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ABSTRACT

This publication is a teacher's guide for teaching seventh grade science in New York City Schools. Activities for four areas -- physics, chemistry, earth science, and biology -- are included. This particular edition is a reprint of Science: Grade 7, Curriculum Bulletin Nos 9a--9d, 1962-1963 Series, which were originally produced in four separate parts. Science: Grade 7 is part of a K-12 program based upon the sequential development of selected scientific concepts. Special features of the format for the course of study as represented by this publication are: topical outline; sequential units in each of the four science areas; outcomes listed for each section of every unit; logically developed classroom lessons with specific content, methodology and techniques; designated laboratory lessons including explanatory notes for the teacher and worksheets for the pupils; and enrichment materials, such as assignments, questions, reports, and projects. Each unit includes a list of suggested references. (BR)

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00-8040-32

SCIENCE
Grade 7

Chemistry

Physics

Bureau of Curriculum Development
Board of Education of the City of New York

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Curriculum Bulletin • 1968-1969 Series • No. 15

SCIENCE
Grade 7

Chemistry

Physics

Biology

Earth Science

Bureau of Curriculum Development
Board of Education of the City of New York

NOTE TO TEACHERS

This edition is a reprint of *Science: Grade 7*, Curriculum Bulletin Nos. 9a-9d, 1962-63 Series, which was originally produced as four separate parts, namely

The Chemistry of Matter
Electricity, Magnetism and Heat
The Materials of Life
Living on the Changing Crust of the Earth

This volume and *Science: Grade 7 (Long Form)*, Curriculum Bulletin No. 14, 1966-67 Series, cover the needs of all teachers and students in this grade.

Curriculum Bulletin • 1962-63 Series • No. 9a

SCIENCE

Grade 7

1. The Chemistry of Matter

Bureau of Curriculum Development
Board of Education of the City of New York

FOREWORD

In these times of great scientific advancement and opportunity, we are increasingly dependent upon a scientifically literate population. Our young people must be led to explore, search for, and discover scientific ideas "which are durable for at least a generation."

A new science course of study for Grades 7-8-9, part of a K-12 program, is currently being prepared. The new course is based upon the sequential development of scientific concepts from the four major science areas.

This bulletin is the first in a series of twelve bulletins, one for each portion of the course — chemistry, physics, biology, and earth science — at each grade level. The materials herein have been applied and evaluated in classroom situations over a period of two years. Teachers and supervisors will find herein practical assistance in putting into practice the chemistry part of the proposed revised course in junior high school science.

The science program, of which this bulletin is a part, envisions in-service training in schools and districts.

It is hoped that this bulletin and the others in preparation will make possible further development and extension of the program.

JOSEPH O. LORETAN
Deputy Superintendent of Schools

MARTHA R. FINKLER
Acting Associate Superintendent
Junior High School Division

JACOB H. SHACK
Acting Associate Superintendent
Division of Curriculum Development

June 1963

CONTENTS

INTRODUCTION v
ELEMENTS 1
COMPOUNDS AND MIXTURES 13
ATOMIC THEORY 24
SUGGESTED REVIEW QUESTIONS 36
SUGGESTED REFERENCES 42

INTRODUCTION

This unit of the revision of Science Grade 7 is a step in a long program which has enlisted the service of the Junior High School Division, the High School Division, the Division of Curriculum Development, the Bureau of Science and the Bureau of Curriculum Research. It is part of a K-12 effort in science curriculum development. *This program is directed toward meeting the need for a scientifically literate population.* In addition, the science program is designed to lead young people to explore challenging scientific ideas and their applications. In this way, those who find the search for and discovery of ideas exciting and rewarding will be encouraged *to prepare themselves for further work in the areas of science.*

By 1960, after the necessary planning, preparation of materials, and experimentation, the K-6 section of the total science program was in such form that the time was opportune for the next major step — a new course of study for Grades 7-8-9.

The Curriculum Council on June 21, 1961, approved a curriculum project in science Grades 7-8-9 which would explore and prepare the junior high school section of the K-12 program. Dr. Joseph O. Loretan, Associate Superintendent, Junior High School Division, and Mr. Jacob H. Shack, Acting Associate Superintent, Division of Curriculum Development, were assigned over-all supervision of the construction of the new course.

The planning and design of the Science Grades 7-8-9 Project is under the direct supervision of William H. Bristow, Assistant Superintendent, Bureau of Curriculum Research, Martha Finkler, Assistant Superintendent, Junior High School Division, and Samuel Schenberg, Director of Science.

To explore the various problems involved in the preparation of a new course of study for the junior high school segment of the K-12 science program, a curriculum advisory committee was appointed. The Science Curriculum Advisory Committee consists of:

Martha Finkler, Assistant Superintendent, Junior High Schools
Seelig L. Lester, Assistant Superintendent, High Schools
Samuel Schenberg, Director of Science; *Chairman*
Alfred D. Beck, Assistant Director of Science, Junior High Schools
Isidor Auerbach, Principal, John Jay High School
Irving I. Cohen, Principal, Thomas Jefferson High School

Darwin S. Levine, Chairman of Standing Committee
on Science Supplies
Mary R. Mullins, Principal, Junior High School 172 Queens
Samuel N. Namowitz, Principal, Junior High School 82 Bronx
Charles Tanzer, Principal, Junior High School 17 Manhattan
Walter W. Wolff, Principal, William Cullen Bryant High School

The Curriculum Advisory Committee accepted with modifications a plan submitted by the Director of Science to employ large blocks of subject matter from the four specialized sciences, sequentially, in Grades 7, 8, and 9. In order to implement this plan, a Junior High School Science Revision Committee was appointed. To work under optimum conditions, the regular members of the revision committee met mainly on Saturdays and thus avoided the necessity of leaving their classes and schools during school hours. All members of the committee except the Director of Science were paid for the Saturday work. The members of the Revision Committee are:

Samuel Schenberg, Director of Science, Office of Science Education, Director of the Project
Charles A. Colman, Assistant Principal, Junior High School 217Q
*Ronald Dermer, Teacher of Science, Junior High School 210K
**Milton Forrest, Acting Principal, Junior High School 190Q
Peter Greenleaf, Supervisor, Bureau of Audio-Visual Instruction
†Paul Kahn, Assistant Principal, Junior High School 45X, Chairman of the Committee
George Kanstroom, Chairman, Science Department, Richmond Hill H.S.
Bernard Kauderer, Assistant Principal, Junior High School 216Q
Leon L. Kurtz, Assistant Principal, Junior High School 143X
Arthur H. Lefgren, Chairman, Technical Division, George Westinghouse Vocational and Technical H.S.
Alfred W. Leichtman, Assistant Principal, Junior High School 216Q
**Joseph M. Oxenhorn, Assistant Principal, Junior High School 216Q
***Alice Pataky, Science Coordinator, Junior High School Division
William Poppel, Assistant Principal, Junior High School 189Q
Marie A. Soscie, Teacher of Earth Science, Newtown H.S.
Eugene Stern, Chairman, Science Department, George Washington H.S.
Jules Weisler, Teacher of Science, Junior High School 217Q
Louis Weiss, Chairman, Chemistry and Biology Department, Brooklyn Technical H.S.

* Appointed to Committee January 1963
** Resigned September 1962 to become principal of an elementary school
*** Resigned January 1963 to assume new assignment for the Junior High School
† Resigned June 1963 to resume assignment in schools

Serving as consultants to the committee:

- Alfred D. Beck, Assistant Director of Science, Office of Science Education, Junior High Schools
- Robert L. Lipton, Assistant Director of Science, Office of Science Education, High Schools
- Harry Milgrom, Assistant Director of Science, Office of Science Education, Elementary Schools
- Julius Schwartz, Consultant in Science, Bureau of Curriculum Research
- Leonard Simon, Junior High School Curriculum Coordinator, Bureau of Curriculum Research

Objectives of the Junior High School Science Course of Study

The objectives of the Junior High School Science Course of Study reinforce the aims of general education. In addition, they include the objectives that are specific to the study of science. These seek to have the pupil continue to:

- Develop the concepts, skills, knowledges, and attitudes which were begun in Grades K-6.
- Develop a firm scientific foundation, including laboratory skills upon which the program in Grades 10-12 can be built.
- Explore the various scientific disciplines for the development of individual interests and abilities.
- Explore the possibility of a satisfying and challenging career in a scientific field.
- Understand science as a unified whole by perceiving inter-relationships among the four fields of science.
- Appreciate the role of science in the progress of civilization and in the development of our technological society.
- Understand the methods employed by the scientist in his attack upon problems affecting the health and welfare of the human race and to rely upon his findings.
- Apply scientific methods and attitudes, where possible, as a way of life.

Innovations in Science 7-8-9

To attain these goals, the program offers a body of up-to-date subject content in a well-developed matrix that should be interesting and exciting to teachers and students alike. The course of study is set forth logically and in detail to provide adequate assistance and direction to new teachers. This is accomplished by delineating methodology, content, and techniques in progressively-developed units of classroom and laboratory lessons. Among the innovations are:

1. *Emphasis upon concepts:* This material calls for an understanding of the important concepts underlying each of the four scientific disciplines as well as the inter-relationships among them. Biological concepts are treated with greater depth of understanding because they are based upon fundamental concepts in the fields of chemistry and physics. There is a reorientation away from reliance on descriptive presentation toward demonstrations and direct pupil experiences in the development and understanding of the concepts.
2. *Focus on the sciences:* Units of fundamental science content from the fields of chemistry, physics, biology, and the earth sciences are presented separately in the seventh, eighth, and ninth grades. Each unit is developed lesson-by-lesson, building upon previous concepts and expanding upon the problem-solving ability of the pupils. Thus, the internal structure of each science is maintained.
3. *Integration of laboratory work:* The new course of study calls for the study of science in the junior high schools of New York City as a major subject area with the allocation of at least four periods per week in Grades 7 and 8 and five periods per week in Grade 9 including one double laboratory period per week. In addition, laboratory assistants are being assigned to assure its successful operation. Both requirements are necessitated by the general approach of teaching science in depth and by the fact that laboratory work is considered here to be an integral part of science teaching. In fact, laboratory lessons are included directly in each unit at the proper times for their presentation.
4. *Stress on critical thinking:* Emphasis is placed upon science as a method of thinking, of investigation, and of operation. To implement these aspects, the committee has selected the scientific concepts after careful deliberation of their significance and their contribution to further and deeper understanding of the nature, structure and inter-relationships of the sciences. The selective process stresses the need for sufficient classroom time and opportunities for mature reflection. To this end, a definite limitation has been placed on the total content in order to enable the teacher to implement the goals of science education.

Format

In accord with the objectives and innovations of the present course of study, it became incumbent upon the committee to devise a distinctive format.

Among its special features are:

- Topical outline
- Sequential units in each of four science areas
- Division of each unit into sections for ease in reviewing and testing
- Outcomes listed for each section of every unit
- Each section designed to be a complete lesson
- Direct reference to inter-relationships among the sciences as they occur in the development of the lessons
- Logically-developed classroom lessons with specific content, methodology and techniques
- Designated laboratory lessons including explanatory notes for the teacher and work sheets for the pupils
- Enrichment materials, such as assignments, questions, reports, and projects

The format provides the framework within which are pictured the two basic types of science lessons, the classroom and the laboratory. Both are described in the sections that follow.

The Class Lesson

Of the twenty-four lessons comprising each of the four units in the seventh grade, approximately sixteen may be classified broadly as classroom lessons. Each one has been numbered sequentially and tailored to fit the standard forty-minute period. Following generally accepted planning procedure, the lessons include a statement of the aim in question form, motivation, development, and a terminal summary. Among the specific techniques that may be found within the broad classification of classroom lessons are demonstrations, discussions, lectures, reports, seminars, reviews, and individual laboratory work of short duration.

In order to help the inexperienced teacher and the one whose area of specialization does not coincide with that of the unit, each lesson has been worked out in detail. The detail encompasses *not only methodology, techniques, content, and outcomes but also inductive development where possible and connection with lessons that precede and those that follow.* Because so much of the burden of lesson planning is obviated by this approach, more time will be available for the preparation of the many demonstrations and other multi-sensory experiences called for in almost every section of each unit.

The class lessons foster an enquiring attitude on the part of the pupils in that they feature thought-provoking questions and demonstrations. As the teacher calls for and encourages pupil replies and questions, a stimulating scientific air will prevail in the classroom. Experience shows that short question periods at the start and at the conclusion of lessons are highly effective in orienting the attitude and thinking of students in the scientific approach to the solution of science problems.

Since reporting is an important pupil activity in the units, the teacher should acquaint the pupils with reliable sources of information and with the proper form, content and structure of a report. Stress should also be placed upon effective presentation of reports to the class. Reports should not be read. The class will evaluate the reports on the basis of such criteria as clarity, interest, completeness and use of illustrative material. An evaluation chart prominently displayed in front of the room, containing a list of the selected criteria, is an invaluable aid toward achieving stimulating reporting.

Finally, the recitation lessons developed in the materials are not intended to be employed as a substitute for individual lesson planning. Lesson plans must be adapted to the capability and personality of the individual teacher and must be geared to meet the specific needs of the students in a given class.

The Laboratory Lesson

Individual laboratory lessons are among the most effective means of reaching many of the objectives of science education such as the inculcation of the scientific attitudes, procedures, and modes of thinking. Individuals learn best by doing and thus secure real experiences. To achieve these goals, *pupils should be given the opportunity of planning the laboratory exercises rather than being directed by specific instructions in a step-by-step manner.* After the planning stage, it is extremely desirable to allow the pupils to carry out their own plans for performing the experiments. This the present course of study aims to do.

However, for successful planning, the teacher must provide the required background techniques and information prior to the laboratory experiences. In addition, adequate safety instruction is more than ever important in laboratory work which allows much freedom to the children. Each teacher must secure a copy and acquaint himself as well as the children with the contents of Board of Education booklet, "For Greater Safety in Science Teaching."

Approximately one-half of the periods in the units are set aside for laboratory work. This time allotment allows for from four to six laboratory lessons, each of which requires a double laboratory period. Assigned two consecutive numbers, the laboratory lessons are also distinguishable in having explanatory notes to the teacher and work sheets for the student. Initially, the work sheets contain detailed step-by-step procedures, which later give way to less detailed problem-solving instructions. It may readily be observed that the laboratory lessons are not all of the problem-solving variety; some offer the opportunity to acquire techniques or skills, while others are designed to teach concepts in a step-by-step manner.

The laboratory lesson is divided into three parts: the introductory or preparatory period, the work or laboratory period, and the discussion period. During the introductory interval, it is suggested that materials be distributed *quietly on trays* by the laboratory assistant and that the pupils be told the required information or technical matter. While this is going on, the teacher should seek to have the slower classes delineate the problem and to suggest possible methods for its solution. For the laboratory period, the class should be divided into groups of 2-4 pupils depending upon the availability of equipment and materials. It is suggested that the pupils retain their original groups and select a group leader who will be responsible for taking and returning the equipment. The pupils should be told to work together, to discuss and rotate tasks, and to call upon the teacher for help as required. It is essential that normal classroom order be maintained during the laboratory interval in order that pupils may hear instructions from the teacher. It is also suggested that the teacher and laboratory assistant circulate about the room to detect difficulties and to encourage and assist individual pupils as needed. After a short clean-up and collection time, at least 20 minutes should be allowed for the discussion of the procedures, observations and conclusions and for the answering of questions. Every good laboratory session points up the many new problems that may be lead to fruitful investigation.

It cannot be overemphasized that if the class is properly trained in laboratory decorum and responsibility, the laboratory work should proceed without difficulty and with much profit. To this end, the teacher must begin the proper training at the very first laboratory period.

Every pupil should be required to keep a science notebook with a laboratory section in which to record his data, observations, conclusions, and answers to the summary questions for each laboratory lesson. If he is encouraged to see new problems as he analyzes the data, he will suggest hypotheses for their solution which may become the bases for additional experimentation, project, and laboratory work.

How to Use This Bulletin

While the lessons are suggestive in nature, the teacher may use them with confidence. No doubt the order of presentation, the motivation, and the activities, among others, may be altered on the basis of experience, nature of the class, and creative bent of the teacher. However, the basic minimal outcomes should remain intact. If some lessons are found to be too long, they may be shortened by omitting some of the supporting activities. If some lessons prove to be too short, enrichment activities in harmony with the aim and the outcomes of the lesson may be added. The New York State Handbooks in General Science, Chemistry, Physics, Biology and the Earth Sciences are excellent sources of pertinent activities.

The teacher who is a beginner in one or more of the sciences should follow the lessons closely. To insure a measure of success, the demonstrations and laboratory exercises must be tried out in advance. The inexperienced teacher would be well advised to schedule frequent reviews, administer short quizzes, and longer examinations, and to grade notebooks regularly. Moreover, some teachers advocate the distribution, collection, and grading of sets of study questions.

One word of caution: The syllabus has been so designed that the laboratory lessons may be presented at the time specified or within a reasonable time thereafter; they should not be attempted before the student has learned the necessary techniques and preparatory content. Thus, not every scheduled laboratory period will be used as such.

Orientation

Experience has shown that the pupil should undergo a period of introduction and orientation before embarking upon any course of study. Because of the complexity of the field of science, the period required may extend to about a week. The teacher will be in the best position to judge the time and the nature of the preliminary material to be introduced. However, the following suggestions may prove helpful in the task of orienting the pupil to the study of science and to assuming his responsibilities.

- —Open the course with a planned motivation. Some teachers prefer discussions of summer science experiences or expectations from the study of science. Others capitalize on interesting science current events.
- —Discuss the types of lessons to be met in science, particularly the laboratory exercise.
- —Practice forming laboratory groups and preparing for laboratory work.
- —Acquaint the pupils with the course requirements; for example, notebooks, contributions to class discussions, reporting, assignments, regular study, quizzes, and examinations.
- —Illustrate, define, and examine the scope of the four sciences to be studied.
- —Distinguish between matter and energy.
- —Introduce metric units of measurement, including the gram, the milliliter, and the centimeter.

Implementation of the Junior High School Science Program

In September 1961, the seventh grade section of the program was introduced into five pilot schools. The present material is based upon the application and evaluation of that preliminary material in classroom situations. Deep appreciation is expressed to the teachers and schools concerned: Mona Abel, JHS 189Q; Martin Beale, JHS 143X; Morris Gartner, JHS 216Q; Bert Valenti, JHS 190Q; and Jules Weisler, JHS 217Q. These teachers met regularly to pool their experiences.

In September 1962, six more pilot schools and twelve teachers were added to the program. The present revision largely reflects their experiences in the classroom. To these dedicated teachers go our sincere thanks: Henry Bednarski, JHS 217Q; Daniel Brandon, JHS 216Q; John Hodnett, JHS 190Q; Martin Karp, JHS 217Q (deceased); Ray Kowalski, JHS 172Q; George Marfesi, JHS 189Q; Renee Sands, JHS 104M; Perry Saunders, JHS 82X; Ernest Streicher, JHS 252K; Pearl Strom, JHS 143X; Howard Wagner, JHS 22X; Arlene Wilson, JHS 109Q.

Projected Time Schedule

Date		*Materials*
1963-64	7th Year	All regular and SP classes in each school use experimental edition (4 booklets, printed)
	8th Year	Some classes in eleven schools use second tryout materials
	9th Year	Some classes in five schools use first tryout materials
1964-65	7th Year	All regular and SP classes in each school use experimental edition (4 booklets, printed)
	8th Year	All regular and SP classes will use experimental edition (4 booklets, printed)
	9th Year	Some classes in eleven schools use second tryout materials
1965-66	7th Year	All regular and SP classes in each school use experimental edition (4 booklets, printed)
	8th Year	All regular and SP classes will use experimental edition (4 booklets, printed)
	9th Year	All regular and SP classes will use experimental edition (4 booklets, printed)
1966-68	7-8-9 Yrs.	Revision of experimental edition Grades 7-8-9

In-Service Training

During the Spring of 1963, a series of in-service science courses was given for the teachers who were selected by the principals to introduce the new science course of study in the 7th Grade of our schools in September 1963. The willingness of these teachers to take time to attend these courses, and of the instructors to provide the training, is greatly appreciated.

The instructors were:

Alfred D. Beck, Assistant Director of Science, Coordinator of the Course

Charles A. Colman, Assistant Principal, JHS 217Q

Harold Horn, Chairman of Department, Taft High School

Paul Kahn, Assistant Principal, JHS 45X

Bernard Kauderer, Assistant Principal, JHS 216Q

Leon Kurtz, Assistant Principal, JHS 143X

Louis Landrecker, Teacher, Bronx High School of Science

Arthur Lefgren, Chairman, Technical Division, George Westinghouse Vocational and Technical High School

Alfred W. Leichtman, Assistant Principal, JHS 210K

Robert Lipton, Assistant Director of Science, High Schools

Samuel Namowitz, Principal, JHS 82X

John A. Polidori, Teacher, Newtown High School

Walter Ross, Chairman, Physical Science Department, Bay Ridge High School

Samuel Schenberg, Director of Science

Marie Soscie, Teacher, Newtown High School

Eugene I. Stern, Chairman, Science Department, George Washington High School

Louis Teichman, Principal, JHS 99M

Acknowledgments

A special note of thanks is due to Herbert Liebeskind, Associate Professor of Chemistry, Cooper Union, who graciously spent many hours in reading and editing the manuscript.

The efficient aid of Frances Moskowitz in typing the material is gratefully acknowledged.

Maurice Basseches, Editor, collaborated in design and production. Simon Shulman was responsible for the illustrations and cover design. Elena Lucchini collaborated in illustrations and production.

Scope and Sequence

The following is a tentative outline of the topics to be covered in the seventh year. This bulletin deals with Unit 7.1. Subsequent publications will cover Units 7.2-7.4.

UNIT 7.1: *The Chemistry of Matter*

A. ELEMENTS

1. Definition
2. Metals and non-metals
3. Identification and classification
4. Preparation and properties
5. Symbols

B. COMPOUNDS AND MIXTURES

1. Definition
2. Preparation
3. Chemical and physical changes
4. Properties
5. Energy relations
6. Mixtures

C. ATOMIC THEORY

1. Historical development
2. Sub-atomic particles
3. Atomic structure
4. Periodic Table
5. Atoms and molecules

UNIT 7.2: *Electricity, Magnetism and Heat*

A. CURRENT ELECTRICITY

1. Circuits
2. Measuring electricity
3. Electrical resistance
4. Ohm's Law

B. MAGNETISM

1. Properties
2. Magnetic fields
3. The earth as a magnet
4. Electromagnetism
5. Electromagnetic induction

C. HEAT

1. Changes caused by heat
2. Temperature measurement
3. Transfer of heat
4. Comparison of heat and temperature
5. Measurement of heat

UNIT 7.3: *The Materials of Life*

A. THE NEEDS OF LIVING THINGS

1. Growing living things at home
2. Life functions
3. The microscope
4. Basic needs

B. NUTRITION

1. Nutrients
2. Food tests
3. Uses of nutrients
4. Adequate diet

C. DIGESTION

1. Organs
2. Process
3. Purpose
4. Absorption

UNIT 7.4: *Living on the Changing Crust of the Earth*

A. THE STORY IN THE ROCKS

1. Fossils
2. Fossil formation
3. Age of fossils and rocks
4. The history of the earth

B. ROCKS AND MINERALS

1. Formation
2. Classification
3. Identification
4. Uses

C. THE CHANGING EARTH

1. Evidences of changes
2. Volcanoes
3. Earthquakes
4. Slow crustal movements
5. Erosion and weathering

ELEMENTS

OUTCOMES **Suggested Time Allotment: 8 Periods**

The organization of junior high school science into four major science areas in each grade provides an opportunity to emphasize the inter-relationships among and the unity within these areas. In this unit, the idea of the universality of matter should be established. The pupils should be led to realize that matter is made up of certain fundamental particles which can be arranged to form elements, compounds and mixtures.

The expected outcomes of this section of the unit include:

- All matter is made up of elements per se or in combination.
- Elements are substances that cannot be separated into simpler substances by ordinary chemical means.
- Elements can be recognized by their properties.
- Elements that have luster, are malleable, and conduct heat are called metals.
- Elements with opposite properties are known as non-metals.
- All elements are represented by an international system of notation or symbols.

NOTE: The present unit evolves naturally from the work of the fifth and sixth grades, as detailed in the latter part of *Earth and Its Resources.** In elementary science, emphasis is placed upon the changes man causes in materials and upon an introductory study of molecules and atoms. Building upon the experiential learnings of the elementary grades, the present unit stresses an organization and explanation of the changes as seen by the chemist. It is assumed that the junior high school science teacher will become familiar with the relevant material in the booklet mentioned. The

**Science*: *Grades K-6* (Curriculum Bulletin No. 2g, 1958-59 Series).

teacher should also be aware that the outcomes listed for all the units relate to content and are generally stated as concepts or understandings. Outcomes in terms of skills, attitudes and modes of thinking do not appear in the listing, but may be found in the explanatory notes.

Suggested Lessons and Procedures

1. WHY DO WE STUDY MATTER?

a. Recall from elementary science that matter has weight, occupies space, and exists in each of three states: solid, liquid and gas. Raise the question, "Why do chemists study matter?" To help provide an answer, prepare four large test tubes on a long test tube rack and pour the following colorless liquids into different test tubes from labeled reagent bottles:

1) Water
2) Alcohol
3) Benzene
4) Concentrated nitric acid

NOTE: Keep the reagent bottles out of sight of the class.

b. Ask the pupils, "Do all the test tubes contain the same liquid?" From their answers, establish the need for experimentation to determine the answer.

c. Demonstrate that the four liquids differ from one another as follows:

1) Place approximately ten drops of each liquid into separate watch glasses. Test each substance for flammability with a lighted taper or match. Have the pupils observe the combustibility of two liquids, the color of the flame and the nature of the smoke.
2) Into two separate test tubes place some copper turnings. Add about 2 ml. of one of the two non-flammable liquids to one test tube and the same amount of the other liquid to the second test tube with the turnings. Observe that the water will not react, whereas the concentrated nitric acid will evolve heavy brown fumes of nitrogen dioxide.

NOTE: The evolution of nitrogen dioxide, which is irritating, can be stopped by diluting with water.

d. At the completion of the demonstration, place the properly labeled reagent bottle before each test tube. Have the pupils read the labels and tell what they found out or learned from the demonstration.

Among the possible conclusions are:

1) Matter may be studied both by experiment and by observation.
2) It is unwise to jump to conclusions.
3) Appearance is not enough to identify matter.
4) In chemistry, tests are employed to identify and analyze matter.
5) Matter is alike in some ways, yet different in other ways.

e. Return to the original question and have the pupils explain that we study matter to observe its similarities and differences and to identify it. Other reasons for studying matter include: to put it to use, to change it, and to determine its composition. Tell the pupils that the similarities and differences are known as *properties* of matter.

2. WHAT CHEMICAL SUBSTANCES MAKE UP MATTER?

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

a. Direct the attention of the class to the apparatus and stimulate questions about it. From the discussion, develop the following:
   1) Electricity is passing through water. The fact that sulfuric acid was added to the water to make it a conductor of electricity may be mentioned.
   2) As the current passes, it decomposes or breaks up the water into two gases, one of which has twice the volume of the other.

b. Recall from the previous lesson that chemists have tests to identify matter and that matter can be identified by its properties. Demonstrate the tests and properties of the two gases as follows:
   1) 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 blackboard.

      NOTE: It is suggested that the teacher demonstrate the difference between a glowing and a burning splint, pointing out that the latter is used to test for hydrogen.

   2) 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 blackboard.

3) Have the pupils summarize the properties of the gases as follows: Both are colorless gases, hydrogen burns or explodes, while oxygen helps other substances burn or supports burning.

4) Stress the fact that neither gas can be broken down into simpler substances by ordinary means, such as electricity, heat or chemicals.

c. Display samples of other simple substances that cannot be broken down further, such as:
aluminum, carbon, copper, iodine, iron, mercury, nickel, nitrogen, phosphorus, sulfur and tin. Explain that some of these substances are metals; others are non-metals. Have the pupils identify the substances they recognize and indicate any property which made identification possible.

NOTE: Cylinders of nitrogen gas are available from the S-1 List. An 8-ounce bottle may be collected by displacement of water.

d. Conclude by having the pupils understand that:

1) All matter is composed of one or more simple substances.

2) These simple substances cannot be broken down into simpler substances by ordinary chemical means.

3) Most of these simple substances may be classified either as metals or non-metals.

4) These simple substances are known as *elements*.

3 and 4. WHAT ARE THE PROPERTIES OF SOME METALLIC ELEMENTS?

TO THE TEACHER: Primarily, this first laboratory lesson is designed to introduce the children to the procedures to be followed in the laboratory: the opening presentation or demonstration by the teacher, the working together in groups of 2-4 students to do the laboratory problems, and the discussion of the results and summary questions — all with proper decorum and care. In the interests of saving time, it is suggested that practice in forming laboratory groups, picking up materials on trays, assigning and rotating tasks, cleaning up and returning equipment, and taking seats quietly should be provided in an orientation period before starting the unit.

Another outcome from the initial laboratory lesson is having the pupils learn how to follow directions properly and in correct order from a laboratory worksheet. Experience shows that a step-by-step approach serves well as a start toward this goal. Therefore, the teacher should demonstrate one step in the procedure at a time, then have the pupils repeat only that step at their tables, and finally go about the room checking for completion of the step before proceeding to the next one. In similar stepwise manner, the entire procedure on the worksheet should be performed.

The final discussion period of the laboratory lesson provides a means for attaining many of the important outcomes of the lesson. About twenty minutes before the close of the double period the teacher should discuss the observations with the pupils, collate, interpret and draw conclusions from the data, as well as go over the summary questions. By glancing down the columns of the table of observations and noting the properties common to all or nearly all the items, the pupils can be led to understand that statements of a general nature, or conclusions, can be reached. For example, all the metals observed have luster and conduct heat — or, almost all the metals observed are solids. The summary questions are intended to assist in this endeavor by calling for a logical thinking process in arriving at conclusions and in recording the lesson. It is recommended that a section of the pupil notebooks be set aside for writing up the laboratory lessons, at first in the formal manner described in the summary. With greater maturity on the part of the pupils, the record may later be altered to become merely a simple statement of procedure and conclusions.

Also out of the lesson should come growth in the ability to use scientific materials effectively and safely. To further this aim, part of each introductory portion of the laboratory period should call attention to any safety hazards that may be present in the exercise. In the first laboratory lesson, the teacher should demonstrate how to strike a match, how to light a burner, how to keep from being burned, how to use the materials and how to prevent equipment from being broken or overturned. It may be found advisable to have the pupils wear laboratory aprons while performing experiments. Encourage boys to roll up their sleeves and ask girls with long hair to wear a net or cap.

LABORATORY WORKSHEET #1

(May be duplicated for distribution to the pupils)

Purpose: To study some properties of metallic elements.

Materials:

1. Three-inch strips of metals, such as copper, aluminum, soft iron, tin or lead
2. Stoppered bottle or test tube with a small quantity of mercury (Do not open the bottle.)

3. Sandpaper
4. Burner
5. Asbestos pad
6. Hammer
7. Safety match (not distributed in advance)

Before you start: Do not touch the equipment until you are told what to do. After instruction, do only one step at a time and have each step checked by your teacher before going on to the next one.

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 whether each is a solid, a liquid, or a gas. In the second column write your observations of the state of each metal.
3. Find out whether each one has a shine or *luster* or whether it is dull. In case of doubt, sandpaper the metal strips. Record your observations in column 3 below.
4. Observe and record the *color* of each metal in column 4.
5. Light your burner. Then hold one end of each metal, except mercury, and place the other end in the flame. Find out if the metal strip will carry or *conduct* the heat to your hand. Record your observations below. Be careful *not* to burn your hand.
6. Strike each metal, except mercury, with a hammer to see whether it breaks or cracks. If it does *not*, the metal is said to be malleable, which means its shape can be changed by hammering. Write your observations in the table below.

TABLE OF OBSERVATIONS

1. Name of Metal	2. State	3. Luster or Dull	4. Color	5. Conducts Heat	6. Malleable or Not

Summary:

1. What was the purpose of this laboratory lesson?
2. What materials did you use?
3. In your own words, tell the method or procedure that you followed.
4. Look down each of the columns of your table of observations. What did you find out that is true of all the metals you observed?
5. What did you find out or conclude that is true about some metals but not about all of them?
6. What did you observe to be true about only *one* metal?
7. What other properties common to all the metals can you name?
8. Give the chemical symbols for the metallic elements you studied.
9. At home and in your own words, write up this experiment using the above questions as a guide.

5. WHAT ARE THE PROPERTIES OF SOME NON-METALLIC ELEMENTS?

NOTE: For the demonstrations below, the teacher may prefer to purchase from the S-1 list cylinders of oxygen and chlorine gas. By water or air displacement, 8-oz. bottles of the gases may be drawn from the cylinders.

a. 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 of *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 hydrogen peroxide. Have the pupils:
   1) Observe the bubbles to realize that a gas is being evolved.
   2) Note that the gas is colorless.
   3) See that a glowing splint bursts into flame when in contact with the gas.
   4) Identify the gas as oxygen and realize that it could not have been hydrogen, which itself would have burned.
   5) Understand that oxygen must be a non-metal because it has none of the metallic properties of luster and malleability and does not conduct heat.

b. Demonstrate the preparation and properties of another non-metallic gaseous element in the following manner: Into a gas collecting bottle place enough potassium chlorate to cover the bottom. Add about 3 ml. of concentrated hydrochloric acid and cover the bottle with a glass plate. Direct the attention of the class to the greenish-yellow appearance of the gas being evolved. Instruct the pupils in how to perform the sniff test safely, by wafting the gas with the open palm from the mouth of the bottle toward the nose.

c. Have the pupils state the properties of the element as a greenish-yellow, non-metallic gas with a stinging, choking, penetrating odor. On the blackboard, write the name of the gas, chlorine, and its chemical symbol, Cl.

d. To show the properties of a non-metal which is also *not* a gas, display a sample of sulfur. Have the pupils observe and describe its properties: it is a yellow solid which is brittle and odorless.

6. WHAT CAN SCIENTIFIC TABLES TELL US ABOUT THE ELEMENTS?

NOTE: Duplicate an alphabetical list of the elements and their symbols including those found in the lesson below. Also, display prominently a large chart of the "Periodic Table of the Elements" or supply the pupils with notebook size copies of the table obtainable from the S-1 List.

a. Distribute individual alphabetical lists of the elements and have the pupils derive rules for determining the symbols as follows:

   1) Ask the pupils to look up the symbols for carbon, oxygen, hydrogen, nitrogen, sulfur and iodine. The pupil should realize that the first letter of the name became the symbol for the element.

   2) Have the pupils find the symbols for cobalt, osmium, helium, neon, selenium and iridium. In these cases, the first two letters distinguish the elements from those previously symbolized.

   3) Consider the elements chlorine, magnesium, zinc and manganese to have the pupils understand that, for some elements, letters other than the first two constitute the symbols.

   4) Note the symbols for the elements copper, iron, lead, mercury and sodium, and explain that they were derived from the Latin names of the elements: cuprum, ferrum, plumbum, hydrargyrum, and natrium.

