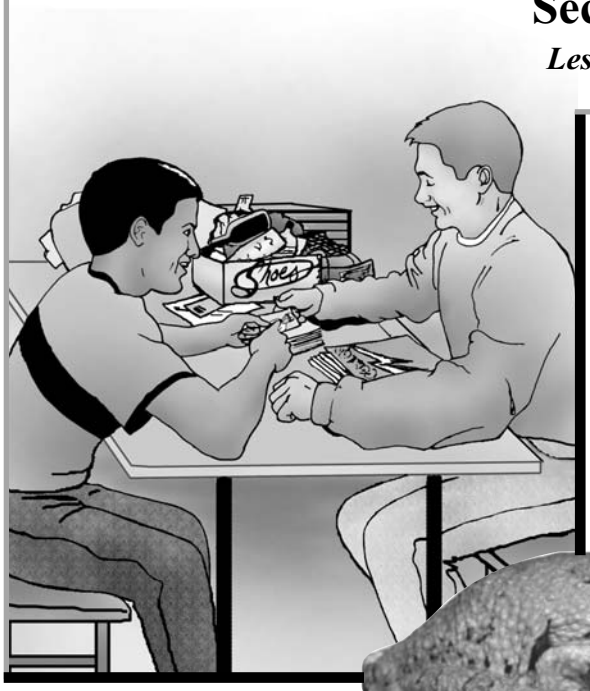
Chapter 1

States of Matter and Animal Kingdom Overview

Section 1

Lessons 1-5

DESCRIBING MATTER



Your school had started a recycling drive. The students and teachers had been asked to bring items to school that might be recycled. Suggested items included plastic containers, glass bottles, newspapers and aluminum cans. You and Jason had been asked to sort the items donated by your classmates. Once the items were organized, they would be taken to the recycling center by yourself and a teacher.



Jason was especially good at sorting the items, because he helped his uncle group things that people brought to the pawnshop his family operated. Jason told you that he and his uncle had discovered some valuable, unwanted items that people decided to trade or sell. He invited you to stop by the pawnshop after school.

Everything that was in the pawnshop and in the recycling bin at school had something in common. All items were made of matter. In fact, you recalled that everything around you was made of matter including the air you breathed, the food you ate, and the clothes you wore.

Matter is simply defined as anything that takes up space and has ***mass***. To take up space means that it fills up a space or a location. You can pour water into a glass. The water fills the glass. You can describe the glass as being occupied by water. Before you poured the water into the glass, air filled the space. Everything takes up space.

The second part of the definition of matter concerns the use of the word mass. *Mass* is the amount of matter in an object or a material. A golf ball and a ping pong ball are about

VOCABULARY

Matter: anything that takes up space and has mass
Mass: the amount of matter in an object
Solids: compose a state of matter that has a definite volume and a definite shape
Liquids: compose a state of matter that has a definite volume but no definite shape
Gases: compose a state of matter that has no definite volume and no definite shape

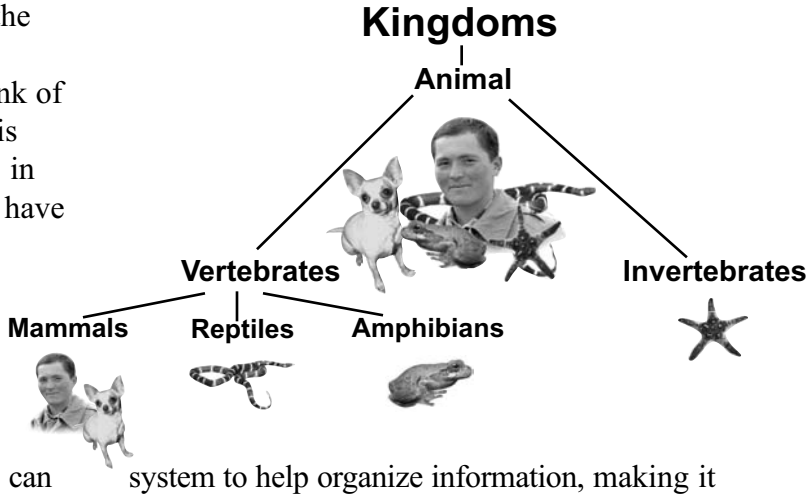
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the same size. However, when you pick them up, you know that the golf ball feels much heavier than the ping pong ball. The golf ball contains more material than the ping pong ball. The golf ball has more mass than the ping pong ball.

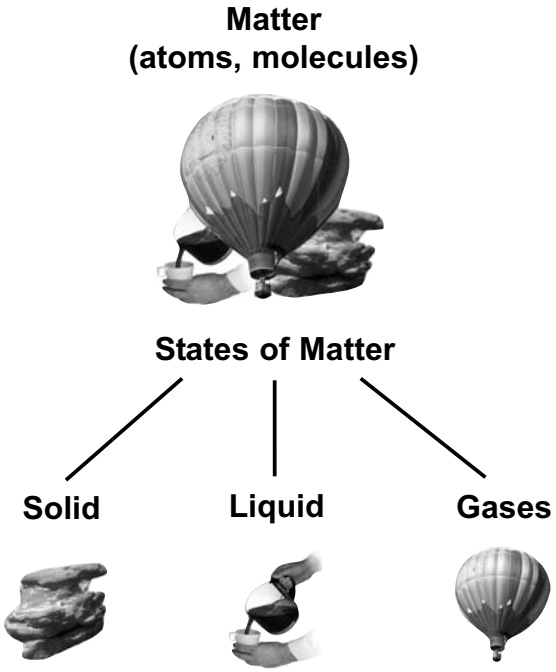
Every physical item you can think of has something in common. Everything is made of matter. Items have other things in common as well. However, some items have major differences also. Scientists group things according to what they have in common so they can be studied more easily.

Examples of how scientists group things include the classification system for living things. All living things can be grouped into five kingdoms according to the types of cells in the living things. You are probably most familiar with two of those kingdoms: the animal kingdom and the plant kingdom.

Humans are classified in the animal kingdom. Although you are not an animal, the cells of human beings are more like those of animals than they are of plants. So humans fall within the animal kingdom. Within that kingdom, you will find groups of animals with certain similarities. Two categories within that kingdom are animals with backbones (called *vertebrates*) and animals without backbones (called *invertebrates*). As you group animals with backbones into smaller groups, you will find such categories as mammals, reptiles and amphibians. This is an example of how scientists use a classification or grouping system to help organize information, making it easier to understand.



Scientists have also divided matter into three groups, called the *states of matter*.



The three states of matter are ***solids***, ***liquids***, and ***gases***. Matter is made up of small particles called ***atoms*** and ***molecules***. A thing is classified as a solid, liquid, or gas according to how tightly its atoms or molecules are held together.

VOCABULARY

Atoms: smallest particles in matter
Molecules: small particles of matter containing more than one atom
Volume: the amount of space taken up by a thing

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In solids, the molecules are packed together very tightly. Any matter that has a definite ***volume*** and a definite shape is a solid. A rock is a solid. A feather is a solid. Although the rock is hard and the feather is soft, both exist as solids. Remember, neither hardness nor softness determines whether or not an item is a solid. The definition depends on the item having a definite volume and a definite shape. That means that when you set the rock and the feather on a table, they maintain their shapes.

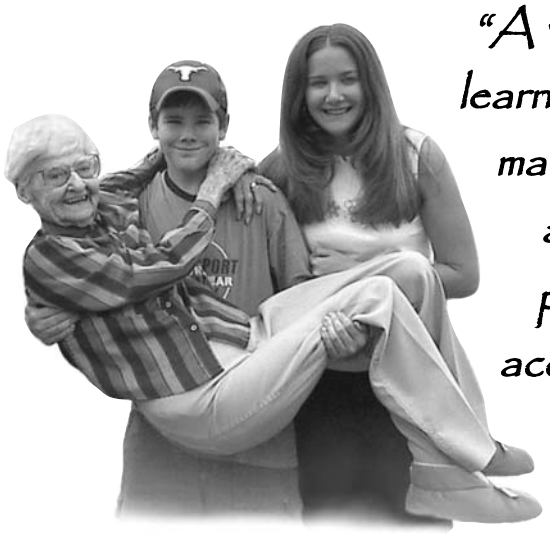
In liquids, the molecules are not packed as tightly together as with solids. Liquids do not have definite shapes the way solids do. If you spill orange juice on the kitchen counter, it will spread out all over the counter. If you pour orange juice from a pitcher into a glass, its shape will change to fit the shape of the glass. If you were to drop a feather into a glass, the shape of the feather would not change. That's because a feather is a solid.

Matter that has no definite shape and no definite volume is a gas. A gas spreads out to fill any container in which the gas is enclosed. Air is a gas. Think of filling a balloon with air. As you blow air into the balloon, the gas takes on the shape of the balloon. The molecules of a gas are spread farther apart than in a solid or a liquid.

Everything around you can be classified as a solid, liquid or a gas. The three states of matter help in identifying the way substances behave and react. Scientists use those patterns of behavior to make new discoveries and inventions.

After school, you stopped by the pawnshop. Jason was already there, sorting through a big box of items that someone had pawned earlier in the day. Jason put all jewelry in one pile, comic books in another pile, and baseball cards in a different pile. He asked you to sort the baseball cards according to teams. That sounded like fun, so you agreed. What you did not realize is that you were about to make an important discovery.

Life Principle



"A wise person learns what really matters in life and sets priorities accordingly."

—Dennie Lindsey

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Lesson 2
Physics

Chapter 1

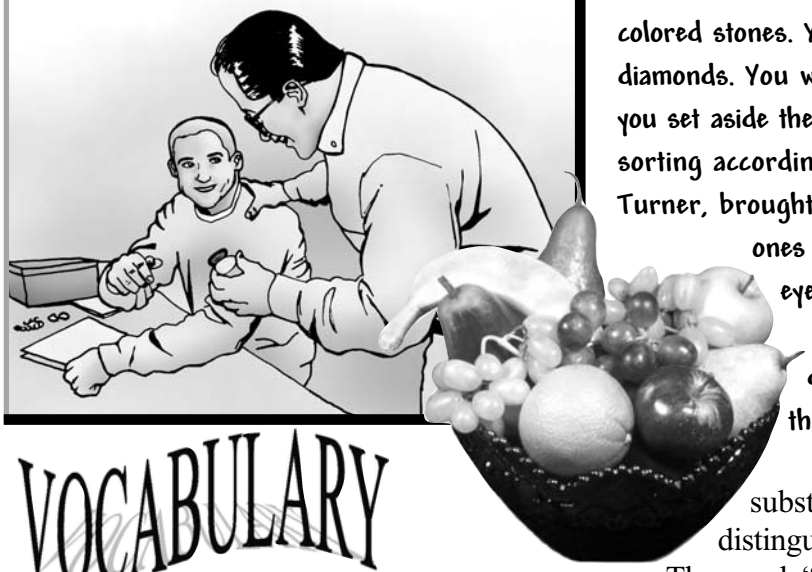
Liquid and Linear Measurements, Weight/Mass Measurements

Section 1

Lessons 1-5

PHYSICAL PROPERTIES OF MATTER

Jason carefully examined all the pieces of jewelry. Then he classified them according to color. Five rings and three necklaces had clear-colored stones. You wondered if any of them were diamonds. You were so interested in the jewelry that you set aside the stack of baseball cards you were sorting according to teams. Jason's uncle, Mr. Turner, brought a jeweler's eyepiece to look at the ones that might be diamonds. The eyepiece was like a magnifying glass. Mr. Turner explained that diamonds had certain properties that made them different from glass.



The *properties* of each substance allow scientists to distinguish one substance from another. The word, "properties," means *characteristics*. You watched Jason sort the jewelry according to color. Color is one of the physical properties of a substance. Other properties include shape, size and brittleness. Any characteristic of a material that can be observed or measured is a ***physical property***. A physical property is a characteristic that helps you identify an object or a substance. State of matter is a physical property.

You can determine many physical properties with your non-sight senses even if you are blindfolded. Taste is one of the senses. You can determine the difference between an orange and a grapefruit by taste. Smell is one of the senses. You can determine the difference between an orange and an apple by smell. Touch is a sense. You can determine the difference between a banana and an apple by the sense of touch. Sight is

Physical property has substance—touch, smell, taste, color, shape, size and brittleness.

VOCABULARY

Physical property: any characteristic of an object that can be observed or measured
Length: the distance between two points
Linear measurements: a system of units for measuring length
Liquid measurements: a system of units for measuring liquid volume
Weight/mass measurements: a system of units for measuring weight
SI: International System of measurement

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also one of the senses. You can determine the differences between fruit by sight.



As you use your sense of sight to determine the physical properties of an object, you can use common measurements to identify its size and shape. In scientific measurement, ***length*** is the distance between two points. Length is a physical property of an object because it can be observed and measured. Common ***linear measurements*** scientists use are millimeters, centimeters, meters and kilometers. These are units of measurement in the International System (***SI***) of Measurement. You may be more familiar with American terms such as inches, feet, yards and miles.

LENGTH	**EQUIVALENT**
1 centimeter (cm)	10 millimeters (mm)
1 meter (m)	100 centimeters (cm)
1 kilometer (km)	1,000 meters (m)

Volume is another physical property because it can be observed and measured. Volume is the amount of space an object or a material occupies. You are probably familiar with buying soft drinks in two-liter bottles. As you learned from the previous lesson, liquid is a state of matter that has no definite shape but does have volume. The liquid fruit drink is poured into a two-liter bottle. The liquid takes the shape of the bottle. ***Liquid measurements*** of liters and milliliters are the most common units used to express the volume of liquids. You may be more familiar with American terms such as cups, quarts and gallons.



Mass is another physical property of a substance because it is observable and measurable. In the previous lesson you determined that the mass of a golf ball is greater than the mass of a ping pong ball. ***Weight/mass measurements*** of objects are usually expressed in grams. You may be more familiar with American terms such as ounces and pounds.

VOLUME	**EQUIVALENT**
1,000 milliliters (ml)	1 liter (l)

The temperature at which a substance

MASS	**EQUIVALENT**
1,000 grams (g)	1 kilogram (kg)

boils, melts or freezes is also a physical property of matter. Temperature measurements in *SI* are often made in degrees Celsius. Each solid substance has its own melting point. The melting point of ice is 0°C while the melting point of copper is 1,083°C.

The state, or form, of a substance depends upon its temperature. A substance is classified as a solid, liquid, or gas according to the state of that substance at room temperature. Room temperature is considered to be 23°C. A substance can change from one physical state to another, depending on temperature.

