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The Grade 7 Science course of study was prepared in two parallel forms. A short form designed for students who had achieved a high measure of success in previous science courses; the long form for those who have not been able to maintain the pace. Both forms contain similar content. The Grade 7 guide is the first in a three-year sequence for grades 7, 8 and 9. Major topic areas are elements, compounds and mixtures, electricity, magnetism, heat, needs of living things, cells, minerals and rocks, the changing earth, and the importance of fossils. Suggested student and teacher activities are included throughout the guide. (BC)

SCIENCE

Grade 7

Long Form

BOARD OF EDUCATION OF THE CITY OF NEW YORK

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FOREWORD

The Grade 7 Science course of study was prepared in two parallel sequences known as the Short and Long Forms. The Short Form (Curriculum Bulletins Nos. 9a-d, 1962-63 Series) is designed to meet the needs of students who achieved a high measure of success in their previous science classes; the Long Form to meet the needs of those who have not been able to maintain pace. It is our conviction that many of these students, some new to our system, need not be assigned to a nonacademic curriculum in science because of their prior inability to keep up with other youngsters.

Both the Long and Short Forms contain the same content prescribed by the course of study for the seventh year. The use of the Long Form, however, requires the programming of classes for five periods per week, one period more than is presently prescribed for other classes.

The Long Form develops a wide range of daily science activities to motivate and assist the students to comprehend the important science concepts underlying the grade 7 segment of our new sequential junior high school science curriculum. Stress is placed upon learning the processes and methodology of science through active participation with concrete materials.

The Grade 7 Teachers' Guide, Long Form, is the first in a three-year science sequence for grades 7, 8, and 9. The experiences gained by the students using this form will enable them, if they so desire, to join the academic stream when they enter high school.

Two other aspects of the program are now in the planning stage. They are the in-service training of science teachers of these pupils and the writing of textbooks on their reading levls.

HELENE M. LLOYD
Acting Deputy Superintendent

March 1967

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The committee to revise the Grade 7 Science course of study was organized and directed by Samuel Schenberg, Director of Science, with the cooperation of the late Joseph O. Loretan, Deputy Superintendent of Schools, and Helene M. Lloyd, now Acting Deputy Superintendent of Schools, Office of Curriculum.

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Benjamin Gamsu, Superintendent of School Supplies, arranged for the mimeographing, collating, and distribution of the course of study to all our junior high schools.

William H. Bristow, Assistant Superintendent, Bureau of Curriculum Development, and Leonard Simon, Acting Assistant Director, cooperated in all phases of the project.

The late Joseph O. Loretan, Deputy Superintendent of Schools; Helene M. Lloyd, Acting Deputy Superintendent of Schools, Office of Curriculum; and Irving Anker, Assistant Superintendent, Office of Intermediate Schools, lent support at all stages of the project.

Aaron N. Slotkin, Editor, Bureau of Curriculum Development, supervised printing production. Lillian B. Amdur and Elena Lucchini prepared the manuscript for the printer. Elena Lucchini was also responsible for the page layout and some of the illustrations. Simon Shulman designed the cover.

CONTENTS

Introduction ix

Unit I: Chemistry xi
Elements 1
Compounds and Mixtures 22
Suggested References 81

Unit II: Physics 83
Electricity 84
Magnetism 106
Heat 135
Suggested References 154

Unit III: Biology 157
Needs of Living Things 158
Cells 175
Suggested References 224

Unit IV: Earth Science 225
Minerals and Rocks 226
The Changing Earth 250
The Importance of Fossils 269
Suggested References 288

Introduction

The Long Form of the Grade 7 Science course of study is an integral part of the early secondary science program now being introduced into the New York City intermediate schools. This program represents an important part of the total K-12 sequential science program.

Present courses are usually designed to meet the needs of students who are academically successful through the grades. There is, however, a group of students, approximately 20%-25% of the total, who have not enjoyed such success. For a variety of reasons they read two or three years below grade level on entering seventh grade. This low reading ability has prevented them from maintaining the pace of other students.

Some of these students are often referred to as "culturally deprived" or "disadvantaged." In this group may be found many students of high potential. They constitute the "underachievers" in our school system. Lack of success through the elementary grades has widened the gap between them and the academic mainstream. This group has, in the past, provided most of our dropouts.

The entire intermediate school science program represents an important educational experiment by the New York City Board of Education to provide a new and promising approach to the solution of an important national problem. The study of science enables the teacher to meet the child on common ground. Science materials and equipment are colorful, interesting, challenging, stimulating, and available on all levels. The science classroom provides a unique environment in which the youngster can observe and experiment with concrete materials to solve problems meaningful to him.

This course of study provides highly motivated material in small units to be taken over a longer period of time. It is structured to enable the students to investigate meaningful science problems in small steps to the same depth required of all other youngsters and thus ultimately to bridge the gap that now exists between them and those who have experienced academic success.

The need for a revision of the present Grade 7 Science course of study was dictated by the experiences gained by teachers under classroom conditions. Teachers observed that, with daily emphasis on student activity and direct participation, they were able to maintain a high level of interest in classes of disadvantaged students.

Both the Long and Short Forms for seventh-grade science are organized into four nine-week segments, each devoted to a single science area: chemistry, physics, biology, and the earth sciences. Both forms cover the same basic concepts in each science field.

In order to conserve materials, to provide maximum flexibility, and to permit better articulation with the high schools, the following sequential order of subject areas is recommended for each grade:

Grade 7: Chemistry, Physics, Biology, Earth Science.
Grade 8: Biology, Earth Science, Chemistry, Physics.
Grade 9: Physics, Chemistry, Earth Science, Biology.

SAMUEL SCHENBERG
Director of Science
Director of the Project

Unit I

CHEMISTRY

Elements

Compounds and Mixtures

ELEMENTS

Suggested Lessons and Procedures

I. WHY ARE SOME KINDS OF SUBSTANCES CALLED SOLIDS?

Outcomes

- A solid occupies a definite amount of space.
- A solid has a definite shape.
- The shape of the solid does not change to the shape of the container in which it is placed.
- A solid has weight.

Teacher Activities

1. Distribute to every 2 pupils a tray on which is a shoe box containing at least 3 items from each group of the following:

Group A	Group B
Iron nails	Rubber bands
Chalkboard chalk	Rubber tubing
Wooden blocks	Cloth strip
Iron bolt	Short piece of rope
Glass marbles	Aluminum foil

   Note: If unavailable, other similar familiar items may be substituted.

   Note: Pupils may be asked to bring in some of the materials.

2. Weigh several objects from pupils' shoe boxes to demonstrate that solids have weight.

   Note: Lightweight materials such as a sheet of paper may require a triple beam balance.

NOTE: Problems involving buoyancy should not be introduced at this time.

3. Direct pupils' attention to uses made of this property of weight; i.e., we buy a pound of sugar, onions, potatoes, etc.

4. Set up 2 plastic bags, each containing one of the following:
 a. Iron nails (large) b. Chalkboard chalk

 Direct the attention of pupils to the following:
 Solids *do not* take the shape of the container in which they are held.

Student Activities

1. Have pupils study the items in their shoe boxes.
 Direct pupils' attention to the idea that there are variations of size, shape, color, luster, and composition. Ask pupils to remove all the solids from the shoe box to the tray. Ask the pupils, "Why did you pick these as solids?" From the discussion, develop the following criteria for solids:
 a. Solids possess a definite shape.
 b. Solids occupy a definite amount of space.

2. Have pupils examine solids which can be stretched, bent, folded, or rolled.
 a. Question the pupils as to whether these things can be called solids.
 b. Challenge the pupils to apply the criteria for solids (developed previously) to these objects.
 c. Elicit the outcome that although these objects lack rigidity they have a definite shape and occupy a definite amount of space at any one moment.
 d. Have the pupils observe that the shape (of the rigid object) or the amount of space occupied by the solids does not change when moved in or out of the shoe box.

Summary

1. Solids have weight.
2. Solids occupy space.
3. Solids possess a definite shape.
4. Solids do not take the shape of the container in which they are held.
5. Solids can be soft or hard (flexible or rigid).

Suggested Homework

1. List 5 solids found in your home.
2. In what 3 ways are solids alike?
3. In what 3 ways may solids differ from each other?
4. Select from the list of materials the ones that are solids:
   Dime Heat Thumbtack Paper cup Water
   Explain.

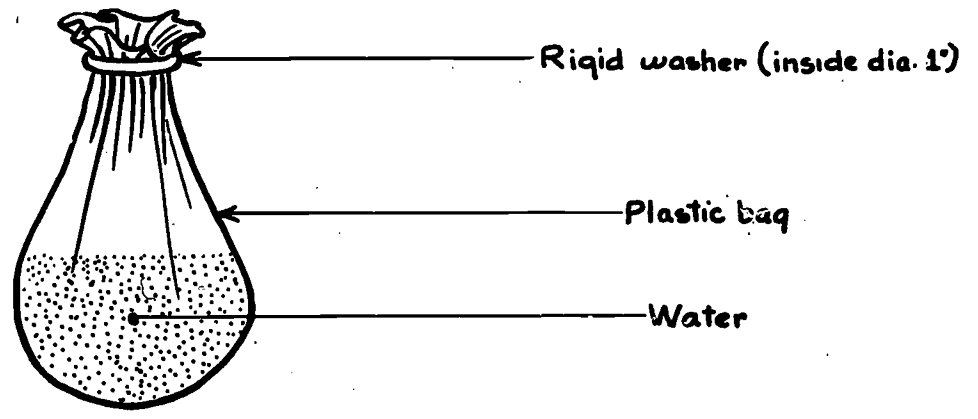
2. WHAT IS A LIQUID?

Outcomes

- Liquids have weight.
- Liquids do not have a definite shape. They take the shape of their containers.
- Liquids occupy a definite amount of space.

Teacher Activities

1. Do liquids have weight?
   a. Place a 250 ml beaker or paper cup on a platform scale (2 lb. maximum) or triple beam balance and pour into the container about 200 ml of water. Have pupils understand that the increase in weight is due to the addition of the water.
   b. Repeat demonstration with other familiar liquids (alcohol, vinegar, etc.).
2. *Liquids do not have a definite shape. They take the shape of their containers.*
   a. Insert a plastic bag through a rigid washer. This will facilitate the pouring of water into the bag. See illustration.



b. To reinforce the concept of shape relationship of liquid to container, have volunteers alter plastic bag's shape by squeezing, prodding, elongating, etc. In each case, elicit that there is a corresponding change in the shape of the liquid.

Student Activities

1. To each pupil's beaker add slightly less than 100 ml of water. Challenge the pupils to suggest a way by which they can figure out the amount of space the water occupies. Point out why answers such as ½ full are not acceptable as an accurate measure of space.
2. Introduce the *graduated cylinder* as an accurate measuring device. Explain that the *graduations* are a measure of space (*volume*). Make sure pupils know what each graduation represents. Write these new terms (italicized) on the board.
3. Distribute a tray of materials to every 2 pupils.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 2

(May be duplicated for distribution to pupils).

Purpose: How may we measure the amount of space a liquid occupies?

Materials

Graduated cylinder—100 ml Beaker—250 ml (½ filled with water)

Procedure

1. Identify each item on the tray.
2. Examine the graduate. How much space does each line represent?
3. Pour all the water from the beaker into the graduate.
4. Note how much space the water occupies.

Questions

1. How much space does each line on your graduate represent? ________
2. How much space did the water in your beaker occupy? ________
3. List 3 other liquids that can be measured in this way.
   a. ________ b. ________ c. ________
4. When the water was poured into the graduate, did the *amount* of space it occupies change? ________ Did the shape change? ________

Summary

1. How are all liquids alike? (3 ways)
2. Why did the water have a different shape each time it was poured?

Suggested Homework

1. List 5 different liquids found in your home. In what ways are they alike?
2. How is a liquid different from a solid?
3. How is a liquid similar to a solid?

3. WHAT KINDS OF SUBSTANCES ARE GASES?

Outcomes

- Gases take up space.
- Gases do not have a definite shape.
- Gases take the shape of the container in which they are held.
- Gases fill the entire container in which they are held.
- Gases have weight.

Teacher Activities

1. Air (a mixture of gases) has weight.

   Point out that because gases are usually very light in weight, they are sometimes falsely thought of as having no weight. Demonstrate that air has weight by balancing a basketball bladder against an identical basketball bladder on a double pan balance. Then inflate one of the bladders with a bicycle pump and return the inflated bladder to its side of the balance. The unbalancing of the scale is due to the addition of the air.

   NOTE: Inflatable, plastic balls similar in size to that of the basketball bladder may be substituted.

2. Gases fill the entire container in which they are held.

   a. To prepare nitrogen dioxide, place some copper foil or turnings into a gas-collecting bottle. Add about 5 drops of concentrated HNO_3 and cover the bottle with a glass plate. Direct the attention of the class to the brown fumes of NO_2. Then stop reaction by filling the bottle with water.

   Materials required

Copper foil or turnings	HNO_3 conc.	Glass plate

   b. Exhibit and demonstrate a small tank of gas such as oxygen or CO_2 to illustrate how gases are contained and shipped.

Student Activities

1. Gases take up space.
   a. Distribute to each two students the following:
      2 flat plastic bags — small, toy horn
      2 balloons of different shapes (elongated, spherical, or spiral)
   b. Recall the experiences of the class with solids and liquids. When something is in the bag, the bag bulges because matter occupies space (Lesson 1, Lesson 2).
   c. Have pupils "scoop" air into a plastic bag and pinch off the open end. Elicit the fact that the bag bulges because something within the bag occupies space. Insert the mouthpiece of a toy horn into the open end of the bag. Hold the plastic bag firmly around the mouthpiece, making an air-tight seal around the mouthpiece. Squeeze the bag to get a "bagpipe effect."
   d. Direct the pupils' attention to the second "flat" bag and explain its use as a control.
   c. Have pupils empty the bag of air and refill by blowing into it. Elicit the fact that we breathe out gases.

2. Gases take the shape of the container in which they are held.
   a. Have pupils inflate an elongated balloon and a spherical (or spiral) balloon.
   b. Elicit the fact that gases do not have a definite shape.

3. Gases fill the entire container in which they are held.
   a. Ask pupils to squeeze the inflated balloon slightly to determine whether any part of the balloon is empty of air.
   b. Elicit from the pupils that gases fill the entire container in which they are held.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 3

(May be duplicated to be used for homework activity)

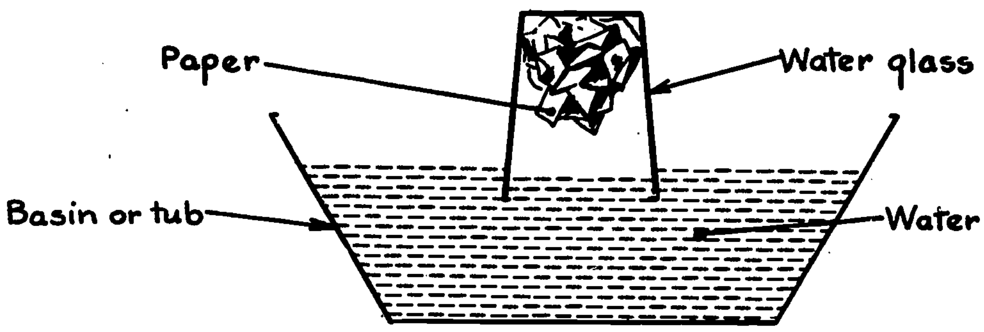
Purpose: Does air (a mixture of gases) occupy space?

Materials: Water glass — Basin or pan — Sheet of paper

Procedure

1. Crumple a piece of paper. Place it into a dry water glass. Make sure all of the paper is inside the water glass.

2. Fill a basin or pan ¾ full of water.
3. Turn the water glass upside down. Submerge the water glass in the water with the open end down. Submerge the water glass *straight down. Do not tilt* the water glass (see diagram).



4. Remove the water glass, holding it upside down. Wipe off the lip of the water glass with a towel.
5. Remove the paper inside of the water glass to see whether it is wet.
6. Repeat the experiment. This time, after submerging the water glass, tilt it slightly to allow some air bubbles to escape.

Questions

1. What two things were in the water glass before it was placed (submerged) under the water? __________ and __________.
2. What was in the water glass after it was placed under the water? __________
3. Is there any air in the water glass when it is submerged? __________ How much? __________.
4. Did the paper inside the water glass get wet? __________. Explain your answer. __________
5. When the water glass is tilted to allow some air bubbles to escape, does the paper get wet? __________. Explain your answer. __________
6. Does air (a mixture of gases) occupy space? __________

4. IN WHAT FORMS MAY MATTER EXIST?

Outcomes

- To be considered matter, a substance must occupy space and have weight.
- The same basic substance can exist in more than one form or state.
- The form of matter in which a substance exists is not permanent. It may be changed from one state into another.

Teacher Activities

1. Distribute a laboratory worksheet to each pupil. Pupils will work in pairs.
2. Discuss the properties of solids, liquids, and gases developed in Lessons 1, 2, and 3.
   a. Place the chart on the chalkboard.
   b. Use check marks on the board chart to help the pupils complete their charts.

PROPERTY	SOLID	LIQUID	GAS
Has weight			
Takes up space			
Has its own definite shape			
Takes the shape of its container			
Fills the container			

   c. Elicit the conclusions that:
      1) Matter may exist in three forms (states): solid, liquid, or gas.
      2) Matter is anything that has weight and occupies space.

Student Activities

1. Have pupils read directions on the laboratory sheet silently as you read them aloud.
2. When the pupils have arranged the apparatus, distribute an ice cube to each station.

NOTE: Care should be taken that the pupils understand that the gaseous form of water is water vapor.

NOTE: To avoid the steam, where necessary, adjust pupils' setup to get only water vapor. This may be done by raising the iron ring.

Conclusion

1. It is relatively simple for a substance to change its state.

2. The same basic substance can, and often does, exist in more than one state.

3. Changes in form observed with water can also be seen in many other substances. Melting, freezing, evaporating represent changes from one state of matter to another.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 4

(May be duplicated for distribution to the pupils)

Purpose: To find out how matter can change form

Materials

Ring stand	Beaker, 250 ml	Ice cube
Iron ring and clamp	Glass plate	Wire gauze
Alcohol burner		

Procedure

1. Place the wire gauze on the iron ring of the ringstand.
2. Place the alcohol burner underneath the wire gauze. Do NOT LIGHT THE BURNER.
3. Adjust the height of ring so that the gauze is one inch above the wick of the burner.
4. Place the beaker on top of the gauze.
5. After your teacher has inspected your setup and given you an ice cube, place this ice cube in your beaker, and light your burner.
6. Heat the contents of your beaker for five to ten minutes or until the ice melts completely.
7. Answer 1 and 2, below, based on what you observed.
8. Continue heating the beaker.
9. Hold the glass plate over the beaker.
10. Remove the glass plate and inspect it.
11. Answer 3, 4, and 5, below, based on what you observed.

Questions

1. The ice cube is an example of the form of matter called a ——————.
2. After the ice cube was heated, ——— began to appear in the beaker.
3. When I continued heating the water, it changed to ———— which is a gas.
4. When I held a glass plate over the beaker, I saw ———— form on the glass plate.
5. On the glass plate the water vapor was changing to ——————.

The following may be answered at home:

6. Matter has three states a) ———— b) ———— c) ————

7. Read the following list of substances:

Put **S** *next to a solid;* **L** *next to a liquid;* **G** *next to a gas.*

Milk ______	String ______	Vinegar ______
Air ______	Pencil ______	Sugar ______
Alcohol ______	Orange juice ______	Oxygen ______

8. Definition: Matter is anything which has ____________ and takes up ____________.

5. WHAT ARE THE BUILDING BLOCKS OF MATTER?

Outcomes

- All matter is composed of one or more simple substances.
- These substances cannot be separated into simpler substances by ordinary chemical means.
- These simple or "elementary" substances may exist as solids, liquids, or gases.
- These "elementary" substances are called *elements.*

Teacher Activities

1. Prior to the entrance of the class, start the Hoffman apparatus for the electrolysis of water as follows: Fill it with a solution containing one part of concentrated sulfuric acid to twenty parts water by volume and apply 9-12 volts direct current from a power supply or from at least four #6 size 1½ volt dry cells connected in series.

   a. Call the attention of the class to the Hoffman apparatus. Guide the pupils to an understanding that an electric current is being passed through the water. Explain that this is being done in an effort to discover the makeup of water.

   b. Point out that gases are forming in the tubes. Elicit the fact that the level of the water in the tubes of the Hoffman apparatus drops as more and more gas is formed. One tube contains twice as much gas as the other. Guide the pupils to an understanding that the electric current is breaking the water up into two gases which they can observe.

   c. Tap off each gas into a small test tube. Test the gas of greater volume with a burning splint. Have the pupils observe the "pop" or burning that occurs. Identify the gas as *hydrogen* and write the word and symbol, *H,* on the chalkboard.

d. Test the other gas with a glowing splint. Call the attention of the class to the fact that the splint bursts into flame and identify the gas as *oxygen*. Write the word and symbol, *O*, on the chalkboard.

e. Stress the fact that water is thus seen to be composed of two simpler substances, hydrogen and oxygen.

f. Hydrogen and oxygen are examples of *elements* which are simple substances which cannot be broken down into simpler substances by ordinary means.

2. Separating the element carbon from sugar.

a. Inform pupils that in this experiment they will separate sugar (sucrose) into the substances which make up sugar. Sugar is made of *carbon (C), oxygen (O),* and *hydrogen (H).* Show the class a sample of powdered carbon.

b. Distribute to every two pupils the materials listed on the laboratory worksheet.

c. Distribute laboratory worksheet for each pupil.

NOTE: The italicized words and symbols should be written on the board during the lesson.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 5

(May be duplicated for distribution to the pupils)

Purpose: To study the substances which make up sugar

Materials

Pyrex test tube with 5 gm. of sugar	Ring stand
Test tube clamp	Test tube rack
Alcohol burner	Glass plate (2″ x 2″)

Procedure

Before you start: Do not touch the equipment until you have read the instructions with your teacher.

1. Place the test tube, containing sugar, in the clamp and tighten the clamp just enough to hold the test tube.
DO NOT MAKE THE CLAMP TOO TIGHT.
2. Place the alcohol burner underneath the test tube.
DO NOT LIGHT THE BURNER.

3. Adjust the height of the test tube so that the bottom is one inch above the wick of the burner.
4. After your teacher has inspected your set-up, light your burner.
5. Heat the contents of the test tube until it begins to turn black or your teacher tells you to stop.
6. When you begin to observe a change, hold the glass plate over the mouth of the test tube.
7. Complete the following, based upon what you have observed.
   a. The color of the sugar at the beginning is ________________.
   b. The color of the solid substance remaining at the end is __________.
   c. When I held the glass plate over the mouth of the test tube I saw ________________ form on the glass plate.
   d. The substance which remained is known as ________________.
   e. This substance is in the ________________ state.
   f. The sugar is changed to ____________ and ____________.
   g. ________________ is used to break up the sugar.
   h. This can be written as follows: Sugar ————→ ____________ and ____________.

Suggested Homework

The following questions are based upon the teacher's demonstration and your classwork:

1. The liquid (water) is changed into two ____________.
2. An ____________ ____________ is used to break up the water into two gases.
3. Water is made up of ____________ and ____________.
4. The reaction can be written as
   Water ————→ ____________ and ____________.
5. Chemists (have, have not) ____________ succeeded in breaking carbon, oxygen, and hydrogen into simpler substances.
6. Chemists call these simplest substances ________________.
7. Sugar, then, is made up of three elements.
   Sugar = __________ + __________ + __________.
8. All matter is made up of elements.
   ________________ cannot be separated into simpler substances by ordinary chemical means.

6. WHAT ARE SOME OF THE PROPERTIES OF METALS?

Outcomes

- Elements can be classified as metals and nonmetals.
- Those features of a substance that enable us to identify it are called *properties* of that substance.
- Metals can be identified by certain properties, some of which are:
  silver-grey color (except copper, gold)
  solid state (except mercury)
  luster
  ability to conduct heat
  ability to conduct electricity
- Copper, aluminum, iron, tin, lead, magnesium, and mercury are all examples of metals.

Teacher Activities

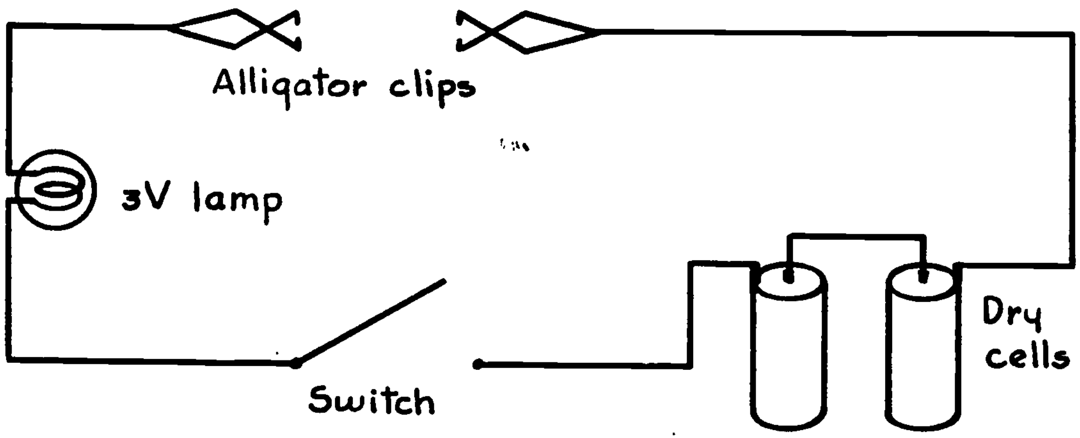
1. Distribute to every 2 pupils a tray containing the materials listed on the laboratory worksheet.

2. Recall previous lesson on elements. Tell pupils that elements can be divided into two main categories—metals and nonmetals. Instruct the class to separate the items on their trays into metals and nonmetals. Question pupils as to why they divided the items as they did. Clarify errors in classification. Challenge the class to determine what all of these metals have in common. Develop with pupils the idea that any substance has certain features which enable us to describe that substance. The scientist refers to these features as *properties.*

3. The properties which identify a substance as a metal are: color, state, luster, heat *conductivity,* and electrical conductivity.
   a. COLOR—Call attention to the color of the metal strips, after stating that copper is one of two exceptions to the ordinary color of metals. Challenge class to describe the color of metals as silver-grey. (Also challenge pupils to name gold as the other exception.)
   b. STATE—Elicit from pupils that all of the metal strips are solids. Tell them that, with one exception (*mercury*), all metals are solids at room temperature.
   c. LUSTER—Introduce this property by focusing pupil attention on the "shininess" or "brightness" or "gloss" (it is suggested that the teacher use these descriptive words) of the metal strips.

d. Heat Conductivity—Recall pupils' personal experiences with conduction of heat.

e. Electrical Conductivity—Demonstrate by means of the following electrical circuit that metals conduct an electrical current.



Insert metal strips between alligator clips and close switch. Repeat with wood and rubber to show that nonmetals will not conduct electricity. Pupils should record data in Column #6 of laboratory worksheet.

Student Activities

Have the pupils do one step of the procedure at a time. As they complete the study of each property (state, luster, color, etc.), encourage the comparison of the nonmetallic substances with the metallic elements on the tray.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 6

(May be duplicated and distributed to pupils)

Purpose: To examine various metals and learn about some of their properties

Materials

3-inch strips of:

Copper	Wooden splint	Sulfur
Aluminum	Glass plate	Alcohol lamp
Soft Iron	Rubber tubing	Chalk
Tin	Zinc	Sandpaper
Lead		

Procedure

1. On the table below, write the name of each metal in the first column.
2. Look carefully at all the metals on your list of materials and state in the second column whether each is a solid, liquid, or a gas.
3. Find out whether each one has a shine (luster) or whether it is dull. In case of doubt sandpaper the metal strips. Record your observation in column 3.
4. Observe and record the color of each metal in column 4.
5. Light alcohol burners. Hold one end of one of the metal strips and insert the other end into the flame. Note which metal feels warmer soonest. Record your observations in column 5. Caution: remove the strip from the flame as soon as you feel the heat.
6. Recall from your teacher's demonstration whether the metals were good or poor conductors of electricity. Record your answers in column 6.

TABLE OF OBSERVATIONS					
Metal	Properties				
1 Name of Metal	2 State	3 Luster	4 Color	5 Conducts Heat	6 Conducts Electricity

Questions

1. Elements can be arranged in two groups, __________ and __________.
2. Features which help us to describe a substance are called the __________ of the substance.
3. The five properties of metals which we studied are:
   1________ 2________ 3________ 4________ 5________.

Suggested Homework

1. List 5 objects found at home which are made of metal.
2. State the main metallic element found in each object you listed.

7. HOW ARE THE NONMETALLIC ELEMENTS DIFFERENT FROM THE METALLIC ELEMENTS?

Outcomes

- Nonmetals may be identified generally by a lack of the metallic properties of luster and electrical conductivity.
- Color, odor, and state of matter are the more readily identifiable features of an element.
- Sulfur and red phosphorus are examples of solid nonmetallic elements.
- Oxygen is an example of a gaseous nonmetallic element.

Teacher Activities

1. Have the pupils recall the properties of metals. Point out to the pupils that nonmetals are identified by their *not* having some of the metallic properties, e.g., silver-gray color, luster, conductivity.
2. Tell the pupils that you are going to demonstrate an element which was studied previously and that they are to identify it from its properties. Without divulging the name of the gas, prepare and show the properties.
3. Prepare oxygen as follows:
   Fill the bottom of a large test tube with manganese dioxide or potassium permanganate, and add about three times as much fresh 3% hydrogen peroxide. *Caution:* Handle potassium permanganate with care. Potassium permanganate will stain hands or clothing.

   Collect 2 bottles of the gas by the water displacement method. Have the pupils:

   a. Observe the bubbles to realize that a gas is being generated.
   b. See that a glowing splint bursts into flame when in contact with the gas.
   c. Identify the gas as oxygen.
   Question to show that oxygen must be a nonmetal because it has none of the metallic properties of solid state, luster, silver-gray color, etc.

d. State the properties of oxygen as a colorless, odorless gas. Have several students make a sniff test. Instruct them how to do this safely, by wafting the gas with the open palm from the mouth of the bottle toward the nose.

NOTE: For the demonstration above, the teacher may prefer to use a cylinder of oxygen from the S-1 list.

Student Activities

1. Distribute to every two pupils a tray containing the materials listed on the laboratory worksheet.
2. Focus pupils' attention on the two samples of nonmetals on their trays. Identify the sulfur and the red phosphorus and write the names on the board. Identify the aluminum and the copper strips.
3. Have pupils recall that electrical conductivity is a property of metals. Point out that the setup which was used in teacher demonstration in Lesson 6 on metals is now available for them to use.
4. Read aloud instructions on laboratory worksheet while the pupils read silently. Have pupils complete the chart.

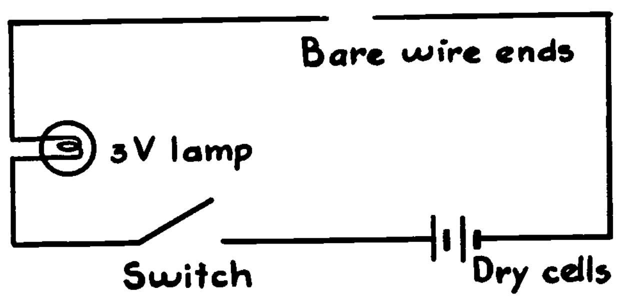
LABORATORY WORKSHEET — CHEMISTRY: LESSON 7

(May be duplicated and distributed to pupils)

Purpose: To study the difference between metals and nonmetals in conducting an electric current

Materials

Conductometer
Sulfur sample
Red phosphorus
Zinc copper strip
Zinc aluminum strip
2 slips of paper (3″ x 5″)



Procedure

Read the instructions silently while your teacher reads them aloud.

1. List each of the elements in column 1 of the chart (following page).
2. Examine the sulfur, red phosphorus, the aluminum strip, and the copper strip, noting the state, odor, and color.
3. Record your observation on columns 2, 3, and 4.

4. Test each substance as to whether it can conduct an electric current. One pupil should touch the two ends of the wire to the copper strip. The other pupil should then close the switch. Record your answer in column 5.
5. Place your samples of sulfur and red phosphorus on separate slips of paper. Do the conductivity test for sulfur and then for the red phosphorus. Record your results in column 5.
6. Using the information you have obtained (2, 3, 4 of your chart), decide whether the element is a metal or nonmetal. Put your answer in column 6.

CHART OF PROPERTIES					
1 Element	2 State	3 Color	4 Odor	Conducts 5 Electricity	Metal 6 Nonmetal

Questions

1. Nonmetallic elements are recognized by (having, not having) ———— properties of metals.
2. Nonmetals are different from metals by not having the properties of ——— ———— and ————.
3. List 2 nonmetallic elements which are gases.
   List 2 nonmetallic elements which are solids.

8. IN WHAT QUICK AND EASY WAY CAN WE WRITE THE NAMES OF THE ELEMENTS?

Outcomes

- There are, at present, 92 elements found in nature and 11 man-made elements.
- Every element has a corresponding symbol.
- The symbols for the elements are the same all over the world.

Teacher Demonstration

1. Display on demonstration table samples of the following elements:

Aluminum	Iodine (tightly closed bottle)	Nickel	Sulfur
Nitrogen	Lead	Oxygen	Tin
Copper	Magnesium	Phosphorus (red)	Zinc
Hydrogen	Mercury	Silver (dime)	Iron

   NOTE: The gases should be displayed in glass-stoppered, labeled bottles; the solids on labeled watch glasses. Mercury should be displayed in a tightly closed bottle.

2. Call attention to the everyday uses of these elements. The chemists, who have to use these names more often than others, have devised a shorthand by using symbols. You may call upon several pupils using initials rather than names or have pupils volunteer information about a family member who uses some kind of shorthand.

3. Distribute the alphabetical list of elements to pupils. Use these lists to point out that:
   a. There are now 103 known elements (92 natural and 11 man-made).
   b. The same symbols are used in every country in the world. Students from classes all over the world are studying these symbols.
   c. Knowledge of these international symbols will greatly facilitate our study of chemistry.

   NOTE: A rigorous memorization of this list is not the purpose for which it is being distributed. Rather, the list is intended to:
   1) Serve as reference material for the pupil
   2) Impress upon the pupil the fact that there are many elements that he has not yet investigated
   3) Point out the elements with which the pupil is more likely to come into contact in his study of chemistry.

4. Ask the pupils to underline the elements which they have used at some time.

5. Briefly explain that usually symbols are determined in one of the following ways:
   a. Capital first letter of element's name—C, I, S, P, O, N.
   b. Capital first letter—small second letter of element's name—Al, Ni.

c. Capital first letter plus some other small letter in the element's name—Mg, Zn.

d. Latin name of the element—Cu (*Cu*prum), Fe (*Fe*rrum), Pb (*P*lum*b*um), Hg (*H*ydra*g*yrum), Na (*Na*trium).

6. Have pupils recall experiments of Lesson 5 and write word and symbol equations for the electrolysis of water and the elements which make up sugar.

water produces oxygen + hydrogen

water ⟶ O + H

carbon + oxygen + hydrogen ⟶ sugar

C + O + H ⟶ sugar

Student Activities

1. Distribute to each two pupils a set of 30 cards, fifteen bearing the names of the elements on display and fifteen bearing the symbols of these elements. Have the pupils match the names and symbols.

   NOTE: It should not be necessary for pupils to refer to their list of elements except for a final check.

2. After the pupils have matched the two sets of cards, call on various pupils to recite their pairings orally.

Alphabetical List of the More Important Elements

Aluminum	— Al	Helium	— He	Platinum	— Pt
Arsenic	— As	Hydrogen	— H	Potassium	— K
Barium	— Ba	Iodine	— I	Radium	— Ra
Boron	— B	Iron	— Fe	Selenium	— Se
Bromine	— Br	Lead	— Pb	Silicon	— Si
Calcium	— Ca	Lithium	— Li	Silver	— Ag
Carbon	— C	Magnesium	— Mg	Sodium	— Na
Chlorine	— Cl	Manganese	— Mn	Strontium	— Sr
Chromium	— Cr	Mercury	— Hg	Sulfur	— S
Cobalt	— Co	Neon	— Ne	Tin	— Sn
Copper	— Cu	Nickel	— Ni	Tungsten (Wolfram)	— W
Fluorine	— F	Nitrogen	— N	Uranium	— U
Germanium	— Ge	Oxygen	— O	Zinc	— Zn
Gold	— Au	Phosphorus	— P		

Suggested Homework

1. Using your list of the more important elements as a guide, find 10 samples or pictures of objects, each of which contains a different element.
2. On the chart below, list the name of the object found, the name of one element found in the object and its chemical symbol.

OBJECT	ELEMENT	CHEMICAL SYMBOL

COMPOUNDS AND MIXTURES

Suggested Lessons and Procedures

9. BUILDING WITH OUR BUILDING BLOCKS

Outcomes

- Elements combine to form new substances.
- These substances are "new" because they have new properties different from their elements.
- These "new" substances are called compounds.
- The names of the compounds can be written in the same shorthand which we use to write the names of elements.
- The name of a compound written in symbols is called the formula.

Teacher Activities

Elements combine to form new substances with new properties:

1. Recall the experiment in which sugar was *decomposed* to C and H_2O and the H_2O electrolytically decomposed to O and H. Elicit that C, H, and O are the building blocks of sugar and are called elements.

   Review briefly the properties of H, O, C, and sugar. Elicit the understanding that sugar has properties different from its elements.

2. Draw the analogy between the elements and the letters of the alphabet. Elicit from the pupils that just as the letters can be combined in various ways to produce a countless number of words, so may the 103 elements combine in various ways to make up countless substances.

3. a. Have pupils examine separate samples of iron filings and sulfur. Challenge the class to identify each element by its properties. Lead the class into the discussion of the magnetic property of iron.

   b. Test each sample with a magnet to show iron is attracted while sulfur is not.

   c. Mix a small portion of iron filings with twice that amount (by volume) of sulfur. Call on pupils to test a part of the mixture with a magnet. Class should discover that iron filings may be separated from the sulphur with the magnet. Elicit: simple mixing of the two elements does not result in any basic change in the properties of these elements.

   d. Fill 1/4 of a pyrex test tube with the iron sulfur mixture. Hold the test tube with a test tube holder and heat the mixture gently at first and then strongly.

   (Keep the test tube in motion in order to heat the tube uniformly.) When the contents of the tube begin to glow, remove the heat and call attention to this glow as an indication that some chemical activity is taking place. Immerse the tube in a beaker of cold water. This should crack the tube and release the contents. If it does not, wrap the tube in a piece of cloth and break it with a hammer. Call attention to the *physical* appearance of the mass. Test the mass with a magnet to show that a new nonmagnetic substance, iron sulfide, has been formed. Guide the class in a comparison of the properties of the elements and the new substance. Elicit: the new substance is different because it has different properties.

4. What is a compound?

   Introduce the word *compound* to describe a substance which has properties different from the elements which make it up. Refer again to sugar and water as examples.

   Ask pupils to name household items which might be compounds. Teacher points out which substances are compounds and which are elements (ammonia, starch, vinegar, aluminum foil, salt, copper wire).

5. What is a formula?

   Tell the pupils that chemists write the names of compounds by using the same symbols which are used for the elements. Write on the chalkboard the symbols for iron, sulfur, and iron sulfide.

NOTE: Although the name iron sulfide may be mentioned, do not at this point go into a discussion on how compounds are named.

Tell the pupils that this name written in symbols is called a *formula.*

Elicit: the formula indicates which elements make up the compound.

NOTE: The teacher should place italicized words on the board.

Summary

1. Elements combine to form ________.
2. Compounds have (different, the same) ________ properties when compared to their elements.
3. (A few, most) ________ of the substances which we use are compounds.
4. The name of the compound in symbols is called the ________.
5. The formula of a compound tells which ________ are in the compound.

Suggested Homework

Distribute the worksheet.

Distribute to each pupil the necessary materials listed on the worksheet.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 9

(May be duplicated for distribution to pupils)

Purpose: Does the simple mixing of iron and sand change the properties of these elements?

Materials

Iron filings   Sand   Magnet   Toothpicks

Magnifying glass (hand lens) (may be purchased at a 5¢ or 10¢ store)

Procedure

1. Place the sand on a small piece of paper.
2. Test the sand with a magnet.
3. Place the iron filings on a second sheet of paper.
4. Test the iron filings with the magnet.
5. Mix the sand and the iron filings together with a toothpick.

6. Examine the mixture with a magnifying glass (hand lens).
7. Attempt to separate the iron filings with the magnet.

Questions

1. When the sand was tested with a magnet it (was, was not) attracted by the magnet.
2. When the iron filings were tested with a magnet, they (were, were not) ———— attracted by the magnet.
3. When the mixture of sand and iron filings was examined with a hand lens, the particles of sand and iron (could, could not) ———— be seen.
4. Testing the mixture with a magnet caused the ———— to be attracted by the magnet.
5. This experiment shows that simple mixing of the sand and the iron filings (does, does not) ———— produce a compound.

10. HOW DO WE WRITE FORMULAS FOR COMPOUNDS?

Outcomes

- A compound is made up of at least 2 different elements.
- The smallest bit of a compound is called a molecule.
- Each molecule of a compound always has the same formula.

Teacher Activities

NOTE: Before the lesson begins set up the Hoffman apparatus and start the electrolysis of water.

1. Mark two beakers, one A and the other B. Fill beaker A with water, leaving beaker B empty. Pour half the amount of water from beaker A into beaker B. Now pour half of the remaining water from beaker A into beaker B. Repeat until perhaps a drop of water is left in beaker A. Ask pupils to imagine the continuation of the process. Elicit: there must be a limit. The final bit of water is called a *molecule.* Pupils should be led to understand that molecules exist for other compounds as well as for water.
2. Refer to the Hoffman apparatus and recall the decomposition of water into hydrogen and oxygen. Call attention to the relative amounts of the gases. Read the volumes to the pupils. Elicit: for each amount (volume) of oxygen there is twice as much hydrogen.

3. Write on the chalkboard two symbols of hydrogen and one of oxygen. (H H O.) Explain that you have written two symbols for hydrogen and only one for oxygen because twice as much hydrogen as oxygen was produced. Ask the pupils for suggestions to combine these symbols into a *formula*. Suggestions such as 2H O, H (2) O, O 2H should be encouraged. Inform pupils that chemists throughout the world have agreed on a certain way of writing such formulas, i.e., H_2O for water, NaCl for pure table salt. Have pupils note that the number 1 does not appear in any of the formulas but is understood to be there, i.e., HCl, KCl, CO_2.

   NOTE: Have pupils understand that a formula stands for the formula of one molecule of the compound.

4. Explain that just as all cake recipes have their ingredients in definite amounts, each molecule of a compound has its elements in definite amounts, i.e.,

SUBSTANCE	RECIPE OR FORMULA	INGREDIENTS	AMOUNT
Plain Cake	Recipe for plain cake	Sugar, Eggs, Flour, etc.	1 Cup of sugar 2 Eggs 2 Cups of flour
Carbon Dioxide	CO_2	Carbon Oxygen	1 Unit of carbon 2 Units of oxygen

5. Illustrate with the following examples the relationship of the formula and its elements.

   HCl .... H one unit, Cl one unit
   SiO_2 .... Si one unit, O two units
   Na_2CO_3.................... Na two units, C one unit, O three units

   NOTE: It is not necessary to introduce the word atom for unit at this time.

Student Activities

1. Have the pupils write the formula of the following compounds: A molecule of the compound has the following elements:

   ferric chloride 1 unit of iron, 3 units of chlorine________
   zinc sulfide 1 unit of zinc, 1 unit of sulfur________
   iron oxide 2 units of iron, 3 units of oxygen________

aluminum chloride	1 unit of aluminum, 3 units of chlorine——
copper sulfate	1 unit of copper, 1 unit of sulfur, 4 units of oxygen ————

2. Distribute vials of these compounds with the name and formula on the label.
3. Have the pupils check their formulas.

Suggested Homework

1. Look through your textbook and list the names of 10 compounds and their formulas.
2. Next to the formula of each of the compounds you have listed, write the number of units of each elements.

11. WHY DOES A COMPOUND HAVE A CERTAIN FORMULA?

Outcomes

- A compound is made up of at least 2 different elements.
- All compounds are made up of metallic elements (or elements which act as metals) in chemical combination with nonmetallic elements.
- Each element has its own combining ability to unite with other elements.

Teacher Activities

1. Demonstrate how to use the element cards to form *representations* of the molecules. Be certain the pupils understand that the element cards represent only the elements.

   NOTE: See preparation of element cards at the end of this lesson. The element cards for the teacher demonstrations should be larger than the cards the pupils use.

2. Represent the HCl molecule by:
   a. Inserting the tab of the hydrogen card into the slot of the chlorine card.
   b. Point out that all the tabs and the slots of each element of the compound must be "used up."
   c. Point out the number of tabs or the number of slots on one of

the element cards will tell us the combining ability of the element. [For example, the combining ability for hydrogen (1 tab) = 1; chlorine (1 slot) = 1]

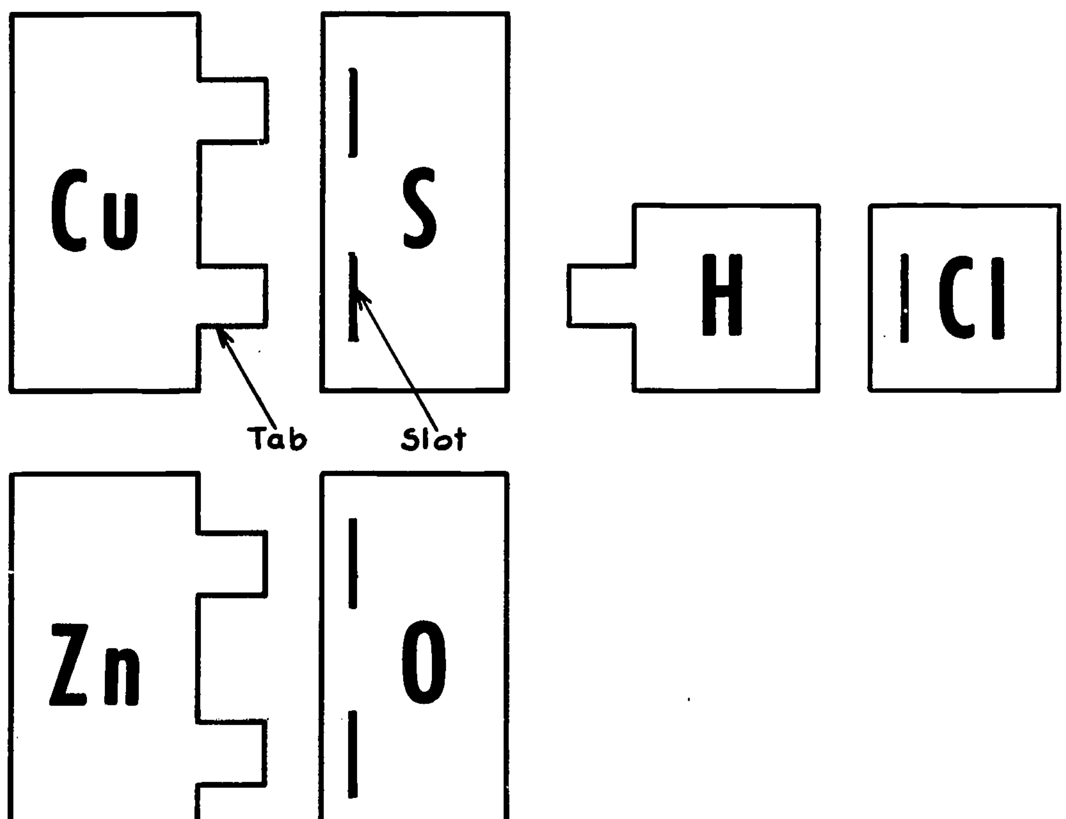
3. Distribute to every 2 pupils the element cards listed on the laboratory worksheet. Hold back one Cl element card. The pupils should become aware that they will need this additional card when they try to construct the models for $ZnCl_2$ and $CuCl_2$. When this difficulty arises, elicit the fact that knowing the combining power of an element helps us to write the formula.

Student Activities

Preparation of the element cards

1. The cards can be made of stiff construction paper. Use two different colors, one color for the metals and the other for the nonmetals.
2. The cards for sulfur, oxygen, copper, and zinc should be twice the size of the cards for hydrogen and chlorine.
3. Make the slots large enough to fit the tabs.

NOTE: If preferred, discs, hooks, and eyes may replace the element card with the tabs and slots.



LABORATORY WORKSHEET — CHEMISTRY: LESSON 11

(May be duplicated and distributed to the pupils)

Purpose

1. What is the least number of different kinds of elements which make up a compound?
2. How does knowing the combining ability of an element help us to write the formula of a compound?

Materials

1 Blue card labeled Cu	1 Yellow card labelled O
2 Blue cards labelled H	1 Yellow card labelled Cl
1 Blue card labelled Zn	1 Yellow card labelled S

Procedure

1. Represent a molecule of HCl by taking one hydrogen card and one chlorine card; now fit them together. Your teacher will show you how this is done.
2. In column 1 of the table below write the formula of your model, HCl. In the second column draw a small diagram of your model.
3. In column 3 list the element with the tab. In column 4 write in the combining ability (the number of tabs).
4. In column 5 list the element with slots. In column 6 indicate the combining ability (number of slots).
5. Make up models of the molecules of the following compounds: CuO, H_2O, ZnO, CuS, H_2S, ZnS, $CuCl_2$, $ZnCl_2$.
6. Fill in the table for these compounds.

1 FORMULA	2 MODEL OF MOLECULE	3 ELEMENT WITH TAB	4 COMBINING ABILITY	5 ELEMENT WITH SLOT	6 COMBINING ABILITY

Note: The actual elements do not have tabs or slots nor does the size of the card indicate the size of the atom. The combining ability of a metallic element may be determined by finding out how units combine with one unit of chlorine. The combining ability of nonmetallic elements may be determined by finding out how units combine with one unit of hydrogen.

Questions

1. The yellow cards represent the (metallic, nonmetallic) ——————. elements. The blue cards present the —————— elements.
2. The element which is a gas and is included with the metals is ——————.

3. Find the combining ability of the nonmetals S. O. and Cl in the following manner:
   a. How many units of hydrogen can combine with 1 unit of sulfur?——— The combining ability of sulfur is ————
   b. How many units of hydrogen can combine with 1 unit of oxygen?—— The combining ability of oxygen is ————
   c. How many units of hydrogen can combine with 1 unit of chlorine? ————. The combining ability of chlorine is ————
4. Find the combining ability of the "metals" Cu, Zn, and H.
   a. How many units of chlorine combine with 1 unit of copper? ——— The combining ability of copper is ————
   b. How many units of chlorine can combine with 1 unit of zinc?——— The combining ability of zinc is ————
   c. How many units of chlorine can combine with 1 unit of hydrogen? ———— The combining ability of hydrogen is ————
5. The formula of a compound depends on the ———— of its elements.

12. HOW CAN WE SORT OUT THE BUILDING BLOCKS?

Outcomes

- The elements can be arranged in a definite sequence.
- The sequential arrangement is based on an important property of the elements—its atomic weight.
- The order of elements results in a grouping by families and periods.
- Elements in the same family exhibit many properties in common.
- The Periodic Table was used to predict the existence of unknown elements.

Teacher Activities

1. Ask the pupils where in a supermarket they would find milk, oranges, steak, and carrots. Elicit from the pupils that there is a need to classify the elements just as there is a need to classify items into departments in a store.

   Tell the pupils that up to the second half of the 18th century there was no known order for the elements. In 1864, John Newlands arranged the elements in the order of their increasing atomic weights. Later, in 1869 Dimitri Mendeleef improved the arrangement by inserting the properties and combining abilities of the elements.

2. Distribute to every two pupils the following:
   a. A randomly arranged pack of 19 insert cards bearing:
      1) Symbols of elements from hydrogen to calcium (omit Mg)
      2) Atomic weight
      3) Metal *or* nonmetal
      4) Combining ability (valence) number

   The element insert cards should be made of stiff cardboard. (Delaney cards may be substituted.)

   Each element insert card should have such information as:

Magnesium, Mg Atomic wt. 24 Metal Combining ability number (2)

   b. A slotted work cardboard
      For the slotted work cardboard, manila folders with horizontal paper strips fastened with staples or cellulose tape may be used. The manila folder should have 8 vertical rows of slots and at least 5 horizontal rows of slots. Each slot should be of sufficient width to accommodate the insert card. (e.g., Delaney books)

3. Direct the pupils' attention to the information on each card. The Mg element card is omitted from the students' pack of cards in order that the pupils may see how the Periodic Table was used to predict the existence of unknown elements.

NOTE: Do not introduce the word valence to the pupils; use combining ability number.

Student Activities

1. Have the pupils attempt to arrange the cards in some kind of order. After a minute or two discuss with the class the possible classifications.
   a. Alphabetical
   b. Metals, nonmetals
   c. Atomic weights
   d. Properties
2. Elicit from the pupils that an arrangement using the properties of the element is the most workable, i.e., atomic weight and combining ability.
3. Suggest that they might start by separating metals from nonmetals.
4. Challenge pupils to study the compounds on the cards and to arrange the cards by their properties of combining abilities.

5. Move about the room to help individual groups. Successful insights on the part of a group should be reported to the class periodically to help other groups. Record these on a chalkboard chart.

6. When the class has arranged the groups, they may not have the elements arranged in increasing atomic weights. Help the pupils realize that if groups 2 to 7 are moved down one row leaving hydrogen and helium alone on the first horizontal row, the elements will be arranged in increasing atomic weights.

7. Discuss the Periodic Table and elicit:
   a. There is an element missing after Na.
   b. The element is a metal.
   c. It has a combining ability of two.
   d. Its atomic weight is greater than 23 and less than 27.

8. Point out that although we may not have the element we can predict the existence of an element and in advance tell what are some of its important properties.

9. Distribute the card for magnesium and tell the pupils that although the existence of magnesium was not predicted by Mendeleef, other elements were predicted and subsequently discovered in this manner.

   NOTE: If questions are raised concerning the order of atomic weights of Ar and K, tell the pupils that later research proved that this is the correct order. Pupils should be told that they may raise these questions again when the atomic energy unit is completed.

   Point out that Mendeleef accepted this arrangement because the horizontal rows (periods) showed a definite order from metals to nonmetals for sets of elements. The table also grouped "families" of elements in vertical columns (groups).

Summary

Now call on pupils to describe their arrangements of the elements, first horizontally, then vertically. When this has been done, compare their tables to a calendar month. Compare the weeks to *periods* (horizontal) and the days of the week to *groups* (vertical). Describe the "Sunday" and "Monday" groups as most metallic in their properties, the "Friday" and "Saturday" (extreme right) groups as least metallic in their properties. Stress the fact that the *groups* only align themselves properly when the correct *periods* are chosen, and name the calendar-like arrangement of the elements as the Periodic Table of the Elements.

NOTE: Classroom discussion will be facilitated by ordering copies of the Periodic Table from the State Board of Regents, Albany, New York.

Suggested Homework

1. Explain how it is possible to use the Periodic Table to predict the properties of any element.
2. Using your Periodic Table, name the elements that you would expect to react similarly to: a. Magnesium, b. Chlorine, c. Argon, d. Potassium, e. Aluminum, f. Phosphorus, g. Oxygen.
3. The left to right (horizontal) order is called a ____________.
4. The top to bottom (vertical) order is called a ____________.
5. In each period, the metals are on the ________ side, and the ____________ are on the right side.

13. HOW CAN WE USE SYMBOLS AND FORMULAS TO TELL A STORY?

Outcomes

- When two or more substances act together to form a new substance with new properties, we call the action a *chemical reaction.*
- We describe the reaction by a statement telling us the substances with which we begin and the substances with which we finish.
- This statement is written in chemical shorthand called an *equation.*
- In a chemical reaction we neither gain nor lose elements. The elements are only rearranged.
- Scientists all over the world write chemical equations using the same symbols.

Teacher Activities

1. Into an Erlenmeyer flask place 10 ml of silver nitrate and a small test tube containing 10 ml sodium chloride solution. Have the pupils observe that the two solutions are not in contact with each other. Stopper the flask and weigh it.

2. Invert the flask so that the NaCl in the test tube reacts with the $AgNO_3$ in the flask. Call to the attention of the class the precipitate as a new product. Point out that when two substances react to form a new substance with new properties the reaction is called a chemical reaction.

3. Write a word statement on the board to describe the reaction. Silver nitrate added to sodium chloride yields (produces) sodium nitrate plus silver chloride. Identify sodium chloride (NaCl) as table salt.

   Recall the shorthand by which we write formulas and elicit the understanding that this shorthand can be used to write the statement above. This is called an *equation*.

   $$Ag\ (NO_3) + Na\ Cl \longrightarrow Na\ (NO_3) + Ag\ Cl$$

   NOTE: Do not discuss the unit NO_3 at this time.

   NOTE: Tell the pupils that the arrow stands for "yields."
   Point out to pupils that scientists all over the world write chemical equations using the same symbols.

4. Weigh the flask again with its contents. Elicit: since there was no gain or loss in weight and all the substances were in a closed flask, the new substances formed came from the original substances. Stress that in a chemical reaction we neither gain nor lose elements. The elements are rearranged to form new compounds.

Student Activities

1. The following activities should lead the pupils to understand that the formation of a precipitate or the production of a gas is evidence of a chemical reaction.

2. Distribute to every two pupils a tray with the materials listed on the laboratory sheet.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 13

(May be duplicated and distributed to pupils)

Purpose: How can we tell whether a chemical reaction has taken place?

Materials
Test tube rack
Test tube with 10 ml dilute HCl

Small strips of zinc sheet
Test tube with 10 ml of 1N $MgSO_4$ (Epsom Salt)
Test tube with 10 ml of 1N $BaCl_2$

Procedure

NOTE: To prepare a 1N solution of $MgSO_4$, add to 60 gms of solid $MgSO_4$ enough water to make 1 liter of solution.

To prepare a 1N solution of $BaCl_2$, add to 104 gms of solid $BaCl_2$ enough water to make 1 liter of solution.

1. Add the barium chloride solution ($BaCl_2$) to the test tube containing the magnesium sulfate solution ($MgSO_4$).
2. Based on your observation, answer questions 1 - 5.
3. Add the zinc strips to the test tube containing the dilute hydrochloric acid (HCl).
4. Based on your observation, answer questions 6 - 8.

Questions

1. When $BaCl_2$ was added to the $MgSO_4$ a new ———— was formed.
2. This shows that a ———— reaction took place.
3. In this chemical reaction a ————(color) solid was formed.
4. The statement of what happened can be written in words:
   ———— plus ———— yields ———— plus ————
5. Complete the chemical equation of what happened.
   ———— + ———— $\longrightarrow$ $BaSO_4 + MgCl_2$
6. When the zinc was placed in hydrochloric acid, a ———— (state) was formed.
7. This shows that a ———— reaction took place.
8. In the chemical equation $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$
   a. The $\longrightarrow$ means ————.
   b. The symbol Zn stands for ————.
   c. The symbol H_2 stands for ————.
   d. The symbol Cl stands for ————.
   e. Place a circle around the new substances formed.

14. HOW DO WE COMBINE SUBSTANCES WITH OXYGEN?

Outcomes

- When a substance combines with oxygen to form a new compound, the process is called oxidation.

- When a substance burns, it combines with oxygen. This is also called oxidation.
- The oxygen is present in the air around us.
- At times the oxygen is derived from other compounds.

Teacher Activities

1. Prepare two 8 oz. bottles of oxygen, using hydrogen peroxide and manganese dioxide. Elicit the identification of the gas by using a glowing splint in one bottle. Explain that the oxygen is derived from the hydrogen peroxide and that the other material is present merely to speed the reaction.

   Explain that hydrogen peroxide is used to bleach hair because it gives off oxygen which combines with the coloring in the hair to produce a different color.

2. Exhibit some steel wool, and point out to pupils that the steel wool represents the element iron. Using forceps, heat this steel wool in a bunsen flame. Remove the heated steel wool and blow on it. Challenge the class to explain what is taking place. Write the word and formula equations for the reaction on the chalkboard.

   $$\text{Iron} + \text{Oxygen} \longrightarrow \text{Iron Oxide}$$
   $$4\ Fe + 3O_2 \longrightarrow 2\ Fe_2\ O_3$$

   NOTE: Although the equation should be balanced, no detailed explanation need be given at this time.