   5) From the foregoing, formulate some rules or general statements for symbolizing the elements:

      a) The capital first letter of the name may be used as a symbol for some of the elements.

      b) When the first letter is in use, the second (or another) letter may be added to the first and shown as a small letter.

b. Call attention to the large "Periodic Table of the Elements," or distribute individual copies to the pupils. Then introduce the table as an indispensable tool in chemistry by asking the following questions:

- From their symbols, what are the names of the elements you recognize?
- In what order are the elements numbered?
- How many elements are now known?
- What are the names of the transuranic or man-made elements?
- In what part of the Periodic Table do we find the metals? Non-metals?
- Are there more metals than non-metals in existence?
- Why is it possible to use the Periodic Table in schools all over the world?

c. Have the pupils review this section of the unit by discussing or filling in the following table of some elements studied:

ELEMENT	SYMBOL	COLOR	ODOR	STATE	REACTION TO BURNING	METAL OR NON-METAL	USES
Oxygen	O	Colorless	None	Gas	Helps things burn	Non-metal	Hospitals, Missiles
Hydrogen	H	Colorless	None	Gas	Burns or explodes	Non-metal	Dirigibles, Torches
Chlorine	Cl	Yellowish-green	Stinging	Gas	Supports burning	Non-metal	Bleach, Disinfect
Copper	Cu	Brownish	None	Solid	Does not burn	Metal	Electrical wire
Sulfur	S	Yellow	None	Solid	Burns	Non-metal	Vulcanizing

NOTE: At this point the teacher may wish to test the pupils on the outcomes of this part of the unit. However, a comprehensive examination should mark the termination of the entire unit. See pages 36 ff. for suggested questions.

7 and 8. WHAT HAPPENS TO THE WEIGHT OF AN ELEMENT WHEN IT IS BURNED?

TO THE TEACHER: This second laboratory lesson enlarges the scope of the first by calling for the following of detailed steps on a worksheet in order to solve an interesting problem. But before attempting the steps in the procedure, the pupils are asked to plan with the teacher a method of solving the problem to prepare them for later laboratory problems to be solved by plans of their own.

It is suggested that the lesson be introduced by having the children venture a guess, or hypothesis, as to what they think will happen to the weight of the steel wool when it is burned. After devising the common plan for finding the answer, the teacher should compare the pupils' plan with that on the laboratory sheet. Then the class should perform the procedure on the laboratory sheets for practice and the teacher should check each step. Some classes may require teacher demonstration of each step before pupil trial; others may need little or no additional aid.

During the discussion period, each group should be asked to report on the weight gained or lost by the steel wool. The teacher should tabulate the figures on the blackboard and have the pupils analyze them to draw conclusions and to determine the reasons for any weight variations. It should be possible for the children to deduce that something must have been added to the steel wool to account for the weight gain. A more specific explanation is forthcoming in lesson #10.

To make for success, the pupils should be supplied with a fine grade of steel wool, such as #000, which should be packed loosely and held continually over an asbestos pad to catch any falling particles. While the teacher should demonstrate the use of the balance, experience has shown that most pupils will master it most effectively as they use it.

LABORATORY WORKSHEET #2

(May be duplicated for distribution to the pupils)

Purpose: To find out how steel changes in weight when it is burned.

Materials:

1. Loosely-packed wad of fine steel wool
2. Asbestos square
3. Tongs or forceps
4. Burner
5. Balance

Before you start: Take a guess as to what you think will happen to the weight of steel wool when it is burned. This is called an hypothesis. With your teacher and class, plan a method for finding out what happens. Then, for practice, follow the procedure below.

Procedure

1. Put an asbestos pad on your balance and record its weight in column 1 of the table below.

2. Add a loose wad of steel wool about three inches in diameter to the asbestos pad on the balance and weigh both together. Enter the combined weight in column 2.
3. Find the weight of the steel wool alone by subtracting the weight in column 1 from that in column 2. Record the result in column 3.
4. Remove the asbestos pad to the table or tray, place a burner on it and carefully light the burner.
5. Grasping the steel wool with a pair of tongs or forceps, hold it in the flame until it glows.
6. Remove the burner from beneath the glowing steel wool. Then, blow hard and continuously on the steel wool keeping it glowing as long as you can.
   NOTE: The steel wool should be held over the asbestos pad to catch any falling particles.
7. When the glowing ceases and the steel wool cools, place it on the asbestos pad along with all fallen particles.
8. Weigh the asbestos pad and burned steel wool together. Record the combined weight in column 4.
9. Subtract the weight of the asbestos in column 1 from the weight entered in column 4 and write the weight of the burned steel wool alone in column 5.
10. Compare the weight in column 5 with that in column 3 by subtracting the smaller from the larger weight. Record the change in weight, if any, in column 6. If weight was lost, place a minus sign (—) in front of the change in weight. If the reverse is true, use a plus (+) sign.
11. Repeat the experiment with another sample of steel wool.

TABLE OF OBSERVATIONS

Sample Number	1. Weight of Asbestos	2. Weight of Steel Wool and Asbestos	3. Weight of Steel Wool Alone	4. Weight of Steel Wool and Asbestos After Heating	5. Weight of Steel Wool Alone After Heating	6. Change in Weight
1						
2						

Summary:

1. What did most or all of your class *observe* that happened to the weight of steel wool when it was burned?
2. How do you explain the change in weight?

3. Did your observations of the weight change differ from the rest of the class? If so, how do you account for the difference?
4. Did both of your samples of steel wool give the same results exactly? If not, how do you explain the difference?
5. Why should the directions to a laboratory lesson be followed step-by-step?
6. Why is it necessary to make a complete record of what you observe in an experiment?
7. At home, write up the experiment using the following outline as a guide: purpose, materials, procedure, observations and conclusions.

COMPOUNDS AND MIXTURES

OUTCOMES **Suggested Time Allotment: 9 Periods**

- Many substances contain more than one element.
- Elements may be united to form new substances called compounds.
- Compounds are substances made of elements but with properties different from those of the original elements.
- There are many compounds each having unique properties.
- A chemical formula represents a combination of elements in definite proportions.
- A chemical equation represents the manner in which elements and/or compounds react with one another chemically.
- A chemical change is one in which the end products differ from the original substances; in a physical change, the end products are chemically the same as the original substances.
- In chemical changes, energy may be absorbed or released; the former is called an endothermic reaction, the latter, an exothermic reaction.
- Many substances are mixtures of compounds and/or elements.
- A mixture is a combination of two or more substances each of which retains its own identity.
- A mixture is formed or separated by physical means.

Suggested Lessons and Procedures

9. WHAT ARE COMPOUNDS?

a. Without telling the pupils the name of the compound, demonstrate the decomposition of mercuric oxide by heating as follows:

Into a pyrex test tube, place about one-half teaspoonful of mercuric oxide. Then heat it strongly in a Bunsen flame for a few minutes and test with a glowing splint every ten seconds or so. Examine the deposit formed on the inside of the upper part of the test tube. Scrape out the deposit on a watch glass to observe it closely. Have the pupils:

1) Identify the gas as oxygen by splint test.

   NOTE: Avoid any inhalation of the gas, which may be contaminated with mercury vapor which is extremely poisonous.

2) Recognize the scrapings as mercury.

3) Offer a possible name for the substance which decomposed.

4) Read the name from the label on the reagent bottle.

5) Write the word and chemical equation for the reaction on the blackboard:

   Mercuric Oxide Yields Mercury and Oxygen

   $$2HgO \longrightarrow 2Hg + O_2$$

b. Have the pupils discuss the meaning of a chemical equation. Point out that a plus sign means "and," an arrow signifies "yields" and the symbols represent the elements. Stress the idea that equations are a short method of depicting a chemical reaction and that the writing of equations is universal among scientists, regardless of the country of origin.

   NOTE: Although the equations should be balanced, no explanation need be given unless pupils inquire what the numbers mean, nor should the students be held accountable for balancing the equations themselves.

c. From an examination of the chemical reaction itself, have the pupils realize that:

   1) Mercuric oxide is made of a *combination* or union of two elements.

   2) To break up the union of the mercury and the oxygen heat is required.

   3) The elements are the building blacks that make up the substance, mercuric oxide.

   4) Substances made up of a combination or union of elements are called *compounds.*

   5) Compounds differ from elements in that they *can* be broken down into simple substances.

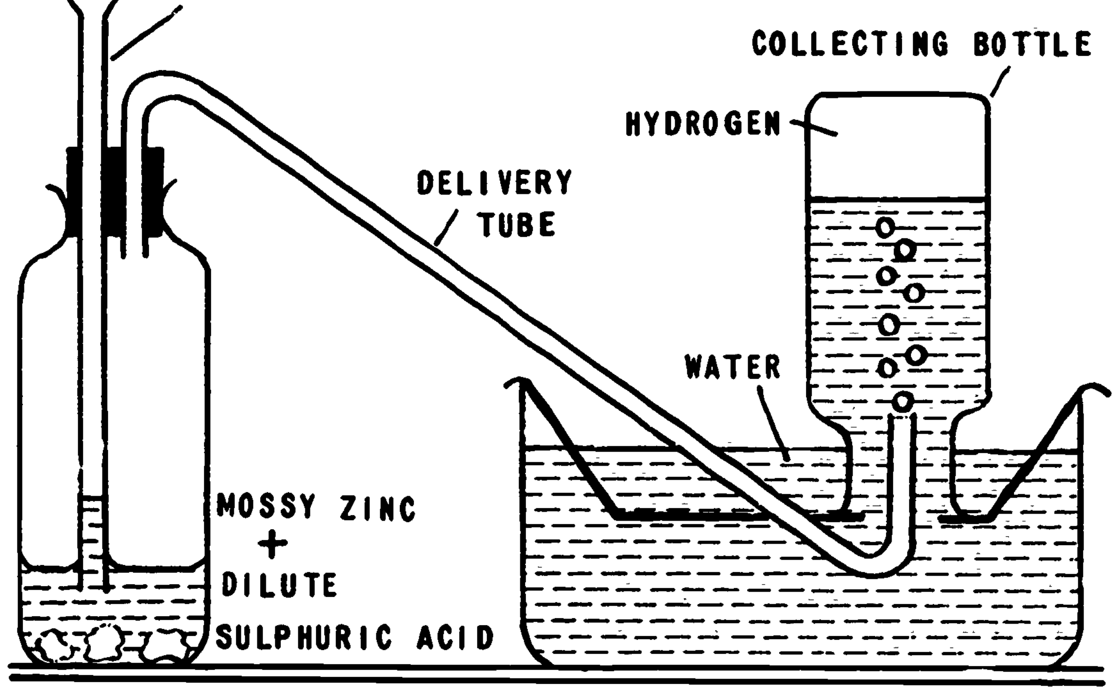
d. Tell the pupils that more than a million compounds exist and have them cite examples, giving the chemical elements of which they are composed. Along with its formula, write each compound mentioned on the blackboard. Some compounds already mentioned in this unit are: water, H_2O; manganese dioxide, MnO_2; and hydrogen peroxide, H_2O_2. In the home are found such compounds as: table salt, $NaCl$; baking soda, $NaHCO_3$; lye, $NaOH$; ammonia, NH_4OH; and cane sugar, $C_{12}H_{22}O_{11}$.

10. WHAT HAPPENS TO ELEMENTS WHEN THEY FORM COMPOUNDS?

NOTE: Because mixtures of hydrogen and air are explosive, extreme care should be exercised in this lesson. No open flame should be brought near the generator. The generator should be rinsed thoroughly with water immediately after use, the zinc being retained.

a. Recall that elements combine to form compounds and have the class raise questions relating to such combinations. Lead them to ask:
   1) Is the combination an addition of the elements in any amounts or quantities?
   2) Do the elements remain the same or do they change when they unite?

b. Toward answering the questions, demonstrate and discuss the laboratory preparation of hydrogen by the displacement of water using the generator shown below:



NOTE: To collect two bottles of a gas, fill three bottles with water and insert them one at a time into the trough with the aid of glass plates. Place the free end of the delivery tube into the water of each bottle in turn and allow the gas to fill the bottle by displacing the water. Discard the first bottle which contains an explosive mixture of hydrogen and air. Keep the glass plates over the other bottles to prevent the escape of the gas.

1) Identify the materials including the zinc and sulfuric acid and write their symbols and formulas on the blackboard:

$$Zn \text{ and } H_2SO_4$$

2) With the aid of the pupils, explain the water displacement technique by pointing out that hydrogen gas pushes the water out of the collecting bottle.

3) Discarding the first bottle, collect another bottle of the gas, test it with a burning splint and show that it is hydrogen. Be sure first to fill the bottle completely, and second to test the gas *away* from the generator.

c. Display another 8-oz. gas bottle, stress the fact that it is *clear* and fill it *completely* with hydrogen by water displacement. Holding a burning splint to the mouth of the bottle, have the pupils observe carefully as the burning of the hydrogen proceeds to the bottom of the bottle. Develop an understanding of the changes in elements when they form compounds as follows:

1) Point to the cloudy appearance of the bottle to show that when hydrogen burns, water is produced. Observe this promptly.

2) Compare the formulas of both substances to indicate that oxygen from the air must have combined with the hydrogen to form the compound, water.

3) Write the equation for the chemical reaction on the blackboard:

$$\text{Hydrogen} + \text{Oxygen} \longrightarrow \text{Water}$$
$$2H_2 + O_2 \longrightarrow 2H_2O$$
$$\text{(2 elements)} \qquad \text{(1 compound)}$$

4) Examine the equation to see that two volumes of hydrogen combined with one volume of oxygen to form two volumes of water vapor, showing that elements combine in definite quantities or proportions.

NOTE: Only with gases do the coefficients relate to volumes as well as numbers of molecules or moles.

5) Contrast the properties of the elements hydrogen, which burns, and oxygen, which supports combustion, with those of the com-

pound water, which puts out fires — evidence that the elements change when they combine to form compounds.

d. Return to the laboratory lesson on the burning of steel wool or iron. Have the pupils realize that oxygen must also have been added to the iron to form the compound, iron oxide. Explain that reactions involving the addition or combination with oxygen are called *oxidations*.

e. Summarize by having the pupils explain that when a compound is formed, the elements combine in definite proportions to form a completely new substance. Such a complete change is called a *chemical change*.

11 and 12. HOW DOES A CHEMICAL CHANGE DIFFER FROM A PHYSICAL CHANGE?

TO THE TEACHER: By the third laboratory lesson, the pupils should be capable of following accurately the directions of a laboratory worksheet. This exercise seeks to reinforce this ability, as well as previously acquired outcomes, in clarifying the difficult concept of the difference between a physical and a chemical change. The teacher should open the lesson by explaining that a chemical change is one in which a new substance or substances is formed during a chemical reaction. In a physical change, the original substances retain their chemical properties, although their size, shape or appearance may be altered.

As always, the teacher should review the safety instructions applicable to the exercise. He should go about the room to see that directions are followed and to give assistance and encouragement.

LABORATORY WORKSHEET #3

(May be duplicated for distribution to the pupils)

Purpose: To study the differences between chemical and physical changes.

Materials:

1. Wood splints
2. Bottle of copper sulfate solution
3. Two-inch iron nail
4. Pyrex test tubes and rack
5. Burner
6. Glass plate
7. Forceps or tongs

Before you start: Bear in mind that a *chemical change* is one bringing about the formation of one or more new substances. This process is called a chemical reaction. In a *physical change,* the original substances keep their identity, although their size, shape or appearance may change.

Procedure:

1. Examine a wood splint and note its appearance. Break it into two pieces and observe how it has changed and whether or not it has retained its original properties of a piece of wood. Fill in your observations on the first line of the table below. Be sure to give the reasons why you think it is a chemical or physical change.
2. Tear a piece of paper into the smallest possible pieces. Record your your observations by filling in the second line of the table.
3. With the aid of forceps or tongs, burn a wooden splint completely. Record your observations on line three, giving the reason why it is a physical or chemical change.
4. Pour one inch of copper sulfate solution into a test tube and carefully place an iron nail into the tube. After about five minutes, remove the nail and observe it carefully. Note the material on the nail to see how it differs from the part of the nail which was not in the solution. Record your observations on line four.
5. Into another test tube pour a small quantity of water. Heat it gently until the water boils. Hold a cool glass plate over the vapor. Observe what happens and enter your observations on line five.
6. What other physical or chemical change would you like to try? Ask your teacher for permission and record your observations on line six.

TABLE OF OBSERVATIONS

Substance	Method of Change (Burn, tear, break)	New Appearance	Chemical or Physical Change	Reason
1.				
2.				
3.				
4.				
5.				
6.				

Summary:

1. What did you find out or conclude from this laboratory lesson?
2. What do you think would happen if you performed the tests for hydrogen and oxygen with water vapor? Explain your answer.

3. In your own words, write up this experiment giving the purpose, materials, procedure, observations and conclusions.

13. WHAT ARE THE PROPERTIES AND USES OF A COMMON COMPOUND?

a. Display a laboratory set up similar to that used to prepare hydrogen, substituting marble chips or sodium bicarbonate for the zinc. To the question, "How can this apparatus be used?", the pupils should reply that you are going to pour acid into the bottle, collect a gas and test it. Remove the trough or basin, enter the delivery tube directly into an 8-oz. collecting bottle, which is held right-side up, and proceed to collect three bottles of the gas by *air displacement,* using dilute hydrochloric acid. Cover the three bottles of the gas with glass plates and show the class the indications of gas production in the generator bottle. Have the pupils discuss the *disadvantages* of this method of gas collection compared with that of water displacement. (By water displacement a bottle of nearly pure gas is obtainable and we can tell rather accurately when the bottle is full of gas and thus avoid having the gas escape into the room unnoticed. Air displacement is used when the gas is soluble in water or when a dry sample of the gas is desired.)

NOTE: When the marble chips react with *dilute* hydrochloric acid, the carbonic acid, which is formed first, is unstable and breaks up into carbon dioxide and water. The CO_2 may be collected by the displacement of either air or water. In this instance, the air displacement method is selected because of the opportunity it affords to broaden the experiences of the pupils. The collecting bottles are kept upright because carbon dioxide is heavier than air. The delivery tube is brought to the bottom of the collecting bottle to push the air up and out.

b. Study the properties of the gas in the collecting bottles as follows:
   1) Observe that it is a colorless gas.
   2) Test one bottle with both burning and glowing splints. Have the pupils understand that the gas cannot be either hydrogen or oxygen.
   3) Place a small candle in the center of a larger jar or beaker, light the candle and pour the gas from the second bottle over the burning candle.
   4) Have the pupils state the properties of the gas and identify it: it is a colorless, odorless gas which puts out fires, is heavier than air and is called *carbon dioxide.*
   5) Write the name and formula, CO_2, on the blackboard.

c. Demonstrate a test for carbon dioxide as follows:

Mix the third bottle of carbon dioxide with about ten ml. of limewater and shake it. Observe the milky appearance of the substance formed.

NOTE: Limewater may be prepared by mixing calcium oxide (lime) with water and filtering. Because limewater tends to deteriorate on standing, it should be tested prior to use and new material prepared if necessary.

d. Show that carbon dioxide is present in exhaled air and is a product of a burning candle. For the first demonstration, a test tube is filled with about one inch of limewater into which air is exhaled through a straw or glass tube. For the second, a gas bottle is inverted over a burning candle until the flame goes out. Limewater is then added to and shaken with the bottle. From the results, have the pupils understand that:

1) Carbon combines with the oxygen of the air to produce carbon dioxide both in the human body and in a burning candle.
2) Oxidation occurs in both cases.

e. Have the class discuss some uses of carbon dioxide, such as in carbonated beverages, in baking, in dry ice, and in fire extinguishers.

14. WHAT HAPPENS TO ENERGY IN A CHEMICAL CHANGE?

a. Exhibit a strip of magnesium ribbon and establish the fact that it is a metallic element by noting its luster and its place among the metals in the periodic table. Holding the strip with tongs, proceed to burn it by starting the reaction in a Bunsen flame. Have the pupils examine the white powder residue to determine that:

1) Probably an oxidation took place in which the magnesium combined with the oxygen of the air.
2) The white powder is the compound which was formed in the reaction and is probably magnesium oxide.
3) A chemical reaction must have occurred in view of the difference in properties of the white powder from both elements, magnesium and oxygen.
4) Light and heat energy were given off during the reaction.

b. Write the equation for the reaction on the blackboard and examine it to find that a metal combined with a non-metal, releasing heat and light energy:

Magnesium + Oxygen ⟶ Magnesium Oxide

$$2Mg \quad + O_2 \longrightarrow 2MgO + \text{Heat} + \text{Light}$$
$$(\text{Metal}) \quad + (\text{Non-Metal}) \longrightarrow (\text{Compound}) + (\text{Energy})$$

c. Show that in some chemical reactions heat energy but no light energy is released as follows: To a 150 ml. beaker half filled with sucrose, add enough concentrated sulfuric acid, with stirring, to char the sugar. Within a few minutes voluminous quantities of steam will ensue.

NOTE: Use care! Try out the demonstration in advance and add the acid a few ml. at a time.

d. Have the pupils recall from their study of this unit other reactions in which energy was absorbed or consumed. For example, the decomposition of mercuric oxide required heat energy while electrical energy was consumed in breaking up water into its elements.

e. Summarize by having the pupils explain that in chemical changes energy is either released or absorbed. Tell them that when heat energy is released, it is called *exothermic reaction;* when heat energy is absorbed, the reaction is known as an *endothermic reaction.*

15. HOW DO MIXTURES DIFFER FROM COMPOUNDS?

a. In view of the class, mix some iron filings with salt and ask whether a *compound* has been formed — which might be called iron salt. Insist upon reasons for the negative answers, such as:

1) A compound could not have been formed since any amount of each substance could have been used.

2) A compound probably was not formed because energy was neither absorbed nor released.

3) A compound could not have been formed because the original substances retain their properties; for example, the colors and crystal structures remain and can be seen.

b. Show that the iron filings retain their magnetic properties by separating them with the aid of a magnet. Explain that the combination of iron and salt is called a *mixture.*

c. Make a mixture of salt and sand and challenge the pupils to suggest means of separating the two substances. Demonstrate the following procedures:

1) Add water to the mixture to dissolve the salt and separate it from the sand.

2) Filter the mixture to recover the sand. Point out the correct

method of folding the filter paper, wetting it, and properly affixing it to the funnel.

3) Evaporate the salt solution in an evaporating dish to recover the salt.

d. Have the pupils discuss the question as to whether the changes wrought by these procedures can be classified as physical or chemical changes. The pupils should understand that since the original substances were recovered, both the making of the mixtures and their separations are physical changes. The following processes are physical changes: solution, filtration, evaporation, and magnetic separation.

e. Summarize by explaining that mixtures differ from compounds in that mixtures are formed by combining various quantities of substances which do not lose their original properties in the process. Mixtures also can be separated by physical means.

16 and 17. HOW CAN MIXTURES BE SEPARATED?

TO THE TEACHER: This is the first complete problem-solving experience in the grade; many more are to follow. Although it should be emphasized that substances in a mixture can be separated because they possess different properties, no further verbal clues should be offered. Directions should be kept to a minimum. Since the required techniques have already been demonstrated, the pupils should encounter little difficulty in making the separations called for in the problem.

Distribute one prepared mixture of three solid substances, such as coarse sand, table salt and iron filings, to each laboratory group and ask them to devise a plan for separating the substances. Approve the plan and then allow the pupils to make the separations. Upon recovery of the substances, check and grade the work.

LABORATORY WORKSHEET #4

(May be duplicated for distribution to the pupils)

Purpose: By physical means, to separate a mixture of three substances.

Materials:

1. Mixture of three substances in a corked test tube
2. Magnet
3. Beaker
4. Burner

5. Test tubes in a rack
6. Funnel
7. Filter paper
8. Tripod *or* ring stand and clamp
9. Evaporating dish
10. Wire gauze
11. Tongs

Procedure:

1. With the classmates in your group, decide on a *plan for separating* the three substances in the mixture at your table.
2. Write down the plan and have your teacher approve it.
3. Following your plan, separate the three substances in your mixture.
4. When you have finished each separation, call on your teacher to check your work.

Summary:

1. What did you find out, or conclude, from this laboratory lesson?
2. Why is it necessary to plan before you do a laboratory experiment?
3. What would have happened if you had evaporated the mixture before filtering it?
4. What substances do you think were present in your mixture? Give reasons for your answer.
5. Write up the experiment giving the purpose, materials, procedure, observations and conclusions.

ATOMIC THEORY

OUTCOMES **Suggested Time Allotment: 7 Periods**

- All matter is composed of small, invisible particles called atoms.
- Atoms are made up of smaller particles including protons, neutrons and electrons.
- The weight of the atom is concentrated in a densely-packed nucleus.
- Electrons are outside the nucleus and in constant motion.
- Electrons are negatively-charged; protons, positively-charged; and neutrons have no electrical charge.
- The Periodic Table of the Elements tells us the number and arrangement of the electrons as well as the relative weight of the atom.
- Electrons are arranged outside the nucleus in shells.
- Atoms of elements whose shells are complete do not ordinarily combine to form compounds.
- During chemical changes, electrons move from one atom to another to complete their outermost shells.
- The flow of electrons from atom to atom constitutes an electric current.

Suggested Lessons and Procedures

18. WHAT IS AN ATOM?

NOTE: The lesson below may be presented as an illustrated lecture from which the pupils can be asked to recall facts and to draw conclusions. To make the historical development of the atom live, a variety of audio-visual aids should be introduced at appropriate times. Throughout the talk, stress should be placed upon the fact that each discovery was built upon preceding ones.

a. Introduce the topic by tearing a piece of paper into the smallest possible particles. Explain that out of such observations Democritus, an early Greek teacher, arrived at his view that all matter is made up of small, hard, invisible, indestructible and indivisible particles. He named these tiny, invisible particles *atoms*.

b. Many years later, in 1803, John Dalton, an English schoolmaster, published his "atomic theory," which involved the following ideas:
   1) All elements are made up of small, indestructible particles called atoms.
   2) Atoms of any element are alike in all their properties, whereas atoms of different elements are unlike in their properties.
   3) When elements combine to form compounds, the atoms of the elements combine to form the molecules of the compound. Hence, the molecule is the smallest particle of a compound.
   4) During chemical changes, the atoms do not lose their identity. For example, hydrogen and oxygen will unite in a chemical change to form water. The water can then be separated by electrolysis to recover the elements unchanged in the process.

c. Continue the talk by pointing out that both Democritus and Dalton held the atom to be indivisible — a view that prevailed for many years. But, in 1897, an English scientist named Joseph J. Thompson discovered a sub-particle of the atom which he called the *electron*. As a result of J. J. Thompson's work and that of Robert A. Millikin it was demonstrated that the electron weighs about 1/1845 as much as an atom of hydrogen, the lightest known element. Following in succession was the discovery of two other sub-atomic particles: The *proton* was suggested by Ernest E. Rutherford in 1922 and the neutron by James Chadwick in 1932. Democritus' and Dalton's "Billiard Ball" atom could indeed be divided — and several times over!

d. Call upon the pupils to remember that:
   1) An atom is the smallest unit of an element that can take part in a chemical reaction.
   2) A molecule, made of two or more atoms, is the smallest unit of a compound that retains the properties of the compound or element.
      NOTE: The smallest particle of a diatomic element, such as O_2, is also termed a molecule.
   3) An atom is composed of at least three smaller particles: the electron, the proton and the neutron. Ordinary hydrogen atoms are exceptions in that they lack neutrons.

4) Each scientific discovery stems from those that precede it.

5) Scientific discoveries transcend national boundaries.

6) The ideas of scientists are usually consistent with the knowledge of their times.

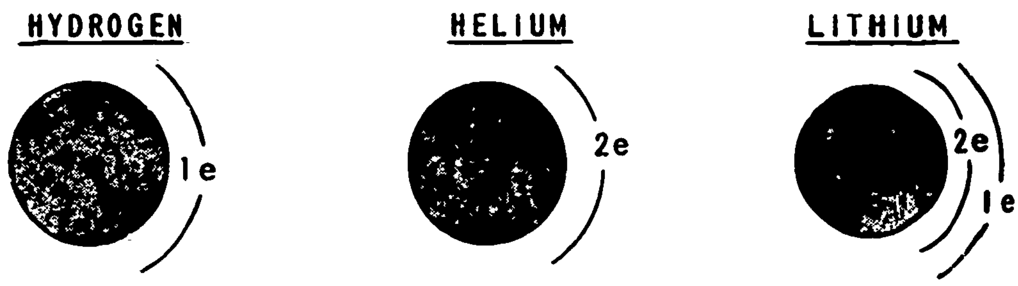
e. Assign the entire class or selected pupils to report on the life and work of *Niels Bohr,* giving his view of the atom. With the class, develop criteria for good reporting, citing illustrations from your own talk. Among the possible criteria, which may be drawn up as a wall chart and displayed in front of the room, are: Was the report interesting? Was it in your own words? Was it well illustrated? Was it complete?

NOTE: It is essential that the first report be a good one to set the tone for those to follow. To this end, a bright youngster should be selected and heard by the teacher in advance. It also will be helpful to suggest to him several sources for the requisite information.

19. WHAT DOES AN ATOM LOOK LIKE?

a. Have a selected pupil report on the work of Bohr indicating his picture of an atom as made up of a central nucleus containing neutrons and protons with planetary electrons moving about it. Call upon other pupils for additional information and evaluate the report in light of the criteria established.

b. Show atomic model, S-1 #56-6968, and have the pupils point out the sub-atomic particles and their locations. Draw diagrams of the atoms of hydrogen, helium and lithium as follows:



c. Summarize by having the pupils understand that:

1) The central part of the atom, containing the neutrons and protons, is called the nucleus.

2) The weight of the atom is concentrated in the nucleus because the electrons have negligible weight. Recall that the hydrogen nucleus or proton weighs 1845 times as much as an electron.

3) The atomic weight of an atom may be calculated by adding together the number of protons and neutrons.

4) Around the nucleus the electrons are in constant motion.

5) The number of planetary electrons equals the number of protons in the nucleus of an atom.

6) Every element differs from all others in possessing a different number of planetary electrons.

d. For practice, have the pupils fill in the missing data in the following table:

ELEMENT	PROTONS	NEUTRONS	ELECTRONS	ATOMIC WEIGHT
Beryllium	4	5	(4)	9
Boron	(5)	6	5	11
Carbon	6	6	6	(12)
Nitrogen	(7)	7	7	(14)
Oxygen	8	8	(8)	(16)
Fluorine	(9)	(10)	9	19
Neon	(10)	(10)	10	20

NOTE: The numbers in parentheses should be omitted when presenting the table to the pupils.

20. HOW DO ATOMIC PARTICLES COMPARE WITH ONE ANOTHER?

NOTE: This lesson enlarges upon and explains some of the phenomena described in *Science: Grades K-6* (Curriculum Bulletin 2a, 1958-59 Series) which deals with Magnetism and Electricity.

a. Expose a radioactive source, such as a radium-dialed watch or a sample of uranium ore, to a Geiger counter and have the pupils note the clicks, scale changes and meter reading. Explain that each click signals the emission of an atomic particle which is amplified and counted by the apparatus. Point out that it is most likely that the particles detected are electrons or beta rays.

NOTE: Comparable demonstrations can be shown with a cloud chamber or by charging an electroscope and then discharging it by striking a match.

b. Show that electrons are electrically charged by constructing a homemade detector as follows: Cut a strip about one inch by five inches from a library card. Fold it in half lengthwise and balance it on a pencil point which is standing upright in the center of a blackboard eraser. The pencil point should indent but not perforate the paper, so that the paper can turn easily. Then,

1) Charge a rubber rod or comb by rubbing it on wool, fur or hair.

2) Bring the comb or rod near the end of the detector and observe that the card follows the comb or rod.

NOTE: By holding a magnet close to the electron stream in a Crooke's Tube, it may be shown that electrons are particles.

c. Have the pupils explain the preceding demonstration as follows:

1) The comb or rod rubbed electrons off the wool or fur, giving the comb a negative electric charge and leaving the wool with a positive charge.

2) Electrons are negatively-charged; protons, positively-charged.

3) The extra electrons on the comb attracted the protons in the card, causing it to follow the comb.

4) Opposite electrical charges attract, similar charges repel.

d. Compare atomic particles by developing the following table with the pupils:

PARTICLE	SYMBOL	CHARGE	ATOMIC WEIGHT	LOCATION
Electron	e	Negative (Minus 1)	Negligible (1/1845 Hydrogen atom)	Outside of nucleus
Proton	p	Positive (Plus 1)	1 (About that of Hydrogen atom)	Within nucleus
Neutron	n	None	1 (About that of Hydrogen atom)	Within nucleus

21. HOW CAN THE PERIODIC TABLE BE USED TO PICTURE THE ATOM?

a. Recall that every element has a different number of electrons, that the number of electrons is equal to that of the protons, and that the weight of an atom equals the total number of protons and neutrons. Ask the pupils, "You can picture any atom if you have the numbers of two particles. What are they?" Perhaps they will correctly suggest the numbers of electrons and neutrons or the numbers of protons and neutrons.

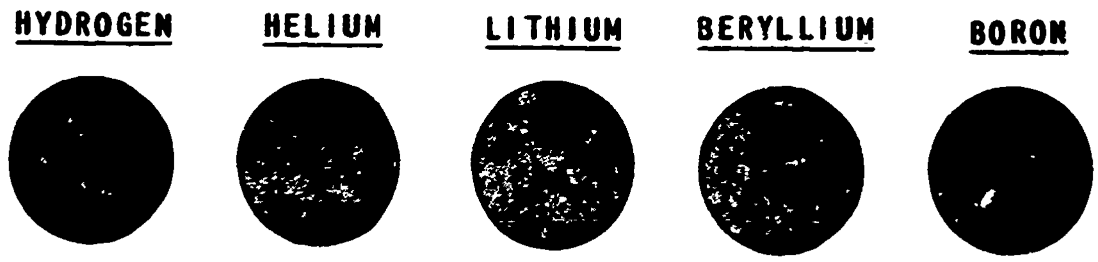
b. Have the pupils examine a wall chart and/or individual copies of the periodic table to note that it contains numbers whose significance has not been disclosed. Direct their attention to the figures on the upper and lower sections of each square and explain their meaning.

1) The lower figure progresses numerically from element to element from number 1 to about 103. It represents the number of electrons (or protons) and is known as the *Atomic Number.*

2) The upper figure is progressive but more irregular. It represents approximately the number of neutrons and protons in the nucleus and is termed the *Atomic Weight.*

3) The number of neutrons alone can be calculated by subtracting the atomic number from the atomic weight written as the *nearest whole number.* Note that practice in this calculation was provided previously.

c. With the aid of the figures in the periodic table draw diagrams of the nuclei of the elements numbered one through five. These may also be shown by means of an atomic model kit.