You are familiar with water in each of the three states. When water is frozen, it becomes a solid and we call it ice. When water is in its liquid state, we simply refer to it as water. When water is boiled, it evaporates into the air as steam or water vapor. That is when it is in its gaseous state. However, in all three states, it still exists as water, which is expressed in chemical terms as H_20. In all three states, the chemical formula never changes. Only the physical state changes.

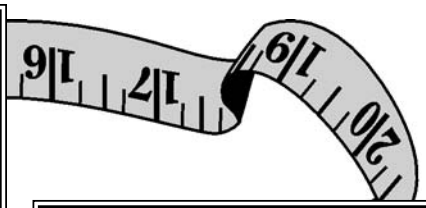


A substance is the same substance after a physical change. You can melt gold and it will still be gold. You can melt lead and it will still be lead. You can melt ice (water in the solid state) and it will still be water (in the liquid state). You can cut a

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copper wire in half and it will still be copper. All of these are ways that you change the physical properties of a substance. Yet, you can not, by physical means, change the substance from what it really is. Nonphysical ways of changing substances do exist, but you will find out about that in another lesson.

You were disappointed to hear Mr. Turner say that no diamonds were among the clear-colored pieces of jewelry. The stones were not hard enough to be diamonds. They do not have the physical properties of diamonds. They were simply other types of stones or pieces of glass. Mr. Turner asked you if you found any interesting baseball cards. Since you had not, you resumed looking through the stack. What you found surprised even Mr. Turner. But more about that later!



LINEAR MEASURE

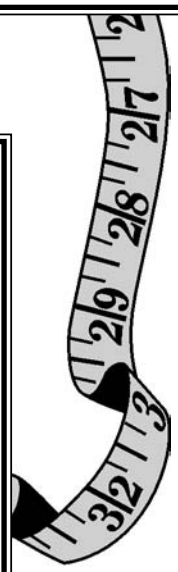
U.S.	Metric
1 inch (in.)	25.4 millimeters (mm) 2.54 centimeters (cm)
1 foot (ft.) = 12 in.	304.8 millimeters (mm) 30.48 centimeters (cm) .3048 meter (m)
1 yard (yd.) = 3 ft.	.9144 meter (m)
1 mile (mi) = 5280 ft.; 1760 yds.	1609.3 meters (m) 1.6093 kilometers (km)

Metric	U.S.
1 millimeter (mm)	.03937 in.
1 centimeter (cm)	.3937 in.
1 meter (m)	39.37 in. 3.2808 ft. 1.0936 yds.
1 kilometer (km)	3280.8 ft. 1093.6 yds. .62137 mi.

MASS / WEIGHTS / MEASUREMENTS

U.S.	Metric
1 grain	.064799 gram (g)
1 ounce = 437.5 grains	28.350 grams (g)
1 pound = 16 oz.	.45359 kilograms (kg)
1 short ton = 2000 lb.	907.18 (kg) .90718 metric ton
1 long ton = 2240 lb.	1016 kilograms (kg) 1.016 metric tons





LIQUID MEASURE

U.S.	Metric
1 fluid ounce (fl. oz.)	29.573 milliliters (ml)
1 cup (c.) = 8 fl. oz.	.2365 liter (l)
1 pint (pt.) = 16 fl. oz; 2 c.	.473 liter (l)
1 quart (qt.) = 2 pt.; 32 fl. oz.; 4 c.	9.4635 deciliters (dl) .94635 liter (l)
1 gallon (gal.) = 4 qts.; 128 fl. oz.; 16 c.	3.7854 liters (l)

Metric	U.S.
1 millilter (ml) = .001 (l)	.033814 fl. oz.
1 deciliter (dl) = .1 (l)	3.3814 fl. oz.
1 liter (l)	33.814 fl. oz. 1.0567 qts. .26417 gal.

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METRIC UNITS / U.S. EQUIVALENTS

(rounded off for easier reference)

Prefix		Metric Unit		U.S. Equivalents				
milli-	= 1/1000	1 millimeter	=	.039 inch				
centi-	= 1/100	1 centimeter	=	.39 inch				
deci-	= 1/10	1 decimeter	=	3.937 inches	=	.32 foot		
		1 meter	=	39.37 inches	=	3.2 feet	=	1.1 yard
deca-	= 10	1 decameter	=	393.7 inches	=	32 feet	=	10 yards
hecto-	= 100	1 hectometer	=	3937 inches	=	328 feet	=	109 yards
kilo-	= 1000	1 kilometer	=	39300 inches	=	3280 feet	=	1090 yards

METRIC CONVERSION CHARTS

(rounded off for easier references)

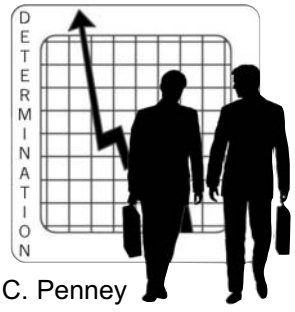
Metric to U.S.					U.S. to Metric				
Length									
millimeters	x	.04	=	inches	inches	x	25.4	=	millimeters
centimters	x	.39	=	inches	inches	x	2.54	=	centimeters
meters	x	3.28	=	feet	feet	x	.304	=	meters
meters	x	1.09	=	yards	yards	x	.91	=	meters
kilometers	x	.6	=	miles	miles	x	1.6	=	kilometers
Volume									
milliliters	x	.03	=	fluid ounces	teaspoons	x	5	=	milliliters
milliliters	x	.06	=	cubic inches	tablespoons	x	15	=	milliliters
liters	x	2.1	=	pints	cubic inches	x	16	=	milliliters
liters	x	1.06	=	quarts	fluid ounces	x	30	=	milliliters
liters	x	.26	=	gallons	cups	x	.24	=	liters
					pints	x	.47	=	liters
					quarts	x	.95	=	liters
					gallons	x	3.8	=	liters
Mass									
grams	x	.035	=	ounces	ounces	x	28	=	grams
kilograms	x	2.2	=	pounds	pounds	x	.45	=	kilograms
short tons	x	.9	=	metric tons	metric tons	x	1.1	=	short tons

Temperature

degrees Fahrenheit	–	32	x	5/9	=	degrees Celsius
degrees Celsius	x	9/5	+	32	=	degrees Fahrenheit

Life Principle

"The possibilities (of success) are measured by determination."



—J.C. Penney

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Lesson 3
Chemistry

Chapter 1

How Substances React With Each Other

Section 1

Lessons 1-5

CHEMICAL PROPERTIES OF MATTER



Most of the baseball cards were of players that you recognized as currently active on a team. Mr. Turner told you that those cards were not as valuable as the older cards of men who played years ago. The older cards were harder to find. Because they were rare, they were worth more money.

As you continued to sort the cards, Mr. Turner examined a gold rock that was in the box with the jewelry and the baseball cards. You wanted to know if it was "real gold" or "fool's gold."



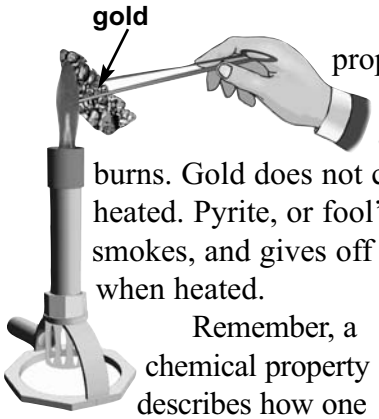
You can tell the difference between different kinds of matter by examining their properties. As you learned in a previous lesson, you can use your senses to distinguish the physical properties of matter, which helps with the identification of a substance. However, in some cases, the properties of a substance are not always noticeable, and other tests for identification need to be made.

Suppose you were trying to distinguish between real gold and ***pyrite***, an iron sulfide mineral compound, which is often called "fool's gold." Certain physical properties distinguish the two pieces of matter. Gold can be scratched with a knife because it is much softer than pyrite. Gold can be hammered without shattering, while pyrite is brittle. Those are examples of physical properties. But suppose that after scratching or hammering the samples, you still were not sure about the identity of your sample. Another test can be conducted as part of the identification process. You can identify the ***chemical properties*** of a substance by observing how a substance responds to, or reacts with, other substances.

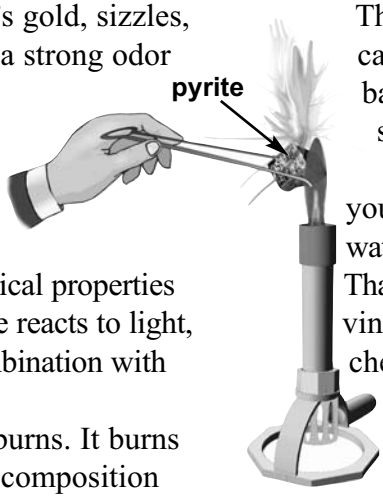
VOCABULARY

Pyrite: a mineral often mistaken for gold; usually called "fool's gold"
Chemical properties: how a substance responds to, or reacts with, other substances
Flammability: the ability of a substance to burn
Hydrogen peroxide: a colorless solution of hydrogen and oxygen used to clean wounds
Opaque: a material through which light is unable to pass
Transparent: a material you are able to see through
Corrosive action: a destructive chemical reaction that wears away a thing

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One chemical property describes whether or not a substance burns. Gold does not change when heated. Pyrite, or fool's gold, sizzles, smokes, and gives off a strong odor when heated.

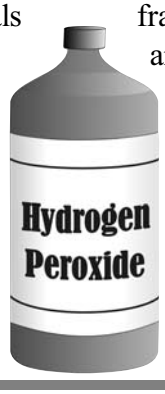


Remember, a chemical property describes how one substance reacts with other substances. Examples of chemical properties would include how a substance reacts to light, or to air, or to water, or in combination with other chemicals.

You know that wood burns. It burns because something within its composition makes it able to burn. This characteristic is called ***flammability*** and is a chemical property of wood. Flammability describes the ability of a substance to burn. If you are going to burn wood, you want to place it in a container that does not have the property of flammability. In other words, you want a fireplace built of stone, bricks or metal. You do not want a fireplace built of wood, paper, straw or any other substance with a high degree of flammability.

The metal called *sodium* reacts so violently with water that an explosion occurs. You would not want a belt buckle made from sodium. Just think what might happen if you got caught outside in the rain. When the water touched your buckle, it would explode! Therefore, belt buckles are made of metals like copper, brass or silver, which do not react violently with water.

Some substances react to light. You might have used ***hydrogen peroxide*** to clean a wound. Did you notice that the bottle of hydrogen peroxide was made of a dark, ***opaque*** material? That is to keep the light from coming in contact with the peroxide. If exposed to light, hydrogen peroxide will change chemically into water and oxygen gas and would no longer be effective for cleaning wounds.



The chemical properties of vinegar cause it to react in the presence of baking soda. When you add baking soda to vinegar, a gas is released. When you add baking soda to water, no gas is produced. That is because water and vinegar have different chemical properties.



The physical properties of aluminum seem to make it ideal for many uses. Aluminum is a lightweight, silvery metal. When aluminum comes in contact with air, the metal rapidly becomes covered with a tough, ***transparent*** layer of aluminum oxide that resists further ***corrosive action***. That means it will not wear away, especially by a chemical reaction. For this reason, materials made of aluminum do not tarnish or rust. Aluminum weighs less than one-third as much as steel, has a high degree of strength and is useful for many products. Because it is lightweight and strong, aluminum is popular in the construction of aircraft, railroad cars, and automobiles. Aluminum is recycled easily. Because it can withstand high heat, it is often used in cooking utensils. Aluminum is also used for siding on buildings and frames for storm windows. Of course, you are familiar with the kitchen product, aluminum foil.

The chemical properties of aluminum, however, can pose some health hazards when ingested or absorbed through the skin. No one takes aluminum pills, but aluminum can enter the body by way of antiperspirants, standard baking powder,

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processed cheese, ladies' makeup items and aluminum soda pop cans, cooking pans and foil.

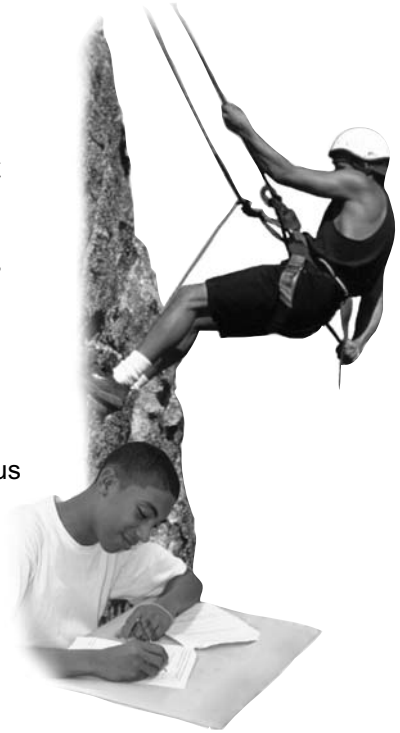
Knowing the physical and chemical properties of substances can be very helpful. Properties can be used to identify substances. Properties can determine the uses and hazards of substances. Remember never to choose a belt buckle made of sodium! (Actually, there are no belt buckles made of sodium.)

Mr. Turner identified the gold rock as pyrite, or fool's gold. Apparently, that box did not contain much of value, unless it was in the form of a baseball card. You had identified several cards of players as New York Yankees. Suddenly, you discovered a Yankee card of a player in an old uniform. Obviously, this was one of the earlier baseball cards. You looked at the name of the player, but you could not believe it! You quickly asked Mr. Turner to look at the card. What he said surprised you.

Life Principle

"Testing reveals our true character."

—Anonymous



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Lesson 4
Chemistry

Chapter 1

How to Tell the Difference

Section 1

Lessons 1-5

PHYSICAL AND CHEMICAL CHANGES



Mr. Turner looked at the baseball card in disbelief. It was a 1956 Mickey Mantle New York Yankees card. That was the year Mickey Mantle won the Triple Crown when he led the American League in home runs, runs batted in, and batting averages. That year he scored 52 home runs, had 130 runs batted in and had a .353 batting average! The card you found was rare and very valuable!

That experience changed the way you looked at the recycling business! If you could find something so valuable among some junk in a box on the first day you were helping, just think what you might find if you continued to sort through other unwanted items!

Mr. Turner was not as excited as you were. He did not want to become rich due to a mistake made by someone else. The woman who brought the box of junk to the pawnshop traded it for a radio she planned to put in her kitchen. Mr. Turner said that he was going to contact the woman to let her know about the baseball card. Mr. Turner had been running an honest business for years. He was not in business to take advantage of people. Therefore, he did not want to make a decision that might change his positive reputation in the neighborhood.