   Again, heat some steel wool to glowing, but this time plunge it into a bottle of oxygen. Challenge the pupils to explain that the presence of the pure oxygen allowed the reaction to take place more rapidly and intensely. Examine the appearance of the ash to reinforce the fact that a new substance has been formed. Question to determine that this new substance is a compound. Introduce the term *oxidation* as indicating the combining of a substance with oxygen.

3. Challenge the pupils to explain why it was possible for the steel wool to burn in air. Elicit the understanding that the air must contain oxygen.

   NOTE: The teacher may prefer to purchase from the S-1 list cylinders of oxygen. Bottles of the gas may be drawn from the cylinders by water displacement.

4. Ignite a short length of magnesium partially screened from the

pupils. Challenge the pupils to explain what chemical reaction took place. Caution pupils not to look directly at the burning magnesium. Write the equation on the chalkboard.

$$2\ Mg + O_2 \longrightarrow 2\ MgO$$

Student Activities

1. The following pupil activity should lead the pupils to understand that the paraffin candle (a substance made of hydrogen and carbon) reacts with the oxygen found in the air to form water and carbon dioxide.

2. Distribute to every two pupils a tray containing the materials listed on the laboratory sheet.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 14

(May be duplicated and distributed to pupils)

Purpose: What substances are produced when a paraffin candle (a fuel) burns in air?

Materials

Wide-mouthed bottle	Alcohol burner
Paraffin candle	Glass plate

Procedure

1. Using the alcohol burner, melt the bottom of the candle and fasten it to the bottom of the bottle.
2. Light the candle.
3. Hold the glass about an inch over the mouth of the bottle.
4. Cover bottle with glass plate and observe that the candle "goes out."

Questions

1. When the candle burned ———— formed on the glass plate.
2. Water, compared to the candle, is a new ————.
3. This new substance meant that a ———— took place.
4. When the bottle was covered with the glass plate the ———— went out.
5. The candle went out because all the ———— of the air was used up.
6. A candle needs ———— in order to burn.
7. A chemical reaction in which a substance combines with oxygen is called ————.

Suggested Homework

Pupils prepare for Lesson 15 by doing the following at home.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 14a

(May be duplicated and distributed to pupils)

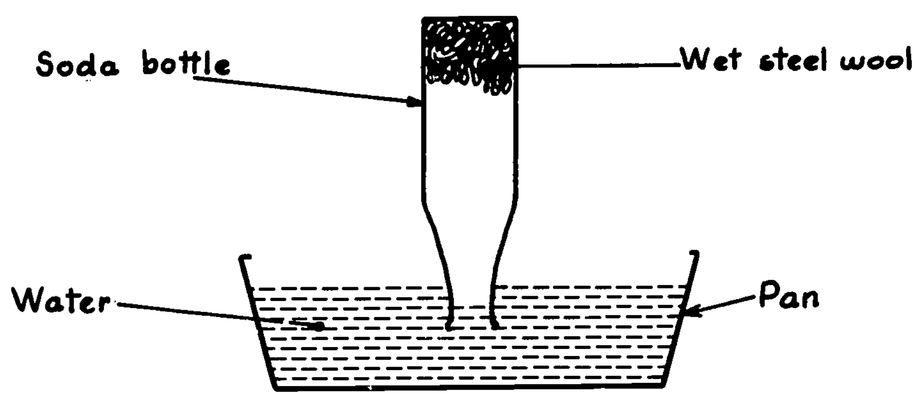
Purpose: Can we "burn" (oxidize) iron?

Materials

2 empty soda bottles (8 oz. size) Pan (at least 6" width)
Fine steel wool (*soapless*)

Procedure

1. Place the steel wool into one of the soda bottles.
2. Using a pencil push the steel wool toward the bottom of the soda bottle.
3. Wet the steel wool by filling the bottle with water.
4. Pour the water out of the bottle.
5. Place the soda bottle upside down in a pan half filled with water.



6. Place a second soda bottle not containing any iron filing in the pan.
7. Set your experiment where it will not be disturbed for at least 4 hours.
8. Mark the water levels on each of the bottles.
9. Report your observations in class the following day.

---

15. WHAT IS THE DIFFERENCE BETWEEN A CHEMICAL AND PHYSICAL CHANGE?

Outcomes

- Any change in which a new substance is produced with new properties is called a *chemical* change.

- When a new gas is produced in a reaction, it is evidence that a chemical change has occurred.
- When a new solid is formed in a reaction, it is evidence that a chemical change has occurred.

Teacher Activities

1. *Physical Change*—A change in which *no new substance* is formed, although the size, shape, or state of the original substance may be changed.

   a. Heat an ice cube in a beaker. Pour the water into a plastic container for making individual ice cubes and place this container in a beaker of "dry ice." The pupils should see that the cube is reformed.

   Elicit from the pupils that the composition of the water is not changed when it is in the solid state. The formula remains H_2O. This kind of change is therefore a physical change.

   b. Illustrate other physical changes such as the stretching of a rubber band, cutting of paper, breaking of a wood splint in half. Elicit: the original properties of the substances are not changed, regardless of the new shape of the object.

2. *Chemical Change*—A change in which a new substance is formed having properties of its own.

   a. Place about 10 ml of lead nitrate solution in a large test tube. In a second test tube place about 10 ml of potassium iodide solution. Have the pupils notice that both solutions are clear. Now add the potassium iodide solution to the lead nitrate solution. The pupils should notice the formation of a bright yellow precipitate (lead iodide).

   potassium iodide + lead nitrate ⟶
   lead iodide + potassium nitrate

   b. Pupils should be led to conclude that the formation of the bright yellow precipitate (a new substance) was the result of a chemical change.

   NOTE: The concentration of each solution is not critical for this demonstration. The more concentrated the solutions, the heavier the precipitate formed. Lead pupils to understand that the formation of a new solid (a precipitate) or the production of a gas as a result of a chemical reaction are evidences of a chemical change.

Student Activities

Introduction to laboratory activities

Have pupils discuss their previous home activity where they oxidized iron (rusting of steel wool). Have the pupils arrive at the conclusion that since a new substance, rust (Fe_2O_3), was formed, the reaction is an example of a chemical change. Recall the activities of the past few weeks in which matter underwent change. Some examples of chemical changes are the oxidation of Mg to Mg O, decomposition of water to oxygen and hydrogen, and the formation of the precipitates of AgCl and $BaSO_4$.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 15

(May be duplicated for pupil distribution)

Purpose: How does a chemical change differ from a physical change?

Materials

Wood splints
Small pieces of chalkboard chalk
Test tube
Alcohol burner
Forceps
Test tube rack
Mortar and pestle
Dilute hydrochloric acid
Test tube—10 ml $MgSO_4$
Test tube—10 ml $BaCl_2$

Procedure

1. Grind up a piece of chalk using a mortar and pestle. Are the small particles still chalk? ——————
   Is this an example of a chemical or a physical change? ——————
2. Place two small pieces of chalk into a test tube and add dilute hydrochloric acid. Look for signs of a chemical change. What do you observe?——————
   Is this an example of a chemical or a physical change? ——————
3. Add the barium chloride solution to the magnesium sulfate solution. What do you observe? ——————
   Is this an example of a chemical or a physical change? ——————
4. Hold a wood splint with a forceps. Now burn the wood splint. Compare the ash to the wood. Did it change? ——————
   Is this change chemical or physical?——————

Suggested Homework

Next to each of the following changes place a letter "P" if it is an example of a physical change or "C" if it is a chemical change.

1. Burning of coal to produce an ash ______
2. Breaking a large rock to small pebbles ______
3. Melting a piece of lead ______
4. The formation of a precipitate due to chemical reaction ______
5. Making carbon dioxide from chalk ______

16. WHAT ARE THE PROPERTIES OF CARBON DIOXIDE?

Outcomes

- Carbon dioxide is a colorless, odorless gas.
- Carbon dioxide does not support combustion.
- Carbon dioxide is produced in burning of carbon fuel.
- Carbon dioxide is produced by the body and exhaled.
- Carbon dioxide is heavier than air.

Teacher Activities

NOTE: For the demonstrations following, the teacher may either prepare carbon dioxide by the reaction of dilute HCl acid and $CaCO_3$ or he may use a cylinder of carbon dioxide *(S-1 List)*. Before the start of the class period, collect 2 bottles of the gas by either displacement of water or air. Cover each bottle with a glass plate.

1. Have the pupils examine one of the gas bottles, noting the gas is colorless and odorless. Identify the gas as *carbon dioxide* or CO_2.
2. Add to the second bottle of CO_2 gas some fresh, clean limewater. Cover with the palm of your hand and shake until the li[illegible] becomes cloudy. Inform the class that this is a test for [illegible] though other gases may be colorless and odorless, no other [illegible] react this way.
3. Now pour the remaining limewater into one of the dry bottles. Crumple a small piece of paper and place it into the bottle so that most of it is still dry. Light the paper with a match. Place a glass plate over the mouth of the bottle. After the flame is extinguished, shake the bottle to cause the CO_2 to react with the limewater. Elicit: the gas produced when the paper (a carbon product) burned was CO_2.

4. Distribute a copy of the worksheet to each student. Read the directions aloud as they read silently. Circulate among pupils to aid and encourage them as they work.

NOTE: Have at hand a supply of dilute hydrochloric acid to reactivate any reactions that have stopped before the pupil could collect samples of the gas.

5. Distribute a tray of materials to every two students.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 16

(May be duplicated and distributed to pupils)

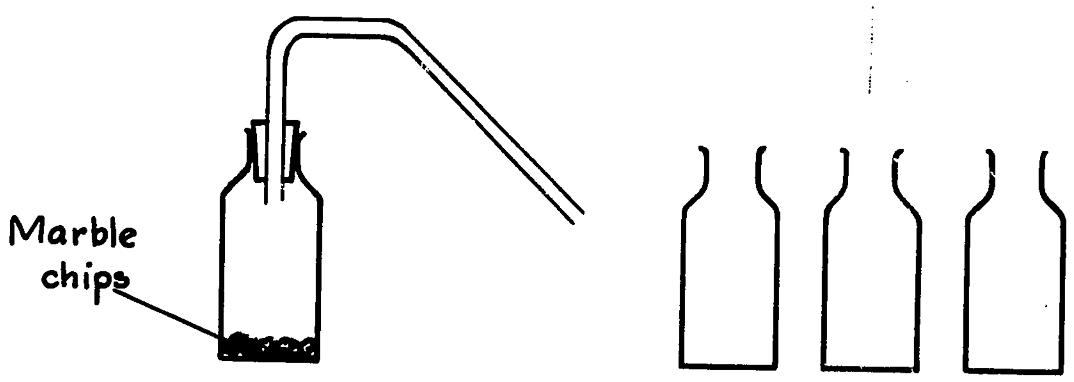
Purpose: To prepare a gas and to identify it by its properties

Materials

Limewater (freshly prepared)
Three collecting bottles, 6 oz.
Three glass plates
Length of wire (1 ft.)
Dilute hydrochloric acid
8 oz. bottle with one-hole stopper fitted with delivery tube
Marble chips—enough to cover bottom of bottle

Procedure

1. Place marble chips into the large bottle. Place the stopper with the delivery tube in the bottle. Line up the three bottles that you will use to collect the gas. Your setup should look like this:



2. When the teacher has inspected your setup, remove the stopper and pour in the acid. Immediately replace the stopper.
3. After about ten seconds have passed, fill 2 bottles with gas as follows:
   a. Keep the collecting bottle upright.
   b. Place the delivery tube in the bottom of the collecting bottle.
   c. Allow the tube to remain in the collecting bottle for about 10-15 seconds.

d. Remove the delivery tube and cover the collecting bottle with a glass plate.
4. You now have two bottles of a certain substance.
5. Wind a few turns of the wire around the candle. Light the candle. While holding the free end of the wire, lower the candle into one bottle of the substance.
   a. Did the candle burn more brightly? ——————
   b. Does this gas allow the candle to burn? ——————
   c. Could this gas be used to put out fires? ——————
6. Now pour about ½ of your limewater into the second bottle of gas. Cover the mouth of the bottle with the palm of your hand and shake.
   a. The clear limewater became ——————
   b. This is a test for ——————

Summary

1. List 5 properties of carbon dioxide.
2. When a fuel (which is made of carbon) burns, —————— is produced.
3. State the test for carbon dioxide.

Suggested Homework

Perform an experiment to determine whether the air you *exhale* (breathe out) contains carbon dioxide. Limewater may be obtained from the drug store. Take a drinking straw, and carefully bubble your breath through the straw.

NOTE: Do not blow the limewater out of the test tube.

17. WHAT IS THE DIFFERENCE BETWEEN A COMPOUND AND A MIXTURE?

Outcomes

- The elements in a compound are in a definite fixed ratio.
- In a mixture of elements there is no definite relationship between the amounts of each element.
- A formula can be written for a compound but cannot be written for a mixture.
- A mixture can be made with substances in any combination of the three states of matter.
- In a mixture, each substance that makes up the mixture retains its own original chemical properties.

Teacher Activities

1. Recall from Lesson 9 the formula of iron sulfide as FeS. Elicit: an important difference between a mixture and a compound is that in a mixture the parts do not have a definite relationship to each other. Therefore, a formula *cannot* be written for it.
2. Use slot and tab cards (see Lesson 11) representing iron and sulfur to demonstrate a lack of definite proportions of a mixture. Point out that any number of "iron" cards could be placed with any number of "sulfur" cards. This arrangement would correspond to a mixture of these elements. However, in the case of the compound, the tabs must interlock with the slots, thus definitely fixing the proportion of iron to sulfur (in this case 1:1). The heating of the mixture caused the tabs to interlock with the slots in the only manner it could; i.e., one "iron" card to one "sulfur" card.
3. Point out that a mixture of sulfur and iron filings is a mixture of a solid and a solid.
4. Open a bottle of club soda; elicit: this is a mixture of a gas and a liquid.
5. Explain to the pupils that floating soap is made by beating air into the soap when it is still soft. Elicit: this represents a mixture of a gas and a solid.
6. Pour alcohol into water; elicit: this represents a mixture of a liquid and a liquid.
7. In a battery jar half full of water, float a short candle on a cork, light the candle, and cover with an 8 oz. bottle. Challenge the pupils to explain why the water rises in the bottle but doesn't fill the bottle. (Other gases must be present.) Elicit: air is a mixture of gases.

Student Activities

Introduction to the experiment

1. Class should be made aware:
   a. That in a mixture each substance that makes up the mixture retains its own original properties.
   b. That in a compound each substance that makes up the compound loses its original properties.
2. Distribute laboratory sheets and a tray of materials to every 2 pupils.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 17

(May be duplicated and distributed to pupils)

Purpose: Has the addition of NaCl to iron filings produced a mixture or a compound?

Materials

Magnet	Test tube rack	Iron filings	Slips of paper
NaCl	Beaker 150 ml	Test tubes (2)	Stirring rod

$AgNO_3$ test solution in a dropper bottle

Procedure

1. Place about 1 inch of water into a beaker.
2. Add a portion of the NaCl to the water, and dissolve by stirring with a glass rod.
3. Add 5 drops of $AgNO_3$ solution (*silver nitrate*). Record your observation in space #1 below.
4. Place a portion of iron filings on a slip of paper and test with a magnet. Record the result in space #2.
5. Mix a portion of the NaCl (*pure table salt*) with a like portion of iron filings.
6. Take your iron filing—salt (NaCl) sample, and test it with a magnet. Record your result in space #3.
7. Using the magnet, remove as much of the iron filings as possible from the sample.
8. Place this remaining portion of your sample (with the iron filings removed) into a test tube.
9. Add twice as much water as sample to the test tube and dissolve the sample.
10. Add 5 drops of $AgNO_3$ sol. Record observation in space #4.

Observations

Original property

NaCl + $AgNO_3$ ——→ (1) ____________________

Fe + magnet ——→ (2) ____________________

Property after mixing

sample + magnet ——→ (3) ____________________

sample + $AgNO_3$ ——→ (4) ____________________

Questions

1. Each substance of the sample had the (same, different) __________ chemical properties as it had before mixing.
2. The sample was a (mixture, compound) ________.
3. A solution is a kind of (mixture, compound) ________.

Suggested Homework

1. List three basic differences between a compound and a mixture.
2. Explain why air is considered a mixture.
3. Explain why a cup of instant coffee is a mixture.

18. HOW DO WE SEPARATE PARTS OF A MIXTURE?

Outcomes

- Mixtures are made up of parts which have their own individual properties.
- In order to separate a mixture, we make physical changes which do not alter the properties of the parts.
- The physical changes to be made depend on the nature of the mixture.

NOTE: This lesson is designed to stimulate pupil growth in problem-solving. The teacher should stress the scientific method in solving this problem.

Student Activities

1. Distribute to every two pupils a tray containing the materials on the laboratory sheet. Distribute a mixture of sand, salt, and iron filings in a stoppered test tube as the unknown.
2. Have the pupils pour a little of the mixture on a watch glass and examine it with the hand lens. Question them as to whether the material is a compound or a mixture. Elicit reasons for their opinions. Guide them to see that the variations in the colors of the crystals are an indication that the material is a mixture. Challenge them to propose a method of separating the mixture into its parts. Lead them to understand that the analysis must be done with physical changes which do not change the properties of the parts.
3. Challenge the pupils to use their knowledge of materials and properties to separate the components of the mixture. If methods are not proposed, review briefly the procedures for effecting a physical change. Elicit: a magnet would separate iron from any mixture. Have the pupils use the magnet to remove the iron filings and set them aside on a watch glass. (For simplicity, the end of the magnet with the filings may be set on the watch glass.)

4. Challenge the pupils to determine by examination whether the remaining substance is a mixture or a compound. Again elicit: color is evidence.
5. Repeat the procedure of step 3 and elicit: dissolving may separate the components of the mixture.
6. Direct the pupils to place the sand-salt mixture into a test tube containing 1-2 inches of water and shake. Have them observe that the white crystals are no longer visible. Elicit: the white crystals of salt dissolved. Challenge them to determine how the visible crystals of sand may be separated from the solution. Hint that a mother has the same problem when she wishes to separate vegetables or spaghetti from the cooking water. Elicit: straining would be the method. Introduce the terms *filtering* and *filtration*.
7. Have the pupils perform the filtration after demonstrating and explaining proper filtering technique. The sand should be set aside on the filter paper.
8. Repeat the procedure of step 3 and elicit that evaporation will remove the water and the crystals will remain.
9. Now have the pupils pour the liquid remaining from filtration into an evaporating dish on a tripod, and heat the solution to complete evaporation with an alcohol burner.

   NOTE: If in step 3 the pupils suggest dissolving and straining as a first procedure, the order of the lesson should be changed.
10. The components of the mixture should now be identified and the pupils complimented.

Suggested Homework

1. Explain why you could or could not describe your separation of iron, sand, and salt by a chemical equation.
2. A boy at the beach spills a cup of sugar into the sand. Describe how he could recover the sugar from the sand.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 18

(May be duplicated for distribution to pupils)

Purpose: To identify an unknown substance

2

Materials

Unknown substance	Funnel	Evaporating dish
Magnet	Filter paper	Wire gauze
Beaker	2 watch glasses	Tripod
Alcohol burner		Tongs
Test tubes in a rack		Hand lens

Procedure

1. The first step was to find out whether the substance was a ________ or a ________.
2. To do this I ____
____

Continue to write, step by step, what you did.
At each step write what you observed.

Summary

1. The unknown substance was a ______________________.
2. It was made up of ________________(number) substances. These substances were ______________________.
3. I used the following techniques ______________________
____.

19. HOW MAY CHEMISTRY BE USED IN "DETECTIVE" WORK?

Outcomes

- Chemistry is used in many different ways both inside and outside the laboratory.
- Review several reactions which were studied during the unit.

NOTE:

This lesson is designed as a problem-solving experience. The investigation of an unknown compound follows the investigation of an unknown mixture. It is also hoped that by utilizing the pupil's interests his enthusiasm for chemistry will be stimulated.

Teacher Activities

Teacher reads letter A (following) to the class and exhibits the unknown dust. He then proceeds to analyze the material. The teacher should explain the procedure which he is following and elicit pupils' suggestions.

LETTER A

Dear Mr. (teacher's name)

The police in Hashville, Kentucky, picked up one Fritz Rockenbottom who was wanted for staging a bank robbery in Memphis, Tennessee. When the police arrested him, he had $100 although the robbery involved a great sum of money. We are interested in the case because he crossed state lines and we are anxious to recover the money.

We had Fritz change clothing and examined his clothes for clues. The shoes had much white dust on them.

I am enclosing this powder and would appreciate your analyzing the powder and giving us some hint of where he may have been.

Sincerely yours,
Sam Fried, Chief
Forensic Chemistry Division
Federal Bureau of Investigation

Procedure

a. Examine the unknown (ammonium chloride, NH_4Cl) with a hand lens. Report that it is uniform. Elicit: it is not obviously a mixture.

b. Proceed on the assumption that it is a compound. Elicit: compounds are usually made up of metals and nonmetals.

c. Tell the pupils that a simple test for copper in the compound would be to put a nail in the solution of the unknown and see whether the nail becomes plated with copper.

d. Use part of the unknown to make a solution and divide this solution into 3 test tubes.

e. Place a clean nail in the first test tube and give the test tube to a pupil to observe while you proceed with the investigation.

f. Add dry calcium hydroxide ($Ca(OH)_2$) to a sample of the dry unknown and heat the mixture. The odor of the escaping *ammonia* indicates that the unknown is an *ammonium compound.* Therefore, the formula for the unknown compound is NH_4 ————. The pupils should report the negative reaction of the copper test.

NOTES: 1. Explain the meanings of *negative* and *positive* in tests.
2. Explain difficult words in the letters.

g. Recall the reaction of barium chloride with sodium sulfate, and explain that it can be used to test for sulfates because it forms a white solid. Add a solution of barium chloride to the second test tube of the unknown solution.

h. Recall the reaction of *silver nitrate* with sodium chloride, and explain that it can be used to test for *chloride* because it forms a white solid of silver chloride. Add a few drops of silver nitrate to the third test tube of the unknown solution. Explain that the positive reaction indicates that chloride is present. Write the word and chemical equations on the chalkboard.

i. Elicit the name of the compound after recalling the parts which were found to be present. Ammonium and chloride = ammonium chloride.

NOTE: If the question is raised, explain that although ammonium is not a metal, in this compound it *acts* as a metal.

j. Read letter B to the class as the letter which was sent to the FBI.

LETTER B

Dear Mr. Fried,

The material which you sent me for analysis is ammonium chloride. This compound is found in the area of Gray's Cave, Kentucky.

I hope that this information will be of some help to you.

Cordially,
Teacher's name

k. Read letter C to the class and tell the pupils that you will permit them to analyze the unknown substance.

LETTER C

Dear (Teacher's Name)

The information which you forwarded to me has indeed been helpful. We went down to Gray's Cave and found the stolen money.

Please accept the thanks of the department for your help. I am sending you another sample for analysis.

Cordially,
Sam Fried, Chief
Forensic Chemistry Division
Federal Bureau of Investigation

Student Activities

1. Distribute a tray of materials for every 2 pupils.
2. The copper sulfate used as the unknown should be a uniform powder.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 19

(May be duplicated and distributed to pupils)

Purpose: To perform tests on an unknown solution in order to identify it

Materials

Test tube rack
Test tubes (3)
Clean iron nail
Hand lens
Silver nitrate solution (with a dropper)
Barium chloride solution (with dropper)
Unknown sample to be tested (*analyzed*)
Flask (100 ml) with water

Procedure

NOTE: As you proceed with the *analysis,* answer the questions below:

1. Examine the powder with a hand lens.
2. Place the unknown sample into a test tube and dissolve it by adding water.
3. Divide the solution into 3 test tubes.
4. Test the solution of the first tube to determine whether it contains copper.
5. Test the solution of the second tube to determine whether it contains a chloride. Add three drops of the silver nitrate solution. *Caution:* Do not allow the silver nitrate solution to come in contact with your skin.
6. Test the third tube for a *sulfate* by adding 3 drops of a barium chloride solution.

NOTE: The blue color of the unknown solution may lead you to think the white *precipitate* is bluish.

Questions

Examine the unknown powder to see whether it might be mixture or a compound.

1. In order to observe the unknown for different kinds of crystals, you used the ——————.
2. There (was, wasn't any) ———— difference in the color of the crystals.
3. You assumed that the unknown was a (compound, mixture) ————.

Test the unknown solution to see whether it was a copper compound.

4. This test was (negative, positive) ————.
5. This showed that ———— (was, wasn't) ———— present.

Test the unknown solution to see whether it was a chloride.

6. This test was (negative, positive) ————.

7. This showed that ____________ (was, wasn't) ____________ present.
Test the unknown solution to see whether it was a sulfate.
8. This test was (negative, positive) ____________.
9. This showed that ____________ (was, wasn't) ____________ present.
Therefore your test showed that the name of the compound is ____________ ____________ ____________.

Suggested Homework

Write up a procedure for the analysis of a compound you suspect is ammonium sulfate.

20. DOES SIZE MAKE A DIFFERENCE IN THE PROPERTIES OF MATTER?

Outcomes

To THE TEACHER: This lesson is designed to review basic concepts of the molecule as well as to condition the pupils to think in terms of fundamental units of matter.

- The individual molecules of a substance are the units which possess the physical and chemical properties of that substance.
- The amount or size of a substance does not ordinarily affect its properties.

Teacher Activities

1. *What is a molecule?*
   a. Call upon a pupil to break a piece of chalk into small pieces. Question the pupils as to the smallest piece of chalk that could exist. Have the pupils recall that a molecule is the smallest particle of a substance that possesses all the properties of that substance.
   b. Recall pupil experiences with several compounds they have encountered, such as carbon dioxide, vinegar, and sugar. Again elicit that the molecule of these compounds is the smallest particle that would exhibit all of their properties (see Lesson 10, Chemistry).
2. Breaking a crystal into molecules
   a. Recall that copper sulfate is a compound, and a small crystal of

it is really made up of many millions of molecules packed closely together.

b. Make a solution of a teaspoonful of copper sulfate crystals in about 200 ml of water in a beaker. Place a cardboard cover over the beaker. Insert 4 clean iron nails through the cardboard. Place the nails so that they are about 1½" apart and have at least half their length immersed in the solution. After a few minutes examine the nails for copper.

c. Lead the class to conclude that the crystals were subdivided into molecules, its smallest possible state. The iron nails coated with copper serve to demonstrate that the copper sulfate molecules had spread throughout the solution and were able to affect all of the iron nails.

NOTE: It is not necessary to mention the ionization of $CuSO_4$ at this time.

Student Activities

1. Distribute to every 2 pupils a tray of materials listed on the laboratory worksheet.
2. Instruct pupils that pure rock salt and pure granulated table salt are different forms of the same compound, sodium chloride.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 20

(May be duplicated and distributed to pupils)

Purpose: Does size make a difference in properties of a material?

Materials

Rock salt (pure)
Granulated table salt (pure)
Hand lens
Glass stirring rod
Two beakers (125 ml), with 50 ml of water
Two sanitary straws
Glass plate

Procedure

1. Examine the rock salt and the granulated salt with a hand lens.
2. Place a pinch of granulated salt in the first beaker. Dissolve it by stirring with a glass rod.
3. Place a drop of the solution on a glass plate and examine with a hand lens.
4. Taste the solution, using the sanitary straw. (Use your own straw.)
5. Repeat steps 2, 3, and 4, using a few crystals of rock salt.

Questions

1. Did you notice any difference in appearance between the rock salt crystals and the granulated salt? ______
2. When you examined a drop of each of the solutions with a hand lens, did you see any salt particles? ______
3. Even though you did not see the salt particles in solution, how did you know that salt is present? ______
4. The smallest possible salt particles in solution are the ______.
5. When granulated salt and rock salt are in solution, they both have the (same, different) ______ properties.

Suggested Homework

Place a tablespoon of baking soda into one saucer and a pinch (a few grains) of baking soda into another. Add 2 tablespoons of vinegar to both. Compare the results. Did the amount of baking soda used make a difference in the kind of reaction that took place? Explain your answer by writing down exactly what happened.

21. WHAT ARE MOLECULES MADE OF?

Outcomes

- The molecule is *not* the smallest unit of matter.
- Molecules of a compound consist of atoms of the elements which make up the compound.
- The *atom* is thus the basic unit of all matter.
- The exceedingly small size of the atom presents a challenge to the scientists' ability to investigate atoms.

Teacher Activities

1. Recall that the molecule is the smallest particle of a compound. The formula of water is H_2O and may be expressed as HHO (Lesson 10).
2. Display a large clay model of a molecule of water composed of 2 balls representing hydrogen and one ball of different colored clay representing oxygen. Using this model, point out that although the modecule is the smallest particle of water that can exist, it can actually be broken down further; hence it is *not* the smallest possible particle of matter.

NOTE: 1. The pupils should be made aware that the clay model only represents the molecule.

2. Small sponge balls or styrofoam balls may be substituted for the clay. These items should be connected with toothpicks and wrapped in a transparent plastic to maintain the unity of the molecule.

Student Activities

1. Circulate a brass weight of 1 gram among the pupils. Have the pupils lift the weight and make a mental note of its weight. Inform the students that scientists have determined the weight of the hydrogen atom to be .000, 000, 000, 000, 000, 000, 000, 001, 667 of the weight they have just picked up.
2. Question the pupils to determine that this tremendously small size and weight of the atom creates problems for the scientist attempting to investigate the atom. Use the following activity to indicate, in a general way, the kind of reasoning that is followed in such investigations.
3. Distribute to every 2 pupils a numbered cardboard box such as a shoe box or milk container. The box may be painted black and tightly sealed with masking tape.
4. Each box should contain one of the combinations of materials listed below:
   a. steel bearing, square wooden block
   b. steel bearing, round wooden ball
   c. steel bearings (2)
   d. square wood block, round wooden ball
5. Before handling their boxes, have the pupils make suggestions as to how they could proceed in attempting to determine the contents of the boxes. Encourage suggestions such as shaking, rattling, and tipping the box. Elicit that the use of a magnet might furnish further information.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 21

(May be duplicated for distribution to pupils)

Purpose: Do we have to see an object in order to gather information concerning it?

Materials

Sealed, numbered box containing one or more items
Bar magnet

PROCEDURE:	QUESTIONS:
1. Record the number of your box.	1. Box number: ________
2. Shake the box gently up, down, and sideways.	2. How many items are there in the box? ________
3. Tilt the box slowly until the objects either roll or slide.	3. What are their shapes? ________ ________ How big are they? ________
4. Place a magnet near each of the items after separating them by shaking the box *gently*.	4. How was the magnet affected by the item in the box? ________
5. Near the end of lesson your teacher will open the boxes. Check off your correct answers.	5. How many correct answers do have? ________

Summary

1. Use this activity to elicit that:
   a. By planning carefully, we were able to think of things that we could do that would give us information as to what was in the box.
   b. With more instruments (x-ray and fluoroscope) we would have been able to determine even more about the contents of the box.
   c. We do not have to see an object in order to gather information about that object.
2. Is the molecule the smallest unit of matter? ________
3. Molecules are made up of particles called ________.
4. Therefore the ________ is the basic unit of all matter.
5. Is it necessary to see an object in order to learn about it? ________
   Explain ________

Suggested Homework

1. Using clay of different colors, make up molecules of the following compounds. (Be prepared to tell what each ball represents.)
   a. Water (Hydrogen Oxide, H_2O)
   b. Salt (Sodium Chloride, NaCl)
   c. Sand (Silicon Dioxide, S_1O_2)

22. THE STORY THAT DID NOT TELL "WHY."

Outcomes

- The English scientist John Dalton declared that each element was composed of its own kind of atoms.
- The atoms of any element are different from the atoms of any other element.
- John Dalton's theory did not explain *why* elements combined as they did.
- Failure of Dalton's theory to explain why atoms behaved as they did as well as certain other observations of matter caused scientists to investigate even further the nature of the atom.

Teacher Activities

1. What was the first significant Atomic Theory?
   a. Display the clay model of a water molecule used in the preceding lesson. Have the pupils identify the hydrogen and oxygen atoms. Tell the pupils that this model of the atom stemmed from the work of John Dalton in the early 1800's. Summarize Dalton's theory as follows:
      1. All elements are made up of small particles called atoms.
      2. Atoms of the same element are alike but are different from atoms of all other elements.
      3. Atoms are solid, indivisible particles.

   b. Display clay balls of the same size and color, and identify each color as atoms of a particular element, i.e., red clay balls for sodium, blue clay balls for chlorine, green clay for hydrogen. Using the clay balls, demonstrate to the pupils how Dalton's atoms could be put together to form molecules. Make molecules of compounds such as sodium chloride, NaCl.
2. Did Dalton's theory explain the nature of matter?
   Elicit from pupils that, although Dalton's theory enabled us to understand what took place during chemical reactions, it did *not* explain *why* certain elements combined with some elements but not with others. (Give examples: sodium combines with chlorine but not with aluminum.)
3. Other observations of matter for which Dalton's theory couldn't supply a satisfactory explanation:
   a. Using a Geiger counter, demonstrate its reaction to a radioactive

substance such as a radium-dialed watch or a sample of uranium ore. Explain this by telling the pupils that the Geiger counter is indicating that the substance is giving off rays of some kind. Briefly tell of the discovery of radium by Monsieur and Madame Curie. Point out that these observations of the disintegration of the radium atom indicated that the atoms were not indivisible as Dalton had stated.

b. Have the pupils recall incidents involving static electricity, such as pulling a woolen sweater over their heads. Elicit: lightning is an example of static electricity. Lead the pupils to an understanding that the origin of such a common occurrence as static electricity is left totally unexplained by Dalton's theory of solid, indivisible atoms as the fundamental units of matter.

Student Activities

1. Distribute the laboratory worksheet.
2. Distribute to every 2 pupils a tray of materials listed on the worksheet.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 22

(May be duplicated for distribution to the pupils)

Purpose: To demonstrate one of the observations that could not be explained by Dalton's Theory

Materials

Strip of thin cardboard 1" x 5"	Piece of wool or fur
An index card 3" x 5"	Hard rubber rod
Pencil	Piece of saran wrap

Procedure

Preparation of a static electricity detector

1. Find the center of the strip of cardboard by first folding the card in half vertically (up and down) and then folding the card in half again lengthwise.
2. Place a pencil through the center of the *larger* card (3" x 5").
3. Use the card as a base. Stand the pencil with point straight up.
4. Balance the folded strip of cardboard on the pencil point. This folded strip should be free to turn easily.

Directions for use of the static electricity detector

5. Change a rubber rod by rubbing it on the wool or fur.
6. Bring the rod close to the tip of the movable part of your detector. What do you observe? ——————

7. Charge a piece of saran wrap by rubbing it with the fur or wool.
8. Bring the saran close to the tip of the movable part of your detector. What do you observe? ——————
9. Static electricity may be formed when the atoms of matter are ———— .

Summary

Summarize by reviewing Dalton's atomic theory of solid, indivisible atoms. Then cite the series of observed phenomena that could not be explained within the framework of this theory. Point out that these observations, along with several others, caused scientists to continue to investigate the nature of the atom.

Suggested Homework

Describe three reasons why scientists were not satisfied with John Dalton's atomic theory.

23. HOW SOLID ARE ATOMS?

Outcomes

- The atoms of the element radium give off three different kinds of rays: alpha, beta, and gamma rays.
- These rays can be used to investigate (probe) the atoms of matter. In this way we are able to gather information concerning the atom.
- Evidence indicates that the atom is not entirely a solid structure but has a great deal of space as well.
- Our present ideas concerning the structure of the atom is based upon the observations and contributions of many scientists through the years.

Teacher Activities

1. Tell the pupils that after 1885 scientists working with radium discovered that the rays given off by this element were actually of three different kinds. Name these rays as alpha, beta, and gamma rays. Demonstrate the presence of beta-like rays by using a cathode ray tube (Crookes tube, S-1 #14-1358, 1965-66) connected to the secondary of an induction coil. (Use this simply to demonstrate the "real" nature of these rays. Do not demonstrate magnetic deflection at this point. This will be done in a succeeding lesson.)
2. Mention that Ernest Rutherford recognized the ability of some of

the radium rays (alpha rays) to penetrate the atoms of matter. The experiments of Rutherford with these rays as *probes* on gold leaf indicated the atoms seemed to contain a "solid" portion as well as a good amount of empty space.

Stress the fact that this "picture" of the atom that we are putting together is based upon the observations and contributions of many scientists through the years.

Student Activities

To develop the understanding how the use of bombarding rays may help us learn about the structure of atoms, guide the pupils through the following activity:

Distribute to each two pupils a pegboard, such as the one illustrated, and a marble. (Illustraiton opposite page)

Prepare the pupils for the activity by telling them that they are about to "bombard" the pegboard with the marble, just as the scientists of the late nineteenth and early twentieth century bombarded the atom with the newly discovered rays.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 23

(May be duplicated and distributed to the pupils)

Purpose: The atom—brick wall or wire fence?

Materials

Pegboard with a marble

Procedure

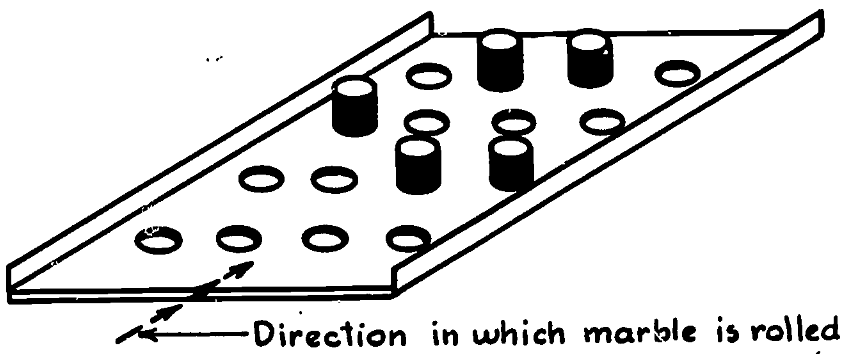
1. Try to roll the marble from one side of the board to the other. What prevents the marble from rolling freely across the pegboard? ——————
2. Remove about half of the pegs from different places on the board. Now try to roll the marble across the pegboard. Why is it now easier to roll the marble across? ——————
3. Aim the marble at a peg and allow the rolling marble to strike the peg. The marble now (was, was not) —————— deflected.

Questions

1. If the pegboard was completely solid then the marble would (go across the board, bounce off) —————— the pegs.
2. If the pegboard represents an atom and the marble represents the probing rays, then an atom is more like a (brick wall, wire fence).

Suggested Homework

1. Read pages 59-63 in the booklet "Chemistry of Matter" very carefully. Write a brief report, *in your own words,* entitled "The History of the Atom." Base the report on answers to these questions:
   a. What did Democritus believe about matter?
   b. What were the two main ideas of John Dalton's atomic theory?
   c. Why was J. J. Thomson's picture of the atom called the "plum pudding" model of the atom?
2. Explain why Rutherford decided that atoms must contain a large amount of empty space.



1. Select a marble too large to pass between 2 pegs, set side by side.
2. Place pegs, initially, so that there is at least one in each column.

24. WHAT DO WE FIND WHEN WE "LOOK" INSIDE THE ATOM?

Outcomes

- Atoms are made up of smaller particles including protons, neutrons, and electrons.
- The center of the atom is called the nucleus; it contains protons and neutrons.
- Electrons are outside the nucleus and orbit the nucleus.
- Atoms differ one from the other in the number of particles they contain.

Teacher Activities

1. What do we think the atom looks like?
   a. Recall from the previous two lessons that investigations by scientists in the early twentieth century had indicated very strongly

that Dalton's concept of the atom was incorrect in the following two respects:

1. The atom was *not* a solid particle.
2. The atoms of the different elements were not completely different; these atoms *did* have something in common.

b. Tell the pupils that these and subsequent investigations have led us to a picture of the atom that is consistent with the results of these new investigations. Using a demonstration magnetic atomic model, demonstrate to pupils the structure of the Rutherford-Bohr atom. Use the model to stress that the atom, for the most part, consists of empty space. (This can be emphasized by asking the pupils to imagine an atom the size of Yankee Stadium, and then telling them that the nucleus of this atom would be the size of a flea standing in the center of the stadium!)

c. Call the attention of the pupils to the little particles that make up the atom model. Elicit from the pupils that most of the particles are located in the center, and that the other particles not actually in the center are in motion around the center. Supply the names of the *particles* as *protons, neutrons,* and *electrons.* Tell pupils that the center of the atom is referred to as the *nucleus* of the atom. Lead the pupils to understand that the atom consists of: 1) a nucleus containing particles called protons and neutrons, and 2) particles called electrons which are in constant motion around this nucleus. Draw the analogy between the structure of the atom and our solar system. Have the pupils liken the atom nucleus to the sun and the electrons to the planets in orbit about the sun.

d. Construct a model of a hydrogen atom.

   Tell the pupils that hydrogen atoms are exceptional in that they contain no neutrons, but merely a proton and an electron.

Student Activities

1. Tell the pupils that the simplest atom other than hydrogen is that of the gas helium. Tell them that this atom consists of 2 protons, 2 neutrons, and 2 electrons. Have the pupils construct the nucleus of the helium atom.
2. Distribute to each 2 students a tray containing the materials on the worksheet.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 24

(May be duplicated and distributed to pupils)

Purpose: To construct a model of an atom of helium

Materials

Styrofoam ball—1 white	— nucleus
Thumbtacks—2	— protons
Paper fasteners—2	— neutrons
Ball of modeling clay	— electrons
Wire, #22, about 9 inches long	— shell
Toothpicks—2	— shell support

Procedure

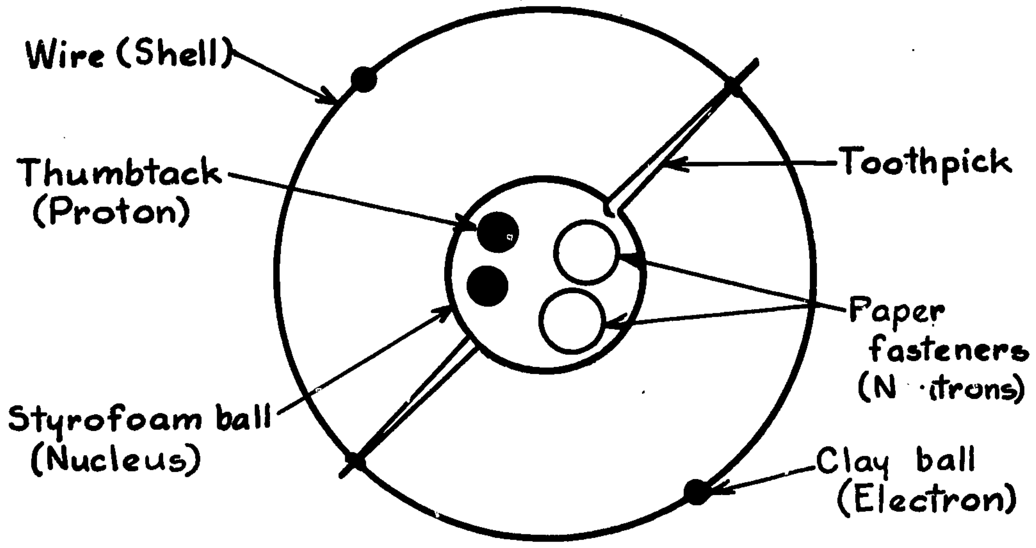
1. Place the neutrons and proton on the nucleus.
2. Place the toothpick in the styrofoam ball and attach the shell.
3. Place the electrons on the wire.

Questions

Compare your model of the helium atom with the model of the hydrogen model constructed by your teacher.

1. What two particles are found in the nucleus? ———— and ———— .
2. What particles are found in the shell? ————————.
3. How is the model of the hydrogen atom similar to the helium atom? ———————— and ————————.
4. How is the model of the hydrogen atom different from the helium atom? ————————.

The following method is suggested for pupil models of the various atoms:



Summary

Summarize the day's activities by eliciting from the pupils a picture of the atom as a nucleus consisting of protons and neutrons surrounded by fast-moving electrons in orbit around the nucleus. Stress the similarities in the two atoms investigated. Emphasize that the different amounts of particles make for completely different chemical properties in the two elements.

Suggested Homework

1. Using Tinker Toy parts, see whether you can build models to represent the following atoms: (Be prepared to tell what each part of your model represents.)
   a. hydrogen
   b. helium
2. Hydrogen and helium are the lightest elements known. Based on what you know about the atoms of these elements, which element would you expect to be lighter? Explain your answer.

25. WHAT IS AN ELECTRON?

Outcomes

- The electron was identified by J. J. Thomson in 1897.
- Electrons are very, very light electrical particles.
- Each electron has a negative electrical charge.
- Electrons are electrically different from protons. Protons have positive electrical charges.
- Atoms are ordinarily electrically neutral; i.e., they contain the same number of positively charged protons as negatively charged electrons.
- Rubbing an object often adds or removes electrons, thus giving that object an electrical charge.

Teacher Activities

1. What is an electron?
   a. Demonstrate the rays produced when a Crookes tube is connected to the secondary of a direct current induction coil. Inform the pupils that this ray has electrical characteristics. As a result it produces a magnetic field.

b. Demonstrate the upward or downward deflection of the ray by placing 2 alnico magnets, one on either side of the Crookes tube with their opposite poles facing each other on a horizontal plane.

Recall pupil experiences with magnetic attraction and repulsion. Elicit the understanding that if the magnets are placed properly there should be a deflection (change) of the path of the rays. Have pupils conclude that the rays have electrical characteristics.

c. The work of Sir Joseph J. Thomson with these rays led him to conclude that:
   1) The rays were made up of many particles which he called *electrons.*
   2) These electrons were very, very light in weight.
   3) These electrons are parts of all atoms.
   4) Electrons have a *negative electrical charge* while protons have an opposite or a positive electric charge.

Student Activities

1. Before the pupils start this activity, the teacher should be sure that the pupils understand that matter usually does not have an electrical charge. This is so because the atoms of matter have the same number of negative electrical charges (electrons) as positive electrical charges (protons). We therefore say that matter has a zero charge or is electrically neutral.
2. We can change the electrical characteristics of matter by either adding electrons or removing electrons from the matter. This can be done to certain kinds of matter by *friction* (rubbing).
3. Distribute to every 2 pupils a tray of materials listed on the laboratory worksheet.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 25

(May be duplicated and distributed to the pupils)

Purpose: What causes static electricity?

Materials

Balloons (2)
Wool cloth
Two-foot lengths of string (2)

Procedure

Inflate the balloons and tie each with a separate piece of string.
Now gently rub one of the balloons.
Place the balloon on the back of your chair.
Now try to place the second balloon (unrubbed) on the back of the chair.
Hang each balloon by its string so that the balloons just touch.
Separate the balloons and rub each with the wool.
While the balloons are still suspended by the string, try to bring the two balloons together.

Questions

1. The balloon that was rubbed with the wool (did, did not) ____________ stick to the back of the chair.
2. The unrubbed balloon (did, did not) ____________ stick to the back of the chair.
3. When the two balloons were rubbed with the wool they (attracted, repelled) ____________ each other.
4. The unrubbed balloon is electrically (neutral, charged) ____________ .
5. If a substance is electrically neutral, its atoms have (the same, not the same) ____________ number of protons as electrons.
6. The balloon that was rubbed was electrically (neutral, charged) ____________ .
7. If the balloon was negatively charged, it means that it (gained, lost) ____________ electrons.
8. We can prove that two balloons are charged alike if they (repel, attract) each other.

Suggested Homework

1. Rub a comb on hair or wool. Compare it with an unrubbed comb in its ability to pick up small bits of paper. Describe your results.
2. Using a piece of wool or a piece of silk, rub different objects, i.e., pen, pencil. See whether any of these objects will pick up small bits of paper. Report your results.

26. HOW CAN THE PERIODIC TABLE OF ELEMENTS HELP US TO GET MORE INFORMATION ABOUT THE ATOM?

Outcomes

- The Periodic Table is arranged according to increasing atomic numbers.

- The atomic number of an element tells us the number of protons present in the nucleus of that atom.
- Knowledge of the atomic number tells us indirectly the number of electrons in the atom.

Teacher Activities

1. Display a large chart of the Periodic Table modified to contain the symbols, atomic number, and atomic weight (to the nearest whole number) of the first 20 elements.
2. Have the pupils recall that in Rutherford's gold leaf experiment the "solid" portion of the atom was the nucleus. Our present-day concept indicates that the nucleus is not solid at all but consists of particles (proton and neutrons).
   NOTE: It is not necessary to mention the other subatomic particles.
3. a. Have the pupils recall the fact that the properties of argon and potassium are such that they are out of place when arranged by *increasing weights* of the atoms. The pupils should be made aware that this situation occurs at other points when all 103 elements are arranged according to their weights.
   Inform the pupils that in 1914 after the existence of the proton had been discovered, the young English scientist Henry Moseley, using X-rays, devised a method of determining just how many protons the atom of each element contained. He found that when he arranged the elements, by increasing the number of protons, this arrangement generally confirmed the previous arrangement by weight and also cleared up the mystery of argon and potassium. Since argon has one less proton than potassium, argon should come before potassium.

   b. Define the atomic number as the number of protons in the nucleus of an atom, and elicit that our present Periodic Table is arranged according to increasing atomic numbers.

   c. Recall the pupils' activities with static electricity during the previous lesson in which it was elicited that the electrically neutral nature of the atom indicates exactly as many protons as electrons. Elicit the understanding that atomic number of an atom tells us not only the number of protons in the nucleus, but also the number of electrons in the shells around the nucleus.

   d. Distribute to every 2 pupils the materials listed on the laboratory worksheet.

NOTE: See the pupil worksheet for model of the insert card. The slotted work cardboard is the same one used in Lesson 12.

Student Activities

LABORATORY WORKSHEET — CHEMISTRY: LESSON 26

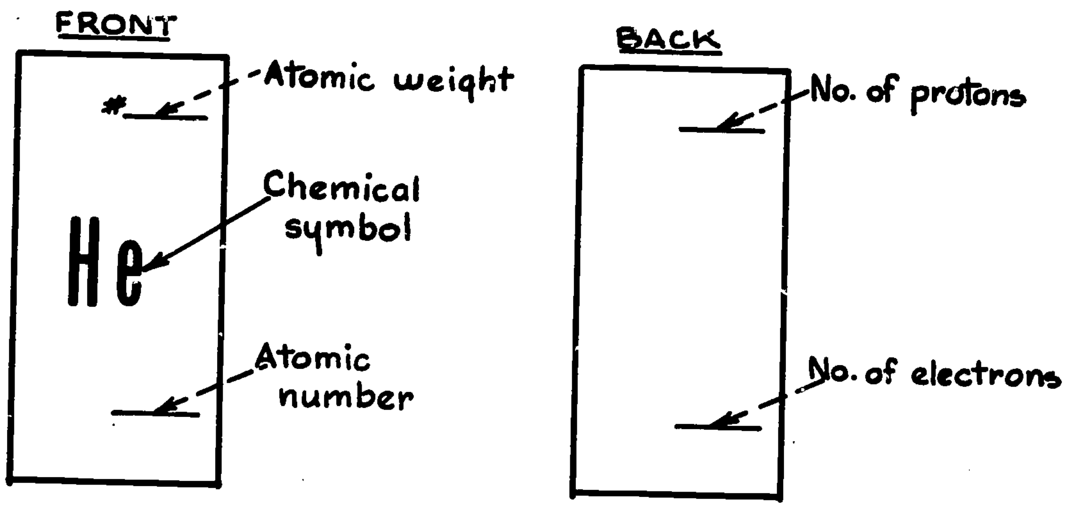
(May be duplicated and distributed to the pupils)

Purpose: To prepare a Periodic Table of Elements according to their atomic number

Materials

A pack of insert cards for the first 20 elements
Slotted, work cardboard

PREPARATION OF ELEMENT INSERT CARD



1. Should be the size of a Delaney card.
2. Each pack of insert cards is made up of one such insert for each of the first 20 elements.

Procedure

1. On the side that has the chemical symbol for the element, fill in the atomic number. This information may be obtained from the chart your teacher has displayed.
2. Turn the cards over. In the spaces provided, fill in the number of protons and the number of electrons for that element.
3. Now check your chart. Each period should have its elements in order of increasing atomic number.
4. Arrange the element insert card for these first twenty elements according to atomic number.

5. Place the element cards in the proper place in your slotted, work cardboard. (Remember the special places for hydrogen and helium).

Questions

1. When you arrange the elements in increasing atomic (number, weight) ——— all of the elements are in their correct order.
2. The atomic number tells us how many (electrons, protons) ——— are in the *nucleus* of the atom.
3. List 4 facts concerning the atom which the Periodic Table can supply us. ———, ———, ———, ———.
4. The atom is electrically neutral because it contains the same number of ——— as ———.
5. An element with an atomic number of 27 has ——— electrons in its shells.

Suggested Homework

(Duplicate the following chart and distribute to pupils. Actual chart has all 20 elements and their symbols.)

Complete the chart, using the "Alphabetical List of the More Important Elements" you were given earlier. (Lesson 8)

Atomic No.	Symbol of Element	Name of Element	Number of Protons	Number of Electrons
1	H			
2	He			
3	Li			

27. WHAT GIVES THE ATOM ITS WEIGHT?

Outcomes

- Neutrons and protons are practically identical in weight.
- Since the weight of an electron is almost negligible, the weight of the atom is concentrated in the nucleus.
- The atomic weight of an atom can be calculated by adding the numbers of protons and neutrons.
- The number of neutrons in an atom can be calculated by subtracting the atomic number from the atomic weight.

- The neutron has a neutral electrical charge.
- The Periodic Table supplies us with the number of protons, neutrons, and electrons in the atom of each element.

Teacher Activities

1. Recall the almost negligible weight of the electron (1/1840 of a proton). Elicit from the pupils that the weight of the atom must therefore be concentrated in the nucleus and that the protons or neutrons or both must be the particles that give the atom its weight.

2. Inform the pupils that the neutron was discovered in 1930 by the English scientist James Chadwick. His experiments showed that this particle had almost the identical weight as the proton but had no electrical charge. Elicit: the weight of the atom is the combined weight of the protons and neutrons in the nucleus of the atom.

3. Instruct the class how to determine the number of neutrons of an atom, using the atomic weight and atomic number; i.e., helium, atomic weight = 4, atomic number = 2. Have the class recall from the previous lesson that the atomic number tells how many protons are present. Therefore helium with an atomic number of 2 has 2 protons.

   If the atomic weight = the number of protons + the number of neutrons, then for helium:

   atomic weight of 4 = 2 protons + 2 neutrons

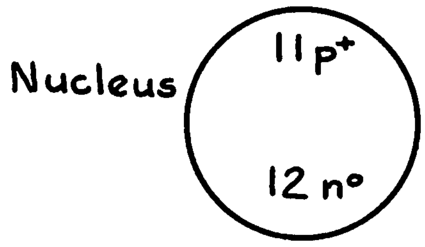
   Help the class to determine the number of neutrons for lithium (atomic weight of 7, atomic number of 3).

   Atomic weight of 7 = 3 protons + 4 neutrons. The pupils should be led to understand that the numbered protons subtracted from the atomic weight = the number of neutrons. Show that hydrogen with an atomic number of one and atomic weight of one cannot have any neutrons. This is the only element without neutrons.

4. Tell the pupils that it is often desirable to draw picture representations of the atoms. Using atomic number 11 as a model, elicit from the pupils the number of protons and neutrons in the nucleus of this atom. Draw the nuclear diagram as shown on page 71, on the chalkboard. Use the following abbreviations for the particles:

   proton = p^+, neutron = n^0, and electron = e^-

sodium atomic number 11, atomic weight 23



5. Distribute the pack of 20 element cards used in the previous lesson.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 27

(May be duplicated and distributed to the pupils)

Purpose: To draw a picture that *represents* the nucleus of the atom

Materials

Pack of 20 element cards used in the previous lesson
Alphabetical list of common elements

Procedure

1. Using the alphabetical list of common elements and the pack of element cards as sources of information, fill in the table below:

ELEMENT SYMBOL	NAME OF ELEMENT	ATOMIC WEIGHT	ATOMIC NUMBER	NUMBER OF NEUTRONS
Be				
B				
C				
N				
O				
F				
Ne				

2. Draw a picture to represent the nucleus of each element listed in the chart.

Questions

1. Most of the atom's weight is due to the particles found in the (nucleus, shell) ________ .

2. The protons are located in the (nucleus, shell) ______________.
3. The neutrons of an atom (do, do not) ______________ have an electrical charge.
4. The (protons, neutrons) ______________ may be determined by subtracting the atomic number from the atomic weight.

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28. HOW ARE THE ELECTRONS ARRANGED AROUND THE ATOM'S NUCLEUS?

Outcomes

- Electrons in atoms are arranged in shells which are designated K, L, M, and so forth.
- Each shell contains enough energy to hold a maximum number of electrons. These maxima are:

  K shell — 2 electrons
  L shell — 8 electrons
  M shell — 8 electrons

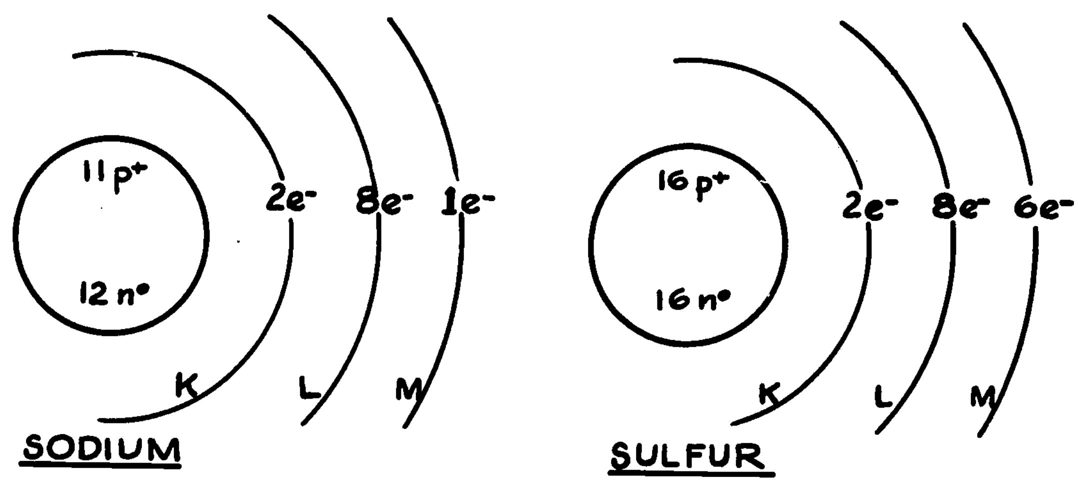
- In the atom the electrons tend to fill one shell before beginning to fill the next.

Teacher Activities

1. Recall the atomic diagrams drawn by the pupils during the previous lesson. Point out that these diagrams did not indicate the location of the electrons, other than by indicating that they were somewhere outside of the nucleus. Ask the question, "Where are electrons found in the atom?"
2. Display the models of the hydrogen and helium atoms constructed in a previous lesson. Elicit from the pupils that in these atoms the electrons are moving in a somewhat circular path some distance away from the nucleus. Provide the name *shell* for this circular path.
3. a. Using the magnetic atomic model: Build the nucleus of the lithium atom. Elicit from the pupils that this atom contains three electrons. Ask for suggestions where these electrons should be placed.

   b. Explain to the pupils that *energy* is required to hold the fast-moving electrons in their path about the nucleus. The pupils should be told that there is sufficient energy in the first shell to hold only two electrons. Elicit: the third electron of the lithium atom will therefore have to go into another shell. Set the three electrons in place on the magnetic model. Inform the pupils that scientists designate the shells as K and L shells. The second shell, the "L" shell, contains only enough energy to hold 8 electrons. Question the pupils as to how the electrons should be arranged for the element with an atomic number of 11.

4. Using the magnetic model, illustrate the electron arrangement of the atoms with the atomic numbers 11 and 16. Demonstrate to pupils one method of picturing these electron arrangements as follows:



5. Introduce the short way of expressing the atomic weight and the atomic number of an element; e.g., for sulfur $_{16}S^{32}$. The subscript is the atomic number and the superscript is the atomic weight.