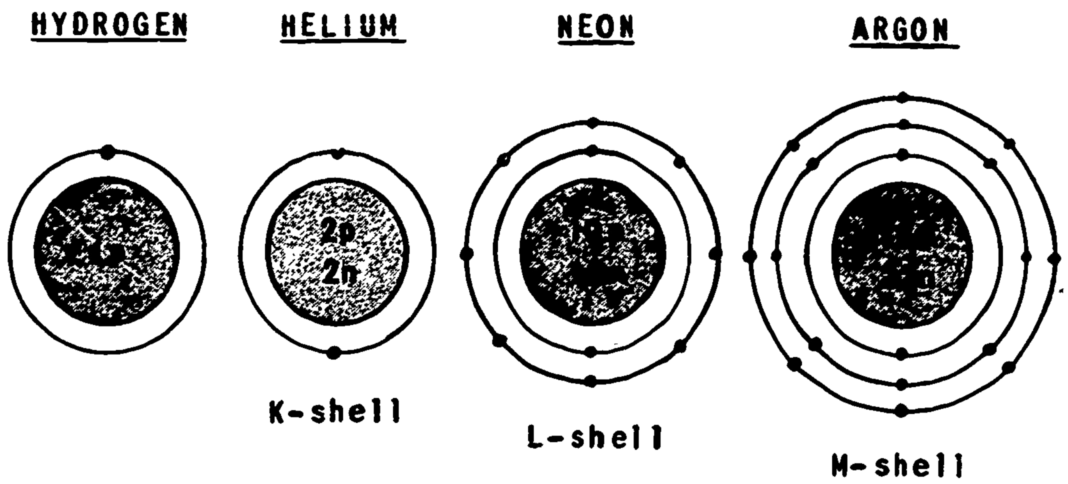


d. Have the pupils practice drawing diagrams of the nuclei of the elements whose atomic numbers are 6 through 20, using the figures on the periodic table.

22. WHAT IS THE ARRANGEMENT OF THE ELECTRONS IN AN ATOM?

a. Raise the question, "Are the electrons arranged in bunches or clusters, like grapes, outside the nucleus?" A pupil discussion should reveal that mutual repulsion of the negative charges should cause them to separate and arrange themselves in some sort of a pattern so that they will maintain the furthest distance from one another while moving.

b. To determine the arrangement of the electrons, turn to the periodic table to note that the first three horizontal rows or periods contain the following numbers of elements respectively: 2, 8 and 8. Explain, too, that each period is terminated by an element which does not ordinarily combine to form compounds. Draw atoms of the inert elements, helium, neon and argon, using dots to represent the electrons, and compare them with an atom of hydrogen.



NOTE: Prepared charts or a transparency with overlays can save a great deal of time in presenting these diagrams.

c. From an examination of the diagrams, have the pupils observe that:

1) Electrons in atoms are arranged in shells, designated by the letters K, L, M, and so forth.

2) The first, or K-shell, is smallest and carries a maximum of two electrons when it is complete.

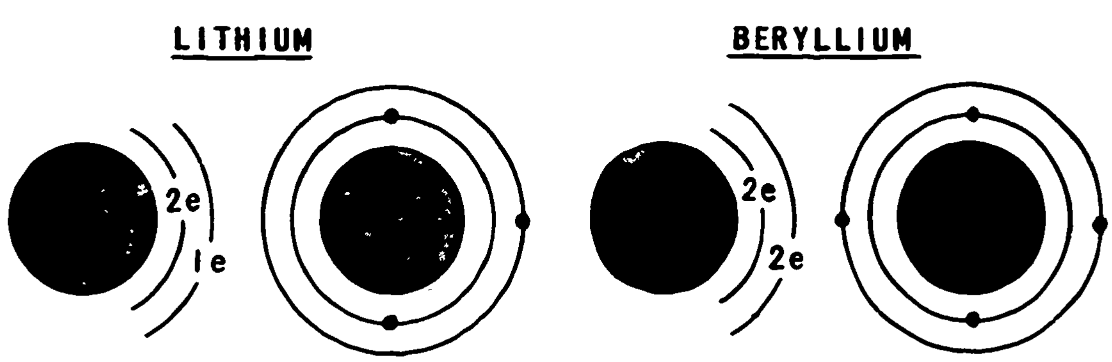
3) The next two shells, L and M, are complete when they reach a total of eight electrons in each.

4) Atoms tend to have complete shells; all shells must be complete before starting a new one.

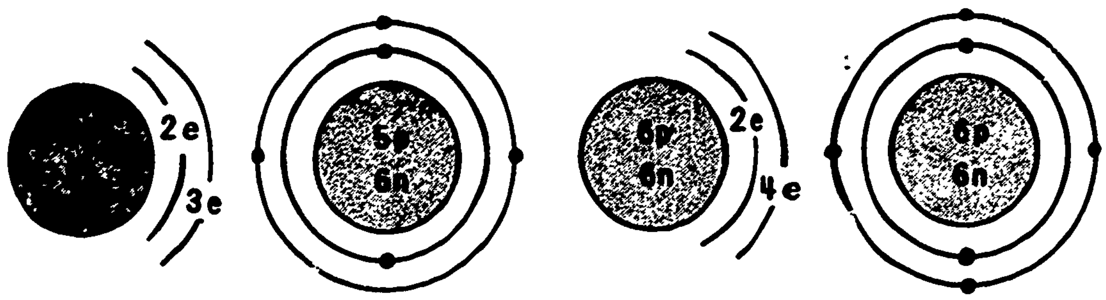
5) When all shells are complete, the element is inert and will not enter easily into chemical reactions.

6) Elements whose outer shells are incomplete will combine to form compounds.

d. With the aid of an atomic model, demonstrate the progressive building up of the shells of elements numbered one through eighteen. Then, draw blackboard diagrams of atoms numbered three to six, using *both* dots and numbers to represent electrons as follows:



BORON CARBON



e. In school and at home, have the pupils practice drawing the atoms of elements numbered 7 through 20, using both dots and numbers to show the shell configurations.

NOTE: For the atomic diagrams done at the desks in school, it is suggested that simultaneous drawings be made on the blackboard so that the pupils may check their own efforts. By going about the room, the teacher can assist pupils experiencing difficulties.

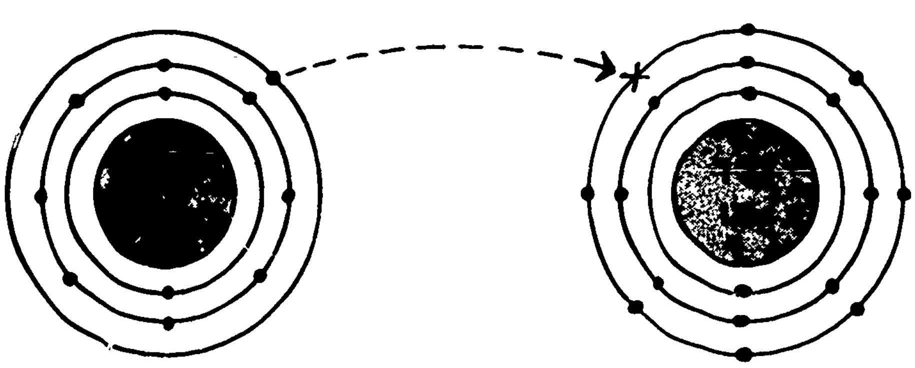
23. HOW DO ATOMS FORM MOLECULES?

a. Recall that molecules are formed when elements combine into compounds and have the pupils cite instances of such reactions:

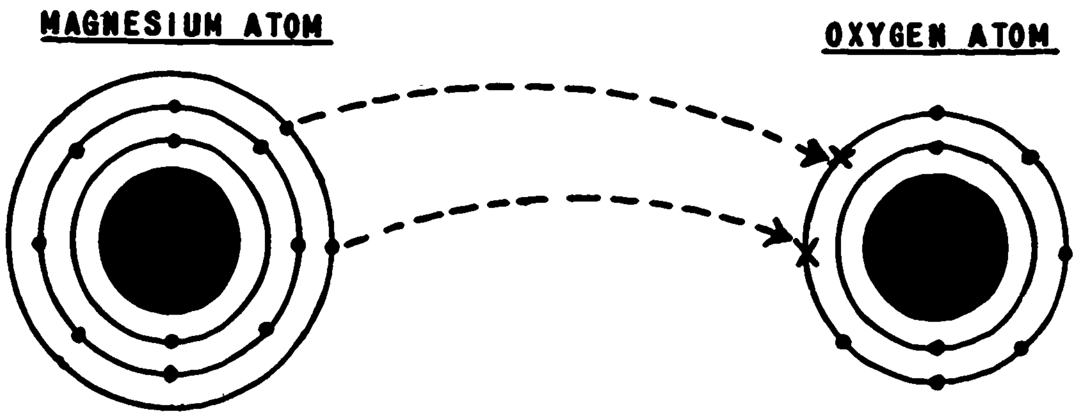
1) Sodium + chlorine ⟶ sodium chloride
2) Magnesium + oxygen ⟶ magnesium oxide
3) Hydrogen + oxygen ⟶ water
4) Iron + oxygen ⟶ iron oxide
5) Mercury + oxygen ⟶ mercuric oxide

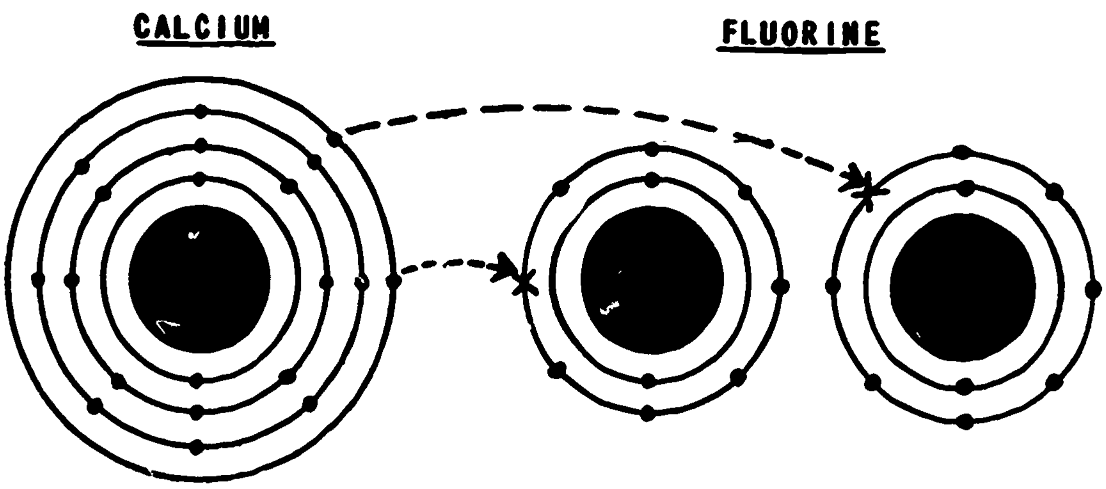
b. By means of a blackboard diagram, chart or transparency of the atoms, show what happens when sodium combines with chlorine. Explain that the sodium atom lends or transfers an electron to the chlorine atom, thereby completing all shells. When all shells are complete, no further reaction can occur.

SODIUM ATOM CHLORINE ATOM



c. Demonstrate and explain combinations involving the transfer of more than one electron; for example, the formation of magnesium oxide and calcium fluoride from the elements. When CaF_2 is produced, it requires two atoms of fluorine to complete the shells of one atom of calcium.





NOTE: In the interests of time, the above reactions can be pictured on a prepared chart which is displayed and discussed briefly. Polystyrene or ball and stick models can alsc be used to visualize the reactions.

d. From the foregoing, have the pupils summarize as follows:
   1) Atoms may form molecules when some have electrons to lend while others can borrow them.
   2) During chemical changes, electrons may move from one kind of atom to another to form molecules.
   3) When atoms combine to form molecules, enough electrons are transferred to complete all the shells.

4) Usually, atoms of metallic elements, which can lend electrons, combine with atoms of non-metals, which can borrow them, to form molecules of compounds.

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

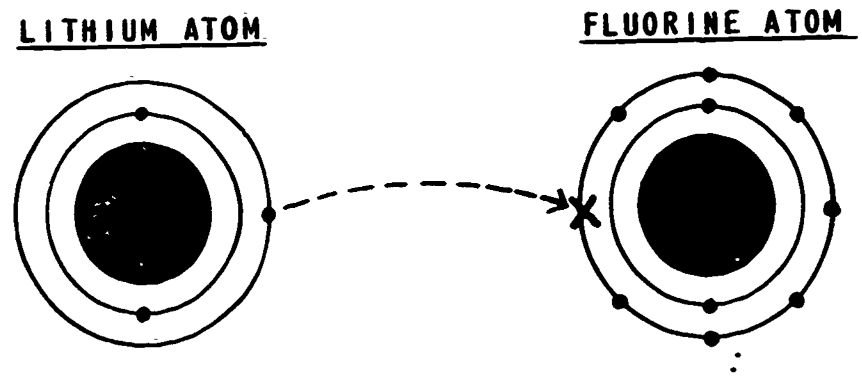
6) For the reason that an exact number of electrons must be displaced in a chemical change, definite proportions of the atoms involved are required to form a particular compound.

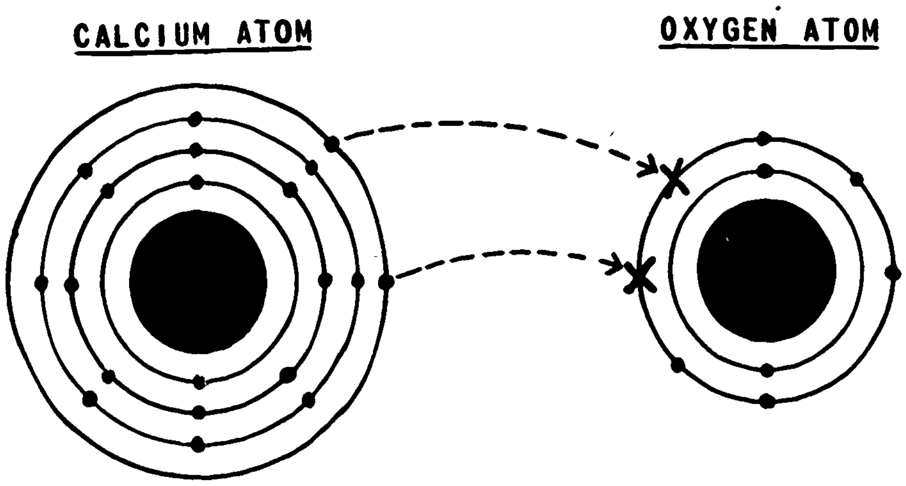
c. As a home assignment, have the pupils practice drawing the union of the following atoms to form molecules:

1) Lithium and fluorine
2) Calcium and oxygen

24. WHAT HAPPENS WHEN ELECTRONS MOVE FROM ONE ATOM TO ANOTHER?

a. Review the preceding homework assignment by having pupils draw the atomic diagrams and show the electron transfer.



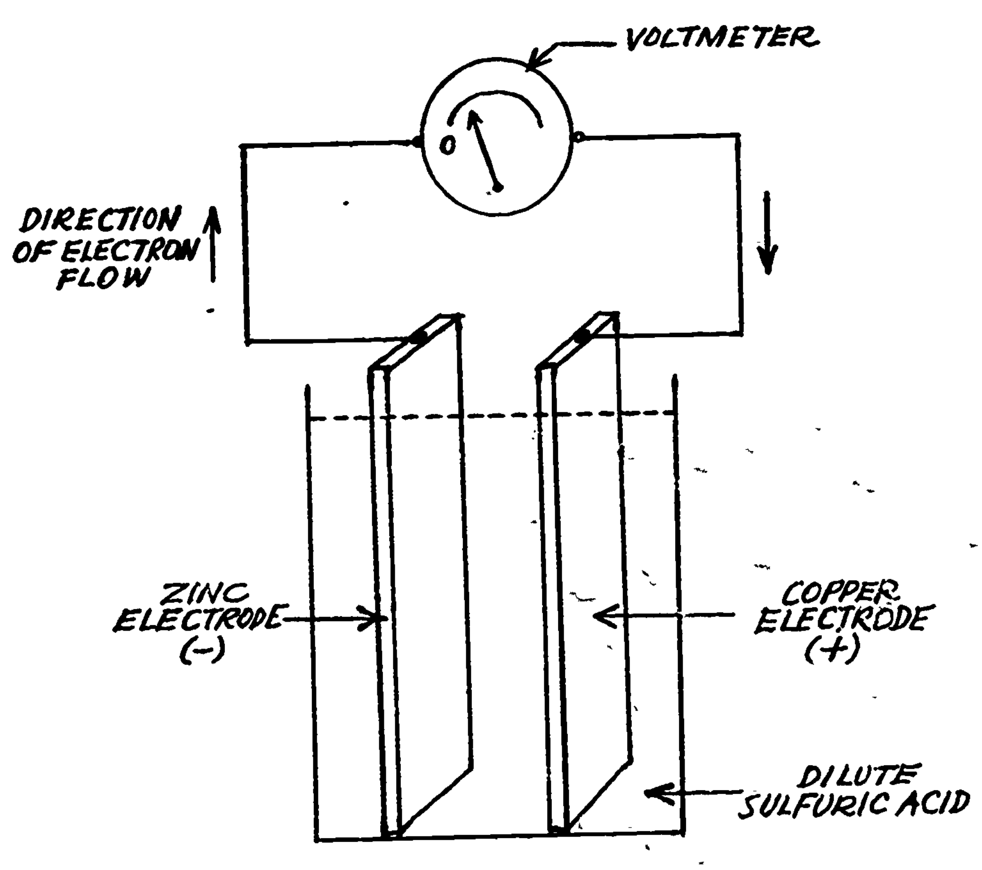


b. Examine the atomic diagrams and the periodic table to discover a relationship regarding the atoms which may combine to form molecules. Lead the pupils to observe that:

1) Atoms of the elements in vertical Group IA appear to combine with those in Group VII A, atom-for-atom.
2) Similarly, those in Group II A combine directly with those in Group VI A.

NOTE: Do not, at this time, discuss the concept of valence or combinations with other columns.

c. Emphasize that, in every case, molecules are formed only when sufficient electrons are transferred to complete all shells. Demonstrate that electrons actually do move from the atoms of one element to another by setting up the following *wet cell*:



NOTE: Use a voltmeter with a range of 0-3 volts. If the deflection is too small, change to a 0-1 voltmeter, or a milli-voltmeter. It also is possible to light a 1½ volt lamp in a miniature socket with the cell.

d. Following the preceding demonstration, have the pupils summarize that:

1) When electrons flow from the atoms of one element to those of another, an electric current is produced.
2) A flow of electrons (electric current) can be controlled, measured and used.

SUGGESTED REVIEW QUESTIONS

The questions that follow are not intended as a diagnostic tool or comprehensive measure of the outcomes of the unit. The teacher may use them for review purposes or as a source of questions for a unit examination.

1. Because of the possible danger involved, which of the following properties should rarely be used to identify a substance?
   (a) state (b) color (c) taste (d) luster (e) weight

2. A substance is a mixture when
   (a) it is a gas (b) it consists of substances in varying amounts
   (c) it consists of definite proportions of elements which have lost their properties (d) it contains oxygen (e) it can be weighed

3. An element which has luster and malleability is generally considered to be (a) a non-metal (b) a metal (c) a gas (d) a liquid
   (e) a non-conductor

4. Oxygen may be prepared from (a) water (b) heat
   (c) hydrogen (d) iron (e) a magnet

5. A gas which is yellow-green in color is (a) hydrogen (b) oxygen
   (c) nitrogen (d) carbon dioxide (e) chlorine

6. A gas which causes a glowing splint to burst into flame is
   (a) hydrogen (b) oxygen (c) chlorine (d) carbon dioxide
   (e) nitrogen

7. A gas which explodes when a burning splint is thrust into it is
   (a) hydrogen (b) oxygen (c) chlorine (d) carbon dioxide
   (e) nitrogen

8. The modern periodic chart shows
   (a) an alphabetical listing of the elements (b) an arrangement of the elements in order of increasing atomic number (c) an arrangement of metals and their compounds (d) an arrangement of elements in order of increasing atomic weight (e) a listing of compounds

9. The probable symbol for the element Osmium is
   (a) O (b) Ot (c) Ox (d) Og (e) Os.

10. Hydrochloric acid (HCl) is (a) an element (b) a mixture (c) a compound (d) a metallic element (e) a non-metallic element

11. $ZnCl_2$ is the formula for (a) Zinc Chloride (b) Zinc Carbonate (c) Iron Chloride (d) Mercuric Chloride (e) Stannous Chloride

12. The missing term in the following equation is $Zn + 2HCl \rightarrow ZnCl_2 + ?$
(a) Zn (b) Cl_2 (c) H_2 (d) N_2 (e) O_2

13. When steel wool is burned in air
(a) its weight decreases (b) its weight increases
(c) its weight remains the same (d) it gives off carbon dioxide
(e) it gives off phlogiston

14. When steel wool is burned in air
(a) it evaporates (b) it combines with oxygen
(c) carbon dioxide is given off (d) water vapor is given off
(e) nitrogen is produced

15. When mercuric oxide is heated we get
(a) only mercury (b) only oxygen (c) water and oxygen
(d) mercury and water (e) mercury and oxygen

16. A magnet may be used to separate
(a) a compound of iron and sulfur
(b) a compound of iron and chlorine (c) a mixture of iron and sand
(d) a mixture of sulfur and sand
(e) a mixture of mercury and oxygen

17. Chemical changes always result in
(a) the production of heat (b) the formation of a new substance
(c) the production of light (d) the formation of water
(e) the formation of carbon dioxide

18. A gas was bubbled into limewater. The limewater turned milky. The gas was probably
(a) oxygen (b) nitrogen (c) hydrogen (d) chlorine
(e) carbon dioxide

19. Dalton considered all matter to be composed of indivisible particles called
(a) molecules (b) atoms (c) neutrons (d) protons (e) electrons

20. Water is a(n)
(a) acid (b) mixture (c) compound (d) element (e) salt

21. The changing of water to steam is an example of
(a) a chemical change (b) breakdown of water into its elements
(c) physical change (d) electrolysis (e) hydrolysis

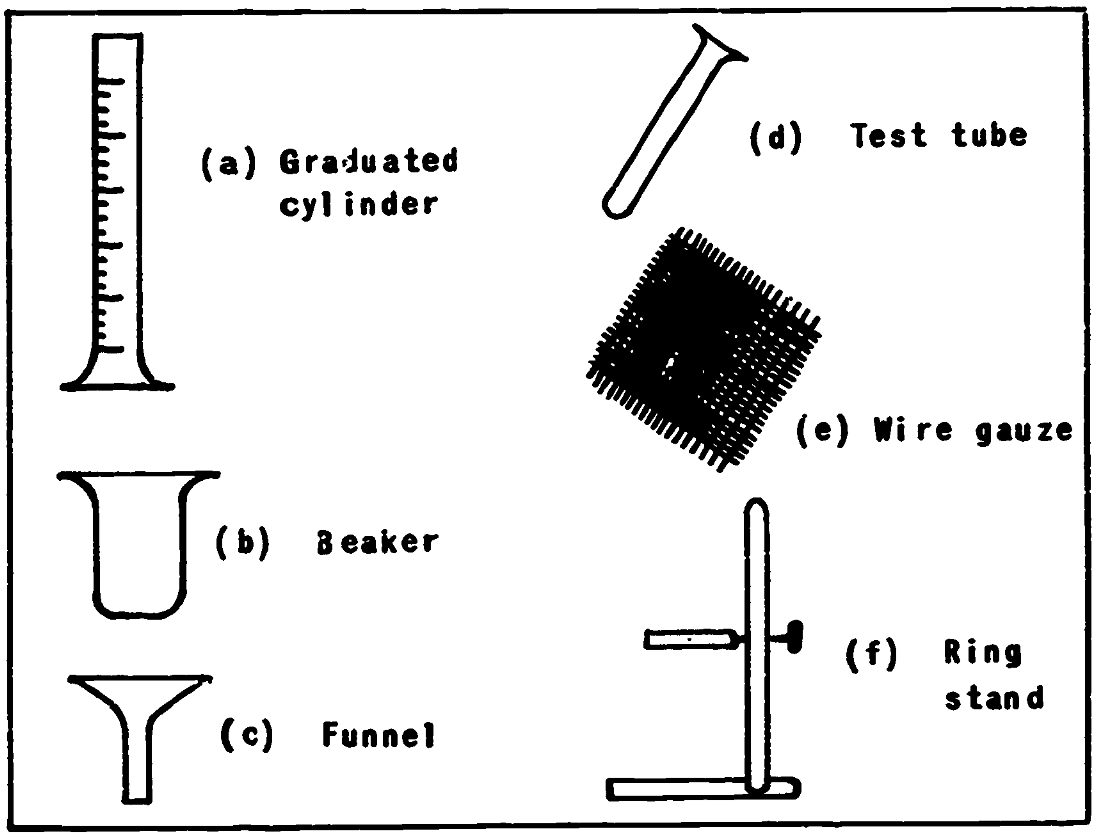
22. A chemical reaction in which heat is given off may be described as
(a) magnetic (b) electrolytic (c) endothermic (d) physical
(e) exothermic

23. The electrical charge on the proton is
(a) negative (b) positive (c) twice the charge of an electron
(d) twice the charge of a neutron (e) neutral

24. The sub-atomic particle with the least mass is
(a) neutron (b) proton (c) electron (d) deutron (e) molecule

25. The lightest element is
(a) oxygen (b) helium (c) nitrogen (d) sulfur (e) hydrogen

The questions below refer to the laboratory items shown in the diagrams.



26. Which item is best used to spread heat uniformly?

27. In which container is mercuric oxide most conveniently heated?

28. In which item is filtration most efficiently performed?

29. Which item is best used to measure quantities of liquid?

30. In which item can large amounts of solution be heated?

Complete the following statements:

31. When hydrogen burns in air, the compound produced is ....

32. The smallest particle of a compound is a(n) ....

33. The smallest particle of an element is a(n) ....

34. A rubber rod is rubbed with wool. The particles which are transferred from the wool to the rod are charged particles known as ....

35. The nucleus of an atom may contain protons and ....

36. A negatively charged object has an excess of charged particles called ....

37. In an atom the number of electrons is equal to the number of ....

38. The number of neutrons in an atom of beryllium (atomic weight of 9, atomic number of 5) is ....

39. The maximum number of electrons in the first shell of an atom is ....

40. The total number of atoms in a molecule of CO_2 is ....

41. Metals combine chemically with non-metals by lending ....

42. The weight of an atom is concentrated in the ....

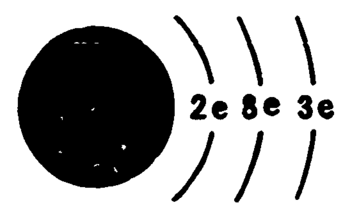
43. The flow of electrons is called ....

44. Compared to the number of non-metals in the periodic table, the number of metals is ....

45. An element whose atoms contain 15 neutrons, 14 protons, and 14 electrons has an atomic weight of ....

46. A metal which is a liquid at room temperature is ....

Refer to the accompanying diagram of the aluminum atom to answer questions 47-50.



47. The atomic number of aluminum is ....

48. The atomic weight of aluminum is ....

49. The part of the atom containing the protons and neutrons is known as the ....

50. In combining with a non-metal, the number of electrons this atom will lend is ....

ESSAY QUESTIONS

1. Give either a brief scientific explanation or draw a conclusion for each of the following observations:
   a. Although water consists of hydrogen which explodes and oxygen which supports burning, water may be used to put out fires.
   b. A rubber rod will *not* be attracted to paper unless it is first rubbed with wool.
   c. When a radioactive source is placed near a Geiger counter, clicks are heard.
   d. Sodium (atomic number 11, atomic weight 23) is not likely to combine with lithium (atomic number 3, atomic weight 7).
   e. In the separation of sand, salt and water, filtration is used before evaporation.
   f. Limewater turns milky when mixed with a gas.

2. Describe the laboratory experiences listed below using the suggested outline as a guide:

   Laboratory Experiences
   - Steel wool is burned in air.
   - A mixture containing powdered sugar, sand and iron filings is separated.
   - The properties of metals are studied.
   - Differences between chemical and physical changes is studied.

Outline

(a) State the purpose or problem.

(b) List the materials.

(c) Write the procedure.

(d) Describe the observations.

(e) List the conclusions.

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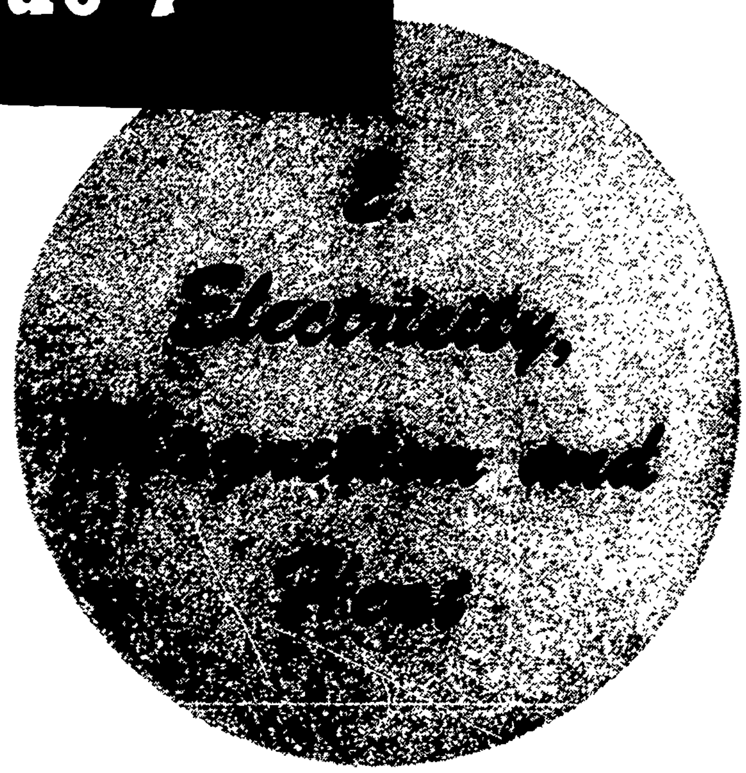
SCIENCE
Grade 7



Bureau of Curriculum Development
Board of Education of the City of New York

FOREWORD

In these times of great scientific advancement and opportunity, we are increasingly dependent upon a scientifically literate population. Our young people must be led to explore, search for, and discover scientific ideas "which are durable for at least a generation."

A new science course of study for grades 7, 8 and 9, part of a K-12 program, is currently being prepared. The new course is based upon the sequential development of scientific concepts from the four major science areas.

This bulletin, "Electricity, Magnetism and Heat," is the second in a series of twelve bulletins, one for each portion of the course — chemistry, physics, biology, and earth science — at each grade level. The materials herein have been applied and evaluated in classroom situations over a period of two years. Teachers and supervisors will find herein practical assistance in putting into practice the physics part of the proposed revised course in junior high school science.

An overview of the revised course of study for grades 7, 8 and 9, including a statement of philosophy, objectives, scope and use, appears on pages vii-xiii of *Science; Grade 7 — The Chemistry of Matter* (Curriculum Bulletin No. 9a, 1962-63 Series). Teachers and supervisors should refer to these pages as they use "Electricity, Magnetism and Heat."

The science program, of which this bulletin is a part, envisions in-service training in schools and districts.

It is hoped that this bulletin and the others in preparation will make possible further development and extension of the program

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October 1963

CONTENTS

ELECTRICITY 1
MAGNETISM 10
HEAT 25
SUGGESTED REVIEW QUESTIONS 32
SUGGESTED REFERENCES 38

ACKNOWLEDGMENTS

The planning and design of the Science Grades 7, 8 and 9 Project is under the direct supervision of William H. Bristow, Assistant Superintendent, Bureau of Curriculum Research; Martha Finkler, Assistant Superintendent, Junior High School Division; and Samuel Schenberg, Director of Science. Joseph O. Loretan, Deputy Superintendent of Schools, and Jacob H. Shack, Acting Associate Superintendent, Division of Curriculum Development, have overall supervision of curriculum projects.

To explore the various problems involved in the preparation of a new course of study for the junior high school segment of the K-12 science program, the following Curriculum Advisory Committee was appointed:

Martha Finkler, Assistant Superintendent, Junior High Schools
Seelig L. Lester, Assistant Superintendent, High Schools
Samuel Schenberg, Director of Science, *Chairman*
†Alfred D. Beck, Assistant Director of Science, Junior High Schools
Isidor Auerbach, Principal, John Jay H. S.
Irving I. Cohen, Principal, Thomas Jefferson H. S.
Darwin S. Levine, Chairman of Standing Committee on Science Supplies
Mary R. Mullins, Principal, Junior High School 172Q
Samuel N. Namowitz, Principal, Junior High School 82X
Charles Tanzer, Principal, Junior High School 17M
Walter W. Wolff, Principal, William Cullen Bryant H. S.

The Curriculum Advisory Committee accepted with modifications a plan submitted by the Director of Science to employ large blocks of subject matter from the four specialized sciences, sequentially, in grades 7, 8, and 9. In order to implement this plan, a Junior High School Science Revision Committee was appointed. To work under optimum conditions, the regular members of the revision committee met mainly on Saturdays and thus avoided the necessity of leaving their classes and schools during school hours. All members of the committee except the Director of Science were paid for the Saturday work. The members of the Revision Committee are:

Samuel Schenberg, Director of Science, Office of Science Education, Director of the Project
Charles A. Colman, Assistant Principal, Junior High School 217Q
*Ronald Dermer, Teacher of Science, Junior High School 210K
**Milton Forrest, Acting Principal, Junior High School 190Q
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† Through August 1963
* Appointed to Committee January 1963
** Resigned September 1962 to become principal of an elementary school

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A special note of thanks is due to I. Fankuchen, Professor of Physics, Brooklyn Polytechnic Institute, who graciously spent many hours in reading and editing the manuscript.

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Maurice Basseches, Editor, collaborated in design and production.

Elena Lucchini was responsible for illustrations and production; Simon Shulman for the cover design.

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* Assigned September 1963 as Acting Assistant Director, Chairman of Committee

** Resigned September 1962 to become principal of an elementary school

*** Resigned January 1963 to assume new assignment

ELECTRICITY

OUTCOMES **Suggested Time Allotment: 6 Periods**

- An electric circuit is one which contains free electrons and an electromotive force to drive them along a complete conducting path.
- Electrons flow from the negative terminal of a source along a circuit and back to the positive terminal.
- Series circuits provide a single path for the electrons while parallel circuits offer more than one path.
- Electromotive force depends upon the source and is measured in units called volts; the rate of electron flow is measured in amperes; and resistance, in ohms.
- Parallel circuits permit independent operation of electrical devices, whereas series circuits do not.
- Resistors may be used to control the flow of an electrical current.
- The resistance of a conductor depends upon its length, cross-sectional area, material and temperature.
- Ohm's Law states that the current in an electrical circuit is directly proportional to the voltage and inversely proportional to the resistance.

NOTE: This unit is built upon the learnings of elementary science as set forth in Handbook #1, *Science*: *K6,* Curriculum Bulletin No. 2a, 1958-59 Series: *"Magnetism and Electricity."* Since success will depend largely upon the visibility of the demonstrations, it is recommended that the teacher make use of demonstration meters, large apparatus and the overhead projector, wherever possible. In addition, some teachers prefer to mount the apparatus permanently on wooden boards.