Changes occur under various circumstances. Some changes can be good. Some changes can be bad, depending on the circumstances involved. However, all scientific changes are not classified as "good" or "bad." The types of changes that occur when working with matter are based upon behaviors of the substances involved.

Matter undergoes two kinds of changes—physical and chemical. A ***physical change*** alters the appearance of a

VOCABULARY

Physical change: changes the appearance of a substance, but does not affect its chemical properties

Chemical change: produces a new substance with different properties than the original substance(s)

Tarnish: to become discolored or dull

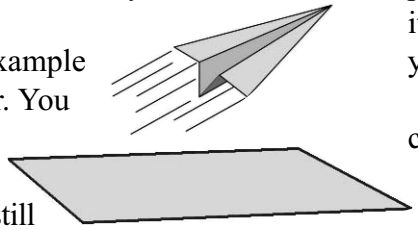
Integrity: a high ethical and moral standard of values

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substance, but does not affect its chemical properties. A physical change affects the way a substance *looks*, but it does not alter what the substance *is*.

For example, think of a piece of chalk. You can break it easily into several smaller pieces; however, it is still chalk, just in smaller pieces than its original condition. You did not change the fact that you are still holding chalk.

Another example is a piece of paper. You can fold it into the shape of an airplane, but it is still paper. Its appearance has changed, but not what it is. It remains a piece of paper.



Think of your hair. You can cut your hair. It might look different, but it is still hair. All you have done is change the physical appearance. The hair did not become another substance.

When you freeze water into ice, you change only the appearance of the water. You do not create a new substance. It is still water, but in a different physical state.

The examples of the chalk, paper, hair and water illustrate that a physical change alters only the size, shape or state of matter of a substance. The substance itself does not change into a different substance.

A change during which at least one of the substances in a material becomes a different substance is a ***chemical change***. This type of change may produce an entirely new substance with different properties.

Think of wood as it is burning. It changes into ash and smoke. Heat is given off as the wood burns. Burning is a chemical change.



Picture in your mind that you are eating an apple. If you eat several bites from it and set it on the counter for a while before returning to eat it, you will notice a change. The part of the apple exposed to the air will have turned brown. That is a chemical change.

The newspapers that you are collecting as part of your school's recycling drive are placed in stacks waiting for you to take the items to the recycling center. Old papers turn yellow. That indicates a chemical change.

Here are some clues that indicate a chemical change has occurred.

Clues that show a chemical change has occurred
Color changes.
A gas is given off.
A solid is formed.
Heat and/or light are given off.
A new substance with new identifying properties is formed.

A bike left outside in the rain will begin to rust. Rust is a reddish brown substance that forms on the metal parts of the bike. The metal reacts with air and water. The new substance that forms is rust. This is a chemical change.

When pennies get old, they ***tarnish***. A new substance forms on the pennies causing them to look dull. The copper in the pennies reacts with the oxygen in the air. This is a chemical change.

Even inside your body, chemical changes are taking place. When you digest food, chemical changes turn the food into substances your body can absorb and use for energy.

All around you, change is taking place. If a physical change takes place, the substance remains the same substance. It has just changed in appearance. If a chemical change takes place, the substance itself has changed in some way, and it is no longer the same.

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Mr. Turner did not want his reputation to change. He wanted to be known as a man of ***integrity***. He did not want to be known as someone who takes advantage of others. He went to the phone to call the woman who had brought in the Mickey Mantle card. As a result of this call, a big change will occur in your neighborhood. But, you will have to wait to see what this change is about!

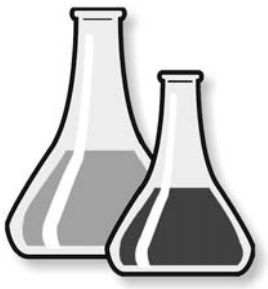
Life Principle

"It is possible at any time to change one's...goals and way of life."

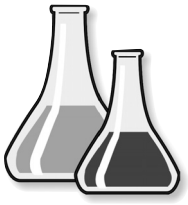
—Paul Gaugina



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Lesson 5
Chemistry

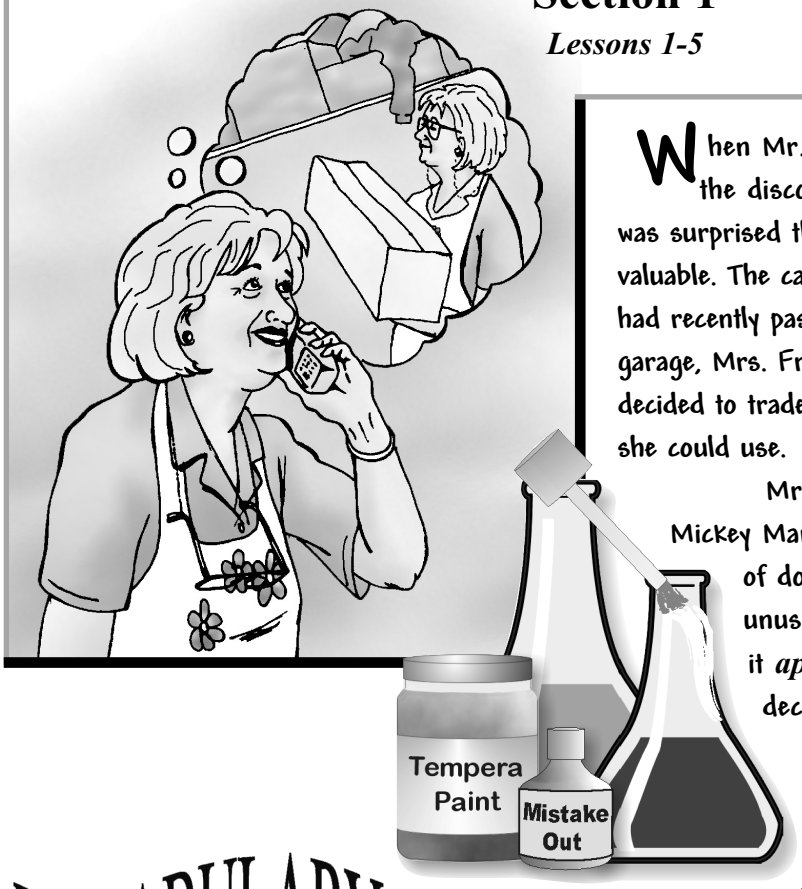
Chapter 1

How "White Out" Came About

Section 1

Lessons 1-5

IMPORTANT DISCOVERIES



When Mr. Turner told Mrs. Franklin about the discovery of the Mickey Mantle card, she was surprised that a baseball card could be so valuable. The cards belonged to her husband who had recently passed away. While cleaning out the garage, Mrs. Franklin found a box of the cards and decided to trade them at the pawnshop for something she could use.

Mr. Turner explained that a 1956 Mickey Mantle card could be worth thousands of dollars. Such a discovery was very unusual. Mr. Turner advised her to have it ***appraised*** by an expert before she decided what to do with it.

Discoveries in science are often made by someone looking for a better way of life. Bette Nesmith was a secretary for the Texas Bank and Trust Company located in Dallas, Texas. The year was 1952. Bette spent most of her days typing on an IBM electric typewriter that used a carbon film ribbon. Whenever she made a mistake and tried to erase the paper, the carbon letters smeared so badly that the page looked too messy to use. She would have to retype the entire page until she could do it without one single mistake. As a result, her boss thought she took too long to type his work, and complained that she was not efficient.

One evening in December as Ms. Nesmith left her downtown office to go home, she noticed two painters painting a holiday scene on the bank's front window. She watched as they painted a mound of snow and a holly branch. With red paint they spelled out the words "Season's Greetings."

VOCABULARY

Appraised: having evaluated the value or worth of a thing
Water-base: soluble in water
Tempera paint: a water-soluble paint; also called *poster paint*; used since ancient times
Grainy: full of tiny lumps or granules
Brittle: likely to break, snap, or crack

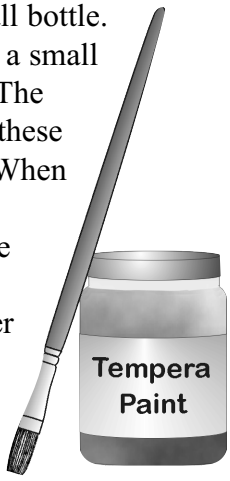
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When one of the painters decided that the final "s" in the word "Season's" was not in line with the rest of the word, the man simply painted over the letter with white paint so that it blended in with the white snow. When the white paint dried, he repainted the "s" in red. It looked perfect. No one could tell that a mistake had been made.

When Bette got home, she talked with her son, Michael, about her day at work. She told Michael about all the mistakes she made while typing. She explained that the carbon ribbon created such a mess that it was impossible to correct her mistakes neatly by using a typewriter eraser. She told Michael that she wished there were a better way to correct typing errors. Michael suggested there must be an easier way than the method his mother was using.

Bette thought about what Michael said and decided to do like the painters did when they made a mistake. They just painted over their mistakes.

That night she found some white, ***water-base, tempera paint*** and put it in a small bottle. Then she obtained a small watercolor brush. The next day she took these supplies to work. When she made her first typing mistake, she painted over it. Unfortunately, after five minutes the paint still was not dry. When her boss saw her just sitting at her desk and not typing, he told her to get busy. She typed over the wet paint, but that made an even bigger mess. Once again, Bette had to retype the entire page.



Two days later, Bette tried a thicker paint, thinking it would dry faster. However it dried ***grainy*** and slowly flaked off the page. The mistake was not even hidden. Several days later she tried a different paint; but it turned ***brittle*** when it dried and cracked when the page was folded.

Bette went to the Dallas Public Library to study paint formulas. Most of what she read was so complicated that she could not understand it. But Bette was determined to find something that worked. She visited Michael's school to speak with his science teacher.

Bette described the type of paint she needed. What Bette did not realize was that she was identifying the physical and chemical properties of paint. Bette was not a scientist. She was just an ordinary person practicing the scientific process. But her experience revealed that she needed paint with specific characteristics.

The following table identifies the properties of the paint Bette wanted.

Bette's Description	Physical Property	Chemical Property
white paint	x (color)	
spread very smoothly	x (texture)	
dry exceptionally fast		x (Paint reacts with the
		oxygen in the air as it
		dries.)
not turn brittle or grainy	x (texture)	
will dry white like paper	x (color)	
cover a mistake	x (density)	
not crack when folded	x (texture)	
stay liquid in the bottle	x (state of matter)	

Michael's science teacher looked through his book of chemicals and gave Bette some suggestions. He also gave her the name of a science professor at a local university. Bette left the school, satisfied that she was going to find a way to paint over her mistakes.

For two years, Bette worked in her kitchen testing various chemicals. She contacted several paint manufacturers for suggestions. Bette tried over 100

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combinations of paints before she found a paint that covered her mistakes professionally.

A few years later, Bette was selling 100 bottles of her special paint each month . Her paint is still being sold today. Many students use it. The first name for her product was "Mistake Out." Later it became "Liquid Paper." Today it is sometimes called "White Out."

Bette Nesmith's story is not unusual. Many science products were discovered just because someone had an idea for doing something better. You will read about more discoveries in other lessons in this chapter.

Bette was not the only one in her family who made an important discovery. Her son, Michael discovered that he could sing and act well. He became a member of a popular television show, *The Monkees*, in the 1960s.

As you progress in your studies, you will read many wonderful stories of ordinary people who made some amazing discoveries.

You discovered the Mickey Mantle baseball card in the stack of cards Mrs. Franklin had brought to the pawnshop. You wondered what Mrs. Franklin would do with the card, now that it had been returned to her. Your wildest dreams could not have prepared you for her response!

Life Principle



"Necessity is the mother of invention."

—Anonymous

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Lesson 6
Chemistry

Chapter 1

Protons, Electrons, Neutrons, Atomic Theory

Section 2

Lessons 6-10

ATOMS— EARLY DISCOVERIES



Several weeks had passed since Mr. Turner returned the baseball card to Mrs. Franklin. After school, Jason told you that his uncle wanted the two of you to stop by the pawnshop for some unbelievable news! When you arrived, you saw Mrs. Franklin and two men talking with Mr. Turner. You recognized one of the men as a baseball coach with the summer league to which you and Jason belonged. The other man was a real estate agent. Mr. Turner explained that Mrs. Franklin wanted you and Jason to join her and the two men as she considered buying a large field near your school. Next came the unbelievable news. With the money Mrs. Franklin made in selling the Mickey Mantle baseball card, she wanted to purchase land and build a ballpark with eight baseball fields that all of the teams in your town could use, free of charge! You said you would have to see that to believe it! Mr. Turner told you to believe it. It was true!

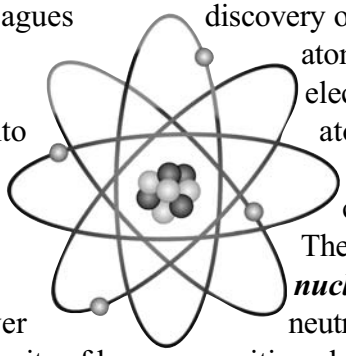
Some things have to be seen to be believed. Some things have to be believed before they can be seen. Some things have to be believed, even if you never actually see them, on the basis of other evidence. Take wind, for example. You know that wind exists, but you cannot actually see it, touch it, or taste it. Yet you know it is real, even though it is invisible. People like Democritus, J. J. Thomson, Ernest Rutherford, and James Chadwick also thought about those things that they could not see. They, too, wondered about "invisible" things, which they believed made up all matter. They knew that matter is anything that takes up space and has mass. They wondered about the *building blocks* of matter.

VOCABULARY

Atom: smallest particle in matter
Atomic Theory: the concept that all matter is composed of atoms
Elements: matter made up of just one kind of atom
Compounds: substances formed when two or more elements combine chemically
Electrons: negatively charged atomic particles
Proton: a positively charged atomic particle
Neutron: an atomic particle with no charge (neutral)
Nucleus: center of the atom consisting of the proton and the neutron
Quarks: subatomic particles

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Over 2,000 years ago, Greek philosopher Democritus tried to imagine what might happen if a material were cut repeatedly. Regardless of how small the object is cut, it retains the same properties, or characteristics. Think of cutting a slice of butter. Whether you cut it thick or thin, it remains the same product. Democritus and his colleagues may not have worked with butter, but as they continued their investigation by cutting objects into smaller parts, other scientists were convinced that tiny unseen units remained intact despite how small items were cut. Perhaps the two scientists sliced pieces of silver into smaller and smaller parts. In spite of how many times a piece of silver was cut, or how small it became, it was still silver. The Greeks gave the name "***atom***" to the tiniest part of matter. To them, "atom" meant "indivisible" implying that regardless how small something was cut, its properties remained the same.