Student Activities

1. Display models of hydrogen and helium atoms. Divide the class into six groups, and assign to each group the construction of a model atom of one of the following elements; atomic number 5, 6, 7, 8, 9, or 10. Circulate among the pupils to encourage them in their construction. See lesson 24 for a description of these models.
2. When the pupils have finished, have each group display and describe its atom.
3. Distribute the materials listed on the laboratory worksheet to each of the six groups. The teacher should display the modified Periodic Table chart and distribute copies to the pupils.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 28

(May be duplicated and distributed to the pupils)

Purpose: To construct a model of the atom of an element

Materials

Thumb tacks (10)	Wire, approx. 15"
Paper fasteners (10)	Ball of modeling clay
Styrofoam ball	Toothpicks (4)
Wire, approx. 9"	Periodic Table (modified)

Name of the atom assigned to you ________.

Procedure	Questions
1. Look up the atomic number and the atomic weight of your element.	1. The atomic number is ______. The atomic weight is ______. The number of protons is ______.
2. Using your styrofoam ball as your nucleus, tack in the proper number of thumbtacks to represent the protons.	2. The number of thumbtacks used as protons. ______
3. Using the fasteners as neutrons, place the proper number into the styrofoam ball (nucleus).	3. The number of fasteners used ______.
4. Take the shorter length of wire and make it into a ring. Insert 2 toothpicks into the nucleus so as to hold up the ring (see the teacher's model).	4. The wire represents the ______ shell of the atom.
5. Make the proper number of clay balls, one for each electron.	5. The *total* number of clay balls representing the electrons in your model is ______.
6. Place the proper number of clay balls (electrons) on this first shell.	6. The number of electrons in the first shell is ______.
7. Make the longer piece of wire into a ring and hold it in its proper place by the use of 2 or more toothpicks.	7. This wire represents the ______ shell. The maximum number of electrons for this shell is ______.

Suggested Homework

1. Draw the diagram of the atom for each of the following elements:
   $_{1}H^{1}$ $_{4}Be^{9}$ $_{15}P^{31}$
2. Indicate for each atom:
   a. the number of protons and neutrons in the nucleus
   b. number and arrangement of the electrons in the shells
   c. name of the atom

29. "BORROWERS" OR "LENDERS"?

Outcomes

- Atoms whose outermost shells are complete do not ordinarily combine with other atoms.
- Atoms whose outermost shells are not complete tend to "lend" or "borrow" electrons to make these outermost shells complete.
- The atoms of elements in the same vertical column of the Periodic Table all have the same number of electrons in the outermost shell.
- Metals lend electrons to attain complete outermost shells; nonmetals borrow electrons to attain complete outermost shells.

Teacher Activities

1. Display a Periodic Table of Elements. Mention the use of gases in advertising signs. Tell the pupils that the gases used are often the elements helium, neon, and argon. Explain that each of these elements is a gas which does not ordinarily react or combine with any other elements. Introduce the word *inert*. Call upon some pupils to draw a diagram of the atom of each of these elements on the chalkboard. Challenge the pupils to discover what all of these atoms have in common. Lead them to an understanding that in each case the outermost electron shell holds all of the electrons that it possibly can. Encourage the pupils to make the generalization that when the *outermost* electron shell is filled, the atom will not enter into chemical combination with other atoms.
2. Using the magnetic atomic model, build the fluorine atom. Elicit from the pupils that this atom is one electron short of having its outermost shell filled. Lead them to a realization that, were this atom to receive an electron from somewhere, then, like the inert gas neon, its outermost shell would be filled. Tell the pupils that atoms

tend to act so that they will always have their outermost shells filled with all the electrons that shell can hold.

3. Distribute to each pupil a copy of the worksheet. Lead the pupils through the steps for the fluorine exercise.

   Repeat the above presentation with the building of the oxygen atom. Elicit: this atom would tend to try to receive *two* electrons from somewhere in order to fill its outermost shell. As before, lead the pupils through the oxygen exercise on their worksheets.

4. Now have the pupils work out the electron arrangements and determine the number of electrons that will be borrowed by the elements in Part I of their worksheets. Circulate to help and encourage the pupils.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 29

(May be duplicated for pupil distribution)

PART I

1. Draw a diagram representing the following atoms:

   $_{9}F^{18}$ $_{17}Cl^{35}$ $_{8}O^{16}$ $_{16}S^{32}$ $_{15}P^{31}$ $_{7}N^{14}$

2. Indicate for each atom how many electrons must be "borrowed" in order to complete the outermost shell.

PART II

1. Draw a diagram representing the following atoms:

   $_{3}Li^{7}$ $_{4}Be^{9}$ $_{5}B^{11}$ $_{11}Na^{23}$ $_{12}Mg^{24}$ $_{13}Al^{27}$

2. Indicate for each atom how many electrons it must "lend" in order to have its outermost shell complete.

---

5. How does the Periodic Table identify "lenders" and "borrowers"?

   Recall the fact that the vertical columns of the Periodic Table identify "families" of elements having similar properties. By having the pupils refer to their worksheets, elicit from them that lithium and sodium each have one electron in their outermost shell, and thus will "lend" one electron. Elicit from the pupils that hydrogen, too, has one electron to "lend."

NOTE: Hydrogen was not mentioned on the worksheet to preclude the pupils from concluding that, having one electron in its K shell, it will tend to borrow another electron to fill this shell.

Lead the pupils to an understanding that all members of the vertical groups have the same number of electrons in their outermost shell and that this number is different for each vertical group.

Elicit: in moving from left to the right, we pass from the "lenders" to the "borrowers" and end up with the inert elements. (Tell the pupils that the two elements with 4 electrons in the outermost shell can either lend or borrow their 4 electrons.) Lead the pupils to a realization that the atoms which lend electrons are all metal, and that the atoms which borrow electrons are all nonmetals.

Summary

1. When the outermost shell of an atom is complete, it ordinarily (does, does not) ——— react with other atoms.
2. Metallic atoms (borrow, lend) ——— electrons.
3. Nonmetallic atoms (borrow, lend) ——— electrons.
4. The number of electrons that an atom "borrows" will complete its ——— shell.
5. The atoms of elements in the same vertical column of the Periodic Table all have the (same, different) ——— number of electrons in the outermost shell.

30. THE STORY THAT DOES TELL "WHY"

Outcomes

- During chemical changes, electrons move from one atom to another to complete their outermost shells.
- Atoms that lend electrons readily combine with atoms that borrow electrons.
- Usually, atoms of metallic elements (electron lenders) combine with atoms of nonmetallic elements (electron borrowers) to form molecules of compounds.

- The chemical formula of a compound represents the number and kinds of atoms that combine to form a molecule of the compound.

Teacher Activities

1. Have the pupils recall Lesson 11 and display some of the element cards with tabs and others with slots. The pupils should be aware that element cards had varying numbers of tabs and slots, which determined the formula of the compounds they formed. Recall that the number of tabs or slots was an indication of the combining power of the element. Work of the previous lesson indicated that atoms form compounds by "lending" or "borrowing" electrons to make their outermost shell complete.
2. Distribute to every 2 pupils a tray of material listed on the laboratory worksheet. Pupils are to construct the electron arrangement of the lithium and fluorine atoms. Do not have the pupils construct the nucleus, since there will be too many particles for the pupils to handle at one time.

LABORATORY WORKSHEET — CHEMISTRY: LESSON 30

(May be duplicated and distributed to the pupils)

Purpose: To show how a lithium atom combines with a fluorine atom to form a compound

Materials

Wire, 9 inches (2)	Round wood splints	Styrofoam balls (2)
Wire, 15 inches (2)	Ball of modeling clay	Toothpicks (4)

Procedure

1. One member of your table will construct the electron arrangement of the lithium atom while the other member of your team will construct the electron arrangement of the fluorine atom.
2. As before, use a styrofoam ball as the nucleus and the wire and toothpick arrangement as the shells.
3. Make two electron shells for each of the atoms.
4. Using balls of clay as electrons, form the electron arrangement for lithium, atomic number 3.
5. The other member of the table will form the electron arrangement for fluorine atomic number of 9.
6. Complete the outermost shell of both atoms by transferring (borrowing or lending) electrons from your completed atoms.

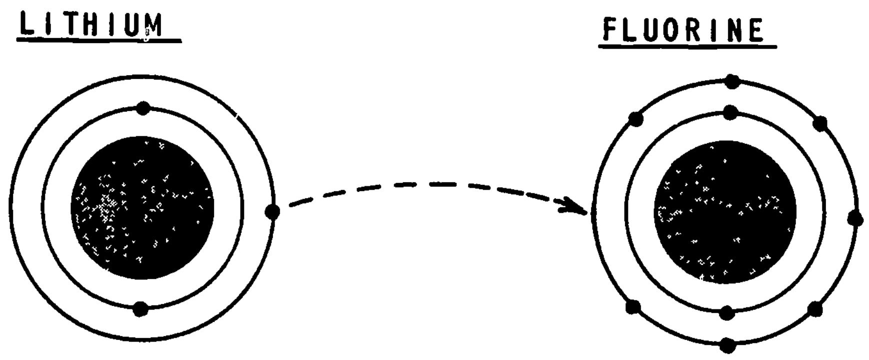
7. Connect the two *nuclei* by means of a wood splint to form a molecule of LiF.

Questions

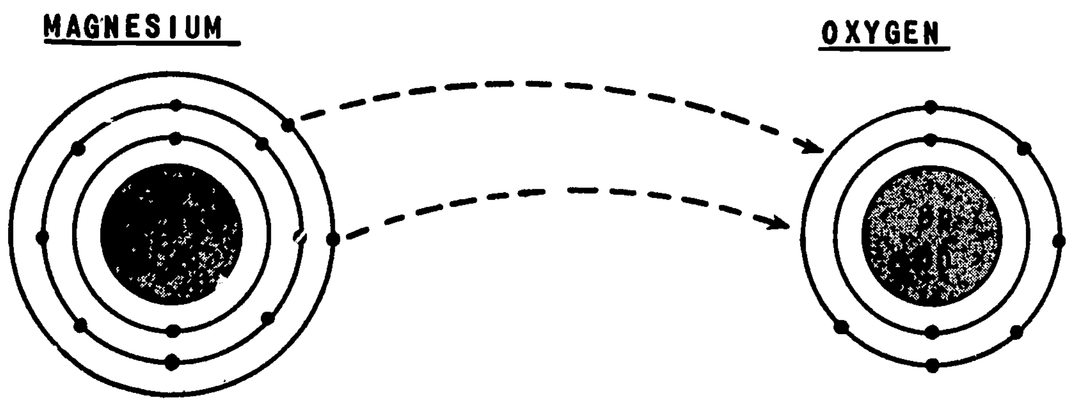
1. In a chemical reaction ―――――― may be transferred from one atom to another.
2. Lithium is considered a metal because when it reacts with other elements it (lends, borrows) ―――――― electrons.
3. The formula LiF tells us that ―――――― atom of Li combined with ―――――― atom of fluorine to form a molecule of lithium fluoride.

Teacher Activities *(continued)*

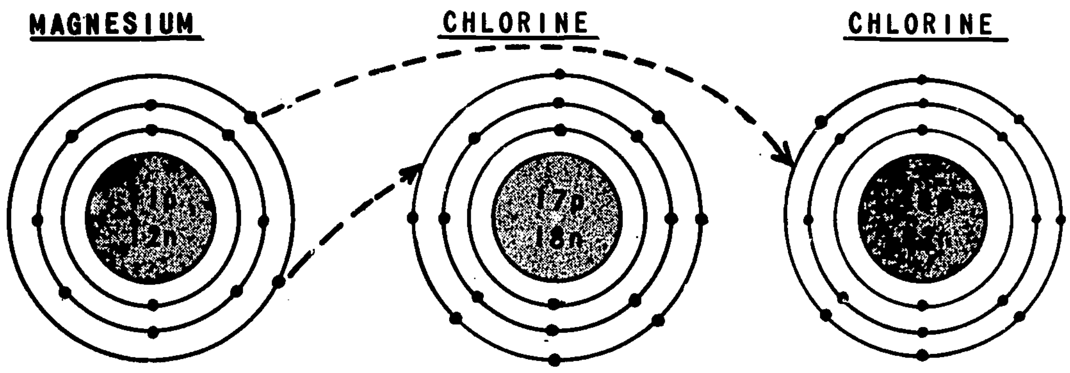
3. After the pupils have completed the laboratory worksheet, reinforce the learning by means of the following chalkboard diagram.



4. a. By means of chalkboard diagrams, charts, or transparency of the atoms, show what happens when magnesium combines with oxygen. Challenge the pupil to show with arrows the transfer of electrons from one atom to the other to form MgO.



b. Demonstrate and explain combinations involving the transfer of more than one electron, as in the formation of $MgCl_2$ from a reaction of magnesium and chlorine. Elicit the understanding that it will require two atoms of chlorine for each atom of magnesium.



Suggested Homework

1. Practice drawing the union of the following atom to form molecules:
   (a) Hydrogen and chlorine
   (b) Calcium and oxygen
2. Using the drawings you have completed for question 1 as a source of information, write the formula for the molecule formed.

SUGGESTED REFERENCES: CHEMISTRY

For the Teacher

BOYLAN, PAUL J. *Elements of Chemistry.* Boston: Allyn & Bacon, 1962.

BRANDWEIN, JOSEPH ET AL. *A Source Book for Physical Sciences.* New York: Harcourt, Brace, 1959.

CHOPPIN, G. R. and JAFFE, BERNARD. *Science of Matter, Energy and Change.* Morristown, N. J.: Silver Burdett Co., 1965.

DORF, LEMKIN, TROIK. *Chemistry For the Nuclear Age.* New York: Oxford Book, 1965.

EHRET, W. F. *Smiths's College Chemistry.* New York: Appleton-Century-Crofts, 1960.

GRAHAM, R. P. and CRAGG, L. H. *The Essentials of Chemistry.* New York: Holt, Rinehart, 1959.

LANFORD, OSCAR E. *Using Chemistry.* New York: McGraw-Hill, 1959.

Manufacturing Chemists' Assoc., Inc. *Matter, Energy and Change.* 1825 Connecticut Avenue, N.W. Washington 9, D.C., 1960.

PARKES, G. P. *Mellor's Modern Inorganic Chemistry.* New York: John Wiley, 1961.

PAULING, L. *General Chemistry.* San Francisco: Freeman, 1958.

SCOTT, E. and KANDA, F. *Nature of Atoms and Molecules.* New York: Harper, 1962.

SELWOOD, P. S. *General Chemistry.* New York: Henry Holt, 1959.

SIENKO, M. J. and PLANE, R. A. *Chemistry.* New York: McGraw-Hill, 1961.

SISLER, H. H. ET AL. *College Chemistry.* New York: Macmillan, 1961.

THOMSON, SIR GEORGE. *The Atom.* Amen House, London: Oxford University Press, 1962.

YOUNG, JAY A. *Elements of General Chemistry.* Englewood Cliffs, N.J.: Hall, 1960.

WASHTON, N. S. *Science Teaching in the Secondary School.* New York: Harper, 1961.

For the Pupil

ASIMOV, I. *Building Blocks of the Universe.* New York: Abelard-Schuman, 1961.

————. *Inside the Atom.* New York: Abelard-Schuman, 1961.

COOPER, ELIZ. K. *Discovering Chemistry*. New York: Harcourt, Brace, 1959.

FREEMAN, IRA and MOE. *All About the Atom*. New York: Random House, 1955.

———. *Fun with Chemistry*. New York: Random House, 1962.

———. *The Story of Chemistry*. New York: Random House, 1962.

HECHT, S. *Explaining the Atom*. New York: Viking Press, 1955.

MORGAN, A. *First Chemistry Book for Boys and Girls*. New York: Scribner's, 1962.

SCHNEIDER, NINA and HERMAN. *Science in Our World*. Boston: Heath, 1956.

VIORST, JUDITH. *150 Science Experiments Step-by-Step*. New York: Bantam Books, 1963.

WOODBURY, D. *The New World of the Atom*. New York: Dodd, Mead, 1965.

WYLER, ROSE. *The First Book of Science Experiments*. New York: Franklin-Watt, 1957.

Unit II

PHYSICS

Electricity
Magnetism
Heat

ELECTRICITY

Suggested Lessons and Procedures

I. HOW DO WE PRODUCE AN ELECTRIC CURRENT?

Outcomes

- An electric circuit must contain a source of electrons (dry cell) and a conducting path.
- An electromotive force is the result of the mutual repulsion of electrons (a push or pull).
- A measurable flow of electrons is called an electric current.

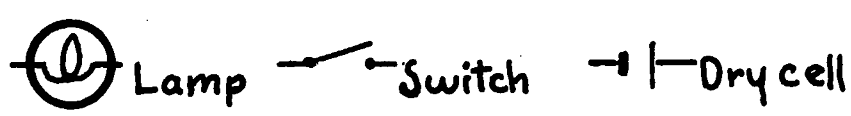
Teacher Activities

NOTE: New vocabulary words are italicized.

1. Review concept from *Science: Grades K-6* (page 17) that electricity travels in a closed circuit. Remind the pupils of the function of a switch in a circuit. Show one or more of the circuits (diagram opposite) mounted on perforated masonite and suspended from the chart hooks above the chalkboard. Name the parts of an ordinary electric circuit—*source* of *electrons* (dry cell), *conducting* wires, and *load (or resistance).* Place these names on chalkboard as they are given. Elicit the fact that a switch may "open" or "close" a circuit. NOTE: Time limit 5-10 minutes.

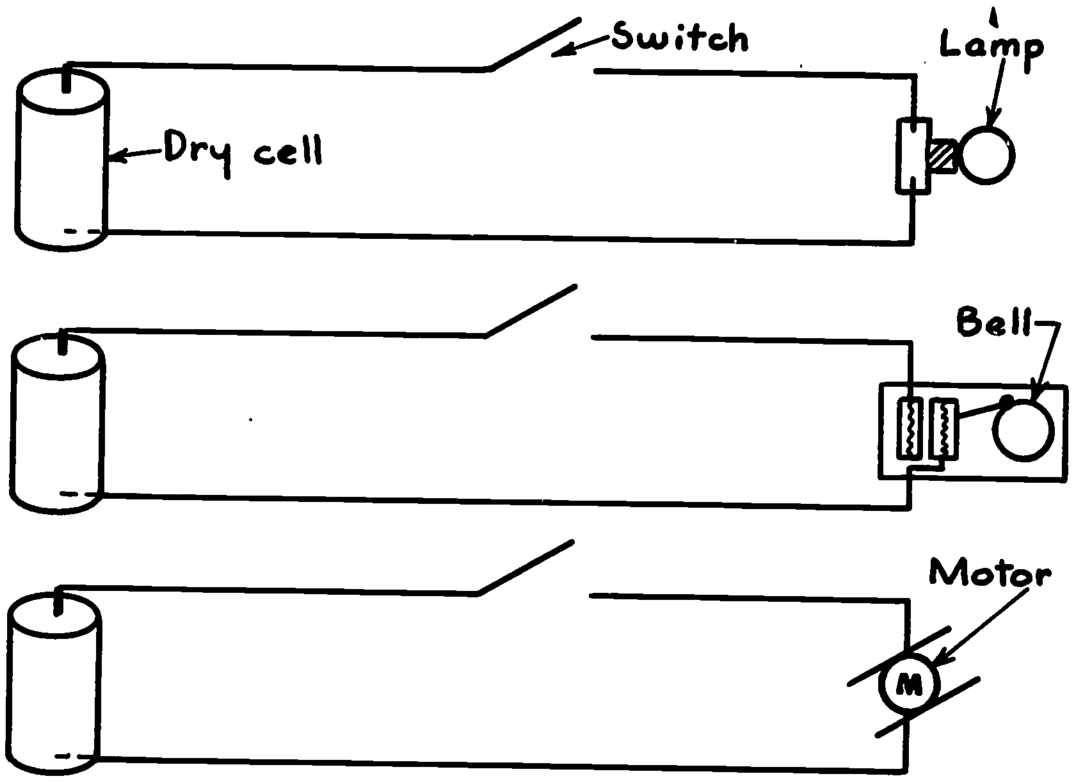
   Ask class, "What things do you see that are the same in these mounted circuits?"

   Remind class that in chemistry we used symbols to save time, e.g., Al for aluminum, etc. We use electrical symbols to save time, too:



2. Demonstrate that to make things move, a "push" or "pull" is needed. Another word for a "push" or "pull" is force. Tell the pupils that in electricity this force is called the *electromotive force* and is abbreviated as emf. Write this on the chalkboard and have the pupils copy it into their notebooks.

3. Tell the pupils that electric current from a cell depends upon this electromotive force. Demonstrate this by having the first row stand and face the class. Direct the pupils to extend their arms to the side. Each pupil represents an atom and the "hand tap" may be an electron. Tap the first pupil on his outstretched hand saying "Pass it." This is the way emf is transmitted. Another analogy: The emptying of a crowded subway car has a "push" which forces out many people.



4. "Let's find out whether we can show that this happens in electricity." At this point introduce the following terms and have pupils find them on the laboratory worksheet. (1 setup for 4 pupils)

voltmeter — measures emf	metal strips — electrodes
HCl — electrolyte	Al, Cu, Zn, Fe

NOTE: Time allowance 20 minutes for laboratory work

LABORATORY WORKSHEET — PHYSICS: LESSON I

(May be duplicated and distributed to pupils)

Purpose: To show the formation of an electromotive force

Materials

250 ml beaker containing an electrolite (either 1:10 HCl or vinegar)
4 metal strips (electrodes)—1 each of copper (Cu), iron (Fe), aluminum (Al), zinc (Zn)
500 ml beaker containing water
3-inch square of 00 sandpaper, emery cloth, or steel wool
Voltmeter—use the 3-volt scale
2 12" lengths of bell wire with alligator clips at one end
Paper towels

Procedure

Connect the two wires to the voltmeter, using the 3-volt scale.

Connect the wire attached to the (+) terminal of the voltmeter to the copper strip, after sanding the strip.

Pupil 1. After sanding one of the other strips, attach it to the negative terminal of the voltmeter. Slowly lower both strips into the electrolyte.

Pupil 2. Read the number on the meter to which the voltmeter needle moves.

Pupil 3. Check the reading on the voltmeter and record it on the chart below.

Pupil 4. Take the metal strip out of the electrolyte (not the copper one) and rinse it.

METAL PAIRS	ZN - CU	AL - CU	FE - CU
VOLTMETER READING	..................VOLTS	..................VOLTS	..................VOLTS

Repeat each step using a different metal strip, but at all times keep the copper strip attached to the (+) terminal of the meter.

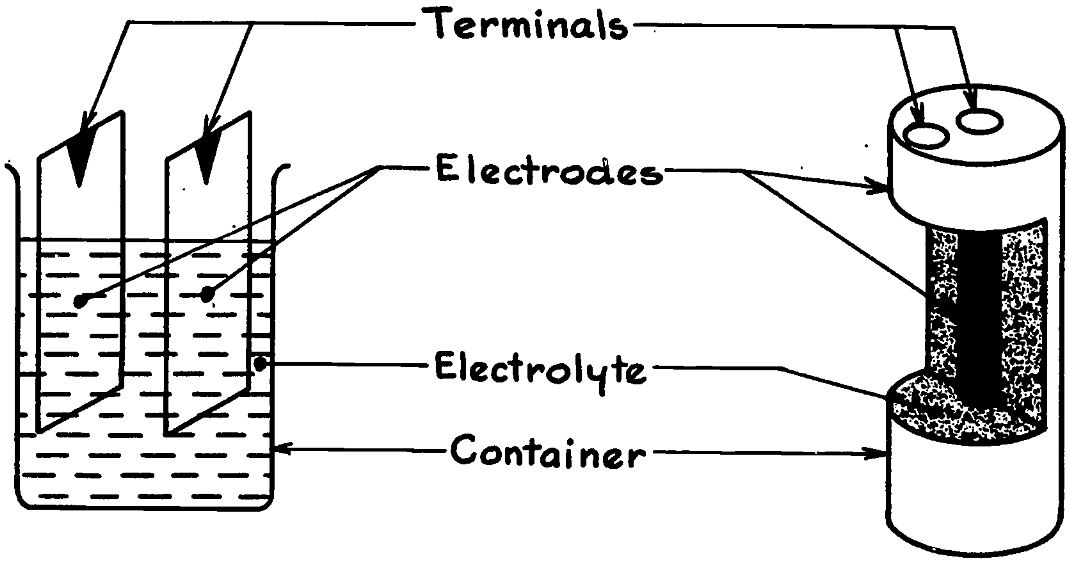
Summary

1. Is there a flow of electrons in each case?
2. How might you explain the difference in your results?
3. What is an electric current?
4. Draw a diagram of today's experiment. Label the parts by using the words: acid, terminal, electrolyte, electrode, metal strip, beaker.

Teacher Activities *(continued)*

NOTE: If magnesium ribbon is substituted for aluminum strip, greater voltage will be developed than between copper and aluminum.

5. Optional Activity
   After the materials have been collected, have the recorder for each group place his data on the master chart on the chalkboard. Explain that all scientific investigations must be repeated many times before we accept the results. This serves to reinforce the self-confidence of the pupils in scientific investigation, collecting data, and in recording data. Discuss results.
6. Summarize by placing a cut-away dry cell (see diagram) on the demonstration table alongside a wet cell similar to that which was made.



7. Recall from chemistry that when a metal becomes an ion it gives up electrons. Discuss the similarities and differences between the wet cell and the dry cell. Record the discussion on the chalkboard and have pupils copy it into their notebooks.
8. Show terminals on various cells and batteries. Add the word *terminal* to the list of new words on the chalkboard.

2. WHY DO MANY BULBS IN A SUBWAY CAR GO OUT AT THE SAME TIME?

Outcomes

- Series circuits provide a single path for electrons.
- Electrons flow from the negative terminal of a source along a circuit and back to the positive terminal.

Teacher Activities

1. Demonstrate how to connect dry cells for this experiment. Point out that the terminal in the middle is called the *positive terminal* and is marked (+), and that the terminal on the rim is called the *negative terminal* and is marked (−). Write these terms and symbols on the chalkboard. Have the students connect the positive terminal of one dry cell to the negative terminal of the second.

LABORATORY WORKSHEET — PHYSICS: LESSON 2

(May be duplicated and distributed to pupils)

Purpose: To make a series circuit

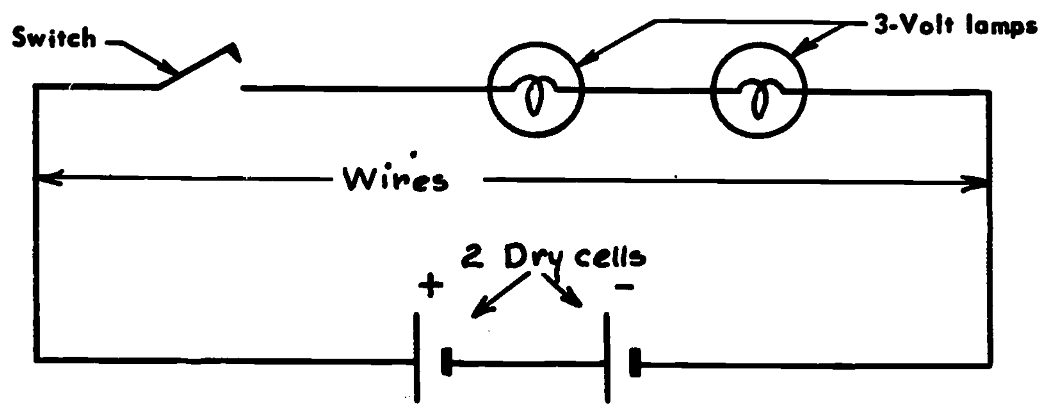
Materials

2 #6, 1½ volt dry cells
Small screwdriver
Bell wire, ends bared of insulation for ½" } 3 12" lengths; 2 6" lengths
Pushbutton or snap switch
2 3-volt lamps in miniature sockets

Procedure

Let teacher check all circuits before you close the switch.

1. Connect the 2 dry cells as shown before. Use one lamp in socket, the dry cells, the switch, and wires to make a simple circuit. Notice the brightness of the lamp.
2. Open the circuit by removing a wire from one side of the socket. Place another socket in series with the first one and make a circuit which follows the diagram below.



3. Compare the brightness of the lamps, when two are in the circuit, with the brightness when only one bulb is in the circuit. What happens when one bulb is unscrewed?
4. Take apart your circuit and replace the parts in the box. (reassemble)

Summary

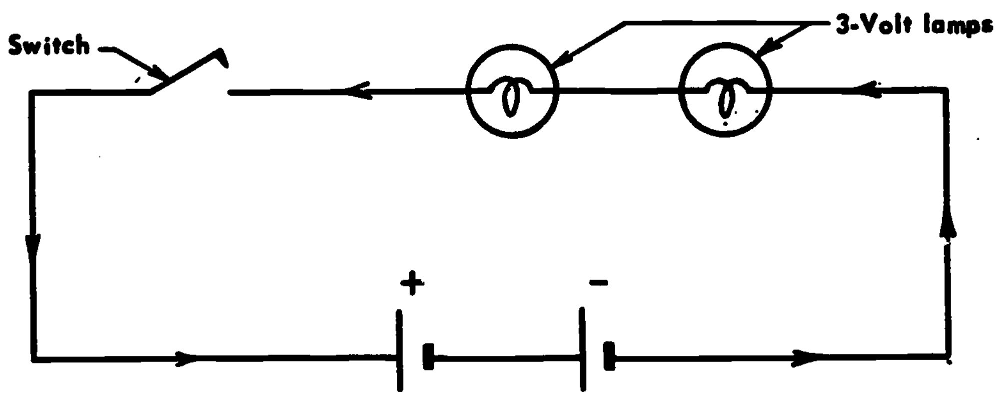
What are the advantages and disadvantages of series circuits?

Disadvantages	Advantages
1. Electricity must be shared by each device in a series circuit.	1. Easy to connect devices in series.
2. All devices stop when one fails to operate.	2. Fuses can be used to protect circuits.
	3. Switches in series are used to open and close circuit.

Teacher Activities *(continued)*

2. "Why were the wires bared at the ends?"
   Elicit from the class that this is necessary because electrons will flow more easily through certain substances.

3. Explain the flow of electrons from the negative terminal of the dry cell around the circuit and back to the positive terminal. This single path for electrons is called a series circuit. Write this term and definition on the chalkboard. Project a transparency of this circuit diagram, if available; otherwise use chalkboard. A pupil is called upon to trace this flow of electrons. Indicate electron flow by adding arrows to the diagram. Pupils likewise indicate direction of electron flow on the diagrams on their laboratory worksheets; they may also label the terminals.



Optional Activity

Remove a miniature socket and lamp assembly and replace with a standard socket containing a household fuse (six amperes or fewer) in good condition. Supply burned-out screw-type fuses, too. This socket should be mounted on a three-inch square wood block (½" - ¾" stock) with terminals exposed. Elicit the fact that no current will flow when a fuse is "burned-out" or removed.

Suggested Homework

1. Speak to your building superintendent or hardware store salesman to find out: "Why do we use a fuse?"
2. Where are the fuses used in your house?
3. For possible extra credit: Connect 2 cells in series with a buzzer and a pushbutton.

3. HOW CAN YOU EXPLAIN WHY ONE HEADLAMP OF A CAR IS LIGHTED WHILE THE OTHER IS NOT?

Outcomes

- Parallel circuits provide more than one path for electrons.
- Parallel circuits permit independent operation of electrical devices.

Teacher Activities

1. Have the pupils recall from the previous lesson that the second lamp went out when the first was removed. Challenge the pupils to act as electrical engineers (designers of electrical equipment, such as wiring in a building or of electronic devices such as a transistor radio) to design a circuit which would permit the second lamp to remain lighted when the first lamp is removed. Permit pupils to make suggestions before moving on to laboratory exercise.

LABORATORY WORKSHEET — PHYSICS: LESSON 3

(May be duplicated and distributed to pupils)

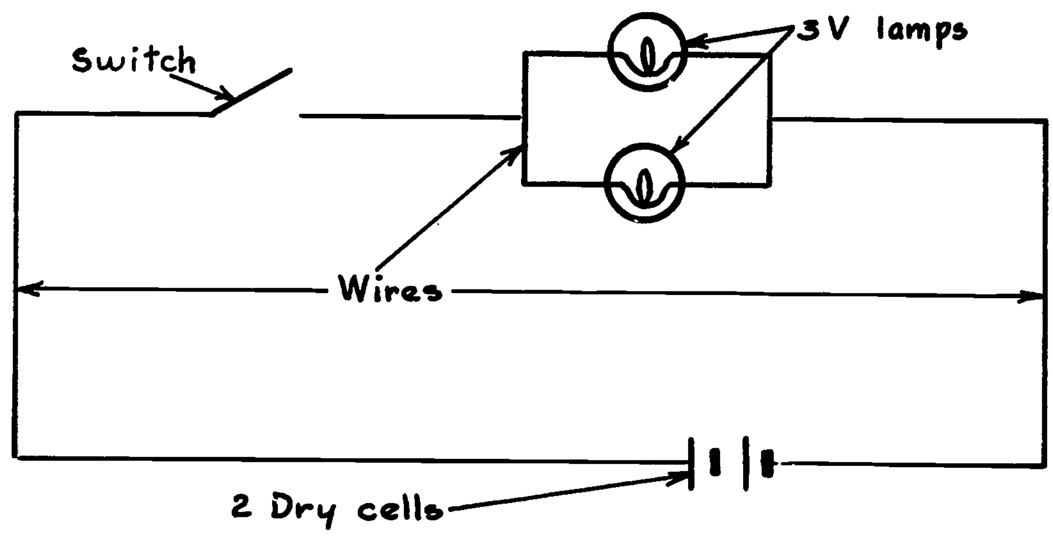
Purpose: To construct a parallel circuit

Materials

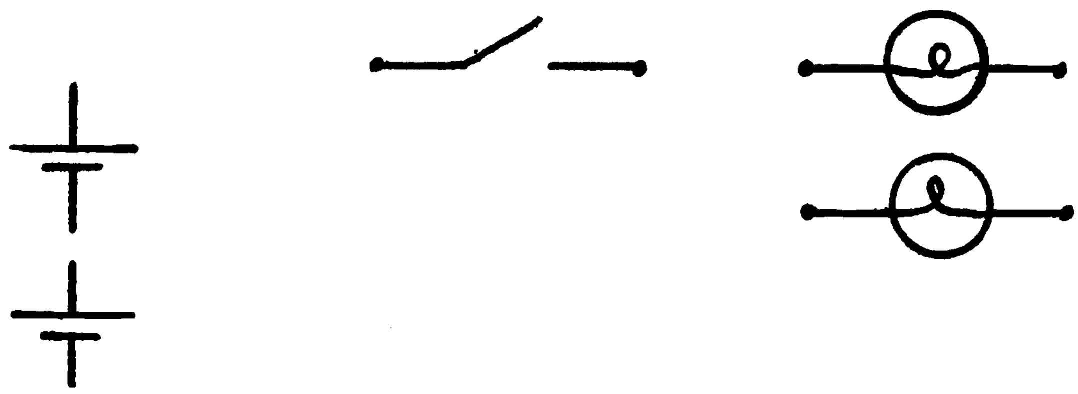
2 #6, 1½-volt dry cells
Small screwdriver
Bell wire, ends bared of insulation for ½" — 3 12" lengths; 4 6" lengths
Pushbutton or snap switch
2 3-volt lamps in miniature sockets

Procedure

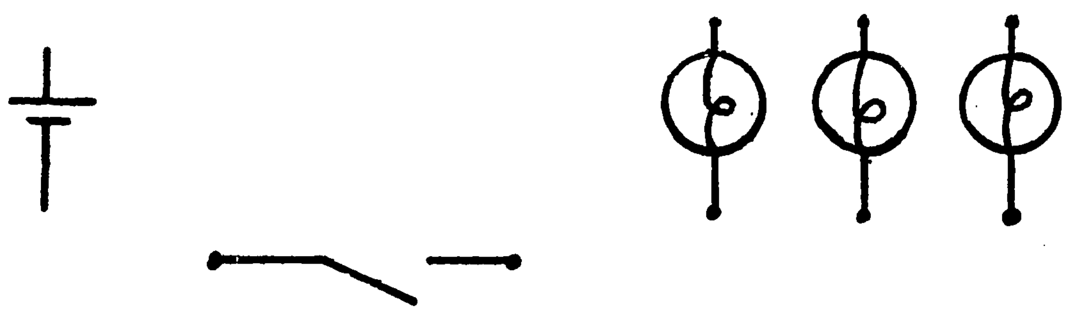
1. Connect the two dry cells in series.
2. Connect the cells, two sockets, wires, and switch as shown on the diagram. Do not close switches until the teacher checks your circuit.



3. When your circuit is approved, close the switch and answer these questions:
   a. How does the brightness of the lamps in a parallel circuit compare with their brightness in the series circuit?
   b. What happens when one lamp is unscrewed?
4. Take all connections apart and return parts to kit.
5. *Summary:* (This may be completed at home.)
   a. Define series circuit.
   b. Use pencil and ruler to complete the series circuit. Label all parts.



   c. Define parallel circuit.
   d. Use pencil and ruler to complete a parallel circuit. Label all parts.



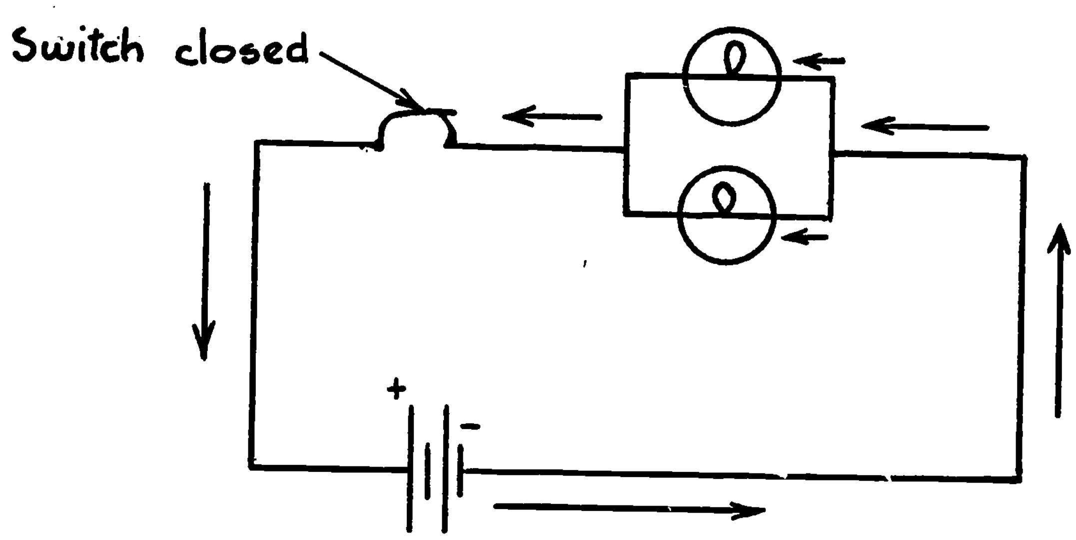
e. Compare series and parallel circuits.

	SERIES	PARALLEL
ADVANTAGES		
DISADVANTAGES		
USES		

f. How are dry cells in a flashlight connected? Why?

Teacher Activities *(continued)*

2. Draw circuit diagram below on chalkboard or project a transparency. A pupil is called upon to trace flow of electrons by using arrows next to the wires. Others place arrows on diagrams on worksheets. Elicit term *parallel circuit,* if possible, or define it for the class as a circuit which permits more than one path for the electrons.



3. Summarize by having pupils discuss the advantages and disadvantages of parallel circuits; for example:

ADVANTAGES	DISADVANTAGES
At home, electric irons, refrigerators, TV's, etc. may operate independently of each other.	As more electrical appliances are connected, more electric current is used and fuses may blow or wiring may be overloaded.

4. WHAT INTERFERES WITH ELECTRON FLOW IN A WIRE?

Outcomes

- The longer the wire, the greater its resistance to electron flow.
- The thinner the wire, the greater its resistance to electron flow.

Teacher Activities

1. Have pupils compare traffic on a wide avenue with that on a narrow street, e.g., St. Nicholas Avenue and Edgecombe Avenue, Prospect Avenue and Beck Street, Nostrand Avenue and Christopher Street, etc. Elicit the concept that a narrow path restricts movement. In electricity this is called *resistance*.

LABORATORY WORKSHEET — PHYSICS: LESSON 4

(May be duplicated and distributed to pupils)

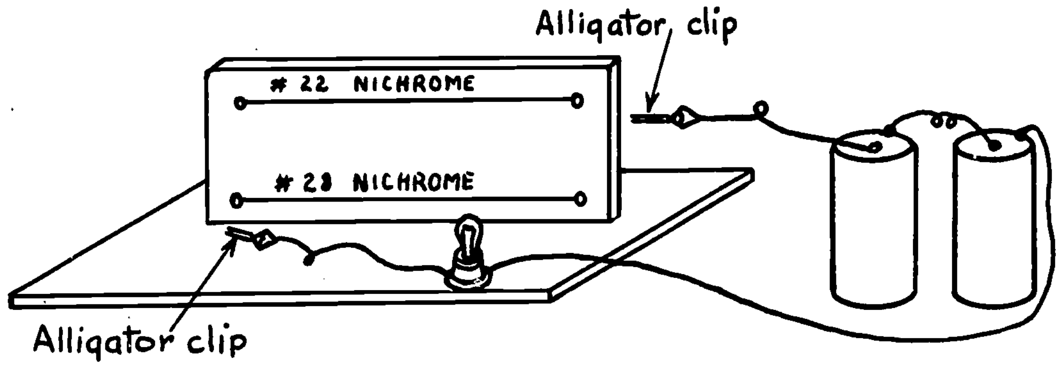
Purpose: To see whether length and thickness of a conductor affects its resistance

Materials

Resistance board (Resistance wires should be at least 2 feet long.)
2 dry cells
2 alligator clips
3-volt lamp in socket
3 pieces of bell wire 12 inches long
Piece of bell wire 6 inches long

Procedure

Connect the dry cells in series; attach the lamp to one terminal of the dry cells and a piece of bell wire to the other side of the lamp. Connect alligator clips to the free ends of the wires. See diagram.



(Welch—Resistance Comparison Board, No. 2816)
(Cenco—Law of Resistance Kit, No. 83115)

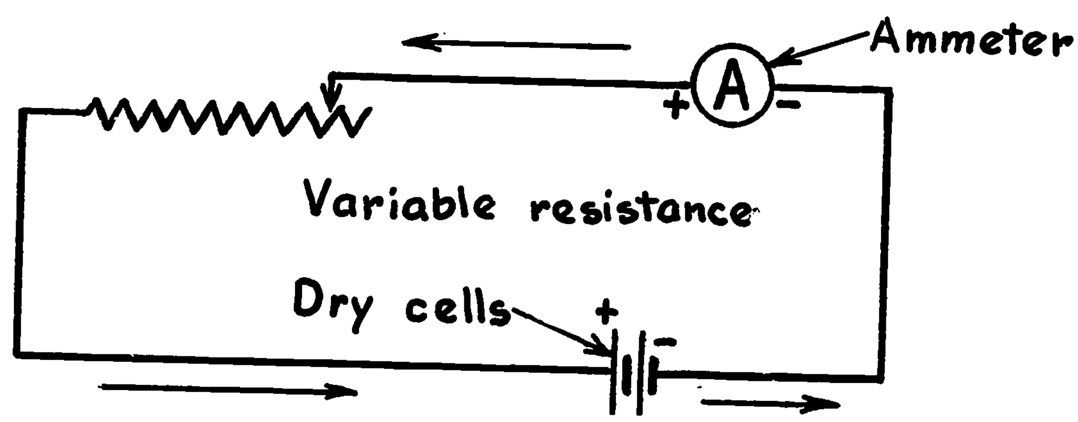
4. Connect one alligator clip to one end of the top wire and slide the other alligator clip along the wire.
   Note the change in lamp brightness. (An ammeter may be substituted for the lamp or added to the circuit for conformation.) Introduce the *ammeter* as a tool to measure current. Use a large demonstration meter.
   Connect the full lengths of each wire in turn, comparing the lamp brightness (or ammeter reading) for the thinner wire with that for the thicker wire.
5. Record your observations.

Summary

1. How does the length and thickness of a wire affect its resistance?
2. Why is plastic (as on a wire) used to protect us from electric shock?
3. Make a list of materials that have such a high resistance that they allow practically no electric current to pass through them.

Teacher Activities *(continued)*

2. On the chalkboard draw a labeled diagram of the circuit shown below. Elicit *resistance* as opposition to the flow of electrons; explain that the *ohm* is the unit of resistance. (The ohm is defined by scientists as the resistance of a column of mercury of a particular length and cross-section.)



3. Pupils should record the above diagram in their notebooks.
4. Elicit why current may have to be regulated. Refer to dimmer switches affecting auditorium lights, picture tube brightness in TV sets, volume control in radio, etc.
   Have, on the demonstration table, a display of laboratory slidewire rheostats and wire-wound volume controls to show how the laws of resistance are applied.

Summary

Discuss what pupils have observed by having two or three write their recorded observations on the chalkboard. The concept should be developed that as electrons pass through a wire, their motion is interfered with. Certain materials offer more interference than others.

Long wires offer more resistance in view of the greater amount of interference; i.e., the path is longer.

Thicker wire has less resistance since it provides a wider path for electrons to flow. Compare with current in parallel circuits.

5. WHAT PROPERTIES OF A WIRE MAY AFFECT ITS RESISTANCE?

Outcomes

- Wires of different metals differ in resistance.
- The resistance of a wire increases as its temperature increases.

Teacher Activities

1. Review, eliciting the fact that current flows in a wire; heat results from the opposition to the flow of current in the wire itself.

LABORATORY WORKSHEET — PHYSICS: LESSON 5

(May be duplicated and distributed to pupils)

Purpose: To see if resistance depends upon the material making up a wire

Materials

resistance board with 2 ft. lengths of #28 copper wire, #28 iron wire, and #28 nichrome wire

2 dry cells	3 pieces of bell wire 12 inches long
3-volt lamp in socket	Bell wire 6 inches long
	2 alligator clips

Procedure

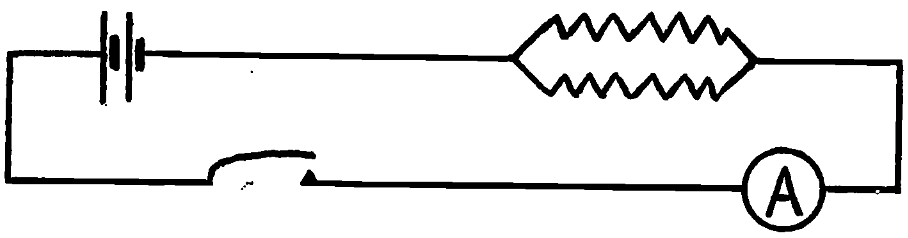
Connect the dry cells in series; attach the lamp to one terminal of the dry cells and a piece of bell wire to the other side of the lamp. Attach a piece of wire to the other side of the dry cells. Connect alligator clips to the free ends of the wires. (Refer to the diagram used in Lesson 4.)

Note that each wire on your resistance board is the same length and thickness; only the material is different.

Connect one alligator clip to each wire in turn, while sliding the other alligator clip along the length of the same wire. How does the resistance of each wire compare with the next? Record your observations.

Summary (may be completed at home)

1. How do different metals compare as to resistance?
2. If a six-inch wire has a resistance of 10 ohms, what would the resistance of a similar wire of 12 inches in length be?
3. Suppose a similar six-inch length of wire were placed in a circuit alongside the first six-inch length. What do you think would happen to the resistance of the circuit? Why?



Teacher Activities *(continued)*

2. Demonstrate the effect of temperature on resistance by one or more of the following:
   a. Wrap a 3-foot length of iron (or nichrome) wire into a compact coil by wrapping it around a length of glass tubing. Suspend the coil of bare wire horizontally so that it can be heated by a bunsen burner or alcohol lamp. Connect the coil to a pair of dry cells and a demonstration ammeter. The class should observe that the current decreases as the temperature increases.
   NOTE: This is an inverse relationship.
   b. Demonstrate the "Temperature Coefficient of Resistance" apparatus (Cenco No. 83064 or Welch #2835).
3. Summarize the lesson by having pupils write their observations on the chalkboard to serve as a springboard for the discussion.
   Have the pupils generalize that:
   a. Wires of different metals differ in resistance.
   b. The resistance of most wires increases as their temperature increases.
4. Resume the discussion of possible causes for wire resistance:
   a. Variations in resistance of different metals may be explained in terms of the freedom of electrons to move in a definite direction in the metal.

b. Higher temperature causes increased movement of the electrons in wire. This increases the opposition to the flow of electrons. Analogy: Person walking across street encounters less resistance if traffic is still. Autos represent molecules of the wire.

6. HOW IS ELECTRICITY MEASURED?

Outcomes

- Current (electron flow) is measured in units called amperes with an instrument called an ammeter.
- Electromotive force is measured in units called volts with an instrument called a voltmeter.

Teacher Activities

1. Motivate by a discussion such as follows:

   "If you stand on a street corner and watch the traffic go by, would you see as many cars pass you between 8:00 and 8:05 A.M. Sunday as between 8:00 and 8:05 on any weekdays? Why?"

   Elicit the fact that fewer people are in a hurry to get to work on Sunday. So it is with electrons. Sometimes there is a greater driving force which causes electrons to move. In electricity this is the electromotive force or *voltage*.

   Develop the term "rate of traffic" as the number of cars passing the corner every minute; set up the analogy with the number of electrons passing any point in a circuit every second. This *rate* is electric current or *amperage*.

2. Measuring amperage (Time limit—15 min.)

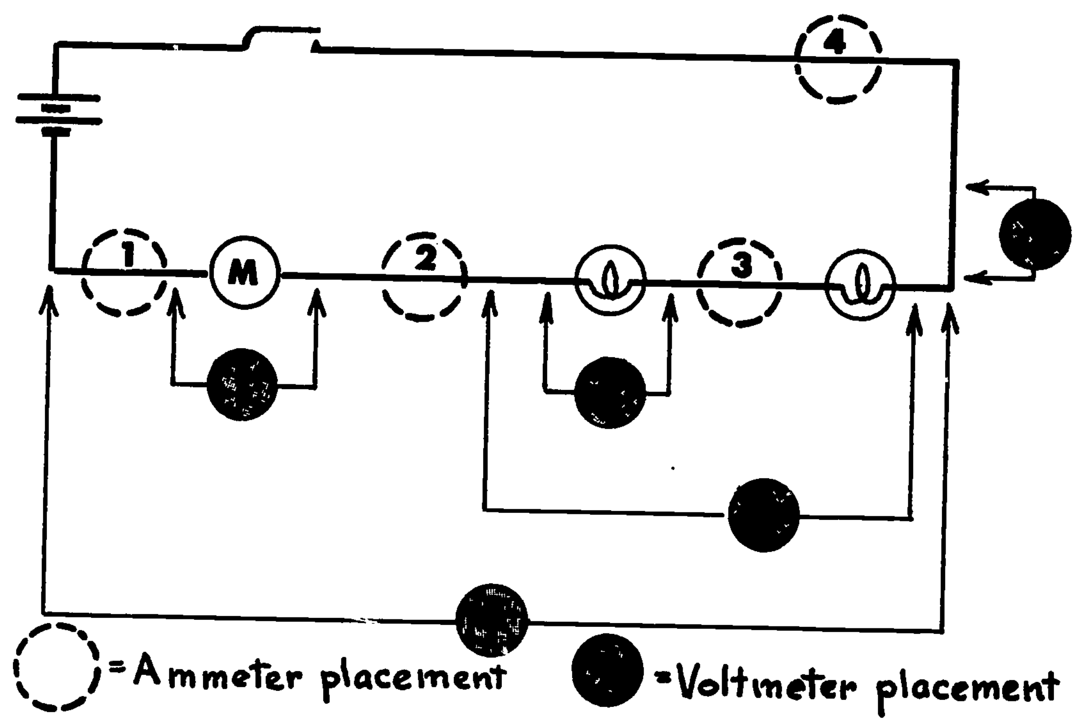
   a) Demonstrate the use of the *ammeter* to measure electron flow by preparing a circuit (see 3d and diagram) in which a demonstration ammeter may be inserted easily by means of leads with attached alligator slips. Stress the delicacy of instrumentation and need for careful handling. Emphasize the reason for attaching the negative terminal to the "negative side of the line" and the positive terminal to the "positive side of the line."

   b) Call on pupils to place the ammeter into the circuit to measure the current at different points. (Take two or more independent readings at each point to emphasize accuracy in reading and recording scientific measurements.) Pupils copy into notebooks as pupil secretary records on board as follows:

	Position of Ammeter	Amperes
1.		
2.		
3.		
4.		

3. Measuring voltage (Time limit—10 min.)
   a) Explain that a *voltmeter* is an instrument used to measure the difference between the force pushing electrons at one point in the circuit with the force pushing electrons at another point (voltage drop). This instrument, therefore, should be connected in parallel with the path connecting these two points.

      (Note: Use demonstration size voltmeter. In position 5 [diagram] there is no load, therefore voltage drop = 0.)
   b) Use pupil aides as in 2b.
   c) Use one color chalk for circuit and another for meters and connections.
   d) In this circuit the loads are *sharing* the voltage.



4. Summary questions (may be completed at home)
   What did we discover about the current in a circuit?
   How did this differ from what we found out about the voltage?
   Compare how a voltmeter is placed in a circuit with how an ammeter is used.

Suggested Homework

1. What is electric current? What are its units of measurement? How is it measured?
2. What is voltage? What are its units of measurement? How is it measured?

7. HOW MAY WE MAKE A LIGHT BULB GLOW BRIGHTER?

Outcomes

- As the voltage increases, the current increases.
- As the voltage decreases, the current decreases.

Teacher Activities

1. a. Display a flashlight with fresh dry cells. Pose this problem:
      "Can we design a flashlight that will give a brighter light?" When an increase in the number of dry cells is suggested, tell the pupils that this theory could be tested in today's experiment.
   b. Optional motivation: Suppose water is being taken from a hydrant to fight a fire. How can the flow be increased when the blaze jumps from the second floor to the fifth floor?
      Elicit the need for more pressure. Is there an analogy with electricity?
2. What would happen to current if we increase pressure (voltage)?
   NOTE: This lesson and the following lesson are problem-solving exercises designed for the development of manipulatory skills, the taking of measurements, and the gathering and interpreting of data.

   Stress the fact that each of the problems may be solved by means of a series circuit. Remind the students that ammeters are always connected in series with the negative binding post connected to the side nearest the negative terminal of the dry cell.

LABORATORY WORKSHEET — PHYSICS: LESSON 7

(May be duplicated and distributed to pupils)

Purpose: To see whether the amount of voltage in a circuit will affect the amount of current

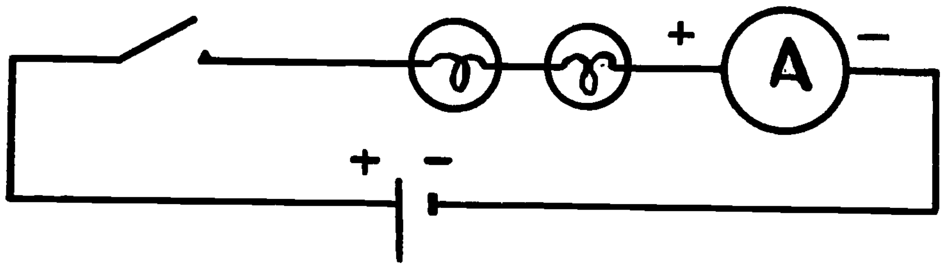
Materials

3 dry cells, each 1½ volts
3 3-volt lamps in miniature sockets
DC ammeter
Pushbutton or snap switch
Small screwdriver

Bell wire with clips
2 2-foot lengths
2 1-foot lengths
3 6-inch lengths

Procedures

Connect 1 dry cell, 2 lamps, a switch, and the ammeter in series as shown in the diagram below.



DO NOT CLOSE SWITCH UNTIL THE TEACHER HAS APPROVED THE CIRCUIT.

Use the highest scale on the meter first. If you get too low a reading, then use the next lower scale. Try to get a reading near the middle of the meter. Make a record of the current in column 4 on the chart.

Connect another dry cell to the first in series. Remember that we add the voltage of each to find the total voltage. Take another reading and record it in the table.

Now connect the third dry cell, and record your reading in the table.

CAUTION: Leave the switch closed only long enough to get a reading.

TABLE OF OBSERVATIONS				
1. NO. OF DRY CELLS	2. VOLTAGE USED	3. NO. OF LAMPS IN SERIES	4. AMPERES MEASURED	5. CLASS AVERAGE
1	1½	2		
2	3	2		
3	4½	2		

Summary (May be completed at home)

1. Why did we use an ammeter in this experiment?
2. How is current affected by voltage?
3. If the voltage of a circuit is decreased, what would happen to the current?
4. Why did we use the class average rather than one student's results?
5. What else may affect the brightness of a bulb, other than voltage?

Teacher Activities *(continued)*

3. a. Summarize by reviewing the class average on the chalkboard. Have the students generalize, "As we decrease the voltage, the current decreases."

   b. Display a variety of flashlights, i.e., penlite, firemen's flashlight, etc. Have the pupils conclude that *one* of the factors determining current is voltage.

8. WHY DOESN'T A FLASHLIGHT HAVE MORE THAN ONE BULB?

Outcomes

- As the resistance increases, the current decreases.

Have pupils recall their experiences in series circuits (Lesson 3) in which they observed dimming of lamps as the number of lamps in the circuit was increased.

LABORATORY WORKSHEET — PHYSICS: LESSON 8

(May be duplicated and distributed to pupils)

Purpose: To see what happens to the current when the resistance of a circuit is increased

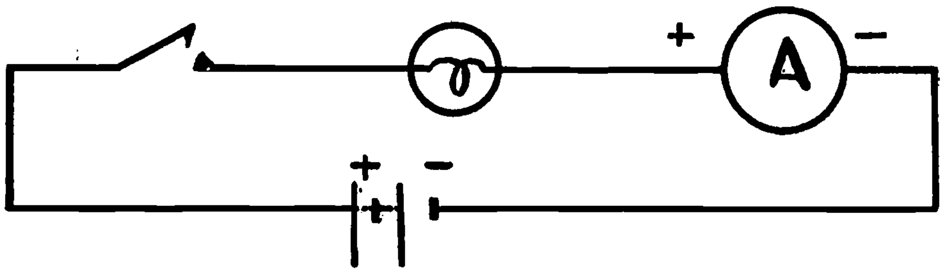
Materials

2 dry cells, No. 6, $1\frac{1}{2}$ volts
3 3-volt lamps in miniature sockets
DC ammeter
Pushbutton or snap switch
Small screwdriver

Bell wires—alligator clips at each end
  2 2-foot lengths
  2 1-foot lengths
  3 6-inch lengths

Procedure

Make a circuit consisting of 2 dry cells, one lamp, a switch, and an ammeter connected in series as shown in the diagram below. (Let the teacher check your circuit before closing the switch.)



CAUTION: Keep switch closed only long enough to read the meter. Record the ammeter reading in Column 4 on the chart below. Place the second lamp in the circuit in series with the first. Again take a reading and record it on the chart. Place the third lamp in the circuit in the same way and take a reading. Record your results on the chart.

TABLE OF OBSERVATIONS

1. NO. OF DRY CELLS	2. VOLTAGE USED	3. NO. OF LAMPS IN SERIES (RESISTORS)	4. AMPERES MEASURED	5. CLASS AVERAGE
2	3	1		
2	3	2		
2	3	3		

Summary

(may be completed at home)

1. What did you find about the current as resistance in the circuit was increased?
2. If the resistance in a circuit is decreased, what would happen to the current?
3. Find out what happens when the resistance (number of lamps in series) is increased. Consider that each lamp has the same resistance.
4. Why are our bulbs at home usually connected in parallel?
5. Which bulb has more resistance, a 100 watt lamp or a 15 watt lamp? Why did you choose the one you did?