Suggested Lessons and Procedures

1. WHAT IS MEANT BY AN ELECTRIC CURRENT?

a. Have the class recall from the chemistry unit that when metals react chemically they tend to transfer electrons from their outermost ring. The flow of electrons in a circuit is said to constitute an electric current.

b. From elementary science the pupils should remember that they observed a 1½ volt lamp to light when a dry cell was connected to it in a complete circuit. Demonstrate a similar circuit consisting of two No. 6, 1½-volt dry cells, bell wire, a knife switch and a 3-volt lamp in a miniature socket. Show that the lamp lights when the switch is closed. Have the pupils identify each part of the circuit. To remove the visibility factor also use a bell or buzzer in place of the lamp.

c. Conduct a discussion of the functions of the parts of the circuit along the following lines:

1) Cut a worn-out dry cell longitudinally in half and explain that the zinc container reacts chemically with the cell contents leaving electrons to accumulate on the negative terminal located on the periphery of the dry cell. The mutual repulsion of negatively-charged electrons creates an electromotive force, of voltage, which can push the electrons along a wire to the positive carbon electrode in the center of the dry cell.

2) Metal wires act as conductors providing a path for the ready passage of electrons, whereas insulators oppose electron flow. This fact may be demonstrated by opening the switch in the above circuit and closing the gap with a variety of insulators and conductors. Moreover, the pupils should have their attention drawn to the insulators in the circuit, such as, the covering on the wire and the non-metallic parts of the switch and the lamp. From the foregoing, the pupils should perceive that a property of metals is their ability to conduct an electric current.

3) The switch is a handy means of opening and closing the circuit, thereby controlling the flow of electrons. Show that the circuit can be opened by detaching any of the wires to the dry cells or the lamp. Display other types of switches, such as push buttons, keys, and toggle switches.

4) The lamp is the load, or the part of the external circuit, upon which the electrons do the work. An electric bell, a motor, and a variety of other devices may be substituted for it.

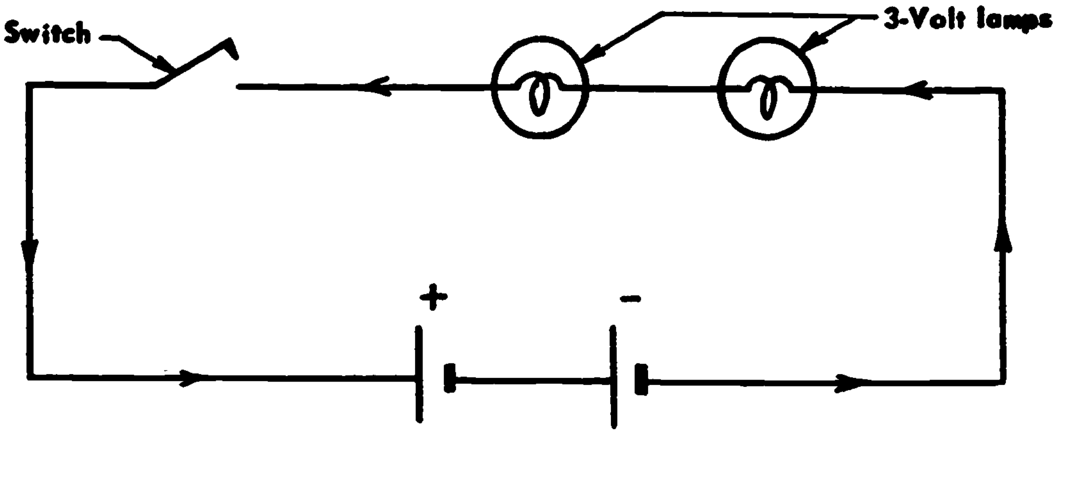
d. Conclude by defining a circuit as one which has an electromotive force, a source of electrons and a conducting path. When the path is complete, the circuit is said to be *closed;* when incomplete, the circuit is *open.*

2. WHAT ARE THE TWO BASIC TYPES OF ELECTRICAL CIRCUITS?

NOTE: For greater visibility the room may be darkened or 110-volt lamps may be substituted in the demonstrations below.

a. Recall that the circuit studied the preceding lesson caused *one* lamp to light. Ask the pupils, "How can we light *two* lamps with the same type of circuit?" Demonstrate the operation of the circuit below, including two 3-volt lamps connected with two dry cells in series. Draw the circuit diagram on the blackboard. Identify each symbol and show the direction of the path of the electrons from the negative to the positive terminal of the dry cells along the wire. Explain that this is called a *series circuit* and that it provides only one path to the electrons.

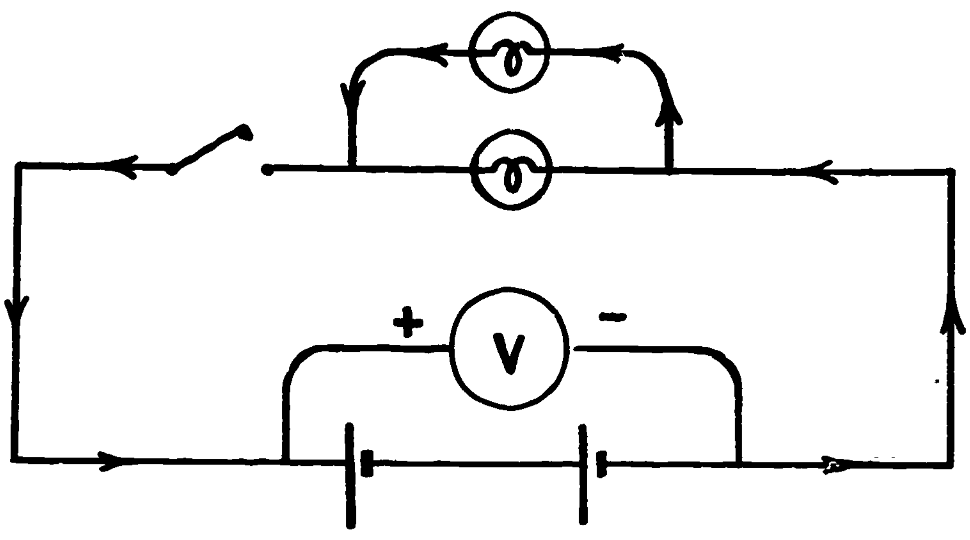
SERIES CIRCUIT



b. Demonstrate that dry cells can be connected in series by attaching the negative terminal of one cell to the positive one of the other. Elicit from the closs why it is necessary to bare the wires at the ends. Point out that each cell is rated at 1½ volts and that two in series will deliver 3 volts.

c. Remove one lamp from the series circuit and show that the other goes out also. With the aid of the above blackboard circuit diagram, lead the pupils to devise another type of circuit to permit the second lamp to remain lighted when the first is removed. Have the pupils understand that an additional path must be provided for the electrons to allow each lamp to function independently. Set up a demonstration of the new circuit to show that it actually operates. Point out that such a circuit is known as a *parallel* circuit and is the one ordinarily present in the home. Compare the brightness of the lamps in the parallel and series circuits.

PARALLEL CIRCUIT



d. In summary, have the pupils explain that two basic types of circuits exist. Series circuits have a single path for the electrons whereas parallel circuits provide them with more than one path.

3. HOW CAN ELECTRICITY IN A CIRCUIT BE MEASURED?

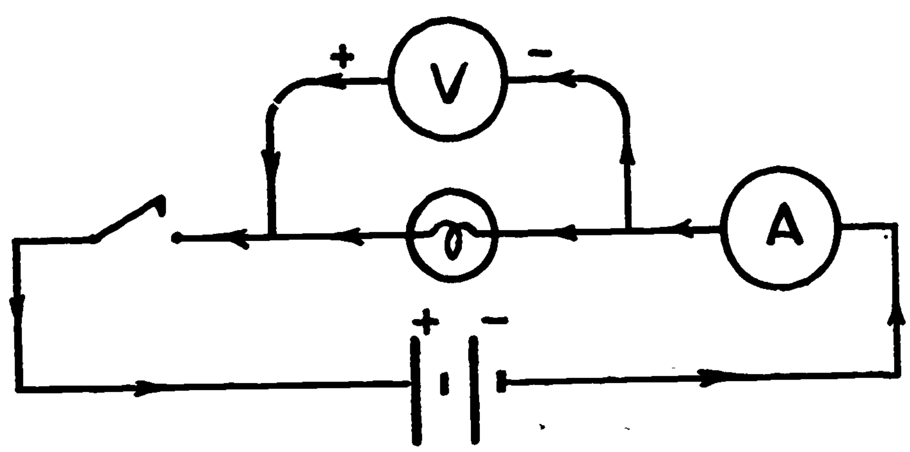
a. Ask the class to imagine the flow of water in a stream or a pipe. Ask the pupils for the factors they might be able to measure. Lead them to suggest the possibility of determining the rate of and the force causing the flow of water. Explain that similar factors are measured in electricity; namely, the rate of flow of electrons is called electrical *current,* while the electrical force or pressure is termed the *voltage.*

b. Display an ammeter and a voltmeter and discuss their purposes:

1) Ammeters measure the rate of flow of electrons known as the electrical current.

2) Voltmeters determine the force or pressure driving the electrons around the circuit. Emphasize that force, E.M.F., is required to push the electrons through a circuit. The voltage source, such as the dry cells, supplies the electromotive force.

c. On the blackboard, draw a simple series circuit for lighting a lamp with dry cells through a switch. Challenge the pupils to signify where to place an ammeter and a voltmeter in the circuit correctly, giving reasons for the suggested placement. A discussion should reveal the necessity for connecting an ammeter in series where the entire flow of electrons can be recorded. By contrast, the voltmeter measures the electromotive force between two points in a circuit and should be connected in parallel with the lamps at the two points. Add the two meters to the diagram, as shown below. Place the ammeter and voltmeter in different parts of the circuit and ask the students to take readings and draw conclusions from the findings.



d. With large demonstration meters, set up a display of the above circuit. Record on the blackboard the actual readings of the meters indicating the units, and:

1) Explain that the unit of electric current is called an ampere. (This is the flow of one coulomb or 6.3×10^{18} electrons past a point in one second.)

2) The unit of electromotive force is the volt, which is defined as the force that will send one ampere of current through a resistor having one ohm resistance.

3) Show how the ammeter is connected in series anywhere in the circuit whereas the voltmeter is connected in parallel with the resistor whose voltage drop is being measured.

4) Stress that the negative terminals of the meters must be attached to the side of the circuit nearest the negative dry cell terminal; the positive meter terminal is placed closest to the positive cell terminal.

5) Caution the class on the use of the proper scales on the meters. Emphasize that one should start with the largest scale and pro-

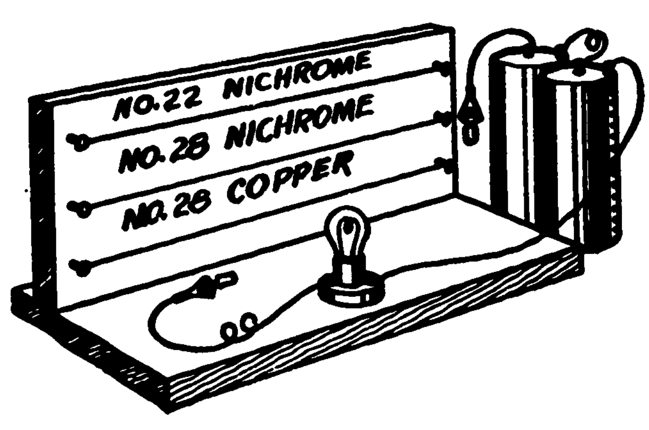
ceed to the smaller ones, finally settling on the lowest scale whose capacity is not exceeded by the dial reading.

e. Have the pupils summarize that electrical current is measured in units called amperes by means of instruments known as ammeters. Voltmeters record electromotive force and voltage drop in units called volts. Ammeters are connected in series in a circuit; voltmeters, in parallel.

4. HOW CAN THE CURRENT IN A CIRCUIT BE CONTROLLED?

a. Set up a demonstration of a simple circuit with a dry cell, switch, lamp, and ammeter. Show that current flows when the switch is closed but stops when the switch is open. Ask the pupils if they can think of any way to regulate the magnitude of the current in the circuit, reducing the flow of electrons without stopping it.

b. To show that resistors can control current and to demonstrate the factors upon which the resistance depends, prepare a wooden board as shown below. Each wire should be about two feet long. Connect one alligator clip to one end of the top wire and slide the other alligator clip along the wire to vary the resistance of the circuit. Note the change in lamp brightness or substitute an ammeter for the lamp and observe the variation in reading. Then, compare the lamp brightness or ammeter reading obtained by connecting the full lengths of each of the wires in turn.



Have the pupils generalize as follows:

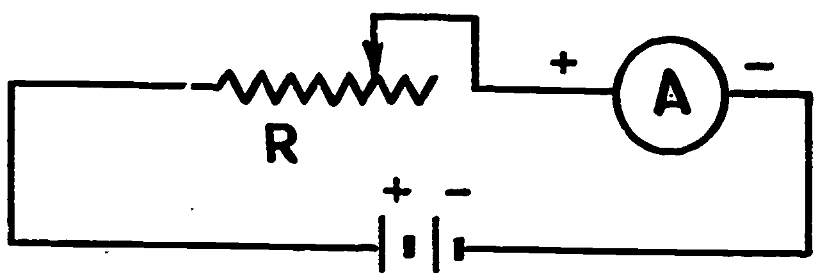
1) Current in a circuit may be controlled by resistance.
2) The resistance of a wire depends upon its length: the longer the wire the greater the resistance.

3) The resistance of a wire depends upon its gauge. The larger the diameter of a wire, the lower is its gauge number and the lower is its resistance.

4) Wires of different metals differ in resistance.

5) The resistance of a wire increases as its temperature increases.

c. On the blackboard, draw a diagram of the preceding demonstration, such as that shown below. Define resistance as opposition to the flow of electrical current and explain that the unit of resistance is called the "ohm." (The ohm is defined by scientists as the resistance of a column of mercury 106.3 cm. long and 1 mm. square in cross section.)



d. Have the pupils discuss possible causes for wire resistance. The concept should be developed that as electrons pass through a wire, their motion is impeded by mutual repulsion with the electrons of the atoms of the element of which the wire is made. (1) Long wires offer more resistance in view of the greater number of repulsions. (2) Thicker wire has less resistance since it provides a wider path for the electrons to flow. (3) Variations in resistance of different metals may be explained in terms of differences in electron configuration. (4) Finally, make the point that heat results from the work done in forcing the electrons through the wire.

e. To illustrate some of the uses to which resistors may be put, display the coiled nichrome wire of a heating element and the coils of thin tungsten wire in a light bulb. Have the pupils explain that the reason for the coiling and the thinness of the wires is for the purpose of increasing length and, therefore, resistance and heat production.

5. and 6. WHAT FACTORS AFFECT THE FLOW OF CURRENT IN AN ELECTRICAL CIRCUIT? (Ohm's Law)

NOTE: This laboratory lesson is part of a series of problem-solving exercises. For the pupil, many purposes are served; for example, the development of manipulatory skills with meters and circuits, practice in making measurements, gathering and interpreting data, and, most important, verifying the relationship among the factors of current, voltage, and resistance in a circuit—a generalization known as Ohm's Law.

The teacher should stress the fact that each of the problems may be solved by means of series circuits. He should 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.

The pupils should be cautioned to use the highest scale first and *not* to make final connections to the dry cells or close the switch until the circuit has been inspected and approved. If clips are attached to the ends of the wires, the pupils will find it much easier to make the required circuits.

Note, too, that the following laboratory worksheets are numbered consecutively with the four presented in *The Chemistry of Matter*, Curriculum Bulletin, No. 9a, 1962-63 Series.

LABORATORY WORKSHEET #5

(May be duplicated for distribution to the pupils)

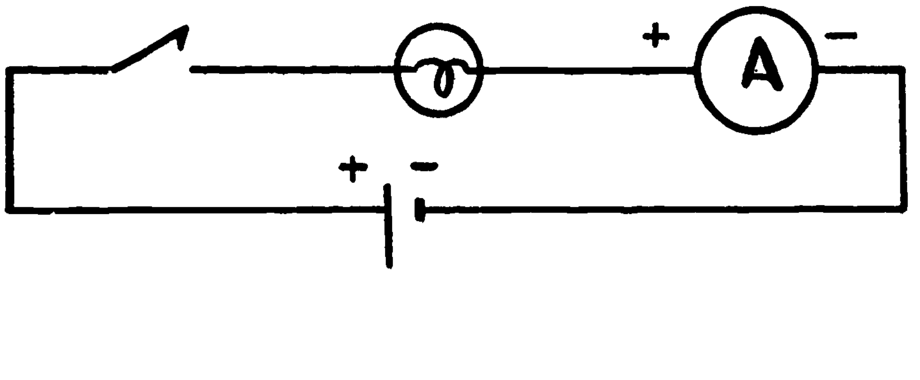
Purpose: To study the factors that affect the flow of current in an electrical circuit.

Materials:

1. Three dry cells, No. 6, 1½-volt each
2. Three 3-volt lamps in miniature sockets
3. Suitable D. C. ammeter to secure a deflection of more than one-half of the scale if possible
4. Push button or knife switch
5. Annunciator or bell type insulated wire

Procedure:

1. Start by setting up a simple series circuit consisting of one dry cell, one lamp and an ammeter as shown in the diagram. Make a record of the ammeter, or current, reading in column 4 below. *Do NOT close the switch or fully connect the dry cell until your teacher has*



inspected and approved the circuit. After receiving your teacher's approval, close the switch only long enough to read the meter.

2. Find out what happens to the current when the voltage in the circuit is increased. Remember that each of the dry cells delivers 1½ volts and that the voltages are added when the cells are connected in series. *Do NOT connect three dry cells and only one lamp* because this will burn out the lamp. You can prevent this from happening by using only the connections shown in the table.
3. What happens to the current when the resistance is increased? Consider that each lamp has about the same resistance.
4. To help you draw conclusions, fill in your observations on the table below.

TABLE OF OBSERVATIONS

1. No. of Dry Cells	2. Voltage Used	3. Number of Lamps in Series (Resistors)	4. Amperes Measured
1	1½	1	
2	3	1	
1	1½	2	
2	3	2	
3	4½	2	
1	1½	3	
2	3	3	
3	4½	3	

Summary:

1. What did you find out or conclude from this experiment?
2. What you found out is known as Ohm's Law. Write this law as a mathematical formula or equation.
3. From what you have learned about electricity, explain why you would expect the conclusions that you drew.
4. If the voltage of a circuit is decreased, what would happen to the current?
5. If the resistance of a circuit is decreased, what would happen to the current?
6. Write up this experiment in your own words following the outline you used previously.

MAGNETISM

OUTCOMES **Suggested Time Allotment: 12 Periods**

- Magnetic materials include iron, nickel, and cobalt.
- The force between two magnets depends upon the strength of the magnets and the distance between them.
- Magnets are believed to consist of atomic groups, or domains, each of which has magnetic properties. When the domains are properly arranged, a magnet is produced.
- Magnetic lines of force represent the path a compass would take in proceeding from the north to the south pole.
- The earth acts as a huge magnet with magnetic poles and lines of force between them.
- The earth is a huge magnet with magnetic poles and lines of force between them.
- Electrons in motion produce a magnetic field.
- The strength of an electromagnet can be increased by increasing the number of turns of wire and/or the magnitude of the current and/or the permeability of the core.
- An electromotive force is induced in a conductor whenever the conductor is placed in a changing magnetic field.
- Electromagnetic induction is of wide use in such devices as generators, transformers, and induction coils.

NOTE: Ordinary permanent magnets tend to lose their activity rapidly as a result of improper storage. It is suggested that bar magnets be paired with opposite poles together when not in use. Horseshoe magnets require a soft iron "keeper" across their poles.

Suggested Lessons and Procedures

7. WHAT DO WE KNOW ABOUT MAGNETS?

a. By means of the demonstrations that follow, review the elementary science learnings on the subject of magnetism:

1) Test the effect of a magnet on different substances, including chalk, wood, tacks, paper, nails, tin can and paper clips. Have the pupils conclude that metals containing iron are attracted by the magnet.
2) Pick up a Canadian nickel with a magnet and show that the element nickel is a magnetic material. Explain or demonstrate that an iron ore, magnetite (lodestone), and alloys such as steel, permalloy and alnico are also magnetic materials.
3) Line up a row of paper clips, place a magnet horizontally over the entire row and show that magnetism is strongest at the poles of the magnet.
4) Exhibit a large magnetic needle compass, show that it is a magnet by picking up several tacks. Then, suspend it from its stand and demonstrate that it will point north and south if allowed to rotate freely. Stress that the ends are known scientifically as north- and south-*seeking* poles. For subsequent use, label the north-seeking pole with red paint or with a paper tab.
5) Set up the following demonstration: Suspend a strong magnet from a ring stand and clamp by means of a string. Beneath the magnet place a block of wood to which one end of another string has been tacked. Tie a paper clip to the other end of the string and allow the magnet to attract the clip toward but not touching it, by adjusting the length of the string. Interpose between the clip and the magnet an assortment of materials including paper, wood, copper, aluminum, lead, iron, steel and soil. Have the pupils conclude that only magnetic materials can affect magnetic lines of force.

b. Demonstrate the *Law of Magnetic Poles* by bringing each pole of a magnet close to the labeled north-seeking pole of the magnetic needle. Have the pupils understand that unlike magnetic poles attract one another whereas like poles repel. Point out the similarity to eleltrical charges. (Precautions should be taken to avoid pulling the magnetic needle from its pivot.)

NOTE: Cylindrical alnico magnets will move apart when like poles are brought together on a smooth surface. When unlike poles are brought close together, the free magnet can be made to follow and obey the one being held.

c. Have the pupils realize that magnetic attraction and repulsion are forces by demonstrating the factors governing magnetic forces, as follows:

   1) Rest a ¼″ steel ball on the laboratory table and gradually bring a magnet closer to the ball until it rolls to the magnet. The table should be raised slightly so that the magnet rests slightly above the ball. Have the pupils understand that as the distance decreases, the magnetic force increases. In fact, magnetic force varies inversely or oppositely with the square of the distance.

   2) Set up a row of several magnets of different strengths. Include an alnico magnet. Find the strongest one by bringing the steel ball gradually closer to each magnet in turn and observing the one that attracts the ball at the greatest distance. Elicit the concept that magnetic force varies directly with the strength of the magnet.

d. Conduct a summary to the effect that magnets are bodies with opposite poles that attract or repel certain substances with a force that varies directly with the strength of the magnet and inversely with the square of the distance from the substance.

8. HOW CAN MAGNETISM BE EXPLAINED?

a. Consider the question, "How can we make a magnet?" and have the pupils cite relevant experiences from elementary science. Demonstrate the following methods of magnetizing steel and iron objects:

   1) With a strong permanent magnet, rub three pieces of steel wire or three steel needles several times in one direction. Test for the acquisition of magnetic properties with tacks or clips.

   2) Hold the strong magnet close to, but not touching, the head of a soft iron nail and show that the nail will pick up tacks or clips. Remove the magnet to observe the release of the tacks and to indicate that the nail has not been permanently magnetized. Explain that the effect of producing magnetism at a distance is termed magnetic *induction*. When magnetism is induced in soft iron, the effect is temporary, ending when the magnet producing the effect is removed. In steel the effect may be permanent.

   3) Test steel cabinets and steel radiators with a compass needle. Explain.

b. Aided by the three previously-magnetized steel wires or needles, show that magnets can be de-magnetized in several ways; for example, rubbing one wire or needle in both directions with a magnet, heating the second until it is red-hot, and striking the third repeatedly with a hammer.

c. Challenge the pupils with the query, "Can a magnet be de-magnetized by cutting or breaking it into small pieces?" Demonstrate that the cutting process merely creates additional magnets by magnetizing a four-inch piece of steel wire. Show that it has a north and a south pole with a magnetic needle. Then, cut the wire into four equal parts and demonstrate that each is a separate magnet with a north and a south pole similar to the original.

d. From the demonstrations, have the pupils understand that magnets consist of atoms or groups of atoms each of which has magnetic properties. When the atomic groups, or domains, are properly lined up, a magnet is produced. By rubbing a piece of unmagnetized steel in one direction with a permanent magnet, or by holding a magnet near a piece of soft iron, the domains can be arranged properly to form a magnet. Heating, striking, or improper rubbing causes the domains to disarrange themselves. In short, magnetism comes about through arranging the domains of a magnet; de-magnetization, by disarranging them.

9. and 10. WHAT IS A MAGNETIC FIELD?

NOTE: This laboratory lesson aims to give the pupil an idea of the nature and characteristics of the magnetic field pattern around a bar magnet.

A simple explanation that magnets have an invisible area or field of force or influence around them should serve to introduce the lesson. It is within this field that magnets act upon magnetic substances. The teacher should point out that the job of each laboratory group is to study this magnetic field pattern which seems to be made up of lines of force.

The introduction should be followed by a demonstration of *only the technique* of making a field pattern by placing a bar magnet below a piece of cardboard or a card, sprinkling iron filings from a shaker over the card, and tapping lightly to jar the filings into place.

From the exercise the pupils should understand that magnetic fields may be detected with iron filings or with a compass, and that lines of force are really the paths a compass north pole would take as it proceeds from the north to the south pole of a magnet. Lines of force are concentrated at the poles which accounts for the fact that horseshoe magnets have advantages over bar magnets.

LABORATORY WORKSHEET #6

(May be duplicated for distribution to the pupils)

Purpose: To find out the nature and characteristics of magnetic fields and lines of force.

Materials:

1. Two bar magnets
2. One horseshoe magnet
3. Iron filings in shaker
4. Cardboard cards
5. Small blocks of wood, iron or brass
6. Small magnetic compass

Procedure: Discover all you can about magnetic fields and lines of force by doing the following experiments:

1. By using the technique demonstrated by your teacher, observe and draw the magnetic field pattern or lines of force around:
   a) One bar magnet
   b) Two bar magnets with north and south poles facing each other
   c) Two bar magnets with north and north pole facing one another
   d) Two bar magnets with south and south poles facing one another
2. Find out the shape of several lines of force as follows: Place a sheet of paper on the laboratory table and center a bar magnet over it. With pencil, mark the outline and polarity of the magnet on the paper. Then place a compass on the paper near one pole and make a pencil dot on the paper at each end of the needle. Move the compass away from the magnet until the end which was nearest the magnet is over the outer of the two dots, and make another dot at the far end of the needle. Continue in this way until the line of dots reaches either the edge of the paper or the other pole of the magnet. Connect the dots to show the line of force. Draw several other lines of force in a similar manner.
3. Find out what advantage a horseshoe magnet has over a bar magnet. Viewing the magnetic field pattern of a bar magnet should help you.

Summary:

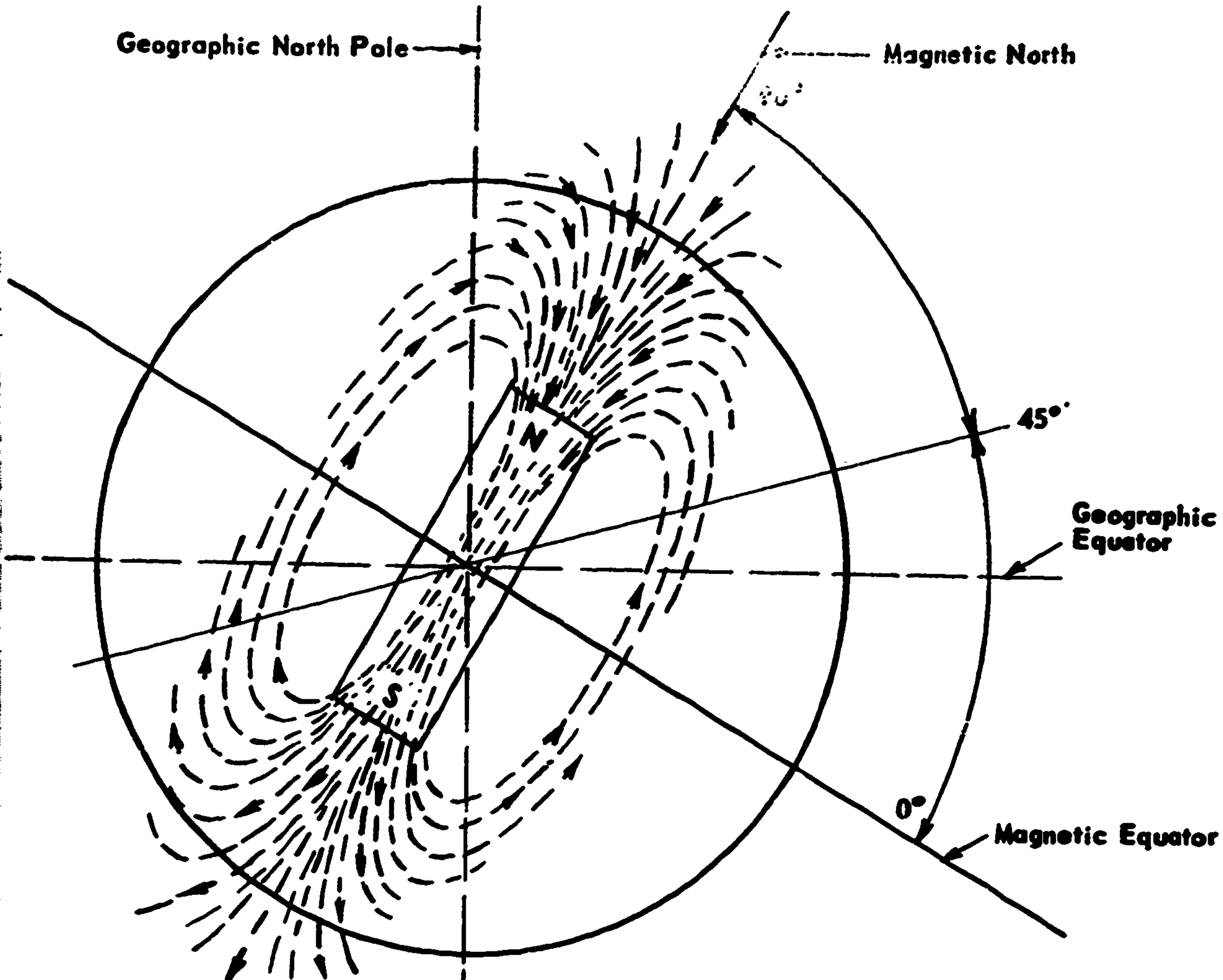
1. What have you found out about the magnetic field around a bar magnet? Two bar magnets?
2. How can a magnetic field be detected?
3. What are lines of force?
4. What advantage does a horseshoe magnet have over a bar magnet?
5. Write up this experiment telling what you did, saw and found out.

11. WHY DOES A MAGNETIC COMPASS NEEDLE APPEAR TO POINT NORTH?

a. Display a magnetic needle and a dipping needle. Have the pupils observe that the magnetic needle points approximately north-south and may be used as a compass while the dipping needle maintains an angle of about 70° in New York. Test bottom and top of steel radiators and iron fence posts with a compass needle. Raise the question, "What can we conclude from these observations?" Develop a reasoning sequence similar to that below:

   1) The constant orientation of the magnetic needles indicates that lines of force are present in the classroom.
   2) The direction of the lines of force seems to be toward the north and toward the earth, as shown by the declination and inclination of the needles.
   3) Because lines of force are affected only by magnetic materials, it is possible that the lines penetrate the earth.
   4) Magnetic compasses, which are magnetic needles, show that lines of force are found everywhere on the earth and constitute a very extensive but weak magnetic field. Such a field must have resulted from a very large magnet.
   5) It is probable that the earth itself acts as a huge magnet with lines of force and a magnetic field large enough to account for the above observations.

b. Picture the earth's magnetic field by means of a chart, diagram, or transparency, as shown below. Interpret the diagram by explaining that the earth's geographic north pole is not the same as the magnetic north pole. It follows that a compass points true north only when it forms a straight line with both the magnetic and geographic north poles. A dipping needle varies in inclination from 0° at the equator to 90° at the magnetic poles.



c. Summarize by exhibiting a magnetic globe or standing a magnet upright on the laboratory table. Indicate geographic north as different from magnetic north. Move a large compass needle around it in a horizontal circle to illustrate the changes in compass direction while travelling around the earth. At several points, stress the variation of compass direction from geographic north. Explain that this variation is called declination. Use a dipping needle to show inclination changes in going north and south.

12. HOW CAN WE MAKE A MAGNET WITH ELECTRICITY?

a. Introduce the lesson by telling the pupils that an important scientific discovery was made accidentally by a professor named Oersted while lecturing to his class at a Danish university in 1819. Re-create the setting by making a wide loop of bell wire, placing a large magnetic needle on a point within and in a plane parallel to the loop, and connecting the ends of the wire momentarily to a dry cell by means of a switch. Have the pupils observe the deflection of the needle as well as its direction. Reverse the current flow by changing the connections to the dry cell and note the reversal of the magnetic needle's direction of deflection. Have the pupils report their version of the principle which was discovered; for example, lines of force and a magnetic field may be detected around a wire during the time it is carrying an electric current; the direction of the lines of force depends upon the direction of the current.

b. Continue by explaining that the foregoing principle became the basis for the introduction of another kind of magnet, now known as an electromagnet. Have the pupils recall their experiences with electromagnets in elementary science. Demonstrate the construction of such a magnet by winding 20-30 turns of bell wire around a soft iron nail about 3-4 inches long, attaching the ends of the wire to a dry cell through a switch, and picking up tacks or paper clips. Stress the fact that each loop is called a *turn;* all the turns constitute a *coil.* Have the pupils understand that an electromagnet consists of a coil of wire, a source of current, and a core.

c. Using the electromagnet previously constructed, demonstrate the differences between permanent and electromagnets by their effect upon magnetic materials or a magnetic needle, as follows:
   1) Open and close the switch to show that the magnetism of an electromagnet can be turned on and off at will, whereas that of a permanent magnet is more fixed.
   2) Remove the iron core from the coil and, in turn, substitute rods of non-magnetic material such as glass, chalk, copper, and wood to compare the effects of magnetic and non-magnetic cores. NOTE: Other methods of increasing electromagnetic strength are the subject of the laboratory lesson to follow.
   3) Recall from the opening demonstration that the direction of electromagnetic lines of force can be changed readily while those of bar and horseshoe magnets are more permanent.

d. In summary, examine both an ammeter and a voltmeter. Have the pupils explain that each meter consists of a coil of wire wound around an iron core and placed within the magnetic field of a permanent magnet. As current passes through the coil from the circuit in which the meters are connected, the coil becomes an electromagnet which is attracted or repelled by the field magnet, thereby being made to rotate an amount depending upon the magnitude of the current.

13. and 14. WHAT ARE SOME WAYS OF MAKING AN ELECTROMAGNET STRONGER?

NOTE: Little or no direct help should be given the pupils in solving the two problems in this exercise. Out of the first problem should arise an understanding that electromagnets are similar to permanent magnets in affecting magnetic materials and in possessing opposite poles and a magnetic field. From the second, the pupils should find that magnetic strength depends directly upon the number of turns of wire in the coil, the number of dry cells, the size and nature of the core and the relative position of the coil with respect to the core.