This and other early theories about "indivisible," unseen particles making up matter did not really become credible with scientists until 1808. Then, John Dalton presented an ***Atomic Theory*** combining his ideas and those of other researchers supporting the idea that all matter is composed of atoms. Parts of his theory remain valid today, including his observation that ***elements*** consist of atoms of the same kind, and that atoms of elements combine in certain ratios to form ***compounds***. Still, even at the current point in history, no one has ever seen an atom. Atoms are too small to be seen.

Yet, scientists have persisted in their investigations of the Atomic Theory because they had evidence that atoms existed. Experiments with electricity gave evidence of charged particles in the air. The behavior of gases and the results of chemical reactions became more predictable when the Atomic Theory was applied. In 1897, J. J. Thomson of England experimented to show that particles of matter even smaller than atoms might exist. Experiments indicated existence of negatively charged atomic particles known as ***electrons***. In 1919, Ernest Rutherford announced the discovery of the ***proton***, a positively charged atomic particle equal in force to the electron. The ***neutron***, the third atomic particle discovered in 1932 by James Chadwick, has no electrical charge.

The center of the atom, called the ***nucleus***, consists of the proton and the neutron. Since the proton holds a positive charge, and the neutron is a particle with no charge, the nucleus is positively charged. Each electron in an atom has a negative charge. An atom includes equal numbers of electrons and protons. As a result, atoms are said to be neutral.

The Atom	Charge
Proton	Positive
Neutron	Neutral (no charge)
Electron	Negative

Scientists are continuing to learn about the atom. During the 1970s, scientists discovered the existence of subatomic particles called ***quarks***. Technology allows scientists to trace the shape of the surface of the atom and to arrange the images to form a pattern through the use of a scanning tunneling microscope. With an increasing understanding of the atom, society can benefit from advances in medicine, energy utilization, transportation, communication, and much more! That "unseen" smallest part is an integral part of our lives, whether or not we see it or even know it exists.

Democritus was correct in his assumption that everything is made up of

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small unseen units. We know those small unseen units are atoms. Your hair, your shoes, your clothes, the floor, the ceiling, even the air around you are all made up of atoms. Even though you cannot see them, they do exist. All matter is made up of different arrangements of small, invisible particles called atoms.

You know that the wind exists because you observe evidence of the wind: you see a flag blowing, you see tree limbs bending, you see dust whirling, and you feel air moving across your face and hair. Many people, like Democritus, believe in the existence of unseen things or forces at work in our lives, because they have some evidence, proof or testimony of the presence of things or forces.

You and Jason wanted some proof that what Mr. Turner told you was true. You could not believe Mrs. Franklin would want to spend her money on a baseball park for students like you to use. As you rode with Mrs. Franklin and the men to see the field, she told you something that made you believe her story!

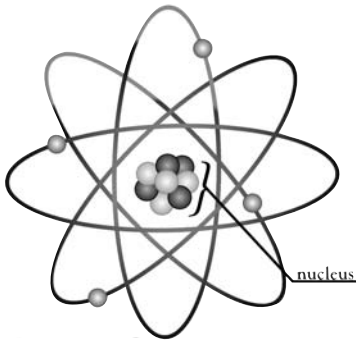
Life Principle

"Some things have to be believed to be seen."

—Ralph Hodgson



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Lesson 7
Chemistry

Chapter 1

Bohr Model, Planetary Model

Section 2

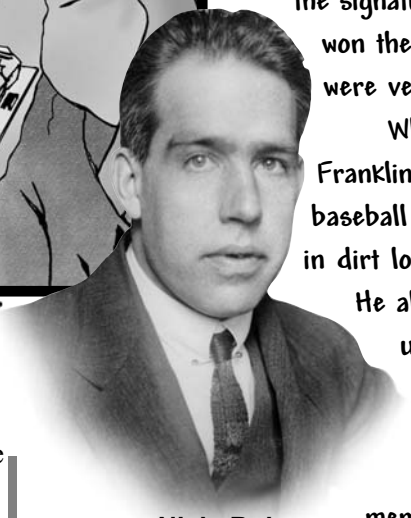
Lessons 6-10

STRUCTURE AND FUNCTION OF THE ATOM



Mrs. Franklin told you that her husband loved baseball and collected baseball equipment and souvenirs. After she realized that the Mickey Mantle baseball card was valuable, she began to think that some of the other items in his collection might be valuable as well. She discovered a bat that was used by Babe Ruth to hit the last homerun of his career and a baseball that had all the signatures of the Chicago Cubs when they won the World Series. Those two rare items were very valuable.

When her husband was young, Mr. Franklin did not have access to a real baseball diamond. He and his friends played in dirt lots or fields in their neighborhoods. He always dreamed of playing in a nice uniform for an organized team on a real baseball diamond; but that never happened.



Niels Bohr

In honor of her husband's memory, Mrs. Franklin planned to sell his baseball collection and wanted to finance the ballpark so that kids would have a nice place to play ball. Mr. Franklin would have wanted it that way. His widow even paid an architect to make a model of the proposed park.

When you arrived at the field, the architect was there with the model. It was a miniature ballpark, complete with eight diamonds, bleachers, snack bars, scoring boxes, dugouts, restroom facilities, and parking lots. Just then, as you stood in the open field, the model of the miniature ballpark helped you visualize what the park would look like once it was built.

VOCABULARY

Bohr model: solar system-like hydrogen model of the atom with an electron moving in a fixed circular orbit around the nucleus

Orbit: path around a fixed point

Planetary model of the atom: electrons revolve around the nucleus of an atom in elliptical orbits

Maximum: greatest amount

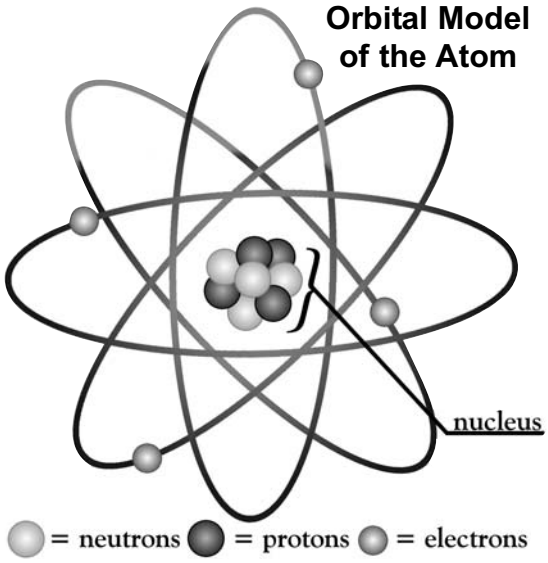
Atomic number: number of protons in an atom's nucleus

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Making things smaller so that we can understand and visualize them is not a new concept. A humorous movie describes the adventures of two children who were accidentally "shrunk" by their father during a science experiment. The children were so small they could hardly be seen. In comparison, insects towered above them. As a result of their size and new perspective, the children saw details they had never before seen when they were of regular size. A few drops of water dripping down a blade of grass almost drowned them. The jaws of an ant's mouth looked ferocious as the children battled for survival. When the experiment reversed, and the children were returned to their normal size, they had a much better understanding of small items.

To aid in the understanding of the structure of the atom, models have been developed to show the relationship of the proton, neutron and electron. Models are not a new concept. In fact, models have been used for years to show an object that is too big or too small to be seen. Models of the Earth, called globes, help us visualize the continents and the oceans. Models of the solar system help us visualize the relationship of the planets to one another and to the Sun.

Niels Bohr, a Danish scientist, developed a model of the hydrogen atom in 1913 to explain how electrons move around the nucleus. The ***Bohr model*** had the single hydrogen electron in a fixed circular ***orbit*** moving around the nucleus, which contained the protons and neutrons. In 1911, British scientist Ernest Rutherford proposed the ***planetary model of the atom*** with electrons orbiting an atom's nucleus in elliptical paths or energy levels. Both models resemble the concept of planets orbiting the Sun and are used to improve understanding of an atom's nucleus, which contains protons and neutrons and the electrons that orbit the nucleus. How interesting is the fact that the largest thing we know about (our solar system) and the smallest thing (the atom), appear very similar in design! We can observe this pattern throughout cultural frameworks: the nucleus, head or leader of any system or enterprise is "orbited" or surrounded by helpers/workers in a teamwork effort for a common goal. The family unit is composed of father and mother (protons and neutron of the nucleus) and children (electrons). Like atoms, some families are stable (functional) while others are unstable (dysfunctional).



Either the Bohr model or Rutherford's planetary model helps identify the placement of electrons on their respective orbits or energy levels. However, scientists currently believe that electron orbits may not be as well defined or uniform in shape. The currently accepted scientific view of the atom is the *orbital model*. The first energy level, closest to the nucleus, can hold a ***maximum*** of two electrons. The second energy level can hold a maximum of eight electrons. The third level

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can hold a maximum of 18 electrons, and the fourth, a maximum of 32 electrons.

Energy Level (orbit)	Maximum Number of Electrons held
Level One	2
Level Two	8
Level Three	18
Level Four	32

The number of protons in the nucleus is called the ***atomic number*** of the element. Hydrogen has an atomic number of one because it has one proton in the nucleus. Helium has an atomic number of two because it has two protons in the nucleus. Knowing an element's atomic number can help you use either the Rutherford or Bohr model to show the placement of electrons on the various energy levels or orbits. Remember that the number of electrons equal the number of protons.

First Ten Elements	
Name of Element	**Atomic Number**
Hydrogen	1
Helium	2
Lithium	3
Beryllium	4
Boron	5
Carbon	6
Nitrogen	7
Oxygen	8
Fluorine	9
Neon	10

The proton and the neutron have about the same mass. The electron is much smaller in comparison. The mass of a single atom is approximately the same as the number of particles in its nucleus since the mass of the electron is so small. Remember that the atom will have the same number of electrons as it does protons.

Scientists use models to describe atoms because they are too small to study. Each atom has a nucleus, which consists of the proton and the neutron. Surrounding the nucleus are the electrons, which move in energy levels. These energy levels can hold only a certain number of electrons. Because the electrons are so small, most of the mass of an atom is found in its nucleus. The atomic number is the number of protons the atom contains. The atom in its natural state will have equal numbers of protons and electrons. Scientists continue to uncover evidences of ways in which small parts play significant roles in crucial discoveries.

As we study models, we can gain a better understanding of the relationship each part of the model has with the entire model. For example, looking at the model of the baseball park helps you see how everything can fit and work together.

You and Jason told Mrs. Franklin that you were on a baseball team and how much you would appreciate having a place, like the model illustrated, where your games could be scheduled. The Coach who accompanied Mrs. Franklin agreed that the selected site was the perfect place. Mrs. Franklin said that once she sold the bat and the autographed ball, she would have enough money to begin the building project.

Unfortunately, there was a problem with the project. Mrs. Franklin would be in for a disappointment when she returned to her house.

Particle	Relative Mass	Charge	Placement
Proton	1	positive	nucleus
Neutron	1	neutral	nucleus
Electron	0.0005	negative	energy level around nucleus

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Life Principle

"Setting a good example is a model for others to follow."

—Dennie Lindsey

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Lesson 8
Chemistry

Chapter 1

Natural and Artificial, Using Symbols

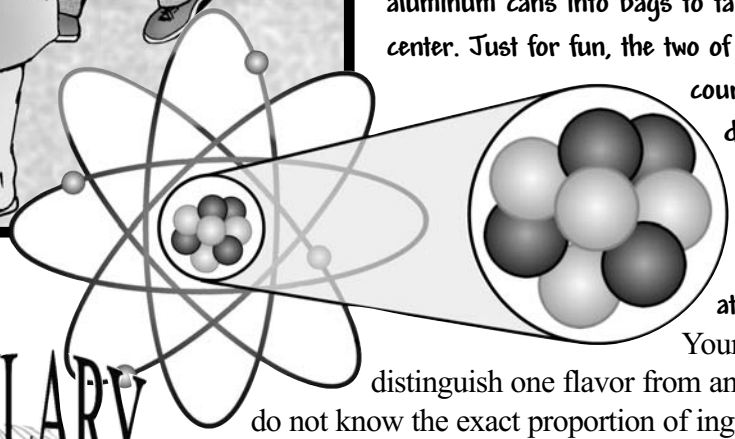
Section 2

Lessons 6-10

ELEMENTS



Several days had passed since Mrs. Franklin took you, Jason, the real estate agent and the coach to the field where the ballpark was to be constructed. Mrs. Franklin invited you and Jason to stop by her house whenever you had a free afternoon. She wanted to show you some more things in her husband's collection. Lately, you had been too busy to visit her because of your work with the recycling project. Each day after school, you helped some of the teachers and other students work on the recycling project. This day you and Jason were loading the aluminum cans into bags to take to the recycling center. Just for fun, the two of you kept an unofficial count of the different soft drink cans tossed in the recycling bins. You wanted to see which soft drink students preferred at your school.



Your taste buds help you distinguish one flavor from another. However, you do not know the exact proportion of ingredients in numerous beverages sold in your community. Advertising campaigns call for people to compare various products. Many people prefer certain brands while an equal number of people seem to prefer other brands. What makes one brand of an item different from other brands of the same item is a well-kept secret.

Ancient Greek ***philosophers*** as well as present-day scientists considered those same types of questions when they looked at the world around them. They wondered what actually made up everything they could see. They wanted to know the differences and the similarities.

VOCABULARY

Philosophers: people who think logically and analytically about important issues
Element: a substance that cannot be separated into simpler substances
Decomposed: broken apart into simpler substances

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Matter made up of just one kind of atom is called an ***element***. Currently, more than 100 elements have been identified, which means that scientists have identified more than 100 atoms. For example, the element "hydrogen" is made up of only hydrogen atoms. The element "helium" is made up of only helium atoms.

An *element* is a substance that cannot be broken down into anything simpler by ordinary physical or chemical means. Elements can, however, be combined, but that will be discussed in a later lesson. Scientists have discovered a total of 92 naturally occurring elements. In addition, several elements have been made by artificial means.