Teacher Activities *(continued)*

1. Summarize by having the pupils discuss their results. Elicit the generalization that, as resistance increases, current decreases. Tie this in with the aim of the lesson.

2. Show pupils the mathematical statement of Ohm's law, $I = \frac{E}{R}$, and how this *formula* is used by electrical workers to check, or predict, one factor of a circuit if they know the other two.

   Remind them that in Lesson 5 they saw an inverse ratio between temperature and current in a conductor. Elicit from them, if possible, that current and resistance are inversely related and, therefore, one appears in the numerator of the formula, while the other appears in the denominator.

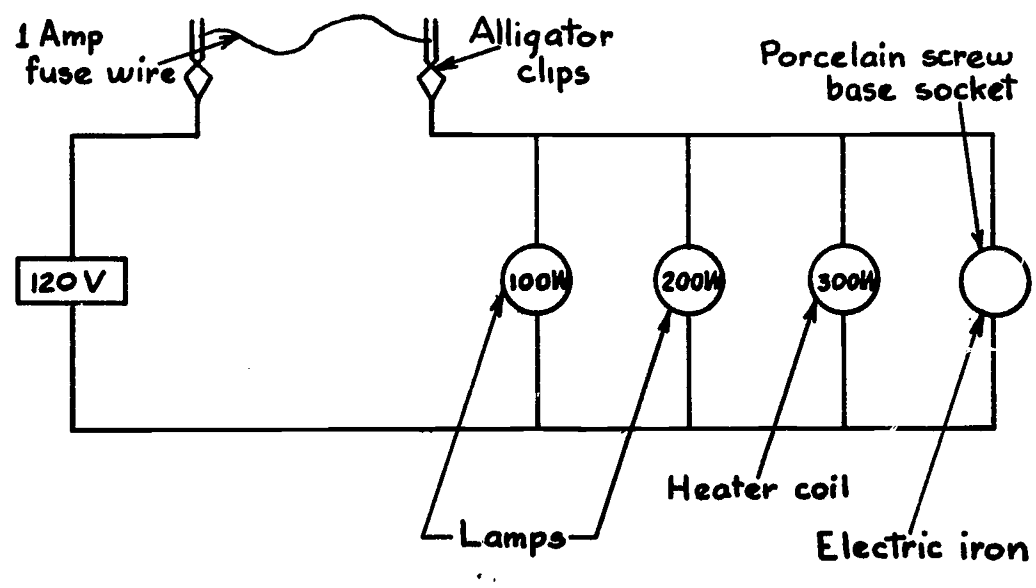
9. HOW MAY WE USE ELECTRICITY SAFELY?

Outcomes

- Electricity may be dangerous if it is not used properly.
- Frayed insulation on wires may lead to short circuits.
- Using extension cords improperly may lead to fires.
- Appliances should be turned off before removing plugs.
- Plugs should be held tightly as they are removed; do not tug at wire.
- Do not touch any electrical switch or appliance while in tub or shower.
- Fuses must be of proper size to protect wires and prevent fires.

Teacher Activities

1. Review parallel circuits; as more resistors are added, current increases.



If wires are made to carry too much current, they get warm or hot. "Octopus" circuits add parallel resistors, and extension cords get warm.

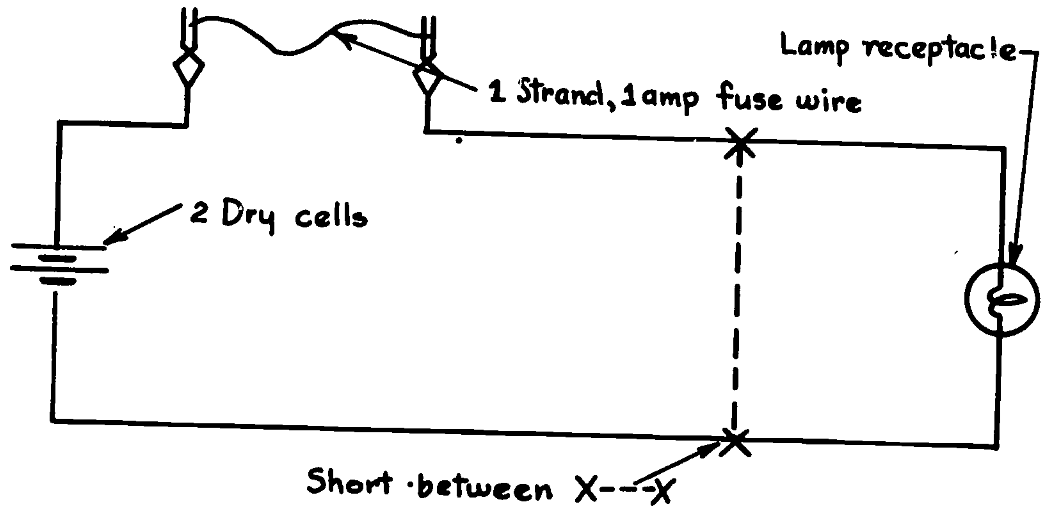
a. Hiding cords under rugs may be dangerous as kindling temperature of rug or dust may be reached.

b. Proper fusing is essential.

c. Extension cords must be of thick enough wire.

2. A circuit without resistance is known as a *short circuit.*

a. These may produce so much heat that they can cause a fire.



b. *Frayed insulation* should be a reason to change the whole cord, not to cover the frayed area with tape.

Teacher should bring in samples of frayed cords showing how insulation around the conductor may be frayed. Taping outside merely hides this.

c. Pulling plugs by their attached wires may cause a short circuit between wires attached to plug.

3. More current will flow through the lesser resistance.

a. Touching an electrical appliance while a person is wet may cause electrons to go through the person rather than through the regular load. More current can go through a low resistance. Never handle electrical devices while bathing. Keep electrical appliances away from kitchen sink.

b. Many appliances use a three-wire cord. The third wire is a "ground" (define "ground" for pupils as a return to source) and carries any leakage current from appliance to ground. Always use this plug properly. Teachers should show special grounding receptacle and PROPER use of a 3 to 2 wire adapter, with the little green wire properly grounded.

4. Emphasis should be placed upon the fact that electricity can be used safely to help us in our daily lives.

Suggested Homework

1. List as many UNSAFE electrical conditions as you can find around the house.
2. Describe a way in which you might correct these conditions.
3. Why is it important to have the proper size fuse at home?
4. Why do most electric drills and air conditioners have a 3-wire cord?

MAGNETISM

Suggested Lessons and Procedures

10. WHAT DO WE KNOW ABOUT MAGNETS?

Outcomes

- Magnetic materials include iron, nickel, and cobalt.
- Magnets are strongest at their poles.
- Like poles of a magnet repel each other; unlike poles attract. This is known as "The Law of Magnetic Poles."

Teacher Activities

Allow some time after distributing worksheets to develop reading skills such as reading for information. Make sure pupils understand unfamiliar words so that directions will be more easily followed.

LABORATORY WORKSHEET — PHYSICS: LESSON 10

(May be duplicated and distributed to pupils)

Purpose: To discover what materials are attracted to a magnet

Materials (for 2 pupils)
Magnetic compass
North-seeking pole (lacquered with red) and stand
Bar magnets (Cenco #78260)
Box of ½" brads
Specimen kit containing wood, chalk, nickel (S-1 #10-7728), cobalt, tin, paper clips, brads, lodestone, aluminum foil, alloys such as steel and alnico, *each in labeled compartment*

Procedure

1. Try to pick up each specimen with a magnet. Complete the table below.

ATTRACTED BY MAGNET	NOT ATTRACTED BY MAGNET

2. Line up 15 brads in a row (end to end). Place a bar magnet on top of this row; then raise it gently. Draw a diagram showing the position of these brads on the magnet. Question: Where is a magnet strongest?
3. Will your compass needle pick up any brads? How many?
4. Permit the compass needle to turn freely by placing it carefully on its stand. The red tip should point to the north.
   a. In what direction of the room is the teacher's desk?
   b. What happens when the north-seeking pole of a magnet is brought close to the red tip of the compass needle?
   c. What happens when you do this with the south-seeking pole?
   d. Can you now state the Law of Magnetic Poles which you have tested?
5. Summary (may be completed at home)
   a. What kinds of materials will a magnet attract?
   b. What are some examples of magnetic material?
   c. How could you find out of a piece of iron is, or is not, a magnet?
   d. What are the poles of a magnet?
   c. How could you find out if a piece of iron is, or is not, a magnet? other?
   f. Using a magnet, test 10 materials at home that you did not test in class. Add them to the list you made.

II. WHAT CAN WE DISCOVER ABOUT THE RULES OF MAGNETISM?

Outcomes

- Different magnets exert forces of varying strengths.
- The force between two magnets depends upon their relative strengths and the distance between them.

Teacher Activities

1. Have each pupil push a book from one end of the desk to the other. Develop the concept that the pupils used a "force" to start the books moving. How is this related to the "Law of Magnetic Poles?"

LABORATORY WORKSHEET — PHYSICS: LESSON 11

(May be duplicated and distributed to pupils)

Purpose: To discover on what the force exerted by a magnet depends

Materials

4 bar magnets of varying strengths

4 washers, ½" diameter

20 one-half inch brads

4 sheets of graph paper ruled 4 boxes per inch

Procedure

1. In turn, hold each magnet over the pile of brads.
   a. Count the number of brads each magnet was able to pick up.
   b. Why does the magnet attract the brads?
   c. Which is the strongest magnet?
   d. Which is the weakest magnet?

MAGNET #	NO. OF BRADS
1	
2	
3	
4	

2. Place the strongest magnet in the middle of the graph paper. Trace its outline so that you may see that it always stays in the same place.
   a. Place one washer one square away from the pole of the magnet. Then try two squares away, three squares away, four squares, etc. until the magnet no longer attracts the washer.
   b. Repeat with two washers, one on top of another.
   c. Repeat with three washers.
   d. Repeat with four washers.

   Check the boxes to indicate when the magnet attracted the washers.

TABLE OF OBSERVATIONS								
	SQUARES							
WASHERS	1	2	3	4	5	6	7	8
1								
2								
3								
4								

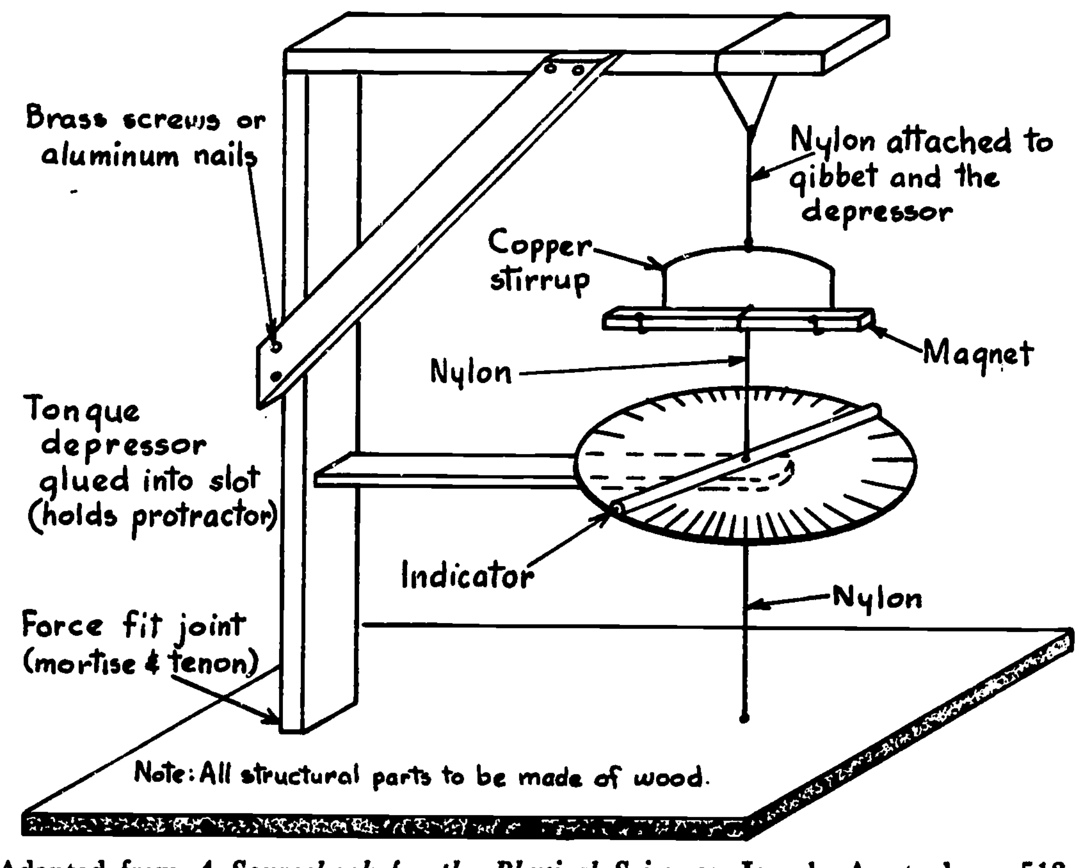
Summary (may be completed at home)

1. What 2 things determine how strong a force a magnet will exert?

2. Try to explain in words how we discovered this.
3. Construct a bar graph showing how the number of washers attracted by the strong magnet depended upon the number of squares the washers were away from the magnet.

Teacher Activities *(continued)*

2. Try to elicit that
   a. Magnetic force depends upon the strength of a magnet.
   b. Magnetic force between the magnet and a magnetic material decreases as the distance increases. (*inversely related*)
3. Optional
   Instead of the laboratory exercise which illustrates the measuring of magnetic forces (the inverse square law), the teacher might demonstrate the following:



Adapted from *A Sourcebook for the Physical Sciences,* Joseph, A. et al., p. 513.

Suspend a magnet in a copper stirrup from a nylon string. Attach the string with rubber bands to the top and bottom of a wooden frame. Before affixing the bottom connection, slip the nylon string transversely through a five-inch soda straw. Place a 360° plastic protractor horizontally so that the straw may serve as an indicator for this angular deflection scale (see diagram).

Have pupil hold another magnet at varying distances to show deflection. Holding magnets of different strengths the same distance from the suspended magnet may show different deflections.

Place data on the chalkboard for pupils to copy into notebooks and to serve as a springboard for discussing the inverse square law.

12. HOW MAY MAGNETS BE CREATED AND DESTROYED?

Outcomes

- We can make magnets by induction and by rubbing (in the same direction) a substance that can be magnetized with a magnet.
- A magnet may be demagnetized by heating, by hammering, or by rubbing it (in both directions) with another magnet.

Teacher Activities

1. Display items containing magnets: toys, recording tape, etc.
   a. "How did these obtain the magnetic force they seem to have?"
   b. "Can ordinary magnetic metals be made into magnets?" Demonstrate that a substance can act as a magnet when held in a magnetic field. Hold a strong magnet close to but not touching the head of a soft iron nail. Use the nail in this position to pick up brads. Remove the magnet to permit the brads to drop. The nail was not permanently magnetized. Explain this effect of producing magnetism at a distance as *induction*.
2. Introduce the pupils to another way of making a magnet as well as ways for destroying magnetism by use of the following exercise.

LABORATORY WORKSHEET — PHYSICS: LESSON 12

(May be duplicated and distributed to pupils)

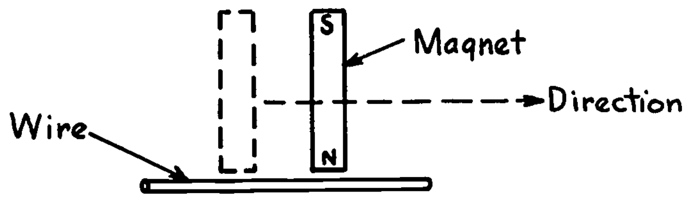
Purpose: To discover how we can make and destroy magnets

Materials

3 pieces of steel wire (4" length)
Strong alnico magnets
Alcohol lamp
Hammer
Pliers
Block of wood—5" sq.
Brads or pins

Procedure

1. Rub the three pieces of steel wire about thirty times with one end of the magnet. Try to pick up brads/pins with each wire. Record your results. *Make sure you rub in only one direction!*



2. Take one wire and rub it vigorously in both directions with the magnet. Try to pick up brads or pins with it. Record your results.
3. Heat second wire about three minutes holding it securely with pliers. After wire cools, try to pick up brads/pins with it. Record results.
4. Strike the third wire with the hammer repeatedly. (To protect the desk, do this on the wood block.) Try to pick up brads or pins with this wire. Record your results.

Summary

1. What is meant by "induction"?
2. (Recall Lesson 10.) What would a pair of scissors have to be made of in order to magnetize it?
3. How would you make the pair of scissors magnetic?
4. Give three ways in which you were able to destroy magnetism.

Teacher Activities *(continued)*

3. The following activities may be used as student projects:
   a. What effect would cooling have on a magnet? (Test a magnet before and after refrigeration.)
   b. Would the magnetic strength of a substance being magnetized be increased by increasing th[illegible] of strokes?
   c. Is the north pole of a magnet [illegible] than the south pole?

13. HOW MAY WE EXPLAIN MAGNETISM?

Outcomes

- Magnets are believed to consist of small parts or domains, each of which has magnetic properties.
- A magnet is produced when the domains are properly arranged.

- Disarranging the molecules destroys the magnet.

  NOTE: A domain is made up of a group of molecules.

Procedure

1. Challenge the pupil by asking, "Can a magnet be demagnetized by cutting it into small pieces?"

   Demonstrate that the cutting process merely creates additional magnets. Magnetize a four-inch length of steel wire. Use a compass needle to show it has a north pole and a south pole. Cut the wire into two equal parts, and show by using a compass needle that each piece has a north and south pole similar to the original. Cut each half and repeat.

   NOTE: Make this demonstration more visible by mounting the compass needle and its stand on the stage of an overhead projector and by approaching it with each end of the cut wire. Steel strap material from wrapping heavy appliances may also be used to advantage.

   Elicit the fact that if we were to continue cutting the wire into smaller and smaller pieces, each tiny piece would still be a magnet. The smallest part that would be a magnet is called a *domain*. Write *domain* and its definition on the chalkboard for pupils to record in the glossary section of their science notebooks.

2. a. Fill a small test tube halfway with iron filings, and cover with a stopper or Cenco 78375. "Let's imagine each of these iron filings to be a domain!" Demonstrate that the test tube of filings is not magnetized since it will attract both ends of a compass needle.

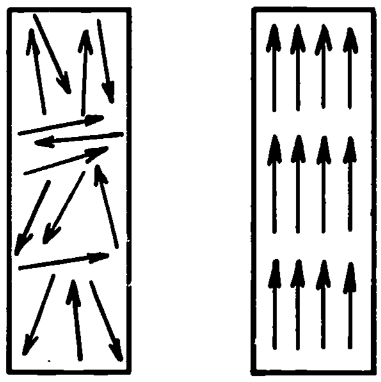
   b. Now stroke the test tube from top to bottom with the north pole of a strong magnet about thirty times. Show that it has polarity in that it will now repel one end of the compass needle. Try picking up brads with it.

   c. Shake the test tube of filings thoroughly; test to see if it behaves like a magnet.

   d. Develop, through questioning, the concept that iron filings when lined up in an orderly manner act together to produce a magnetic force. When they are arranged in a random manner, they appear unable to act together to manifest a magnetic force.

      Use analogy of the health education period when the children are engaged in "free" activities such as three-man basketball, chinning, or practicing tumbling skills on the mats. This is a *random arrangement*. When they line up at attention on their spots, each in his own squad, and each facing the front of the gym, they are in an *orderly arrangement*.

3. Illustrate the following by means of a chart or transparency:



(Arrows indicate domains)

Pupils to copy this chart into their notebooks and to write an explanation of this phenomenon. Call on some volunteers to read what they have written.

Summary and Assignment (may be completed at home)

1. Redisplay the test tube of iron filings. Use magnet model (S-1 #14-1668) to show alignment of domains.
2. From what you learned today, explain:
   a. How did you make a magnet in the last lesson?
   b. Why were you successful? (Describe the material.)
   c. How did you destroy the magnetism?
3. Fill in the blank spaces in the story following by using the word (s) from the list below only once:

both directions	induction	one direction
domains	jarred	soft iron nail
experiment	magnetic	stroke
heat	nonmagnetic	

OUR EXPERIENCES IN SCIENCE

My science teacher, Mr. ________________, performed an interesting ________________ in class today. He was able to make a ________________ pick up some brads by holding it near the pole of a strong magnet. When Mr. ——— removed the magnet, the brads fell away. This method of making a magnet is called ———————.

When I came home, I made a pair of scissors magnetic by rubbing them with another magnet in ——— ———————. My mother uses these scissors to pick up small pins.

In our laboratory exercise we tried to destroy magnetism. One method we used was ——————— the magnetic needle we had made in ——— ——————— with another stronger magnet. Another method was to ——————— the magnet until it was red hot in the flame. We were careful to hold the wire with a pair of pliers so we didn't burn our hands. Finally, we ——————— the wire repeatedly with a hammer.

It was interesting to discuss "The Theory of Magnetism" which states that when the ——————— are properly lined up, substances are ———————; and that when they are not properly lined up, the substances are ——— ———.

14. HOW CAN WE MAKE PICTURES OF MAGNETIC FIELDS?

Outcomes

- Magnetic fields may be detected with iron filings.
- Lines of force are concentrated at the poles, giving horseshoe magnets advantages over bar magnets.

Teacher Activities

1. Motivate the pupils by announcing that each laboratory group is to act as a unit of detectives. They are to try to discover that invisible area near a magnet in which magnetic substances are influenced.
2. Use an overhead projector to demonstrate how to make a magnetic field pattern. Place a bar magnet on the stage of the projector, frame this with 4 pieces of 1/4″ plywood sticks 1/2″ wide, 2 of 10″ length,

and 2 of 7″ length so that when a clear acetate sheet is placed over this magnet, it will approximate a horizontal plane. Sprinkle iron filings gently over this plastic and tap lightly to align filings. Spray for two seconds at a six-inch distance with lacquer from aerosol container after shutting off the light from the projector.

LABORATORY WORKSHEET — PHYSICS: LESSON 14

(May be duplicated and distributed to pupils)

Purpose: To see how we can show the presence of a magnetic field

Materials

2 bar magnets
Horseshoe magnet
Five 5x8 cards
Salt shaker containing iron filings
8 checkers or wood blocks 1″ sq. x ¼″ high as platform for cards

Procedure

Using the technique you have just observed, locate the magnetic field pattern about:

a. One horseshoe magnet (please replace keeper after use)
b. One bar magnet
c. Two bar magnets with north and south poles facing each other—½″ apart
d. Two bar magnets with north and north pole facing one another—½″ apart
e. Two bar magnets with south and south poles facing one another—½″ apart

Label each card before sprinkling. Draw the pattern you get for each step above (a - e).

Summary

1. How does the magnetic field about two bar magnets with opposite poles facing each other differ from the field about one bar magnet?
2. What are lines of force?
3. What advantage does a horseshoe magnet have over a bar magnet?
4. Bring in the picture of the magnetic field pattern about the single bar magnet for tomorrow's lesson.

Teacher Activities *(continued)*

3. Summarize by having pupils display their "pictures" of magnetic field patterns. Reinforce the concept that a scientific generalization may be made only after sufficient evidence has been presented. "Does each detective squad agree with the findings of every other squad?" Where was the greatest concentration of lines of force?

4. Discuss the reasons for storing magnets either with opposite poles in contact as with bar magnets, or with a keeper as on horseshoe magnets.

5. Important demonstration: (as time permits)
Dip the ends of two cylindrical alnico magnets into iron filings. Bring like poles within 1½" and then unlike poles to the same distance. The pupils will see a three-dimensional representation of the magnetic fields. They will unify their concepts of lines of force, magnetic fields, and laws of poles.

15. HOW CAN WE SHOW THE PRESENCE OF MAGNETIC LINES OF FORCE AROUND US?

Outcomes

- Magnetic lines of force represent the path a compass would take going from the south magnetic pole to the north magnetic pole.
- The earth acts as a huge magnet with magnetic poles and lines of force between them.
- A magnetic field may be affected by magnetic material.

Teacher Activities

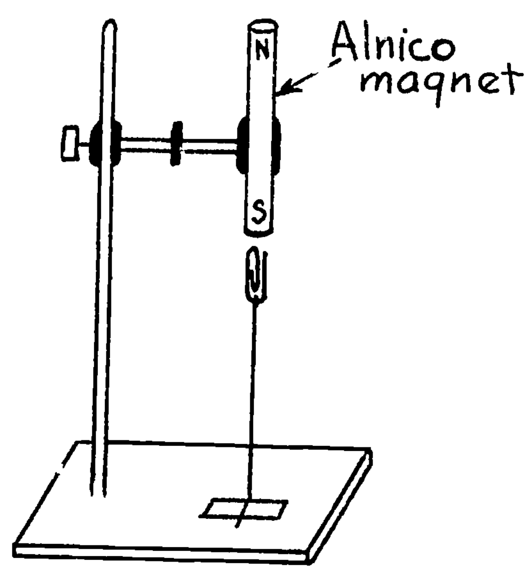
1. Distribute a magnet and encased compass needle to every two pupils. Place magnet on magnetic field pattern (done in the previous lesson) so that the field surrounds it. Using the small compass, follow the path made by the iron filings from pole to pole. Describe the movements of the compass needle as you do this.
2. Elicit: lines of force may also be detected by means of a compass needle. These lines of force are really the paths a compass needle would take going from the south magnetic pole to the north magnetic pole. Remind pupils that magnetic materials held in a magnetic field become magnets by induction. (Lesson 12)
3. To communicate the concept of the three-dimensional magnetic field, suspend, with a thread, a small cylindrical magnet in a cooling beaker of lemon jello after having stirred in iron filings very thoroughly. (Have lab technician prepare several of these displays well in advance of this lesson.) Demonstrate a large dip needle (Welch 1876). Why does the needle indicate 70°?

4. Develop the following:
   a. The constant orientation of the magnetic needles indicates that the lines of force are present in the classroom.
   b. The direction of the lines of force appears to be northward (compass) and towards the earth (dip needle).
   c. The magnetic lines of force affecting our compasses constitute a large magnetic field. Since compasses are used by land surveyors, by navigators of submarines, and by airplane pilots, such a field must stem from a very large magnet—our earth.
5. Challenge the pupils by asking, "Is it possible for magnetic lines of force to penetrate the earth?" Demonstrate, with pupil aides, the following:
   a. Suspend a strong alnico bar (or cylindrical) magnet from a slotted rubber stopper held in a clamp. Tape the end of a cotton thread to the base of the ring stand, tying the other end to a paper clip.
   b. Adjust the clamp so that the clip is attracted to the magnet but leave a substantial air gap in which assorted materials may be inserted by pupil assistants. These should include:

Slate	Glass	Aluminum plate
Paper	Plastic	Copper "
Cardboard	Clay	Lead "
Wood	Soil sample	Iron "
		Steel "

   c. Have pupil secretary chart the results on the chalkboard. How do materials affect magnetic lines of force?

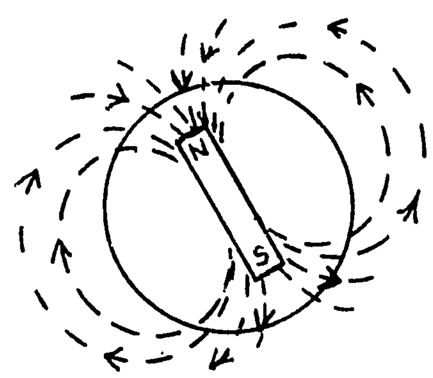
LINES	
GO THROUGH	DO NOT GO THROUGH



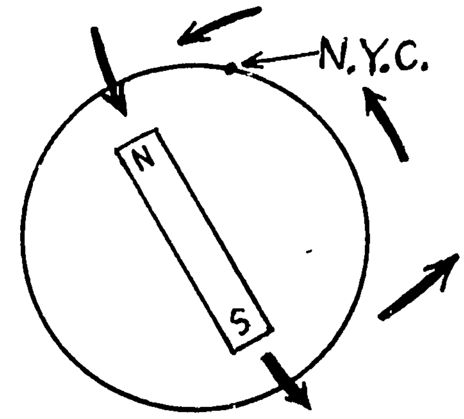
d. Pupils may copy the problem, the diagram, and the data into their notebooks.

6. Lead the pupils to conclude that magnetic lines of force are affected by magnetic materials; since soil is nonmagnetic, it is possible for lines of force to penetrate the earth. The earth's magnetic force is probably produced below earth's crust.

7. Summarize by means of a diagram (on chart or transparency), illustrating why the north-seeking pole of a compass often may not point to the geographic north pole.



Earth acts like a huge magnet. Use a globe to show approximate locations of the magnetic poles.



Dipping needle points to magnetic poles.

Suggested Homework

1. Does a magnetic compass really point to the geographic north pole of the earth?
2. How could a pilot or ship's navigator make use of a compass?
3. What conditions would we need to find on Mars in order to be able to use a magnetic compass?

16. HOW MAY WE USE ELECTRICITY TO MAKE A MAGNET?

This is the initial lesson of a sequence which attempts to develop concepts of electromagnets (16-18), means of inducing currents mechanically (19-20), and of combining the two to produce electricity (21-22).

Outcomes

- A wire carrying a current is surrounded by a magnetic field.
- The direction of the magnetic field (lines of force) depends upon the direction of the current.

Teacher Activities

1. Prepare an electric circuit consisting of a large coil of wire, a dry cell, a switch, and a compass needle suspended in line with the plane of the coil. (N.Y.S. *General Science Handbook, Part III,* #3220.)
   a. Explain to the class that in 1819 a Danish Professor, Dr. Hans Oersted, was teaching his class about circuits when he happened to close the switch. Close the switch and ask pupils.
      What did you observe? Why did it happen?
   b. Elicit the fact that the compass needle moved and that it must have been caused by the introduction of a magnetic field.

LABORATORY WORKSHEET — PHYSICS: LESSON 16

(May be duplicated and distributed to pupils)

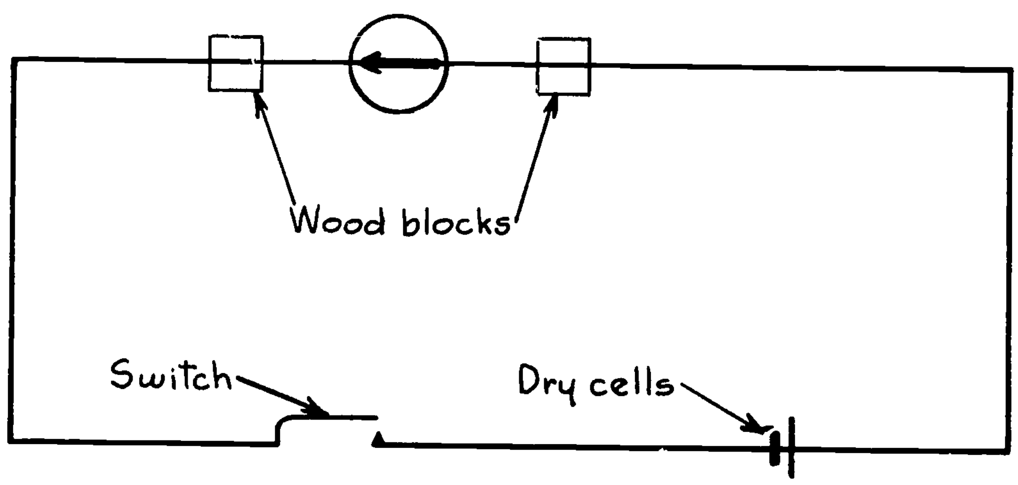
Purpose: To discover what happens around a wire-carrying current

Materials

#6, 1½-volt dry cell	Magnetic compass
3½ feet of #18 copper wire, insulated	2 wood blocks (2" x 2" x 1")
Pushbutton or snap switch	

Procedure

1. Wire the dry cell and switch as shown below.



2. Place the wooden blocks far enough apart so that the copper wire rests across the space between the blocks.
3. Place the compass between the blocks of wood (under the wire).
4. Rotate the wire (and the blocks of wood) until the wire is parallel to the compass needle. (Recall enough of magnetism to the class to assure their understanding that the compass needle has two poles and it points north. Also, caution the class to keep the area free of iron.)
5. Close the switch momentarily (only long enough to observe the effect) and observe the compass needle. Record your observation.
6. Hold the compass *above* the wire and again close the switch long enough to observe the effect. Record your observation.
7. Reverse the direction of the current (by reversing the connections to the dry cell) and repeat steps 5 and 6. Record your observations.

Summary (may be completed at home)

1. What happened to the compass needle when you closed the switch?
2. What happened when you opened the switch?
3. What is the effect on a compass needle when it is held near a wire-carrying electric current?
4. How did Hans Oersted make this discovery?

Teacher Activities *(continued)*

2. Summarize to elicit the following generalizations:

   There is a magnetic field around a wire when (and only when) a current is flowing.

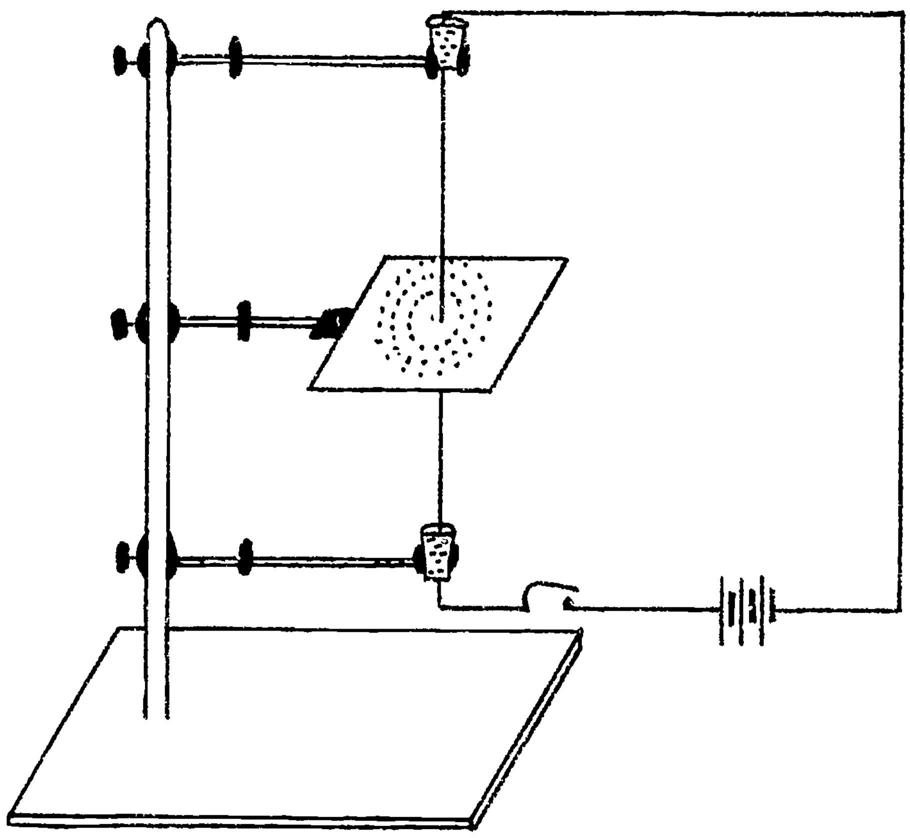
   The direction of this magnetic field depends upon the direction of the current.

   Some questioning might be:

   a. Why do we use a magnetic compass in this experiment?
   b. How did the results differ when you reversed the current?

3. Optional activity: show magnetic field around a conductor. How can we show that a magnetic field (lines of force) exists around a current-carrying wire?

   Demonstrate the magnetic field about a straight wire (held vertically and passing through a piece of white cardboard) with the aid of iron filings as well as a compass needle. Hold switch for a few seconds. Sprinkle iron filings on cardboard. Tap the cardboard gently to get circular patterns. Open switch.



From *"A Sourcebook for the Physical Sciences."* Joseph, et al., page 517.

17. HOW DOES THE CORE OF AN ELECTROMAGNET AFFECT ITS STRENGTH?

Outcome

- The nature and size of its core affects the strength of an electromagnet.

Teacher Activities

1. a. Review the homework: A magnetic field is created about a wire through which a current flows:

   b. Have pupils recall their experiences with electromagnets in grade 5. (*Science, Grades K-6, Book 1,* pp. 21-24.)

   c. Demonstrate the construction of such a magnet by coiling bell wire around a ten-penny nail of soft iron, and connect it, in series, with a switch and dry cell. Emphasize that each "loop" is a "turn" and the "turns" comprise a "coil."

d. Elicit the components of an electromagnet as a coil of wire, a source of current, and a core.

2. Read, with the class, the instructions on the laboratory worksheet. Caution the class to await approval of each circuit before beginning. Warn pupils not to keep the current flowing longer than necessary in order to prolong the life of the cell.

LABORATORY WORKSHEET — PHYSICS: LESSON 17

(May be duplicated and distributed to pupils)

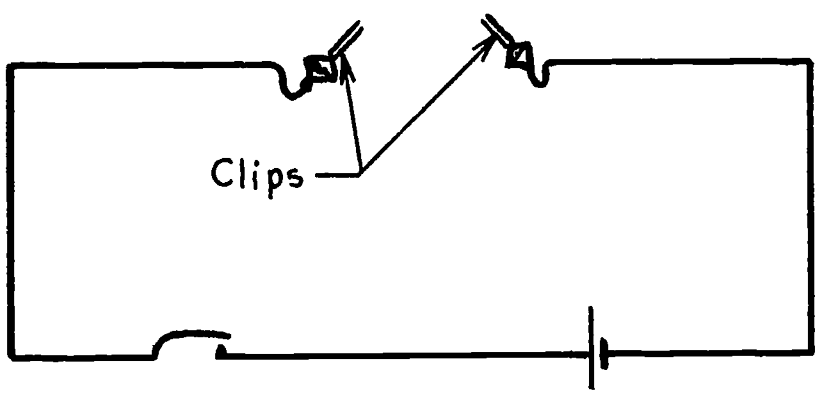
Purpose: To test the effect of a core on an electromagnet

Materials

#6, 1½-volt dry cell
3 2-ft. lengths of bell wire
Smaller pieces (1 ft.) of bell wire
Pushbutton or knife switch
Small iron brads
2 soft iron nails about ¾ inches long
Rods (¾ inches long) of glass, chalk, wood
Magnetic compass
3″ test tube

Procedure

1. Make an electromagnet of 15 turns by winding the wire around the small test tube and then removing the test tube. The turns should be wound close together.
2. Connect the switch and the wires (with the clips) to the cell as shown in the diagram. Do *not* make final connections or close the switch until the circuit has been approved by your teacher.



3. Connect the clips to the coil and test each end with the compass needle and the brads. Then insert, in turn, as a core, each of the cores provided, then one nail, and then two nails. In each case close the switch only long enough to see whether the magnet will:

   a. affect a compass needle
   b. pick up brads—use the END of the core.

4. Record your results in the table below and in the space provided on the chalkboard.

TABLE OF OBSERVATIONS			
CORE	DID COIL AFFECT COMPASS NEEDLE? (YES OR NO)	NUMBER OF BRADS PICKED UP	
		MY RESULTS	CLASS AVERAGE
No core			
Glass rod			
Chalk			
¼″ wood dowel			
1 nail			
2 nails			

Summary

1. Which cores produced the strongest magnet?
2. Why do you think this happened?
3. Did two nails work better than one nail?
4. What type of core would you use to make a strong electromagnet?
5. Why did you make that choice?

Teacher Activities *(continued)*

5. Conduct a discussion and elicit the conclusions:
   a. Nonmagnetic materials (chalk, glass, etc.) do not make good cores.
   b. Soft iron cores produce strong magnets.
   c. Two nails are better than one; i.e., the size of the core is important.
   d. Cores of magnetic materials bring together the lines of force around a current-carrying wire, thereby increasing the magnetic strength of the coil. Emphasize this concentrating function of the iron core.

18. HOW DO THE NUMBER OF TURNS AND THE CURRENT IN AN ELECTROMAGNET AFFECT ITS STRENGTH?

Outcomes

- Increasing the number of turns in the coil increases the electromagnet's strength.
- Increasing the current in the coil increases the electromagnet's strength.
- Electromagnets are useful in various devices such as communication devices, motors, lifting devices, instruments.

Procedure

1. Review the assignment on "cores." Ask pupils whether other variables might affect the strength of the electromagnet.

LABORATORY WORKSHEET — PHYSICS: LESSON 18

(May be duplicated and distributed to pupils)

Purpose: To discover whether changing the number of turns of the coil and changing the current in the coil changes the strength of the electromagnet

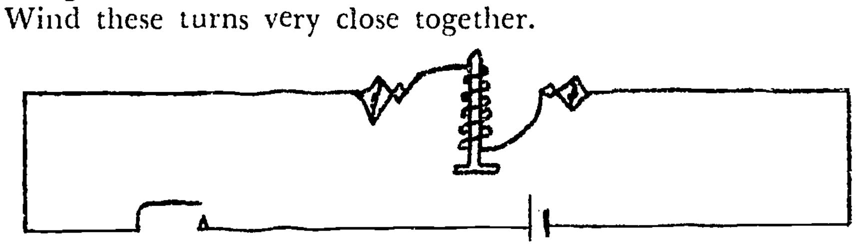
Materials (for 2 pupils)

#6, 1½ volt dry cells	5 2-ft. length of bell wire — 2 with clips at ends
Pushbutton snap-switch	Smaller pieces (1 ft.) of bell wire
Small iron brads	2 soft iron nails about ¾ inches long
Small test tube	

Procedure

Review all safety procedures such as closing the switch *only* during the brief period of conducting each test.

1. Make two electromagnets, one of fifteen turns and one of thirty turns, by winding the wire around the small test tube and then removing this tube. Wind these turns very close together.



2. Connect the switch, wires, and cell into a circuit, making sure not to close the switch until your teacher has checked your connections.
3. Using two nails as a core, compare the 15-turn coil with the 30-turn coil.

4. Place the second dry cell into the circuit in series with the first. Compare the fifteen turn coil with the 30-turn coil, recording your results in the space provided on the chalkboard as well as in the table below.

Turns	Number of Brads Picked Up with 1 Dry Cell		Number of Brads Picked Up with 2 Dry Cells	
	My Results	Class Average	My Results	Class Average
15				
30				

Summary (may be completed at home)

1. What are three ways in which we increased the strength of an electromagnet?
2. Why are electromagnets sometimes more useful than permanent magnets?
3. List as many things as you can which use electromagnets. You may ask the owner of an electric fix-it shop or a radio repair shop to help you.

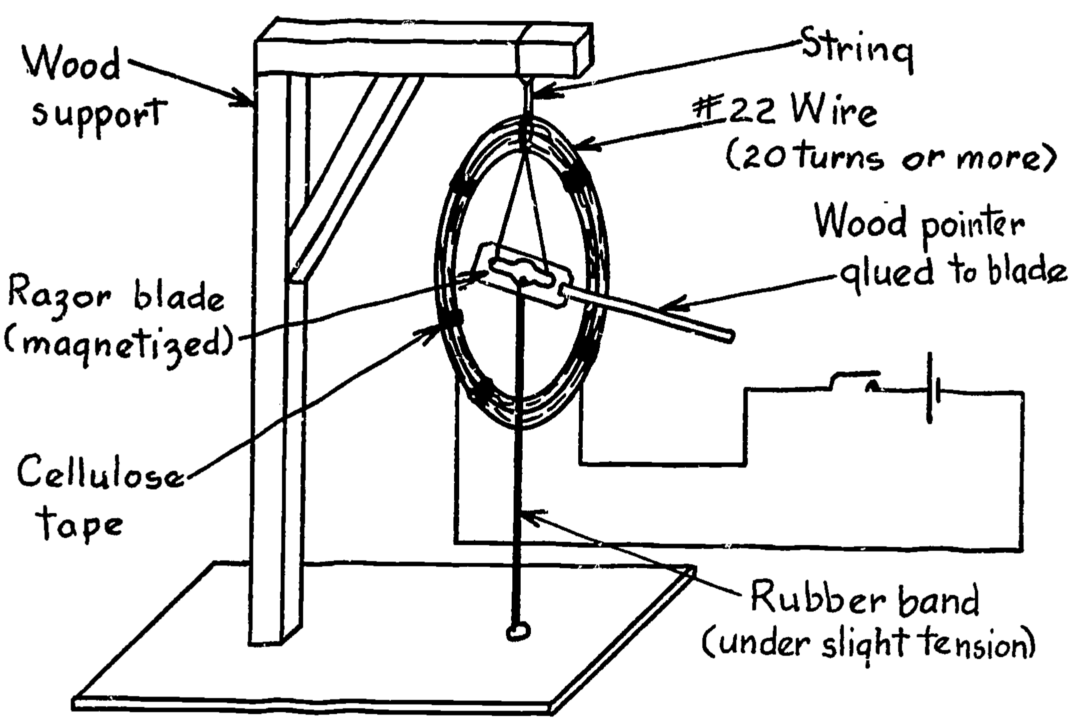
Teacher Activities *(continued)*

2. Summarize by having pupils discuss the results of their observations and by calling on some to read the answers they recorded. Utilize the class average on the chalkboard to impart the idea that individual measurements may have errors. This may be reduced by taking into account many measurements and taking the average.
3. Display dismantled bells, buzzers, chimes, etc. Have pupils identify the function of the electromagnet in each case. (Joseph et al. *Sourcebook for the Physical Sciences,* p. 520; O.K. Kit EM 400)

Optional Activities (may be assigned as projects)

1. Use discarded loudspeaker magnets, solenoids, radio speaker, and electromagnets, if available, describing their specific functions.
2. Issue rexographed plans (obtainable from electric wiring shop teacher) for making telegraph sounders and receivers. (Joseph et al., *op. cit.,* pp. 534-535)
3. Dismantle a telephone receiver (S-1 #14-3038) to point out the electromagnet.
4. Show picture of an electromagnet lifting an automobile. Demonstrate "lifting effect" of an electromagnet. (S-1 #14-1638, #14-1648, or p. 520 *Sourcebook for the Physical Sciences,* Joseph et al.)

5. Make a demonstration galvanometer (*Part III,* N.Y.S. *General Science Handbook,* #3220). Additional Sources:
   a. S-1 14-2058
   b. O.K. Magnetism Kit—(Reference-Unit EM 521, 550.)



Have students recall their experiences using ammeters and voltmeters and have them locate electromagnets in dismantled meters, if available.

19. CAN YOU MAKE ELECTRICITY USING ONLY A COIL OF WIRE AND A MAGNET?

Outcome

- An electric current may be created (induced) in a wire by the relative motion between a wire and a magnet.

Teacher Activities

1. Demonstrate a coil of wire connected to a large galvanometer (centered needle) and a strong alnico magnet. Have the pupils observe that no dry cells are about. Recall what Oersted did (Lesson 16) and ask: "If electricity can produce magnetism, can magnetism produce electricity?" (Faraday)

   This discussion should be followed by moving the magnet inside the coil.

LABORATORY WORKSHEET — PHYSICS: LESSON 19

(May be duplicated and distributed to pupils)

Purpose: To discover how we can make electric current, using wire and a magnet

Materials (for 2 pupils)

Alnico rod-shaped magnet — Galvanometer (center needle type)
Wire coil (4" - 6" dia.), 50 turns, ends bared
(Use electrical — friction — tape to keep shape of coil.)

Procedure

1. Connect the bared ends of the coil to the terminals of the galvanometer. *Remember:* The galvanometer is a sensitive, delicate instrument and should be handled with great care!
2. Hold the coil stationary and vary the speed of moving the magnet into and out of the coil.
3. Hold the magnet stationary and vary the speed of moving the coil on the magnet and off again.
4. Record your results in the table below:

Table of Observation		
MOTION	GALVANOMETER READING	DIRECTION OF DEFLECTION
N — pole in rapidly		
N — pole in slowly		
Magnet at rest in coil		
N — pole out rapidly		
N — pole outside of magnet		
S — pole in rapidly		
S — pole out rapidly		
Coil on magnet rapidly		
Coil off magnet rapidly		

Summary (may be completed at home)

1. In addition to the coil and magnet, what else was needed to create (induce) an electric current?
2. Does a current have a direction? How can you show this?
3. How does the speed of a moving magnet (or coil) affect the current?
4. What is an "induced" current?
5. What is an "alternating" current?

Teacher Activities *(continued)*

2. Summarize by discussing answers to worksheet questions. Elicit: "The direction of the current depends on the relative motion between the magnet and the coil." (Such a current is an "induced current.")

   "A current may flow in both directions; this is known as alternating current when it occurs."

20. HOW MAY WE USE A SMALL INDUCED CURRENT TO LIGHT A BULB?

Outcomes

- Induced current depends on the strength of the magnetic field.
- Induced current depends on the number of turns of the coil.
- Induced current depends on the relative speed of motion between a magnet and a coil.

Procedures

1. Utilize homework definition to have pupils recall that they induced a current to flow in a wire by moving either a coil or a magnet in the other's presence. Ask how the current was increased, and how else we might have increased the current.

LABORATORY WORKSHEET — PHYSICS: LESSON 20

(May be duplicated and distributed to pupils)

Purpose: To discover how we can increase the induced current in a coil

Materials (for 2 pupils)

2 Wire coils (4″ - 6″ dia., 25 turns & 50 turns). See Lesson 19.
(Differently colored insulating material may help in identification.)

Weak magnet (so labelled)

Galvanometer (center needle)

Strong magnet (so labelled)

Procedure

1. Connect the bared ends of the 25-turn coil to the terminals of the galvanometer. Move the north-seeking pole of the weak magnet into and out of the coil slowly. Then do it quickly. Record your observations on the chart. Repeat with the south-seeking pole. Record your observations.
2. Repeat the above experiment with the strong magnet. Record your observations with care on the chart.

3. Repeat experiments, using procedure one and two above with the 50-turn coil attached to the galvanometer. Record your observations on the chart.

Observations: Induced Current				
	25-Turn Coil		50-Turn Coil	
TYPE OF MOTION	GALVANOMETER READING	DIRECTION OF DEFLECTION	RDG.	DEFL.
Weak N in slowly				
Weak N out slowly				
Weak N in quickly				
Weak N out quickly				
Weak S in slowly				
Weak S out slowly				
Weak S in quickly				
Weak S out quickly				
Strong N in slowly				
Strong N out slowly				
Strong N in quickly				
Strong N out quickly				
Strong S in slowly				
Strong S out slowly				
Strong S in quickly				
Strong S out quickly				
Strong Magnet at rest				
Weak Magnet at rest				

Summary

1. What are three factors which determine the strength of an induced current?
2. How would you use the magnets to increase the induced current? (*Hint:* How would you hold the poles?)
3. Compare the ways in which we increased the strength of an electromagnet with those ways in which we increased the induced current.

Teacher Activities *(continued)*

2. Summarize by demonstrating a magneto (S-1 #14-1808). Have the students identify the large wound core and the permanent magnetic field. Have a pupil operate the magneto, first slowly, then rapidly. Use a neon lamp (S-1 #14-1718) to show the alternate glowing of

each plate. Relate this to the observed deflection of the galvanometer needle in both directions. Refer to the homework question on alternating current to reinforce the definition.

3. Have pupils read their answers to summary question (1) of their laboratory lesson to ascertain that they understand that an induced current may be increased by strengthening the magnetic field, increasing the number of turns in the coil, increasing the relative motion between the two.

21. HOW CAN ELECTROMAGNETISM BE USED TO CREATE INDUCED ELECTRICITY?

Outcomes

- When an electric circuit is closed, lines of force (magnetic field) spread out (move) as the wire (a coil) becomes an electromagnet.
- When a magnetic field is created in a coil, this magnetic field may induce a voltage in another nearby coil.
- When a circuit is opened, the magnetic field collapses and, in doing so, may induce a voltage in a nearby coil.

Teacher Activities

1. Have students recall their experiences in producing alternating current by moving a magnet in the presence of a wire. Lead the students to generalize that this is not a very satisfactory method for generating A.C.

2. a. Record the following on the chalkboard:
   Moving Magnets Produce an Electric Current
   Electric Currents Produce Magnetic Fields

   b. Challenge the pupils: "Can you combine these two phenomena (natural occurrences) to get an electric current?"
   Explain to the class that a great scientist, Michael Faraday, was faced with this very problem. "Together, can we devise an experiment to help solve this problem?"

LABORATORY WORKSHEET — PHYSICS: LESSON 21

(May be duplicated and distributed to pupils)

Purpose: To see whether turning current off and on in one coil can induce current in another coil

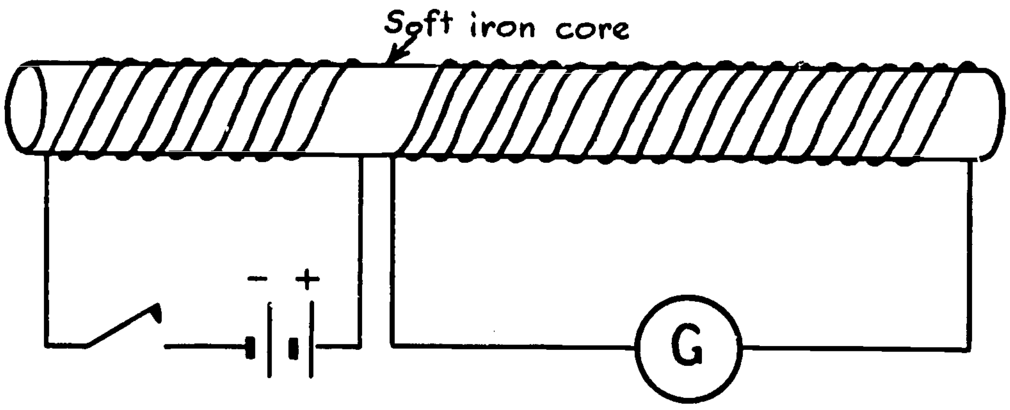
Materials (for 2 pupils)

Soft iron bar (6″—8″ long nail)
2 #6 1½-volt dry cells
Pushbutton or snap switch
Galvanometer

Bell wire, 2 ends bared ½ inch
4″ length
1½ foot length
1-foot length

Procedure

Wind 10 turns of wire around one half of the iron bar and connect it in series with a switch and two dry cells as shown below; wind 20 turns on the other half and connect this wire to a galvanometer.



1. Observe the galvanometer needle's deflection, recording your observation under Trial #1 in the table:
   a. the instant the switch is closed
   b. a very short time after the current is established
   c. the instant the switch is opened

   (Caution: To prolong the life of cells, permit the switch to remain closed no longer than needed to obtain observation.)
2. Repeat the experiment, again recording your results in the table under Trial #2.

Activity	Galvanometer Reading		Direction of Deflection	
	Trial #1	Trial #2	Trial #1	Trial #2
Before switch is closed				
The instant switch is closed				
Shortly later				
The instant the switch is opened				

Summary (may be completed at home)

1. Define primary coil and secondary coil.

2. What forms around the primary coil when the switch is closed?
3. Why was the galvanometer needle deflected *only* at the instant the switch was opened or closed?
4. How can you tell that an alternating current was caused in the secondary coil?

Teacher Activities *(continued)*

3. Conclude this lesson by having the pupils compare the creation of induced current by moving a magnet with induced current created by the alternating current in an electromagnet. Record this data in chart form, eliciting statements from pupils, as follows:

Motion of a Magnet Causing an Induced Current	Alternation of Current in an Electromagnet Causing an Induced Current
a. The magnet has a permanent magnetic field with lines of force around it.	a. When he primary circuit is closed, an electromagnet is produced with magnetic lines of force around it.
b. When a magnet is moved into a coil of wire, the galvanometer needle deflects in one direction.	b. When the switch is closed, a magnetic field is set up around the core; because the core is in the secondary coil, a current is induced in the secondary circuit.
c. When the magnet is at rest inside the coil, there is no deflection of the galvanometer needle.	c. When the current flows in the primary coil, there is no induced current in the secondary coil.
d. At the instant the magnet is removed, a current is induced in the coil in the other direction.	d. At the instant the switch is opened, a current is induced in the secondary coil in the other direction.
e. Continued movement of the magnet induces an alternating current in the coil of wire.	e. By repeatedly opening and closing a primary circuit, an alternating current can be induced in the secondary circuit.

Suggested Homework

Ask an automobile repairman, or find out at an automobile parts shop, how induction coils are used in automobiles.

22. HOW CAN AN INDUCED CURRENT HELP AN AUTOMOBILE TO OPERATE?

Outcomes

- The induced voltage depends upon the number of turns in the coils, the type of core, and the distance between the coils.
- An induction coil consists of 2 coils—a primary coil (of few turns) in which the circuit is alternately opened and closed and a secondary coil in which a high voltage is induced.

Teacher Activities

1. Review the previous lesson to elicit that the induced current produced was rather weak. Ask the pupils to recall (a) the methods used to increase the strength of an electromagnet (Lessons 17 and 18); (b) how the induced current, caused by moving a magnet, was increased (Lesson 20).
2. Plan, with the students, an experiment to test their suggestions for increasing the strength of a current caused by electromagnetic induction.

LABORATORY WORKSHEET — PHYSICS: LESSON 22

(May be duplicated and distributed to pupils)

Purpose: To see whether the induced current formed by an electromagnet can be increased

Materials (for 2 pupils)

Long, soft iron nail or rod
Knife switch or pushbutton switch
2 #6 1.5 volt dry cells
Galvanometer
1- foot length of bell wire
2½-foot length of bell wire

Procedure (See diagram on Worksheet—Lesson 21)

1. Wind ten turns of wire tightly around one end of one long nail and connect it in series with a switch and two dry cells. At the other end wind twenty turns of wire and connect it to the galvanometer.
2. Close the switch just for a second and record your observation in the table.
3. Increase the number of turns in the secondary coil from twenty to forty. Attach ends to the galvanometer.
4. Close the switch for a second and record your observation in the table.
5. Slide the ten-turn coil very close to the forty-turn coil. Close the switch for a second. Record your observation in the table.

6. Remove the nail core from the coils of wire.
Place the 10-turn coil alongside the 40-turn coil of wire.
Close the switch for a second and record your observation in the table.

GALVANOMETER READINGS	
EXPERIMENT	READING
20-turn secondary	
40-turn secondary	
40-turn coil near 10-turn (on nail core)	
40-turn coil alongside 10-turn coil (*no* core)	

Summary (may be completed at home)

1. What three factors may affect a current induced electromagnetically?
2. What purpose did the core serve in this experiment?
3. What does an automobile ignition coil consist of?
4. How does it produce a spark hot enough to ignite a gasoline vapor-air mixture?

Teacher Activities *(continued)*

1. a. Summarize by having the students explain how an induced current of varying strength may be produced.
   b. Operate an induction coil (S-1 #14-1398). Show that the spark produces a large amount of heat by setting a small piece of paper on fire by holding it in the spark gap. Call attention to the interrupted spark on the side of the induction coil's housing; this corresponds to the opening and closing of a switch, a requisite to inducing current electromagnetically (Lesson 20).
   c. Display a dissected automobile ignition coil to show the windings. Develop the understanding that the heat produced by the spark due to this high voltage (at the gap in the spark plug) can explode the gasoline-air mixture in a cylinder of the automobile engine.

HEAT

Suggested Lessons and Procedures

23. WHY IS THE RADIATOR WARM?

Outcomes

- Heat is a form of energy.
- The amount of heat a substance has is due to the motion of all of its molecules.

Teacher Activities

1. Recall from the Chemistry Unit that matter exists in different states (Lesson 4) and that a molecule is "the smallest bit of a compound" (Lesson 10).
2. a. Place a wad of cotton soaked in ammonia in a covered Petri dish on the demonstration table. (Prepare in advance of lesson and keep sealed.)

   b. Ignite touchpaper (S-1 #14-0968) or a cigarette. Uncover Petri dish of "a" above, surreptitiously. Ask pupils to explain why turbulence occurs four to five inches away from the lighted end.

   c. Ask pupils to raise their hands if they notice an unusual odor. Indicate the source of the ammonia and question how the pupils in the rear might smell this.

   d. Elicit the facts that: gas molecules travel; molecules may collide as evidenced by random movement.
3. Boil water in an open beaker. (Utilize a dark background so pupils may see steam more easily.)

Elicit the fact that molecular activity increases as heat is added, sometimes to the extent of changing the state of the substance.