Electrical theory holds that doubling the number of dry cells in series should double the current and thus double the electromagnetic strength. To see how closely practice agrees with theory, the teacher is well advised to tabulate the data in the first row of the table of observations for all the laboratory groups. Deviations from theory should be explained by the pupils with the aid of the teacher. If the results are averaged, it can be shown that a larger number of observations are likely to be more accurate than a smaller number. A similar procedure may be followed with regard to doubling the number of turns of the electromagnet.

In order to prolong the life of the dry cells, all electrical circuits should be inspected and approved by the teacher before permitting final connections to the cells. Moreover, the pupils should be cautioned to close the switch only when the electromagnet is actually in use.

LABORATORY WORKSHEET #7

(May be duplicated for distribution to the pupils)

Purpose: To study the properties of an electromagnet.

Materials:

1. One bar magnet
2. Two dry cells
3. Four-foot length of bell wire
4. Smaller pieces of bell wire bared at the ends
5. Two soft iron nails, and two steel alloy rods about 3-4 inches long
6. Magnetic compass
7. Tacks or paper clips
8. Knife switch or push button
9. Shaker of iron filings
10. Piece of cardboard about 8 inches square

Procedure: With your experimental team, plan how to do each of the following tasks:

1. Make an electromagnet of 15 turns and connect it to a dry cell through a switch. Do NOT make final connections to the cell until your circuit is approved by your teacher.
2. Use the electromagnet you have made and the bar magnet to discover THREE ways in which they are similar.
3. How many ways can you find to make your electromagnet stronger? Use table below to help you.
4. What would be the effect of using a steel alloy instead of the nail as a core? Try it.

TABLE OF OBSERVATIONS

		Number of Tacks Picked Up With 1 Dry Cell		Number of Tacks Picked Up With 2 Dry Cells	
Turns	Core	My Results	Class Average	My Results	Class Average
15	1 Nail				
30	1 Nail				
15	2 Nails				
30	2 Nails				

Summary:

1. In what ways are electromagnets similar to bar magnets?
2. What methods did you use to find this out?
3. What ways did you find out of increasing the strength of an electromagnet?
4. Did doubling the number of dry cells or turns double the number of tacks the electromagnet picked up? Explain your results.
5. Is the average of the class more accurate than the results of one group? Why?
6. Write up this experiment in your own words, telling what you did, saw, and found out.

15. HOW CAN WE MAKE ELECTRICITY WITH A MAGNET?

a. Recall that Oersted had shown that electric currents in a wire produce magnetic effects and raise one question asked by Faraday to see if the reverse is true, "Is it possible to obtain electric current from magnets?" Have the pupils discuss and see clearly that since electric current can produce *motion* of magnets, it should be possible to have magnet *motion* produce electric current.

b. Connect a coil of about 50 turns of wire to the terminals of a large demonstration galvanometer and have the students suggest motions of magnets that might produce an electric current, such as:

1) Motion of the magnet in different directions both inside and outside the coil. Motion of coil relative to the magnet.
2) Changes in speed of motion.
3) Changes in polarity of side of magnet entering the coil.

c. Using an alnico rod magnet, demonstrate the suggestions and record the results on the blackboard in a table such as the following:

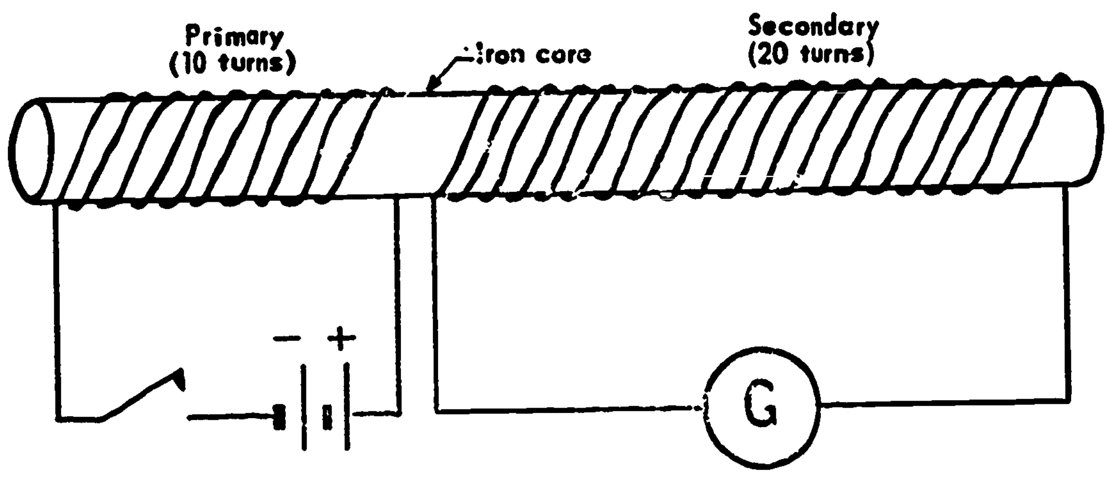
Motion	Galvanometer Reading	Direction of Deflection
N-pole in rapidly		
N-pole in slowly		
Magnet at rest in coil		
N-pole out rapidly		
N-pole outside of magnet		
S-pole in rapidly		
S-pole out rapidly		
Coil in magnet rapidly		
Coil out of magnet rapidly		

d. From the data above, have the pupils realize that the direction and magnitude of the induced current in a coil depends upon the speed and direction of the motion of a magnet relative to the coil. The faster the magnet or coil moves, the larger the current. The direction of the induced current depends upon the direction of motion of the magnet or coil and its polarity. In short, motion is essential. But the effect is the same whether it is the coil or the magnet which is in motion as long as lines of force are cut in the process.

e. Summarize the foregoing principle by operating a hand A.C. generator both slowly and rapidly. Use a neon lamp to show that the current periodically reverses itself as indicated by the fact that each plate glows in turn. Have the class explain that the repeated reversal of the direction of the current is a characteristic of *alternating current.*

16. HOW CAN WE INDUCE ELECTRICITY WITHOUT MOVING EITHER A MAGNET OR A COIL?

a. Challenge the pupils to explain the following demonstration using their knowledge of the induction of electricity by motion of magnets: Around one-half of a soft iron bar or long nail, wind 10 turns of insulated wire and connect it in series with a switch and two dry cells as shown below; on the other half, wind 20 turns of wire and connect it to the terminals of a demonstration galvanometer. Have the pupils note that the deflection of the meter occurs only when the circuit is opened or closed. When the current flows steadily in the first coil, or primary, no current is induced in the secondary coil. (Caution: Only permit the switch to remain closed long enough to obtain a reading.)



A pupil discussion should make clear that:

1) When the primary circuit is closed by means of the switch, it becomes an electromagnet with a magnetic field and lines of force around it.
2) Because the core extends into the secondary coil, an electric current is induced into the secondary circuit. The effect is analagous to that of introducing a magnet into the secondary coil.
3) When the primary circuit is opened, it no longer is an electromagnet and the current induced into the secondary circuit is reversed—an effect comparable to that of removing the magnet.
4) Hence, by repeatedly opening and closing a primary circuit, an alternating current can be induced into a secondary circuit.

b. Explain that such an arrangement is similar to an induction coil and can produce very high voltages by increasing the number of turns in the secondary coil. Demonstrate the operation of an induction coil, showing the spark produced and the make and break of the armature.

c. Raise the question, "Is it possible to induce a current into a secondary circuit without opening and closing a primary circuit?" A pupil discussion should reveal that an alternating current reverses its direction very rapidly. The rapidly increasing and decreasing field induces a corresponding alternating EMF in the secondary.

Develop the topic of transformers as follows:

1) Exhibit several of such devices used to ring bells, move model trains and light neon signs.
2) Explain that they are called transformers and operate only on A.C. current.
3) Point out that some lower the voltage and are called step-down transformers; others raise the voltage and are called step-up transformers.
4) The amount that the voltage is raised or lowered depends upon the ratio of the number of turns in the secondary to that of the primary. Thus, if the secondary coil has twice the turns of the primary, the voltage will be doubled.

d. As time permits, or as a homework assignment, do the following transformer problems:

1) The secondary coil of a transformer has one-half the number of turns of the primary. Is this a step-up or a step-down transformer?
2) If the voltage across the primary is 50 volts, how much voltage is present across the secondary?
3) Another transformer has a secondary coil voltage of 100 volts and the secondary coil has twice the number of turns as the primary. What is the voltage across the primary coil?

17. and 18. HOW CAN THE CURRENT INDUCED IN A COIL OF WIRE BE INCREASED?

NOTE: This laboratory lesson is an exercise in careful observation in order to draw conclusions in the solution of three problems. The teacher is advised to prepare individual coils of bell wire each about 4-6 inches in diameter and consisting of about 50 turns. The coils should be securely fastened at several points with electrical tape. To prevent severe damage to the galvanometers, the pupils should be strongly cautioned to avoid connecting the dry cells to the meter in any manner.

LABORATORY WORKSHEET #8

(May be duplicated for distribution to the pupils)

Purpose: To discover some factors involved in electromagnetic induction.

Materials:

1. Coils of bell wire of about 25 and 50 turns
2. One 4-6 foot length of bell wire
3. Two bar magnets
4. Galvanometer
5. Iron nail
6. Knife switch or push button
7. Tacks or clips
8. Screwdriver, if available

Procedure: Plan a method and solve the following problems using the materials at your table.

1. Show that there are THREE methods to induce a voltage in a coil of wire with a bar magnet. Record the resultant current that flows in the wire as shown on the galvanometer.

METHOD NUMBER	NAME OF METHOD	GALVANOMETER READING AFTER USING METHOD
1		
2		
3		

2. Find out if an electromagnet is as good as a bar magnet in inducing a current in the same coil of wire. Make an electromagnet of about 15 turns of wire and compare the highest galvanometer readings of both magnets. Be sure that you do NOT connect the dry cell to the galvanometer.
3. How many ways can you find of reversing the direction of an induced current?

Summary:

1. What did you find out or conclude from the first problem? Which method increased the current the most?
2. Explain why the two bar magnets had to be held in a special way to increase the current induced in the coil of wire.

3. What did you conclude from the second problem?
4. Why should a galvanometer not be attached directly to a dry cell?
5. What are the ways you discovered for reversing the current induced in the coil?
6. Write up this laboratory lesson including your procedure, observations and conclusions.

HEAT

OUTCOMES **Suggested Time Allotment: 6 Periods**

- Heat generally causes solids, liquids, and gases to expand.
- Temperature is measured by thermometers in units called degrees Fahrenheit and Centigrade are two of the scales in general use.
- Heat is transferred by methods known as conduction, convection, and radiation.
- Heat is measured in units called calories by devices known as calorimeters.
- A calorie is the amount of heat required to raise the temperature of one gram of water one degree centigrade.
- Heat can be explained in terms of the motion and energy of molecules.

Suggested Lessons and Procedures

19. HOW DOES HEAT AFFECT THE SIZE OF MATTER?

a. Have the pupils recall that the flow of electricity through resistors or wires is generally accompanied by the production of heat, providing the basis for electrical heaters, cookers, and the like. Explain that during this process electrical energy is converted to heat energy and ask, "What is the effect of heat energy upon the size of solids?" To find out, demonstrate the expansion of solids by heating the "Ring and Ball" apparatus. Plunge the heated ball into cold water to show contraction with decrease in temperature.

b. Demonstrate the relationship of heat to expansion and contraction of other forms of matter; namely, liquids and gases, as follows:

1) Fill an Erlenmeyer or Florence flask with colored water. Fit the mouth of the flask with a one-hole rubber stopper containing

a piece of glass tubing which projects about one inch below and six inches above the stopper. Heat the flask and have the pupils observe the rise of the water in the tubing. The reverse effect may be seen upon cooling the flask.

2) Prepare a similar empty (dry) flask and, with a rubber band, secure a balloon to the longer end of the glass tubing. Upon heating the flask, the expanding air should cause the balloon to inflate. Cool the flask to observe the effect of contraction of the air.

c. With a Bunsen burner, heat a straight bi-metallic, 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 phenomenon, the pupils should realize that two different metals are joined together (possibly iron and brass) and that they expand at different rates.

d. In summary, have the pupils cite illustrations of useful applications of the expansion and contraction of matter: thermometers, thermostats, riveting, and casting molds. Follow with examples of harmful effects, such as, the buckling of sidewalks, roads, and rails in the summertime or during fires, as well as the cracking of drinking glasses because of extreme temperature changes. Conclude by having the pupils realize that matter generally expands upon heating and contracts when cooled.

20. HOW IS TEMPERATURE MEASURED?

a. Demonstrate the unreliability of the sense of touch as a measure of temperature: Half-fill one battery jar with hot water, a second jar with water at room temperature and a third jar with very cold or ice water. Have a pupil put one hand in the first jar and the other hand in the third, for a period of about one minute. Then have him place both hands into the second jar, reporting his sensation of temperature to the class.

b. Show how the principle of expansion and contraction of solids and liquids can be applied more accurately to the measurement of temperature as follows:

1) Display a mercury thermometer and have a pupil report on its operation, indicating the *regular* expansion of the mercury with rise in temperature.

2) Exhibit the compound bar in an oven thermometer. Have a pupil explain the regularity of bending in response to temperature changes.

c. Explain the mechanism and show the salient features of some special thermometers. The clinical thermometer has a constriction for holding the mercury at the highest point; it requires shaking before being re-used. For low temperature, alcohol is the liquid of choice because of its low freezing point. Electrical thermometers utilize the junctions of two metals which when heated unequally cause a slight electric current to pass through a galvanometer.

d. Develop the topic of thermometer scales as follows:

   1) Have the pupils read a Fahrenheit thermometer and report the temperature reading of the room. Emphasize the fact that the numbers refer to degrees F.

   2) Discuss the manner of selection of the numbers or degrees. Point out that in the Fahrenheit thermometer the freezing point of pure water is standardized at 32° F. and the boiling point at 212° F. The intervening space in the thermometer is divided evenly into 180 parts or degrees.

   3) Show a Centigrade thermometer and explain that the standard points on this scale were set at 0° C for the freezing point of water and 100° C for the boiling point.

   4) Make a side-by-side drawing on the blackboard showing a comparison between the two scales at certain key points, such as the freezing point of water, its boiling point, room temperature, and normal body temperature.

21. HOW DOES HEAT TRAVEL?

a. Recall from the first laboratory lesson in chemistry that metals were shown to be good conductors of heat. Raise the question, "Do all metals conduct heat equally well?" Compare the conductivity of different materials with a conductivity wheel or as follows: Prepare rods 3-feet in length and made of such substances as iron, copper, aluminum and wood. Have several students hold one end of each rod, put the other end into a Bunsen flame and report to the class the moment they sense that heat has reached their hands. Point out that heat travels through solids by a method known as *conduction;* metals generally are good conductors of heat, non-metals are poor conductors or insulators.

b. Demonstrate a second method of heat transfer by holding a pinwheel, smoking stick or punk over a Bunsen flame to show the rising current of heated air. That cooler air enters to push and replace the heated air may be revealed by lighting 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. Explain that the transfer of heat by motion of gases and liquids is called *convection*.

c. Light a Bunsen burner, candle, or toaster and hold a block of paraffin near one side of it. (If paraffin is unavailable, a pupil may simply hold his hands on both sides of the flame to sense the radiant heat.) Have the pupils attempt to explain how the heat from the flame is able to melt the paraffin. From the ensuing discussion, the students should understand that conduction could not take place since no solid is present between the flame and the paraffin. Nor could convection account for the transfer of heat in view of the fact that heated air rises above the paraffin block. Only a third method of heat transfer could explain the observations—a method referred to as *radiation*. With the aid of a radiometer placed in sunlight, show that the energy of sunlight reaches us by radiation. Place radiometer near a gas or candle flame and explain the results.

d. Summarize by examining 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.

22. WHAT IS HEAT?

a. Open a bottle of ammonia and have the pupils raise their hands as soon as they detect the odor. Observe that the hands go up from the first row back. After a short time, stopper the bottle and ask, "How is it possible to smell a substance even though it is some distance away?" Recall from chemistry that compounds are composed of molecules and explain that the molecules of solids are close together, those of liquids further apart, and those of gases at the furthest distance from one another. Have the pupils understand that since odors can be detected at a distance and that since the odor seems to travel outward from the source, molecules must be in constant motion.

b. Demonstrate that the motion of molecules can cause larger particles to move in patterns known as Brownian movement, as follows: Darken the classroom and project a light across it. Add smoke or chalk dust to the air and observe the dance of the dust particles caused by the bombardment they receive from the air molecules.

c. Show that heat increases the motion of molecules in the following manner: Heat the mercury in the Molecular Demonstration Apparatus, obtainable from the S-1 list, and call attention to the movement of the beads or wood chips. Point out the high speed of the tiny molecules necessary to move the relatively huge beads. Indicate that the bounding of the beads speeds up with increased temperature.

NOTE: A similar demonstration can be made by adding a half inch of mercury to a pyrex test tube and floating a dozen or so wood chips on the surface of the mercury. By means of a one-hole rubber stopper and glass tubing, connect the test tube to a vacuum pump and evacuate it.

d. Explain that the foregoing demonstrations support a theory of heat which holds that 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; cold bodies exhibit less molecular movement, thereby contracting in size. Since heated fluids expand, they tend to become less dense and are pushed up by surrounding masses of denser fluids giving rise to convection currents in gases and liquids. Note and explain the expansion of water from 4° C to 0° C as an important exception. Conduction of heat is explained by assuming that rapidly-moving molecules collide more violently and thus cause neighboring molecules to accelerate their motions.

23. and 24. HOW IS HEAT MEASURED AND EXCHANGED?

NOTE: This laboratory exercise is designed to teach the pupils the basic techniques and calculations of calorimetry. From the computations should come an understanding of the concept that heat differs from temperature as well as a demonstration of the validity of the Law of Heat Exchange.

During the introductory portion of the lesson, the teacher should inform the pupils that heat is measured in a unit known as a calorie, defined as the amount of heat required to raise the temperature of one gram of water one degree Centigrade. It follows that *heat in calories* can be determined by multiplying the *mass of water in grams* by the *change in temperature*. To simplify matters, the teacher should stress the fact that one milliliter of water weighs about one gram.

Because of the inherent heat loss in the suggested laboratory technique of calorimetry, the lesson offers an ideal vehicle for careful observation and clear thinking on the part of the pupils. Toward this end, the results obtained by each group should be tabulated on the blackboard during the discussion period. At that time, a comparison and analysis of the findings should be made and the summary questions should be explored. To show the importance of a control, the teacher should prepare and demonstrate the answer to summary question number two.

LABORATORY WORKSHEET #9

(May be duplicated for distribution to the pupils)

Purpose: To study the measurement and exchange of heat.

Materials:

1. Two 500 ml. beakers
2. Centigrade Thermometer
3. Graduated cylinder, 500 ml.
4. Calorimeter or tin can
5. Burner
6. Tripod or ring stand and clamp
7. Wire gauze

Procedure: With your laboratory team, decide on a plan to solve the following problems:

1. How much is the temperature raised and how much heat is gained when you heat 100 ml. of tap water in a beaker for five minutes? Remember that calories of heat are computed by multiplying the mass of water in grams by the change in temperature. Also, it will help you to know that one ml. of water weighs about one gram.

   TEMPERATURE CHANGE IN DEGREES CENTIGRADE .... __________

   HEAT GAINED IN CALORIES .... __________

2. How much heat is gained and how much is the temperature raised when you heat 400 ml. of tap water in a beaker for five minutes?

   TEMPERATURE CHANGE IN DEGREES C.......... __________

   HEAT GAINED IN CALORIES .... __________

3. What happens to the heat in both beakers of water when you pour them together into a calorimeter or a tin can? Be sure to stir the mixture after pouring. To help you with this problem, fill in your results under trial number one on the table below. Show heat lost with a minus (—) sign and heat gained with a plus (+) sign.

4. Try the same experiment a second time with 200 and 300 ml. of water in each of two beakers. Record your results as trial number two.

Trial Number	Beaker Number	Quantity in ml.	Change in Temperature	Heat Lost or Gained
1	1	100		
	2	400		
2	3	200		
	4	300		

Summary:

1. From your results in problems one and two, explain whether heat and temperature are the same.
2. What would have happened to the temperature change if you had started with the same amounts of tap water in the two beakers and heated them in the same way?
3. What did you find out or conclude from the third problem about heat lost by one beaker of water as compared with the heat gained by the other? (This is known as the Law of Heat Exchange.)
4. Were the results you obtained in each problem the same as those of the other laboratory groups? Explain any difference.
5. All the heat released by the burner was not transferred to the water. How was much of the heat lost?
6. How could this group of experiments have been made more accurate?
7. Write up this laboratory lesson including procedure, results, conclusions and sources of error.

SUGGESTED REVIEW QUESTIONS

The questions that follow are not intended as a diagnostic tool or comprehensive measure of the outcomes of the unit. The teacher may use them for review purposes or as a source of questions for a unit examination.

Directions (1-30): Choose the *letter* of the term which best completes the statement.

1. An electric current is a flow of electrons from
   (a) minus to plus (negative to positive)
   (b) minus to minus
   (c) plus to minus
   (d) plus to plus
   (e) anode to cathode

2. In normal house wiring, electrical outlets are connected in
   (a) a parallel circuit
   (b) a series circuit
   (c) a short circuit
   (d) opposite directions
   (e) an open circuit

3. The resistance of a piece of copper wire is 4 ohms. The resistance of a second piece of copper wire of the same thickness, but twice as long is
   (a) 1 ohm (b) 2 ohms (c) 4 ohms (d) 6 ohms (e) 8 ohms

4. If EMF or voltage is increased in a circuit
   (a) the current will remain the same
   (b) the current will decrease
   (c) the current will increase
   (d) the resistance will immediately change
   (e) the voltage will divide equally among all parts of the circuit

5. If the resistance in a circuit were doubled and the voltage applied kept the same, the
   (a) current would not change
   (b) current would increase
   (c) current would be reduced to half its original value
   (d) battery would not last as long
   (e) none of these would apply

6. A voltmeter
   (a) is more easily damaged than an ammeter
   (b) is always connected in series with the rest of the circuit
   (c) does not have much resistance
   (d) is always very cheap
   (e) is usually connected in parallel with some other part of the circuit

7. Ammeters
   (a) are not used as often as voltmeters
   (b) can never be connected to a lamp circuit
   (c) should be connected across a battery
   (d) should be connected in series with the rest of the circuit
   (e) are used only in parallel circuits

8. Parallel circuits
   (a) are seldom used
   (b) permit independent operation of electrical devices
   (c) draw less current from the source
   (d) are used only with lamps
   (e) are not as good as series circuits

9. Which of the following will not affect the resistance of a wire?
   (a) the length
   (b) the thickness
   (c) the nature of the metal
   (d) temperature
   (e) insulation

10. Strong magnets are made of
    (a) nickel (b) copper (c) brass (d) cobalt (e) alnico

11. By moving two north poles toward each other you may
    (a) increase the force of attraction
    (b) increase the strength of the magnets
    (c) increase the force of repulsion
    (d) decrease the force of attraction
    (e) decrease the force of repulsion

12. A device largely dependent upon induced currents for its operation is
    (a) the electric doorbell
    (b) the transformer
    (c) incandescent lamp
    (d) transistor
    (e) storage battery

13. A high voltage can be obtained from low voltage by the use of
    (a) a resistor
    (b) a rectifier
    (c) a relay
    (d) an induction coil
    (e) a rheostat

14. To increase the strength of an electromagnet
    (c) decrease the applied voltage
    (d) use a copper coil
    (a) increase the current through it
    (b) increase its resistance
    (e) heat the coil

15. When a magnet is in motion near a closed loop of wire so that lines of force are cut, a current flows in the wire. This was discovered by
    (a) Ampere (b) Volta (c) Faraday (d) Henry (e) Oersted

16. When the North Pole of a bar magnet approaches a piece of brass, the end of the brass nearest the magnet
    (a) becomes a north pole
    (b) becomes a south pole
    (c) becomes an electromagnet
    (d) remains unaffected
    (e) is attracted

17. The current in a conductor increases with an increase in voltage between the ends of the conductor. This principle was established by
    (a) Alessandro Volta
    (b) Andre Ampere
    (c) George Ohm
    (d) Joseph Henry
    (e) Michael Faraday

18. The core of an electromagnet is made of soft iron because soft iron
    (a) is an electrical conductor
    (b) is easy to shape
    (c) is easily magnetized and demagnetized
    (d) retains its magnetism
    (e) is cheap

19. The voltage rating of a dry cell is
    (a) 1 volt (b) 1½ volts (c) 3 volts (d) 6 volts (e) 110 volts

20. The wire in the heating element of an electric toaster is made of
    (a) aluminum
    (b) copper
    (c) nichrome
    (d) tungsten
    (e) silver

21. The rising column of smoke from a lighted cigar is due mainly to
    (a) conduction
    (b) convection
    (c) radiation
    (d) reflection
    (e) induction

22. Heat is a form of
   (a) force
   (b) power
   (c) energy
   (d) fuel
   (e) temperature

23. All Fahrenheit thermometers have
   (a) 180° between freezing and boiling points of water
   (b) mercury
   (c) 100° between freezing and boiling points of water
   (d) alcohol
   (e) compound bars

24. Heat can cause changes in
   (a) length
   (b) color
   (c) molecular motion
   (d) temperature
   (e) all of these

25. Energy from the sun reaches the earth by
   (a) radiation
   (b) convection
   (c) conduction
   (d) reflection
   (e) induction

26. As a flask of water is heated
   (a) the color will change
   (b) air will be taken into the flask
   (c) the liquid will increase in volume
   (d) the flask will break
   (e) the flask gets heavier

27. A compound bar bends when heated because the metals of which it is made
   (a) do not expand
   (b) expand at the same rate
   (c) expand at different rates
   (d) resist the heat
   (e) contract

28. When a body is heated the molecules
   (a) expand
   (b) contract
   (c) move close together
   (d) move more slowly
   (e) move faster

29. When current flows through a resistance wire for a length of time
   (a) the wire will melt
   (b) the wire may become longer
   (c) the current will increase
   (d) the restance of the wire will become less
   (e) the battery voltage will go up

30. Solids transfer heat by the process of
    (a) conduction
    (b) convection
    (c) radiation
    (d) induction
    (e) reflection

Directions (31-40): Complete the statements that follow.

31. A substance through which electrons do not move easily is called a (n) . . . .

32. The heat required to raise the temperature of 1 gm of water 1° C. is called a (n) . . . .

33. The Centigrade equivalent to 32° F is . . . .

34. Thermometers are used to measure . . . .

35. A bar magnet is broken into four equal parts. The number of magnets produced is . . . .

36. A conductor carrying a current is always surrounded by a (n) . . .

37. The lines of force of a bar magnet are concentrated at the . . . .

38. The angle of dip at the magnetic north pole is . . . degrees.

39. The current in a circuit is measured in units called . . . .

40. The motion of a compass indicates that the earth acts as a huge . .

Directions (41-50): Identify as *TRUE* if the statement is correct; if the statement is *not* correct, *change* the *italicized* word to make the statement true.

41. In all parts of a series circuit, the *resistance* must be the same.

42. The rate of flow of electrons may be measured with an *electrometer.*

43. The electromotive force in a circuit is measured in *watts.*

44. Turning a switch to the "off" position produces a *short* circuit.

45. Electromagnetism is associated with the motion of *neutrons.*

46. Mercury or alcohol is used in most *calorimeters.*

47. A generator is a device for producing *electrical* energy.

48. The voltage ratio in a transformer depends upon the *current* ratio.

49. In a step-up transformer, the secondary always has a greater amount of *energy*.

50. The lines of force around a magnet may be changed by placing a piece of *iron* near the magnet.

Directions (1 and 2): Answer both of the following essay questions.

1. Give *either* a brief scientific explanation *or* draw a conclusion from each of the following:
   (a) A compass can be used to show that an iron bar is magnetized.
   (b) Electromagnets can be made stronger than permanent magnets.
   (c) A balloon attached to an "empty" flask inflates when the flask is heated.
   (d) A boy connects two lamps to a battery. They glow dimly. Another boy connects the same two lamps to the battery and they glow brightly.
   (e) Train rails have spaces purposely left between their ends.
   (f) A vacuum bottle keeps liquids hot or cold.

2. Write up the laboratory experiences listed below, using the suggested *outline* as a guide:

Laboratory Experiences

Factors affecting the flow of electricity
Nature of magnetic fields and lines of force
Factors affecting the strength of an electromagnet
Factors involved in electromagnetic induction
How heat is measured and exchanged

(a) State the purpose or problem
(b) List the materials
(c) Write the procedure
(d) Describe the observations
(e) List the conclusions

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SCIENCE
Grade 7

3. The Materials of Life

Bureau of Curriculum Development
Board of Education of the City of New York

FOREWORD

In these times of great scientific advancement and opportunity, we are increasingly dependent upon a scientifically literate population. Our young people must be led to explore, search for, and discover scientific ideas "which are durable for at least a generation."

A new science course of study for grades 7, 8 and 9, part of a K-12 program, is currently being prepared. The new course is based upon the sequential development of scientific concepts from the four major science areas.

This bulletin, "The Materials of Life," is the third in a series of twelve bulletins, one for each portion of the course — chemistry, physics, biology, and earth science — at each grade level. The materials herein have been applied and evaluated in classroom situations over a period of two years. Teachers and supervisors will find herein practical assistance in putting into practice the biology part of the proposed revised course in junior high school science.

An overview of the revised course of study for grades 7, 8 and 9, including a statement of philosophy, objectives, scope and use, appears on pages vii-xiii of *Science; Grade 7 — The Chemistry of Matter* (Curriculum Bulletin No. 9a, 1962-63 Series). Teachers and supervisors should refer to these pages as they use "The Materials of Life."

The science program, of which this bulletin is a part, envisions in-service training in schools and districts.

It is hoped that this bulletin and the others in preparation will make possible further development and extension of the program.

JOSEPH O. LORETAN
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December 1963

CONTENTS

THE NEEDS OF LIVING THINGS 1

CELLS 10

NUTRITION 19

SUGGESTED REVIEW QUESTIONS

Part I 32

Part II 38

SUGGESTED REFERENCES 40

THE NEEDS OF LIVING THINGS

OUTCOMES **Suggested Time Allotment: 6 Periods**

- Living things carry on a number of basic activities or processes in common.
- These processes or functions are essential for maintaining an organism.
- For these processes, living things require food, oxygen, water and proper environmental temperature.
- The microscope is an important tool in revealing the structure and functions of living things.

NOTE: 1. Many of the outcomes listed above have in one way or another been developed in *Living Things.** It is recommended that the teacher be aware of the outcomes and experiences which the booklet offers.

2. All experiments requiring dissection of animals (on any grade level) must be performed in the classroom under the immediate supervision of the science teacher.

3. Animals which must be sacrificed for classroom use should not be killed, pithed, or decapitated in the presence of the pupils. This preparation should be made prior to the lesson by the teacher or the laboratory assistant.

Suggested Lessons and Procedures

1. HOW CAN LIVING THINGS BE GROWN AT HOME FOR STUDY?

a. Introduce the unit by asking, "How can we search for and collect living things that are near us?" Contribute to the discussion by explaining that although we cannot see some of them, interesting living things are present all around us. As a guide in the growth and study of such organisms, duplicate and distribute the following sheet of directions on the next page.

**Science: Grades K-6* (Curriculum Bulletin No. 2c, 1958-59 Series)

HOW TO GROW LIVING THINGS AT HOME

NOTE: 1. For most of these activities, use a jar with a wide mouth, such as a one pint peanut butter or mayonnaise jar.

2. Observe and record changes that occur during growth and development.

Growing Bread Mold: Obtain a wide-mouthed jar. Cut blotters or pieces of paper towelling in the shape of a circle and put them on the bottom of the jar. Moisten the paper and keep it damp. Sprinkle some dust on a piece of bread and place it on top of the moist paper. Cover the jar loosely and set it in a warm, dark place. Examine the bread daily for the white cottony growth of bread mold. Observe the changes that occur.

Culturing Bacteria: Crush a dozen dried lima beans and place them in a wide-mouthed glass jar half-filled with water. Do *not* cover the jar for about one day. Keep it in a warm, dark place. After that time, cover the jar.

Growing Yeast: To a wide-mouthed jar, add about one inch of water in which has been dissolved about two teaspoonsful of sugar. Buy and mix in about one-quarter teaspoonful of fresh yeast. Cover the jar and keep it in a warm, dark place. Find out the role of yeast in making bread and wine.

Germinating Seeds: Line the inside of a wide-mouthed, glass jar with a blotter or paper towelling. Between the glass and the paper, place about five seeds halfway up from the bottom of the jar. You may use lima beans, after soaking them in water for 24 hours, radish seeds or any other kind of fast-growing seeds. Pour about one-half inch of water into the bottom of the jar. Do *not* cover it.

Growing Plants from Parts of Plants: Stick three or four toothpicks into the sides of an onion, a sweet potato, a carrot top or a beet top. Immerse the bottom of the specimen in a jar or glass filled with water. Be sure that the specimen does not fall into the water.

Raising Animals: If you have a pet animal, observe it daily and keep a record of the food it eats and its feeding habits. Keep a record of the care you give it. Weigh it once a day at the same hour if a suitable scale is available. Record the weights.

Finding Protozoa and Algae: If you have an aquarium, observe the sides and bottom of the tank every day. Look for a green growth on the sides and for debris on the bottom of the tank. Examine bits of these materials under a microscope or magnifying glass. Look for small living things.

Caution: Be sure that the bacteria and yeast cultures are well covered while being examined. Before transporting them, the cap of each jar should be opened slightly to relieve any pressure. The jar should then be closed tightly, and wrapped securely in many layers of paper, and carried in a box. Upon arrival at school, the cap should be opened slightly and stored in that condition in the science room or laboratory.

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b. Assign each pupil, as soon as possible, the task of growing at least one organism at home. Using actual materials, demonstrate the method of growing bread mold and answer questions relative to the other techniques. Discuss possible sources of materials and places to store their growing organisms at home. To stimulate the pupils and to serve as a model, set up about the room an exhibit of growing organisms. Invite the pupils to contribute to the exhibit. Make certain that the exhibit contains as many living organisms as possible.

c. Raise the question, "What may we find out about the living things we grow?" For the suggested investigations, have the pupils devise procedures to test the organisms under *controlled* conditions; thus, yeast may be grown in different jars, with and without sugar, or bread mold grown with and without moisture. A student secretary should record the name of each pupil and what he is investigating, such as:

- On what type of bread does mold grow best?
- Will mold grow on dry bread?
- How does bread mold grow?
- To what extent does yeast grow without sugar?
- Is air necessary for yeast to grow?
- How does yeast make bread and cake rise?
- How does yeast reproduce?
- How well will bacteria grow in a refrigerator?
- Do seeds need water to grow?
- What does my pet need in order to grow?

d. Discuss problems that may arise in trying to raise some of the organisms. Discuss the effects of variations in temeprature, food, light, moisture and air on growth and how to test for these effects.

e. Have the class discuss the measures necessary for success of their experiments. The pupils should be required to:

1) Make a daily notebook record, or log, of everything done including care and maintenance.