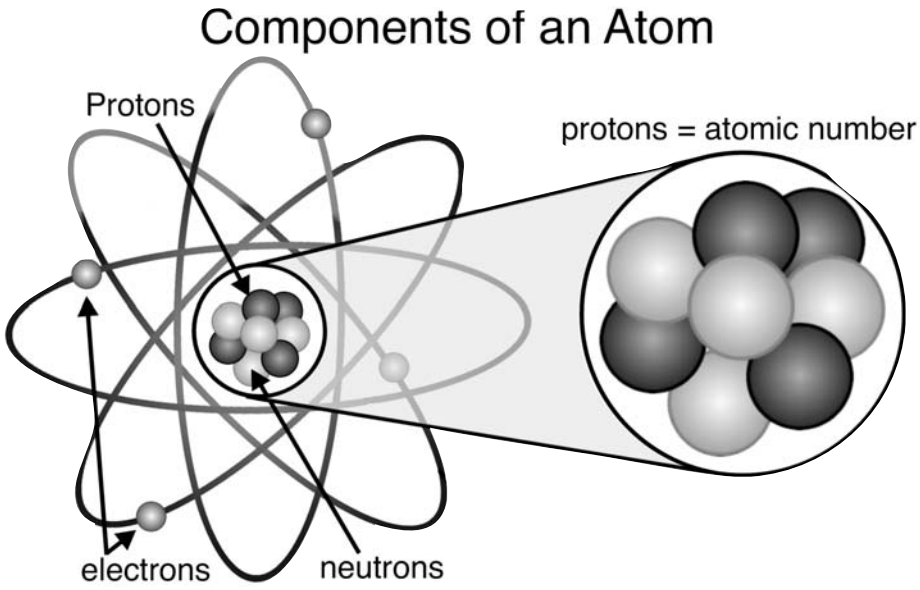
Everything in the universe is composed of elements or a combination of elements. The ancient Greek philosopher, Aristotle, thought that only four basic elements existed: earth, air, fire and water. This idea was accepted for nearly 1,500 years until around 1780 when Henry Cavendish, a British scientist, discovered that water could be ***decomposed*** into two colorless gases: hydrogen and oxygen. That experiment was the beginning of many discoveries that led to the contemporary understanding that more than 100 elements exist.

For many years, the full name of each element was used every time the name of the element was written. Swedish chemist Jons Jakob Berzelius noted that since symbols were used for algebra and physics, perhaps symbols could be used for elements. His idea was well received and, as a result, he established a system by which elements were identified with letters.

An example of a current system of symbols is the official abbreviations for the 50 states of the United States used by the U.S. Post Office. The name of each state is abbreviated with two letters to represent the full name of the state. For example, TX represents Texas and AR represents Arkansas. Arizona is represented by AZ, while California is symbolized by CA.

Most of the symbols for the elements use one or two letters to represent the name of the element. Newer elements have symbols with three letters. The first letter is capitalized. If a second or third letter is used, it is not capitalized. For example, the symbol for hydrogen is *H*. The symbol for helium is *He*.

Some symbols seem unrelated to their names. These symbols represent elements that were discovered when Latin was the language of science. An example would be



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Au, which is the symbol for gold. *Aurum* is the Latin term for *gold*, which gives us the basis for the symbol, *Au*. More recently discovered elements seem to be named for famous people or places. Californium, atomic number 98 and symbol *Cf*, was named for California. An international committee of scientists is responsible for naming newly discovered elements and selecting their symbols.

You learned in a previous lesson that each atom is given an atomic number that equals the number of protons the atom contains. That number is what makes one element different from another element. One element cannot be changed into another element by ordinary chemical means. For years, early scientists tried to change lead (symbol *Pb,* atomic number 82) into gold (symbol *Au,* atomic number 79). Some things can be changed, like attitudes, habits and preferences for beverages. Many other things cannot be changed.

In the previous lesson, you studied a chart listing the first ten elements and their atomic numbers. In this lesson, that chart has been expanded to include the symbol as well.

If everything in the universe can be broken down into elements, that means that the human body must be composed of elements. That is a correct assumption. Physically, the human body is simply a combination of elements. The table below lists the most common elements contained in the human body.

ELEMENTS TABLE

ELEMENT	SYMBOL	ATOMIC NUMBER
Hydrogen	H	1
Helium	He	2
Lithium	Li	3
Beryllium	Be	4
Boron	B	5
Carbon	C	6
Nitrogen	N	7
Oxygen	O	8
Fluorine	F	9
Neon	Ne	10

An element is the simplest form of matter and cannot be chemically changed into anything else. All known matter in the universe is made up of elements, either alone or in different combinations, and that includes everything . . . from planets to baseball cards to textbooks to beverages, to you.

Most Common Elements Found in the Human Body

ELEMENT	SYMBOL	ATOMIC NUMBER
Oxygen	O	8
Carbon	C	6
Hydrogen	H	1
Nitrogen	N	7
Calcium	Ca	20
Phosphorus	P	15
Potassium	K	19
Sulfur	S	16
Sodium	Na	11
Chlorine	Cl	17
Iron	Fe	26

After you and Jason dropped all the aluminum cans at the recycling center, you decided to stop by Mrs. Franklin's house. She was pleased to see the two of you and invited you to look at the bat used by Babe Ruth. She looked in the closet where she had always kept Babe's bat, but she could not find it. She asked you and Jason to search the closet just in case she had overlooked the bat. It was nowhere to be found.

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Life Principle



"A wise person changes the things in his or her life that need changing and accepts those things that cannot be changed."

—Anonymous

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Lesson 9
Chemistry

Chapter 1

Mendeleev, Element Families and Periods

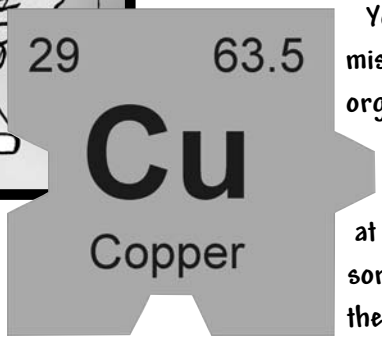
Section 2

Lessons 6-10

ORGANIZING THE PERIODIC TABLE



Mrs. Franklin was very distressed that she could not find the bat used by Babe Ruth. You and Jason looked through the closet where the bat had been placed. The closet was very disorganized. Things seemed to be thrown in there without any thought or plan. You began to sort the items from the closet into groups. All the clothes went in one group, all the shoes in another group, all the sports equipment in another group, and all the old records and tapes in another group. But you did not find a bat anywhere in the closet.



You knew that items could be misplaced without some type of organization for storing things. That's why you were so good at helping with the recycling project at your school. You were good at sorting through things and putting them into groups for storage.

You may have had to take apart something in order to clean or repair individual parts. Most people who work with lawn mowers, audio sound systems, or computers know that the finished product is made up of smaller parts. Usually, when the product is disassembled, the individual parts can be grouped according to common characteristics. Screws can be piled together, wires would make another pile, while nuts or bolts would compose a third and fourth pile.

Breaking down a product and identifying the parts is similar to identifying elements. Grouping those parts with common characteristics is like finding similarities among the elements. For example, wires can consist of copper,

VOCABULARY

Atomic mass: weight of protons and neutrons in the nucleus of an atom

Periodic Table of the Elements: a chart identifying elements by atomic number and mass; arranged by families

Families: elements arranged in vertical columns labeled by Roman numerals on the periodic table; represent elements with similar properties

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aluminum, iron or tin. Copper, aluminum, and tin are elements that are metals, have common properties, and are used for similar purposes.

Once scientists established that all known matter in the universe is made up of elements, either alone or in different combinations, they looked for a way to group, or arrange, these elements. During the nineteenth century, chemists began to list elements by ***atomic mass*** (weight). The weight of protons and neutrons in the nucleus of an atom represent most of the mass of the element, since electrons have such little mass in comparison to the proton and neutron. Early scientists used atomic mass (weight) to organize the elements.

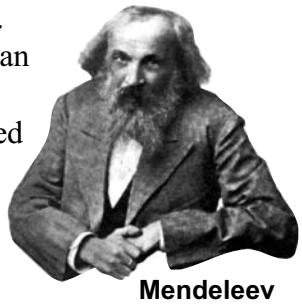
VOCABULARY

Period: established by horizontal rows on the Periodic Table representing elements with the same number of occupied energy levels

Malleable: a material that can be hammered or pressed into shape without breaking

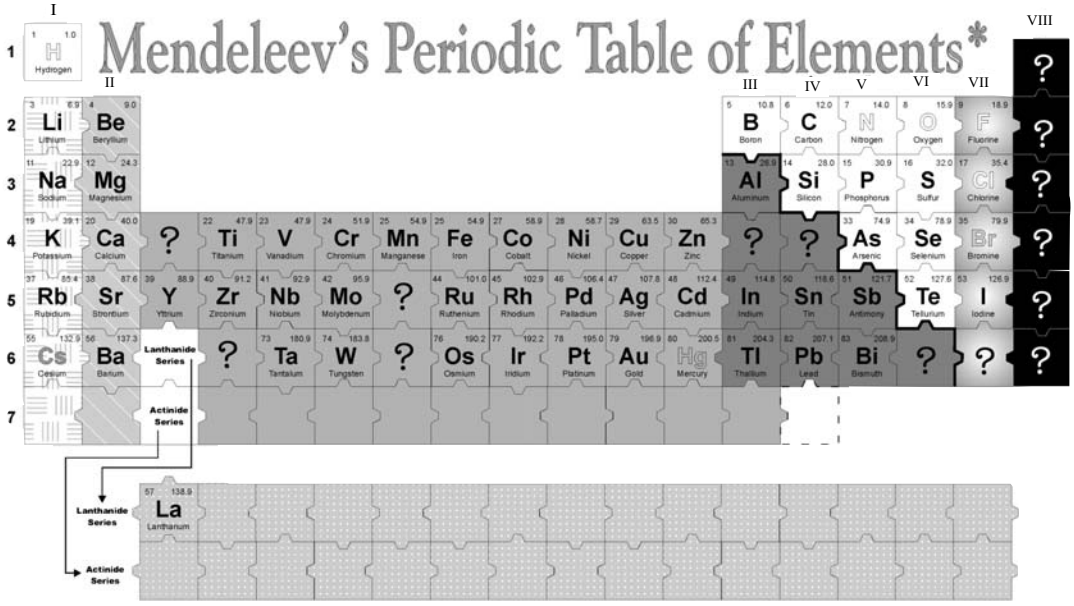
Ductile: a material that can be pulled into a wire without breaking

Insulators: substances through which heat and electricity are unable to pass easily



Mendeleev

In 1869, Russian chemist Dmitri Mendeleev, reorganized the way elements were listed, by grouping elements that shared some properties. Because of the predictable repeating nature of properties, Mendeleev described his organization as "periodic." He placed the known elements on a chart with columns, leaving gaps in the chart for elements with similar properties which could be predicted to fall in the same row. He used atomic mass to organize the elements and



*Elements that Mendeleev believed to exist (but had not been discovered) are labeled "?" The boxes that are blank, are represented in the *modern* periodic table of elements, but were unknown to Mendeleev

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predicted that new elements would be discovered to fill those blank spaces. Mendeleev believed that the composition of matter was orderly and predictable, as though created by a master designer.

Mendeleev was correct in his assumption that there was a repeating nature of the properties of the elements, and that new ones would be discovered. His chart became known as the ***Periodic Table of the Elements*** and only slight adjustments have been made to his original chart. Currently, the elements are arranged in the Periodic Table according to atomic number from least to greatest. All the vertical columns list elements with similar properties. These are called ***families***. Each horizontal line or row is called a ***period***. These contain the elements with the same number of occupied energy levels. The zigzag line to the right of center represents a boundary between two major types of elements: the metals and the nonmetals.

The zigzag line separates the metals from the nonmetals. Metals are to the left of the line and share certain properties. They can be polished to look shiny. Many metals are ***malleable***, that is, they can be hammered or pressed into shape without breaking. Many metals are also ***ductile***, which means that they can be stretched out to form a wire without breaking. Most metals conduct electricity and heat.

Nonmetals, which mean "not metals," are to the right of the line. Hydrogen, a gas, is the only exception to this placement pattern and is found to the left of the zigzag line. Most nonmetals are solids or gases at room temperature and pressure. Nonmetals cannot be polished to look shiny. Nonmetals are ***insulators***. That means that heat and electricity do not pass easily through them. Also, nonmetals usually cannot be hammered, shaped, or stretched to form wires.

Notice that the box containing hydrogen is slightly above the rest of the Periodic Table. Hydrogen is a gas and has properties of a nonmetal. It is placed in family I, rather than in family VII or VIII with the other gases, because the formulas for its compounds are similar to those formed by family I elements. You will learn about compounds and formulas in a later lesson.

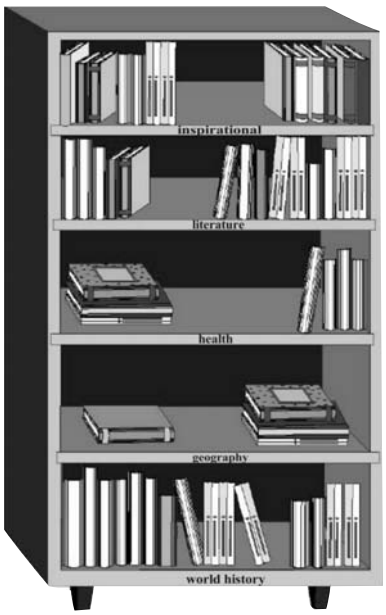
The two separate rows at the bottom of the page are too long to fit into the drawing of the Periodic Table. These two rows belong in periods 6 and 7 and should be placed between families II and III. The table is made more compact and useful by placing them at the bottom.

Mendeleev's Periodic Table gave the scientific community a valuable tool for conducting scientific research that could predict discovery of as yet unknown elements. Chemical properties and chemical behaviors of elements not yet discovered could be anticipated and predicted with Mendeleev's chart. The Periodic Table helps us to see similarities and differences at a glance and have a better understanding of how the world is created in an organized manner.

You had a better understanding of Mrs. Franklin after seeing her closet. No wonder she did not know that she had a valuable Mickey Mantle baseball card mixed in with the newer, less valuable cards she brought to the pawnshop. She did not organize or sort through things. You and Jason offered to look through the rest of her house and her garage to look for the bat. She was thankful for the help. You and Jason were about to be shocked at something else you would find.

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Life Principle



"Things done decently and in order improve understanding and efficiency."