4. Demonstrate Stoekle's Tube (S-1 #14-0188) to show how mercury molecules increase their velocities when heated (to reinforce the concept). This is also called a "molecular demonstration apparatus." Heating the mercury causes its molecules to gain so much energy and move so fast that these molecules, in hitting the small pieces of blue glass, cause them to jump around quite vigorously.

   CAUTION: Remove heat when glass beads start to jump around. The bottom of the tube remains hot for quite a while.

LABORATORY WORKSHEET — PHYSICS: LESSON 23

(May be duplicated and distributed to pupils)

Purpose: To discover some of the ways of making a metal warm

Materials (for 2 pupils)

3" nail
Claw hammer
2" square of lead
4" length of steel wire
6" block cut from 2" x 4" board

Procedure

CAUTION: Read this entire sheet, including questions to be answered at the end, *before* you begin any activity!

1. Bend the wire back and forth until it breaks. Touch the metal near the break.
2. Hammer the nail halfway into the board. Use the claw end of the hammer to withdraw the nail. Touch the shaft of the nail.
3. Pound hard several times on the piece of lead, keeping it on the block. Touch it immediately after hammering.

Summary (may be completed at home)

1. In what way did the metal feel different after bending it many times?
2. How did the nail feel different right after pulling it out of the wood?
3. Did the lead feel different after hitting it?
4. List two other ways in which heat may affect different materials.
   EXAMPLE: Heated wax gets soft.

Teacher Activities *(continued)*

5. Summarize by having pupils discuss their observations. Explain that it was the physical energy added to the metal by *motion* (mechanical energy) which caused the molecules in the nail, the steel wire, and the lead block to move faster. This is the way we define heat: HEAT IS THE TOTAL ENERGY OF ALL THE MOLECULES IN A MATERIAL.

   The radiator in the room then feels warm because its molecules are moving faster than the molecules in other objects in the room. Why is the radiator warm, even though there is no bending, banging, or stretching? Elicit the fact that there is steam or hot water in the radiator which causes its molecules to move faster.

24. WHY DO SIDEWALKS HAVE REGULAR SPACES?

Outcomes

- Heat generally causes matter to expand.
- Liquids expand more than solids.
- Expansion is the result of increased molecular motion.

Teacher Activities

1. Recall to the class that the flow of electricity through resistors or wires is generally accompanied by the production of heat (Lesson 5), providing the basis for electrical heaters, cookers, etc. Explain that during this process electrical energy is converted to heat energy. Review homework on how heat affects matter.

2. Suspend a 1-foot length of copper wire (#28 or thinner) horizontally between two supports. Demonstrate that when a dry cell is connected (momentarily) to the wire, the wire becomes hot (a paper rider on the wire will show this) and will sag. Elicit: the sagging is due to the increase in length (expansion) of the wire.

3. Heat the same wire with a bunsen burner to show that it will expand. Elicit: the expansion is due to the heat regardless of the source of heat. Call attention to the fact that the wire, upon cooling, contracts to its original length.

LABORATORY WORKSHEET — PHYSICS: LESSON 24

(May be duplicated and distributed to pupils)

Purpose: To see whether heating a material changes its size

Materials (for 2 pupils)

Test tube and holder
6" long glass tube, fitted into 1-hole rubber stopper (to fit test tube)
Container of water
Alcohol burner

Procedure

1. Fill the test tube with colored water and insert the stopper so that the water rises about ½ inch into the glass tube.
2. Heat the test tube gently.
3. Record observations.

Summary (may be completed at home)

1. Why did the water rise in the tube?
2. Explain what you saw by describing:
   a. The change in distances among the molecules
   b. The change in movement of the molecules
3. How are problems of expansion in the summertime solved when workmen:
   a. Lay railroad tracks b. Build bridges c. Build a concrete highway?

Teacher Activities *(continued)*

4. Discuss observations with pupils, eliciting that:
   a. The water rises in the tube because its rate of expansion is greater than that of the glass (a solid).
   b. The rise of the water could be used to measure how hot the water is.
5. Demonstrate the ball and ring apparatus (S-1 #14-0888) to show further the expansion and contraction of solids.

   Show the great forces involved in expansion and contraction by demonstrating the Tyndall apparatus (S-1 #14-1158).
6. Encourage the pupils, in summary, to use their knowledge of molecules to explain:
   a. Heat can cause solids and liquids to expand.
   b. The forces involved are large.
   c. Why must there be spaces in sidewalks?

d. How do we know liquids seem to have a greater rate of expansion than solids?

NOTE: It is suggested that Biology Lesson 1 be read since preparation for this lesson should begin two weeks in advance.

25. DO ALL SUBSTANCES EXPAND AT THE SAME RATE?

Outcomes

- Gases expand when heated.
- Solids differ in rates of expansion.
- Liquids differ in rates of expansion.

LABORATORY WORKSHEET — PHYSICS: LESSON 25

(May be duplicated and distributed to pupils)

Purpose: To discover the effects of heat on air

Materials (for 2 pupils)

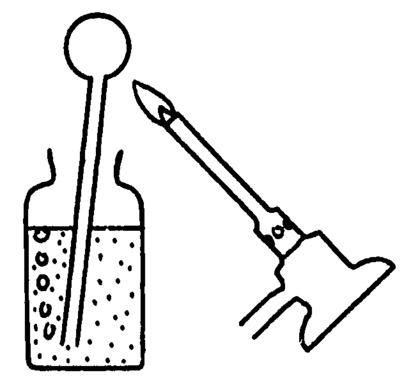
Air thermometer bulb (S-I #15-0678)
Gas-collecting bottle (4-6 oz.)
Colored water (⅔ bottle)
Test tube and holder
Rubber balloon
Rubber band
Alcohol burner

Procedure

1. Use the rubber band to secure the balloon to the upper end of the test tube. (Stretch balloon before attaching.)
2. Heat the test tube until the balloon inflates; then let the test tube cool. Record what you have done and observed.

Optional procedure

1. Insert the open end of the air thermometer bulb into the bottle which is ⅔ full of colored water, as shown below:



2. Gently heat the bulb until about a dozen bubbles of air are forced out of the bulb. *Let the bulb cool* and observe the liquid rise into the bulb. Why did the liquid rise? Record your answer. Grasp the bulb with the hand and observe how the warmth of the hand causes the air to expand and force the liquid down. Why did the liquid g. down?

Summary (may be completed at home)

1. Why does the balloon inflate?
2. Using your knowledge of molecules tell what happens above:
   a. What happens to the distance between molecules after heating?
   b. What happens to the speed of the molecules after heating?
3. What is the effect of heat on gases?
4. Why was the water pushed out of the air thermometer?

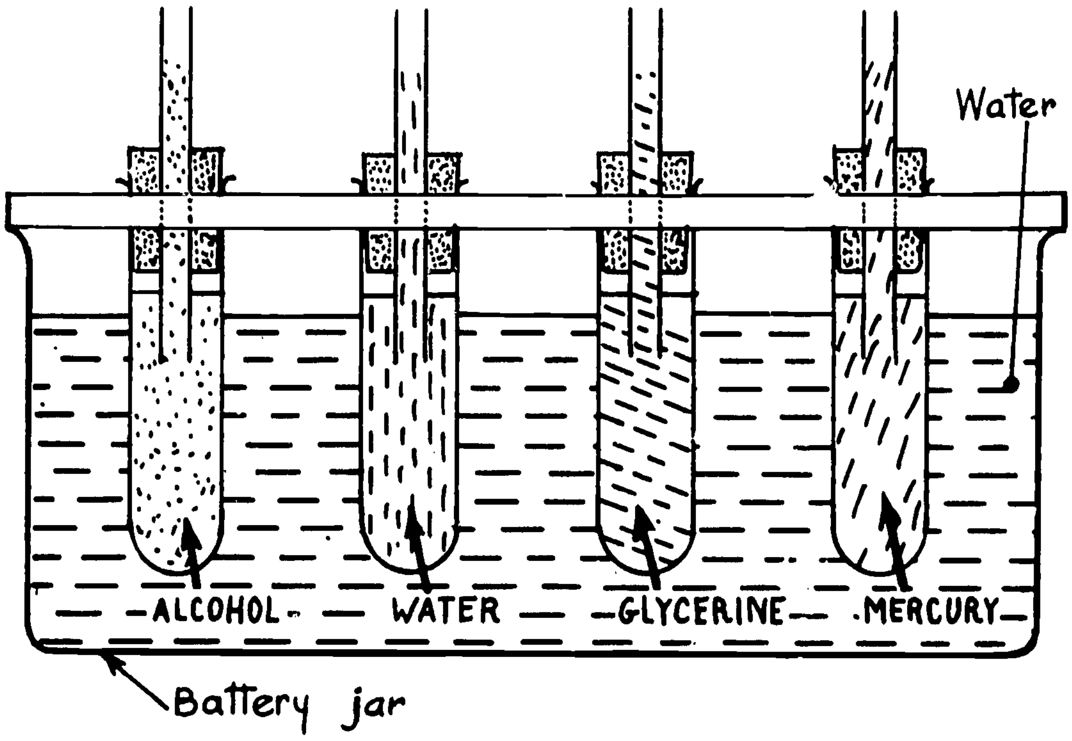
Teacher Activities

1. Review homework on expansion problems of subway tracks, concrete highways, etc.
2. With a bunsen burner, heat a straight bimetallic compound bar and challenge the pupils to explain the bending that occurs. Immerse the device in cold water to observe the bar's return to its former shape. From a discussion of the phenomena the pupils should realize that two different metals are joined together (possibly iron and brass) and that they expand at different rates. Alternate demonstration: Thermostat (S-1 #14-2018)
3. Do liquids expand at the same rate?

   To demonstrate the unequal expansion of liquids, immerse four test tubes containing different liquids (water, alcohol, glycerine, and mercury) in a battery jar of hot water and observe the expansion (in glass tubes inserted into rubber stoppers and then into the test tubes; the liquid may be colored for better observation). The test tubes may be supported in a wooden slat from a test tube rack. (See diagram opposite.)
4. Summarize by having pupils discuss the comparisons they recorded.
   a. Different solids have different rates of expansion.
   b. Different liquids have different rates of expansion.

Suggested Homework

1. What kinds of thermometers do we use?
2. How do they differ?



3. How can you apply your knowledge of expansion of metals and electric circuits to create a fire alarm system?

26. HOW MAY WE MEASURE TEMPERATURE?

Outcomes

- The property of expansion may be used to measure temperature.
- Temperature is measured in degrees according to a scale.
- Fahrenheit and Celsius (centigrade) are two thermometer scales in general use.

Teacher Activities

1. Review homework with emphasis on the expansion properties of substances.
2. Have pupils demonstrate the unreliability of the sense of touch as a measure of temperature.
   a. Prepare three battery jars of water, "A" of temperature of about 130° Fahrenheit, "B" of room temperature, and "C" which had been on the outside windowsill for a while.
   b. Have one pupil place one hand in "A," the other hand in "B,"

and indicate which is the warmer. Have a second pupil simultaneously place one hand in "B," the other hand in "C," and ask her to indicate which is the warmer. Call on two other pupils to repeat this.

LABORATORY WORKSHEET — PHYSICS: LESSON 26

(May be duplicated and distributed to pupils)

Purpose: To find an accurate way to measure temperature

Material (for 2 pupils)

Sheet of graph paper, 4 boxes to the inch
Container of cracked ice
Metric ruler
Thermometer (double scale, F&C, S-1 #14-1048.01)
Ungraduated thermometer (Welch #1621, or Cenco 77320)
NOTE: If this is unavailable, the apparatus similar to that used to show water expansion, (Worksheet, Lesson 24, Procedure 1) may be substituted. Be certain to roughen one side with sandpaper so that pencil marks may register.

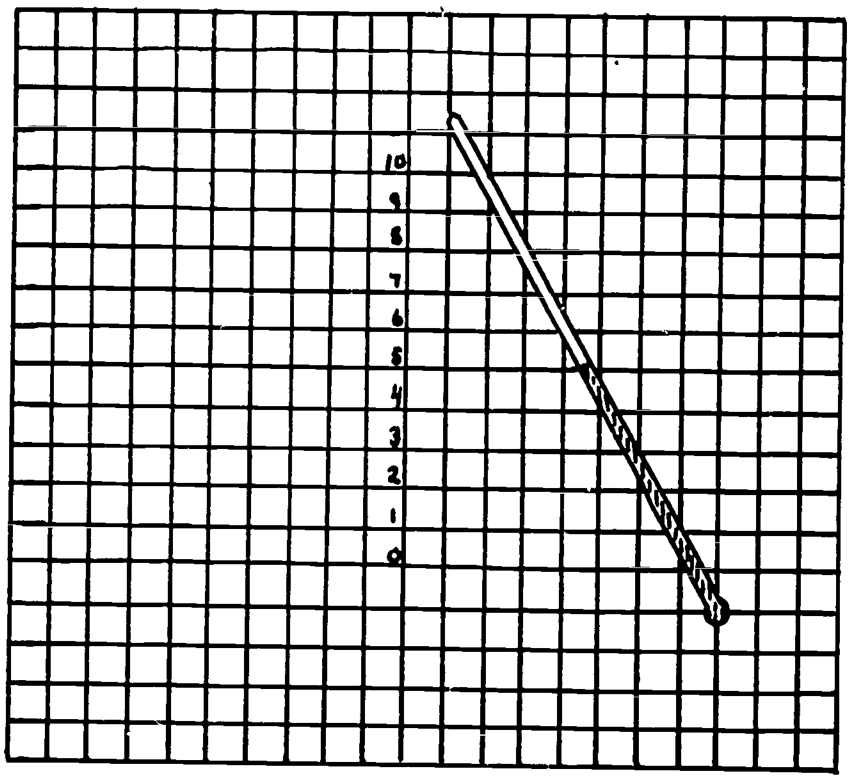
Procedure

1. Read the procedure through before going to work.
2. Examine the double-scale thermometer and observe:
   a. The thin glass mercury reservoir (bulb).
   CAUTION: Handle the thermometer gently and do not permit it to strike the surface of a container. The bulb is very thin and can easily be broken.
   b. The thin uniform "bore" (passageway) running the length of the tube.
   c. The F (Fahrenheit) scale, especially the freezing point (fp) of water (32°) and the boiling point (bp) of water (212°). How many "degrees" (lines) are there between the fp and the bp?
   d. The C (Celsius or centigrade) side. What number on this scale corresponds to 32° on the F scale? to 212° on the F scale? How many degrees are there between the fp and bp on the C scale?
3. Place the bulb of the ungraduated thermometer in the cracked ice. (Be sure the bulb is surrounded by ice.) With a pencil, mark the lowest point reached by the mercury. This point will be marked 32°F by half the class and 0°C by the others (as instructed by your teacher).
4. Bring your thermometer to the front of the room and place the bulb in the container of boiling water. With a pencil mark the highest point reached by the mercury. This point will be numbered either 212°F or 100°C (as instructed by your teacher).

Optional

1. With your ruler measure the distance between the two pencil marks and then, on the glass, mark off convenient numbers (as instructed by your

teacher) by placing the tube diagonally on the graph paper so that eighteen 10-squares lie between the two pencil marks you inscribed.



2. How many degrees are represented between any two lines?
3. Take several temperature readings (room temperature, tap water, etc.) with both thermometers and record pencil line on thermometer.

Summary (may be completed at home)

1. Did you make a Fahrenheit or a Celsius thermometer?
2. What are the differences between a Fahrenheit and a Celsius thermometer?
3. What liquids are used in thermometers?
4. Can body temperature be accurately determined by placing a hand on your forehead? Why?
5. Use the graph paper to draw side-by-side drawings of the Fahrenheit and Centigrade Scales. Indicate freezing and boiling points of water, normal room temperature (68°F, 20°C), and normal body temperature (98.6°F, 37°C).

Teacher Activities *(continued)*

3. Summarize by having pupils discuss their answers to worksheet questions. Distinguish between the *precision* of measurement of the instrument compared to the *accuracy* of the person using the instrument and recording the data.

Lead the discussion to the following conclusions:

a. Thermometer scales are derived from arbitrary fixed points (the freezing point (fp) and boiling point (bp) of water).
b. On the Fahrenheit scale, the fp is 32° and the bp is 212°. The intervening space is divided evenly into 180 parts or degrees.
c. On the Celsius (centigrade) scale, the fp is 0 degrees and the bp 100 degrees. The intervening space is divided evenly into 100 parts or degrees.

27. WHAT IS THE DIFFERENCE BETWEEN HEAT AND TEMPERATURE?

Outcomes

- Heat is the total motion energy of all the molecules in a material.
- Temperature is the average motion energy of the molecules in the material.
- Temperature tells us which way heat will travel between two bodies, or a body and its surroundings.
- Heat may be transferred by convection.

Teacher Activities

1. Review homework and explain the advantages and disadvantages of mercury and alcohol as used in thermometers.
   a. *Mercury*
      Adv. — uniform expansion　　Disadv. — fp not low enough
      — high bp
      — visible
   b. *Alcohol*
      Adv. — Low fp　　Disadv. — bp too low
2. a. Demonstrate the difference between heat and temperature by measuring equal quantities of water of the *same* temperature into two beakers. Have two pupil aides take the temperatures of each. Ask pupils: "What do you think may happen if we add boiling water to each beaker?"
   b. "Suppose we add more boiling water to one beaker than to the other, what will happen to the temperature of the first beaker compared to the second?"

c. Elicit:
"The larger amount of water transferred *more heat* although the added water in both cases was at the *same* temperature."
"The larger amount of water had more heat (energy) although its temperature (speed of motion of molecules) was the same as that of the smaller amount."

d. An analogy between heat and temperature might be:
Two classes take a test. Class I, with 20 pupils, gets a total score of 2000 points; Class II, with 30 pupils, gets a total score of 2400 points. Class II has a higher total score (heat), but the average score of Class I pupils is 100 as compared with 80 for Class II (temperature).

e. A radiator has a temperature (average energy) of 180°F. A match has a temperature (average energy) of 500°F. Elicit from the class that a radiator is used to warm a room because even though its average energy is lower, there is more total heat available to give to the room. Also, a spark from a grindstone has a temperature of over 1000° but doesn't even feel warm because its total energy (heat) is quite low.

LABORATORY WORKSHEET — PHYSICS: LESSON 27

(May be duplicated and distributed to pupils)

Purpose: To show how heat may travel in gases and liquids

Materials (for 2 pupils)

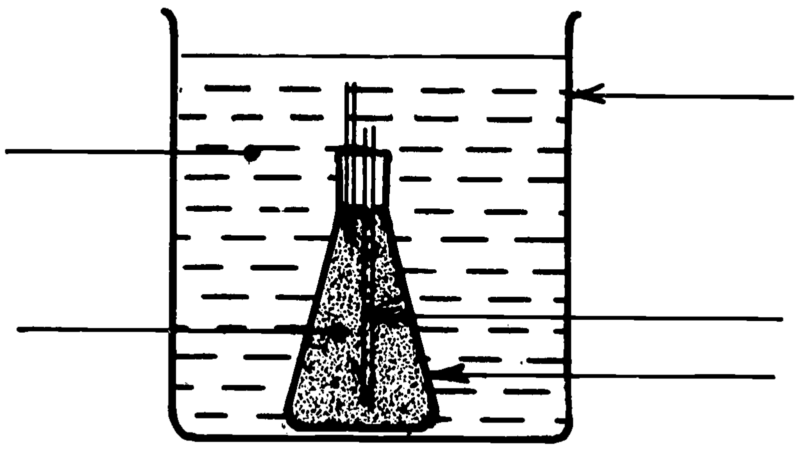
Alcohol lamp
3 or 4 safety matches
Erlenmeyer flask, 125 ml
Large beaker or small battery jar
Tripod and wire gauze
Two-holed stopper with one glass tube fitted to the base of *flask* and one short glass tube rising 1½" above opening of glass tube
Small bottle, half filled with red or blue ink and capped with eye dropper

Procedure

1. Light the alcohol lamp.
   a. Bring a match toward the flame, *slowly,* from the side, and observe how close to the flame a match can be brought before it receives enough heat to cause it to ignite.
   b. Bring another match to the flame, this time from about 6 inches above the flame, moving it slowly downward.
   c. Record your answers to the following:
      Which match lit first?

How far did the heat travel in "a" compared with "b"?
What carried or "conveyed" the heat to the match?

2. Fill beaker halfway with cold water.
   a. Place warm water (from demonstration table faucet) almost to top of flask; add several drops of ink gently to the water. Record what happens to the particles of ink. Explain why this happens.
   b. Stopper the flask, heat gently until water rises in tube; set it into the beaker (or battery jar) so that the higher glass tube remains an inch or so below the surface of water in the beaker.
   c. Label the diagram.



Summary (may be completed at home)

1. Why did the water in the little flask rise up the tube when you heated the flask?
2. What happened to the inky water in the flask?
   Why do you think this happened?
3. Define convection.
4. Why are radiators and other room heaters kept close to the floor?

Teacher Activities *(continued)*

3. Pupils discuss the observations they recorded in their notebooks. Elicit:
   a. Heat is a form of energy caused by the motion of molecules. According to this theory hot objects expand because they consist of rapidly moving molecules which require more space the faster they move.
   b. One process by which heat is carried or "conveyed" from one place to another by molecules is called convection.
   c. By knowing the temperature of two bodies, or of one body and

the temperature of its surroundings, we can tell in which direction the heat will flow. Heat always goes from higher energy to lower energy, from *hot to cold.*

Elicit from class that heat is taken out of the food in the refrigerator and transferred to the outside. The insulation of the box keeps more *heat* from *coming in.*

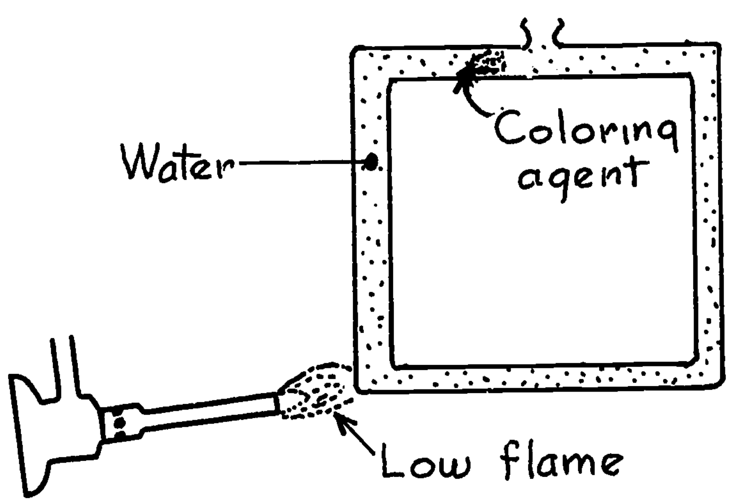
28. HOW CAN WE MOVE HEAT?

Outcomes

- Heat energy may be transferred as a form of light, i.e., radiant energy. This process is called *radiation.*
- Heat travels through a substance by molecular collision, a process called *conduction.*
- Metals are better heat conductors than nonmetals.
- Solids are better conductors than liquids.

Teacher Activities

1. Review the assignment of previous lesson, eliciting that the process by which heat is transferred by the motion of molecules in gases and liquids is called convection. You may wish to recall this concept by igniting a candle, setting a glass chimney over it on blocks of wood, and by holding the smoking stick, rope, punk, or incense beneath the chimney. (Convection of gases apparatus #14-0578—S-1 list; or, as shown below, S-1 #14-0588, Welch #1729 and H 1729 —convection of liquids apparatus)



2. Pose this question:
   "If you place your hand *below* a lighted lamp, do you feel heat? Could this heat have travelled by convection?"

   Elicit: since warm air rises, convection was not the method of heat transfer. Explain radiation, demonstrating a radiometer (S-l #14-0988) near a candle, a gas flame, or sunlight, if available.

3. Have the students touch the wooden and metal parts of their desks and observe that the metal feels colder than the wood. If the wooden and metal parts of their desks and seats have the same temperature, why should the metal feel colder than the wood?

LABORATORY WORKSHEET — PHYSICS: LESSON 28

(May be duplicated and distributed to pupils)

Purpose: To show how heat travels through solids

Materials (for 2 pupils)

Large test tube   Water
Alcohol burner
Several 8-10 inch rods (or strips) of different metals (including, preferably iron and copper) and one of wood
Sheet of asbestos or plywood (to protect table surface)

Procedure

1. Hold, in one hand, a metal rod, and in the other hand, a wooden rod. Hold the free end of each rod in the flame. Record the time it takes to sense the heat reaching either hand and remove both rods immediately.
2. Repeat, using two different metals. Record your impression of which rod "conducted" (carried) the heat to your hand faster.
3. Pour water into a test tube to ½ inch from the top. Hold the bottom of the test tube between thumb and forefinger while holding the top inch of the test tube in the flame. (Be careful not to spill the water.) Although the water boils, why does the bottom of the test tube remain cool? Record your explanation.

Summary (may be completed at home)

1. Why is the glass bulb of a thermometer made very thin?
2. Why are cooking utensils made of aluminum or copper?
3. How many different methods of heat transfer are used in your own heating system at home?

Teacher Activities *(continued)*

4. Have the pupils discuss their answers to the worksheet questions. Elicit the conclusions that:
   a. The heat traveled from one end of the metal rod to the other more rapidly for one metal (copper) than another (iron).
   b. The heat traveled more rapidly through metal than through wood (a nonmetal) because the molecules are closer together.
   c. In liquids molecules are farther apart. Liquids, therefore, are poorer conductors than solids.

5. Summarize by reviewing the operation of a vacuum or Thermos bottle which is designed to maintain the temperature of its contents; mirrored surfaces reflect radiant energy; the vacuum between the walls precludes convection currents which require the presence of gases or liquids; while the insulating cork, along with the vacuum and the double-walled container, inhibits the transfer of heat by conduction. (The Thermos Insulation Demonstration unit, S-1 #14-1108, Welch-1703A, consisting of 4 Dewar flasks in different stages of treatment, may be used as a summarizing demonstration.)

Optional Activities

1. Demonstrate the conductometer (S-1 #14-0908) to show a more accurate comparison of rate of conduction through various metals.
2. Demonstrate the conductivity indicator (Welch #1649).
3. Demonstrate the poor conductivity of water as follows: Take a large pyrex test tube and place some chipped ice in the lower one-third. Place a brass nut on the ice, and fill the test tube to within 1½ inches of the top. Use a bunsen burner to heat the top 1" of water to the boiling point. The ice is still very much intact.
4. Demonstrate the poor conductivity of gases (e.g., air) as follows: Hold a hand alongside and quite close to a bunsen flame (palm toward the flame) to show that the air between the flame and the hand is a poor conductor. Place a sheet of Celotex, glass wool, or asbestos on the palm of a hand and play the bunsen flame on the sheet. Call attention to the porosity (air spaces) of the material.
5. Challenge the class to explain why "double-wall" protection (such as storm windows, hollow cement blocks, "insulation batts," etc.) are effective; also the use of layers of newspapers under a light coat on a cold night.

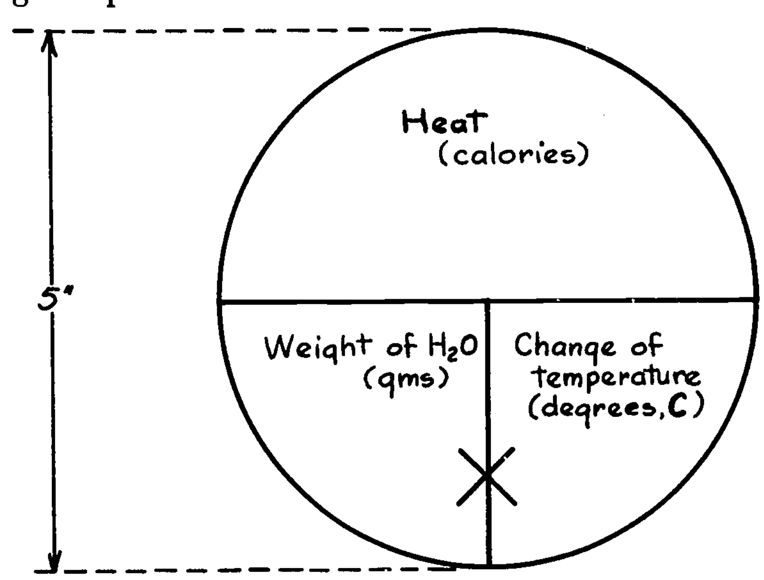
29. HOW IS HEAT MEASURED?

Outcomes

- Heat is measured in units called calories.
- A calorie is the amount of heat required to raise the temperature of one gram of water one degree centigrade.

Teacher Activities

1. Have pupils recall how they measured temperature. Elicit: temperature is measured in degrees with an instrument called a thermometer.
2. "How can we measure a change in the amount of heat a body has after it absorbs or gives off heat?" Explain that a change in heat would be indicated by a change of temperature. Tell the class that the accepted unit of heat, the calorie, represents the amount of heat that would produce a temperature change of one centigrade degree in one gram of water. The heat, in calories, can be determined by using the problem-solver below:



HEAT = MASS x CHANGE IN TEMPERATURE

For example, if you were to raise the temperature of one gram of water by 3°C., you would have added three calories of heat to the water. In order to use the problem-solver to find *heat,* one covers *heat* and finds that *weight* and *change of temperature* are multiplied. To solve for *temperature,* cover *temperature,* and note that *heat* is divided by *weight.* It is desirable to make a game out of using this device.

LABORATORY WORKSHEET — PHYSICS: LESSON 29

(May be duplicated and distributed to pupils)

Purpose: To measure the amount of heat added to water

Materials (for 2 pupils)

500 ml beaker
Celsius thermometer
500 ml graduate cylinder
Wire gauze
Tripod
Alcohol lamp

NOTE: We will use one ml as being equal to one gram.

Procedure

1. Pour 100 grams (100 milliliters) of tap water into a beaker. Measure its temperature. Heat it for five minutes and measure its temperature again. Record your observations on the table.
2. Repeat, using 250 grams (250 milliliters) of water. Record your observations carefully.
3. Use your problem-solver to find the heat gained in calories (Column 5).

QUANTITY H_2O	TEMPERATURE AT START	TEMP. AFTER FIVE MINUTES	CHANGE IN TEMPERATURE	HEAT GAINED IN CALORIES
100 gms.				
250 gms.				
If time permits, 400 gms.				

Summary

1. What is a calorie?
2. Why didn't we need to use a balance to weigh the water?
3. How many calories of heat would be lost to the air when the temperature of ten milliliters of water changes from 20°C to 18°C?
4. A tank for tropical fish contains two liters (2,000 grams) of water at 20°C. If 8,000 calories of heat are added, what is the new temperature of the tank?
5. Bring "problem-solver" to class for next lesson.

Teacher Activities *(continued)*

3. Summarize by reviewing the laboratory lesson with the pupils. Verify that heat causes a change in temperature proportional to the

amount of heat added. Relate the mass of one gram of water being approximately equivalent to one milliliter of water.

30. HOW IS HEAT EXCHANGED?

Outcomes

- When heat is transferred from one body to another, the loss of heat of the first body equals the gain in heat of the second body.
- A calorimeter is used to measure heat transfer.

Teacher Activities

1. "Imagine that your bowl of hot soup is becoming cool. You add more hot soup from the pot to your cold soup. How would the temperature of the new mixture compare with that of the cold soup and hot soup?"

   (Elicit, through this motivating question, that the final temperature of the soup in the bowl would be somewhere between the temperature of the hot soup you added and the temperature of the soup that had cooled.)

NOTE: Read, with the class, the procedures on the worksheet. Emphasize the construction of the calorimeter (insulation, prevention of heat loss, etc.)

LABORATORY WORKSHEET — PHYSICS: LESSON 30

(May be duplicated and distributed to pupils)

Purpose: To compare the amount of heat given up by a hot liquid with the amount of heat taken up by a cold liquid

Materials (for 2 pupils)

2 beakers, 250 ml	Alcohol lamp
Celsius thermometer	Tripod
Graduated cylinder, 250 ml	Wire gauze

Calorimeter (Cenco #77970) or homemade no. 1 can centered in no. 7 can, held in place by newspapers and capped by plastic coffee can cover; stirrer may be made of 1/4" dowel with acetate vanes.

Procedure

1. Prepare equal amounts (100 grams) of warm water and tap water in separate beakers. Measure the temperature of each. Record these temperatures.

2. Pour both beakers of water into the *inner* can of the calorimeter. Stir the mixture carefully and gently with the stirrer and read the immersed thermometer. Record this temperature.
3. On the chart below, indicate the temperature change. Use a plus sign (+) for gain and a minus sign (—) for loss.
4. Repeat the above experiment, using 50 grams of tap water in one beaker and 150 grams of warm water in the other.
5. Use "problem-solver" to determine the heat lost or gained. Use plus sign (+), if gain, and minus sign (—), if loss.

CHART FOR DATA					
	BEAKER	WEIGHT OF WATER	TEMPERATURE	TEMPERATURE CHANGE	HEAT GAINED OR LOST
1	warm water	100 gms.	———°C	———°C	——calories
2	tap water	100 gms.	———°C	———°C	——calories
×	mixture (1 + 2)	200 gms.	———°C	×	×
1	warm water	150 gms.	———°C	———°C	——calories
2	tap water	50 gms.	———°C	———°C	——calories
×	mixture (1 + 2)	200 gms.	———°C	×	×

Summary (may be completed at home)

1. How did the heat gained by one quantity of water compare with the heat lost by the quantity of water with which it was mixed?
2. What object gained or lost heat, in this experiment, that we did not take into account?
3. In which direction did the heat travel, from warm to cool, or from cool to warm?

Teacher Activity *(continued)*

2. Summarize by tabulating the results of each team of experimenters on the chalkboard, calling attention to diversities based on heat losses to the surrounding environment. Elicit: two objects of different temperature, if placed together, would eventually have the same temperature since heat would travel from the warmer to the cooler object.

SUGGESTED REFERENCES: PHYSICS

For the Teacher

BRANDWEIN, P. F. ET AL. *Teaching High School Science: A Sourcebook in Physical Science.* New York: Harcourt, Brace & World, 1959.

BURNS, E. ET AL. *Physics, A Basic Science.* Princeton, N. J.: Van Nostrand, 1954.

HALTON, G. AND G. H. ROLLER. *Foundations of Modern Physical Science.* Reading, Mass.: Addison-Wesley, 1958.

JOSEPH, A. ET AL. *Sourcebook for the Physical Sciences.* New York: Harcourt, Brace, 1961.

MILLER. *College Physics.* New York: Harcourt, Brace & World, 1959.

SEARS-ZEMANSKY. *College Physics.* (3rd ed.) Reading, Mass.: Addison-Wesley, 1960.

SHORTLEY, G. AND D. WILLIAMS. *Principles of College Physics.* Englewood Cliffs, N.J.: Prentice-Hall, 1959.

SMITH, A. AND J. COOPER. *The Elements of Physics.* New York: McGraw-Hill, 1957.

VERWIEBE, ET AL. *Physics, A Basic Science.* Princeton, N. J.: Van Nostrand, 1962.

For the Pupil

ADLER AND DEWITT. *The Wonders of Physics.* New York: Golden Press, 1966.

BEELER, N. F. AND F. M. BRANLEY. *Experiments with Electricity.* New York: Crowell, 1956.

BEISLER, G. AND A. BEISER. *Physics for Everyone.* New York: E. P. Dutton, 1956.

BENDICK, JEANNE. *Electronics for Young People.* New York: McGraw-Hill, 1955.

BOYD, C. AND M. VERE DE VAULT. *Physics.* Austin, Texas: Steck-Vaughn, 1959.

BOYLAN, P. J. *Elements of Physics.* Boston: Allyn & Bacon, 1962.

BRINCKERHOFF, R. F. ET AL. *Exploring Physics.* New York: Harcourt, Brace & World, 1959.

CAVERLY, D. P. *Primer of Electronics and Radiant Energy.* (2nd ed.) New York: McGraw-Hill, 1952.

DULL, ET AL. *Modern Physics*. New York: Holt, Rinehart & Winston, 1960.

EBY, ET AL. *Physical Sciences*. Boston: Ginn, 1960.

EFRON, A. *Basic Physics*. New York: J. F. Rider, 1957.

ELLIOT, L. P. WILCOX. *Physics: A Modern Approach*. New York: Macmillan, 1957.

HOGBEN, LAUNCELOT. *The Wonderful World of Energy*. Garden City, N. Y.: Garden City Books, 1957.

LEWELLEN, J. B. *Understanding Electronics*. New York: Crowell, 1957.

MORGAN, A. P. *The Boy Electrician*. New York: Lothrop, Lee, Shepard, 1948.

NORTH, STERLING. *Young Thomas Edison*. Boston: Houghton Mifflin, 1958.

SKILLING, H. H. *Exploring Electricity*. New York: Ronald, 1948.

TAFFEL, A. *Visualized Physics*. New York: Oxford Book, 1957.

YATES, R. F. *Boy and a Battery*. New York: Harper, 1959.

————. *Boys' Book of Magnetism*. New York: Harper, 1959.

Unit III
BIOLOGY
Needs of Living Things
Cells

NEEDS OF LIVING THINGS

Suggested Lessons and Procedures

I. HOW CAN LIVING THINGS BE GROWN AT HOME FOR STUDY?

Outcomes

- There are many kinds of living things that can be grown at home or in school.
- Living things have certain needs in order to live. All these needs must be present at the same time.
- An experiment is used to test one or more of these needs at one time.
- A control serves as a basis for comparison with the experimental condition. Change in the experimental condition is measured from the control.
- The control and the experimental animals or plants must be treated the same and kept under the same conditions except for the one thing for which you are testing.

Teacher Activities

1. Elicit from the students the names of pets, flowers, vegetables, other plants or animals which they have seen in their homes. Ask: "How are these things taken care of?"
2. Exhibit to the pupils the growing organisms and the controls that had been prepared previously. Each organism should be carefully and clearly labelled.
3. Identify the "control" and the experimental organisms. Instruct the pupils to make notes of any differences they observe. Make a summary of the observed differences. Now ask, "Why do you think

there are these differences? Is something present in one jar which is not present in the other?"

4. Guide the pupils to an understanding that a necessary factor was missing in each "control." Every other factor was similar.
5. Distribute the worksheet. Read aloud as pupils follow silently.
6. Explain to the pupils that they will now prepare specimens for use at a later date.
   a. Divide class into groups based upon number of microscopes available.
   b. Each group will prepare a culture of protozoa and algae.
   c. Distribute the following items to each group:

Label	Beaker or jar
Hay or dry grass or dry leaves	Water (pond)

   d. Instruct pupils to prepare the specimen as follows:
   Place hay or grass into the beaker of water.
   Write your group number on the label and paste it on the jar.
   e. Teacher collects jars and stores them away until Lesson 5.
7. In summarizing, elicit from the pupils the meaning and purpose of a "control." They should be guided to understand that many conditions (air, light, temperature, moisture, water, or food) affect the growth of a given plant. These conditions operate at the same time. To discover the effect of each factor on the growth, it is necessary to keep all conditions the same except for the one under investigation.

Suggested Homework

1. Assign two or more selected pupils to prepare reports on Janssen and Van Leeuwenhoek to be presented in Lesson 3. Cite references for the pupils and explain how reports are to be made.
2. Select an item you would like to grow. Write your name and the name of the organism on a slip of paper to be handed in during the next lesson. Pupils will prepare specimens and record observations on the log sheet.

LABORATORY WORKSHEET — BIOLOGY: LESSON 1

(May be duplicated for distribution to pupils)

Purpose: To learn how to grow living things

Procedure

1. Simple Plants
   a. Mold
   Place a thick slice of boiled potato on the bottom of a wide-mouthed jar. Place outside a window for fifteen minutes. Remove the jar from the windowsill and cover it. Be sure the cover is not on tight. Put the jar where the teacher tells you.
   b. Mold
   Put a piece of orange on the bottom of a wide-mouthed jar. Do the same steps as stated above for the potato.

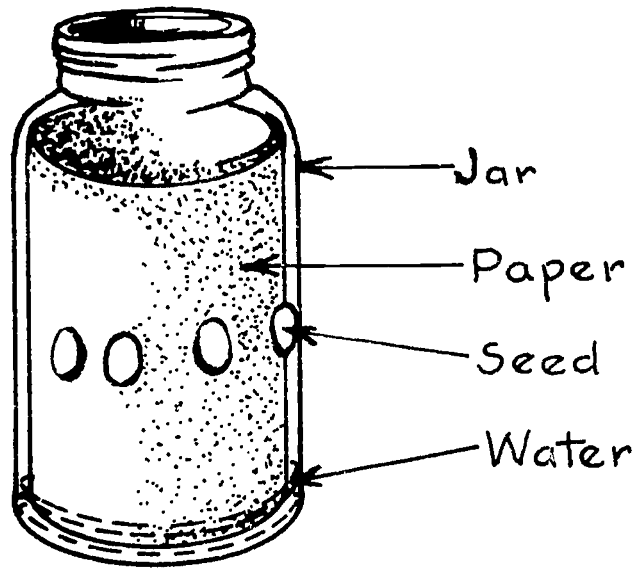
NOTE: See that bottles of moldy food remain closed.

2. Leafy Plants
   a. Seeds
   Get a blotter or towelling paper from the teacher, if you do not have any. Line the inside of the jar with the paper by rolling it and placing it in the jar as shown in the diagram.

   Place 5 to 10 seeds between the sides of the jar and the paper about halfway between the top and bottom of the jar. Leave a little space between the seeds.

   Pour a little water into the jar, enough to cover the bottom of the jar and touch the paper. Keep this level of water by adding a little each day.

   Write on your log sheet any changes you see. If roots, leaves, and stems develop rapidly, replant in flowerpot.



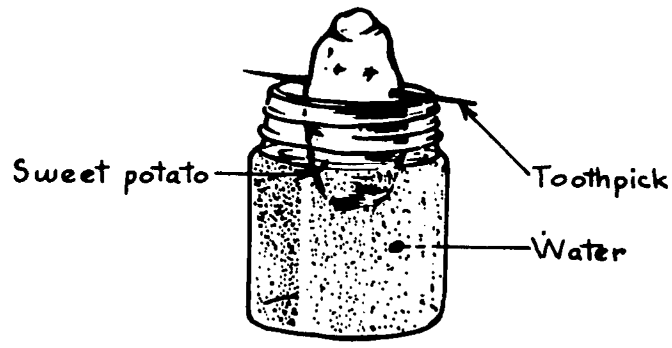
   b. Cuttings
   Cut a two-inch piece from a plant such as a geranium. Put it in a jar or beaker which has been half filled with water. Put the jar on a windowsill where it will get some sunlight. Keep the water at the same level. Write any changes you see on the log sheet.

c. Roots or Stems

1) Sweet Potato

Put a sweet potato, root end down, in a glass or jar. If the potato is a lot smaller than the jar, push 3-4 toothpicks or wood splints halfway into the side of the potato. The potato may be put into the jar so that the toothpicks rest on the rim of the jar. Pour enough water into the jar to cover the lower part of the potato. Keep this level of water by adding a little each day.

Write any changes you see on the log sheet.



2) White Potato

Wet a piece of blotter or towelling paper. Put it into one part of a Petri dish. Place a piece of white potato which has at least one bud or "eye" on top of the blotter. Put the dish on the windowsill or in a light warm place. Keep the blotter wet. Write any changes you see on the log sheet.

3. Animals: Earthworms

Look for earthworms after a heavy rain, before the water has had time to drain away. At other times they may be found under rocks or piles of leaves near lakes or other wet places like drains in parks.

Fill a 6″—8″ jar with leaves, dirt, and grass. Cover the sides of the jar with black paper. Put the earthworms into the jar and put a tin pie pan or heavy piece of cardboard with holes on top of the jar. Store it in a cool, dark place.

Coffee grounds, lettuce, or mashed potatoes may be mixed with the dirt to give the earthworms food. The dirt should be kept moist. Write on your log sheet any changes you see.

Log Sheet

1. What is the name of your animal or plant? ____________________
2. What things did you need for your project?
   a. ____________ c. ____________
   b. ____________ d. ____________
3. How did you set it up? ____________________
4. What did you do for your plant or animal? List, in order, everything you did and the things you gave it. ____________________

5. What changes did you see in your plant or animal during the past two weeks? List any change, no matter how small.

Observations		
Day	Month	Changes Seen

2. HOW CAN WE TELL THE DIFFERENCE BETWEEN A LIVING AND NONLIVING OBJECT?

Outcomes

- Living things differ from nonliving things in that living things carry on life activities such as taking in food, digestion, respiration, circulation, excretion, response to stimuli, growth, and reproduction.
- Both plants and animals are living things and both carry on life activities.
- We are animals. Our bodies carry on life activities.

Teacher Activities

1. Seat the pupils in groups.
2. Distribute to each group the following items or substitutes for them:
   small growing plant — plastic flower or leaf
   small pebble — rubber or plastic insect
   small snail in a est tube with a sprig of Elodea
3. Ask the pupils to arrange their objects into two groups—*Living* and *Nonliving* Objects.
4. Elicit from the pupils reasons why they placed an object in a particular group. Make a list of the reasons on the chalkboard.
5. Challenge the pupils with the question, "How do you know that you are alive?" Develop the understanding that living things carry

on certain basic activities—locomotion, ingestion, circulation, digestion, respiration, excretion, response to stimuli, growth, and reproduction.

6. List the life processes on the board and discuss each in simple terms. (Pupils copy into notebooks.) Use common synonyms and examples of life processes as an aid to comprehension of the terms.
   a. Respiration—Breathing
   b. Digestion—Changing food to a form the body can use
   c. Ingestion—Getting food; eating
   d. Response to stimuli—Use examples (body senses)
   e. Reproduction—Use examples (seeds and plants)
   f. Excretion—Getting rid of waste materials (refer to bathroom routines)
   g. Locomotion—Moving from place to place
   h. Circulation—Carrying materials to all parts of the body
   i. Growth—Forming new living material
7. Guide the pupils to understand that in order for the basic needs to be met, the life processes are necessary.
8. Summarize by asking, "How will you know if a plant or animal is alive?" "What must you do in order to keep it alive?"

Suggested Homework

Continue to work on Log Sheet.

3. HOW DOES A MICROSCOPE WORK?

Outcomes

- The microscope is a delicate instrument and must be handled properly.
- The various parts of the microscope work together to enable us to see objects more clearly and to see those which cannot be seen with the naked eye.
- In a compound microscope the total magnification is determined by the strength of the eyepiece times the strength of the objective used.

Teacher Activities

1. Call on selected pupils who were to make reports on Janssen and Leeuwenhoek. Put summary of the findings on the chalkboard.

2. Distribute the following:
   Two convex lenses
   Diagram of a compound microscope
3. Have the pupils observe the size of a letter on a printed page through a double convex lens and describe the result. Add a second convex lens to the first and have the pupils observe the increased magnification.
4. Explain to the students that a compound microscope consists of 2 lenses, one called the eyepiece and the other the objective. Using simple numbers, explain total magnification equals strength of eyepiece times strength of objective.
5. Locating the parts of the microscope
   With the aid of a wall chart and a microscope on the demonstration table, point out the parts and discuss the functions of each. Pupils should refer to their microscope diagrams.

   Eyepiece — Lenses next to the eye which serve as a magnifier

   Body Tube — Tube between the objective and eyepiece

   Objectives — High- and low-power lenses next to the object to be studied. Low-power objective is always the shorter of the two

   Nosepiece — Located at end of the body tube; used for attaching 2 or more objectives

   Stage — Platform upon which the slides are placed for examination

   Diaphragm — Under stage; controls the amount of light reflected through the microscope

   Mirror — Reflector used beneath the stage to direct light up through the microscope

   Clips — Metal pieces which hold down the slide

   Coarse Adjustment — Turning mechanism (large knob) which can quickly set the microscope in focus on the slide

   Fine Adjustment — Turning mechanism (small knob) used only after the field has been located with coarse adjustment

   Arm — Provides a handle for carrying the instrument

   Base — Feet or bottom that supports the microscope, usually horseshoe-shaped.

Suggested Homework

Examples related to magnification:

If the eyepiece of a microscope magnifies 10 times and an objective magnifies 20 times, what is the total increase in size that is seen?

4. HOW DO WE USE A MICROSCOPE?

Outcomes

- Microscopes are expensive, delicate pieces of equipment.
- Proper handling of a microscope involves the correct use of each part of the microscope.
- The responsibility for the care and operation of a microscope rests with each individual.
- Microscopes help us to study by magnifying objects and structures in living things.

Teacher Activities

1. Distribute worksheets and materials listed thereon.
2. Demonstrate the safe method of carrying the microscope and the safe method of focusing. Be sure that the pupils understand *the reasons* for all safety measures. The pupils will be more apt to remember if they know *why* they are taking such precautions.
3. Show pupils how to use the forceps, medicine dropper, water, slide, and cover slip to prepare a slide from the cutout letter "e." Do this step by step as the pupils follow. Check each group after each step. Explain that this is how most slides are made.
4. Demonstrate how the slide is mounted on the miscroscope and focused.
5. Have pupils mount their slides, make observations and drawings. (Use low-power objective only.)

LABORATORY WORKSHEET — BIOLOGY: LESSON 4

(May be duplicated and distributed to pupils)

Purpose: To learn to use the microscope

Materials

Compound microscope
Microscope slide
Cover slip
Medicine dropper
Forceps
Lens paper
Cutout letter "e" from want ads

Safety Rules

1. Hold the arm of the *microscope* with one hand and place the other hand below the base.
2. The objectives are to be turned away from the stage when the microscope is not in use. This is called the neutral position. Put objective in position by turning until you hear a click.
3. Do not touch the lenses or the mirror with the fingers. Fingerprints will change the image or the view.
4. Use lens paper to clean the lenses and mirror.
5. When you turn the *fine adjustment* or *coarse adjustment* for focusing, always focus upward.
6. If an object is being viewed under high power, use *only* the fine adjustment to change focus, a half turn at a time.
7. The teacher should be notified at once when damage to a microscope is discovered or when an object cannot be seen properly.

Procedure

1. With medicine dropper put a drop of water on the slide.
2. Add the letter "e."
3. Touch cover slip to edge of drop of water.
4. Gently lower the cover slip onto the drop of water.
5. Place slide on microscope stage and focus.
6. Draw what you see.
7. Remove "e" slide from microscope stage.

Questions

1. How can you tell the low-power objective from the high-power objective?
2. What is being done wrong if the cover slip on a slide is broken while you are observing?
3. What is the right way to carry a microscope?
4. How is the mirror helpful?
5. In what way does the position of the object on the slide look different when you look at it through the microscope?

Teacher Activities *(continued)*

5. Summarize by having pupils review method of preparing a slide and mounting it on the microscope.

Suggested Homework

1. Complete answers to questions on the worksheet.
2. Study safety rules and diagram of the microscope .

5. WHAT CAN WE SEE IN A DROP OF WATER?

Outcomes

- Under the microscope, small structures (parts) can be observed in living things which cannot otherwise be seen.
- There are living organisms which are too small to be seen with the naked eye.
- A drop of water may contain many living things which can be seen with a microscope.

Teacher Activities

1. Distribute worksheet and materials listed thereon.
2. Give oral instructions in the preparation of the slides. (See number 3 on worksheet.) Each pupil should prepare one slide from the hay infusion and one from the moss.

   NOTE: Demonstrate how to add a few strands of cotton to the drop on the hay infusion slide to slow down the organism.
3. Inform pupils of possible organisms to be found in the hay infusion after which you will instruct them to follow the directions on the worksheet for completion of the investigation.

LABORATORY WORKSHEET — BIOLOGY: LESSON 5

(May be duplicated and distributed to pupils)

Purpose: To study living things under the microscope

Materials

Compound microscope
Slides and cover slips (2)
Medicine dropper
Beaker or small bottle of water
Forceps
Lens paper
Test tubes or bottles containing samples of hay infusion

Procedure

1. Examine your microscope to be sure that it is in proper working order.
2. Review your safety rules.

3. Use your medicine dropper and take a little water from the hay infusion.
   a. Place a drop on the slide.
   b. Add a few strands of cotton (with your forceps) to the drop. (Your teacher will show you how.)
   c. Use your thumb and forefinger to pick up a cover slip and place it carefully on the liquid.
4. Now place the slide on the stage, clip it in place, and view the drop under the *low-power objective.*
   Draw what you see and tell what the organisms are doing.

   When you finish your drawing, remove the slide from the stage, and set it aside in your tray.
5. Wash your medicine dropper carefully by placing it in the beaker of clean water and squeezing water out several times.
6. Now take a drop of the mossy water from the test tube, using your previous procedure for covering and observing. Draw what you see.
7. What do you see in your test tubes of hay infusion and mossy water without the microscope? ________________
8. Take your first slide which you set aside on the table and place it on the stage again, clip it, and focus on the edge of the cover slip.
   What has happened to the living things that were there? ________________
   Why? ________________
   What does this prove? ________________
   How did you know they were living things in the first place? ________________
9. How did the things you saw get their basic needs? ________________

Teacher Activities *(continued)*

4. In summarization guide the pupils to understand that the microscope made possible the observation of organisms and parts of organisms which cannot be seen with the naked eye.

Suggested Homework

Write a report about A, B, or C listed below. Include in your report the answer (s) to the question (s). Reports are due in four days.

A. Robert Hooke:
   1. What did he use in his experiments?
   2. What name did he give to what he saw?

B. Robert Brown:
   1. What part of the cell did he discover?
   2. What name did he give to this part?

C. Schleiden and Schwann:
   What did their Cell Theory state?

6. WHAT LIFE ACTIVITIES CAN WE STUDY WITH A MICROSCOPE?

Outcomes

- Life processes of tiny plants and animals may be studied under the microscope.
- There are small parts of living things which cannot be seen except by means of a microscope.
- Stained slides help us to see things more clearly.

Teacher Activities

1. Review quickly the previous lesson on hay infusion.
2. Using the bioscope, project the prepared slide of paramecia undergoing fission and/or conjugation. Point out and explain the life activity taking place. (Introduce the terms *fission* and/or *conjugation* and write them on the chalkboard.)
3. Distribute worksheet and materials listed thereon.

LABORATORY WORKSHEET — BIOLOGY: LESSON 6

(May be duplicated and distributed to pupils)

Purpose: To study life activities using the microscope

Materials

Compound microscope	Lens paper
Slides and cover slips	Small bottle of water
Medicine dropper	Forceps
Mold in test tube or bottle	

Procedure

SLIDE A — MOLD

1. Take a clean slide from your tray and place it on the desk.
2. Use medicine dropper to place a drop of water in the center of slide.
3. Your teacher will place a few threads of mold in the drop of water.
4. Place a cover slip over the mold.
5. Put the slide on the stage of the microscope and clip it in place.
6. Focus the microscope.
7. Draw what you see — in diagram form.
8. On your diagram, indicate which part is the same as the parts of a regular plant—root, stem, seed.
9. What do you think the "seed" parts will do?
10. What does the "root" part do?

SLIDE B — ROOT HAIRS

1. Take a clean slide from your tray and place it on the desk.
2. Place the seedling on the slide so that the fuzzy part of the root is in the center of the slide.
3. Put small drop of water on the root.
4. Cover the root with a cover slip.
5. Place slide on microscope and clip it in place.
6. Focus the microscope. Observe the slide.
7. Using medicine dropper, put a drop of ink water between the slide and cover slip. (Teacher demonstrates.)
8. Draw what you see.
9. Which time did you see the root better?
10. What things were easier to see?

Teacher Activities *(continued)*

4. What life activities were taking place on each of the three slides?

Summary

1. Paramecium reproduces by fission and/or conjugation.
2. Roots of the mold take in food.

3. Seed of the mold (spore) grows to form another plant.
4. Root hairs take in (absorb) water.
5. Staining helps us to see the specimen better.

Suggested Homework

Prepare a report on your growing experiment for tomorrow.

7. HOW DO YOU KNOW THAT YOUR PLANT OR ANIMAL IS ALIVE?

Outcomes

- Plants and animals are living things.
- Plants and animals must be supplied with basic needs (food, water, proper temperature, air, moisture).
- Life activities depend upon basic needs.
- We can determine the basic needs of living things by experimenting with them.

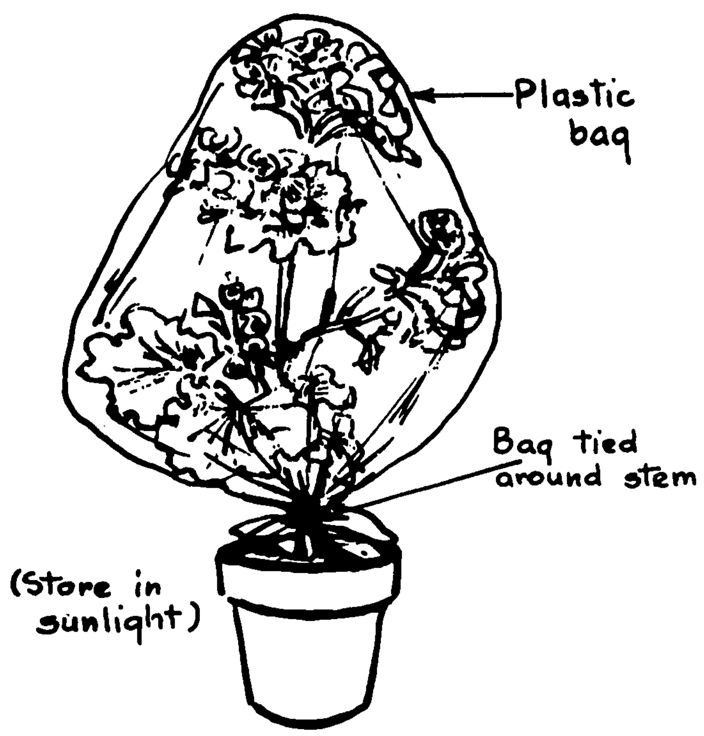
Teacher Activities

1. Seat pupils in groups according to their growing experiments. Instruct the pupils to choose a group leader who will make a report for the group. Have pupils in each group work together to compile the results of the experiment on a particular animal or plant.
   NOTE: Prepare a summary chart on the chalkboard.
2. Each group leader will bring the best specimen from the group to the front of the class and make his report. Some time must be allowed for pupil questions and for recording results of each group on the summary chart.
3. It is extremely important that experiment failures be reported and that the pupils be encouraged to suggest possible reasons for failures. This may be done better after the summary has been completed.
4. Help the pupils to see the connection between the changes produced in their plant or animal with the things they gave to it or did for it. Use one of the failures as an example of what happens

when basic needs are not obtained by a living thing. (Point out the specific needs which were not supplied in each case.)

DEMONSTRATION

5. Set up, as a demonstration for the next lesson, a growing plant (geranium, coleus, begonia). Explain to the pupils why this experiment is being set up.



LABORATORY WORKSHEET — BIOLOGY: LESSON 7

(May be duplicated and distributed to pupils)

Purpose: To show that plants carry on life activities

Materials

Stalk of celery
Beaker
Ink in test tube
Small tray

Procedure

1. Cut ½" from bottom of celery.
2. Half fill beaker with water.
3. Add the ink.
4. Put the stalk of celery into the beaker so that it stands upright.
5. Place on the tray and store in sunlight for the next lesson.

SUMMARY CHART			
ANIMAL OR PLANT	WHAT WAS DONE FOR IT OR GIVEN TO IT?	WHAT CHANGES TOOK PLACE?	POSSIBLE LIFE ACTIVITY

Suggested Homework

Complete the summary sheet and bring it to class for the next lesson.

8. HOW CAN WE STUDY SOME LIFE ACTIVITIES IN PLANTS?

Outcomes

- Plants carry on the life activities of breathing and circulation.
- These life activities in plants are similar to the same activities in animals. The products, parts, and methods of carrying out the activities are different.
- All living things, regardless of size or whether plant or animal, carry on life activities.
- We can learn about life processes by experimenting with living things.

Teacher Activities

1. Call attention to the plastic-covered plant (set up in Lesson 7) on the laboratory desk. Pupils come up in groups to observe it, and to make notations on Lesson 7 worksheet.
2. Pupils take celery experiments set up in Lesson 7 to their desks.
   a. Have pupils observe the celery and record their observations on the worksheet. Movement of liquid through the stem is called circulation. Introduce the term and write it on the board.

b. As an analogy to veins have pupils cut out a vascular tube. (These can be located by the red or blue coloring.)