2) Observe and record any changes that take place.

3) Record the observed needs of living things and the conditions under which they appear to grow best.

4) Revise and utilize at least one control for each growth experiment.

5) Be ready to report to the class on the results of the experiments.

6) For the next laboratory period, bring their cultures to school for further study.

2. HOW CAN WE TELL THAT A THING IS ALIVE?

a. Remind the pupils that, by now, their cultures and investigations should be under way at home. They should be able to recognize whether the organisms are alive and growing. If no signs of life appear, students should start to grow new organisms. As an aid in distinguishing living from non-living things, display a variety of living plants, living animals, and samples of fur, wood, bread, rocks, chemical elements and chemical compounds. Have the pupils select, with reasons, those they consider to be alive. Perhaps the animals will be chosen because they move and the plants because they grow.

b. Challenge the pupils with the question, "How do you know that *you* are alive?" Develop the concept that living things engage in such basic activities as locomotion, ingestion of food, digestion, circulation, respiration, excretion, response to stimuli, growth and reproduction. Explain that these functions are referred to as *life processes.*

c. Promote an understanding of some of the life processes mentioned by listing them on the chalkboard and discussing each in simple terms; for example, locomotion is movement from place to place; irritability is the ability to respond to stimuli. Stimulate the class to respond to such questions as:

- How can we tell if bread mold is alive?
- Do plants move?
- How can we tell if bacteria and yeast are growing?
- Do plants respond to stimuli?
- How can you be sure if an animal or plant is growing?
- How do bacteria, yeasts and molds reproduce?

NOTE: From the exhibit of growing organisms about the room, the pupils should be able to answer some of the questions; others may be answered by recalling previous science experiences. Pictures or diagrams may serve to show that plants move and react to such stimuli as touch, light, water and gravity, and that bacteria reproduce by binary fission, yeast by budding, and molds by sporulation. The teacher may find it desirable to show and discuss a suitable film on the activities of living things to clarify each of the life processes.

d. Sumarize by testing the ability of the class to distinguish living from non-living things. Display a bean or other seed along with a pebble of similar appearance and have the pupils decide whether one is alive. From the discussion, the idea should evolve that until the seed is grown, it is hard to prove that it is alive, since some seeds may not be alive and will not germinate. "Clinch" the concept by displaying a plant grown from a similar seed.

e. Assign the class or selected pupils to report on the life and work of Anton van Leeuwenhoek. Stipulate that the report should emphasize his contribution to the development of the microscope, to the study of organisms, and to our knowledge of living things.

3. HOW DOES THE MICROSCOPE HELP US STUDY LIVING THINGS?

NOTE: Prepare and duplicate worksheets of a diagram of a compound microscope. Provide spaces for pupils to label the parts and to describe the purposes of each part.

a. Call upon the students to present their reports on the life, work, and contributions of Leeuwenhoek.

b. 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 close to the first and have the pupils observe the increased magnification. Explain that a compound microscope consists of two lenses, one called the eyepiece and the other the objective. Total magnification is arrived at by multiplying the magnification of one lens by that of the other. Ask the pupils to determine the total magnification of the low-power and the high-power lens systems of the microscopes used in school.

c. Distribute the duplicated worksheets (on the microscope) and have the pupils complete them as the lesson proceeds. With the aid of a large chart of a compound microscope, demonstrate the main parts and discuss the functions of each. Call upon pupils to repeat the identifications, using a school microscope. Acquaint the students with the fact that microscopes are delicate and expensive instruments and develop a set of rules for their care, such as:

- Hold and carry the microscope with both hands, one on the arm and the other below the base.

- Always keep the objectives in neutral position when not in use.
- Focus upwards.
- When the object is being viewed under high power, use only the fine adjustment to change the focus.
- Do not touch the mirror or either lens with the fingers.
- To clean the lenses and mirror use lens paper.
- When damage to the microscope is discovered or when objects cannot be observed properly, the teacher should be notified at once.

d. In summary, have the pupils explain that microscopes help us study living things by magnifying them so that their structures may be

NOTE: Remind the pupils to bring to the next laboratory and classroom periods, the microscope organisms they are studying at home. Microscopes will be available for further study of these organisms during the laboratory period.

4. and 5. WHAT DOES THE MICROSCOPE SHOW US ABOUT SOME OF THE LIVING THINGS GROWN AT HOME?

NOTE: To the junior high school pupil, perhaps the most exciting aspect of biology is the use of the microscope to observe and examine the microscopic world that it reveals. This laboratory lesson is designed to follow up the learnings of the previous lesson (in terms of parts, functions and care of the microscope) with the development of skill in its actual use. It also affords the pupils the opportunity to widen their study of the organisms grown at home. From their observations, the pupils should see evidences of life in yeasts and molds and observe locomotion in protozoa. Careful observation may reveal such needs of living things as air (protozoa tend to cluster near the edge of the drop), food (molds penetrate and dissolve bread) and water (protozoa shrivel and die as the drop dries up).

Experience indicates that initial teaching of the microscope is accomplished best by means of a step-by-step procedure similar to that described in the first laboratory lesson of the chemistry unit. After the pupils have practiced each of the steps using a microscopic slide of Elodea or of bread mold, and after each step is checked, the teacher should allow the pupils to solve the other problems in the exercise.

NOTE: Because of the possible danger that pathogenic bacteria were cultured at home, the teacher should *not* permit the pupils to make and examine slides of bacteria under the microscope.

LABORATORY WORKSHEET #10

(May be duplicated for distribution to the pupils)

Purpose: To learn to use a compound microscope to study the living things grown at home.

Materials:

1. Compound microscope
2. Home-grown cultures of molds, yeasts and protozoa
3. Leaf of Elodea
4. Microscopic slides and cover slips
5. Forceps
6. Medicine dropper

Before Starting:

Remember that:

1. Microscopes are very valuable and easily damaged. Therefore, you will be given exact instructions. Do *not* touch anything or do anything until you are told what to do and when to do it.
2. You must be quiet in order to hear the instructions. The lesson cannot proceed until there is absolute quiet and attention.

Procedure:

1. Swing the low-power objective into position. Listen for the click, which shows it is in place. How can you identify the low power?
2. While looking at its side, lower the barrel until the low-power objective reaches bottom without touching anything. Why should you carefully watch the barrel as it is lowered?
3. With your hand at the side and on the same level as the objective, tilt the concave mirror until it is apparent that a ray of light is passing through the stage into the objective. Check to insure that the diaphragm is wide open. What is the job of the diaphragm?
4. Now look through the eyepiece and tilt the mirror until you see a very bright circle of light. Why should this be the brightest light you can get?
5. Make a slide of a drop of water with a leaf of Elodea plant. Place a cover slip or glass at an angle over the slide and carefully lower it so that no air bubbles form. Why? What does an air bubble look like?
6. Place your slide on the stage and make sure that the specimen is directly over the opening in the stage. Place the clips on the slide. Why?
7. Using the coarse adjustment and looking through the eyepiece, focus upwards slowly. *Never focus downward.* Why?
8. Stop, when the object is in focus, and use the fine adjustment to obtain a sharp focus.
9. Draw what you see in the field of the microscope in your notebook.
10. Now, *slowly* revolve the high power objective over the slide until you hear a click. Watch carefully to be sure that the high power objective does not strike the slide.
11. While looking into the eyepiece, bring the specimen into sharp focus using the *fine* adjustment knob. Never use the coarse adjustment under high power. Why?
12. Draw what you see.

Problems:

1. Make a slide of *one* microscopic living thing that you grew at home, following the instructions of your teacher. Carefully observe the specimen under the microscope. Pick up a bit of bread mold with forceps and place it on a slide with a drop of water. View it under the low-power objective of your microscope. Protozoa move rapidly; try to slow them down with threads of lens paper. Yeasts require high power and can be seen best near the edge of the drop of water if the light is reduced somewhat. Do *not* make a slide of bacteria. Be sure to ask your teacher if you need help.
2. Make a drawing of the specimen as seen under the microscope.
3. Describe any activity or changes that you see which may indicate that the organism is alive.
4. Try to find evidence that the living specimen needs air, water or food. What happens when the drop of water dries out?

Summary:

1. What did you find out about the living thing you observed?
2. What evidence did you find for believing that the organism you grew and observed is alive?
3. What evidence did you see that the living thing had certain needs?
4. From the different organisms observed by your class, what conclusions can you draw about living organisms?
5. Write a report of this lesson in your notebook.

---

6. WHAT DID WE FIND OUT ABOUT LIVING THINGS?

a. Conduct a seminar by having the pupils deliver talks on their home experiments with living things. Encourage them to display their cultures as they describe their investigations. The teacher should insist that the observations be stated accurately and specifically and that the conclusions be limited to the experimental evidence and recorded data. For example, a pupil may observe that his hamster drank water regularly and that the water bottle was empty after several days. From the data he may conclude that his hamster may require water to keep alive.

b. To promote a spirit of inquiry, ask the pupils to suggest and discuss questions arising from the experiments:

- Why should fermenting or decaying mixtures *not* be kept sealed too long?
- What should be done with the cultures after they have been studied?
- What happens to the bread which is host to the bread mold?
- Why do some breads remain free of mold longer than others? What are spores?

- What substances are produced when yeast is grown in sugar solution?
- Where do germinating seeds get the food they require?
- Do germinating seeds need light to grow?
- Why can certain plants be grown from parts of the plants?
- What are protozoa?

NOTE: It is suggested that explanations be kept brief. For example, jars of fermenting or decaying materials release gases which may accumulate and exert pressure great enough to burst the container; molds make bread unpalatable; some breads contain a mold inhibitor; and in yeast fermentations, sugar may be converted to alcohol and carbon dioxide.

c. At this point, there may be considerable profit in discussing the problems of the pupils who were less successful in growing living things at home or in carrying through their experiments. Encourage the class to suggest possible reasons for failure and means for solving the problems so that these pupils may perform their experiments successfully.

d. By way of summary, have the pupils consider the question, "What did we find out about the organisms we studied?" From the discussion, the pupils should come to the conclusion that, in order to perform their life functions, living things need food, oxygen, water and proper environmental temperature.

CELLS

OUTCOMES **Suggested Time Allotment: 8 Periods**

- Almost all living things are made of cells.
- The shape of cells varies and depends upon their functions.
- Almost all cells contain a nucleus, cytoplasm and a cell membrane.
- Plant cells usually have cellulose cell walls.
- The chloroplasts of green plant cells assist in the manufacture of carbohydrates by a process called photosynthesis.
- Most cells ars microscopic in size.
- Living cells consist of a complex mixture of various chemicals known as protoplasm.
- A group of cells similar in structure and function and which work together is named a tissue.
- An organ is a group of tissues which are coordinated to do a specific job or jobs.
- When several organs work together to perform a life function, they are called an organ system.
- A living thing is termed an organism.

NOTE: Prior to the start of the unit, the teacher should order a sufficient number of live frogs for laboratory lesson No. 12 (page 18). In addition, a chicken thighbone should be placed in a jar of white vinegar or dilute hydrochloric acid for use in the lesson.

7. WHERE IS DIGESTED FOOD USED IN THE BODY?

a. Provide the basis for the cell theory, that living things both animal and plant are made up of cells, as follows:

1) Show pictures, diagrams, charts, slides or filmstrips of the *cells* making up a variety of animals: protozoa, sponges, hydra, worms, insects and vertebrates. Call attention to the nucleus in the cells.
2) Demonstrate that plants, such as algae, fungi, liverworts, ferns and higher plants are cellular in structure with visual material of various kinds.

3) Point out that cells are the building blocks of living things and are the structures that utilize food to perform the life functions.

b. Distribute a piece of clay, and a bead, for the nucleus, to each of the laboratory groups. Have them make clay cell models and evaluate them to realize that cells are three-dimensional in structure, that the nucleus is *within* the cell, and that cell sizes and shapes vary.

NOTE: This may be done as a demonstration in the interest of time.

c. Discuss such questions as:

1) Are there *parts* of living things *not* made of cells? (Crystalline lens of the eye)
2) Are there cells without nuclei? (Red blood corpuscles)
3) Do some cells have more than one nucleus? (Striated muscle cells)
4) Can we see any cells with the naked eye? (Egg cells of birds)
5) Are any living things not made of cells? (Probably viruses)

d. Summarize by drawing conclusions, such as the following:

1) Almost all living things are made of cells.
2) Some living things are one-celled; others are multi-cellular in structure.
3) Cells are usually microscopic in size.
4) Cells vary greatly in shape.
5) Within each cell is a structure called a nucleus.
6) Digested food must reach and be used by the cells since these structures make up living things.

e. Assign selected pupils or rows of pupils to report on the historical background of the cell concept. Include reports on Hooke, Brown, Schleiden and Schwann.

8. WHAT DO THE PARTS OF A CELL DO?

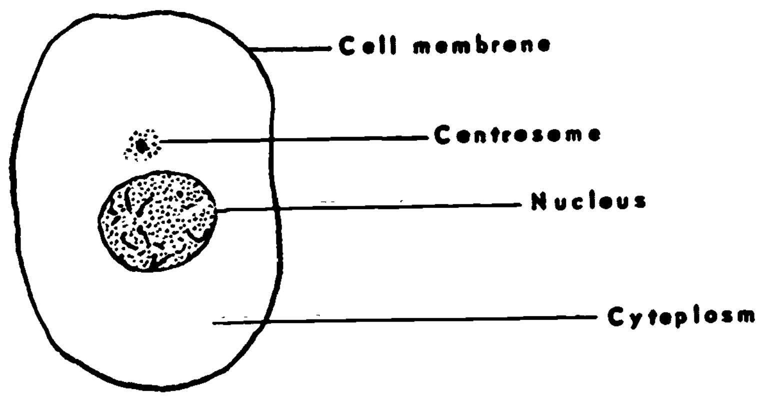
a. From the reports assigned, have the pupils learn that the cell was named by Hooke, the nucleus discovered by Brown and the cell theory stated by Schleiden and Schwann. These extraordinary scientific advances were made possible by the discovery and the improvement of the microscope.

b. Develop diagrams of the microscopic structure of typical animal and plant cells as follows:

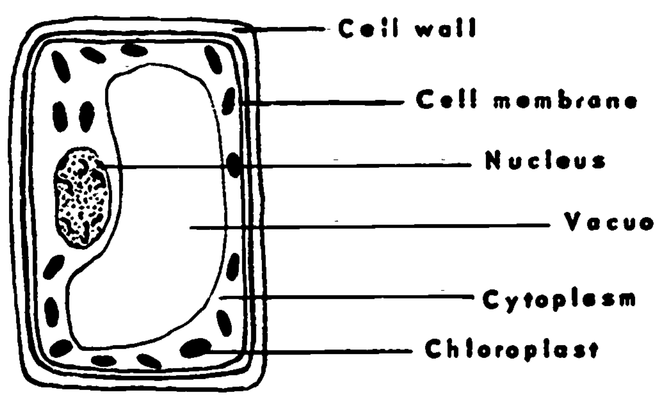
1) Using a bioscope, help the pupils identify the cell membrane, cytoplasm and nucleus in a slide of epithelial tissue. Human cheek

cells may be scraped from the inside of the cheek with the broad end of a flat toothpick. Spread them in the center of a clean slide, add a drop of Lugol's or methylene blue solution and observe under the highest power.

2) Draw and label a diagram of a generalized animal cell on the blackboard:



3) Repeat the above for a generalized green plant cell adding the cell wall and the chloroplasts. Prepared slides of the cross-section of a leaf should be applicable.



c. Tell the pupils that scientists have determined the functions of the cell structures and ask them how it was possible to do so. Perhaps they may suggest chemical analysis, micromanipulation and removal of cell parts, or tagging of digested food with radioisotopes.

d. Explain the jobs of each cell structure:

1) The *nucleus* is the directing agent; its removal affects cell life. Moreover, it determines the heredity of the individual.

2) The *cell membrane* allows digested food and oxygen to enter the cell and wastes to leave. These cell exchanges occur through the membrane by diffusion.

3) The *cytoplasm* is the "cell factory;" many cell activities and life processes take place here.

4) The *cell wall* keeps plant cells rigid and gives them shape since plants have no skeletal structures. It is made of a thick, dead, cellulose material (Wood is made of cellulose.)

5) The *chloroplasts,* with the aid of a pigment called chlorophyll, make carbohydrates from water and carbon dioxide by a process called photosynthesis. Green plant cells also synthesize proteins, fats and oils, and vitamins.

9. and 10. WHY DO CELLS HAVE DIFFERENT SHAPES?

NOTE: The following laboratory lesson is designed to give the pupils experiences in the use of the microscope for comparing the structure and functions of the different types of cells in plants. Moreover, it seeks to have the pupils solve two problems relative to the "cells" that Hooke observed, and to the size of cells.

It is suggested that the use and care of the microscope be reviewed in order to facilitate observations and to avoid damage. Then the teacher should demonstrate methods of preparing tissues and making slides as follows:

1) Leaf epidermal tissues may be peeled off the inside of an onion *or* obtained by cutting a strip of Bryophyllum, spinach, geranium, begonia or coleus leaf about one-fourth inch wide. With a razor blade or scalpel cut the strip part way through crosswise from the top. Bend the strip where it has been cut and peel off the lower epidermis. Place a bit of this tissue on a drop of water on a micrroscope slide and add a cover slip. Onion cells may be stained with a drop of Lugol's solution.

2) To show guard cells, a lettuce leaf may be torn at an angle to produce a thin edge which may be mounted on a slide.

3) Break a celery stalk, cut off a piece of "thread" and mount it on a slide in order for the pupils to observe tube cells.

As a related problem, the pupils may wish to observe the adaptations of root hairs or cells for absorbing water and minerals. Have available for this purpose either live radish seedlings or prepared root tip slides.

(*See Laboratory Worksheet #11, on page 14.*)

11. WHAT ARE CELLS MADE OF?

a. Have the pupils recall from the previous lesson that scientists study cells by observing them with a microscope and also try to analyze them chemically. Hold up an Elodea sprig and a piece of beef and explain that these methods will be used in class in an effort to answer the question, "What sort of matter makes up cells?"

LABORATORY WORKSHEET #11

(May be duplicated for distribution to the pupils)

Purpose: To find out the relation of the shapes of plant cells to their jobs.

Materials:

1. Microscope
2. Three slides and cover slips
3. Lugol's solution in a dropper bottle
4. Single-edge razor blade or scalpel
5. Forceps and two dissecting needles
6. Onion, Bryophyllum, geranium or coleus leaf
7. Lettuce leaf
8. Piece of cork
9. Ruler, 6 or 12 inch

Procedure:

1. Find out if the shapes of plant cells are well suited to their jobs. To help you, follow the method demonstrated by your teacher for preparation of the slides of the plant cells.
   a) Epidermal or surface cells cover and protect the plant.
   b) Guard cells of leaves form openings to allow gases to enter and leave.
   c) Tube cells in celery or other plant stems permit liquids to flow up and down.
2. Make drawings of each type of cell to show how its shape helps it do its job well.
3. Were the cork cells observed by Robert Hooke complete living cells? To find out, use your razor blade to slice narrow wedges from a small box-shaped piece of cork (approximately ¼ by ⅛ cross section).* Observe the thinnest sections with your microscope.
4. Choose any cell and find out how long it is. Look at the cell under the microscope with one eye and at a ruler with the other eye. Remember to divide by the magnification of the microscope.
5. What related problem would you like to investigate? Ask your teacher for materials and obtain his permission to proceed.

Summary:

1. How are the cells you observed well-adapted to do their jobs?
2. In what ways are different plant cells similar to one another? Different?
3. In what ways are plant and animal cells similar? Different?
4. Why do cells come in so many different shapes?
5. What did you find out about the "cells" that Robert Hooke observed?
6. How long was the plant cell you observed?
7. How did it compare in size with the cells your neighbors observed?
8. What conclusion can you draw about the size of cells?
9. If you tried another problem, what did you find out?

*See New York State Biology Handbook, p. 19, Section 1.08.

b. With the aid of a bioscope, and/or microscope demonstrations show the movement of chloroplasts and cytoplasm in Elodea as follows: Mount a leaf from the growing tip of the plant, rightside up, in a drop of warm water on a microscope slide. Add a cover slip and focus on the upper layer of cells near the midrib under high power. From their observations, have the pupil understand that the material making up the inside of the cell appears to:

1) Allow light to pass through (translucent).
2) Be colorless. Chloroplasts give plants the green color.
3) Be fluid or semi-fluid since the chloroplasts move in it.
4) Contain granules.

c. Analyze the beef muscle chemically for water by placing a small amount in a dry test tube and heating to show condensation along the cooler sides of the tube. Show the presence of protein in muscle cells by means of the Biuret test. Have the pupils recall that since digested nutrients arrive at the cell, it may also contain digested sugars, fats, minerals and vitamins. In addition, because food is used for energy, repair and growth, waste products like carbon dioxide also may occur in the cell. Have the pupils understand that some of the substances like sugars and minerals are probably dissolved in the water; others like proteins and the granules are probably suspended; and fats are emulsified. The entire contents of the cell is thought to be a complex mixture that is constantly changing.

d. Raise the question, "What other means which were studied in the chemistry unit may be used to determine the make-up of cells?" The pupils should suggest methods of separation of cell components by centrifugation, solution and evaporation, coagulation and precipitation. Explain that by high speed centrifugation the granules in cells have been separated and found to control energy production, growth and reproduction in the cell. *For brighter groups,* the granules may be identified as follows:

1) Larger granules in the cytoplasm called mitochondria release energy as needed by the cell through a chemical called ATP (Adenosine Tri-Phosphate).
2) Smaller granules in the cytoplasm known as microsomes direct the manufacture of proteins for growth and repair by means of a compound called RNA (Ribo-Nucleic Acid).
3) Genes in the nucleus form chromosomes and determine reproduction and heredity by means of a remarkable substance termed DNA (Deoxyribo-Nucleic Acid).

e. Summarize the nature of the material that makes up cells as follows:
   1) It is a complex mixture made up of many substances.
   2) The cell material is capable of growth, repair, reproduction and the release of energy.
   3) The material of the cell is very difficult to study because it is always changing and because it makes up life. Once we analyze it chemically, it is no longer living.
   4) The living material of the cell is known as *protoplasm.*

12. HOW DO CELLS FORM LIVING THINGS?

a. Introduce the topic of *tissues* as follows: Remove the chicken bone, prepared earlier, from the jar of vinegar or acid. Demonstrate that the bone can now bend easily even to the point of forming a knot. Tell the pupils that the liquid is an acid and have them realize that the mineral hardening substance in bone must have been dissolved, leaving the cells in a flexible condition. Show a diagram or slide of bone tissue indicating the cells and the mineral (calcium carbonate) matrix. Have the pupils note that all bone cells are alike in structure and function. Define a tissue as a group of cells similar in structure and function, working together as a group.

b. With the aid of the bioscope, microscope demonstrations, or by means of charts, diagrams or pictures, show prepared slides of the animal tissues listed below. Have the pupils identify each, giving its job(s) and relating its structure to its function:
   1) Epithelial tissue
   2) Bone tissue
   3) Muscle tissue (striated)
   4) Blood tissue
   5) Nerve tissue
   6) Connective tissue (white elastic)

c. 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 to the leg as a tough white cord which stimulates muscle contraction. Explain that the leg is a body *organ* which does specific job, movement, through the coordinated action of many tissues: muscle, connective, bone and nerve.

d. Using a mannikin or chart of the human body, have the pupils give illustrations of other organs. Lead them to observe that organs work together to form organ *systems,* such as the digestive, circulatory, respiratory and nervous systems, each of which performs a life function. The organ systems are likewise coordinated to form a living thing, or an *organism,* which performs all the life functions.

e. Summarize by developing definitions which give the relationships among cells, tissues, organs, organ systems and organisms.

13. AND 14. WHAT DO SOME ORGANS AND ORGAN SYSTEMS REALLY LOOK LIKE?

NOTE: The following laboratory lesson aims to provide pupil experiences enabling them to understand the external and internal structures of a frog and to observe their division into organs and organ systems.

Before class period, the frogs should be sacrificed by putting them in an airtight jar with a piece of ether-soaked cotton for about ten minutes. Prominently displayed, should be a chart of the anatomy of a frog. In its place, individual mimeographed diagrams of the frog's internal structures may be substituted and distributed to the laboratory groups. Living frogs should be ordered at least ten days before needed. Show the Bureau of Audio-Visual Instruction (BAVI) frog dissection filmstrip rapidly. This may allay squeamishness which may be anticipated in a small percentage of the pupils. In the exercise on dissection, many teachers find it desirable to "talk through" the steps of a dissection.

Observe the groups carefully at each step to see that they follow these directions: Place the frog on its back on the tray and pin down its arms and legs tightly. Grasp the skin and body wall of the lower part of the body cavity between the thumb and forefinger, lifting them away from the internal organs. With the tips of the dissecting scirrors snip through the pinched up tissues. Then insert the point of the scissors into the opening and make an incision the length of the central body wall. Make another incision from this one to the base of each forelimb forming two large flaps of tissue that can be folded back, exposing the internal organs. Insert pins through the flaps into the tray to keep the body cavity exposed. As related observations, the pupils may find the time to view frog tissues microscopically. In this connection, epithelial, blood or muscle tissue may be recommended.

LABORATORY WORKSHEET #12

(May be duplicated for distribution to the pupils)

Purpose: To study the external and internal structures of the frog.

Materials:

1. Frog
2. Dissecting tray and pins
3. Scissors forceps, and medicine dropper
4. Chart or diagram of internal anatomy of the frog
5. Small beaker with 1% sodium chloride solution
6. Straw

Procedure:

1. Carefully examine the external structure of the frog to observe each of the following:
   a) Color on top and bottom
   b) Webbing on feet
   c) Attachment of tongue to mouth
   d) Number of eyelids
   e) Texture of the skin
2. Dissect the frog to observe its internal structure. Be sure to follow the directions of your teacher carefully.
3. Observe the beating of the heart. Find out if a beating frog heart means it is still alive by removing the heart carefully and placing it in a beaker of salt solution.
4. Identify the following organs: lungs, liver, gall bladder, stomach, intestine, kidneys and eggs (if present).
5. Find out the length of the digestive system compared with the frog's body by dissecting it out completely.
6. Trace the respiratory system by blowing air into the frog's mouth with a straw. Observe the inflating of the lungs.
7. What other observations would you like to make on the frog? Obtain materials and your teacher's permission.

Summary:

1. How is the frog protected from its enemies?
2. How is the frog adapted for life in the water? on land?
3. Why is the frog's tongue attached as it is?
4. Why is the frog's skin moist?
5. What did you find out about the beating of a frog's heart? Was the frog alive when you got it?
6. What tissues did you observe in the dissected frog?
7. Name 10 organs present in a frog.
8. What did you learn about the digestive system of a frog?
9. Why do the frog's lungs have so many blood vessels?
10. Did you find out anything else about the frog? If so, what?

NUTRITION

OUTCOMES **Suggested Time Allotment: 11 Periods**

- All foods contain useful substances called nutrients.
- The nutrients required by all living things (plants and animals) are carbohydrates, proteins, fats and oils, water, vitamins, and minerals.
- Green plants synthesize the nutrients they need.
- Animals ultimately depend upon green plants for their food.
- Foods can be tested for their nutrient content.
- Foods provide living things with energy and raw materials for growth and repair.
- Carbohydrates and fats are good energy sources; proteins supply materials for growth and repair of tissues.
- Minerals and vitamins are required by living things to promote optimum health.
- The energy value in foods is measured in the unit called the large calorie or kilocalorie or Calorie.
- The human energy requirement varies with the age, weight, sex, occupation, and physical activity of the individual.
- An adequate diet is one that includes the necessary nutrients in quantities sufficient to maintain good health.

Suggested Lessons and Procedures

15. WHAT USEFUL CHEMICAL SUBSTANCES DO FOODS CONTAIN?

a. Recall that food is a basic need of living things. Have the pupils discuss the foods that are eaten by the organisms they have grown, by their household pets, and by familiar zoo animals. Compare the foregoing foods with those eaten by the pupils themselves during the past day or so. From the discussion should come the realization that:
   1) The diets of all living things are basically similar.
   2) Living things utilize a wide variety of foods.

b. Tell the pupils that, although animals eat a variety of foods, the different foods are similar chemically in that they contain a few basic substances known as *nutrients*. Distribute copies of food charts (obtainable from the Superintendent of Documents, Washington, D. C. or from the school Home Economics Department), and have the pupils find the names of the nutrients: starches, sugars, fats, proteins, water, minerals, and vitamins. Explain that sugars and starches may be considered together as carbohydrates.

c. To develop facility in the use of food charts, have the pupils study them and answer such questions as:

- What foods are good sources of starch?
- Name some foods rich in sugar.
- What protein-rich foods come from animals? Plants?
- What foods should not be eaten if a doctor recommends that fats be eliminated from the diet?
- What foods contain no water?
- What foods are almost all water?
- Why is milk sometimes called the "perfect food?"
- What nutrients does coffee contain?
- What foods contain only one nutrient?

d. Have the pupils summarize that: foods contain useful chemical substances called nutrients; the nutrients are carbohydrates, fats, proteins, water, minerals, and vitamins; most foods contain more than one nutrient; some foods are rich in one or more nutrients; all foods contain water.

16. WHAT IS A FOOD TEST?

NOTE: Prepare two sets of seven test tubes, each one-third full of the different nutrients: starch suspension (boil corn starch with water until it forms a stable cloudy suspension); 2 per cent glucose or dextrose solution; corn or olive oil; water; 2 per cent peptone of beef broth suspension; 2 per cent table salt; and part of an ascorbic acid tablet dissolved in water. Lugol's solution may be prepared by dissolving one gram of iodine crystals and two grams of potassium iodide in 300 ml. of water.

a. After a brief review of the nutrients present in foods, display one set of the prepared test tubes with labels identifying the name of the nutrient in each. In turn, add several drops of Lugol's solution to each test tube. Call upon the pupils to observe that the color changes to blue-black only in the test tube containing the starch suspension.

b. Conduct a discussion of the implications of the demonstration. The pupils should understand that the color reaction forms the basis for the chemical test for starch and that:

   1) The test is specific for only the one nutrient.
   2) The tests made with the other nutrients were for comparison purposes and are called *controls.*
   3) Tincture of iodine may be substituted for Lugol's solution since the principal ingredient of both is the same.

   NOTE: Emphasize that no foods which have been tested should be eaten because the chemicals added may be injurious.

c. To show the applicability of a test to actual foods, have a pupil assistant test several foods, including bread and potatoes, with Lugol's solution to find examples of foods which contain starch.

d. In summary, have the pupils point out that a food test involves a color change that is specific for each nutrient. Verify this thesis by demonstrating the test for a *simple sugar* as follows: Add one-third of a test tube of Benedict's solution to each of the second set of different nutrients. Heat to boiling and have the pupils observe the presence of an orange or brick-red color in the test tube containing the glucose or dextrose but not in the others. Show that the test applies only to simple sugars not to disaccharides by testing table sugar.

   NOTE: The color changes from blue to green to yellow to orange and brick-red can serve as a rough approximation of increasing amounts of simple sugars.

17. WHAT ARE THE TESTS FOR THE OTHER NUTRIENTS?

NOTE: Biuret solution may be prepared by adding 2.5 ml. of 3 per cent copper sulfate solution to 100 ml. of 10 per cent sodium or potassium hydroxide solution. Because Biuret deteriorates rapidly, the component solutions should be stored separately and mixed within 48 hours of use. Prepare indophenol as a 0.1 per cent solution by dissolving one gram of 2,6-Dichlorophenol-indophenol in a liter of water.

a. Briefly review the tests for starch and sugar. Demonstrate the test for *minerals* as follows: Heat a sample of food, such as bread or a dry dog biscuit in a crucible or evaporating dish over a Bunsen flame until it turns to white ash, which represents the mineral content of the food.

b. While awaiting the results of the mineral test, demonstrate the test for *proteins*. Add an equal amount of Biuret solution to a small amount of raw egg white or plain melted gelatin. Mix thoroughly. In the presence of protein, a violet or pink-violet color appears.

c. Show the test for *fats and oils* by rubbing some butter or oil on unglazed paper, such as a brown paper bag. In a positive test, a translucent grease spot which does not evaporate will appear on the paper. Heat the paper gently over a lamp, hot plate or radiator to drive off the water and to show that the fat spot will not evaporate.

d. Demonstrate the test for *water* by inserting some lettuce or celery into a *dry* test tube. Heat the tube gently over a Bunsen flame. If water is present, droplets will appear on the cooler upper inside of the tube where the water has condensed. This test may be made more dramatic if an apparently dry food sample such as a piece of toasted bread or a raisin is used.

e. Demonstrate the test for *vitamin C* by placing about 1 inch of indophenol in a test tube and adding, drop-by-drop from a medicine dropper, a solution of 1 per cent ascorbic acid. With each drop, shake well and observe the change from a blue color to a colorless state. (The intermediate pink color should be disregarded.)

f. For the next laboratory period, ask the pupils to bring the class samples of foods from home. Include an onion. To prevent an excess of foods from appearing, each laboratory group should divide the responsibility for the variety of foods to be brought in. A list of suggestions may be placed on the chalkboard to avoid duplication.

18. and 19. WHAT NUTRIENTS CAN WE FIND IN COMMON FOODS?

NOTE: This laboratory lesson is intended to provide the pupil with practice in the skills of performing the food tests. It should also verify the presence of more than one nutrient in a food and offer some surprises, such as the fact that onions contain sugar.

It is suggested that a chart be drawn on the chalkboard to summarize the results of the food tests. The period should be concluded with an examination of the class results and a discussion of the summary questions. Where results for a specific food test differ, reasons should be sought and a retest should be made. Suggestions for the improvement of procedures should emerge from the discussion.

LABORATORY WORKSHEET #13

(May be duplicated for distribution to the pupils.)

Purpose: To find out which nutrients are present in some common foods.

Materials:

1. Foods from home
2. Test tube rack with at least four test tubes
3. Alcohol or other burner
4. Dropper bottles of Lugol's, Benedict's and Biuret solutions
5. Unglazed paper (brown bag or paper towel will do)

Before You Start:

Recall the following food tests:

1. Test for starch: Food with Lugol's solution turns black or blue.
2. Test for simple sugar: Food with Benedict's solution is heated and turns green, orange, or brick-red.
3. Test for protein: Food with Biuret solution turns violet or pink.
4. Test for fats and oils: Food rubbed on unglazed paper produces a translucent grease spot which does not disappear when heated gently.
5. Test for water: Food in heated dry test tube forms droplets of water on the cold upper part of the tube.

Procedure:

1. Find out what nutrients are present in all the foods you brought from home. Exclude the tests for minerals and vitamins: A laboratory lesson on vitamins is scheduled for a later date.
2. Write your results in the table of observations below. Indicate the presence of a nutrient with a plus sign and its absence with a zero.