—old proverb

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Lesson 10
Chemistry

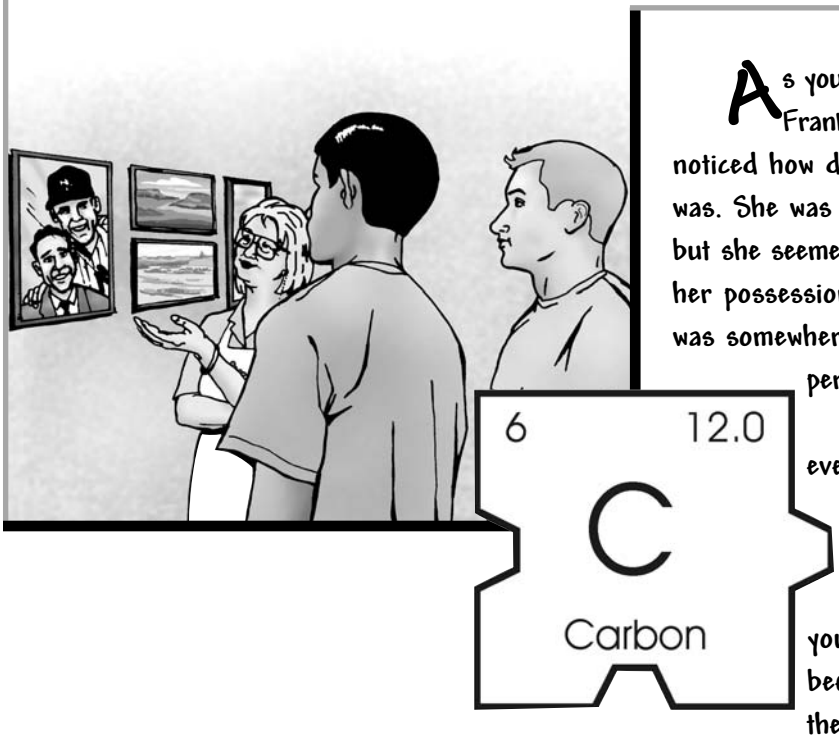
Chapter 1

Atomic Number and Mass, Metal, Alkali Metal and Noble Gas Families

Section 2

Lessons 6-10

INTERPRETING THE PERIODIC TABLE OF THE ELEMENTS



As you and Jason searched Mrs. Franklin's house for the bat, you noticed how disorganized her entire house was. She was a very nice and generous woman, but she seemed to lack the ability to organize her possessions. You assumed that the bat was somewhere in the house, so with her permission, you continued to look.

Stacks of things were everywhere. Several maps of New York were open on a table. Mrs. Franklin mentioned that she was looking at the maps just before you and Jason arrived and had been ***reminiscing*** about some of the places she and her husband had visited in New York. She pointed out locations of the Statue of Liberty, the Empire State Building, and Yankee Stadium. She and her husband had relied on those maps to locate places of interest when they traveled.

VOCABULARY

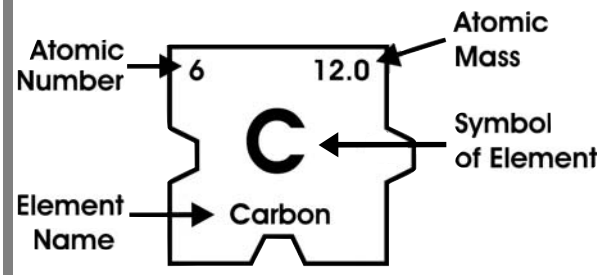
Reminiscing: awakening memories; bringing to mind past events
Alkali: an active base substance; neutralizes acids; in soil is detrimental to crops
Luster: shine
Format: the plan, organization or style of a chart, paper, book, program or other thing

Many people use a map to locate points of interest or to provide directions to a specific location. Others use a map to get an overall picture of an area. Scientists also use maps, charts, and graphs to locate information. The Periodic Table of the Elements is much like a map that helps you to find information quickly and easily as well as helping you to find common points of interest among the elements.

The elements are divided, much like a city, into various sections. Instead of sections with parks, industrial areas, neighborhoods, or shopping malls, the Periodic Table of the Elements has sections of elements that are organized according

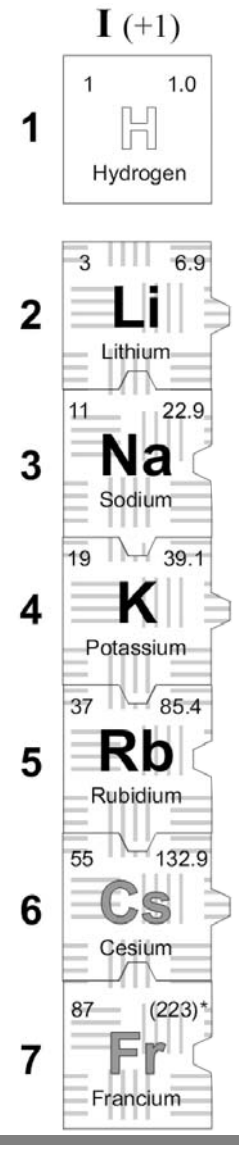
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to common properties. The Periodic Table of the Elements allows you to locate specific elements rapidly and arrive at conclusions about their behavior.



Each box on the Periodic Table of the Elements contains information about one of the known elements. The *whole number* at the top is the *atomic number*. You will recall that the atomic number equals the number of protons contained in the nucleus of each atom (of each element). The symbol of the element, which is an abbreviation of its name, is located at the center of the box. Beneath the symbol is the actual name of the element. The other number is the *atomic mass* (weight), which, represents the *mass* (weight) of the atom. It may be located at either top or bottom; but it is always expressed as a *decimal*.

The elements that are arranged in vertical columns are called *families*. The families are numbered with Roman numerals from I to VIII. In much the same way as with brothers and sisters in a human family, elements in the same family resemble each other and react in similar ways to other substances. Brothers and sisters in some families tend to react in similar ways because they have been raised by the same rules within the same house. Elements in some of the families tend to react in similar ways because each has the same number of electrons on the outer energy level. In most cases, the number and placement of electrons on the outer energy level cause specific behavior of the element. Atoms that have completely filled energy levels or that have eight electrons in the outermost energy level do not lose electrons easily. In other words, the elements of these atoms will be more stable and not react or combine easily. Atoms with less than eight electrons in their outermost energy level are unstable. Those atoms are looking for a combination of at least eight electrons to complete their outermost energy levels. Turn to the Periodic Table of the Elements, at the back of your text. Notice family number I beginning with lithium. All items are metals, but each element has only one electron in its outer energy level, causing each element to be very unstable. That means family I members react strongly with other substances, including water. Lithium bursts into flame in water. Elements in family I are called ***alkali*** metals. They are so soft they can be cut with a knife. Alkali metals have a metallic ***luster***, and conduct heat and electricity. In nature, these metals react immediately with air, water or other substances.



Each element in family number II has two electrons in the outer energy level. This family is called the *alkaline earth metals*. They are not quite as reactive as the alkali metals.

Elements in families number III, IV, V, VI, VII, and VIII continue the pattern of the family number identifying the number of electrons in the outer energy level. For example, elements in family number III have 3 electrons in the outer energy level;

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elements in family number IV have 4 electrons in the outer energy level. This periodic pattern continues through family number VIII. It is one of the several patterns found in the Periodic Table. The following chart identifies this pattern.

Family Number	Number of Electrons in Outer Energy Level
I (1)	1
II (2)	2
III (3)	3
IV (4)	4
V (5)	5
VI (6)	6
VII (7)	7
VIII (8)	8

Family VII, the halogens, are very reactive and often combine with other elements. In addition, all the elements in family VII are poisonous. Each element has seven electrons in its outer energy level or orbit.

Family VIII elements are very stable. That is because each one has eight electrons in its outer energy level. Family VIII consists of gases that do not combine easily with other elements. Family VIII gases were given the name "noble" gases because like "noblemen," they refused to mix with the "common" people (or in this case, with other elements). They do not mix easily with other elements.

A *pattern* is information organized in a repeating ***format*** that helps us to remember the facts as well as make predictions regarding those facts. We find patterns in calendars, in clocks, in music, in football plays, in seasons, in zip codes, in the metric system . . . the list could go on and on. The Periodic Table of the Elements contains several patterns that help us to understand and predict the behavior of the elements and the families to which they belong.

When you came to a long hallway, you noticed family pictures on the wall. You paused to look at one of a man in a suit standing next to a man in a baseball uniform. Mrs. Franklin told you that the man in the suit was her husband. The baseball player was wearing an old, New York Yankee uniform. The picture was about 40 years old. You and Jason stared at the picture in shock. You were sure you recognized that face and that uniform. Mrs. Franklin told you that her husband and that player were from the same family.

You asked Mrs. Franklin to tell you about the picture. She said that it was a story worth repeating! But, just as she began, the doorbell rang.

Life Principle



"Basic elements of love, joy and peace characterize stable, happy families."

—Nancy Johnson

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Lesson 11
Chemistry

Chapter 1

Covalent and Ionic

Section 3

Lessons 11-15

KINDS OF CHEMICAL BONDS



Jason's mom rang the doorbell at Mrs. Franklin's house and told you and Jason that the money your school had collected for the recycled products was missing. Your principal wanted you and Jason to return to school that evening to meet with the other students and teachers involved in the project.

Mrs. Franklin's story about the picture would have to wait. The search for the missing bat would have to be ***postponed*** as well. The important thing just then was that the project money be located. Unfortunately, you did remember where you saw the money last. Jason had put the money in his pocket earlier in the week when the two of you bundled up all the newspapers and took them to the recycling center.

You were certain about one thing: Jason was not a thief. In fact, Jason was like his uncle, Mr. Turner, who did not want to take advantage of Mrs. Franklin by keeping the valuable Mickey Mantle baseball card, even though she had traded it for a radio. Maybe the money had stuck to something in Jason's pocket and accidentally been thrown away. Things can stick together unintentionally. In fact, that had happened to you recently when you accidently threw one of your homework assignments into the trash can. Realizing your mistake, you had quickly retrieved the paper, but it was stuck to some gum. You had to redo the assignment because you tore the paper while removing the gum.

VOCABULARY

Postponed: delayed until later
Chemical bonds: forces that hold together the atoms in a compound
Compound: a substance formed when two or more elements combine chemically
Molecules: smallest particles into which an element or compound can be divided without changing its chemical properties
Covalent bond: type of bonding produced when atoms share electrons
Carbon dioxide: gas made up of carbon and oxygen; used by plants

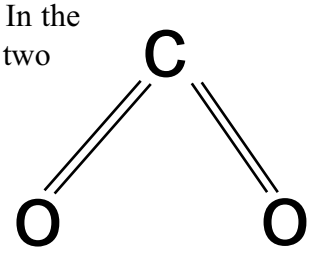
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However, suppose you want to stick two items together. You have many choices. Some of the most common ways are to tie them, glue them, tape them, chain them, thumb tack them, or weld them together. Your choice should certainly depend on composition of the items. Two bulldogs would quickly become very upset if you tried to tape them together! Obviously, the substance with which you are working determines the bonding method. The same is true with atoms. When atoms combine with other atoms, ***chemical bonds*** are formed. Chemical bonds are forces that hold together the atoms in a ***compound***. A compound is a substance formed when two or more elements combine chemically to form ***molecules***.

Atoms form chemical bonds in two general ways. Atoms either share electrons to become stable or they gain or lose electrons to become stable. Remember that the atom is trying to become stable by either filling up its outer energy level with the maximum number of electrons allowed, or by having at least eight electrons on its outer energy level.

When atoms share electrons to fill their outer levels, the chemical bond that forms is called a ***covalent bond***. Water is an important covalent compound. Each molecule of water contains two atoms of hydrogen and one atom of oxygen. The oxygen atom's outer level is filled by sharing an electron from each of the two hydrogen atoms.

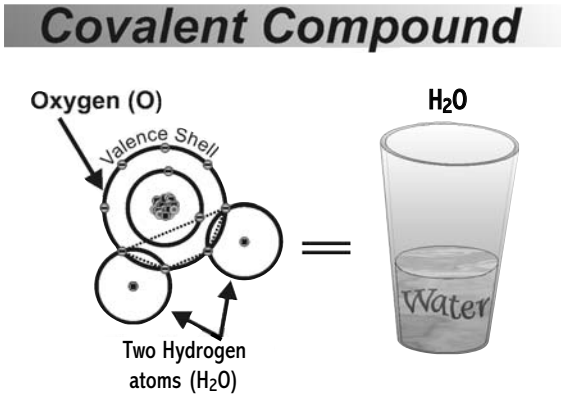
Another covalent compound is ***carbon dioxide***. This gas is produced by animals with lungs or by burning carbon products. Plants use the carbon dioxide produced by animals during respiration. In the carbon dioxide molecule, two atoms of oxygen and one atom of carbon share electrons.



In a covalent bond, electrons spend time in the outer energy levels of the atom, allowing each atom to have, at some time, a full outer energy level. Since they are sharing an electron, a neutral particle is formed. These neutral particles are called molecules. Both the atoms and the molecules remain neutral.

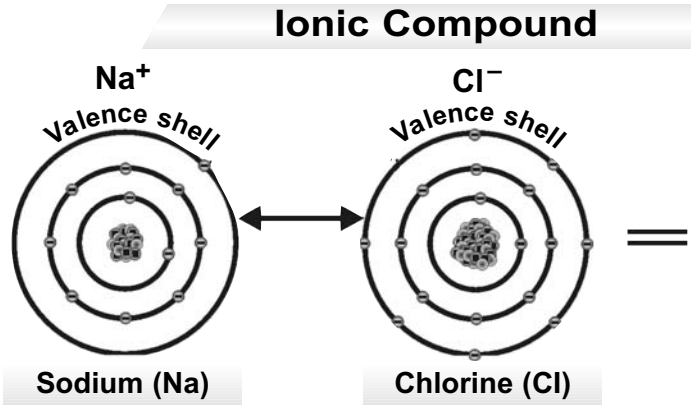
Another method of atomic bonding is the process in which atoms gain or lose electrons. An atom that gains or loses an electron becomes an *ion*, and becomes either positively or negatively charged. Remember that before the bonding process occurs, an atom is neutral. This is because it has the same number of positive charges (protons) as it does negative charges (electrons). The atom that loses an electron, loses a negative charge. That leaves more positive charges than negative charges in the atom, so it becomes positively charged. The atom that gains an electron, takes on one more negatively charged unit than it has positively charged units. That gives it a negative charge. An attraction forms between these two oppositely charged atoms because "opposites attract." Positive ions and negative ions attract each other strongly. This is called *ionic bonding*.