Student Activities (Pupils participate at demonstration table)

Testing exhaled air with limewater

1. Fill large test tubes with limewater.
2. Have several students blow air out slowly through the drinking straw into limewater. Do NOT EXHALE THROUGH YOUR NOSE.
3. Repeat for one minute.
4. Elicit answers to the following questions:
   a. What change do you notice in the test tube?
   b. Why do you get this change?

Testing for moisture (water)

1. Several pupils hold a plate glass about ½ inch below their noses.
2. Tell the pupils to breathe on the plate glass and observe.
   a. What do you notice?

Teacher Activities *(continued)*

3. Summarize the pupils' answers to the questions on the worksheet. From these answers guide the pupils to the following conclusions:
   a. Plants carry on circulation and breathing. These life activities are in addition to growth, reproduction, ingestion, response to stimuli and movement.
   b. Plants give off oxygen and water when they breathe; animals give off carbon dioxide and water.
   c. Liquids circulate through plants through tubes which are similar to our blood vessels.
   d. Even though the products are different, the basic needs of plants and animals are the same.
   e. The size of a plant or animal does not determine its activities.

Suggested Homework

1. Complete and correct the answers on your worksheet.
2. Start a scrapbook of newspaper articles on air pollution and water pollution. This will be due for Lesson 29.

CELLS

Suggested Lessons and Procedures

9. HOW HAVE SCIENTISTS HELPED US TO IDENTIFY THE CELL IN LIVING THINGS?

Outcomes

- We become familiar with the methods of scientists by studying the lives and works of scientists.
- We use the discoveries of scientists from different countries to develop broad concepts in science.
- All living things are made up of one or more cells.

Teacher Activities

1. Selected pupils make their reports on Hooke, Brown, Schleiden and Schwann. Put summaries of these reports on the board for pupils to put on their worksheets. Allow time for questions and comments.
2. Distribute worksheet and materials listed thereon to pupils. Have pupils follow directions on worksheet.

LABORATORY WORKSHEET — BIOLOGY: LESSON 9

(May be duplicated and distributed to pupils)

Purpose: To learn about cells

Materials: Hand lens Piece of cork

Procedure

1. Reports (short summary)
   a. Robert Hooke b. Robert Brown c. Schleiden and Schwann

2. Cork

a. Look at the piece of cork without the hand lens. Draw what you see. Now look at the same piece of cork with the hand lens. Again draw what you see.

WITHOUT THE HAND LENS | WITH THE HAND LENS

b. Draw what you see on the screen. (Teacher shows slide on screen)

CORK SLIDE | SLIDE MADE FROM CHEEK CELL

Questions

1. Where do we get cork? ________________________________
____
2. What did the spaces in cork suggest? ____________________
____
3. How is it possible to see cells? _________________________
____
4. What conclusion can you draw from the lesson? ____________
____

Teacher Activities *(continued)*

3. Project cork slide, prepared earlier, on the bioscope (see 2b on worksheet). Allow time for pupils to draw what they see. Ask the pupils to compare this with what they saw with the hand lens. Refer to the report on Hooke. Elicit that this is similar to what Hooke saw. (If a bioscope is not available, set up a microscope on the laboratory desk and have the pupils walk up to see the cork slide.)
4. Flash on the screen a previously prepared slide of cheek epithelium under high power for the class to see. Pupils will immediately see how these cells differ from the cork cells. Allow time for drawing. Call pupil attention to size, shape, material inside, etc.
5. Summarize by first eliciting that a plant and animal cell were studied. Lead the pupils to the conclusion that all living things are composed of cells.

NOTE:

Prepare a microorganism culture for use in Lesson 12.

Place some leaves obtained from a pond into a battery jar. Cover with pond water.

Allow the jar to stand several days in a warm place.

Suggested Homework

Why did Hooke name the spaces which he saw "cells"?
What difference did you notice between the cork cell and the other cell?
State as simply as you can what is meant by "cell theory."

10. WHAT DO THE PARTS OF A CELL DO?

Outcomes

- Each cell has specific parts which make up the whole.
- The nucleus is the most important part of a cell.
- Each part of a cell has a specific function to perform.
- There are certain structures which are found in plant cells which are not found in animal cells.

Teacher Activities

1. Identify the paramecium and other microorganisms studied in previous lessons as *one-celled organisms*. Introduce the term and write it on the chalkboard. Elicit suggestions from the pupils as to how these organisms carried on life activities. Tell the pupils they will find out how this is done in this lesson.
2. Distribute to each pupil a worksheet containing a diagram of an animal cell and of a plant cell in parallel position with enough space between them to write the labels.

LABORATORY WORKSHEET — BIOLOGY: LESSON 10

(May be duplicated and distributed to pupils)

Purpose: To study different parts of the cell

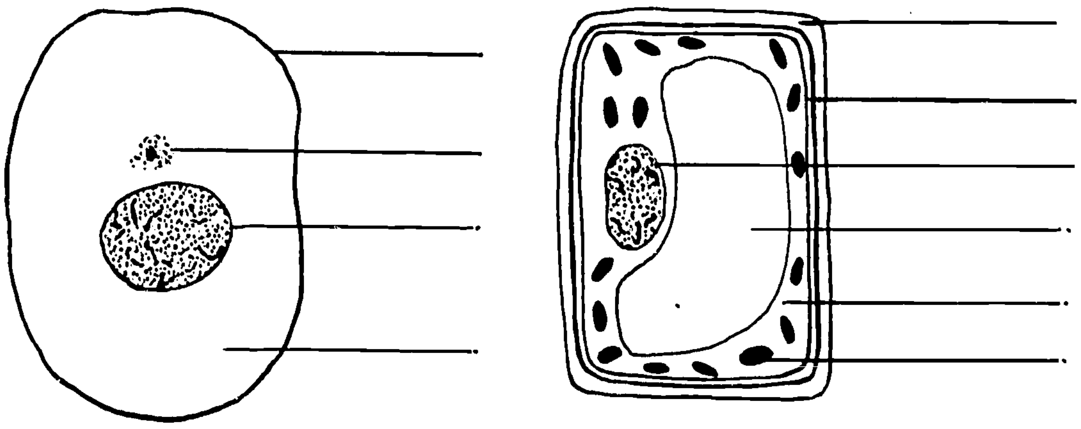
Questions

1. Which parts do we find in both animal and plant cells? ____________
____

2. What gives green plants their color? ______________________

3. How can you tell a plant cell from an animal cell? ______________________

STRUCTURE



Structure (Part)	Plant/Animal Cell?	Function

Teacher Activities *(continued)*

3. Use a laboratory model of the cell or a model prepared from gelatin (as described in the "Biology Handbook," page 15, Article 1.04). Point out the parts of the cell common to both plant and animals. List the name of each part on the board and then direct the pupils to label the same part on the worksheet. Now state the function of each part. Direct the pupils to fill in the appropriate columns. Elicit from the pupils the fact that certain parts have not been labeled on the diagram of the plant cell. After discussion, point out to the pupils that the remaining parts are not common to both plant and animal.

   As the lesson progresses, the following information should be on the board and on the pupils' charts.

   Cell Wall: gives plant cells a shape and keeps them stiff. It is made of thick material. (When you eat celery, you bite through the cell walls.)

   Cell Membrane: Allows digested food and oxygen to enter the cell and wastes to leave.

Nucleus: This acts as a director for activities and contains material which determines *heredity.*

Vacuole: Space containing a liquid or sap.

Cytoplasm: This is the material inside of the cell *except* the nucleus. The various activities and life processes take place here.

Chloroplasts: The small objects in the cytoplasm, containing the green coloring, chlorophyll. Green plants need this in order to make food.

Protoplasm: Consists of *all* of *the living* material inside of the cell membrane—cytoplasm and nucleus.

Summarize by asking the pupils about the differences between the plant and animal cells, by reviewing the labeled parts on the board, and by questioning the pupils about the functions of each part.

NOTE:

At this time the teacher is to put 4 or 5 chicken thigh bones into a jar of white vinegar or dilute hydrochloric acid. These will be used during Lesson 28.

Suggested Homework

1. Study the diagrams on your worksheet.
2. Learn the functions of each part of a cell.

11. WHAT IS THIS LIVING THING WE CALL PROTOPLASM?

Outcomes

- Protoplasm is the living, active part of a cell.
- Protoplasm appears to be semi-fluid and contains many dissolved chemical compounds.

Teacher Activities

1. Distribute the worksheet and materials listed thereon.
2. Instruct the pupils to adjust the microscope and place a clean slide on the stage between the edge and the opening of the diaphragm. Put a few drops of the amoeba culture on each slide. Tell the pupils to observe the drops carefully with the naked eye and draw what

they see. (With the dark color of the microscope in the background, the amoebas may be seen as white specks.)

3. Have the pupils put the slide in position for viewing through the microscope and clip it into place. Tell them to move the slide around until an amoeba is located in the drop. If possible, have pupils focus up and down to notice depth in the cell. Guide the observations of the pupils so that they will notice the following:
   a. Structure of the amoeba
   b. Grayish color and jelly-like consistency of the protoplasm
   c. Movement by pseudopods
   d. The football-shaped nucleus
   e. The granular cytoplasm
   f. The contractile vacuole (in action, if possible)
   g. Ingestion of food, if possible
   h. Transparency of cytoplasm

LABORATORY WORKSHEET — BIOLOGY: LESSON 11

(May be duplicated and distributed to pupils)

Purpose: To witness living protoplasm as it carries on some life activities

Materials (for each group)

Microscope
Slide
Cover slip } (If high power
Forceps } is to be used)

Procedure

1. Set up the microscope.
2. Put a clean slide on your microscope stage as your teacher tells you to do it. Wait until your teacher puts drops on your slide.
3. a. Do not move the slide. Look at the drops carefully. Draw what you see.

   b. What life activity do you see taking place?
4. a. Clip your slide into place and focus the microscope. Move the slide around slowly until you see an amoeba. Your teacher will show you how to do it and tell you what it looks like. Draw what you see.

   b. Now shift to the high-power objective. Be sure to follow your teacher's instructions. Again draw what you see.

c. What is happening to the shape of the amoeba?
d. What is the color of the inside of the amoeba?
e. How does the amoeba move?
f. What is the shape of the large particle in the middle of the amoeba? What is the name of this part?
g. What other structures did you find?
h. What life activities besides the two given did you notice? (taking in food, motion).

Teacher Activities *(continued)*

4. Allow time for pupils to answer the questions on their worksheet. (Pupils may have to make several observations in order to answer all of the questions.) Summarize the answers to these questions. Lead the pupils to conclude that:
   a. Protoplasm is the living material.
   b. Protoplasm is a jelly-like substance.
   c. Protoplasm contains a nucleus, vacuoles, and other particles.
   d. Protoplasm is transparent.
   e. Protoplasm contains materials needed for carrying on life activities.
   f. The entire cell is made of protoplasm.
5. Tell the pupils that protoplasm contains dissolved materials—protein, sugar, etc.
6. Summarize the lesson by having the pupils compare the amoeba to the plant and animal cell studied in the previous lesson.

Suggested Homework

1. Complete the worksheet.
2. Work on your scrapbook.

12. WHY ARE CELLS CALLED THE "BUILDING BLOCKS" OF LIVING THINGS?

Outcomes

- All living things are composed of cells.
- The cell is the smallest unit of living things.

- Cells have basic needs and carry on life activities.
- Some living organisms are composed of one cell only; others are composed of many cells.

Teacher Activities

1. Distribute worksheet and the materials indicated.
2. Tell the pupils to view the prepared slide with the microscope. (Review microscope procedure.)
3. Instruct the pupils to prepare a slide with Elodea according to their worksheet.

LABORATORY WORKSHEET — BIOLOGY: LESSON 12

(May be duplicated and distributed to pupils)

Purpose: To study the cell as the smallest unit of living material

Materials

Scalpel	Forceps
Microscope	Iodine
2 slides	Cover slips
Elodea	Prepared slide of *epithelial* tissue (animal)

Procedure

1. a. Take the prepared slide of epithelial tissue from your tray. Place it on the microscope and focus. Draw what you see.
   b. What does the whole picture look like?
   c. Was this slide made from an animal or a plant?
2. a. Take a clean slide from your tray and put it on the desk.
   b. Using your forceps, take one leaf from the Elodea plant. Place it on the slide. Put a drop of water on it.
   c. Place a cover slip over the leaf.
   d. Put the slide on the microscope and focus; draw what you see.

   e. Describe what you see. ______________________
   f. What do you see here that you did not see in #1? ______________________
   ____
   ____
3. a. Look at the drawing you made of the cheek slide in Lesson 9. Now look at one cell on the drawing you made of the Elodea. What dif-

ferences do you see? ______________________

____

____

b. Compare both of these drawings with the drawings you made of the paramecium and alga in Lesson 5.
   1) How are they alike?
   2) How are they different?
   3) How many cells do you notice in the paramecium and algae?
   4) What life activities do you think are carried on by each cell?

Teacher Activities *(continued)*

4. Have the pupils compare the general appearance of their drawings of the epithelial tissue with the Elodea. It is important for the pupils to see that on each slide the cell represents one unit of the whole. The structure may be compared to building blocks or stones.
5. Ask the pupils to compare their drawing of the epithelial cell studied in Lesson 9 with a single cell of the Elodea. Elicit basic differences between the plant and animal cell. (presence of chloroplasts and wall in plant cell)
6. Recall the study of the hay infusion. Mention the paramecia and one-celled algae if found in the infusion. Lead the pupils to see that cells may make up a complete organism or be the part of an organism.
7. Give the pupils examples of cells which can be seen without the microscope. (chicken eggs; bird eggs; ostrich eggs)
8. Summarize the lesson by asking the pupils to give some facts from this lesson to prove that the "cell theory" is true.

Suggested Homework

1. Complete your answers to the questions on the worksheet.
2. Compare a brick wall to the cells of a leaf.
   How are they alike?
   How are they different?
3. a. Which of the following basic needs does a one-celled living thing have? (Underline)
      1) food, 2) air, 3) water, 4) proper temperature, 5) light
   b. How do you know?

13. WHAT SHAPES AND SIZES DO CELLS HAVE?

Outcomes

- Cells vary greatly in size and shape.
- The shape and size of cells are related to the job they do.

Teacher Activities

1. Elicit pupil reaction to the question, "Are all the cells of living things the same in size and shape?"
2. Introduce to the pupils:
   a. Picture of an ostrich or dinosaur egg
   b. Opened hard-boiled egg (Circulate the yolk on a dish or in a small beaker.)
   Tell the pupils that this represents a cell. Point out the relative sizes of the cells.
3. Call the attention of the pupils to the worksheet and the spaces left for diagrams.
   Project onto the screen, using the microprojector or bioscope, the nerve cell, bone cell, blood cell, and a root hair. Allow pupils time to draw each.

NOTE: If slides are not available, use colored charts. Microscopes of prepared slides of muscle, guard, or epithelial cells may also be set up and pupils allowed to view them after finishing their drawings.

4. Guide the pupils into a discussion of the variations in sizes and shapes which they have seen. Relate the size and shape of the cell to the part of the organism from which it was taken and the general purpose of that part. Lead them to the understanding that there is a relationship of size and shape to function.
   The pupils should be able to come eventually to the conclusion that cells vary in size and are part of the structures which make up all living things.

CLASSROOM WORKSHEET

(May be duplicated and distributed to pupils)

1. Draw what you see as each slide is flashed on the screen. If one is larger

than the other, draw it that way.

a. Nerve Cell b. Blood Cell c. Root Hair d. Bone

2. What part of the organism does each of the cells come from? What is the job of each of the parts you named?

a. ______________ ______________

b. ______________ ______________

c. ______________ ______________

d. ______________ ______________

Suggested Homework

1. Complete the questions on your worksheet.
2. The plant does not have any bones. What makes it stiff and gives it its shape?

14. HOW IS THE SHAPE OF A CELL RELATED TO ITS FUNCTION?

Outcomes

- Different kinds of cells are specialized to do certain tasks (jobs).
- The shape of a cell is related to its carrying out a specific task.
- All of the cells in an animal or plant work together.

Teacher Activities

1. Display a wall chart and/or models of cells and call on individual pupils to identify each type of cell by referring to his or her worksheet for Lesson 13. As each cell is identified and its function discussed, have the pupils list it on the worksheet and record its functions.

   a. Epithelial—Covers the surface of the body, the inside surface of the digestive tract, the inside of the nose, throat, and windpipe. Protects the body and produces secretions.

   b. Nerve —Carries impulses which cause muscles to act and tells us about our surroundings.

c. Muscle —Produces movement.

d. Blood —{ Red blood cells carry O_2 to body cells, CO_2 to lungs. White blood cells destroy germs. }

e. Bone —Makes up the body framework and allows for movement.

f. Root Hair—Absorbs water and minerals from the soil.

g. Guard —Regulates the amount of O_2 and water leaving the leaf and the amount of CO_2 entering.

h. Egg —Forms another living thing.

NOTE: Use simple words and phrases in giving the above functions.

2. As a concrete experience, have the pupils prepare a model of a typical cell using gelatin as described in the New York State *Biology Handbook,* page 15, article 1.04. Divide the class into 4 groups and distribute the worksheet and materials to each. Green peas are to be distributed to two groups only.

NOTE: Prepare a container of colorless gelatin. Keep it warm in water bath. When preparing gelatin, use half the amount of water recommended. (Will not be necessary to store in refrigerator) Plant cells are to be displayed in a refrigerator box, animal cells in plastic bag.

LABORATORY WORKSHEET — BIOLOGY: LESSON 14

(May be duplicated for distribution to pupils)

Purpose: To study the functions of types of cells

Materials

Marble or button	Plastic bag
Green peas	Transparent plastic refrigerator box

Procedure

1. Teacher will pour gelatin into the plastic bag for your group.
2. Place plastic bag in transparent refrigerator box.
3. Whip gelatin to give it a frothy appearance as it begins to harden.
4. Put marble or button in center to represent the nucleus.
5. Add green peas to represent chloroplast.
6. Tie the bag and place the lid on the box.

Type of Cell	Function

Teacher Activities *(continued)*

Using transparent material enables the pupils to see the cell in three dimensions. The model with green pea represents the plant cell; others represent the animal cell.

3. To summarize the lesson, return to the cell chart displayed. Pointing to the various cells, call upon students to name them and to give the function of each.

Suggested Homework

Choose one type of cell you would like to make a model of, using any other method you know. Bring it to class for following lesson.

15. HOW DO CELLS WORK TOGETHER IN LIVING THINGS?

Outcomes

- A group of cells, similar in structure and function, which work together, is named a tissue.
- The tissues can be identified by the cells of which they are made.
- A tissue is named for the work it does or for its location.

Teacher Activities

1. Instruct the pupils to pick up their gelatin models of cells which were prepared in Lesson 14 and return to their desks. They may remove the model from the refrigerator box and observe it. At this point, clear up questions concerning cell structure.
2. With the aid of the bioscope and microscope demonstrations, show prepared slides of the following tissues:

   epithelial, bone, blood, nerve, muscle.

As each is projected on the screen have the pupils identify it. Explain the function of each. Call attention to the parts of the body where tissue differentiation is noticeable. (Examples—hand, head, face, lips) Have pupils enter each on their worksheet.

LABORATORY WORKSHEET — BIOLOGY: LESSON 15

(May be duplicated for distribution to pupils)

Purpose: To study tissues and their function

Procedure

As each tissue is identified and discussed, enter it on the chart below:

TISSUE	FUNCTION	WHERE FOUND

3. To dramatize the role of cells in relation to tissues, and to help pupils associate tissues with particular functions, have the pupils summarize the learnings by the following pupil activity:

   Tell the pupils to assemble (in their seats) in groups according to the models they made at home. Now have each group, one at a time, come to the front of the class. Explain to them that they are to act out the role of a tissue, each pupil being a cell. Examples might include the following:

   a. Have one pupil (cell) attempt to cover and protect another pupil. Then have the group of pupils (cells) do the same.

   b. Send one pupil out of the room and instruct him to pull on the door. Now have one pupil (cell) from the group attempt to open the door from the inside. Follow this up by telling all pupils in the group to hold hands and open the door.

   c. Set up a code and relay a message from the front of the room to the rear.

   Pupils should be permitted to use their ideas for dramatizations.

4

16. HOW DO TISSUES WORK TOGETHER TO FORM ORGANS?

Outcomes

- Many different tissues work together to form an organ.
- Each body organ performs a certain job.
- Organs are identified by names.

Teacher Activities

Motivate the lesson by asking the pupils to name parts of animals or plants that they eat. Make a list of these parts on the chalkboard. The pupils will probably give the name of the food instead of the part. Be prepared to associate the name of the food with the plant or animal part from which it comes or is part of. Examples:

Roots	*Stems*	*Leaves*	*Flowers*	*Seeds*	*Fruits*
Beets	Sugar cane	Cabbage	Broccoli	Beans	Oranges
Carrots	Celery	Lettuce	Cauliflower	Peas	Lemons
Turnips	Rhubarb	Collards	Artichoke	Rice	Apples
Rutabagas	Asparagus	Turnip greens			Tomatoes
Sweet potatoes	White potatoes	Spinach			Grapefruit
Peanuts					Mango
					Watermelon
					Plums
					Grapes
					Corn

Consult meat charts (beef, veal, pork, lamb) to find from which part of the animal the various cuts can be found.

4. Identify the parts described as organs of plants and animals which are composed of several types of tissues and which perform a specific function.
5. Demonstrate the coordinated functioning of the many different tissues in an organ by means of a dissected chicken leg. Remove the skin from the complete leg and separate the individual muscles and tendons to the toes by carefully cutting the connective tissue between them. Show that the contraction of individual muscles moves specific toes by means of tendon connections to the bones. Exhibit the nerve as a tough white cord which stimulates muscle contraction. Explain that the leg is a body organ which does a specific job. Movement occurs through the coordinated action of many tissues: muscle, connective, bone, nerve.
6. Use charts and models to point out organs of other organisms.

Summary

Elicit from the pupils that:

1. The leg is a body organ which does a specific job.
2. The job is done by the united action of the various tissues of which the organ is composed.
3. The food we eat comes from the organs of plants and animals.

Suggested Homework

1. Get a plant or animal part from a butcher or supermarket. Bring it to class to use tomorrow. Examples: heart, lungs, kidneys, liver.
2. Explain what this organ does.

TEACHER PREPARATION FOR FOLLOWING LESSONS

Prepare rexograph of body organs for the next 2 lessons.
Rexograph should contain diagrams of the parts of the digestive, respiratory, circulatory, nervous, and excretory systems IN RANDOM ORDER. (See Lesson 17 Worksheet.)

17. WHAT ARE THE ORGANS FOUND IN OUR BODIES?

Outcomes

- The organs in our bodies are composed of many different tissues.
- Each organ has a specific shape and function.
- There are many different types of organs found in our bodies.

Teacher Activities

NOTE: Have available a manikin of the human body and charts of body systems.

1. Distribute worksheets and diagrams of body organs.
2. Motivate the lesson by permitting the pupils who have brought in animal parts to exhibit them and tell the class about them.
3. Calling attention to the manikin, ask for pupil volunteers to come to the demonstration table and point to and name familiar organs, noting the position of each organ in relation to others in the body.
4. Write the names of the organs on the board as the pupils name them.

5. Through class discussion elicit from the pupils that:
   a. Organs are varied in shape and location.
   b. In order to do work, the organs use many different tissues such as connective, nerve, bone, muscle, epithelial.
   c. Different types of organs seem to fit together or are linked together in a pattern.

LABORATORY WORKSHEET — BIOLOGY: LESSON 17

(May be duplicated and distributed to pupils)

Purpose: To learn which organs are found in our bodies

Materials

Diagrams of body organs drawn to scale

Procedure

1. Look at the animal parts your classmates brought to class.
   a. Name the part b. What does it do?
2. Look at your diagrams of body organs. When the teacher writes the name of an organ on the chalkboard, find it on the diagram page and write the name under the organ.
3. Questions
   a. Make a list of 5 organs and tell what tissues you think are in each one.
   b. Which organs fit together?
      Number the organs in the order that they are put together.
   c. How do you know that several organs work together?

Suggested Homework

1. Complete your worksheet.
2. Learn the names of the organs listed on your worksheet.

NOTE: Bring your worksheet to class for the next lesson.

18. HOW DO ORGANS WORK TOGETHER?

Outcomes

- The systems are composed of separate organs which work together to perform a specific job.

- The names of the systems tell us what they do, such as *circulatory* system, *digestive* system, *respiratory* system.
- These systems operate without our conscious effort to make them do so.

Teacher Activities

NOTE: The following material should be ready for demonstration:

a. Overhead projector
b. Charts of the body systems
c. Manikin of the human body
d. Overlays consisting of diagrams of the body systems.

1. Prepare the materials listed on the worksheet and distribute them and the worksheets to each group of pupils.
2. Review the names of organs identified in the previous lesson. Call on selected pupils to give the names of the five organs they chose and give their function.
3. Instruct the pupils to construct five body systems from their worksheet for Lesson 17 according to the worksheet procedures in this lesson.

LABORATORY WORKSHEET — BIOLOGY: LESSON 18

(May be duplicated and distributed to pupils)

Purpose: To get to know the organs of the various systems

Materials

Scissors
Transparent tape or glue and a brush
5 sheets of paper for each pupil

Procedure

1. Take out worksheet and diagrams for Lesson 17.
2. Cut out each organ on the diagram page and put it on your desk.
3. Look at each chart hanging in front of the room, and notice what organs are on each chart.
4. Find the same organs (the ones that you have cut out) as those you see on the chart.
5. Put all of the organs you see on one chart into a separate group.
6. Arrange the organs the same way they are on each chart.
7. Paste each group of organs on a separate sheet of paper.

Questions

1. What do you call each group of organs?
2. What job does each group of organs do? What is the special name for each group?
3. How is it possible for all of th _.oups of organs to fit into the body?

Teacher Activities *(continued)*

4. Tell the pupils that each group of organs is called a *system*.
5. Use overhead projector and overlays to show how the organs and systems fit into the body cavity.
6. Summarize by calling on pupils to name a system, give the parts in that system, and give the basic function of the system.
   NOTE: Set up materials for Lesson 24.

Suggested Homework

Muscle is a type of cell. Explain how it can be a cell, a part of a tissue, a part of an organ, and a part of a system.

19. HOW DO THE BODY SYSTEMS CONTROL OUR ACTIVITIES?

Outcomes

- The proper functioning of our systems and organs is affected by our activities.
- Organs work together in systems. Systems work together in an organism.
- The human body works as a unit.

Teacher Activities

1. Motivate the lesson by asking pupils to describe in detail how they feel when they get angry, afraid, tired, or happy. Lead them to point out specific things such as their temperature (hot or cold); how fast they breathe; how the legs and arms feel; ease of movement; etc.
2. Describe the results of Dr. Walter B. Cannon's well-known experiments upon animals which led him to his theory of adrenal action. He found that in a quiet undisturbed animal, adrenalin is absent

from the blood. When, however, the animal is excited by pain, fear, or anger, adrenalin increases. As a result, the heart beats more strongly, breathing becomes deeper and more rapid, intestinal action ceases, the liver releases sugar more rapidly, the muscles respond more quickly to stimulation, the tonus of the blood vessels is raised, the coagulability of the blood increases, and so, the animal is prepared either to run or to fight.

3. Interpret the results of the Cannon experiments. Do *not* attempt to discuss adrenal action. Relate the changes to the emotions. Outline on the chalkboard the changes and the organs in which they took place. Elicit from the pupils (they may use their diagrams from Lesson 17) the systems to which each of the organs belong. Guide them to see that the systems work together to produce a single action of the organism.

4. Follow up the interpretation with the following activities:
   a. Group pupils in pairs. Instruct them how to take the pulse and respiration rates. Each pupil will then take his partner's pulse and breathing rate while sitting. Then, one pupil from each pair will jump up and down 25 times. His pulse and breathing rates are to be taken again and other observations made according to the worksheet. Repeat this procedure for the second pupil in each pair.

CLASSROOM WORKSHEET

(May be duplicated and distributed to pupils)

1. Take your partner's pulse and breathing rate. Your teacher will show you how. Record it here.

   Pulse ______________ Breathing ______________

   a. Observe his face carefully. Remember how it looks. ______________

   b. How does he feel? (rested, tired, sick) ______________

2. Your partner will now jump up and down 25 times. You do the counting.

3. After your partner has finished, make your observations again.

   a. Pulse ______________ b. Breathing rate ______________

   c. Face (sweaty, pale, flushed, red) ______________

   d. How does he feel? ______________

Summary

1. What changes did you notice?

   a. Pulse ______________ b. Breathing rate ______________

   c. Face ______________

   d. Feeling ______________

2. Why do you think these changes took place? ______________

____

____

Teacher Activities *(continued)*

5. Allow some time for the pupils to answer the questions on the worksheet. From their answers and experiences the teacher should be able to lead the pupils to conclusions such as:
   a. Our activities cause changes in the actions of systems.
   b. Body systems work together.
   c. One body action may involve the action of several systems.
   d. There is a limit to body activity.
   e. The action of one system may depend upon another system.

Suggested Homework

Complete the questions on your worksheet.

20. WHY AREN'T YOU A SINGLE GIANT CELL?

Outcomes

- One-celled animals are microscopic and carry on life activities; larger animals need organs and systems of many cells to carry on life activities.
- The cell membrane could not support a giant cell; there are not enough "entrances" for food and air in a giant cell. The middle of such a cell would starve.
- Since there is a limit to cell size, we have many cells, tissues, organs, and systems.
- Body systems are long, twisted or branched, and wrinkled like an accordion so that there are enough entrances for food and air.

Teacher Activities

1. Refer pupils to their notes and diagrams from Lesson 12. Remind them that there are cells of different size. It should be pointed out that the largest cells are egg cells because they store food.
2. Introduce the topic by having pupils consider such facts as:
   a. all one-celled animals are microscopic; these animals can perform all life activities.
   b. Larger animals are made of many cells; tissues, organs, and systems are needed to perform life activities.
   c. There are no large animals or people made of a single giant cell.
3. Ask pupils what would happen if a cell kept getting larger. The following demonstration should show that oversize cells confined by thin cell membranes would burst like punctured balloons because of pressure.

TEACHER DEMONSTRATION

Tell class you are going to make a "blob" or giant cell. Fill a balloon with water. Hold the balloon over the sink and keep adding water until the balloon bursts. Pupils should be able to conclude that a cell membrane would not support a giant cell.

4. Divide class into two groups. Distribute worksheets and materials.

LABORATORY WORKSHEET — BIOLOGY: LESSON 20

(May be duplicated and distributed to pupils)

Purpose: To learn why the surfaces of organs are wrinkled

NOTE: As organs get larger, their volume (content) is much greater than their area (surface).

Materials

Pieces of lung, brain, stomach	Hand lens
Aluminum "brain"	Beaker of water

Procedure

1. Use your hand lens to look at the piece of stomach.
   Draw what you see.
2. Use your hand lens to look at the piece of brain. Draw what you see.
3. Use your hand lens to look at the piece of lung. Draw what you see.

4. Put the piece of lung into the beaker of water. What do you notice?

____

5. Look at the piece of stomach and your drawing of it. What would happen to the size of the stomach if it were stretched out until it was very smooth and flat? ______________________________

6. Look at the aluminum "brain." Describe it. (wrinkled, smooth, lumpy, round, square) ______________________________.

7. Smooth or stretch the "brain." What happened to the size of the brain?

____

8. How would you know that there are a lot of places in the lungs for air?

____

Teacher Activities *(continued)*

5. Have pupils observe that:
   a. The stomach and brains are not smooth but wrinkled; the lung has a lot of air spaces in it.
   b. If these organs were stretched out they would take up more room.

6. After pupils summarize their results, tell pupils that, as cells get larger, their contents are much bigger than their surface (or size). Hold up an orange and grapefruit to demonstrate this. Pupils should notice that while the grapefruit is twice as wide as the orange, it is more than twice as big.

7. Elicit or tell pupils that since there is a limit to cell size, we have many cells, tissues, organs, and systems of a single giant cell.

8. Show that systems like the digestive and respiratory have solved the problem of getting enough "entrances" for food and oxygen by being long, twisting, branching, and wrinkled. An accordion, vent pipe from a washing machine, camera, or 'slinky' may be shown to reinforce pupil observations on the folding and wrinkling of surfaces in different systems.

Suggested Homework

1. Why aren't there any giant cells, amoebas, or "blobs"?
2. Prepare a chart with two columns. (*This will be used in next les-*

son.) List the life activities in the first column. In the second column, next to each activity, write what organ system carries out that life activity.

3. If one whole system is removed from a person, the person dies. How do you explain this?

Life Activity	System
Reproduction	Reproductive
Response to stimulus	Nervous
	Endocrine
Ingestion	Digestive
Excretion	Excretory
Form	Skin
	Bone
Respiration	Respiratory
Circulation	Circulatory
Digestion	Digestive
Growth	All systems
Movement	Muscles

21. HOW DO SYSTEMS WORK TOGETHER?

Outcomes

- Systems of the body depend on each other.
- Systems of the body work at the same time.
- Alcohol and other substances like coffee, tobacco, and dope have an effect on the speed "rate" at which the systems work.

Teacher Activities

1. Ask pupils for answers to homework questions 2 and 3 of Lesson 20. Elicit that the systems are dependent upon each other.

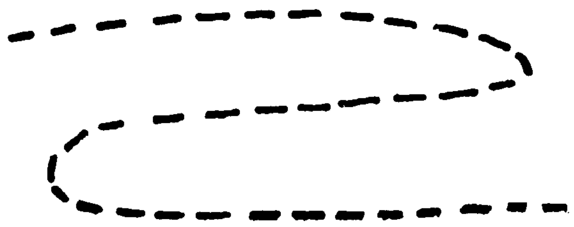
   NOTE: For demonstration living Daphnia (water flea) are needed. These are sold by aquarium or pet shops. If these have to be kept for any length of time, keep them refrigerated. Take them out a few hours before class meets.

2. Distribute worksheets, Daphnia diagram, and materials to students.
   a. Show pupils how to make a slide of Daphnia. This may be done by using a depression slide and cover slip; making a hanging

drop slide (*Adventures in Biology,* Activity 56, pages 71-72); or using small pieces of broom straw (or substitute) to make a square on a regular slide.

b. The movement of the Daphnia can be reduced by placing edge of paper towel near cover slip edge. Leave enough water to keep the Daphnia alive.

c. Illustrate for pupils that the pencil taps for heartbeat must be in a continuous zigzag line, as shown.



d. To show the effect of alcohol on the heartbeat, alcohol is added to the slide. The reduction in the rate of the beat depends on the concentration of alcohol used. A 45% concentration of alcohol reduces the heartbeat to less than 10. This concentration may prove to be too strong and may kill the Daphnia. A less concentrated solution may be used.

e. You may want the pupils to do the alcohol part of the experiment on a fresh preparation. If not, the drops of alcohol may be added at the edge of the slide. Show the pupils how to do this.

3. Have pupils summarize their observations. They should have observed the digestive, circulatory, and reproductive system; the simultaneous activity of these systems; the action of alcohol on one of these systems.

LABORATORY WORKSHEET — BIOLOGY: LESSON 21

(May be duplicated and distributed to pupils)

Purpose: To study how systems work together

Materials

Microscope
Slide
Cover slip
Bottle of alcohol
Medicine dropper
Paper towel
Daphnia

Procedure

1. Make a microscope slide of Daphnia. Your teacher will show you how.
2. Place the slide under the low power of the microscope. Use the diagram of the Daphnia to identify the parts of the Daphnia.
3. Watch the head. Do you notice it moving? ____________
4. Look at the intestines. What do you notice? ____________
5. What do you think is happening in the intestines? ____________
6. Locate the egg sacs. About how many eggs are there? ____________
7. Try to get a rough idea of the heartbeat. You can do it by tapping with a pencil point on paper in rhythm with the heartbeat. Your teacher will show you how. At the end of a minute count the number of dots. This is almost equal to the number of times the Daphnia's heart beats in a minute. Write your answer here. ____________
8. Now add a drop of alcohol to the slide. Your teacher will show you how.
9. Count the heartbeat again. Write your answer here. ____________
10. What difference do you notice? ____________
11. Name some systems you have observed.
    a. ____________
    b. ____________
    c. ____________
12. Do they all work together or at different times? ____________
13. Give an explanation for your answer to 12.

Suggested Homework

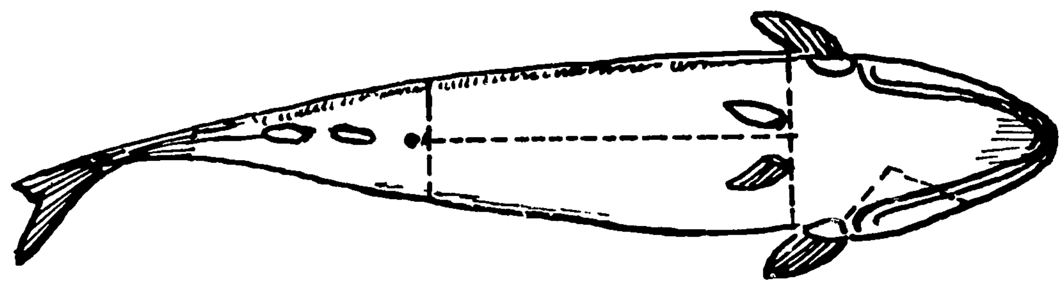
1. Why do all the systems work at the same time?
2. How do you know that they do work at the same time?
3. What effect does alcohol have on the heart?
4. How do you think doctors test the effect of tobacco, coffee, and dope on the heart?
5. Why is the *overuse* of these substances considered to be "bad" for the heart?
6. Get your notebook ready for Lesson 22.

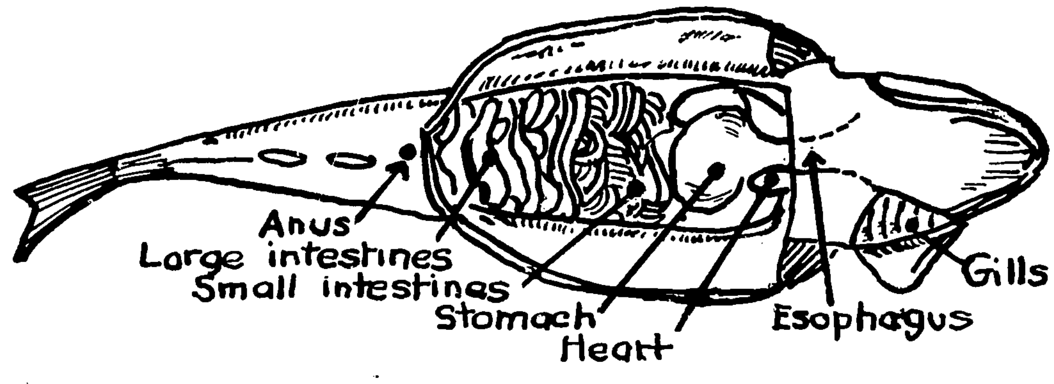
22. WHAT DO ORGANS AND SYSTEMS IN A FISH LOOK LIKE?

Outcomes

- The organs and systems when actually seen, are not always exactly as pictured on a chart.
- There are special techniques which have to be used in the dissection of an organism.
- We learn best through our own experiences and observations.
- Organs and systems in a fish are similar to those in man.

  NOTE: The teacher may wish to order frog specimens. It is suggested, however, that city children are more familiar with fish and that the organ systems are larger and more readily seen.





Teacher Activities

1. Review briefly organs and systems and their relationship to each other. Stress the respiratory, circulatory, and digestive systems since

these will be the systems more clearly seen in the lesson. If available, use a chart of the perch (item 12-2978, 1965-66 S-1 List) to point out the location of organs in the fish.

2. Read the instructions on the worksheet to the pupils while they follow silently. Follow this with a demonstration of a dissection, step by step. Answer any questions concerning procedure. Stress safety in the handling of the instruments.

3. Instruct the pupils to dissect the fish according to the worksheet instructions. (The organs which are easily seen include the esophagus, stomach, small intestines, large intestines, rectum, and liver. The heart may be seen by lifting organs which cover it. Modify the diagram, depending on the fish used and parts to be shown.)

LABORATORY WORKSHEET — BIOLOGY: LESSON 22

(May be duplicated and distributed to pupils)

Purpose: To study the external and internal structures of a fish and to observe its division into organs and systems

Materials

Fish—mackerel, porgy, whiting, perch, etc.	Scalpel
Dissecting tray	Scissors
2 picks (probe)	Hand lens

Procedure

1. Look at the fish carefully.
   a. What kind of outside covering does the fish have?
   b. How does it feel?
   c. What does it have instead of legs and arms?
   d. What does it have instead of a nose?
   e. What other parts do you see?
2. a. Turn the fish on its back.
   b. Find the gills. Cut away the gill cover on one side as your teacher did. Observe it.
   c. Using the scalpel, make two cuts across the fish as your teacher did. Using scissors, cut the fish down the middle of its "stomach" between the other two cuts.
   d. Fold back the skin and muscles so that you can see the parts inside. Observe the parts.
      1) What parts do you see?
      2) Take the probe and lift all of the parts you see. What other parts do you see?

3) How are these parts different from the parts on the chart or diagram?
4) On the chart, list the names of the systems seen, the organs which make up the system, and the function of each system.

SYSTEMS	ORGANS	FUNCTION

5) List several differences between the fish's systems and man's systems.

Teacher Activities *(continued)*

4. Call on pupils to give their answers to the questions and make a summary of the answers on the chalkboard.

Suggested Homework

Review for a unit test.

NOTE: Set up materials for starch grains (Lesson 24).

23. WHAT USEFUL CHEMICAL SUBSTANCES DO FOODS CONTAIN?

Outcomes

- People and animals differ in the food that they eat.
- All foods contain useful substances called nutrients.
- The nutrients required by all living things are: carbohydrates, fats, proteins, vitamins, minerals, and water.

Teacher Activities

1. Recall that food is a basic need of living things. Have pupils discuss the foods eaten by their household pets and by familiar zoo animals.
2. Ask several pupils of varying national origin to write on the chalk-

board what they had for dinner the night before. Call attention to the different food habits of the pupils.

3. From this discussion should come the realization that:
   a. The diets of all living things are basically similar.
   b. Living things utilize a wide variety of foods.
4. Tell pupils that although animals eat a variety of foods, the different foods are similar chemically since they contain a few basic substances known as nutrients. Write the names of the nutrients on the chalkboard.
5. Distribute worksheets. Divide the laboratory groups into sections and distribute the materials listed on the worksheet.

LABORATORY WORKSHEET — BIOLOGY: LESSON 23

(May be duplicated and distributed to pupils)

Purpose: To find out what nutrients are in milk

SECTION I

Materials

Test tube of milk
Stopper for test tube
Beaker
Piece of paper
Piece of cloth (cheese or gauze)
Rubber band
or
Small fishnet or strainer

Directions

1. Look at the test tube.
2. Draw what you see.
3. Put the stopper on the test tube.
4. Hold the test tube in one hand. Put your thumb on the stopper.
5. Shake the tube up and down for a few minutes. *Do not shake too hard.*
6. Write or draw what happened to the milk.
7. Take the stopper off the

SECTION II

Materials

Beaker of skimmed milk
Bottle of vinegar
Plastic spoon or stirring rod
Funnel
Filter paper
Flask
Piece of paper

Directions

1. Look at the beaker.
2. Draw what you see.
3. Add a few drops of vinegar to the skimmed milk. Stir the milk with your spoon. Keep adding the vinegar and stirring until no more lumps appear in the milk.
4. Draw what the milk looks like now.
5. Remove the biggest lumps with the spoon. Put them on the piece of paper.
6. Your teacher will show you how

tube. Put the piece of gauze (or cheesecloth) on top of the tube. Tie the cloth on with the rubber band.

8. Hold the test tube over the beaker. Pour the contents of the tube into the beaker.
9. After all the liquid has poured out of the test tube, take the cloth off the test tube. Spread the cloth on the piece of paper.
10. Look at the liquid in the beaker. Look at what is on the cloth.
11. Feel the substance on the cloth.

Questions

1. What do you think happened to the milk in your test tube?
2. What happened to the milk when you shook it up?
3. What do you think the solid on the cloth is?
4. How does this solid feel? (rubbery, silky, greasy, spongy)
5. What do you think this solid might be used for?

to fold the filter paper.

7. Put the filter paper cone in the funnel.
8. Hold the funnel over the flask and slowly pour the remains of the milk into the funnel.
9. After all the milk has gone through the funnel, take the filter paper cone out of the funnel. Add the lumps found on the filter paper to the substance you already took out.
10. Look at the liquid in the flask. Look at the solid on the paper.
11. Feel the solid with your hand.

Questions

1. How is skimmed or nonfat milk different from regular milk?
2. What happened to the milk when you added vinegar?
3. What did the lumps from the milk feel like? (rubber, fat, sponge, wood, silk, grease)
4. What do you think this solid might be used for?
5. Name some things you eat that are like this solid?
6. How did the milk look after you filtered it?
7. What do you think is in milk?

Teacher Activities *(continued)*

6. Instruct Section I and Section II to exchange the final products for examination (butter, buttermilk, casein, and skimmed milk filtrate).
7. Tell pupils that the lumps (solid) produced by Section I's experiment are a kind of protein. Elicit from Section I that milk contains grease (fat). Summarize by asking, "What things did we find in milk?"
8. Elicit that vitamin D is present in milk by directing the class's attention to the milk container. The words fat (grease), protein, and vitamin are then listed on the board.

9. Display the lactose and albumin and tell pupils that if they had continued boiling the milk, they would have obtained these also. Have a pupil taste the sugar to determine its nature. The word *sugar* is added to the list on the board.
10. Ask pupils whether they would eat pure fat by itself or pure sugar by itself. Then ask for names of other foods that contain sugar, fat, or vitamins (protein foods are not as well known).
11. Elicit from pupils the fact that although they do not all eat the same foods, the different foods contain some of the same substances—for example, sugar and fat. At this point, tell the pupils that these substances are called nutrients and draw their attention to the four nutrients on the board.
12. Use pupil answers as a basis for summary. Elicit the conclusions:
    a. Some foods are rich in one nutrient;
    b. All foods contain water;
    c. Most foods have more than one nutrient.

Suggested Homework

1. Write down all the foods you eat for the next three days. Be sure to include all foods eaten between meals.

LOG OF MEALS				
Day	Breakfast	Lunch	Dinner	Other Times
#1				
#2				
#3				

Questions

1. What kind of food did you eat most?
2. What nutrients do these foods contain in great quantity?
3. What kind of food did you eat only a few times?
4. What nutrients do these foods contain in great quantity?
5. Do you feel that you are eating foods that will keep you in good health? Why?

24. HOW CAN WE FIND OUT WHAT NUTRIENTS ARE IN THE FOODS WE EAT?

Outcomes

- Some chemicals change color when they are added to a particular nutrient.
- These chemicals can be used to tell whether a special nutrient is present in a food.
- When a chemical changes color with only one nutrient, it can be used in a food test.
- Iodine changes to a black color when it is added to a food that has starch.

Teacher Activities

1. Briefly review the nutrients present in food.
2. Distribute to each group the worksheet and materials listed thereon. Ask pupils, "How can we find what nutrients are in these foods?"
   Pupils may suggest separating the nutrients as they did with milk. Some may suggest using the food charts.
3. Tell pupils that they will do an experiment which will help them find an answer to the question. Tell them further that the Lugol's solution is a chemical containing iodine.

LABORATORY WORKSHEET — BIOLOGY: LESSON 24
(May be duplicated and distributed to pupils)

Purpose: To find out what nutrients are in the food we eat

Materials

Rice
Brown sugar or raisins
Water
Salt
Lard
Chicken or other meat
Citrus fruit
Starched cloth
Dropper bottle of Lugol's solution
Test tube rack with 7 labelled test tubes, each 1/3 full of a different nutrient

Procedure

1. Add a few drops of Lugol's solution to each sample of food and observe the results. Record the observation below.

2. Add a few drops of Lugol's solution to each test tube and observe the results. Record the observation on the chart.

FOOD	CHANGES OBSERVED
RICE	
BROWN SUGAR OR RAISIN	
LARD	
CHICKEN OR OTHER MEAT	
CITRUS FRUIT	
STARCHED CLOTH	
SALT	
WATER	

NUTRIENT	CHANGE	NUTRIENT	CHANGE
STARCH SUSPENSION		2% TABLE SALT	
2% GLUCOSE SOLUTION		WATER	
CORN OR OLIVE OIL		ASCORBIC ACID	
2% PEPTONE OR BEEF BROTH		TABLET IN WATER	

Teacher Activities *(continued)*

4. Call upon the pupils to observe that the color changes to blue-black only where starch is present.
5. Conduct a discussion of the implication of the laboratory experiment. The pupils should understand that the color reaction forms the basis for the chemical test for starch and that:
   a. The test is specific for only the one nutrient.
   b. The tests made with the other nutrients were for comparison purposes and are called controls.
6. In summary, have the pupils point out that a food test involves a color change that is specific for each nutrient.

Suggested Homework

1. How would you test foods for starch?
2. What foods do you think contain much starch?

25. HOW CAN WE TEST FOR NUTRIENTS FOUND IN FOODS?

Outcomes

- There is a chemical test for every nutrient.
- Biuret solution makes proteins turn a purple or violet color.
- When Benedict's solution is added to a simple sugar and heated, the mixture will change color from blue to green to yellow to orange and finally to brick red.
- The blue chemical indophenol becomes clear when Vitamin C is added to it.
- If a sample of food is burned as completely as possible, the ash remaining is the minerals in the food. This test shows only that there are minerals in the food but does not show what the minerals are.
- When fat is rubbed on brown paper, a spot appears on the paper. Light can pass through this spot (translucent). Heating does not remove the spot.
- Heating a food causes the water in the food to evaporate. As the water vapor cools, small drops of water collect on the sides of the container or a glass plate held over the food.

Teacher Activities

1. Divide the laboratory groups into two sections. Then distribute the materials listed on the pupil lab sheets.
   NOTE: Test tubes of sugar, starch, and protein should be prepared.
2. Read the directions aloud as pupils read silently. Safety measures on the use of Sterno should be stressed. When pupils are finished using the Sterno, the teacher should show students how to extinguish it with the cover.
   CAUTION: Do not put cover on tightly until the can is cool.
3. The teacher should demonstrate the method of heating a test tube. Group I should be cautioned to heat their tubes gently and to point the tube away from the members of the group. Those in group II should be directed to hold the tube of celery almost horizontal. This is to prevent cracking of the tube by condensed water dripping back to the heated end.
4. Pupils perform the experiment and enter observations on their laboratory sheets.

LABORATORY WORKSHEET — BIOLOGY: LESSON 25

(May be duplicated and distributed to pupils)

Purpose: To study the tests for the other nutrients

Materials

GROUP I	GROUP II
3 empty test tubes	Test tube of starch
Test tube of sugar (¼ full)	Test tube with rice
Test tube of molasses (¼ full)	2 test tubes of egg white
Test tube with lard (¼ full)	Test tube of protein
Test tube rack	Test tube of lemon juice
Test tube holder	Test tube of water
Can of Sterno	Test tube with celery
Piece of asbestos	Test tube rack
Piece of brown paper	Test tube holder
Piece of lard and celery	Can of Sterno
Bottle of each:	Piece of asbestos
Benedict's sol.	Tongs
Indophenol	Peanut
Vitamin C	Bottle of Lugol's solution
Lemon juice	Biuret A
Corn oil	Biuret B

NOTE: Clinitest tablets or Clinistix may be used instead of Benedict's solution for sugar tests. The advantage of these is that there is no need of heat. The tablets and cardboard may be obtained from Ames Co., Inc., Elkhart, Ind.

Directions

You will be doing the food tests for fat, vitamin C, and sugar.

1. Write the words—*corn oil, lard, and celery* on the piece of brown paper. Next to the words *corn oil* put 2 drops of corn oil. Rub the lard next to the word *lard.* Rub the celery next to the word *celery.* Put the paper aside for a while.
2. Put an inch of indophenol into the three empty test tubes. Add 10 drops of vitamin C to one tube. Add lemon juice to the sec-

Directions

You will be doing the food tests for starch, protein, minerals, and water.

1. Put a few drops of Lugol's solution into the test tubes of starch and rice. Do the same thing with *one* of the tubes of egg white.
2. Write what happened.
   starch: ____________
   rice: ____________
   egg white: ____________
3. Put about 10 drops of Biuret A and 10 drops of Biuret B into

ond. Pour ½ of the molasses into the third tube.

3. Write what happened.
   vitamin C: ______
   lemon juice: ______
   molasses: ______
4. Put Benedict's solution into the test tubes of sugar, molasses, and lard until they are ½ filled.
5. Put the can of Sterno on the piece of asbestos. Take off the top of the can. Your teacher will give you a match to light the Sterno.
6. Pick up the test tube of sugar. Your teacher will tell you how to heat it. Heat it until it no longer changes color. Put the tube back in the rack. *Do not touch it with your fingers.*
7. Do the same thing for the tubes of molasses and lard.
8. Write what happened.
   sugar: ______
   molasses: ______
   lard: ______
9. Your teacher will show you how to put out the flame on the Sterno.
10. Examine the piece of brown paper. Tell what you see.
    corn oil: ______
    lard: ______
    celery: ______
11. Hold the paper up to the light. Write what you notice.
    ______
    ______

the other test tube of egg white. Do the same thing with the tubes of protein and lemon juice.

4. Write what happened.
   protein: ______
   egg white: ______
   lemon juice: ______
5. Put the can of Sterno on the piece of asbestos. Take off the top of the can. Your teacher will give you a match to light the Sterno.
6. Pick up the peanut with the tongs. Hold the tongs so that the peanut is in the fire. Do this for about 3 minutes. Put the peanut and tongs on the asbestos.
7. When the peanut is cool, examine it. What does it look like?
   ______
   ______
8. Pick up the test tube with the celery. Your teacher will tell you how to heat it. Heat the celery for about 3 minutes.
9. Your teacher will show you how to put out the flame on the Sterno.
10. Tell what happened to the celery.
    ______
    ______
11. Examine the test tube. Tell what you see.
    ______
    ______

Teacher Activities *(continued)*

5. Have groups summarize their findings. Elicit from the groups the particular food tests as stated in the expected outcomes. Have pupils notice that their tests included the pure nutrient, a food with the nutrient, and a food without the nutrient. Elicit from

pupils of group II that all foods have water and some minerals. This is the reason that no negative test is done for water and mineral. Emphasize that the negative tests for the other minerals are for comparison purposes. Elicit that these tests are controls. Have pupils copy these conclusions in their notebooks.

6. Collect, beforehand, food samples from the students for their next class. If pupils have not already brought these, they should be reminded at the end of this lesson. To prevent an excess of foods, each group should be responsible for specific items.

Suggested Homework

1. Use your food charts to find out what nutrients are in the foods you tested today. Put your answer on the chart. Under each food put a check (√) next to the nutrient it contains.

NUTRIENTS FOUND IN FOODS TESTED							
NUTRIENT	MOLASSES	LARD	LEMON JUICE	RICE	EGG WHITE	CELERY	PEANUT
Starch							
Sugar							
Fat							
Protein							
Vitamin C							
Minerals							

2. If you were going to do all the food tests on an apple, write how you would do it. Tell which test you would do first; which test second; which test third; which fourth; which fifth; which sixth; and which last.

26. CAN YOU LIVE ON BREAD ALONE?

This lesson is designed to give pupils experience in organizing an experiment and doing a complete set of food tests on a single food.

Outcomes

- If a living thing is supplied with all seven nutrients, it should be healthy.
- By testing food, you can find out what nutrients the food contains.
- A food sample may be used for all the food tests if the sample is divided into pieces.
- The tests for fat, water, and minerals may be done on a single piece of food. The tests for starch, sugar, and protein must be done separately on different pieces of food.
- Using food tests, you can show that all of the nutrients are not present in a single food.

Teacher Activities

1. A few minutes should be allowed at the beginning of the period for pupils to enter information about meals on their log sheet.
2. Ask the students,
   "Why does a baby drink so much milk?"
   "What other foods does a newborn baby eat?"
   "Why are these other foods given to the baby?"

   Elicit the facts that milk is easy for the baby to digest and that it contains most of the nutrients. However, the baby also gets orange juice and vitamins. Guide the students to the conclusion that all of the nutrients are needed by a living thing.
3. Ask, "Does bread have all the nutrients to keep us healthy?"
   "How would you find out?"

   Pupils should realize that they can use the food tests to find an answer to these questions.
4. The pupils are given the materials listed on the laboratory sheets and asked how they are going to set up their experiment.
5. Pupils perform the experiment and enter observations on their laboratory sheets.

LABORATORY WORKSHEET — BIOLOGY: LESSON 26

(May be duplicated and distributed to pupils)

Purpose: To find out what nutrients are in bread

Materials

Piece of bread
Piece of asbestos
Paper towel
Can of Sterno
Test tube rack
5 test tubes

Bottle of each:
- Lugol's solution
- Benedict's solution
- Indophenol
- Biuret A
- Biuret B

Directions

1. Test the piece of bread for the nutrients.
2. Do the food tests for starch, protein, vitamin C, and fat first.
3. When you have finished the tests mentioned, uncover the can of Sterno and place it on the asbestos. Light the Sterno and do the rest of the food tests.
4. Record your results on the chart. If you found the nutrient in the bread, put a plus sign (+) . If you did not find a nutrient in the bread, put a minus sign (—) in the space.

TABLE OF OBSERVATIONS

FOOD	STARCH	PROTEIN	VITAMIN C	FAT	SUGAR	WATER	MINERALS
Bread							

Teacher Activities *(continued)*

6. In summary, have pupils report their observations. They should conclude that since bread does not have all the nutrients, you could not live on bread alone.

   NOTE: Prepare for Lesson 28

   Prepare two sets of seven test tubes, each one-third full of the different nutrients: 2 percent glucose or dextrose solution; corn or olive oil; 2 percent peptone of beef broth suspension; 2 percent table salt; part of an ascorbic acid tablet dissolved in water; and a 2 percent solution of glucose or dextrose and peptone.

Suggested Homework

Finish the log sheet on meals which you received in Lesson 23. Bring it to the next class. Answer the questions at the bottom of the log sheet.

27. HOW DO LIVING THINGS OBTAIN ENERGY?

Outcomes

- Food gives us energy for life processes.
- Oxidation of foods (nutrients) releases water, carbon dioxide, and heat energy.
- Living things use food and oxygen and give off water, carbon dioxide, and heat.
- Sugar, starch, and fat are the chief sources of energy, but protein is also an energy source.

Teacher Activities

1. Introduce the topic of energy by asking, "Why do some athletes chew on chocolate bars before a game?" The pupils should understand that food supplies living things with energy. Recall that food is needed for the life processes and discuss the effects of deprivation of food, such as sluggish motion and decreased heart and breathing rate. From the discussion lead the pupils to the realization that energy is required for the performance of the life processes.

2. With tongs, hold a burning marshmallow aloft and ask the question: "How is energy obtained from food?" Develop the answer as follows:

   a. Demonstrate the presence of carbon in a marshmallow by the blackening effect of incomplete burning.

   b. Run the flame of the burning marshmallow over the chalkboard to show the formation of water.
   Recall from the chemistry unit the composition of water. Write the formula H_2O on the board. Elicit that water is being formed in this process.

   c. Invert a gas bottle over the burning marshmallow until the flame goes out, and test with limewater to show the evolution of carbon dioxide. Use a fresh unburned marshmallow and a second bottle as a control.
   Recall from chemistry the composition of CO_2. Write the formula on the board.

   d. Observe that energy in the form of light and heat are released in an *exothermic* reaction.

   e. Write the chemical equation for the reaction on the chalkboard and explain that since oxygen is consumed, oxidation of the food must have occurred to release the energy:

$$C_6H_{12}O_6 + {}^6O_2 \rightarrow \text{Energy} + {}^6CO_2 + {}^6H_2O$$

Pupils may recall oxidation from their study of chemistry.

3. Continuing this development, ask the question, "Does oxidation of food take place in living things to release the energy needed for the life processes?" Have the pupils recall and discuss such evidence as: living things require food and oxygen; some living things are warmer than their surroundings. Have pupils recall from the unit on living things that we give off carbon dioxide and water when we exhale.

4. Introduce the concept that nutrients are capable of being oxidized. Call two pupils to the laboratory desk. Have one pupil hold a test tube of water while the other, using tongs, holds a burning peanut under the test tube.