TABLE OF OBSERVATIONS

Food	Starch	Sugar	Protein	Fats and Oils	Water

Summary:

1. What did you conclude from this laboratory lesson?
2. Did your tests for any food differ from those of other pupils? If so, why?
3. What suggestions do you have for the improvement of the procedure in this laboratory lesson?
4. Which food that you brought from home do you consider to be the most nutritious? Why?

(*Continued on next page.*)

5. Are the tests you made here sufficient to make a final judgment on the quality of foods? Explain.
6. Which of your results surprised you? Why?
7. Write a report of this laboratory lesson in your notebook.

20. HOW DO LIVING THINGS OBTAIN ENERGY?

a. Introduce the topic of energy by asking, "Why do some athletes chew on chocolate bars before a contest?" The pupiis 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.

b. With tongs, hold a burning marshmallow aloft and ask the question, "How is energy obtained from food?" Develop the answer as follows:

1) Demonstrate the presence of carbon in a marshmallow by the blackening effect of incomplete burning.
2) Run the flame of the burning marshmallow over the chalkboard to show the formation of water. This is evidence of the presence of the element, hydrogen, as a constituent of the marshmallow.
3) Invert a gas bottle over the burning marshmallow until the flame goes out and test with lime water to show the evolution of carbon dioxide. Use a fresh unburned marshmallow and a second bottle as a control.
4) Observe that energy in the form of light and heat are released in an exothermic reaction.
5) 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:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow \text{Energy} + 6CO_2 + 6H_2O$$

c. Continuing this development, ask the questions, "Does oxidation of goods 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; it was shown in the chemistry unit that we give off carbon dioxide when we exhale; and it can be demonstrated that breathing against the chalkboard causes it to become wet.

d. Introduce the concept that nutrients are capable of being oxidized. Burn a peanut or a butter candle and a cube of sugar dipped in cigarette ash. Explain that carbohydrates and fats are our chief sources of energy but that proteins are also sources of energy. Hold a test tube with water over the burning food and ask, "How can we find out how much energy food contains?" The pupils should recall from the physics unit that heat energy was measured in calories by heating water in a calorimeter. 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.

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.

21. HOW CAN WE FIND OUT IF PROTEINS ARE IMPORTANT FOR GROWTH?

NOTE: For the experiment on bacterial growth in this lesson, use 2 per cent solution of glucose or dextrose and peptone. Because turbidity is the measure of growth of the organisms, the cloudy starch suspension should be eliminated. It is recommended that the lima bean culture grown by the pupils be the source of bacteria and that sterile precautions need not be observed.

a. Recall that foods are oxidized by living things to provide the energy required to perform the life processes. Ask the pupils to suggest other uses of foods. Perhaps they may remember that growing children, as well as persons recovering from illness or injury, may eat a great deal—indications of the possible use of food in promoting growth and the repair of tissue.

b. Exhibit fresh samples of pictures of liver, heart, kidney, meat or poultry and raise the question, "What nutrients do these foods contain that enables them to be used for growth and repair of living things?" The pupils should understand that these foods are parts of living things and contain chemical elements or substances required for growth and repair.

c. To study the chemical composition of the foods discussed in (a), heat a sample and show by the charring that it contains carbon. If water is driven off by heat and condensed on a cool glass plate, the presence of hydrogen and oxygen may be demonstrated. From the conspicuous odor, characteristically different from that of burning carbohydrates or fats, have the pupils realize that other elements must be present also. Tell the pupils that similar observations may be made when using pure *proteins*. In fact, the foregoing foods are rich sources of proteins. Explain the following statements:

1) Carbohydrates consist of the elements carbon, oxygen, and hydrogen alone, whereas proteins contain additional elements including nitrogen, sulfur, and phosphorus.
2) The elements in proteins form compounds called amino acids.
3) There are about 23 different amino acids which are arranged in long chains to form proteins.
4) The principal complex material in living tissue is protein.

d. Conclude with a discussion of the following question, "How can we use the materials and living things with which we worked to show that proteins promote growth?" Lead the pupils to suggest trying to grow bacteria in test tubes containing the different nutrients. Introduce the required materials which were previously prepared and have the pupils suggest a design for the experiment, perhaps as follows:

1) Inoculate each test tube of the pure nutrients with about three drops of the bacterial suspension of the lima bean culture.
2) Mix equal quantities of peptone and sugar solution. Inoculate with bacteria as above.
3) Plug each tube with cotton, making certain that each tube is properly labelled.
4) Place each tube in an incubator or other dark, warm place for 24 to 48 hours.
5) Have the pupils discuss possible results, keeping in mind that the degree of turbidity is a measure of the amount of growth.
6) Demonstrate that the greatest growth occurs in the test tubes containing protein and sugar.

22. HOW ARE MINERALS USED BY LIVING THINGS?

a. Challenge the pupils by asking, "What is an 'Atomic Cocktail'?" Some pupils may know that it is a radioiodine solution employed in the detection and treatment of thyroid conditions. Continue the discussion of mineral radioisotopes. Radioiron is injected into the bloodstream for treatment of cancer of the red blood cells and radiophosphorus is a diagnostic tool in the detection of brain tumors.

b. Recall the test for minerals wherein a food is heated until an ash remains. Demonstrate that there are other tests for specific minerals, as follows:

1) With a wire loop, heat some sodium chloride crystals in a Bunsen flame. A yellow-colored flame indicates the presence of the sodium ion.

2) To a solution of sodium chloride add several drops of silver nitrate solution. The presence of the chloride ion is shown by the formation of a white precipitate which is insoluble in dilute nitric acid.

c. Exhibit pictures of plants and animals with specific mineral deficiencies.

d. Duplicate and distribute a table of minerals, such as that below. Have the pupils formulate and ask questions of one another based upon the table. Start the session yourself with some of the following questions:

1) Which minerals were included in your diet today?

2) A doctor finds a patient to be anemic. What two foods might he prescribe?

3) What two minerals build strong teeth?

4) What pure mineral food found in the home is enriched with another mineral?

5) If a doctor injected radio-sulfur into the blood, where might it later appear in large amounts in the body?

6) Name one food that might help the blood to clot.

MINERAL	SYMBOL	SOURCES	VALUE TO THE BODY
Calcium	Ca	Milk, Cheese, Green Vegetables, Cereals, Citrus Fruits	Helps to build strong bones and teeth and blood to clot
Phosphorus	P	Meats, Milk, Cheese, Cereals, Poultry, Seafood, Eggs	Builds strong teeth and bones and a healthy nervous system
Iron	Fe	Liver, Red Meat, Eggs, Spinach, Fruits and Vegetables, Cereals	Builds red blood cells. Prevents some forms of anemia
Sulfur	S	Meats, Poultry, Fish, Egg Yolk, Peas and Beans	For building healthy skin, hair and nails
Iodine	I	Seafood, Vegetables, Iodized Salt	Helps control the rate of the use of energy. Needed for a healthy thyroid gland

e. Notify all pupils to bring samples of fruit juices to class for testing during the next laboratory period. Also, for the next recitation period, assign selected students to report on the work with vitamins of Dr. James Lind, Dr. Christian Eijkmann, and Dr. Joseph Goldberger.

23. and 24. WHICH JUICE CONTAINS THE MOST VITAMIN C?

NOTE: This laboratory exercise is a problem-solving experience which all the pupils should enjoy. Since the test for vitamin C has already been demonstrated, the teacher need merely review it, stressing the fact that indophenol should be placed into the test tube first and then the material to be tested should be added drop-by-drop, with constant shaking, until the color changes from blue to colorless. The intermediate pink color may be disregarded.

From this lesson the pupils are expected to determine:

a. The fact that the amount of vitamin C in a food is inversely proportional to the number of drops required to decolorize the indophenol; i.e., the fewer the drops necessary, the more the vitamin C content.

b. The need for a control by keeping the original amount of indophenol placed in the test tubes constant for all the juices. This may be done approximately by adding the same number of drops to each tube, possibly ten drops of indophenol.

c. The fact that several juices may decolorize the indophenol with the same number of drops. This may be resolved by similarly diluting or reducing the concentrations of the juices involved. For example, each juice may be diluted to half strength by adding an equal amount of water and stirring.

d. The fact that the amount of vitamin C in different juices varies and that it can be reduced materially by the addition of bicarbonate of soda, as is sometimes done in cooking.

LABORATORY WORKSHEET #14

(May be duplicated for distribution to the pupils)

Purpose: To compare the vitamin C content of different juices.

Materials:

1. Fruit juices from home (if concentrated, dilute according to directions on the container)
2. Dropper bottles of 0.1 per cent indophenol
3. Test tube rack with at least four test tubes
4. Dropper bottle of bicarbonate of soda solution

5. Medicine dropper

Procedure: With your laboratory team, plan experiments to solve each of the following problems:

1. Compare all the fruit juices you brought from home to find the one that has the greatest vitamin C content. Be sure to control the amount of indophenol you use so that you can make the comparison.
2. Prepare a table of juices arranging them in order from the highest to the lowest quantity of vitamin C. If two or more juices test the same, devise a method for finding out if there is any actual difference.
3. Find out whether the addition of bicarbonate of soda to juices will affect their vitamin C content.

Summary:

1. What conclusions can you draw from this laboratory lesson?
2. How did you control your experiments so that you were able to compare the vitamin C content of each of the juices?
3. When two or more juices decolorized the indophenol with the same number of drops, how did you find out if there was any actual difference in vitamin C content?
4. What related experiments would you like to try?
5. Write a report of this laboratory lesson in your notebook.

25. WHAT FOODS WILL GIVE US ALL THE ESSENTIAL VITAMINS?

a. 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: carbohydrates, 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:

   1) The foods ordinarily eaten by the rats contained materials that the five pure nutrients did not apparently supply.
   2) The missing materials seem to be necessary for life.
   3) The missing nutrient is one or more vitamins. Point out that *vita* means life.

b. Call on the selected pupils to report on the stories of the vitamins:

   1) Why the British sailors are called "Limeys."
   2) How Dr. Lind first prevented scurvy.
   3) The work of Dr. Goldberger with pellagra.
   4) How Dr. Eijkmann and his chickens found the cure for beri-beri.

c. Using food and nutrient charts, have the pupils discover and discuss the major food sources and value to the body of Vitamin A, Thiamin (Vitamin B), Niacin, Ascorbic Acid and Vitamin D.

d. 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 phoshorus.

e. 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 supplies:

   1) A sufficient number of Calories to meet the energy requirement of the body

   2) A variety of foods which contain all the essential nutrients including vitamins and minerals

   3) Bulk and roughage for satisfying hunger and for the proper elimination of solid wastes

26. and 27. HOW DO GREEN PLANTS SYNTHESIZE NUTRIENTS?

The following laboratory lesson is designed to give students an opportunity to suggest as well as to test a variety of hypotheses. Both these skills frequently play a significant role in scientific inquiry. Furthermore, this lesson should enable the students to effectively incorporate some of the qualitative chemical tests which they have previously used to solve a science problem. The teacher will probably find it helpful to motivate this lesson, prior to the lab lesson or on the preceding day, by a short discussion to develop the understanding that green plants are the basic source of all our food materials. Any representative "Food Chain" might be chosen to illustrate this principle.

The students should thus be prepared to respond to the question, "How are green plants able to make their food?" The students usually will find it necessary to break down this general problem into a series of specific sub-problems such as:

"What kind(s) of nutrients does the green plant synthesize and store?"

"What substances does a green plant utilize in making foods (nutrients)?"

The students should be encouraged to suggest and evaluate hypotheses for the various sub-problems. Among the logical hypotheses which might be suggested are:

"The green plant uses water to help it make food."

"The green plant uses air (What part?) to help it make food."

"The green plant must have sunlight in order to make food."

"Only the green parts of the plant can make food."

"The roots absorb the water as well as other essential materials."

NOTE: The diversity of potential hypotheses will necessitate the investigation of these different hypotheses by different laboratory teams.

In order to discriminate between the ability of green and non-green parts of the plant to synthesize nutrients (starch and sugar) the silver-leafed geranium plants should be exposed to direct sunlight (or a photoflood lamp) for several hours prior to the laboratory meeting.

The geranium plant to be used by the laboratory team which is investigating the role of light in food manufacture, should be kept in the dark for at least 24 hours before exposing its partially masked leaf to sunlight or a photoflood lamp.

Caution: The alcohol which is needed to remove the chlorophyll from the leaves should be heated on a hot plate or with a water bath at the teacher's laboratory table. This procedure takes place after the leaves have been boiled in water to break down the cell walls.

Materials:

1. silver-leafed geranium plants or green and white coleus plants
2. hot water bath or hot plate
3. forceps
4. alcohol
5. petri dishes
6. iodine or Lugol's solution
7. black paper or aluminum foil for masking leaf sections
8. limewater

SUGGESTED REVIEW QUESTIONS

The questions that follow are not intended as a diagnostic tool or comprehensive measure of the outcomes of the unit. They may serve the teacher for review purposes, as a source of questions for a unit examination, or in any way deemed desirable.

Part I

1. Non-living things differ from living things because non-living things are *not*:
   a. made of smaller units
   b. able to adjust to stimuli
   c. made of various chemicals
   d. made of solids, liquids and gases
   e. affected by heat

2. Bread molds grow best on foods:
   a. in a warm, moist, dark place
   b. in an open jar
   c. in water
   d. during the winter
   e. in a refrigerator

3. To provide energy, a nutrient must combine with:
   a. water
   b. minerals
   c. carbon dioxide
   d. oxygen
   e. vitamins

4. The difference between a simple and a compound microscope is that the compound microscope has:
   a. a barrel
   b. a reflecting mirror
   c. adjustment for light
   d. adjustment for focusing
   e. two or more lenses

5. The microscope objective is:
   a. close to the eye
   b. the part that holds a slide
   c. the part that finely adjusts the slide
   d. the lens that is further from the eye
   e. the barrel

6. A microscope has 10X and 43X objectives and a 10X ocular. The highest magnification possible is:
   a. 43 b. 53 c. 63 d. 430 e. 4300

7. All living things you observed under the microscope had:
   a. green-colored bodies
   b. round cells
   c. cell membranes
   d. organs for locomotion
   e. organs for excretion

8. From your study with the microscope, you can conclude that all living things:
   a. are made of different materials
   b. are made of cells
   c. show no resemblance to each other
   d. do not have to perform the same tasks to stay alive
   e. live in the same surroundings

9. Most foods contain:
   a. one nutrient
   b. all the nutrients
   c. at least four nutrients
   d. all the vitamins and the nutrients
   e. more than one nutrient

10. Milk helps growing boys and girls because:
   a. it is our only source of iron
   b. it is easily purchased
   c. it contains all the nutrients
   d. it is our best source of vitamin B complex
   e. it can be quickly consumed

11. Overweight pupils should reduce their weight by:
   a. omitting sugar from their diet
   b. avoiding cholesterol
   c. eating meat twice daily
   d. following a physician's advice
   e. using diets found in newspapers

12. The nutrient present in smallest amounts in foods is:
   a. carbohydrates
   b. fats
   c. proteins
   d. water
   e. vitamins

13. Lugol's solution is used to test for:
   a. starch
   b. sugar
   c. protein
   d. minerals
   e. fats

14. A nutrient that contains only the three chemical elements—carbon, oxygen and hydrogen—is:
    a. protein c. amino-acids e. water
    b. sugar d. mineral

15. The nutrient which can be found in a relatively short time without the use of a test chemical or test animal is:
    a. mineral c. sugar e. vitamin C
    b. starch d. protein

16. A good supply of vitamin C is present in:
    a. bread c. beef e. tomatoes
    b. dry cereals d. chicken

17. A good source of protein is:
    a. apples c. beans e. spinach
    b. lettuce d. oranges

18. In selecting your food for a day, it is desirable to:
    a. prepare for one good meal such as supper or dinner
    b. try to balance each meal
    c. have a light breakfast or none
    d. skip lunch and have a 3 o'clock snack
    e. have some meat or other protein food at each meal

19. Coffee should be avoided by junior high school boys and girls because:
    a. hot drinks are hard to digest
    b. it is more expensive than milk
    c. it is an adult drink only
    d. it has little food value and contains unneeded stimulants
    e. it tends to limit growth of teenagers

20. Which of the following has the highest fuel value per ounce?
    a. water c. carbohydrates e. fats
    b. minerals d. proteins

21. A superior source of calcium for our diets is:
    a. broiled liver c. seafoods e. hard boiled eggs
    b. sirloin steak d. cottage cheese

22. The substance needed in largest quantity as a growth-promoting material is:

a. protein
b. fat
c. iron
d. calcium
e. phosphorous

23. The energy value of foods is measured in:

a. grams
b. degrees Centigrade
c. Calories
d. meters
e. degrees Fahrenheit

24. A valuable source of dietary iodine is:

a. seafood
b. salt
c. cereals
d. cane sugar
e. beet sugar

25. Which of the following vitamins is stored if taken in excess?

a. A b. B_1 c. C d. Niacin e. B complex

26. Which of the following represents the probable caloric need per day for a one hundred pound thirteen year old boy?

a. 1800 d. 3800 c. 3000 b. 2500 e. 4500

27. A good source of nutritional iron is:

a. peanuts
b. liver
c. butter
d. lettuce
e. margarine

28. A mineral ash was heated in a bunsen flame. It caused the flame to become yellow. The ash probably contained:

a. silver
b. potassium
c. sodium
d. mercury
e. chlorine

29. The vitamin most difficult to supply from natural food sources is vitamin:

a. A b. B_1 c. C d. D e. Niacin

30. Of the following, the best source of vitamin A is:

a. chicken
b. eggs
c. lima beans
d. steak
e. strawberries

31. Cells without nuclei are:
   a. striated muscle cells
   b. cardiac muscle cells
   c. white blood corpuscles
   d. smooth muscle cells
   e. red blood corpuscles

32. The scientist who first saw the cells in cork was:
   a. Brown
   b. Hooke
   c. Schleiden
   d. Schwann
   e. Leeuwenhoeck

33. The living material present in a cell outside of the nucleus is the:
   a. nucleoplasm
   b. cell membrane
   c. nuclear membrane
   d. cytoplasm
   e. cell wall

34. One difference between an animal cell and any plant cell is the:
   a. cell wall
   b. cytoplasm
   c. nuclear membrane
   d. cell membrane
   e. nucleus

35. The green pigment in a green plant cell is found in bodies called:
   c. centrosomes
   d. chromosomes
   a. nuclei
   b. chloroplasts
   e. genes

36. Factors carrying the heredity of a cell are found in the:
   a. cell wall
   b. cytoplasm
   c. centrosome
   d. nucleus
   e. cell membrane

37. Digested foods and oxygen enter a cell through the:
   a. nucleus
   b. cell membrane
   c. chloroplasts
   d. nuclear membrane
   e. cytoplasm

38. The process by which green plant cells manufacture carbohydrates from water and CO_2 is:
   a. diffusion
   b. osmosis
   c. photosynthesis
   d. digestion
   e. absorption

39. The openings in the underside of a leaf are called:
   a. guard cells
   b. pores
   c. air spaces
   d. breathing spaces
   e. stomates

40. Root hairs help in the absorption of:

a. proteins
c. carbohydrates
e. fats and oils
b. minerals and H_2O
d. vitamins

41. The nutrients which can*not* be synthesized by green plant cells are:

a. fats and oils
c. carbohydrates
e. proteins
b. vitamins
d. minerals

42. Energy is released in cells through a chemical called:

a. ATP b. RNA c. ADP d. CNS e. DNA

43. Microsomes direct the manufacture of proteins for growth and repair by means of a compound called:

a. ATP b. RNA c. ADP d. CNS e. DNA

44. Genes in the chromosomes determine reproduction and heredity by means of a chemical called:

a. ATP b. RNA c. ADP d. CNS e. DNA

45. A group of similar cells performing the same function is an:

c. living thing
a. organ
e. organ system
d. tissue
b. organism

46. The main supporting tissues in our body are bone and:

a. nerve
d. muscle
c. cartilage
b. epithelial
e. white elastic

47. A tissue adapted for carrying messages is:

a. nerve
c. cartilage
e. white elastic
b. epithelial
d. muscle

48. A test made for the purpose of comparison is called a(n):

a. experiment
d. enzyme
c. control
b. chemical change
e. physical change

49. To test for the presence of protein we use:
    a. Benedict's solution
    b. Biuret solution
    c. Lugol's solution
    d. silver nitrate
    e. hydrochloric acid

50. Tissue adapted for movement is:
    a. nerve
    b. epithelial
    c. cartilage
    d. muscle
    e. white elastic

Part II

51. Tincture of iodine drops fell on a boy's shirt. The shirt turned blue-black because:
    a. tincture of iodine contains alcohol
    b. the shirt had starch in it
    c. the cotton fibers in a shirt are mostly cellulose
    d. the laundry had scorched the shirt
    e. cotton, though a tough durable fiber, corrodes easily

52. Five foods were tested for simple sugar and none was found. Each food was then retested for sugar after it had been mixed with saliva for several minutes. Two now showed positive reactions because:
    a. proteins are very complex compounds
    b. fats, like carbohydrates, are composed of carbon, hydrogen, and oxygen
    c. fats, like carbohydrates are important energy sources
    d. enzymes are present in digestive juices
    e. carbohydrates were in some of the foods

53. A student tested bread for sugar, starch, protein, and fat. All of the tests were positive. He was probably:
    a. right
    b. mistaken on several of the tests
    c. mistaken on most of the tests
    d. mistaken except for starch
    e. mistaken except for sugar and starch

54. A food put into a test tube and then heated turned yellow and then black. This proves:
    a. starch is present
    b. nothing
    c. starch and sugar are present
    d. more than one nutrient is present
    e. sugar is present

55. Food from the market had made a translucent spot on the bag in which it was carried. This shows the food probably contained:

a. fat b. water c. water or fat

d. a substance which further tests would prove to be fat

e. a substance which further tests would prove to be water

56. A student testing for the presence of water heated spinach in a test tube until it charred (browned) slightly. His technique was:

a. good b. poor but acceptable

c. unacceptable because he used up excessive amounts of heat

d. unacceptable because oxidation produces water

e. unacceptable because evaporation was too rapid

57. Which of the following statements is true about cork seen by Robert Hooke?

a. the structures could not be seen well with his poor microscope.

b. the structures seen were not cells.

c. the tissue showed cytoplasm clearly.

d. nuclei were found only in the larger cells.

e. most of the cells had nuclei.

58. Which of the following is true?

a. all cells have a single nucleus.

b. all cells are microscopic.

c. all living things are made of one or more cells.

d. all cells contain protoplasm.

e. all cells have a cell wall.

59. The statement of the cell theory is usually credited to:

a. Hooke

b. Leeuwenhoeck

c. Brown

d. Hooke and Leeuwenhoeck

e. Schleiden and Schwann

60. The easiest way to show a stomate under the microscope is to use the:

a. lower epidermis of a begonia leaf

b. outer skin of a section of mature onion bulb

c. long section of an onion stem

d. cross section of a young root

e. cross section of a celery stalk

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SCIENCE
Grade 7

4. Living on the Changing Crust of the Earth

Bureau of Curriculum Development
Board of Education of the City of New York

FOREWORD

In these times of great scientific advancement and opportunity, we are increasingly dependent upon a scientifically literate population. Our young people must be led to explore, search for, and discover scientific ideas "which are durable for at least a generation."

A new science course of study for grades 7, 8 and 9, part of a K-12 program, is currently being prepared. The new course is based upon the sequential development of scientific concepts from the four major science areas.

This bulletin, "Living on the Changing Crust of the Earth," is the fourth in a series of twelve bulletins, one for each portion of the course — chemistry, physics, biology, and earth science — at each grade level. The materials herein have been applied and evaluated in classroom situations over a period of two years. Teachers and supervisors will find herein practical assistance in putting into practice the earth science part of the proposed revised course in junior high school science.

An overview of the revised course of study for grades 7, 8 and 9, including a statement of philosophy, objectives, scope and use, appears on pages vii-xiii of *Science; Grade 7 — The Chemistry of Matter* (Curriculum Bulletin No. 9a, 1962-63 Series). Teachers and supervisors should refer to these pages as they use "Living on the Changing Crust of the Earth."

The science program, of which this bulletin is a part, envisions in-service training in schools and districts.

It is hoped that this bulletin and the others in preparation will make possible further development and extension of the program.

JOSEPH O. LORETAN
Deputy Superintendent of Schools

MARTHA R. FINKLER
Acting Associate Superintendent
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Division of Curriculum Development

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CONTENTS

THE IMPORTANCE OF FOSSILS.............. 1
ROCKS AND ROCK-FORMING MINERALS.... 10
OUR CHANGING EARTH..................... 29
SUGGESTED REVIEW QUESTIONS........... 44
SUGGESTED REFERENCES 48

ACKNOWLEDGMENTS

The planning and design of the Science Grades 7, 8 and 9 Project is under the direct supervision of William H. Bristow, Assistant Superintendent, Bureau of Curriculum Research; Martha Finkler, Assistant Superintendent, Junior High School Division; and Samuel Schenberg, Director of Science. Joseph O. Loretan, Deputy Superintendent of Schools, and Jacob H. Shack, Acting Associate Superintendent, Division of Curriculum Development, have overall supervision of curriculum projects.

To explore the various problems involved in the preparation of a new course of study for the junior high school segment of the K-12 science program, the following Curriculum Advisory Committee was appointed:

Martha Finkler, Assistant Superintendent, Junior High Schools
Seelig L. Lester, Assistant Superintendent, High Schools
Samuel Schenberg, Director of Science, *Chairman*
†Alfred D. Beck, Assistant Director of Science, Junior High Schools
Isidor Auerbach, Principal, John Jay H. S.
Irving I. Cohen, Principal, Thomas Jefferson H. S.
Darwin S. Levine, Chairman, of Standing Committee on Science Supplies
Mary R. Mullins, Principal, Junior High School 172Q
Samuel N. Namowitz, Principal, Junior High School 82X
Charles Tanzer, Principal, Junior High School 17M
Walter W. Wolff, Principal, William Cullen Bryant H. S.

The Curriculum Advisory Committee accepted with modifications a plan submitted by the Director of Science to employ large blocks of subject matter from the four specialized sciences, sequentially, in grades 7, 8 and 9. In order to implement this plan, a Junior High School Science Revision Committee was appointed. To work under optimum conditions, the regular members of the revision committee met mainly on Saturdays and thus avoided the necessity of leaving their classes and schools during school hours. The members of the Revision Committee are:

Samuel Schenberg, Director of Science, Office of Science Education, Director of the Project
Charles A. Colman, Assistant Principal, Junior High School 217Q
*Ronald Dermer, Teacher of Science, Junior High School 210K
**Milton Forrest, Acting Principal, Junior High School 190Q
Peter Greenleaf, Supervisor, Bureau of Audio-Visual Instruction

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† Through August 1963
* Appointed to Committee January 1963
** Resigned September 1962 to become principal of an elementary school

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Elena Lucchini was responsible for illustrations and production; Simon Shulman for the cover design.

* Assigned September 1963 as Acting Assistant Director, Chairman of Committee
** Resigned September 1962 to become principal of an elementary school
*** Resigned January 1963 to assume new assignment

THE IMPORTANCE OF FOSSILS

OUTCOMES — **Suggested Time Allotment: 6 Periods**

- A fossil is the remains of an organism or the product of its activity preserved in rocks.
- Fossils provide information and material of value to science and industry.
- Fuels are the partially decomposed and carbonized remains of former organisms — usually plants.
- The absolute age of fossils or of a geologic formation may be estimated by the determination of decay rates of radioactive minerals.
- Fossils indicate that there appears to be a progression of life in time coincident with great crustal changes.
- The geologic history of the earth can be classified into time divisions.

NOTE: From the previous unit, *The Materials of Life,* and from the study of Curriculum Bulletin #7, 1958-59 Series, *Earth and Its Resources,* pupils should know enough about ecology to realize that the life cycle is closely related to changing conditions in the environment. Thus, it should come as no surprise that evidences of organisms in various stages of their development have been preserved within the changing crust of the earth and that the study of these remains is of importance.

Suggested Lessons and Procedures

1. HOW WERE FOSSILS FORMED?

a. Distribute fossil specimens and low-power magnifying glasses. Specimens should include examples of land and marine fossils such as:

- Foraminifera and/or Diatoms
- Dinosaur bones (fragments)
- Dinosaur eggs (fragments)
- Petrified wood
- Insects in amber
- Brachiopod (lamp) shells
- Bryozoa
- Fusulina
- Fissispongia
- Lignitized wood
- Fossil fern leaf
- Fossil shark teeth
- Coal
- Trilobites

Each pupil is to describe and/or draw details of one fossil in each of the four categories, as follows:

1) land-type animals
2) land-type plant
3) marine-type animal
4) marine-type plant

b. Have selected pupils report briefly on and show models or photographs of:

- Prehistoric animals and plants
- Animal evolution in past geologic eras
- The sequence of events in the formation and discovery of a fossil
- Typical environments of ancient times such as the Jurassic and Cretaceous periods or the Ice Age.

c. Lead the pupils to ask and answer such questions as:

1) What and how did these prehistoric animals eat?
2) When and where did they live?
3) What was the climate when they lived?
4) Why did they die out?
   NOTE: Possibly the result of great climatic and crustal changes.
5) How do we know that they actually lived?

d. Have the pupils arrive at the idea that there are three different types of fossil remains:

1) Actual or unaltered remains, as the shells of mollusks or the bones of dinosaurs.
2) Altered or petrified remains: petrified wood.
3) Indications of former presence: molds, casts, prints, and artifacts.

e. Have the pupils discuss the question, "Why are some fossils so rare in view of the probability that millions of such organisms have existed on earth?"

NOTE: Most organisms decay when they die.

- The soft parts decay or dissolve first, the hard parts, bones and shells, later.
- After some time nothing usually remains of the organism.
- Since decay prevents fossilization, fossils may be formed only if decay of hard parts is prevented by quick burial in fine-grained materials.

f. Have the pupils recall from their experiments with the home-grown organisms in the Biology Unit that bacteria cause decay and to evolve the idea that by depriving bacteria of air, food, water or proper temperature, decay may be prevented and fossils formed. For wooly mammoths in ice, insects in amber, and animal remains in the La

Brea Tar Pits, have the pupils explain which bacterial need or needs were not met to produce the fossils we have found.

g. Perform the following demonstration: To a graduate half full of water add sand, soil, and *small* sea shells. Mix and allow it to stand until the mixture settles. Have the pupils explain a possible location of the shells and what would happen to them after a long interval of time. Lead the pupils to understand that:
   1) The shells have settled and are in the layers of sediments.
   2) The sediments above squeeze out most of the air and water from the layers below, so that decay is slow and takes a very long time.
   3) All or part of the organism may decay leaving bones, shells, imprints, casts or molds.
   4) Sometimes, as parts decay, they are replaced by some mineral such an iron oxide, iron pyrites, silica, carbon to become *petrified.*
   5) Insects may be preserved in hardened resin of pine trees.

h. Develop a definition of a fossil as the preserved remains of an organism or the product of its activity.

i. Assign readings in one of the following: ***Handbook of Paleontology for Beginners and Amateurs, Part I, The Fossils,*** by Dr. Winifred Goldring, New York State Museum, Albany, N. Y., 1950, pp. 367; *Cornell Science Leaflet,* Vol. 52, No. 2, Fall, 1958; *The Old Forest and the Naples Tree,* by Janet Stone, Educational Leaflet No. 14, N. Y. State Museum and Science Service, Albany, 1963, pp. 24. (See pp. 20-22 for directions for optional activities — "How to Make 'Fossil' Casts" and "How to Make a 'Fossil' Impression."

2. and 3. MICROSCOPIC STUDY OF DIATOMACEOUS EARTH

LABORATORY WORKSHEET #15

(May be duplicated and distributed to the pupils.)

Purpose: To study a useful fossil

Materials:

Small vial of calcined diatomaceous earth (Celite)
Dropping bottle of castor oil or water
Microscope slide glass
Cover glass
Lens paper
Toothpicks
Prepared slide of diatoms
Microscope
Samples of toothpaste, silver polish, and scouring powders
Watch glass
Piece of tarnished silver

Procedure:

1. Prepare the microscope for use.

2. Examine the prepared slide of diatoms. Draw several examples of different types. Estimate how many there are of each type shown on the slide.

3. With a toothpick, put a drop of castor oil on a slide blank. Mix into it a tiny amount of diatomaceous earth. Study the mixture under the low (x100) and then under the high (x440) power lenses. Draw 4-5 typical specimens.

4. Using a clean slide, prepare specimens of toothpaste and other types of household cleaners for viewing under the microscope. Illustrate types of diatoms that may be seen. Compare these findings with the previous observations. Describe in your own words what the characteristics of diatoms are.

5. Put a small amount of the powder into a watch glass. Add water, noting how much is needed to form a paste. Now apply some of the paste with a small square of cloth or piece of lens paper to a tarnished piece of silverware. Note the cleaning power of the earth and whether or not it scratches the surface of the metal. If desired, the metal surface may be examined under the microscope before and after the cleaning to detect scratches.

6. Summarize in your own words, the conclusions you have reached as a result of your observations.

7. Investigate in the library and make a list of other uses of diatomaceous earth.

4. WHY ARE GAS, PETROLEUM, AND COAL CALLED FOSSIL FUELS?

a. Have the pupils discuss where fossil fuels are found:

- Oil is usually found in permeable porous layers of sedimentary rock like sandstone (open anticlines, not tight anticlines).
- Natural gas is often associated with oil and occurs above it since it is less dense than oil.
- Show pictures to indicate that bituminous coal is likewise found in the strata of sedimentary rock.

b. Have the pupils note that fossils are found under similar circumstances and lead them to hypothesize that the fossil fuels may be the remains of partially decayed organisms.

c. Raise the question of what evidence exists that these fuels are fossil remains:

- Show pictures of plant imprints in coal.
- Explain that sea water and sea organisms are often present in oil pockets. (Some geologists believe in the theory of inorganic origin of oil as opposed to the organic theory.)
- All the fuels contain carbon, an essential element in living things.

d. Have the pupils discuss how coal was formed:

- In the Carboniferous Period large areas of the earth were low, moist and warm.
- Great swampy forests of giant ferns and scale trees (Sigillaria) existed.

- The land sank gradually.
- The sinking allowed great thicknesses of plant debris to accumulate in swamp waters without filling the swamps.
- Eventually, sinking got ahead of filling and the plants were drowned.
- Eventually, the remains were buried under great deposits of sediment hundreds of feet thick and partially preserved.

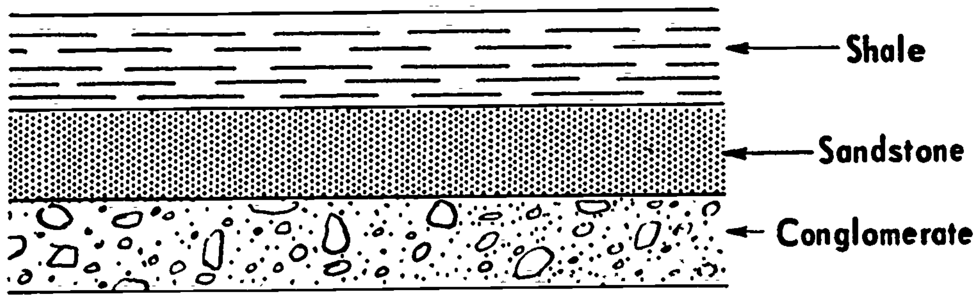
e. Lead the pupils to ask and answer such questions as:

- What does the presence of coal in the Antarctic tell us about the former climate there?
- What is the difference between bituminous and anthracite coal?
  NOTE: Anthracite, much purer carbon, is formed from bituminous by metamorphic action.
- What is peat?
  NOTE: Plants partially decaying in swamps form peat.
- How is oil or petroleum formed?
  NOTE: Probably from single plants and animals. (See page 4, item 4c, regarding theory of inorganic origin of oil.)
- How can fossils be used to locate oil deposits?