An example of ionic bonding is the process in which sodium atoms and chlorine atoms come together. Sodium atoms have 11 electrons with one electron being in the outer level. That makes sodium very unstable. Rather than sharing its outer electron, sodium tends to lose one electron completely to become stable. The chlorine atom has 17



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electrons altogether, with seven of them in the outer level. As you recall, an atom tries to fill its outer shell so that it has eight electrons. Chlorine wants to gain an electron. Sodium wants to lose an electron. Therefore, for both atoms to become stable, the sodium atom will lose one outer electron to the chlorine atom. The two oppositely charged ions are then electrically attracted to each other. Sodium and chlorine form an ionic bond to become sodium chloride, which is common table salt.



When an atom becomes an ion, it assumes an electrical charge. The + stands for the positive charge and the - stands for the negative charge. The sign is written at the upper right of the symbol, indicating that it is an ion rather than an atom.

Most ionic compounds will conduct an electric current when the compounds are melted or dissolved in water. Most of them are solid crystals with high melting points.

Atoms are trying to stabilize whether by sharing electrons or gaining or losing electrons. As a result, atoms join with other atoms either through covalent bonding or ionic bonding. The electrons determine the method of how they "stick together."

You were going to stick with Jason because you believed in him. When you arrived at the meeting, the first thing you did was tell the principal that you had seen Jason put the money in his pocket, but you know that he did not steal it. The principal asked Jason for an explanation.

Jason explained that he planned to turn the money in, but that he could not find it the next day when he searched his pockets. He did not say anything about it, because he thought it must have fallen out and that he would find it. Then, with all the activities at school and at his uncle's pawnshop, as well as with Mrs. Franklin, he simply forgot about it. Jason's mother looked shocked.

She told Jason that he should have communicated with her about the missing money because she knew exactly where it was. She had washed Jason's clothes along with her husband's clothes that same night, although she had forgotten to check the pockets of the pants before she washed them. In the bottom of the clothes dryer, she found sixty dollars. She just assumed that it had fallen out of her husband's pants, so she decided to deposit it in their bank account. She told the principal that she would return the sixty dollars the following morning.

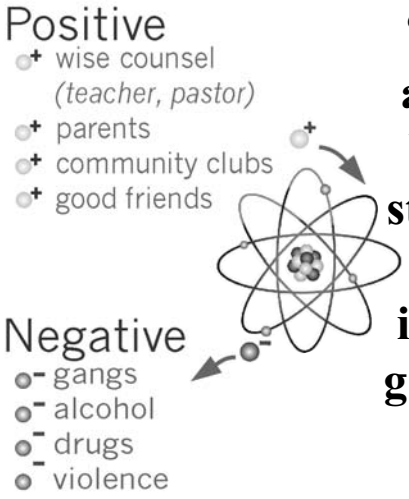
The principal realized that this was an honest mistake. He believed Jason and his mother because their family had such a good reputation in the community. The principal had heard the story about Jason's uncle returning the valuable baseball card to Mrs. Franklin; so he knew that the family valued honesty and integrity.

The principal suggested that the boys needed a better system of organization for turning in the money from the project. He explained that unless things were managed in an organized way, they easily could be lost. You knew that was true because Mrs. Franklin could not find Babe Ruth's old bat.

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You were glad you had stuck by Jason. You knew he would have a good explanation. The next day, you and Jason planned to resume the search for the bat and hear the story about the picture of Mrs. Franklin's husband and the Yankee baseball player.

Life Principle



"Like many atoms, we can become more stable by losing negative influences and gaining positive ones."

—Anonymous

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Lesson 12
Chemistry

Chapter 1

Adhesion and Cohesion

Section 3

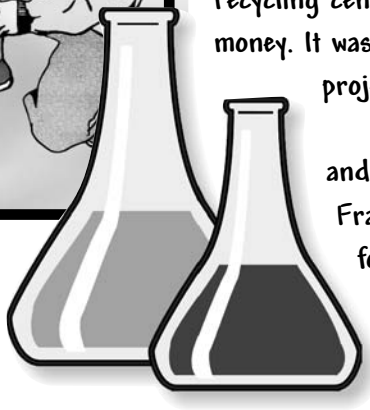
Lessons 11-15

ADHESIVES



Jason's mom brought the sixty dollars to the principal the next day. That raised the project account to almost five hundred dollars that your school had made just from collecting paper, plastic and aluminum cans. The principal set up a system for you and Jason to return the money to the school office each time you hauled the items to the recycling center and issued you a receipt for the money. It was a good system and helped the project to be more organized.

Several days passed before you and Jason had time to return to Mrs. Franklin's house. You hoped she had found the baseball bat, but she had not. As you searched her garage and closets, you helped her develop a system for organizing her possessions. In her garage, you and Jason put tools in one box, old books in a different box, screws, nuts and bolts in still another box, and old letters in another box. You did the same for items in Mrs. Franklin's closet. Before you closed each box, you wrote the contents of the box on a card and taped it to the box. That process enabled her to read the card to identify contents without having to open each box. Mrs. Franklin liked that idea. When you ran out of tape, you used glue to secure each card to its box.



VOCABULARY

Chemists: scientists who study matter and the changes that happen to it
Adhesives: materials that can hold substances together
Adhesion: the attraction force between atoms or molecules of different types
Cohesion: the attraction between atoms or molecules of the same type

You can be thankful for men and women who developed the chemicals used for manufacturing glues and tapes. ***Chemists*** are scientists who study matter and the changes that happen to it. By combining various chemicals, scientists have produced many types of ***adhesives***. An adhesive is a material that can hold

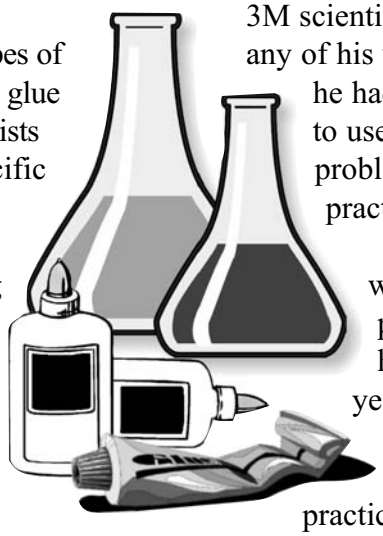
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substances together. Glues and tapes are adhesives that come in various strengths.

Chemists work with compounds and their properties to learn more about ***adhesion***. Adhesion is the attraction which occurs between atoms or molecules *of different types*. When you put glue on a surface of an object, the glue begins to seep into the tiny cracks where it sticks to the molecules of that surface by adhesion. Some of those glue molecules do not come in contact with the surface, but just stick to other molecules of the same glue. That type of attraction is called ***cohesion***, and is defined as the attraction between molecules *of the same type*.

Some adhesives have natural origins. You may have used rubber cement to glue some of your projects in school. Rubber cement is a thick substance made of rubber, as the name implies. Casein glue is glue in which milk protein is a major ingredient. Paste is a mixture of flour (or other starch) and water used to stick something to paper or other substances.

Many types of glue are manufactured because many types of surfaces need adhesives. Not all glue will work on all surfaces. Chemists develop specific glues for specific surfaces. Epoxy resin is a complex mixture of chemicals which are applied after mixing two parts together. Strong adhesives will always be needed. For example, scientists have helped develop specific glues for dentists to bond broken teeth.



We have not always had glues that would form strong bonds and dry quickly. In January of 1970, a chemist named Spencer Silver worked for the 3M Company, a company that made a full line of glues. Mr. Silver thought he could develop a super glue that would be extremely strong, yet dry quickly. He wrote a proposal regarding his idea and sent it to one of the executives in the company.

Mr. Harris Buell, Vice-President for New Product Development, gave permission for Mr. Silver to work in the chemistry lab for six months to develop this super glue. He even gave Mr. Silver two assistants to help him.

Every day for six months, Mr. Silver tested chemical combinations trying to produce strong glue. He developed over 100 combinations, but nothing worked. He could not produce strong, super glue that would also dry quickly. (He produced a very weak glue that dried quickly.)

At the end of the six months, the super glue project was considered a failure and cancelled. Everyone in the 3M Company believed that Mr. Silver had failed. Although moving on to other prospects, he saved one batch of his weak glue and put it in a storage locker. Mr. Silver continued to work for the company, but was assigned other projects.

Four years later, Arthur Fry, another 3M scientist, asked Mr. Silver if he still had any of his weak glue. Mr. Silver replied that he had saved one bottle. Mr. Fry wanted to use it to see if it would help solve a problem he was having at choir practice.

Mr. Fry explained that he would use little pieces of yellow paper to mark certain hymns in his hymnal. These little pieces of yellow paper were like bookmarks. However, he used quite a few of them each evening at choir practice, and as he would turn from one page to the next, they would usually fall out, dropping to the floor. He would lose his place and would distract other choir members.

Mr. Fry wanted to apply some of Mr. Silver's weak glue to little pieces of yellow paper to see if they would stick to the hymnal

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(church song book) pages. He wanted the paper to stick long enough to last the evening, but not to tear or mark the page when removed. Mr. Fry thought that Mr. Silver's weak glue might solve the problem of lost page markers.



The glue worked perfectly and held the little pieces of paper to the page until the paper tabs were peeled off. No damage was done to the pages of the hymnal after the tabs were removed. Within a month, the entire choir was asking for some of the markers.

Those little pieces of paper with Mr. Silver's weak glue were soon in big demand. The 3M Company recognized the need for a weak glue that would peel off without damaging a surface. Within a year, 3M named them "Post-it Notes." Once considered a failure, Mr. Silver's project became a success.

You hoped your project of finding the baseball bat would not end in failure. What you did not realize is that because of your search, you would achieve success in a way you never imagined. But more about that later!

Life Principle



"Every failure can be a stepping stone to something better."

—Colonel Harland Sanders

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Lesson 13
Chemistry

Chapter 1

Meaning and Use of Element Symbols and Numbers

Section 3

Lessons 11-15

CHEMICAL FORMULAS



The next day when you stopped by Mrs. Franklin's house, you smelled chocolate chip cookies baking. You and Jason were invited to the kitchen for a snack before you continued searching for the lost baseball bat. Mrs. Franklin had intended to bake the cookies last week, but she discovered that there were no chocolate chips in her pantry.



You asked if that was before or after the bat had been misplaced. Mrs. Franklin remembered carrying the bat over to the light to get a better look at what was inscribed on it, but she put the bat somewhere when the phone rang. She just could not remember what she had done with it, but she did think it was the same day she had wanted to bake the cookies.

You decided to look in her kitchen pantry where she kept all her baking ingredients. There it was! Babe Ruth's bat! Mrs. Franklin must have put the bat in the pantry and simply forgot about it.

You looked carefully at the bat. It had Babe Ruth's signature on it. You called the coach who helped sell the Mickey Mantle baseball card and the autographed baseball. He had a buyer for the bat and was glad you found it. The money from the baseball card, the ball, and the bat would cover all expenses for building the baseball park.

Mrs. Franklin was thrilled that you found the bat. She thought you did an extraordinary job of searching for it. She served you and Jason cookies and big glasses of milk. The

VOCABULARY

Baking soda: a white powder known as *sodium bicarbonate*

Baking powder: a mixture of baking soda, starch, and an acidic compound such as cream of tartar; used in baking

Chemical formulas: combinations of symbols and numbers to identify amounts of elements in compounds

Leavening agents: certain ingredients in baked products that make them rise

Carbonates: derived from carbonic acid which is made when carbon dioxide dissolves in water

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cookies were as good as they smelled. They were moist and chewy. Mrs. Franklin was an extraordinary cook! She told you that the cookie recipe was an old one that had been in her family for years.

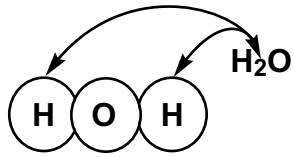
Most cooks do not realize they perform chemical experiments when preparing meals. Many recipes are based on chemical reactions. Cookies, cakes, and breads are moist and tender partially due to the combinations of various chemicals. Although some of the ingredients have common names like ***baking soda*** or ***baking powder***, they are actually the result of chemical interactions and can be described with ***chemical formulas***. Chemical formulas are combinations of symbols and numbers used to identify amounts of elements in compounds.

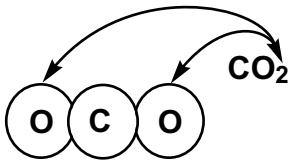
Baking soda, for example, is actually sodium bicarbonate represented by the formula $NaHCO_3$. It is a white powder that decomposes when heated in air above 55°C (131°F). Both baking soda and baking powder produce the necessary carbon dioxide gas to cause certain types of dough to rise or swell in volume. Baking soda and baking powder are used as ***leavening agents***. Baking powder is often used in the preparation of "quick breads," a name given to bread recipes that do not contain yeast and therefore do not require a lengthy time of rising. In quick breads, the baking powder causes the dough to rise by the interaction of ***carbonates*** and acids in a short amount of time, while the item is baking.



Scientists around the world can communicate with one another using chemical formulas regardless of the national language spoken. The Periodic Table of the Elements is recognized and accepted by all scientists worldwide. For example, all scientists agree that *H* is the symbol for hydrogen, *He* is the symbol for helium, and so on throughout the entire chart.

The chemical formula for water is H_2O. Notice that the number "2" is written slightly smaller and below the line and is called a *subscript*. In the formula, H_2O, the subscript "2" indicates that two atoms of the element hydrogen are present. The letter *O* has no subscript, which indicates the presence of just one atom of oxygen. When a subscript does not follow a letter, only one atom is present.





The formula for carbon dioxide is CO_2. Notice that no subscript follows the *C*, which means that element (carbon) has only one atom. CO_2 has one atom of carbon and two atoms of oxygen.

Every chemical compound can be described by a chemical formula. The same elements can combine to form more than one compound. Hydrogen peroxide is H_2O_2. The same elements are used for water as for hydrogen peroxide. Those elements are hydrogen and oxygen. Look closely at the formulas. For hydrogen peroxide, the subscript "2" has been added after the *O*. That makes a big difference. Hydrogen peroxide is used to kill germs on cuts and scrapes. H_2O and H_2O_2 seem almost alike, but that little "2" after the '0' makes a big difference. We can drink H_2O, but not H_2O_2.

Chemical formulas are much quicker and easier to express than writing out the name of the compound. This type of code allows scientists to determine the makeup of a chemical compound rapidly and to communicate easily and accurately.

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You may not have remembered the chemical formula for baking soda, but you did appreciate the fact that it helps cookies, cakes, breads, and biscuits become light and fluffy. You asked Mrs. Franklin for a copy of her chocolate chip cookie recipe for your mom. Maybe she would bake a batch of cookies if you helped!

Life Principle

"Formula for success:
Study + Work +
Preparation +
Perseverance."