   Pupils should be able to observe evolution of heat and light energy. They can also use burned peanut to write on a piece of paper. Elicit that the burned peanut is carbon. Then burn a cube of sugar dipped in cigarette ash and a butter candle or wick dipped in dish of oil. Elicit that the items tested represent the nutrients sugar and fat.

5. Explain that sugar, starch, and fat are our chief sources of energy but that proteins are also sources of energy. Ask pupils how they could use their experiment to find out how much energy the food contains.

   The pupils should recall from the physics unit that heat energy was measured in calories by heating water. They should realize that food energy can be determined similarly. Tell the pupils that human energy requirements vary with age, weight, sex, activity, and occupation. Junior high school boys require about 30 Cal. per pound of body weight; girls, about 23 Cal.

Suggested Homework

1. Why do teenagers eat so many foods that are rich in sugar, starch, and fat?

2. A diet book has the following information:

a piece of chocolate cake	300 calories
a tomato	50 calories

an apple	100 calories
a slice of bacon	150 calories
a chicken leg	100 calories

Which food will give the most heat and energy?

3. Explain why the cake and bacon have the biggest number of calories.

NOTE: The energy in foods is measured in large calories, or kilocalories (Cal.), which are defined as the amount of heat required to raise the temperature of 1000 grams (1 kilogram) of water one degree centigrade.

28. HOW CAN WE FIND OUT WHY PROTEINS AND MINERALS ARE IMPORTANT FOR US?

Outcomes

- Food is used for growth and repair of the body.
- The best foods for growth, such as meat or fish, come from animals.
- Protein is the best nutrient for body growth.
- Minerals are important for body health and energy. Calcium, an example of a mineral, is important for strong bones and teeth.

Teacher Activities

1. Recall that foods are oxidized by living things to provide the energy required for life processes. Ask pupils to compare their weight and height now to their weight and height at birth. They may also remember that growing children, as well as persons recovering from illness or injury, may eat a great deal. This discussion should lead pupils to suggest the use of food in growth and repair of the body.
2. Ask pupils to name foods which they have been told are good for their health (or good for a person recovering from illness). Pupils will probably suggest vegetables and meats (liver and steak). Have pupils look these foods up on their food charts to note their high protein, mineral, and vitamin content.
3. Have pupils discuss the following question:
"How can we show that living things need protein to grow?"
Pupils will probably suggest growing organisms, using the different nutrients.

4. **Demonstration**
   Display both sets of nutrients previously prepared (see Lesson 26) and tell pupils that microscopic plants—bacteria—were added to one set and not to the other. Have pupils compare the appearance of the experiment and control. Elicit that the test tube of protein and sugar with bacteria appears different from the control test tube. Ask them, "What do you think caused the change?" Students should be able to attribute the change to the bacteria. Tell the students that the cloudiness indicates the growth of the bacteria. Elicit that the greatest growth occurred in the test tube of protein and the mixture of protein and sugar.

5. Tell pupils that because of time they will be able to study only one mineral—calcium. Tell them that this mineral is important for bones, teeth, and in other animals—egg shells. Have them discuss the question, "How can we show that calcium is important for hard parts of animals?" Pupils will probably suggest experiments with controls to show calcium deficiency.

6. Demonstrate with bones or an egg that was set up beforehand. Have pupils notice that the bones are rubbery and pliable without calcium and that egg is soft and has no shell when calcium is removed.

7. Have pupils summarize their observations of the importance of proteins in growth and calcium in bones and teeth. Lead pupils to the understanding that protein-rich foods come from parts of animals.

8. Assign selected pupils to report on the work with vitamins of Lind, Eijkmann, and Goldberger.
   (Distribute a table of minerals.)
   Note: Prepare Carbon Filter Column for Lesson 29.

Suggested Homework

1. Use the table to answer these questions:
   a. Which minerals were in the food you ate today?
   b. What two minerals build strong teeth?
   c. Which foods are good for your blood?
   d. The skin and nails contain a considerable quantity of a certain mineral. What mineral is it?
2. Bring your scrapbook on air and water pollution to the next class.

29. ARE YOU DRINKING "DIRTY" WATER?

Outcomes

- Our water supply is in danger of becoming polluted.
- Water pollution also reduces our supply of fish foods.
- Polluted water tastes and smells bad. It may even cause sickness.
- Because water is so important for life, polluted water must be made clean and safe from disease.
- Polluted water can be cleaned by filtering, adding chemicals, and mixing with cleaner water.

Teacher Activities

1. Introduce the topic of water pollution by leading pupils into a discussion of notebook articles on water pollution. Discussion should include the following ideas:
   a. Since water is a nutrient, polluted water is a danger to our health.
   b. Since polluted water causes the death of fish and plants, it is a danger to our food supply.
   c. Badly polluted water can cause sickness; e.g., irritation of the digestive system by this water may lead to poor nutrition and skin disorders.
   d. Polluted water has a bad smell and taste.
2. Elicit the need to "clean up" water. The even greater need for this during a water shortage may be mentioned.
3. NOTE: To show how water may be cleaned or made safe, prepare the following for a demonstration:
   a. Carbon Filter Column
      1) A small amount of glass wool should be used.
      2) The glass tubing — about 12″ long and 1″ in diameter.
      3) The charcoal may be obtained from a store that carries aquarium supplies.
      4) The carbon filter column should be washed by passing distilled water through the column; clamping the tube at the bottom; filling the column with water again; letting it stand, preferably for several hours; and draining before the test.
   b. Solutions:
      1) 500 ml of water and a small amount (about 0.05g) of a detergent that foams generously when shaken

2) 500 ml of water and 100 mg of phenol
3) 500 ml of water and 1/4 g of baking soda
4) 500 ml of water and 2 1/2 ml of laundry bleach (one that contains chlorine)

Using solutions 2, 3, and 4 setup:

5) 200 ml of 2
6) 200 ml of 2 and 2 ml each of 3 and 4. (This should be mixed and let stand for at least 10 minutes.)
7) 100 ml of 2 mixed with 1 ml of 3 and 6 ml of 4. (This should be mixed and let stand for at least 30 minutes.)

4. To demonstrate water purification by filtration:
Fill a test tube 1/2 full of the detergent solution. Hold your thumb over the mouth of the tube and shake it vigorously. Have class observe what happens. Pass 100 ml of the original detergent solution through the column. Collect in a test tube some of the solution coming through the column. Shake vigorously. Have pupils compare this tube to the original tube and note the difference between the amount of soapsuds.

5. To show treatment of water to eliminate odors, do the following:
   a. Have a few students cautiously smell the plain solution of phenol (3b-5) and describe the odor.
   b. Have them do the same with the solution of phenol to which bicarbonate and chlorine were added (6). You may tell them that phenol gets into the water through the discharge of industrial wastes. When chlorine is added to the water at water plants, the material they have just smelled is formed and causes a bad odor.
   c. To show how this odor may be treated, pour 100 ml of this solution (6) through the column and collect. Have pupils compare the smell of this material to some which was not filtered. Have pupils smell the solution of phenol and bicarbonate to which excess chlorine has been added (7). They can compare this odor to that of the filtered and unfiltered solutions above.

6. Have pupils summarize the ways to purify and deodorize water. The importance of water purification may also be reviewed.

7. Remind those pupils who were selected to report on vitamins that their report is due tomorrow.

Suggested Homework

1. Why may we "starve" because of polluted water?
2. When water is cleaned up, what is taken out of the water?
3. Try this experiment at home. Fill two glasses with water. Put one tablespoon of Epsom salts into one glass and mix it up. Now put a little bit of soap powder into each glass. Mix or shake the glasses until you get soapsuds. What do you notice?

30. WHAT FOODS WILL GIVE US ALL THE ESSENTIAL VITAMINS?

Outcomes

- Vitamins are necessary for life.
- Different vitamins perform different jobs in the body.
- Vitamins keep the body working properly. They also prevent deficiency disease.
- All the nutrients are included in the Basic Four (food groups).
- An adequate diet contains foods that supply: all nutrients, bulk and roughage, energy needs of the body.

Teacher Activities

1. Tell the story of the famous experiment of Dr. Frederick Hopkins, who in 1906 selected a large number of healthy rats, recorded their weights and then fed them five pure nutrients: sugar, starch, proteins, fats, minerals, and water. Within a short time, the rats stopped growing, slowly lost weight, and then died. Ask the pupils what this experiment showed. Elicit the following:
   a. The foods usually eaten by rats contained something that the five pure nutrients did not supply.
   b. The missing thing seems to be necessary for life.
   c. The missing nutrient is one or more vitamins. (Point out that *vita* means life.)
2. Call on the selected pupils to report on the stories of the vitamins:
   a. Why the British sailors are called "Limeys"
   b. How Dr. Lind first prevented scurvy
   c. The work of Dr. Goldberger with pellagra
   d. How Dr. Eijkmann used chickens to find the cure for beriberi

3. Using food and nutrient charts, have the pupils discover and discuss the major food sources and values to the body of vitamin A, thiamin (vitamin B), niacin, ascorbic acid, and vitamin D.
   A vitamin chart may be distributed instead of using food charts.

4. Stress that vitamins are credited with the prevention of deficiency diseases. They also play an important role in the functioning of the body. For example, vitamin D enables the body to absorb and use calcium and phosphorus.

5. Display a chart of the four basic food groups, featuring dairy products, meat and poultry, fruits and vegetables, and whole grain bread and cereals. Show that all the essential nutrients and vitamins are included within the four groups. Have the pupils realize that an adequate diet contains:
   a. Foods that supply energy needs of the body. (The concept of calories may be mentioned.)
   b. Foods that supply all the nutrients, including vitamins and minerals.
   c. Bulk and roughage for satisfying hunger and for the proper disposal of solid wastes.

Suggested Homework

1. What made scientists think that some diseases were caused by the lack of certain foods?

2. Some people think that as long as they take vitamin pills, they do not need to eat foods that have vitamins. Do you think this is true? Give your reasons.

3. a. Which vitamin is not found in many foods?
   b. Tell two ways you can get more of this vitamin.

4. How can you use the Basic Four food groups as a help to good eating?

5. Write a list of foods that you would eat at breakfast, lunch, and dinner. Check to see whether you included the foods and amounts suggested in the Basic Four.

NOTE: The charts (Basic Four and Vitamin Chart) on page 223 may be duplicated and distributed to the pupils.

BASIC FOUR

1. MILK GROUP: milk, cheese, butter, and ice cream.
2. BREAD - CEREAL GROUP: bread, macaroni, noodles, rice, spaghetti, pizza pie, waffles, and pancakes.
3. MEAT GROUP: meat, chicken, fish, eggs, nuts, dry beans, and peas.
4. VEGETABLE - FRUIT GROUP.

YOU SHOULD HAVE (DAILY)

Group 1. 4 or more cups of milk. Butter, cheese, or ice cream can take the place of a cup of milk.

Group 2. 4 or more helpings.

Group 3. 2 or more helpings.

Group 4. 4 or more helpings. One citrus fruit and one green or deep yellow vegetable are necessary.

VITAMIN CHART
(To be duplicated for pupils)

VIT.	FOOD SOURCES	USES IN BODY	DISEASE CAUSED BY LACK OF THIS VIT.
A	Fish-liver oils Green, yellow vegetables Milk and cheese	Growth Health of eyes, skin, teeth	Slow growth Infections Night blindness Xerophthalmia
B	Seafood Green vegetables Liver Soybeans Whole-grain bread	Growth Helps body use sugar, starch Health of heart, nerves, skin, mouth, eyes, muscles, stomach Health of blood	Slow growth Loss of appetite, weight, energy Poor skin, eyesight Mental sickness Pellagra Poor digestion — beriberi
C	Citrus fruits Green vegetables	Growth Health of teeth, gums, blood vessels	Sore gums Bleeding Bruise easily Scurvy
D	Sunlight Egg yolks Enriched milk Liver Fish Fish-liver oils	Growth Building bones, teeth Helps body use minerals, including calcium, phosphorus	Soft bones Tooth decay Rickets
K	Green vegetables Soybeans Milk Eggs	Helps blood to form scabs, clots to stop bleeding Health of liver	Continued bleeding of cut — hemorrhages

SUGGESTED REFERENCES: BIOLOGY

For the Teacher

ASIMOV, I. *Chemicals of Life: Enzymes, Vitamins, and Hormones.* New York: Abelard-Schuman, 1958.

BEISER, ARTHUR. *Guide to the Microscope.* New York: Dutton, 1957.

BUTLER, J. A. V. *The Life of the Cell: Its Nature, Origin, and Development.* New York: Basic Books, 1964.

CORRINGTON, JULIAN D. *Exploring with Your Microscope.* New York: McGraw-Hill, 1957.

MORHOLT, et al. *Teaching High School Science: A Source Book for the Biological Science.* New York: Harcourt, Brace, 1958.

SCHNEIDER, LEO. *You and Your Cells.* New York: Harcourt, Brace, 1964.

SIMPSON, G. G. and BECK, W. S. *Life: An Introduction to Biology.* New York: Harcourt, Brace, 1965.

Humane Biology Projects. Animal Welfare Institute, 22 East 17 St., New York 10003.

Laboratory Animals, Care and Feeding. Ralston Purina Company, St. Louis 2.

For the Pupil

BEELER, N. and BRANLEY F. *Experiments with a Microscope.* New York: Crowell, 1957.

COSGROVE, MARGARET. *Strange Worlds Under a Microscope.* New York: Dodd, Mead, 1962.

GLEMSER, BERNARD. *All About Biology.* New York: Random House, 1964.

GORAN, MORRIS. *Experimental Biology for Boys.* New York: John F. Rider, 1961.

HANAUER, ETHEL. *Biology for Children.* New York: Sterling, 1962.

MOON, J. T. *Modern Biology.* New York: Holt, Rinehart, 1965.

RIEDMAN, SARAH R. *Food for People.* New York: Abelard-Schuman, 1954.

SELSAM, MILLICENT. *The Plants We Eat.* New York: William Morrow, 1955.

SLATON, WILLIAM and NELLIE. *Bacteria and Viruses: Friends or Foes?* Englewood Cliffs, N. J.: Prentice Hall, 1965.

SMITH, T. E. et al. *Your Biology.* New York: Harcourt, Brace, 1958.

Unit IV

EARTH SCIENCE

Minerals and Rocks
The Changing Earth
The Importance of Fossils

MINERALS AND ROCKS

Suggested Lessons and Procedures

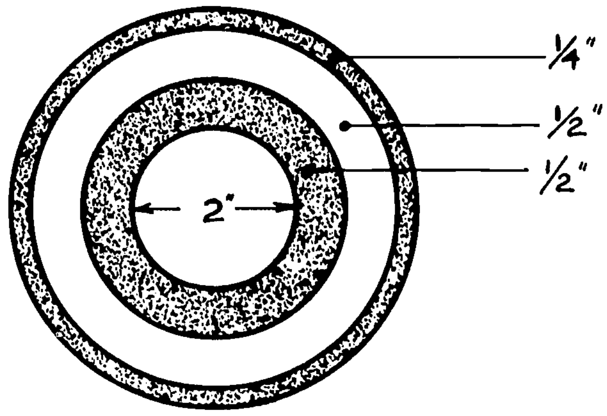
I. HOW HAVE VARIOUS CONDITIONS FORMED OUR EARTH?

Outcomes

- The earth at one stage of its creation was in the molten or gaseous state.
- The earth is divided into four layers:
  crust, mantle, outer core, inner core.
- The earth's surface consists of a very thin layer of water (70% of the surface) with small portions of the crust (30%) exposed through it.
- Scientists know little about the crust and far less about the earth's interior. Much exploration remains to be done.

Teacher Activities

1. Prepare a clay sphere as shown in the diagram. Prepare a six-inch length of glass tubing fire-polished on one end.
   Use different colors for each layer. The diagram measurements are suggested approximate thicknesses.
2. Display the ball of clay. Tell children that it represents the earth. Ask "How can we find out what is inside this ball without cutting it in half?" Lead pupils to suggest pushing the tube through the clay. (Lubricate glass tube with water.)
   Suggestion: Warm clay between palms of hands and afterwards push glass tube through with a twisting motion. Caution: Use



paper toweling wrapped around glass tube when pushing through the clay. Clay ball must be on demonstration table.

3. Display a globe of the earth. Ask the pupils, "How do we know what lies beneath the surface?" Elicit from the pupils that borings into the earth help us to understand its structure.
4. Point out the latest information about Project Mohole.
5. Into a glass cylinder pour water (tinted blue with copper sulfate), yellowish vegetable oil, and mercury. Shake. Allow it to stand for a few moments and tell the class to observe it.
6. Place one inch of moth flakes into a large test tube. Heat gently over the alcohol lamp. Let the molten material cool in the test tube rack. Elicit from students what they saw and how they would explain what happened. Introduce the term molten.
7. Reinforce the work above. Elicit from your pupils that lighter liquids float on top of heavier ones. In addition, point out that the molten material cooled and returned to the solid state. Briefly review changes in the state of matter if you feel it is necessary. Relate these activities to the layers of the earth by telling them that the earth was believed to be molten (liquid) at one time. From the above demonstrations elicit that there was a separation and hardening of the liquids that eventually formed layers within the earth.
8. Show the class a diagram or transparency of the interior of the earth. Indicate to the students that the earth is not completely a solid. Point out that when the earth cooled it must have separated into layers. At this point, tell the pupils that from temperature readings in mine shafts and borings into the earth, we find that the temperature of the earth increases with depth (1° per 60 feet).

Because of the different effects of temperature and pressure on rock, we believe some layers of rock still to be molten.

9. Elicit that the whole earth is a sphere of various layers, that the surface is mostly water (70%), and surrounding the earth is a gaseous blanket called the atmosphere.

10. Point out that much of the earth's surface is still being explored. Also indicate that we know very little about the oceans since they are still largely unexplored.

    NOTE: It would be helpful at this point to indicate that the I.G.Y. (International Geophysical Year, 1957-1958) and the I.Q.S.Y. (International Year of the Quiet Sun, 1964-1965) were international attempts to learn more about the earth and its atmosphere.

Suggested Homework

1. What are the possible reasons for the earth's being divided into the four layers?
2. Why does the temperature increase as we go deeper into the earth's crust?
3. Why is Jules Verne's novel *Journey to the Center of the Earth* highly improbable?

2. WHAT VALUABLE SUBSTANCES CAN BE FOUND WITHIN THE EARTH'S CRUST?

Outcomes

- A mineral is a natural substance, chiefly of inorganic origin, having definite physical characteristics and a definite chemical composition.
- An ore is a mineral or group of minerals containing a metal that can be extracted economically.

Teacher Activities

1. Display a chart showing the eight most abundant elements, their symbols, and their percentages by weight. Cover the first four elements and their symbols. Tell the students, "The four most abundant elements in the earth's crust are iron, aluminum, silicon, and oxygen." Write these words on the board. Ask the pupils, "Which

of these four do you think is the most abundant?" Ask them to arrange the elements in order of abundance. Uncover the elements. Have the pupils compare their results with the chart. Recall the definition of an element from the chemistry unit. Ask the pupils, "Why isn't oxygen found as a gas in the earth's crust?" Elicit the fact that many elements are found combined.

2. Have the pupils note that oxygen comprises almost 50% of the crust.

3. Have the pupils predict, from the chart, compounds that might be present on the earth, such as the oxides of silicon, iron, aluminum, and calcium.

4. Mention the names of some common compounds such as: Silicon dioxide (SiO_2), Quartz; Calcium carbonate ($CaCO_3$), Calcite; Ferric oxide (Fe_2O_3), Nematite; Calcium sulfate ($CaSO_4 \bullet 2H_2O$), Gypsum, etc.

5. Have the pupils become aware that a mineral is a natural substance, chiefly of inorganic origin, having definite physical characteristics and chemical composition.

   NOTE: Samples of the above-named items should be displayed. If possible, show specimens of minerals used for jewelry in the raw and polished forms. Ask students to show rings, etc. that contain natural minerals. Gem stones are mineral rarities of fairly common substances.

   NOTE: Demonstrate the procedure for this activity before the class tries it.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 2

(May be duplicated and distributed to pupils)

Problem: How can iron ore be changed to iron?

Materials

Blowpipe—short bent glass tube, tapered at one end
Piece of iron ore (1/4″ long, 1/16″ thick) (example—hematite)

Steel knife	Alcohol lamp
Bar magnet	Charcoal block (6″ x 2″)

CAUTION

Do not touch the hot ore.
Remove blowpipe from the mouth before inhaling.

Procedure

1. Using steel knife, carve out a hole in the charcoal block (½ inch wide). Put the hematite in the hole. Hold the magnet near it. Does the magnet attract the iron? ————
2. Place the alcohol lamp on the desk in front of you. Hold the charcoal block in one hand. Put the blowpipe in your mouth and bend down so that when you blow through it, the air blows towards the dark part of the flame steadily. Be sure the flame touches the depression in the charcoal block. Try to get a blue flame. From time to time, stop and let the ore cool.
3. Hold the magnet near the ore. What is the result?
   What color change has occurred?
   Repeat procedure until the magnet attracts the ore.

Conclusion

1. What has happened to the iron ore because of the heating?
2. How do you know a new substance has formed?
3. What kind of change is caused by heating?

Suggested Homework

1. Have pupils report on the reasons for the value of certain minerals.
2. Have pupils report on gem cutting and lapidary work.

3. WHAT ARE SOME PROPERTIES THAT MINERALS EXHIBIT?

Outcomes

- The properties of minerals enable us to tell one from another.
- The properties of a mineral determine its use.

Teacher Activities

1. Hold up a specimen of fluorite or other fluorescent mineral. Darken the room and shine an ultraviolet lamp on various fluorescent minerals. Elicit from pupils that fluorescence is just one property of certain minerals.
2. Show the pupils large samples of copper, zinc, aluminum, and iron. Compare these to samples of glass, sulfur, quartz, and limestone. Elicit from the pupils the main difference in appearance between each group. Elicit from the pupils the terms metallic and non-metallic. Point out that most minerals can be classified as having a metallic or nonmetallic luster.

3. Distribute materials listed on worksheet. Distribute containers of the following minerals—numbered, not labelled—to the pupils: quartz (crystal form), graphic, talc, galena, calcite, magnetite.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 3

(May be duplicated and distributed to pupils)

Purpose: To determine some properties that minerals exhibit

Materials

Small beaker of *dilute* hydrochloric acid	Test tube
Very soft pencil	Chalk
Iron—block, bolt, bar or nut	Glass rod
Small quantity of talcum powder (labelled)	Magnet
Lead sinker or other lead material	Large nail

Procedure

Introduction

Minerals have certain properties which make it possible for us to identify them. These properties also determine how we use these minerals in the home and in industry. You will try to match the man-made item with the mineral that it came from.

1. As you handle each item indicate whether it is metallic or nonmetallic.
2. Use the pencil on your tray to fill in this circle. O
   Run your finger over the circle. What do you feel? See?
3. Which item is attracted to the magnet?
4. Place a small amount of talcum powder in the palm of your hand. Rub the powder with your finger. Describe what you feel.
5. Use the glass rod to place a drop of acid on the piece of chalk. What happens? Try this test on the other materials.
   (CAUTION: Avoid spilling or touching the acid since it can cause serious burns.)
6. Pick up the sinker. Does it feel heavy for its size? Compare the sinker's weight to the other materials.
7. Try scratching each item with your fingernail and with the regular 3" nail. Which two seem to be the hardest?
8. Which sample looks most like glass?

After you have completed the above activities, look at the box of minerals in front of you. Each of the man-made items was made from one of these minerals. Can you match the mineral with the thing that is made from it? Test each mineral by doing the same activities you did with the pencil, bolt, talcum powder, etc.

Summary

Many things we use in home and school come from ———————— found in the earth. The ———————— of the minerals decide how we use them.

Teacher Activities *(continued)*

4. Review with the class the answers given on their worksheets. Elicit from the pupils that each mineral and its product have certain characteristics which make identification possible. Elicit these characteristics from the pupils such as: magnetic, soft, hard, shiny, heavy, metallic, nonmetallic, color, chemical change, feel, and structure.

Suggested Homework

1. Imagine yourself as one of the future astronauts exploring the surface of the moon. You discover a substance you have never seen before. Wishing to know what it is, you radio back to Earth for help from a geologist. What questions should you be ready to answer in order for the geologist to help you?
2. List 4 items in your home having metallic luster and 4 items with nonmetallic luster.
3. Which sample that you worked with today might be used to help a key slide into a lock? What could you do if your house key can't go into the lock? (Hint: Will a pencil help? How?)

4. HOW CAN MATERIALS BE IDENTIFIED BY THEIR PROPERTIES?

Outcomes

- Minerals can be identified by testing for several of their physical properties.
- More than one property of a mineral should be used to identify it.

Teacher Activities

1. Display a specimen of pyrite (fool's gold). Ask students to identify it. Relate that many prospectors mistakenly thought it was gold.
2. Explain that to identify a mineral correctly a geologist makes use of a combination of properties exhibited by a mineral.

3. Distribute materials listed on student worksheet.

   NOTE: Place corresponding numbers on worksheet and specimens.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 4

(May be duplicated and distributed to pupils)

Purpose: How do we learn about different minerals?

Materials

Specimens of (same size): milky quartz, rose quartz, sulfur, galena, calcite, hematite, pyrite, talc, graphite, magnetite
Iron nail
4" x 4" glass plate
Bar magnet

Procedure

1. COLOR—Most minerals have several colors due to the chemicals in them. A few minerals always have the same color.
   a. Look at sulfur (#———) What is its color? ——————
      Look at galena (#———) What is its color? ——————
      The colors of the two minerals are always the same.
   b. Look at rose quartz (#———) What is its color? ——————
      Look at milky quartz (#———) What is its color? ——————
      Why isn't color always a good way to identify a mineral?

2. LUSTER is the way a mineral reflects light from its surface. You have studied some words in chemistry to describe luster as dull, waxy, nonmetallic, metallic, glassy. Use these words to describe the following minerals:
   pyrite (#———) Its luster is ——————.
   hematite (#———) Its luster is ——————.
   rose quartz (#———) Its luster is ——————.
   graphite (#———) Its luster is ——————.
   sulfur (#———) Its luster is ——————.

3. HARDNESS is the ability of one substance to scratch another. A mineral is said to be harder than any other substance *it can scratch* or softer than any other substance which scratches it.
   a. Try scratching the talc (#———) with the iron nail.
      Does the iron nail scratch the talc? ——————
      Which is harder, talc or iron? ——————
   b. Try scratching the calcite with the talc.
      Does the talc scratch the calcite? ——————
      Try scratching the calcite with the nail.
      Does the nail scratch the calcite? ——————

Is calcite harder than talc? ____________
Is calcite harder than iron? ____________

c. Try scratching the quartz with the iron nail.
Does the iron nail scratch the quartz? ____________
Try scratching the glass plate with quartz.
Does the quartz scratch the glass? ____________
Now try to scratch the glass plate with the nail.
Does the nail scratch the glass?____________

d. List the following minerals (calcite, glass plate, iron nail, quartz, and talc) in order of hardness. Name the hardest mineral first.
1) ____________ 2) ____________ 3) ____________
4) ____________ 5) ____________

4. WEIGHT: A mineral can be identified by comparing its weight to another one of the *same size.*
   a. Place galena (#______) in one hand.
   Place sulfur (#______) in the other hand.
   Which one is heavier?
   b. Compare the other specimens of the same size. List them in order of weight for size. Name the heaviest mineral first.
   1) ________ 2) ________ 3) ________ 4) ________ 5) ________

5. MAGNETISM is the property by which a magnet will be attracted to a mineral. Recall the iron extraction experiment. Place a bar magnet near each of the minerals in your tray. Which one will be attracted to the magnet? ______________ Why?

Summary

1. Why can't a geologist depend on only one test to identify a mineral?
2. Which of the tests is the most helpful in identifying a mineral?
3. Which of the tests is the least helpful in identifying a mineral?

5. HOW ARE OTHER PROPERTIES USED TO IDENTIFY MINERALS?

Outcomes

- A mineral can be identified by other physical properties such as structure, the way a mineral breaks, and the color of the streak.
- Minerals can also be identified by the action of an acid on them.

Teacher Activity

1. Distribute materials listed on the laboratory worksheet.

2. Have students start immediately on the laboratory work.
   NOTE: Caution students to handle acids carefully.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 5

(May be duplicated and distributed to pupils)

Purpose: What are other properties that can be used to identify minerals?

Materials

Graphite	Rose quartz	Dilute hydrochloric acid in dropper bottle
Hand lens	Galena	Chrysolite (asbestos)
Hematite	Mica	Quartz crystal
Table salt	Halite	
Calcite		

Procedure

1. STRUCTURE—This property deals with the shape or form of the mineral. Words used to describe this property are: crystal (smooth-faced shape), stringy, flaky, and sharp edges where one face meets another. Use these words to describe the following minerals:
   a. Look at table salt (#———). Its structure is ———————.
   b. Look at quartz crystal (#———). Its structure is ———————.
   c. Look at asbestos (#———). Its structure is ———————.
   d. Look at mica (#———). Its structure is ———————.

2. BREAKAGE—Minerals can break in different ways. The samples you are looking at were broken from larger samples.
   a. Minerals can split along smooth flat surfaces.
      Break a small piece of mica (#———) by peeling off a thin layer. How did it come off?
   b. Look at galena (#———). Does it have a boxlike appearance? ———————
   c. Look at halite (#———). Does it look like galena? ———————
   d. Look at calcite (#———). Are the sides slanted or straight? ———————

   Minerals can break along lines that are not even.

   e. Look at quartz crystal (#———) which already has been broken at one end.
      Is it jagged and rough or smooth and flat? Describe it.

3. STREAK TEST—The streak of a mineral is the color of its powder. A streak plate is a piece of unglazed porcelain. Rub the following minerals on the streak plate: graphite, calcite, pyrite, hematite. Fill in the following chart:

Mineral	Color of Mineral	Color of Streak
GRAPHITE		
CALCITE		
PYRITE		
HEMATITE		

a. Which minerals have the same color streak as the color of the minerals? ________

b. Which minerals have different color streaks from the colors of the minerals? ________

c. Which test (color or streak) is best for recognizing a mineral? ________ Why?

4. ACID TEST—Minerals can be identified by their reactions with acids. CAUTION: Handle acids very carefully. They can cause burns.

a. Place one drop of the acid on each of the following minerals: calcite, quartz. What was the reaction with the calcite ________ and the quartz ________ ________?

b. Calcite has the chemical formula $CaCO_3$
Hydrochloric acid has the chemical formula HCl.
What gas do you think was given off? ________
(Hint) $CaCO_3 + 2\ HCl$ —— $CaCl_2 + H_2O +$ (Gas) ________

Summary

1. What new tests did you learn today to help you identify minerals?
2. Which tests were physical? Which were chemical?

Suggested Homework

1. At home, place some vinegar on a seashell, eggshell, chalk, baking powder. What is the result? What gas is given off?

   CAUTION: Use an open jar while working.

2. List all the tests you have studied in order to identify a mineral.

6. HOW ARE IGNEOUS ROCKS FORMED?

Outcomes

- Most rocks are mixtures of minerals.

- Igneous rocks probably covered the earth as the first type of rock.
- Crystal size of minerals in igneous rock depends upon the cooling rate of the magma.

Teacher Preparation

Prepare the following setup:
Dissolve as much salt as possible in a beaker of hot water to form a saturated salt solution. Pour some of the solution into two evaporating dishes and heat one of them to cause rapid evaporation. Allow the other evaporating dish to stand for a few days.

Teacher Activities

1. Distribute to pupils a hand lens, samples of granite, feldspar, mica, and quartz. Ask the students, "How did the minerals feldspar, mica, and quartz become so thoroughly mixed inside the piece of granite?" Elicit that during its early history:
   a. The earth was in a hot molten state with all the minerals mixed together.
   b. The earth's surface then cooled and hardened into a kind of rock called igneous rock (fire-made rock).
   c. Igneous rock probably covered the earth as the first type of rock.
2. Show pupils the evaporating dishes with salt that were prepared in advance. Allow the pupils to observe the salt crystals in the evaporating dishes. Tell the pupils that you heated one of the evaporating dishes and allowed the other one to stand a few days. Tell the class to compare the size of the crystals in both dishes. Ask, "How do they differ?" Elicit that the salt crystal formation depends upon the rate of cooling. Point out that larger crystals form because slow cooling gives the salt's ions an opportunity to move together and form fewer large crystals rather than many small ones.
3. Show a picture or a cross section of an erupting volcano. Explain that *magma* is the liquid or molten material deep in the earth's crust and that *lava* is magma that comes to the surface.
4. Ask students to suggest the relative crystal size that will develop from both the magma and the lava.
5. Distinguish between igneous rocks formed from cooled magma and lava as follows:

a. Show samples of granite (a magma) and basalt (a lava) and explain that they were formed from cooled magma. Have the pupils examine and compare them to observe that the granite is coarse-grained whereas the basalt contains fine particles or crystals which are harder to see.
   NOTE: A hand lens may be used as an aid.
b. Exhibit pictures of lava flows and such samples of cooled lava as pumice and obsidian. Have the pupils note their lack of grains, particles, or mineral crystals.

6. Conclusion:
   a. What is the difference between lava and magma?
   b. What is the difference in size between crystals formed on top of or below the earth's surface?
   c. How does molten material reach the earth's surface?

Suggested Homework

CRYSTAL GROWING

Dissolve an ounce or two (if it is very soluble) of one of these minerals (table salt, sugar, alum) in a half pint of water. Pour the solution into a shallow bowl. Hang a string in the bowl, leaving a free end over the edge. Allow the solution to evaporate slowly over a period of a few days. A coating of small crystals will form along the string and the sides of the bowl. (The crystals will be larger if they evaporate slowly.) Examine the crystals with a hand lens.

7. HOW CAN WE RECOGNIZE IGNEOUS ROCKS?

Outcomes

- Igneous rocks are recognized by their individual properties and the minerals they contain.
- Igneous rocks are classified according to the particular method by which each was originally formed.

Teacher Activities

1. Display pictures of erupting volcanos. Ask, "Why would the material coming out of the volcano form rocks that have no visible crystals?" Develop that rapid cooling caused formation of very small crystals.

Display a specimen of pumice. Ask, "Why does it look like a sponge?" Display a cellulose sponge and explain how the escaping gases formed the spaces.

Explain that we classify igneous rocks according to whether they formed beneath or above the surface of the earth.

2. a. Distribute materials listed on student worksheet.
   b. Try to use feldspar that has the same color as the granite and pegmatite.

NOTE: Place corresponding numbers on worksheet and specimens.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 7

(May be duplicated and distributed to pupils)

Purpose: How can we recognize igneous rocks?

Materials

Minerals: quartz, biotite, mica, feldspar
Rocks: pegmatite, granite, obsidian, pumice, basalt
Hand lens (10x)
400 ml beaker, half full of water

Procedure

1. Examine granite (#) by using the hand lens.
   a. The material in the granite (rock) that is flaky and black might be ______________.
   b. The mineral that looks like broken glass is ______________.
      (Hint: Look again at the minerals: quartz, feldspar.)
2. Look at pegmatite (#), using the hand lens.
   a. Are the minerals the same as those in granite? ______________
   b. What are they? ______________
3. a. Compare the crystals in both granite and the pegmatite.
   b. Which rocks have larger crystals? ______________
4. a. Look at basalt (#)
      The luster of the rock is ______________.
   b. Using the hand lens, can you see any crystals? ______________
5. How can you tell the difference between basalt and granite?
6. Look at obsidian (#______)
   a. Is it glassy or dull? ______________
   b. Can you see crystals? ______________
7. Look at pumice (#______)
   a. What color is it? ______________
   b. Put the rock in the beaker with the water.
      Does it float or sink? ______________ Why? ______________

Summary

1. Which rock has the most minerals?
2. Which rock has the largest crystals?
3. Which rocks cooled quickly?
4. Which rocks cooled slowly?
5. Which rock looks like glass?
6. How were these rocks formed?
7. In what ways can we use some of these minerals and rocks?

Suggested Homework

1. Collect rock specimens found around your home and neighborhood. Place them in an egg box. Bring them to school and compare them to ones you studied in class. Try to label them after you have compared them to the samples in school.
2. Look at buildings in your neighborhood.
   Are they made of granite? How can you tell?
   What is the color of granite?
   Do the same for rock specimens you may have at home.

8. HOW ARE SEDIMENTARY ROCKS FORMED?

Outcomes

Sedimentary rocks may be formed by one of these methods:

- Rocks are broken down after long exposure to weathering. The fragments of the weathered rock may be later compressed or cemented together to produce new rocks.
- When water containing dissolved minerals evaporates, the mineral sediments left behind form rocks.
- Rocks can also be formed from the remains of plants and animals.

Teacher Preparation

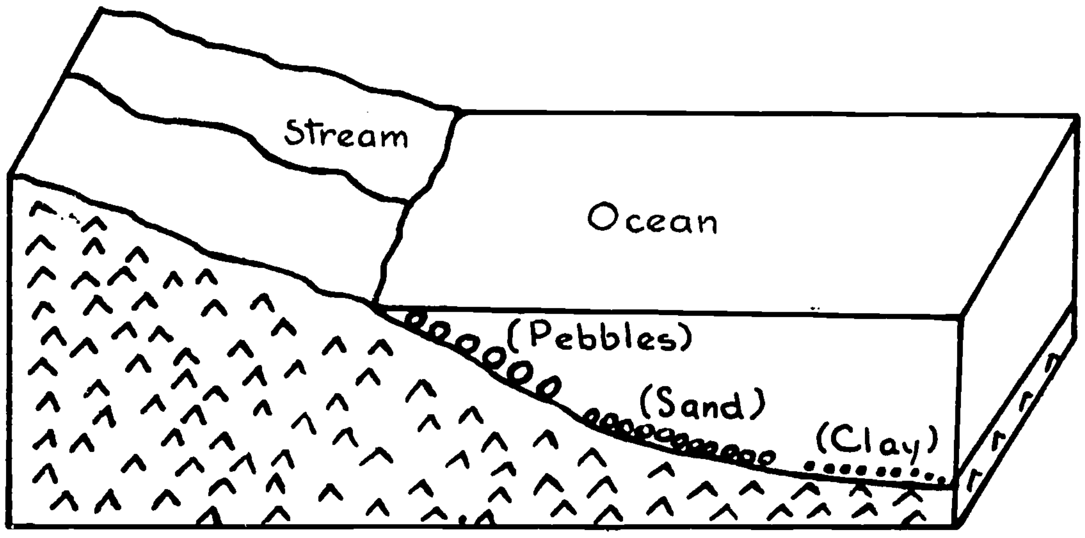
At the beginning of the period add 40 grams of sodium chloride to 100 grams of water, and boil the solution until all the water evaporates.

Teacher Activities

1. Display a weathered rock sample of granite or basalt which is crumbling and easily broken apart. If the rock sample is not available, tell the pupils that when rocks are exposed to the weather

they will break up into fragments. Explain that the rock fragments will be of different sizes (pebbles, sand, and clay). Display a small pile of each.

2. Elicit the fact that these rock fragments will eventually reach shallow water areas after being washed away by rains and streams.
3. Draw or project the following diagram and elicit that when a river flows into a lake or ocean it gradually loses its speed. Ask, "Which fragments or sediments are deposited first? Why?"



Explain that these rock particles separate according to size and pile up in tremendous quantities.

4. Display a large sample of shale and some powdery clay. Explain that the shale is composed of clay. Demonstrate this by subjecting the clay to a large amount of pressure. Point out that the clay sediments stick together without a cementing material.
5. Display a large sample of sandstone, conglomerate, and a small amount of sand. Tell the pupils that the sandstone may be composed of sediments like sand. Repeat the above demonstration, using sand instead of clay. Have the pupils observe that the sand grains do not stick together. Recall that rocks are mixtures of minerals. Explain that some minerals in the ocean waters are natural cements such as gypsum, hematite, calcite, silica (from quartz). Ask the pupils, "How might the sandstone and conglomerate rocks be formed?" Elicit from the pupils that the rocks are formed by the cementing together of various size rock particles by certain minerals.

Summarize at this point by stating that rocks formed by the cementing and compressing of many layers of rock fragments are called *sedimentary rocks.*

6. Focus attention on the demonstration started at the beginning of the period. The salt deposits should be at the bottom and sides of the beaker. Ask the pupils, "How could salt deposits be formed in nature?" Elicit from the pupils that the continuous evaporation of salt lakes and shallow bays caused mineral deposits such as sodium chloride, gypsum, and some types of limestone.

7. Display large rock samples of coquina, shell and coral limestone, and different types of seashells. Explain that many lime-forming animals live in the sea (clams, oysters, snails, mussels). The lime contains the mineral calcite. As they die, their shells accumulate on the ocean floor. Ask, "How could the shells form rocks?" Elicit from the pupils that the seashells are broken into fragments by the action of the waves and pile up on the sea bottom. These broken pieces of shells form layers which are compact and cemented together. In this way, another type of sedimentary rock is formed.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 8

(May be done at home)

(May be duplicated and distributed to pupils)

Purpose: How can we make sedimentary rock?

Materials

Plaster of paris	Sand
Glass jar	Gravel
Milk container	12″ wood stick
Pebbles	

Procedure

1. Using the stick, mix the sand, clay, pebbles, and gravel with water in the jar. Allow the material to settle.
   a. List the rock particles from the top to the bottom of the beaker.
   ________ ________ ________ ________
   b. Which rock is the heaviest?
   c. Which rock is the lightest?
2. Cover the bottom of a milk container with pebbles, sand, and gravel. Add water to cover them. Slowly sprinkle in some plaster of paris. Using the wood stick, mix the mixture until it is creamy. Tap the sides of the

container to let the bubbles escape. After a few hours or when it is hard, examine contents by peeling away container.

Conclusion

1. How can rock particles be stuck together to form rocks?
2. Why is plaster of paris used in making the mixture of rock?
3. Why does sandstone have different colors?

9. HOW CAN WE IDENTIFY SEDIMENTARY ROCKS?

Outcomes

Sedimentary rocks can be identified in the following ways:

- The kind and size of rock particles
- The organic material present in the rock
- Reaction to acid

Teacher Activities

1. Discuss the homework activity from the previous lesson. Elicit from the pupils that evaporation and the cementing action of the plaster of paris caused the rock mixture to harden. Recall from Lesson 8 that halite, hematite, calcite can also act as a cementing substance for rocks. Point out that the cementing material in the plaster of paris is gypsum. Relate the prepared rock to concrete—a man-made mixture of rock particles. Display a large sample of concrete.
2. Distribute materials listed in laboratory worksheets.
3. Caution students on the use of dilute acid.

NOTE: Place corresponding numbers on worksheets and specimens.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 9

(May be duplicated and distributed to pupils)

Purpose: How do we recognize sedimentary rocks?

Materials

Rocks—conglomerate, sandstone, shale, rock gypsum, coal (bituminous), coquina, limestone

Hand lens (10x)

Dropper bottles of dilute hydrochloric acid

Beaker with water

Paper towels

Procedure

1. Sedimentary rocks can be formed by the deposition of fragments from weathered rocks:
   a. Look at conglomerate (#)
   Is the size of the pebble in the rock large, medium, or fine? ________
   b. Look at sandstone (#)
      1) Is the size of the particle in the rock large, medium, or fine? ______
      2) Is the particle in the rock a pebble, sand, or clay? ________
      3) Does the rock feel rough or smooth? ________
   c. Look at shale (#)
      1) Is the size of the particle in the rock large, medium, or fine? ______
      2) Is the particle in the rock a pebble, sand, or clay? ________
      3) Does the rock feel smooth or rough? ________
2. Sedimentary rocks can be formed from the remains of once living plants and animals:
   a. Look at coquina (#)
      1) Does it appear to have seashells? ________
      2) Add a few drops of acid to the rock. Does it bubble? ________
      3) What mineral reacts with acid? ________
   b. Look at coal (#) It is called bituminous coal.
      1) What is its color? ________
      2) Can you see particles here? ________
      3) Does it break easily? ________
3. Sedimentary rocks can be formed by the evaporation of water leaving behind deposits of minerals:
   a. Look at limestone (#)
      1) What color is it? ________
      2) Add a few drops of acid to the rock. Does it bubble? ________
      3) Which mineral reacts with acid? ________
      4) Does it contain fossils? ________
   b. Look at rock gypsum (#)
      1) Scratch the rock with your fingernail. Does it feel hard or soft? ________
      2) What color is it? ________

Summary

1. Which rock has the largest rock particles in it?
2. Which rock reacts with the acid?
3. Which rock may have the fossils in it?
4. List the 3 groups of sedimentary rocks.

Suggested Homework

1. Which rock would be harder to break apart, igneous or sedimentary?

2. Why would some sandstone rocks be reddish-orange in color?

3. Try the following experiment: Add some vinegar to windowsill or stone porch. Is there any bubbling? Why?

10. HOW ARE METAMORPHIC ROCKS FORMED?

Outcomes

- A metamorphic rock is one that has been changed in form.
- A metamorphic rock is changed by heat, pressure, and chemical action.
- Increased pressure may form harder rocks and rearrange the minerals into parallel bands resembling layers of sedimentary rock.

Teacher Activities

1. Exhibit a piece of graphite (or carbon). Describe how industrial diamonds are made by dissolving graphite in a metal and subjecting the combination to great heat and pressure. Introduce the term *metamorphic* as change in form.
2. Mix some sawdust and modeling clay into small balls. Ask, "Do the particles of sawdust appear scattered or lined-up evenly in the clay?" Place the mixture on a piece of cardboard. Put another cardboard on top and press down firmly with your hand. Take the top piece of cardboard away and examine the clay. Elicit that the sawdust particles are lined up (banded) in the clay.
3. Display a large sample of granite. Have pupils notice its salt and pepper appearance. Ask the pupils, "What minerals are present in the rock?" They will see mica and quartz. Compare it to a large sample of gneiss, a metamorphic rock. Point out the similarity in mineral content. Ask the pupils, "How do they differ?" Elicit from the pupils that the different types of minerals in the gneiss have a layered or banded appearance. Point out that heat and pressure squeezed and stretched the minerals in the rocks, forming bands. Ask, "Where was pressure applied in order to form the bands?" Point out that increased pressure causes an increase in heat.
4. Point out that sedimentary and igneous rocks can be changed by heat, pressure, and chemical action and that these changed rocks are called metamorphic (change in form) rocks.

5. Discuss explanations as to the possible cause for the heat and pressure that form metamorphic rocks.
6. Summarize lesson by showing a filmstrip on the formation of metamorphic rocks.

Suggested Homework

1. How are metamorphic rocks used in industry?
2. What are the ways in which metamorphic rocks are formed in the earth?

11. HOW CAN WE RECOGNIZE METAMORPHIC ROCKS?

Outcomes

- Some metamorphic rocks can be recognized because the minerals they contain form bands.
- Nonbanded rock can be recognized by its reaction to the acid test and its hardness and compactness.

Teacher Activities

1. Display large samples of gneiss and one of mica schist. Ask, "Why do the minerals appear in bands?" Elicit from the pupils that extreme pressure and heat changed the existing rock. Have the pupils observe the difference in the width of the bands in the rocks. Elicit that the minerals in gneiss are arranged in wide bands. Elicit that the minerals in schist are flattened out into extremely thin wavy sheets. Ask, "What would be one way to recognize metamorphic rock?" Explain that there are many kinds of gneiss with bands of varying widths. (Granite is one source of gneiss.) Schist, having narrower bands, shows many varieties as well. Most schist rocks are derived from shale.
2. Display large samples of limestone and sandstone. Ask, "What mineral is mainly found in limestone? in sandstone?" "What types of rocks are they?" Explain that since these sedimentary rocks contain one mineral, the metamorphic rock derived from limestone and from sandstone will not show "banding." These rocks can be recognized by their hard or solid appearance and lack of banding. Display large samples of marble, anthracite coal, and quartzite.

Tell pupils they are changed rocks. Ask, "What would be the source of anthracite coal?" Tell them that the source of marble is limestone and that the source of quartzite is sandstone.

3. Distribute materials listed on laboratory worksheet.
4. Caution students on the use of dilute acid.

NOTE: Place corresponding numbers on worksheet and specimens.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 11

(May be duplicated and distributed to pupils)

Purpose: How do you recognize metamorphic rocks?

Materials

Rocks—gneiss, slate, schist, granite, shale, anthracite coal, marble, quartzite
Minerals—quartz, mica 4" x 4" glass plate
Dropper bottle of dilute HCl

Procedure

1. Look at the rock sample gneiss (#)
   a. Does it have light and dark bands? ______
   b. Look at the light band. Which mineral is present, quartz or mica? ______
   c. Look at the dark band. Which mineral is present? ______
   d. Does the gneiss have a shiny or dull appearance? ______
2. Look at schist (#)
   a. Are the bands thinner or wider than the gneiss? ______
   b. If you can peel off any flakes of minerals, what mineral is it? ______
   c. Can you see the mineral quartz in the schist? ______
3. Look at slate (#)
   Is its appearance smooth or rough? ______
4. Look at shale (#)
   a. Is its appearance smooth or rough? ______
   b. How does it differ from slate? ______
5. Look at marble (#)
   a. Add a drop of dilute HCl. Does it bubble? ______
   b. What gas is given off? ______
   c. What mineral reacts with the acid? ______
6. Look at quartzite (#)
   a. Does it scratch glass? ______
   b. Add acid to quartzite. Does it bubble? ______
7. Look at anthracite coal (#)
   a. Is it shiny or dull? ______
   b. Is it hard or soft? ______

8. Compare anthracite with bituminous coal.
   a. Which one is soft? ____________
   b. In what other ways can we compare them? ____________

Summary

1. How do we recognize metamorphic rocks? ____________
2. How are nonbanded rocks identified? ____________

Suggested Homework

1. Add vinegar to rocks you may find in your neighborhood. Does the rock bubble? Why?
2. List any objects at home that may be made of marble. What is its appearance?
3. Can fossils be present in slate? Why?

12. HOW ARE ROCKS AND MINERALS USED?

Outcomes

- The ores must be broken down to separate the useful substances from the impurities or from their compounds.
- Rocks and minerals are commonly used in ceramics, building trades, jewelry designs, and abrasives.

Teacher Activities

1. Display common objects made of metals such as aluminum pots, copper wire, iron nails, and lead fishing sinkers. Ask, "Where did these metals come from?" Elicit from the pupils that these metals were extracted from rocks and minerals. Review by asking, "What is an ore?" Display large specimens of bauxite, hematite or magnetite, galena, chalcopyrite, or chrysocolla. Ask, "How are metals obtained from ores?" Recall from previous lesson the extraction of iron from hematite. Explain that in the process of extracting a metal from its ore, oxygen, sulfur, and other elements with which the metal is combined are removed. This is called *refining*. The teacher may suggest other refining techniques such as electrolysis of copper and aluminum.
2. Display large samples of limestone, marble, gneiss, and granite.

Elicit that these rocks can be used as building materials. Mention examples of buildings in the neighborhood made of these rocks. If possible, show polished samples of the above rocks.

3. Show specimens of minerals used for jewelry. Elicit why certain types of jewelry are so expensive. Point out that gems are very rare forms of minerals.

4. Point out that rubies and sapphires are the gem varieties of the mineral corundum. Emerald comes from the mineral beryl. Point out that each month of the year has a corresponding birthstone (i.e., diamond, the birthstone for April). List some of the students' birthstones on the chalkboard.

5. Display samples of sandpaper and emery cloth. Point out that certain minerals have been broken down into small pieces and pasted to a backing. Elicit from the students that these minerals were chosen because of their hardness. Have students note that the hardness of the mineral must suit the job for which it is intended. (Scouring powders can't be too hard.) Point out that all these minerals are called *abrasives*.

6. Discuss the methods used in the polishing of a crude gem stone into the finished product. If possible, display pictures or the equipment used to do this. Point out that many people do this as a hobby.

Suggested Homework

1. List 10 objects made of metal in and around your home.
2. List 3 places in your neighborhood where polished stone may be found.
3. Why must people be careful of the scouring powder used on fine dishes?
4. What is the main purpose of toothpaste?

THE CHANGING EARTH

Suggested Lessons and Procedures

13. WHY DOES THE EARTH'S CRUST MOVE?

Outcomes

- The heat in the earth's interior produces convection currents in the molten (plastic) layer of the mantle.
- It is believed that the convection currents in the earth are one cause of mountain building.
- Continents appear to be "floating" on the plastic layer of the earth.
- Continents can be uplifted because of the deposit of sediments on the ocean floor.

Teacher Activities

1. Have the pupils recall the evidence for the heat in the earth's interior. Display the convection apparatus used in the physics syllabus. Repeat the demonstration to show how the heat produces motion in the liquid. Perform the following demonstration:

   Set up a pyrex "loaf" dish on a tripod. Fill it with water and cover its surface with sawdust and wood chips. Heat both ends of the pyrex dish over a low flame. Use a wing-top to spread the flame.

   Elicit from the class that convection currents are produced. Have them observe that the sawdust on the water collects in the center of the dish. Relate this to the process of convection in the earth. Let the earth's surface be represented by the sawdust. Elicit that mountains may form if the earth's crust is pushed together.

2. To help explain one of the theories that account for the raising of land to great heights, perform the following demonstration:

Stack about 20 wood checkers (alternate colors) into a graduated cylinder. Add enough water so that the stack of checkers floats as high as possible. Have the pupils note the level at which the bottom checker rests. Remove one checker at a time. Ask "How is the level of the bottom checker affected?"

Compare this to the continents *floating* on the plastic layer of the earth. As layers of rock are removed by erosion, the continent tends to move upward. Layers that were once deep in the earth are raised higher.

3. a. Distribute materials listed in worksheet.
   b. Point out that the cylindrical wood bead represents the land masses.
   c. Have pupils observe diagram before they set up the apparatus.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 13

(May be duplicated and distributed to pupils)

Purpose: How can we show that large land areas rise?

Materials

Ring stand
Clamp
Beaker of water
8″ U-shaped tube
Package of ½″ wood cylinder beads
Glass-marking pencil

Procedure

1. Clamp the U tube to the ringstand. Place an equal number of wood beads about halfway up each arm of the tube. Add water so that 4 beads float above the surface in each arm. Using a glass-marking pencil, mark where the bottom bead rests in each arm of the U tube.
2. Remove one bead from one of the arms of the U tube.
3. Does the stack of beads in that arm of the U tube go up or down? ______
4. Does the stack of beads in the other arm of the U tube go up or down? ______
5. Remove another bead from the same arm of the U tube as in Step 2. What happens now?

Summary

1. Why do the heights of the stacks of beads in each arm of the U tube differ when the beads are removed from one stack?
2. If the North American continent is rising, how can you explain this by referring to the experiment you just did?

Suggested Homework

1. What are convection currents?
2. How do they explain movements of large land masses?
3. How are continents affected as sediments are carried from the land to the ocean?

14. HOW ARE EARTHQUAKES FORMED?

Outcomes

- Internal pressure in the earth's crust can cause a break or crack in the rocks, called a fault.
- Sudden movement of rocks is the principal cause of earthquakes.
- Volcanic eruptions, land slides, and man-made explosions can cause earthquakes.

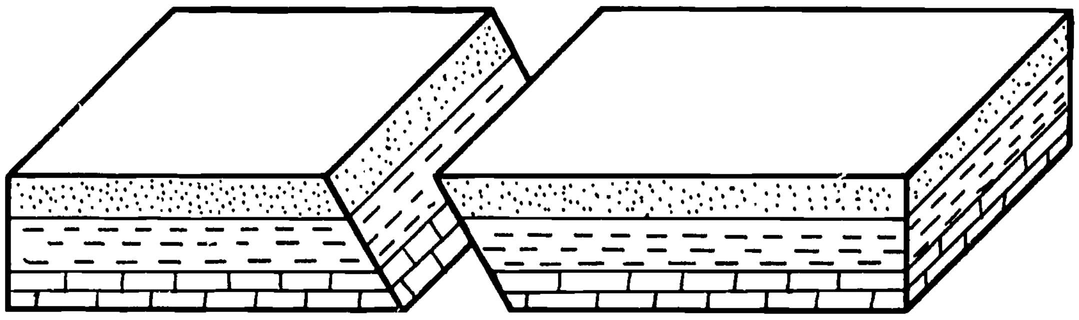
Teacher Activities

1. Refer to (or show the class) newspaper headlines or photos of recent earthquake disasters. Relate these movements of the earth to the release of pressure in the earth in this way: Slowly bend a stick. Point out that pressure is being exerted to cause the stick to bend. It does not break because of the strength and elasticity of the stick. Exert more force until the stick snaps.

   Ask, "Why did the stick snap?" Elicit from the pupils that the force applied was greater than the strength of the stick. Point out that each half of the stick is now as straight as it was before because the pressure was suddenly released. Relate this activity to a break in rocks in which one part slides past the other. This is called a *fault*. Explain that internal pressure can cause the rocks to break in the earth's crust. The movement of the rocks is called *faulting*.

2. Demonstrate faulting with models such as those shown opposite. Place them side by side and move them horizontally and vertically. Show the pupils photographs of the San Andreas Fault.

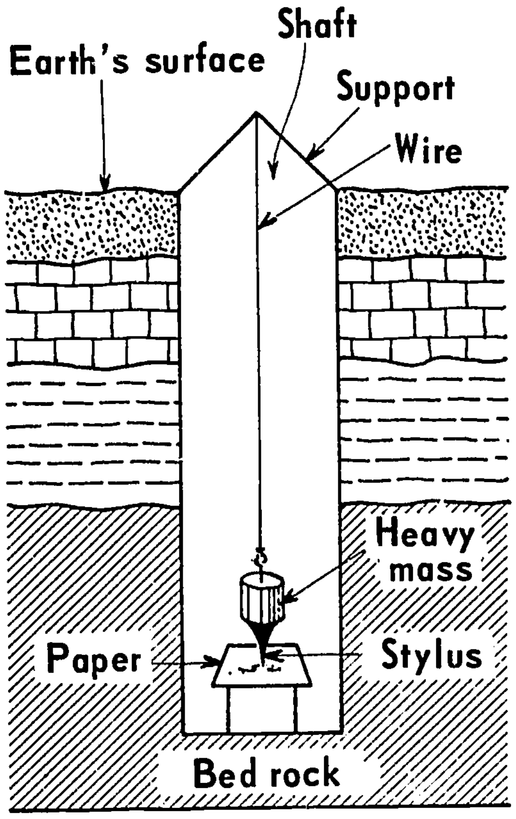
3. Have some pupils do this demonstration. Quickly pull a piece of *Silly Putty* apart (obtained at toy or hobby shops). It snaps. Explain that this also illustrates how internal pressure can cause faulting. Ask, "How can faulting produce changes in the earth's



See N.Y.S. *Earth Science Handbook,* p. 75.

crust?" Point out that the sudden movement of rocks is called an earthquake. Most earthquakes are caused by faulting. Point out that earthquakes can be recorded.

4. a. Demonstrate a working model of a *seismograph* or show a pictogram of a seismograph, such as that below, and have the pupils discuss its operation.



   b. Show a real *seismogram* and explain that the height of the vibrations is an indication of the strength of an earthquake.

5. Display pictures of volcanic eruptions, landslides, cave-ins, and man-made explosions. Elicit that these activities can also cause earthquakes. Point out the above may occur on the ocean floor and

that huge waves are formed which travel towards coastal areas at speeds of hundreds of miles per hour, inflicting much damage. These waves are called *tsunamis*. The origin of the word suggests the frequency of such sea waves on the isles of Japan.

Ask, "How do earthquakes change the earth's surface?" Elicit that level land can change because of sudden movement of rocks.

Summary

1. Explain faulting of rocks.
2. How are earthquake shock waves produced?
3. List the ways in which earthquakes are produced.
4. What may cause rocks to snap apart?

Suggested Homework

1. Make a model of an earthquake recorder.
2. Why is it important to have earthquake recorders?
3. Where are the earthquake belts located?

15. HOW HAVE VOLCANOES AND VOLCANISM CHANGED THE EARTH'S SURFACE?

Outcomes

- Volcanoes or lava flows result when pressure in the earth's interior push magma to the surface, usually through a weak spot in the crust.
- There are 3 general classifications of volcanoes: explosive, quiet, and intermediate.
- Molten rock which does not reach the surface will push the surface upward or squeeze between rock layers.