—Anonymous

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Lesson 14
Chemistry

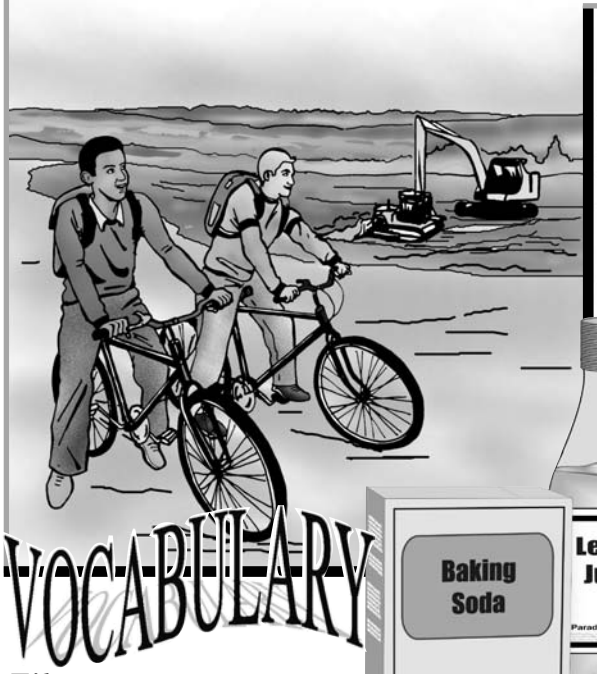
Chapter 1

Acids, Bases and Litmus Paper

Section 3

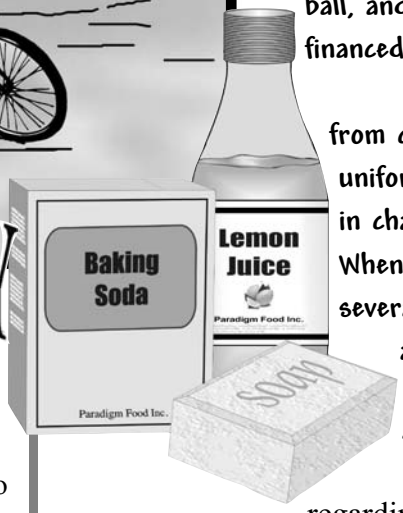
Lessons 11-15

CHEMICALS THAT CLEAN



Several months had passed since you found the Babe Ruth bat in Mrs. Franklin's pantry. After school, you and Jason often rode your bikes to the field where the ballpark construction had begun. You liked watching it take shape. The baseball bat, the autographed ball, and the Mickey Mantle baseball card had financed the project.

Mrs. Franklin wanted coaches from community teams to pick out new player uniforms. Mrs. Franklin put you and Jason in charge of ordering catalogs for uniforms. When the catalogs arrived, you selected several samples to be reviewed by coaches and team representatives. Teams were assigned various colors so the uniform selection could begin.



VOCABULARY

Fibers: threads or yarn in a fabric
Corrosive: destructive; the property of some chemicals to eat way at substances
Litmus paper: a paper specially treated with a dye to distinguish between an acid and a base
pH scale: numbers from 0 to 14 used to indicate the strengths of acids and bases
Widow: a woman whose husband has died
Salve (sav): an ointment that soothes or heals damaged skin
Psoriasis (sor i′ asis): a skin disease marked by recurring inflammation and scaly patches

One of the big questions regarding the uniforms was how they would withstand repeated washings. Guarantees guarding against shrinking or fading would be a major factor. Certain soaps work best on certain ***fibers***. Chemists have made many improvements in the development of laundry products and soaps that remove dirt while preserving color and size of garments.

Cleaning products such as soaps and laundry detergents are examples of a group of compounds called bases. A *base* is a compound that releases hydroxide ions in water. This ion with a negative charge is composed of oxygen and hydrogen. Bases have a bitter taste and feel slippery.

Scientists classify compounds into groups according to certain properties. Bases are one of those groups. Acids are another group of compounds. In water, hydrogen atoms break

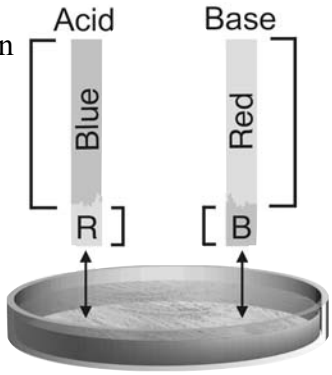
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away from acid molecules, forming hydrogen ions. A hydrogen ion has a positive charge. Weak acids give food a sour, sharp flavor. Citrus fruits, vinegar, yogurt, sour cream, and soda pop are examples of weak acids.

Strong acids and strong bases can burn your skin and are poisonous. Sulfuric acid is used in car batteries. Sulfuric acid is a very strong acid and care should be taken when working on a car battery. Never touch sulfuric acid; it will burn you and "eat" your clothing!

Lye is a strong base and it is used in many drain-cleaning products. You should never touch lye because it, too, is ***corrosive***.

A special type of paper is used to test compounds in order to identify which are bases and which are acids. ***Litmus paper*** is an indicator that changes color when mixed with an acid or a base. An acid turns blue litmus paper to a red color. A base turns red litmus paper to a blue color.



The following table illustrates what occurs when litmus paper is placed in an acidic or basic solution.

COMPOUND	TURNS BLUE LITMUS PAPER TO RED	TURNS RED LITMUS PAPER TO BLUE	IDENTIFICATION
lemon juice	x		acid
orange juice	x		acid
vinegar	x		acid
baking soda		x	base
soap		x	base
ammonia		x	base

Scientists developed the ***pH scale*** to describe the strengths of acids and bases. The pH scale goes from 0 to 14. A pH less than 7 refers to acids. A pH more than 7 refers to bases. The stronger the acid, the lower its pH number. The stronger the base, the higher its pH number. A pH of 7 is neutral. A neutral solution is neither acidic nor basic.

Most soaps and shampoos used on the body are neutral solutions or very weak bases. Madame C. J. Walker was a black woman who became a millionaire by developing a formula for soaps and shampoos and other hair and skin care products in the early 1900s.

Madame Walker was born Sarah Breedlove in 1867. Her parents were former slaves. The family was poor and both parents died by the time Sarah was seven, so she went to live with a sister. Sarah eventually married, but unfortunately, her husband was killed, leaving Sarah as a young ***widow*** with a daughter. The pair moved to St. Louis, Missouri where Sarah worked as a washerwoman and a maid to support herself and her young daughter, Lelia.


Madame Walker

While in St. Louis, Sarah began losing her hair. Alarmed, Sarah tried many hair-care products, but none worked. Finally, she began experimenting with different products and chemicals and finally developed something that helped her condition. Other women with hair loss problems tried her products with excellent results.

Sarah called her product "Wonderful Hair Grower" and began selling it door-to-door. In 1905 she moved to Denver, Colorado and developed other hair products including a ***salve*** for ***psoriasis*** of the scalp. Her products worked well. In 1906 she married Charles Joseph Walker, a Denver newspaperman. Unfortunately, the marriage lasted only a few years, but it began the Madame C. J. Walker Manufacturing Company.

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Madame C. J. Walker organized and trained women to sell her products door-to-door. She established schools to train hair stylists and beauticians. She built a factory to manufacture her hair solutions, facial creams, and related cosmetics. She built a laboratory to research and develop new products.

Madame Walker was a very successful businesswoman who became the first black female millionaire in the United States. She was very generous with her money and gave to many charitable organizations and educational institutions. Tragically, she died in 1919 of kidney failure at the age of 52, possibly due to extensive exposure to chemicals used in her experiments.

People who work with chemicals must exercise extreme caution in handling the substances, knowing their properties, not breathing their fumes and not mistaking one chemical for another. The following sad poem depicts a young chemist who carelessly mistook sulfuric acid (H_2SO_4) for water (H_2O):

Willie was a chemist,
But Willie is no more;
For what he thought was H_20,
Was H_2SO_4 !

Mrs. Franklin gave generously to provide a baseball complex, but she was not very organized. Fortunately, she recognized that you and Jason were good organizers and very responsible with money. She appreciated the way the two of you cleaned and organized her house while looking for the missing baseball bat. She asked you and Jason to stop by her house the next day. She wanted to tell you about the picture you saw in the hallway— the one with her husband and a Yankee baseball player.

Life Principle

"Beauty and optimism go hand in hand."



—Elizabeth Arden

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Lesson 15
Chemistry

Chapter 1

Artificially Produced Substances for Everyday Use

Section 3

Lessons 11-15

THINGS THAT MATTER



You and Jason stopped by Mrs. Franklin's house after school to hear her story about the picture you saw hanging in her hallway when you were looking for the missing baseball bat. She told you that the man in the suit was her husband. The baseball player was a distant cousin of her husband's. Although the two men saw each other only at a few family reunions when they were children, they had one thing in common. They both loved baseball. Even though he did not have the opportunity to play for any kind of organized team, Mr. Franklin played with friends on any available vacant lots or fields. Whenever he went to family reunions, he loved to talk about baseball with his cousin who did have the opportunity to play on a real team. When the cousin grew up, he became a famous New York Yankees player who often provided free game tickets for Mr. Franklin. Mr. Franklin's distant cousin was none other than Mickey Mantle!

You asked to see the picture again, but several months had passed since you noticed it in the hallway. Mrs. Franklin told you that she sent the picture to the Yankees Organization to hang in their Hall of Fame Museum. Jason asked if she had been paid for the picture. She said the Yankee Organization offered to buy it from her, but that she had refused to accept any money. She wanted it to be a gift in appreciation for all of the enjoyment she and her husband had from watching Mickey Mantle play ball. That is what mattered most to her.

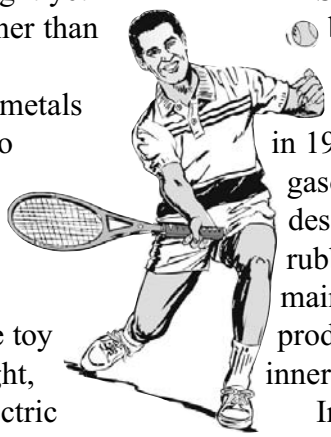
Scientists know that different things matter to different people. Although scientists spend much of their time developing

VOCABULARY

Graphite: a carbon-based material with a metallic lustre; used in pencil lead, lubricants, etc.
Titanium: a strong, low-density metallic element
Synthetic rubber: an artificially produced substance that resembles the chemical and physical properties of natural rubber
Silicon: a nonmetallic element occurring extensively in Earth's crust

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products that will improve the safety and health of people, they also invent things which are just for fun. ***Graphite*** tennis racquets are light and easy to swing. ***Titanium*** golf clubs are lightweight yet make golf balls travel much farther than do clubs made of other metals. Specifically shaped plastics and metals developed for skis allow skiers to perform difficult tricks and jumps. Scientists invent products for adult sports and childhood pleasures.



Silly Putty™ is a pleasure toy invented by scientist James Wright, when he worked for General Electric Research Facility during World War II. Mr. Wright developed Silly Putty by accident while working to produce a ***synthetic rubber*** needed for war-related uses. The outbreak of war in 1939 cut down the supply of natural rubber available to the United States. The federal government spent more than $700 million for establishment of synthetic-rubber plants. Any artificially produced substance that resembles the chemical and physical properties of natural rubber can be called synthetic rubber.

James Wright was a part of a research group working diligently to produce a synthetic rubber that could be used for making truck tires, boots, airplane tires, and other products necessary for equipment used in World War II. Mr. Wright and many other chemists had worked on this project for three years without success.

Some synthetic rubbers had already been produced, but more types were needed, because demand was so great. *Neoprene* was first developed in 1931 and used in hoses for pumping gasoline. *Buna-type rubber* was designated as the general-purpose rubber for the war effort and was used mainly for truck tires. *Butyl rubber* was produced initially in 1940 and used for inner tubes in tires.

In the spring of 1944, Mr. Wright searched for a way to make a rubber substitute from ***silicon***. Silicon is easily refined from sand. His work for the day was to combine silicon oil with several acids. Mr. Wright carefully released a dozen drops of ***boric acid*** into the silicon oil. The mixture bubbled, released white smoke, turned cloudy and ***solidified***. When he poked the soft, lumpy goo with a glass stir rod, it felt springy like rubber.

Next, Mr. Wright ran a pH test to see if this product was strongly acidic or basic. It was pH neutral, meaning it was neither acidic nor basic. He picked up the "goo" and began to observe its properties. It bounced and stretched. When he hit it with a hammer, the substance shattered, but returned to its original shape when the individual pieces were rolled back together. It would pick up the newsprint when pressed against comics.

Mr. Wright and the other scientists had fun playing with this new discovery all day. When the Director of the Research Project came to the lab in the afternoon, he was not pleased with what he saw. He asked if this silly toy was suitable as a rubber substitute. Mr. Wright replied that it was not because it lacked sufficient strength and ***integrity***.

VOCABULARY

Boric acid: a white or colorless compound occurring in nature or made from borax; used as an antiseptic and in making soap, glass, cement, etc.
Solidified: having become solid
Integrity: (of a substance) ability to maintain its properties

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The Director instructed the scientists to put away their silly toy because it did not have a practical use. Then, he told the men to get back to work.

Five years later, in 1949, Peter Hodgson, thought of a use for Wright's invention. Hodgson was a student lab technician in the building the day when Mr. Wright and the others had fun with the gooey mixture. The Director was right. It was a silly toy, but that did not mean it was useless. Although it was not a synthetic rubber suitable for war-related uses, the product could be used as a toy that millions of people could enjoy. Mr. Hodgson made a large batch of the goo, packaged it in plastic Easter eggs and named it *Silly Putty*™. It is still very popular today.

Scientists study the chemical and physical properties of compounds to determine their uses. Some compounds can be used to save lives. Other compounds can be used simply to add enjoyment to our lives. Scientists know that we need some of each.

Mrs. Franklin knew that too. She recognized the work you and Jason had done with the recycling project at your school. She also recognized your organizational skills and management abilities, so she asked you to be in charge of the Snack Shop when it opened at the ballpark. The Snack Shop would feature the chocolate chip cookies you liked so much. Mrs. Franklin volunteered to put the profits into a scholarship fund for you and Jason to attend college! Managing the Snack Shop would be hard work, but she knew the two of you could handle that responsibility. You and Jason were excited about her proposal! You would get paid for something you enjoyed doing and you would still have time to play baseball. That really mattered to you!

Life Principle



"Going out of your way to show kindness matters: 'what goes around, comes around.'"

—old proverb

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