Teacher Activities

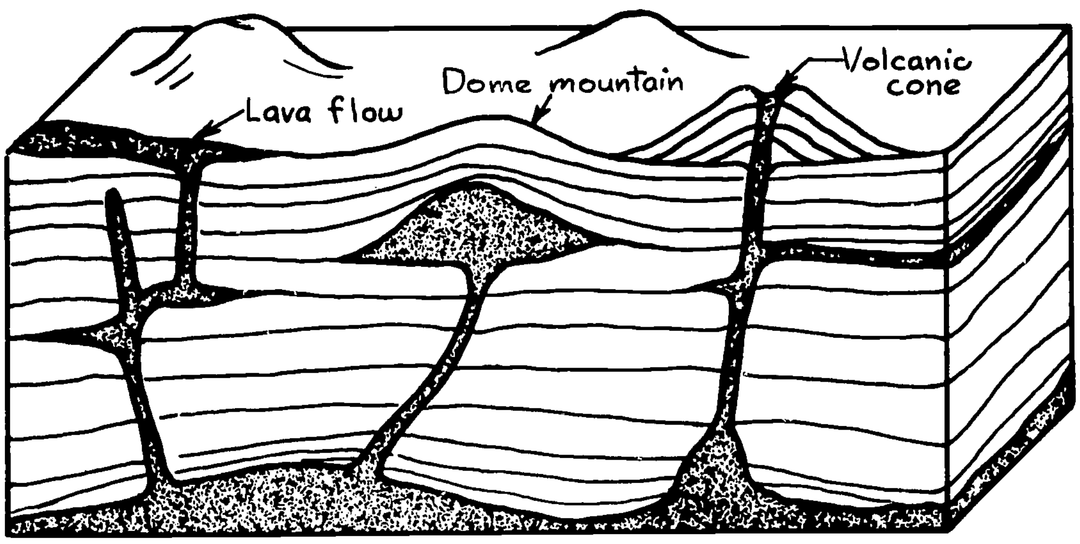
1. Force putty between layers of cardboard, the top one having a hole in it. Have the pupils note that the putty is squeezed between the layers of cardboard when pressure is applied. Point out that some putty comes out through the hole. Relate the activity to the heat and pressure present in the earth's crust which can force the hot molten magma through weak spots in the earth's surface, causing volcanic eruptions. When it fails to reach the surface, it can spread out over large areas beneath the earth. The magma that reaches the surface is called lava. Elicit that the opening in the

earth's crust through which an eruption takes place is called a *volcano.*

2. A day before the lesson, prepare a model volcano in the following way: Using clay, mold a volcano about 8" high on a metal sheet 12" square. Place a metal cup about the size of a "D" dry cell or a small crucible in the opening at the top of the clay volcano. Simulate the formation of a volcanic cone in the following demonstration: Place a few small bits of magnesium ribbon and some granular ammonium dichromate into the metal cup. Add a few sprinkles of ammonia chloride to make smoke. Insert a 2" magnesium ribbon into the chemical. Light the "fuse" of magnesium ribbon with a bunsen flame until it burns vigorously. Have students note the relatively steep cone built up with the "ashes." This is known as a cinder cone. Elicit from the class the shape of the cone that would form if lava were to come out of the crater (broad, gently sloping cone). Point out that this is called a quiet volcano. Explain that most volcanoes are of the intermediate type, combining features of explosive and quiet volcanoes.

3. Relate to the pupils some famous volcanic eruptions that have taken place around the earth.

4. Draw or project a diagram (see diagram) of a typical area of volcanic activity. Point out that there are enormous storehouses of magma located in the earth's crust. From this storehouse, magma tries to reach the surface. If unsuccessful, different types of underground formations are formed which may affect the surface scenery. (For example, domed mountains form when magma pushes the overlying rocks into oval domes.)



5. Elicit that in time the magma will harden into igneous rock.

Suggested Homework

1. Have students report on famous volcanic eruptions.
2. Make a chart of a quiet volcano and an explosive one.
3. Make a cut-away model in clay or papier-maché of a volcano.

16. HOW ARE MOUNTAINS FORMED?

Outcomes

- Internal pressure at the sides of layers of sedimentary rocks over long periods of time can raise the level of the land and form folded mountains.
- Gas, oil, and water may be trapped in the sandstone layer of the sedimentary rocks.
- The rising and lowering of rocks along fault lines over long periods of time may lead to the formation of fault mountains.

Teacher Activities

1. Have pupils quickly pull a piece of *Silly Putty* apart as they did in a previous lesson. Now pull the piece of *Silly Putty* apart slowly. It stretches. Elicit from the students that the force you exerted was exerted over a long period of time. The *Silly Putty* behaved like a plastic material. Point out to the pupils that this is similar to that which occurs in nature. Forces acting slowly over a long period of time squeezing sections of the crust together will bend or fold the crust rather than snap it apart.

   Ask the pupils, "How can mountains be formed by the slow pressure at the sides of the rock layers?" Elicit from the pupils that the pressure will cause ups and downs in the rock layers which then form *folded mountains.*

2. Demonstrate how mountains are formed by compression in the following way: Take a package of 12" x 18" colored construction paper. The several colors in the package will represent sedimentary layers. Push the ends of the package together. Point out to the class that the folds which are produced are similar to ones produced in layers of rock in the earth's crust. (See N.Y.S. *Earth Science Handbook,* p. 80.)

3. Elicit from the pupils that when great heat is produced by pressure, metamorphic rocks are formed. Show the class samples of anthracite and bituminous coal to refresh their memory. Show them a map of the coal-producing areas of the United States, and point out the anthracite areas in folded mountains. Point out that oil, gas, and water may be found in the upfold of sedimentary rock like sandstone.
4. Display the models of geologic faults as described in a previous lesson. Ask "How could mountains be formed?" Elicit from the pupils that if large blocks of the earth's surface are displaced upwards, mountains may be formed. Show pictures of the Sierra Nevada Mountains as examples of *faulted mountains.*
5. Display a block model of a domed mountain. (See N.Y.C. *Earth Science Handbook,* p. 81.) Note that the thick magma rising to the surface may meet layers of rock through which it cannot go. The magma forces the overlying layers into a dome mountain.
6. Display pictures of *volcanic mountains* such as Mount Etna in Sicily and Mt. Lassen in the U. S. Point out that volcanic eruption may build up the land to form a mountain.

Suggested Homework

1. How can internal pressure which is applied slowly affect the layers of sedimentary rock?
2. If oil, gas, and water are found trapped in a layer of sandstone, which one would be at the bottom? Which one of the substances would be at the top?
3. How are fault block mountains formed?
4. How are domed mountains formed?
5. How are volcanic mountains formed?

17. HOW DOES THE WEATHER CHANGE THE EARTH'S SURFACE?

Outcomes

- Weathering is the physical and chemical breakup of bedrock at or near the earth's surface from exposure to atmosphere, weather, plants, and animals.
- The end product of weathering is soil or eventually a new rock.

Teacher Activities

1. Have the pupils recall the constant repairs necessary to the city streets. Elicit from the pupils that it is in the spring, soon after the winter, that most of the damage is apparent. Demonstrate the effect of the freezing of water in confined spaces in the following manner: Completely fill an ice bomb with water and seal it. Place it in a container with crushed ice, salt, and water. Cover it with a plastic bag and put it away from students. While this is working, have the pupils recall what may occur to milk bottles left at the doorstep in freezing weather. When the ice bomb explodes after about 10 minutes, show the broken pieces of iron to the class. Have them realize that if freezing weather can split apart metal 1/4" thick, it can easily break apart rocks, if water is trapped within tiny cracks. Point out to the class that this is a physical change. The rock is merely broken into smaller pieces.
2. Display pieces of weathered rock and compare them to freshly broken pieces. Break off some of the crumbly stone and place it in a watch glass. Elicit from the class that it resembles soil.
3. Recall the effect of acid on calcium carbonate (marble chips). Point out to the pupils that some of the CO_2 in the atmosphere dissolves in rainwater and falls as carbonic acid. This dilute acid, as well as other acids, reacts with minerals on the surface of the earth to decompose them.

Student Activity

The pupils will do a series of elementary activities which should help them see some of the factors involved in weathering. Prepare and distribute materials listed in worksheet.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 17

(May be duplicated and distributed to pupils)

Purpose: To understand how rocks in the earth's crust are being weathered

Materials

Watch glass	Matches	Dilute hydrochloric acid (1:4)
Iron filings	Limewater	Sandstone
Water	Slate	Marble chips (calcium carbonate)
Splints	Bottles	Quartz sand (silicon dioxide)

5

Procedure

NOTE: Be careful when using the hydrochloric acid.

1. Put some iron filings into the dish. Add a little water. Recall the results from the chemistry unit.
   a. The iron will ———— by taking oxygen out of the air.
   b. The color of the iron filings now is ————.
   c. The color of the iron filings 20 minutes later is ————.
2. Place a few drops of water on top of the sandstone and on top of the slate.
   a. The ———— soaks up the water.
   b. The color of the sandstone is ————.
3. a. Place marble chips on the bottom of one bottle and quartz sand on the bottom of another bottle.
   b. Pour a small amount of HCl over the marble chips and over the quartz sand.
   c. Place a lighted splint into each bottle. (Caution: Do not let the splint burn for more than a few seconds.)
   d. The lighted splint went out or burned more slowly in the jar containing the ————.
   The jar in which no bubbling took place contained the ————.
   e. The gas produced in the jar with the marble chips was ————. (Hint: Try testing the gas by pouring some of it into the jar of limewater. To test the gas make fresh gas in the third bottle.)

Summary

1. Rocks or minerals which contain iron weather more quickly when near ————.
2. Rainwater, which soaks into a rock and later freezes, is most likely to break ———— apart faster than ———— (sandstone, slate). Sandstones are held together by different cements such as lime (calcite), iron, and silica.
3. Brown sandstone is probably held together by ————. (calcium, iron).
4. The sandstone which will probably weather most slowly would be held together with ————. (silica, iron, calcite).
5. Acid will break down rocks which contain ———— more readily.

18. HOW DOES WATER WEAR AWAY THE SURFACE OF THE EARTH?

Outcomes

- Erosion is the process of breaking up and removing rock materials by moving forces such as streams.

- Running water, acting under the influence of gravity, is the most effective agent of erosion.
- The slope of the land affects the rate of erosion.

Teacher Activity

Draw or project a diagram of the water cycle on the board. Have students come to the board and point out the major source of water on earth and where evaporation and condensation take place. Let a student point out that rainfall can take two paths back to the ocean.

Student Activity

The pupils will duplicate, on a small scale, run-off conditions on a gentle and steep slope to observe the differences in gullying and absorption and will study other phenomena associated with running water.

Some groups should prepare their troughs as indicated below to produce variations in the flow of the water.

a. If one or two pebbles or a stick is buried along the course of the stream, meanders can be shown.

b. A dam of clay, deposited across the open end, will cause a delta to develop. (See p. 62 of N.Y.S. *Earth Science Handbook.*)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 18

(May be duplicated and distributed to pupils)

Purpose: To study the effects of running water on soil

Materials

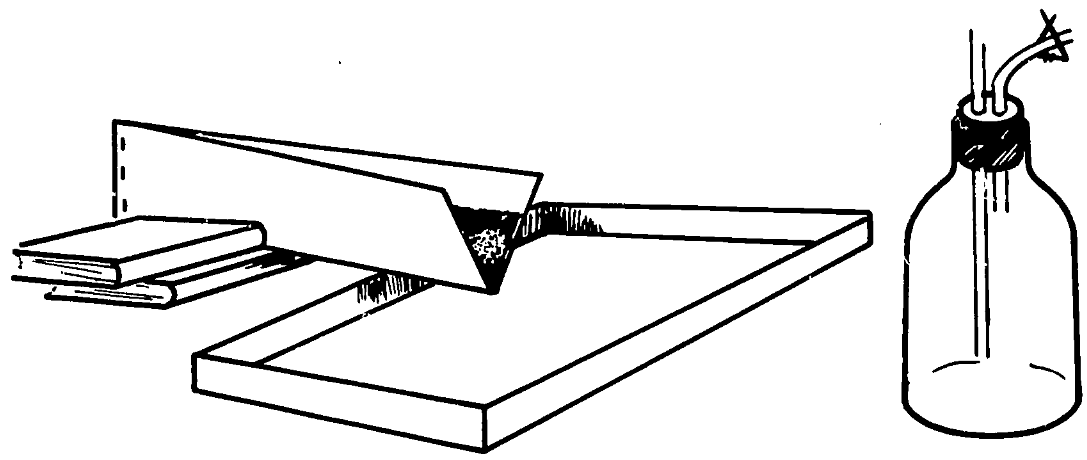
Plastic bottle (laundry detergent or bleach type) 1 gallon size
2-hole rubber stopper to fit plastic bottle
Glass tubing—one 4″ length, one 8″ length
Rubber tubing — Clamp
Heavy oaktag, 24″ x 24″ — Funnel
Tray — Cheesecloth
Graduated cylinder, 500 ml

NOTE: The oaktag should be prepared as follows:

1. Fold it over once.
2. Crease the doubled oaktag down the middle.
3. Staple one doubled end together.

Set up the materials being used in this activity as shown in diagram.

CAUTION: Do not dispose of the dirt or run-off water in the laboratory sink.



Procedure

1. a. Place the soil into the trough.
   b. The soil should be about 3" deep in the cardboard trough and as level as possible.
   c. Place books against the sides of the trough (outside the tray) to keep the trough steady.
   d. Place 1000 ml of water into the large cylinder.
   e. Pour the water into the large bottle.
   f. Place the rubber stopper into the large bottle.
   g. Hold the bottle upside down over the upper part of the trough. Take off the clamp and let the water run out until the bottle is empty. Watch closely.
   h. Slowly pour the water from the tray into the large cylinder; use the funnel lined with cheesecloth to do this.
      1) The water made one or more long grooves in the soil, called gullies. These gullies were ———— inches deep.
      2) We started out with 1000 ml of water (about 1 quart).
         a) We removed from the tray ———— ml of water.
         b) The soil soaked up about ———— ml of water. (Subtract b from a)
2. Repeat 1, a - h but raise the trough 6 inches at one end.
   a. The gullies in this experiment are (THE SAME, DEEPER, NOT AS DEEP) as in experiment 1. ————
   b. Use fresh cheesecloth when pouring the run-off water through the funnel. The amount of water that ran off was ———— ml.

Summary

1. When the slope of the land is steeper, the water that runs off is ————. (increased, decreased, the same)
2. When the slope of the land is steeper, the soil that is carried away is————. (increased, decreased, the same)
3. If grass and other plants are growing in the soil, the run-off should be————. (increased, decreased, the same)

Teacher Activities *(continued)*

2. Relate the student activities 1 and 2 to the effect of rainfall on hillsides. Have pupils recall what occurs to the sides of a hill or newly seeded lawn or in a nearby lot after a rainstorm. Elicit from the students that erosion has taken place.
3. Have the pupils discuss how raindrops become great rivers:
   a. Rain falls on the hillside following the slopes, forming rivulets and streams.
   b. These rivulets and streams form larger streams, forming river systems.
   c. From the moment that the water started running downhill, it carried soil, sand, and pebbles along with it.
4. Illustrate the effects of erosion by showing the pupils photographs of gullies and comparing it to photographs of the Grand Canyon.

Suggested Homework

1. What steps do farmers take to prevent gullying and erosion on their farms?
2. How does the building of a dam across a river affect erosion?
3. How does the planting of forests along hillsides prevent erosion?
4. Why do forest fires help erosion?

19. WHAT HAPPENS TO THE WATER THAT SEEPS INTO THE EARTH?

Outcomes

- Rainfall and other precipitation which seep into and collect in the earth provide us with water.
- Different soils transmit water at varying rates.
- Water from the ground is usually "hard" water because it dissolves minerals as it travels through the ground.
- The top level of the water saturating the earth is called the water table.
- Detergents help us overcome the problem of hard water.
- Caverns are formed in limestone regions.

Teacher Activities

1. Refer to the chart of the water cycle used previously. Have a student point out the below-surface route that water may take as it moves back to the ocean.
2. The following activities should lead the pupils to understand some of the outcomes of the lesson.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 19

Purpose: To understand how underground water affects man

Materials

8 test tubes with rack	Limewater
Sand, gravel, clay	Liquid soap
Water	Liquid detergent
Large beaker	4 rubber stoppers for test tubes
Glass chimney	

Procedure

1. a. Put clay into the first test tube, sand into the second, and gravel into the third. Each test tube should be filled equally to a height of about 3″ - 4″.
   b. Pour equal amounts of water into each test tube. Watch closely.
      1) The water seeped in most rapidly in the test tube with the ———.
      2) Almost no water seeped into the —————.
2. a. Place the glass chimney inside the large beaker. Be sure it is close to one side of the jar.
   b. Add the gravel to the beaker.
   c. Add water (rain).
   d. After a few minutes look at the level of the water in the glass chimney and in the jar.
      1) The top surface of the water in the earth is called the water table.
      2) To get water out of the earth a well has to be sunk below the ————— —————.
      3) As the water soaks into the earth it may carry with it minerals such as ————— (calcite, silica).
      4) The bottom of the jar stopped the water from going any deeper. If this were a sedimentary rock underground, which rock is it most likely to be —————? (slate, sandstone.)
3. This activity shows what happens to water when it picks up minerals as it soaks through the earth.

   NOTE: The limewater is man-made but it could have been made in the earth, as rainwater passed through sediments and dissolved calcite (limestone) in it.

STEPS:

a. Place about 2″ of limewater into 2 test tubes and about 2″ of tap water in each of the other two test tubes. Be sure each test tube is filled to the same height.

b. Add one drop of liquid soap to
   1) a test tube containing limewater
   2) a test tube containing tap water

c. Place a stopper into the opening of each of these two test tubes.

d. Shake well for about 10 seconds.

e. Do the same steps a, b, and c with the liquid detergent.

4. Fill in this chart. Use these terms: *no suds, little suds, lots of suds*

	TAP WATER	LIMEWATER
SOAP		
DETERGENT		

a. When soap is used with water which has minerals in it, we get ——— suds. We get ——— suds when we use a detergent.

b. If we find it hard to make suds in water, we call the water hard water.

c. Chemists invented (soap, detergents, limewater) to help make washing easier.

d. The fewest minerals would be found in (rainwater, river water, well water, sea water) ———.

e. If a little soap makes lots of suds we must have (hard, soft) ——— water.

Teacher Activities *(continued)*

3. Summarize the lesson by reviewing the effect different soils have on transmission of water and how water collects in the earth. Elicit from the students that underground water is a major source of our water supply. Minerals are dissolved by this water. This produces caverns in limestone regions and also hard water which is so mineral-rich that it is difficult to produce suds with soap. Chemists invented detergents to overcome this problem.

Suggested Homework

1. What is the source of water in your home?

2. Is the water in your home hard or soft?
3. What happens if too much detergent is used to wash clothes?
4. Can water travel hundreds of miles through the earth? Read about artesian wells in your school or neighborhood library.
5. Make a diagram or clay model of an artesian water system.

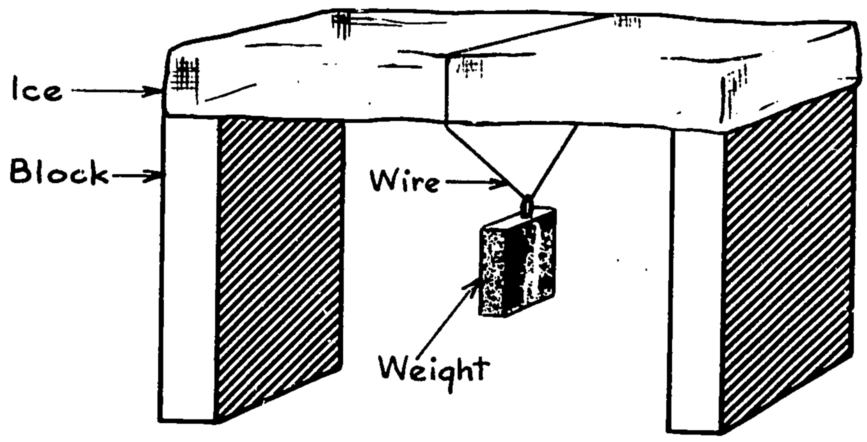
20. HOW HAVE GLACIERS CHANGED THE SURFACE OF THE EARTH?

Outcomes

- Glaciers once covered large areas of the earth.
- Glaciers are a very powerful means of erosion.
- Glaciers have produced many land features in and around N.Y.C.

Teacher Activities

1. Show the class a picture or tell them of a giant boulder that has been moved many miles from its original position. Elicit that a very powerful means of erosion was the cause. Show a picture of a valley glacier that is carrying large boulders. Tell the class that this heap of snow and ice is called a *glacier*.
2. Ask the pupils, "Could snow pile up, become ice, and be higher than the Empire State Building?"
3. Show pictures of continental glaciers. Point out the vast amount of ice and snow in these glaciers.
4. Show samples or pictures of rock that have been scratched by other rock imbedded in the bottom of a glacier. Point out that many rocks in Prospect Park and Central Park show these scratches.
5. Ask the students to suggest ways that a glacier can move. The following demonstrations will show that when ice piles up to a great thickness, its weight helps it to move.
   a. Place an asbestos square on each of 2 ice clubes. On one of the pieces of asbestos place a heavy weight. Have the students observe the rate of melting by comparing the heights of the asbestos sheets.
   b. To show how the melted ice can refreeze when the pressure is removed, set up the following demonstration.



After a few minutes the wire will be cutting down through the block of ice and the melted water above the wire will refreeze.

6. Elicit from the pupils that in the first demonstration, pressure causes the ice to melt faster. Relate this to the melting of ice at the bottom of a glacier. Elicit that this provides a means by which the glacier can move. Point to their experiences with trying to open jars with wet hands to get the understanding of "slippery" across to them.

   Elicit from the pupils that in the second demonstration, when pressure is removed from the top of the ice, the ice refreezes. Point out that pieces of rock will be caught in the ice as it refreezes and be carried along with the glacier.

7. Refer to the Empire State Building buried under snow. Elicit from the pupils that snow accumulating over a very long period of time and hardly melting or not melting at all could end up a mile deep.
8. Elicit from the pupils where glaciers may exist today. Point out that two types of glaciation can occur—valley and continental.
9. Point out that when a glacier melts it deposits the materials it is carrying. These deposits produce many land features.
10. Discuss some of the glacial features in and around New York City.

Suggested Homework

1. Recommend field trips to see glacial features.
2. Have selected students make a report on the "ice age."
3. Have students make models and charts of glaciers and glacial terrain.

21. HOW DOES WIND HELP TO CHANGE THE SURFACE OF THE EARTH?

Outcomes

- Wind helps change the surface of the land, particularly in dry regions.
- Soil is picked up by the wind in some regions and deposited in other regions, often in the form of sand dunes.
- A plant covering is important in saving our top soil.

Teacher Activities

1. Discuss pictures of men cleaning buildings with sandblasting equipment. Elicit that the buildings are cleaned by an artificial form of erosion.
2. Show pictures of desert scenes, sand dunes, and the beautifully sculptured rocks in Bryce Canyon Natural Park. Elicit from the class that wind can pick up small particles from the soil and carry them away. Some students may have been caught in a windstorm at the beach. Ask them to describe the effects of the windblown sand on them and on objects around them. Show the effects of wind and sand by performing the following demonstration:
3. Pour a pile of sand on the bottom of a large carton. (See New York State *Earth Science Handbook,* p. 67.) Turn an electric fan on the pile of sand and have the class notice how the particles are moved.
4. Relate this demonstration to the surface of the earth, particularly the drier farmland of central U.S. Draw the pupils into discussions of the effects of the erosion of top soil. Elicit from the students the need of a protective covering over the soil to prevent its loss.

   Point out that at many beaches on Long Island, grasses hold the sand from being blown into the ocean.
5. Distribute samples of dune sands from nearby beaches or other sources. Have the students examine the sand with a hand lens or stereoscopic microscope. Have the pupils identify minerals they have already learned. Have students describe the grains. Are they rounded or angular?
6. Show a film or filmstrip illustrating destructive and constructive forces of the wind. Point out that in the 1930's millions of tons of soil were removed by the wind from farms in Texas, New Mexico,

Kansas, North and South Dakota, and other western states and carried as far as the Atlantic Ocean.

Suggested Homework

1. In what kind of climate is the wind very effective as an agent of erosion?
2. How would it be possible for wind to move a sand dune hundreds of feet long?

THE IMPORTANCE OF FOSSILS

22. WHAT ARE FOSSILS?

Outcomes

- Fossils are the remains or evidences of animals and plants that lived during former geologic times.
- Fossils are related to modern forms of life.
- Fossils range in size from microscopic to large specimens.

Teacher Activity

1. Show class a piece of chalk and tell them that it was once alive.
2. Show a picture of the Dover Cliffs in England and tell students that it is made of chalk also.
3. Put a drop of dilute hydrochloric acid on chalk and elicit that it contains the same materials as limestone.
4. From the students' knowledge about sedimentary rocks, ask for possible explanations on the formation of the Dover Cliffs.
5. Show students large pictures of one-celled shell animals and tell them that the foram remains (tiny shells) make up the Dover Cliffs. Elicit from the pupils how this could be possible.

   The following activities should help the pupil grasp the concept of deep accumulation of one-celled animals:

   a. Noting the accumulation of dust on the chalkboard shelf
   b. Dusting two erasers over dark construction paper
   c. Snow accumulating over a long period.

   NOTE: Some chalk deposits are 1000 feet thick.

6. Show models, filmstrips, or photographs of
   a. Prehistoric animals and plants
   b. Animal evolution in past geologic eras
   c. The sequence of events in the formation and discovery of a fossil
   d. Typical environments of ancient times.
7. By use of the previous pictures or models elicit:
   a. Where did these prehistoric animals live?
   b. What was the climate where they lived?
   c. Why did they die out?

   NOTE: Possibly the result of great climatic and crustal change
8. Show pictures of dinosaurs and modern reptiles. Have students list on chalkboard the similarities between dinosaurs and today's crocodiles, lizards, etc. Elicit that some fossils are related to forms of life present today.
9. Display samples of trilobites and leaf imprints.

   Tell the pupils that the trilobite lived about ½ billion years ago. Ask a pupil to squeeze the trilobite between his fingers and to describe how it feels (hard or like a rock). Point out that today's cousins of the trilobite are the crabs, lobsters, and crayfish. Elicit that a lobster or crab shell "gives" when squeezed.

   Tell the pupils that the trilobite is a fossil. Ask a pupil to look at the second sample (leaf imprint). Elicit from the pupil that a living thing left its "print" in the rock. Ask the pupils where they think the original plant has gone. Point out that although the plant is gone, we still call this imprint a fossil. Elicit from the pupils that the imprint filled in with sediments (which later harden) would be a leaf made of rock, and therefore this is called one type of fossil.

   Elicit a temporary definition of a fossil: Fossils are the original or changed remains or prints of plants and animals that lived long ago. (Write this on the board. Have the pupils copy it into their notebooks.)

Suggested Homework

1. How do geologists know that trilobites lived many millions of years ago?
2. How do we know what the dinosaurs looked like if their soft parts are not present today?

23. HOW CAN PLANTS OR ANIMALS BE PRESERVED TO LAST FOR MILLIONS OF YEARS?

Outcomes

- Organisms may be fossilized in various ways. One of the ways in which organisms become fossils is by preservation.
- Some factors in the preservation of plants and animals are: drying, freezing, chemicals, and burial.
- Most fossils we find consist largely of the hard parts of plants and animals.
- Flesh and other soft tissues have been preserved under some rather unusual conditions, such as freezing and in tar pits.

Teacher Activity

1. Ask the pupils, "Would you eat a piece of meat which is one million years old?" Allow a few moments for comments. Show pictures of mammoths. Point out that wolves and dogs have eaten flesh of animals which died thousands of years ago and were not poisoned. Ask how this could be possible. Elicit that freezing preserves the flesh. (Make a comparison to modern freezers.)

   Show a picture or tell the pupils about the La Brea tar pits. Point out that the tar helps to preserve animals.

2. Distribute open boxes of fossils to the pupils.
   Ask the pupils to find any soft (flesh) parts that have been preserved. Elicit that the soft parts are either eaten or rotted away. Ask the pupils to suggest ways of preserving the soft parts. Point out that an animal may become a fossil if buried quickly so as to protect it from animals and the weather.

3. Review the conditions: moisture, moderate warmth, food, and air which are best for growth of molds and bacteria from the biology unit. Point out that conditions unfavorable for growth of bacteria are favorable for preservation. Give examples such as:
   a. extremely low temperatures in the Arctic regions
   b. extremely dry conditions in deserts
   c. favorable conditions in tropical regions (ideal for growth)

Student Activity

This activity should help the pupil duplicate the conditions which produce fossils in sediments.

The activity will be finished the following day.

Prepare the following materials described in the worksheet and distribute them and the worksheet to the students.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 23

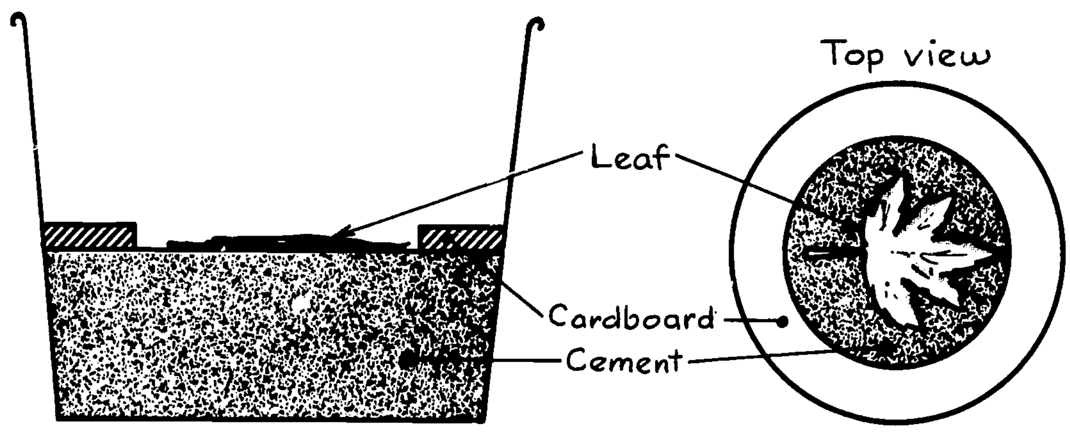
(May be duplicated and distributed to pupils)

Purpose: To make a fossil using a leaf, sand, and cement

Materials

Cardboard ring to fit inside diam. of cup
Leaf—maple or other flat type (2" diam.)
Waxed cup (4" - 5" diam.)
Paper dish (6" - 8" diam.)
Spoon or stick for mixing
Fine sand (6 oz.)
Cement (6 oz.)
Water
Petroleum jelly

NOTE: After the cement mix (1 part sand to 1 part cement) is prepared, the setup, in steps 6 and 7, should look like this:



Procedure

1. Mix the sand and cement together in the paper dish.
2. Add water slowly and mix as you do this.
3. Keep mixing and adding water until the mixture is like pancake mix.
4. Pour about half of this cement mix into the paper cup.
5. Grease the cardboard ring; use petroleum jelly.
6. Place the ring on top of the cement.
7. Place the leaf in the center of the ring (do not grease).
8. Pour the rest of the mix over the leaf.
9. Print your group number on the top of the cement mix with a lead pencil when it hardens a little.
10. Allow one day to harden.

Answer these

1. If the leaf is gone or has changed, could you call what remains a fossil? ____________ Why? ____________

2. What do you think the leaf will look like tomorrow? Next week? (Hint: What does a leaf first lose when it dies?)

Summary

Elicit the various methods of preservation.

Point out how the student activities are attempts to duplicate what happens in nature.

Suggested Homework

1. How long can you keep frozen foods safely in your refrigerator?
2. Why are foods vacuum-packed?
3. List 5 foods you have at home which are preserved.
4. If you bury a dead bird, will it become a fossil? Explain.

24. ARE ORIGINAL PLANT AND ANIMAL REMAINS THE ONLY TYPES OF FOSSILS THAT WE FIND?

Outcomes

- Sediments which cover plants and animals help to form fossils.
- The type of sediment which is ideal for producing fossils is made of very fine materials.
- Replaced remains or filled in copies of once-living organisms are also fossils.
- Fossils are often in the form of molds or casts.
- Molds show the shape of the original organism imprinted in rocks.
- Casts are formed by minerals which fill in the molds. The casts are materials which take the place of the original.
- Minerals which fill in casts are usually carried in solution by ground water.

Teacher Preparation

Prepare beforehand the following materials for demonstration of the petrifaction processes:

Permineralization—porous shells and bones are often altered by having mineral matter deposited in them by percolating water.

Replacement—results from simultaneous solution of the original material and deposition of the new substance.

1. Impregnate 2 small cellulose sponges (about $1'' \times 1'' \times 4''$) with melted paraffin (an example of permineralization).

2. Dissolve one of these sponges in concentrated nitric acid (the paraffin will remain). Use extreme caution. Make small holes in the specimen with a dissecting needle to hasten penetration of the acid. The cellulose dissolves in 3-4 days.

   Discard the nitric acid. Rinse with water.

3. Pour thin plaster of paris into the paraffined sponge and let it harden.

4. Heat the paraffin-plaster "sponge" at a low temperature to remove the paraffin. The specimen will look as it did originally but it will be an example of replacement.

Teacher Activities

1. Show a small cellulose sponge and the replaced sponge. Ask a student to hold each sponge in his hand and to describe each sponge. Elicit that the replaced sponge looks like the original sponge but it is harder and made of a different material.

   Tell the pupils that you used the original sponge to make a copy of it.

   Point out that some fossils are formed by being filled in with minerals (comparison—sponge impregnated with paraffin), and others are formed by replacement of the original components (comparison—plaster sponge, copy of original).

2. Ask the pupils whether they ever broke an arm or leg. Elicit the term cast and its inside appearance when cut open. Point out that some fossils are formed by the formation of a mold or the filling in of a mold to form a cast. Tell the pupils about the ash-covered town of Pompeii where plaster of paris has been used to preserve the external form of men and animals bur 1 by ashes from the eruption of Mt. Vesuvius, 79 AD.

Student Activity

In the first activity the pupils will break open the hardened cement mix from the previous lesson and observe the buried leaf. (A fine fossil-like imprint is produced.)

Distribute hardened cement mix, screwdriver, hammer, worksheets.

CAUTION: Stress safety procedures for splitting open the cement mix.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 24

(May be duplicated and distributed to pupils)

Introduction:

If a leaf is buried in sediments, it may fossilize or leave its impression in the sediments.

Procedure

Carefully break open the hardened cement mix made in the previous lesson. Use the small knife or screwdriver to pry the hardened mix apart.

1. Place the cement on a few pieces of paper toweling with the flat sides facing the walls of the room.
2. Place the screwdriver on top of the mix where the cardboard ring is located.
3. Tap lightly with a hammer.
4. Turn the cement slowly and tap again about an inch away from the original point. Continue step 4 until the cement splits open.

Questions

1. The hardened cement broke along a flat surface. Some rocks we have studied, which break along flat surfaces, are shale and ———— (granite, slate).
2. The particles that make up shale and slate are very ——— (large, small).
3. Shale is a ———— type rock (igneous, metamorphic, sedimentary).
4. Shale can change under great pressure into ————.
5. The leaf has left its ——— in the rock.
6. Rocks we are most likely to find fossils in are ———— and ————.
7. Which one of these rocks, igneous, metamorphic or sedimentary, is least likely to have fossils in it? ———— Why? ————

Suggested Homework

After class discussion of the worksheet activity, *thoroughly* explain the homework activity. Point out that nonfossils may be used if actual fossils are not available.

The purpose of this activity is to demonstrate how actual fossils and nonfossils can leave their forms impressed in sediments and how we can reproduce their forms by filling in the impressions.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 24A

(May be done at home)

(May be duplicated and distributed to pupils)

Purpose: Reproducing a fossil and a nonfossil

Introduction: If a plant or animal leaves its shape pressed into a rock, we can make a copy of the original living thing. In this activity you will make models of fossils and nonfossils.

Materials

#1 molding plaster (preferably) or plaster of paris
Clay (modeling clay works very well—to fill paper dish to depth of about 2″
Mixing tool—spoon, stick, etc.
Samples of nonfossils or fossils, if available (suggestions: trilobite, mollusks, teeth, small bones, fingernail, coins, charms, rings, etc.)
Large paper dish
Water
Small, soft brush
Petroleum jelly

Procedure

1. Cover the bottom of the paper dish with at least 2″ of clay.
2. Press the shells and fossils deeply into the clay.
3. Remove the shells and fossils with care.
4. Very lightly brush petroleum jelly over the imprints.
5. Mix the plaster with water until you get a paste a little thinner than pancake mix.
6. Pour the plaster mix into the imprints (holes) in the clay.
7. When the plaster has hardened remove each "model" from the molds.

Summary

1. When we pressed the samples into the clay we produced ____________.
2. When we filled in the holes (cavities) we produced ____________.
3. Minerals carried by ground ____________________ fill in casts.

Questions

1. If you think the item is a cast, made from a mold, print CAST next to it:
   a. ice pop ____________
   b. pencil ____________
   c. bottle ____________
   d. statue or trophy ____________
   e. telephone ____________
   f. iron railing ____________
   g. bottle cap ____________
   h. tire ____________
   i. light bulb ____________
   j. bar of soap ____________
   k. book ____________
   l. watchcase ____________
2. Mount the plaster (fossils) models produced, on cardboard. Label and write a few sentences about the fossil model, telling when it lived or where it lived or how it became a fossil.

25. HOW CAN WE LEARN TO IDENTIFY FOSSILS?

Outcomes

- Molds or bodies of insects may be preserved in the hardened resin (amber) of pine trees.
- Some preserved fossils are found as trails, burrows, footprints, ripple marks, or raindrop marks in rocks.
- Soft-bodied plants and animals are sometimes preserved as carbon films on rocks.
- Fossils may be identified by comparison to living things.
- Plants and animals change through the ages.

Teacher Activities

1. Show fossil ripple marks or raindrops in a rock. Pass it among the pupils. Ask them, "What kind of fossil is this?" Allow a few moments for suggestions. Point out that some fossils are marks left by the activity of nonliving things.
2. Relate to the activity with molds and casts where the students made impressions in clay with their fingernails. Elicit: animal tracks may be preserved as fossils in the form of worm trails, burrows, and footprints. Show pictures of dinosaur tracks. Relate these to similar tracks found in rocks in New Jersey and Connecticut.
3. Show pupils a manufactured fossil: plastic cubes containing flies, bees, etc. Tell the pupils that the idea for these might have come from nature. Pass around an insect preserved in amber, if available. Point out that this insect lived millions of years ago. Ask the children how they think it was fossilized. Have a student rub a freshly cut pine branch in his hand. Elicit that the sap is sticky. Point out that the same kind of sticky sap called resin trapped the insect and then hardened. Tell the pupils that we call the hardened substance amber.
4. Hold up a fossil that shows the process of carbonization (process where an organism's carbon remains are printed on rocks as a result of pressure and heat). Elicit from the class how the process of carbonization occurred.
5. Prepare the following materials and have them prominently displayed on the demonstration desk. These *8 items* should have large labels attached so they can be seen easily by the pupils.

a. Clam or other pelecypod
b. Snail or other gastropod
c. Bone—chicken, steak, or ham
d. Starfish or other echinoderm
e. Fern or other plant leaf
f. Sponge (natural)
g. Coral
h. Crayfish or horsehoe crab

6. Distribute trays of these labeled fossil materials.
   a. Fossil clam (mollusk)
   b. Fossils snail (mollusk)
   c. Fossil bone
   d. Fossil starfish
   e. Fossil leaf (carbonized)
   f. Fossil sponge
   g. Fossil coral
   h. Fossil trilobite

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 25

(May be duplicated and distributed to pupils)

Purpose: To compare fossils with their modern cousins

Introduction

Although fossils lived millions of years ago they have modern "cousins" living on the earth today.

Materials: Eight numbered fossil specimens

Procedure

1. Look at the eight samples on the teacher's demonstration table. You have fossils on your tray which are related to those in front of the room. Try to match the fossil with its modern "cousin." Write the number of the fossil next to the name it is related to.
2. Write the names of any fossils you think you know in the space called—FOSSIL NAME.

No.	MODERN SPECIMEN	FOSSIL NAME
	Clam	
	Snail	
	Bone	
	Starfish	
	Fern Plant	
	Sponge	
	Crayfish	
	Coral	

Summary

1. The fossils which looked most like their modern "cousins" were ________, ________, and ________.
2. The fossils which looked least like their modern "cousins" were ________ and ________.
3. The only plant in this group of fossils was the ________.
4. Only two of these fossils lived on land all or most of the time; they are ________ and ________.

Teacher Activities *(continued)*

Elicit from the pupils that there are remarkable similarities among organisms which lived millions of years apart. Point out that many fossils are no longer living (extinct). Elicit that plants and animals change over long periods of time.

Suggested Homework

1. How can fossils be compared to living things?
2. How would you compare a scientist interested in fossils to a detective?

26. WHY ARE COAL AND OIL CALLED FOSSIL FUELS?

Outcomes

- Coal is one of our largest sources of energy.
- Coal is the end product of metamorphic processes from prehistoric plants to peat to lignite to bituminous to anthracite coal.
- Evidence of prehistoric life is called a fossil; hence coal as well as oil and gas are called fossil fuels.
- The probable source of petroleum is tiny marine plants and animals.
- Natural gas is often found together with oil, and it is probably derived from the plants and animals from which the oil was produced.

Teacher Activities

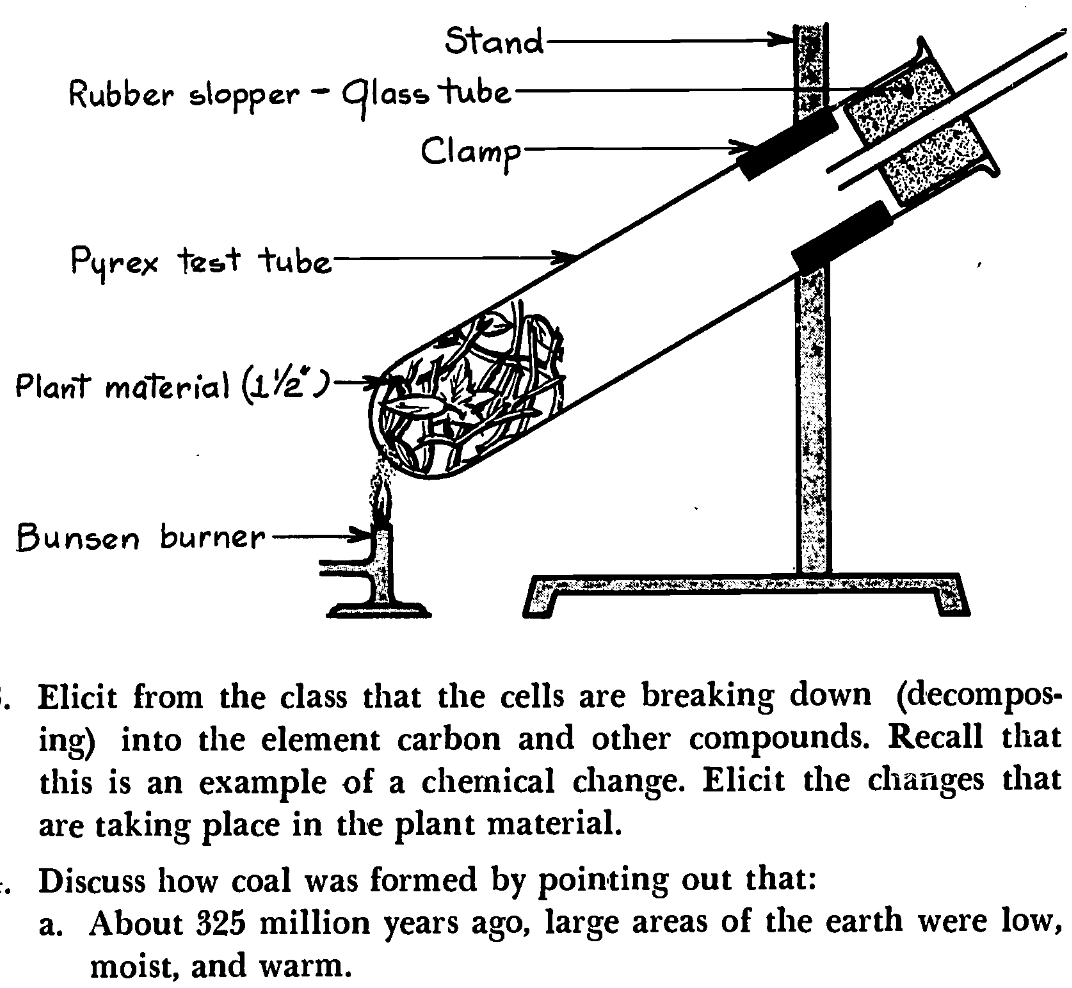
1. Show the students a fern leaf or an entire fern plant. Ask the pupils, "Could this leaf make an automobile go?" Allow a few minutes for suggestions.

   Point out that today's activities should help us answer this question.

2. In the following activity you will show the changes that take place when plants, such as twigs and/or leaves, are heated.

   Into a test tube place some plant material (plants, twigs, leaves, pine needles, etc.) and set up the apparatus as shown in the diagram following.

   CAUTION: Check the glass tubes for obstructions which might prevent the gases from escaping, in order to prevent possible explosions. Heat the test tube for a few minutes. After a few minutes smoke should be coming out of the glass tube. Try to light this smoke (gas) with a lighted splint.



3. Elicit from the class that the cells are breaking down (decomposing) into the element carbon and other compounds. Recall that this is an example of a chemical change. Elicit the changes that are taking place in the plant material.
4. Discuss how coal was formed by pointing out that:
   a. About 325 million years ago, large areas of the earth were low, moist, and warm.
   b. Great swampy forests of giant ferns and scale trees existed.
   c. The land sank gradually.
   d. The sinking allowed great thicknesses of plant debris to accumulate in swamp waters without filling the swamps.
   e. Eventually, the remains were buried under great deposits of sediment hundreds of feet thick and partially preserved.

f. Metamorphism gradually changed the original plant material to coal.

NOTE: Review metamorphism from the Earth Science lessons (10 and 11) on rocks.

Student Activity

To show the sequence of events from plant life to coal, distribute the following materials:

1. Plants—fir or pine leaves, also wood splints
2. Samples of peat, lignite, bituminous coal, and anthracite coal (labelled).

The pupils will observe these materials to see the changes that take place in plants as they evolve into coal.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 26

(May be duplicated and distributed to pupils)

Purpose: To study the various forms of coal

Introduction

The plant materials on your tray will show the changes that take place in plants as they are changed to coal.

Materials

Peat	Bituminous coal	Hand lens
Lignite	Anthracite coal	

Procedure

1. Observe specimens with hand lens.
2. The materials in which we can best see original plant materials are ____________ and ____________.
   The color of these samples is ____________.
   The sample which easily comes apart in your hands is ____________.
3. Which of the two coals is harder? ____________.
   (Try scratching bituminous coal with anthracite coal.)

Summary

Coal is formed from ____________ which are changed by ____________ into carbon. Since the coal is harder than the peat and lignite, it probably was formed under great ____________.

Teacher Activities *(continued)*

5. At this point show a fossil containing plant imprints in coal. Elicit from the class that these imprints are the remains of plants that lived about 320 million years ago. Relate this to the distillation of wood activity just completed which shows the sequence from plants to coal.

6. Briefly account for the presence of oil and natural gas as originating from marine plants and animals. (Write to American Petroleum Institute, 50 W. 50th Street, New York, N. Y. 10020, for a free wall chart, "In Search of Oil" and other materials on oil.)

   By relating to the above activity on the burning of gases, point out that natural gas is often found with oil which is believed to come from plants and animals that had once lived.

   Summarize the lesson by reviewing the origin of coal, its metamorphism, and use as a fuel. Use the term *fossil fuels* to describe coal, oil, and gas, and ask for an explanation of the term.

Suggested Homework

1. a. What kind of fuel is used to heat your home?
   b. Do you have a water heater? If so, what kind of fuel does it use?
   c. What dangers are present if you have a gas heater in your home?
   d. What safety steps should be taken to overcome these dangers?
2. Read about the many other uses for coal. Look up coal tar in an encylopedia in the school library. (Report by selected students)
3. Read about the many other uses for petroleum. Look up petroleum, kerosene, gasoline, in the school library. (Report by selected students)

27. HOW DOES MAN MAKE USE OF PLANTS AND ANIMALS THAT LIVED AGES AGO?

Outcomes

- Many products we use come from fossils.
  - We use many coal derivatives — nylons, TNT, plastics, asphalt, etc.
  - Metamorphosed carbon is used as a lubricant (graphite) and in lead pencils (graphite and clay).

- Graphite, a form of carbon highly metamorphosed, produces diamonds.
- Some building materials such as limestone, used in school buildings, are made from fossils.
- Microscopic plant shells found in toothpaste and scouring powders are used as fine abrasives in cleaning and polishing.

● Fossils help man to better understand the Earth's past history.

Teacher Activity

1. Show a piece of coal and a piece of plastic. Point out that we get many products from coal derivatives such as plastics, nylons, T.N.T., asphalt, etc.
2. Review briefly the changes that took place when leaves were heated in a test tube. Elicit from the class that heat changes leaves to carbon. Point out that under great heat and pressure carbon changes to graphite which is used as a lubricant, electrical conductor, and in lead pencils. Ask students which precious gem would be produced if graphite was further metamorphosed.

   Have students suggest other materials in school building made of animals that lived millions of years ago. (chalk, limestone building materials)
3. Show pictures of men digging up fossil clams from sedimentary rocks on top of mountains. Ask students how this is possible.
4. Pass around samples of coral. Point out that at one time this was an animal's house. This animal lived in warm (68°F) waters. As these animals piled up, coral islands and reefs were formed. Coral reefs have been found near Greenland where it is very cold nowadays. The water near Greenland must have been quite warm millions of years ago.

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 27

(May be duplicated and distributed to pupils)

Purpose: To study a useful fossil

Introduction

Diatoms are tiny plants that died millions of years ago.
Their remains (shells) are used to polish and clean things we use every day.

Materials

Microscope
Diatomaceous earth
Glass slide
Cover slip
Lens paper
Dropper bottle of water
Toothpicks
Scouring powder
Toothpaste

Procedure

1. Prepare the microscope for use.
2. With your toothpick, put a speck of diatomaceous earth on a clean microscope slide. Put one drop of water over it and stir with the toothpick. Place the cover slip over it. Look at this slide under low power (100X) first. What is its appearance? ____________
3. Now examine the slide under high power (400X). What do you see? ____________
4. The organisms you see are the cell walls of microscopic plants called diatoms. These cell walls are made of quartz (silica). What is the hardness of quartz (silica)? ____________
5. Now look at the scouring powder under the microscope. Begin with 100X and then use the high power (400X) to look at the powder. Scouring powder contains ____________
   This substance is commonly used in polishes, scouring powder, and toothpaste. Explain why. ____________

Teacher Activities *(continued)*

5. Summarize by eliciting the variety and importance of materials derived from fossils.

Suggested Homework

1. Cut out a picture of something which came from a fossil that we use in the home, neighborhood, or school. Paste the picture on a piece of paper. Write its name on top of the paper and describe the fossil it came from in one sentence.
2. Research other uses of diatomaceous earth and list these.

28. WHAT DO FOSSILS REVEAL TO US ABOUT PREHISTORIC ENVIRONMENT?

Outcomes

- Pupils acquire an appreciation and understanding of the expanse of geologic time and man's place in this time period.

- The earth's crust has been changing continuously over billions of years.

Teacher Activity

This activity ties together the fossil story and helps to develop an understanding of the earth's geologic past.

1. Prepare the worksheets and distribute them to the students.

   Point out the structure of the chart to the pupils, stressing the following:

   a. Eras are long periods of time in which marked differences in the earth and in plants and animals have taken place.

   b. Many plants and animals did not survive from one era to another.

   c. The column Years Ago indicates when the plant or animal first appeared.

   d. The time line is disproportionate to the actual lapse of time.

   e. The last column shows some of the physical activities through the ages.

   f. Point out that the chart shows a very small part of all the plants and animals that ever lived and physical occurrences that have taken place over a period of 2 billion years.

   g. Have students complete the worksheet in class.

2. After completion of worksheets:

   a. Elicit the probable age of the earth as more than 4½ billion years.

   b. What advantages were there in life on land compared with life in the sea?

   c. Why are there no actual remains of the earliest living things? NOTE: Graphite deposits in the earliest strata indicate that probably only soft-bodied organisms existed then.

   d. Discuss the adventures of fossil-collecting.

HISTORY OF THE EARTH TIME CHART				
ERA (*Time period*)	How Long Each Era Lasted	How Many Years Ago Plant or Animal First Appeared	Life Through the Ages as It First Appeared	Some Changes Which Took Place in Each Era
		Approximate		
CENOZOIC	60 million years	1 million	man	Great Lakes were formed.
		40 million	elephant	Glaciers cover large parts of U. S.
		60 million		N. Y. C. largely covered by ice thousands of feet thick.
				New Appalachians rise.
MESOZOIC	125 million	100 million	flowers	Rocky Mts. begin to rise.
		150 million	birds	
		180 million	dinosaurs	Palisades formed along Hudson Riv.
PALEOZOIC	335 million	230 million	reptiles	Old Appalachian Mts.
		325 million	ferns	Great coal-forming swamps in U. S., especially in Penn., Ohio, W. Virginia, Illinois, and Indiana.
		440 million	fish, clams	
		500 million	trilobites	
		520 million	seaweed	
PROTEROZOIC	1.2 billion	over 1 million	worms	Volcanic activity
			sponges	Mountain-building
ARCHEOZOIC	2.5 billion		one-celled plants	Great volcanic activity

STUDENT WORKSHEET — EARTH SCIENCE: LESSON 28

(May be duplicated and distributed to pupils)

Purpose: What can we learn from History of the Earth Time Chart?

Introduction

You have learned how fossils are formed and how man measures the age of fossils and rocks. This activity will help you understand the story of the earth for the past 2 billion years.

Most of these sentences may be filled in by using the *History of the Earth Time Chart.*

1. The first kinds of life we find on the earth were the ______________.
2. The (sponges, worms) ____________________ were more likely to leave fossils because they had harder parts.
3. Half the U.S. was under water about ______________ million years ago.
4. About 320 million years ago the first ______________ appeared on the earth.
5. Dinosaurs are reptiles. The first dinosaurs appeared about __________ million years ago.
6. The Mesozoic Era is called the "Age of ____________________________".
7. Palisades Amusement Park is sitting on rock which hardened from lava about ____________________ million years ago.
8. The great coal-forming swamps must have had very large numbers of ________________________growing in them. One of these plants was the ________________________.
9. The glaciers left New York City about 11,000 years ago. At one time part of all of New York City must have been buried under __________ ________________________.
10. Man is first noticed on the earth about ____________ million years ago. When the glaciers covered New York, early man probably moved to the ____________________ to stay alive.
11. A geologist drilling into the earth finds a trilobite. Is he correct if he says that the layer in which he found the animal is about 150 million years old? ____________ Why? ____________
12. Certain fossils lived when oil was formed on the earth. The fossils are of small sea creatures such as clams and coral. Fossils of sea animals are found near oil. Would it be worthwhile to drill in rocks of the Archeozoic Era for oil? ______________ Why? ______________
13. Which plant or animal that lived about 500 million years ago is no longer living (extinct) today? ____

SUGGESTED REFERENCES: EARTH SCIENCE

For the Teacher

BATEMAN, A. M. *Economic Mineral Deposits.* New York: Wiley, 1950.

BATES and SWEET. *Geology; An Introduction.* Boston: Heath, 1966.

BILLINGS, M. P. *Structural Geology.* Englewood Cliffs, N. J.: Prentice-Hall, 1954.

DANA, J. D. *System of Mineralogy.* (7th ed.) New York: Wiley, 1944.

DUNBAR, C. O. *Historical Geology.* New York: Wiley, 1948.

EMMONS, et al. *Geology.* New York: McGraw-Hill, 1961.

FENTON, C. L. and M. A. *The Fossil Book.* New York: Doubleday, 1958.

FLINT, R. F. *Glacial and Pleistocene Geology.* New York: Wiley, 1957.

HELLER, R. L. (ed.). *Geology and Earth Sciences Source Book.* New York: Holt, 1962.

HURLBUT, C. S. *Dana's Manual of Mineralogy.* (17th ed.) New York: Wiley, 1959.

JAEGER, E. C. *The North American Deserts.* Palo Alto, Calif.: Stanford University Press, 1957.

JOSEPH, A. et al. *A Source Book for the Physical Sciences.* New York: Harcourt, 1961.

KRUMBEIN, W. C. and SLOSS, L. L. *Stratigraphy and Sedimentation.* (2nd ed.) San Francisco: Freeman, 1964.

LAHEE, F. H. *Field Geology.* (6th ed.) New York: McGraw-Hill, 1961.

LEET, L. D. *Physical Geology.* Englewood Cliffs, N. J.: Prentice-Hall, 1962.

LONGWELL and FLINT. *Introduction to Physical Geology.* New York: Wiley, 1962.

LOOMIS, F. B. *Field Book of Common Rocks and Minerals.* New York: Putnam, 1957.

RICHTER, C. F. *Elementary Seismology.* San Francisco: Freeman, 1958.

SHIMER, J. A. *This Sculptured Earth.* New York: Columbia University Press, 1959.

STRAHLER, A. N. *Physical Geography*. New York: Wiley, 1960.

———. *The Earth Sciences*. New York: Harper and Row, 1963.

U.S. Dept. of Agriculture. *Water, 1955 Yearbook; Soil 1957 Yearbook*. Supt. of Documents, Washington, D.C. 20402.

WHITE, J. F. *Study of the Earth*. Englewood Cliffs, N. J.: Prentice-Hall, 1962.

ZIM, H. S. *Rocks and Minerals*. New York: Simon and Schuster, 1957.

ZUMBERGE, J. H. *Elements of Geology*. New York: Wiley, 1964.

For the Pupil

AMES, WYLER. *Planet Earth*. New York: Golden Press, 1963.

ANDREWS, R. C. *In the Days of Dinosaurs*. New York: Random, 1959.

BLOUGH, G. O. *Discovering Dinosaurs*. New York: Whittlesey House, 1960.

BUEHR, W. *Volcano*. New York: Morrow, 1962.

ENGLISH, G. L. and JENSEN, D. E. *Getting Acquainted with Minerals*. New York: McGraw-Hill, 1958.

FENTON, C. L. and M. *In Prehistoric Seas*. New York: Doubleday, 1963.

HEFFERNAN and SHAFTEL. *The Minerals Story*. Syracuse, N.Y.: Singer, 1963.

IRVING, R. *Volcanoes and Earthquakes*. New York: Knopf, 1962.

KNIGHT, D. C. *First Book of Deserts*. New York: Watts, 1964.

LAUBER, P. *All About the Planet Earth*. New York: Random, 1962.

LEOPOLD, S. A. and the Editors of LIFE. *The Desert*. New York: Time, Inc., 1962.

LIFE and BARNETT, LINCOLN. *The World We Live In*. New York: Golden Press, 1956.

MARCUS, R. B. *The First Book of Glaciers*. New York: Watts, 1962.

MATTHEWS, W. H. *Exploring the World of Fossils*. Chicago: Childrens Press, 1964.

MILNE, L. J. and M. and the Editors of LIFE. *The Mountains*. New York: Time, Inc., 1962.

PEARL, R. M. *Wonders of Rocks and Minerals.* New York: Dodd, Mead, 1961.

POUGH, F. H. *Our Earth.* Racine, Wis.: Whitman, 1961.

RUCHLIS, H. *Your Changing Earth.* New York: Harvey House, 1963.

VAUGHN-JACKSON, GENEVIEVE. *Mountains of Fire.* New York: Hastings House, 1962.

WATSON. *Dinosaurs and Other Prehistoric Reptiles.* New York: Golden, 1960.

WHITE, A. T. *Rocks All Around Us.* New York: Random, 1959.

WYCKOFF, J. *The Story of Geology.* New York: Golden, 1960.

ZIM, H. S. *Rocks and How They Were Formed.* New York: Golden, 1961.