5. HOW CAN WE TELL THE AGE OF FOSSILS AND ROCKS?

a. Motivate the lesson by pointing out that there are cycles or rhythms in various biological processes such as: aging, the metamorphosis of insects, and the seasonal growth of plants. Illustrate this with a 3″ diameter (or larger) tree trunk which has been sawed into sections and made smooth so that the rings of seasonal growth are clearly visible. These should be counted after the class has had an opportunity to guess the age of the tree.

b. Turn to the problem of dating fossils in sedimentary rock by reviewing the process of sedimentation to note its regularity and predictability in the order of laying down of sediments in water: the coarser and heavier sediments fall first. Illustrate this order as follows:



c. Lead the pupils to ask and answer pertinent questions:

- Which layer (illustration, page 5) is the youngest? Oldest?
- If an igneous intrusion were forced between the sandstone and the conglomerate, what would its age be compared to the sedimentary rocks?
- How fast are sediments laid down?

  NOTE: It varies greatly from region to region and from time to time. However, rates have been determined for specific areas.
- What can we tell about the approximate age of fossils in sedimentary rock?

  NOTE: We can tell relative age, and where sedimentation rates are known, estimated absolute age.
- How can fossils be used to determine the relative age of rocks?

  NOTE: They are called index fossils, or guide fossils, and identify the relative geologic age of rocks.
- Environmental fossils indicate the climatic conditions of the times.

d. Demonstrate a Geiger counter and take a count for one minute of a radioactive substance, such as a radium dial of a wrist watch. Point out that the time it takes for the count to be reduced to one half the amount is called the half-life. For Carbon 14, the half-life is about 5,000 years: for Uranium 238 it is about 4½ billion years. Lead the pupils to the realization that by comparing the count of the original substance with that of the fossil, we can tell the age of the fossil.

e. Have the pupils discuss Carbon 14 (radioactive) dating to understand that:

- Nitrogen of the air is changed by cosmic rays to C14, which is combined with oxygen and taken in by plants as carbon dioxide.
- By comparing the count of a fossil plant with the same type of living plant, we can determine the age of the fossil plant.

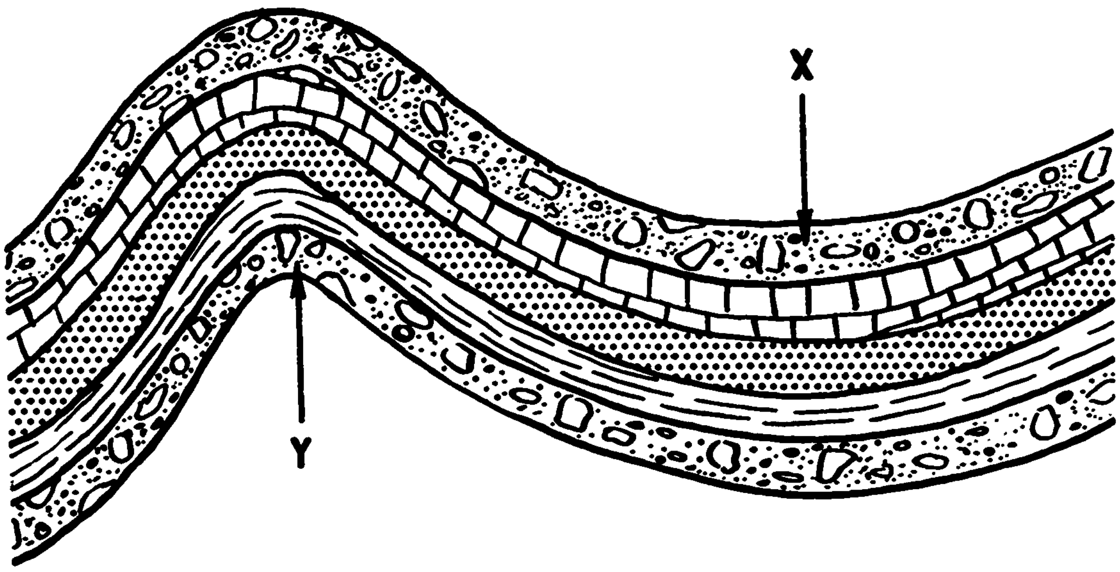
  NOTE: As soon as a plant dies its C14 begins to decrease.
- If the fossil count is ½ that of the living plant, the former is 5,000 years old. If it is ¼ the count, the fossil is 10,000 years old, etc.
- This method is reliable for about 10 half-lives or up to about 50,000 years.

f. Point out that for fossils or rock layers more than 50,000 years old uranium dating is used and that by this method it was determined that the earth is about 5 billion years old. Have the pupils calculate that about one half-life of uranium must have passed since the beginning of the earth.

NOTE: Uranium deposits have decayed to lead. About one half the original amount of uranium remains.

g. Some suggested practice problems in dating follows:

1) Which layer is the younger, X or Y?



ANSWER: *X*

2) A wooden idol has a count of 250 cpm (counts per minute) while a similar piece of fresh wood reads 1,000 cpm. How old is the idol? Answer: 10,000 years old.

3) What is the half-life of a substance whose Geiger counter readings are as follows: Monday, 400 cpm; Tuesday, 300 cpm; Wednesday, 200 cpm; Thursday, 150 cpm; Friday, 100 cpm. Answer: 2 days.

6. WHAT DO FOSSILS REVEAL TO US ABOUT PREHISTORIC ENVIRONMENT?

a. Have a pupil report on the geologic features of the Grand Canyon. Have the assigned pupil report on the Grand Canyon specifying its depth, erosion by the Colorado River and exposure of sedimentary layers which contain many fossils. (Indicates environmental and climatic conditions.)

b. Show pictures, slides, transparencies of the Grand Canyon to illustrate the features above.

c. Display or distribute charts of the geologic eras to develop a simple table of the crustal changes and the development of life.

ERA	DURATION IN YEARS	CHARACTERISTIC LIFE	CRUSTAL EVENTS
Cenozoic	60 million	Age of mammals and flowering plants. Man appears.	Mountain-building in Asia and Europe. Glacial age.
Mesozoic	125 million	Age of dinosaurs and ferns and conifers.	Mountain-building in Western U.S. (Great invasion of the sea)
Paleozoic	335 million	Sea life, first appearance of land animals.	Mountain-building in east U.S., continents rising and sinking
Proterozoic	1.2 billion	Simple worms, sponges	Volcanic action Mountain-building
Archeozoic	2.5 billion	Simple marine organisms. No life on land.	Great volcanic activity

NOTE: Do *not* require rote memorization of the chart.

d. From the table have the pupils generalize:

- The probable age of the earth is more than 4½ billion years.
- There appears to be a progression in time of life from simple to complex organisms.
- Early life existed only in the sea.
- Changes in types of organisms in any era coincide with great crustal changes on earth. (Exception: change from marine to land types or *vice versa.*)
- Geologic time is divided into eras separated by the great changes in life and in the earth's crust. (These changes are not now accepted as abrupt, as they were previously considered.)
- Man originated very recently in geologic time according to fossil evidence.
- Were there men alive at the time of the great dinosaurs?
- 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.
- Why was there so much volcanic activity in the earliest geologic eras?
  NOTE: Probably the earth hadn't cooled greatly then.
- Why did mountain-building *follow* the period of early volcanic activity?

NOTE A: Mountain-building may have occurred as the result of other earth movements.

NOTE B: Shrinking probably occurred after the earth's cooling-off period.

- What advantages were there in life on land compared with that in the sea?
- Why is study of fossils important a) to science, b) to industry?

f. Suggest that fossil hunting can be a real adventure. Point up that:
   - Many of the fossil dinosaurs and their eggs in the American Museum of Natural History were brought back by Roy Chapman Andrews.
   - Some fossils are extremely rare and difficult to find, and difficult and expensive to remove and ship.
   - Fossil hunters often travel great distances to find fossils.
   - Fossils are found mainly in sedimentary rock.
   - Great care must be taken to remove and preserve fossils.

   NOTE: The Catskill Region is probably the closest area which might be recommended for fossil hunting in New York.

For further reading, refer to:

"Fossils Lift the Veil of Time." *National Geographic Magazine,* pp. 363-385, March 1956; and

Dorothy and Joseph Samachson, *Good Digging* (New York, Rand, McNally, 1960), pp. 224.

Rocks and Rock-Forming Minerals

OUTCOMES **Suggested Time Allotment: 9 periods**

- The outermost shell of the earth is its rocky crust.
- The crust is made up of elements or combinations of elements known as minerals.
- Most minerals can be identified by their physical and chemical properties.
- Atoms or groups of atoms in minerals are usually arranged in orderly fashion to form crystals.
- Most rocks are mixtures of minerals.
- Rocks can be classified according to their origin and mineral content.
- Rocks and minerals are of great value to man.

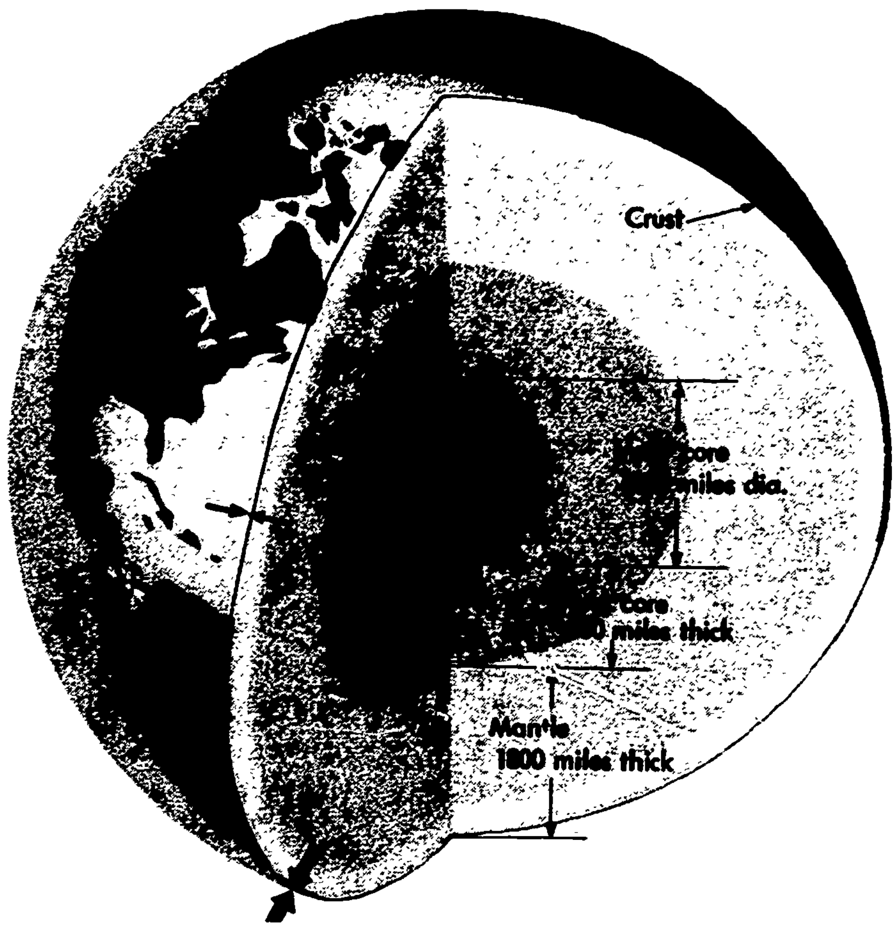
NOTE: Where Thermofax copiers are available, transparencies of geologic diagrams and pictures may readily be made using special paper. These transparencies may then be projected for discussion and analysis, even in broad daylight, by means of the overhead projector. In other cases, the Bureau of Audio-Visual Instruction, the District or the Borough Office should be in a position to offer assistance.

7. WHAT VALUABLE SUBSTANCES CAN BE FOUND WITHIN THE EARTH'S CRUST?

a. Introduce the unit by telling the pupils that west of Mexico the United States is drilling a hole beneath the ocean floor more than seven miles into the bowels of the earth. Why?
NOTE: The "Moho Project" aims to penetrate the crust into the mantle, taking samples at regular intervals. Such a hole would yield valuable information about the composition and history of the earth.

b. To see what the earth is believed to look like beneath the surface, show the following diagram and have the pupils note:
1) Name and thickness of the layers.
2) Relative density and possible composition of the layers.
NOTE: The crust is probably composed of lightweight rocks like granite and basalt; the mantle, of heavier rocks and much iron;

both the outer and inner cores consist of iron and nickel, the former in a plastic state and the latter in very dense solid condition.



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c. With the pupils develop the idea that scientists studying the earth are called geologists or earth scientists, and that the earth sciences include geology, oceanography, meteorology and astronomy.

d. Display a chart of the eight most abundant elements making up about 98% of the earth's crust showing:

Element	*Chemical Symbol*	*Percentage*	*By Weight*
Oxygen	O	49.5	46.71
Silicon	Si	25.8	27.69
Aluminum	Al	7.5	8.07
Iron	Fe	4.7	5.05
Calcium	Ca	3.4	3.65
Sodium	Na	2.6	2.75
Potassium	K	2.4	2.58
Magnesium	Mg	1.9	2.08

1) Have the pupils note that oxygen comprises almost 50% of the crust.

2) 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.

3) Have the pupils learn the names of some common compounds such as: Silicon dioxide (SiO_2), Quartz; Calcium carbonate ($CaCO_3$), Calcite; Ferric oxide (Fe_2O_3), Hematite; Calcium sulfate ($CaSO_4 \cdot 2H_2O$), Gypsum, etc.

4) Have the pupils become aware that a mineral is a natural substance, chiefly of inorganic origin, having definite physical characteristics and chemical composition. Most important is a characteristic internal structure. For example, differences which exist between diamond and graphite are due to the difference in internal structure or atomic arrangement.

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 freaks, i.e., freakish forms of fairly common substances.

e. Have the pupils discuss the reasons for the value of minerals in terms of beauty, rarity and utility:

- Gems: diamonds, rubies, emeralds, sapphires, topaz and amethyst.
- Rare metals: platinum, gold, and silver.
- Ores: carnotite and other uranium ores, hematite (iron), galena (lead), bauxite (aluminum), chalcopyrite (copper).
  NOTE: An ore is a mineral or aggregate of minerals which contains at least one metal in such abundance that it can be exeracted profitably.

f. To illustrate the process by which an element is extracted from its ore, demonstrate the reduction of copper oxide (CuO) into metallic copper by placing copper oxide and powdered charcoal in a test tube and heating strongly. If a delivery tube leading to a bottle of limewater is added, the production of carbon dioxide can be shown. Write the word and symbol equations on the blackboard:

Copper Oxide + Carbon → Copper + Carbon Dioxide

$$2CuO + C \rightarrow 2Cu + CO_2$$

NOTE: If copper oxide is unavailable, lead oxide may be substituted.

g. As time permits, have the pupils discuss the following topics:
   1) Prospecting for uranium with a Geiger counter.
   2) Mining methods, such as open-pit mining.
   3) The manufacture of iron and steel.
   4) Fireproofing with the mineral, asbestos.
   5) Uses of minerals based upon their special properties.

h. Encourage the pupils to:
   1) Collect minerals and bring them to class for identification and display.
   2) Visit the Museum of Natural History to view its mineral collection.

8. HOW CAN COMMON, ROCK-FORMING MINERALS BE IDENTIFIED?

a. Recognition of Hardness: Have the pupils try to scratch a piece of quartz with a piece of gypsum. A line will result. Ask which specimen was scratched. Then brush off the powder. Ask again which was pulverized. Now have the pupils scratch a piece of gypsum with quartz. Which became pulverized? Which is harder? Use the collection of minerals which are arranged according to the Mohs' scale of hardness.
   NOTE: Hardness is resistance to scratching.

   Demonstrate that hardness can be used for identification by means of the following development:
   1) Explain that four common substances can be used for approximate determination of hardness on the basis of their known hardness: A thumbnail has hardness of 2.5, a copper penny has a hardness of 3.0, a piece of glass has a hardness of 5.5-6.0, and a steel nail a hardness of 6.5-7.0.
   2) Point out that a substance which scratches another is harder than the substance it scratches.
   3) Scratch gypsum and quartz with the thumbnail to show that gypsum has a hardness of less than 2.5 while quartz has a greater hardness.
   4) Scratch a glass slide with gypsum and quartz to show that quartz has a hardness greater than 6.0.
   5) Scratch one mineral with another to find the harder of the two. NOTE: Be sure to rub your thumbnail mark to make certain there is a scratch and not a streak of powder. Do NOT teach Mohs' scale of hardness.

b. Recognition of Fracture and Cleavage: Show pupils what happens when you hit a large piece of quartz with a hammer. Explain that whenever anything breaks in an irregular way like this, the surface shows *fracture*. Now hit a large piece of calcite with a hammer and show all the pieces have the same kind of smooth surfaces. Explain that whenever anything breaks in this way, it is said to show *cleavage*. Demonstrate how mica can be peeled off in layers. Ask the pupils whether this shows fracture or cleavage. Demonstrate fracture of a specimen of gypsum. Ask the pupils to describe it. This shows that the test of fracture may not enable us to distinguish between two similar minerals.

e. Recognition of Color in Minerals: Show pupils specimens of biotite mica and obsidian. Ask if these are the same mineral. Uncertain and incorrect answers indicate that color alone is not sufficient identification. Yet color may help. For example, clear calcite and clear quartz appear similar, but some clear quartz is pink or yellow. Point out that these colors are due to impurities. Compare quartz with calcite. How can they be distinguished?

d. Recognition of Luster in Minerals: Show the class some strips of metal and also some non-metallic materials. Call attention to the difference in which these items reflect light. Tell the class that this characteristic of metals is known as *luster*.

Distribute from mineral collections a specimen of clear quartz and a specimen of clear gypsum (or distribute a specimen of milky quartz and milky gypsum) and elicit from the pupils a comparison of the luster of the two specimens. They should notice that the quartz has a glassy luster while the gypsum has a waxy luster. Now issue a specimen of talc and have the pupils compare its luster with the other specimens. Compare its dull luster with that of quartz and gypsum. Collect these specimens.

e. Recognition by the Wet Test: Another means of comparing two similar minerals (milky quartz and calcite or marble chips) is by means of wetting with dilute hydrochloric acid. Pupils should note the effervescence of calcite or marble, while quartz remains unaffected by the acid. Let a pupil identify the gas given off by the calcite as carbon dioxide.

Point out the similarity of the reaction to that obtained by the use of marble in the chemistry unit and have the pupils derive the chemical equation:

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

f. Recognition by Streak Test: Show the students a streak plate. Tell them that it is an unglazed piece of porcelain. Have them understand an unglazed bathroom tile or the unglazed edge of a broken plate is similar in surface to the streak plate.

Draw a piece of hematite across the face of the streak plate. Tell the students that the powdered residue of a mineral which has become pulverized as a result of having been forced against something harder than itself is called a *streak*. Ask a student to make a streak test with muscovite mica, biotite mica, graphite, malachite, etc. Pass streak plates out to the class. Give each pair of pupils a different metallic ore specimen. Have them write down a description of their specimen, and the streak.

NOTE: Lightly brush the loose powder off with your fingers.

The streak produced by drawing certain minerals across a streak plate is produced by the presence of a metallic impurity. The streak test, therefore, is not particularly useful in identifying the common, rock-forming minerals, but it is very good for identifying metallic minerals.

NOTE: Streak test is most important with dark colored minerals.

Start a chart of identifying characteristics on the blackboard.
(See page 16 for a sample chart.)

g. Recognition of Crystal Form: Exhibit crystals of quartz and garnet. Pupils should note that the six-sided prism or pyramid(s) are characteristic of quartz. These should be compared with a perfect crystal of garnet. Point out that the smooth faces are natural and not cut by man. Have the pupils understand that a crystal is a geometric pattern characteristic of a mineral which has been given the time and space to take this form.

NOTE: Minerals do not normally occur in nature with good crystal form due to imperfect lattices and crowding. Good crystals are exceptions.

h. Pupils who would like to "grow" crystals at home might be encouraged to start as follows: Dissolve about one ounce of table salt in a half pint of boiling water and pour the solution into a saucer. Place a string in the solution and over the edge of the dish. Allow the solution to evaporate slowly for a day or two and, with a hand lens, note the crystals in the dish and along the string. Repeat using sugar, alum, or borax.

IDENTIFYING CHARACTERISTICS OF METALLIC ORES

METALLIC ORE	STREAK	OTHER IDENTIFYING CHARACTERISTICS	USES
Galena	essentially black	Cube crystal form. When it breaks, cube form continues.*	Source of lead
Graphite	black	Flakes	"Lead" for pencils
Sphalerite	brown		Ore of zinc
Malachite	green		Copper ore
Pyrite (fool's gold)	black	Cube crystal form.	Source of sulphuric acid
Chalcopyrite	greenish black		Source of copper
Iron Ores Hematite Magnetite	 reddish brown black		 Source of iron Source of iron
Cinnibar	red to orange red		Source of mercury
Native metals Copper Silver	copper color silver white		

* Introduce the term *cleavage* – a way of breaking. The term will be discussed in detail in next lesson.

9. and 10. WHAT MINERALS ARE THESE?

NOTE: This laboratory lesson is designed to provide the pupils with practice in identifying some common minerals. It also offers a problem-solving experience in planning and devising a scale of hardness as well as in keying out an unknown mineral. The teacher should emphasize that a mineral is harder than anything it can scratch.

Since this exercise probably represents the introduction of the use of identification keys to most seventh graders, it is suggested that the teacher carefully explain the key included in the laboratory instruction sheet below. To arrive at the proper identification, the pupils should determine all the required properties before deciding on the identity of the mineral. Moreover, it is essential that the labeled minerals be collected before the distribution of the unknown mineral. Lack of time would doubtless prevent the identification of more than one or two unknowns.

Safety is of prime importance here. Even though the hydrochloric acid is dilute, the pupils should be cautioned to use only one drop at a time, and that carefully, making certain to wipe it off with paper toweling soon after the observation. It is also advisable that hands and minerals be washed in water after completion of the exercise.

Another aspect of safety in this lesson has to do with the test for breaking. Do not permit pupils to hammer or crush specimens unless you take precautions to protect their eyes from flying fragments. This can be done by covering the specimen with a heavy cloth before it is hit a blow and/or by having pupils wear heavy-duty goggles.
NOTE: This is of value only to test cleavage or lack of it.

It is of prime importance that the unknown distributed be included in the key and that the pupils be asked to key out one unknown at a time. In some advanced classes, he pupils may identify three or even more unknown minerals by using the key.
NOTE: The complete Worksheet #16, including tables for student reference and completion, continues through page 21.

LABORATORY WORKSHEET #16

(May be duplicated and distributed to the pupils.)

Purposes:

1. To study some physical properties of minerals
2. To set up a scale of hardness for some known minerals
3. To use a key to identify some unknown minerals.

Materials:

1. Numbered specimens of feldspar, gypsum, mica, talc, calcite and quartz, etc.
2. Unglazed porcelain tile
3. Small vial of dilute hydrochloric acid
4. Hand lens
5. Glass slide
6. Copper penny
7. Steel nail or file

Before you start:

To obtain the value of the hardness of your minerals, make use of the following scale:

If scratched by	*Mineral's hardness is*
Thumb nail	2.5
Copper penny	3.0
Glass	5.5-6.0
Steel nail	6.5-7.0

Procedure:

1. Note the number of your first specimen in the first column of the TABLE OF OBSERVATIONS (see page 19).
2. Note the color of the specimen. Record this in column 1.
3. Describe its luster or lack of luster, column 2.
4. Using the hardness scale above, test the mineral and enter hardness in column 3.
5. With the teacher's permission, and while he is watching, test the way the specimen breaks. Note this in column 4.
6. If the mineral has a regular crystal form, draw a picture of it in column 5. If there is no characteristic form, note this.
7. Try to obtain a streak test. If you succeed, note the results in column 6. If there is no result, note this fact.
8. Using the technique taught to you in lesson 8, make a wet test and note the result in column 7.
9. On the basis of your observations and the data furnished to you on the chart of CHARACTERISTICS OF MINERALS, enter what you believe to be the name of the specimen in column 8. If you are correct, put a check in column 9.
   If not, review your results and select a new name for your specimen. Check it again, until you are correct.

Summary:

1. What are five physical properties by which you can identify minerals?
2. Why is it necessary to have more than one test for a mineral?
3. Using your textbook, compare your results with those indicated in Mohs' Scale of Hardness.
4. Will the fact that a mineral will scratch glass prove that it is a diamond? Explain your answer.

TABLE OF OBSERVATIONS OF MINERALS

Specimen Number	1 Color	2 Luster	3 Hardness	4 Way of Breaking	5 Crystal Form	6 Streak	7 Wet (acid) Test	8 Name	9 √

CHARACTERISTICS OF MINERALS†

(To be duplicated and distributed to the pupils with Worksheet #16)

Name	Color	Luster	Hardness	Way of Breaking	Crystal Form	Special Characteristics and Uses
Quartz	Varies	Glassy *	7	No cleavage, Conchoidal fracture.	Hexagonal	Because of low index of refraction—used in making lenses
Feldspar	Salmon White Dark	Glassy	6	Good cleavage in 2 directions. Fracture in third direction.		Because of hardness and colors, used in jewelry. Peizoelectric quartz used in walkie-talkies. When weathered, kaolin forms, used in porcelain and china. Used in Kaopectate.
Hornblende	Black to green Black	Dull	6	Fair cleavage. Not as good as feldspar.		
Apatite	Apple green	Glassy	5	Fracture		
Fluorite	Green Purple Tan	Glassy, though at times crystals look waxy	4	Excellent cleavage in 4 directions.	Cubic	Base for hydrofluoric acid.
Calcite	Clear white Grey	Glassy	3	Good cleavage in 3 directions (rhombic)		Has double refraction—used in petrographic microscopes. Basis of all limestones and marbles.

Mica	Light (muscovite) Brown to black (biotite)	Glassy	2 to 2½	Excellent cleavage in 1 direction.	Hexagonal outline	Clear variety used as electrical insulators in appliances, etc.
Gypsum	Same as calcite	Waxy	2	Good cleavage in only 1 direction. Not as good as mica.		Source of plaster of paris. One variety known as alabaster. Used for bookends, paperweights, powder boxes, etc.
Talc		Waxy	1	Good cleavage in 1 direction. Forms flakes.		Feels soapy to touch. Used to make talcum powder. One variety known as soapstone, used for laboratory tables; acid-resistant and alkali-resistant.

† Only those minerals which are plentifully found in crystal form are listed.

* Glassy — vitreous.

11. WHY DO WE FIND MINERALS IN ROCKS?

a. To demonstrate that minerals are found in rocks, distribute samples of coarse-grained granite, mica schist, and gneiss. Have the pupils point out the minerals using a dissecting needle or an old dental pick.* Help the pupils to identify such minerals as mica, quartz, and feldspar. Elicit the following conclusions:

- Granite, mica schist and gneiss are rocks and that rocks are made of minerals.
- Each of the minerals in rocks retains its own identity and can be recognized.
- Most rocks are *mixtures* of Minerals. Some are monominerals, or nearly so. Neither obsidian nor pumice contains minerals. (Review definition of mixture Chemistry Unit.)

  * CAUTION: For this activity, pupils are required to wear safety goggles.

b. Raise the question, "How did the minerals become mixed in igneous rocks?" to have the pupils understand that, *during its early history*:

- Originally the earth was in a hot molten state.
- The earth's surface then cooled and hardened into a kind of rock called *igneous rock.*
- Igneous rock probably covered the earth as the first type of rock.

c. That similar processes have persisted to the present time may be shown by displaying a sample of obsidian and having a pupil examine it to determine how it was made. Its glass-like appearance should suggest that it cooled from a hot molten state. Have the pupils realize that this condition is met in volcanoes and point out that the hot molten material below the earth's surface is called *magma* while that escaping to the surface is known as *lava.*

d. Distinguish between igneous rocks formed from cooled magma and lava as follows:

1) 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.

2) 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.

c. Lead the pupils to realize that the size of the grains or particles is determined by the rapidity of cooling: the slower the rate, the larger the grains. Since magma cools more slowly than lava which is exposed to the air, igneous rocks formed below the surface of the earth have larger particles or grains. Such cooling means minutes, hours, days or weeks. Slow cooling means tens of thousands to hundreds of thousands of years.

12. HOW ARE ROCKS FORMED UNDER WATER?

a. Recall that in its early history the earth was covered with igneous rocks and ask, "What eventually happened to igneous rocks on the earth's surface?" Ask pupils to suggest ways to find the answer to this question.

b. To find out what happened, display a sample of sandstone and a sample of sidewalk concrete and ask how they might have been made. Have the pupils examine each to:

- See that it is a mixture of particles or grains of sand.
- Understand the need for cement to hold the particles or grains of sand.

  NOTE: Pupils should associate the use of cement to hold sand and gravel together in making concrete roads and sidewalks.

c. Determine the kind of cement holding the sandstone together:

1) Apply a drop of dilute hydrochloric acid to the rock. If the material between the grains bubbles or fizzes, a calcium carbonate (limy) cement holds the particles together.
2) If the rock is a shade of brown, yellow or red, the cementing material is probably iron oxide.
3) If the sandstone is uncolored, the cement is probably silica or quartz if it does not fizz upon the addition of dilute hydrochloric acid.
4) Point out that other cements may be used, even table salt.

d. To demonstrate how the process occurs in nature, mix sand, powdered clay and gravel in half a graduate full of water. Allow it to settle and point out the layers or stratification. Explain that the pebbles settle first because of their great density to form conglomerate; sand follows to form standstone; and clay, least dense and finest grained, settles last to make shale.

e. Show samples of sedimentary rocks such as limestone, sandstone, shale and conglomerate. In addition, exhibit pictures of diagrams of rock strata to have the pupils realize that:

- The samples of rocks were formed under water and are composed of particles or sediments of different sizes.
- These rocks are found in layers or strata.
- Fossils may be found in these rocks.
- Such rocks are called *sedimentary rocks.*

f. Interested pupils may make sedimentary rocks at home in the following way:
   1) Take several different kinds of rock (sandstone, limestone, brick, etc.) and pulverize them by wrapping a cloth around them and hitting them with a hammer.
   2) Half fill a milk carton or container with water and add the fine particles of the crushed rock.
   3) Allow the container to stand in a warm place so that the water will evaporate.
   4) In about two weeks peel open the container to expose the rock.

13. HOW CAN HEAT AND PRESSURE CHANGE ROCKS?

a. Exhibit a piece of graphite (or carbon) and an assortment of industrial diamonds (or a diamond jewel, preferably uncut). 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 structure.

b. Develop the idea of metamorphic rocks as follows:
   1) Show samples of: clay slate, shale and schist; quartzite and sandstone; marble and limestone; gneiss and granite; anthracite and bituminous coal.
   2) Have the pupils compare the above pairs of rocks. Explain that the first rock in each group was formed from the second.
   3) Have the pupils offer suggestions of how these changes came about. From chemistry they may offer the action of heat, pressure and chemical action.
   4) Derive the definition that metamorphic rocks are formed from sedimentary or igneous rocks by action of heat, pressure or chemicals.
   5) Have pupil point out the unique and valuable characteristics of these rocks.

c. Have the pupils indicate the advantages and uses of rocks such as:
   - Red sandstone, marble, mica schist in buildings.
   - Slate for chalkboards.

- Flagstone for walks and patios.
- Marble and granite for facades and monuments.
- Limestone for window sills, etc.

d. Consider such disadvantages of using natural rocks such as: their unavailability in certain areas, the difficulty of shaping them, and their lack of transparency, to have the pupils understand the reasons why man had to develop artificial rocks. Have the pupils discuss the merits of and the processes for making some artificial rocks:

- Concrete is made by mixing the correct proportions of cement, sand, gravel and water.
- Bricks are made from impure clay mixed with sand and water, pressed into shape and baked in a kiln.
- Glass is made by heating a mixture of quartz, limestone, soda ash and sand in a furnace.

e. As an assignment, have the pupils identify and note the origin, characteristics, and use of as many rocks and minerals as they can observe in the school, in the neighborhood, and at home. Their observations may be recorded in chart form:

	Check One			
Where Is It?	Natural	Man-Made	What Is It?	What Is It Like?
Example: classroom	√		Slate chalkboard	Dark grey, smooth, hard

14. and 15. HOW CAN WE IDENTIFY ROCKS?

NOTE: This laboratory lesson is designed to build upon previous learnings and experiences by affording the pupils another opportunity to practice using a key and by having them construct keys of their own.

It is suggested that the teacher explain that there are three sets of rocks at each table and that only the igneous rocks are unidentified. Samples of basalt, granite and obsidian should be distributed but not identified. The job of each group is to identify the igneous rocks with the aid of the given key and to make separate keys for the sedimentary and metamorphic rocks, all of which are identified. For ease of handling and identification, all specimens should be labeled with a number.

Write corresponding name of the rocks you want to identify on the chalkboard. Thus, for example, all specimens of basalt will bear the same number.

It is suggested that the students key out the sedimentary rocks on the basis of size of particles, coldness, hardness, and by bubbling with dilute hydrochloric acid. The metamorphic rocks may key out by observation of colo:, types of minerals, banding, reaction to acid, and hardness.

LABORATORY WORKSHEET #17

(May be duplicated for distribution to the pupils.)

Purpose: To use and make keys for the identification of rocks.

Materials:

1. UNLABELED (but numbered) specimens of igneous rocks.
2. Labeled specimens of sedimentary rocks: sandstone, shale, and limestone.
3. Labeled specimens of metamorphic rocks: marble, gneiss, schist, and slate.
4. Hand lenses and small vials of dilute hydrochloric acid.
5. Copper penny, steel nail, glass slide, and porcelain tile.

Before you start:

1. Be sure you have the specimens and equipment you need.
2. Select the box of IGNEOUS rocks and open it. Keep the other boxes closed. Note that each specimen bears a number.
3. Your first job is to compare each specimen with the facts, describing it in the following key:

KEY TO SOME COMMON IGNEOUS ROCKS

TEXTURE	COLOR	NAME	SPECIMEN NUMBER
Coarse-grained	light	Granite	
Coarse-grained	dark	Gabbro	
Fine-grained	light	Felsite	
Fine-grained	dark	Basalt	
Glassy*	light or dark	Obsidian (glassy)	
Glassy*	dark	Scoria (like furnace cinder)	

**Note*: Glassy texture means containing no grains at all.

Procedure:

1. Identify the igneous rocks using the above key. The texture or grain may be determined by feeling the rock with your thumb or by using a hand lens to observe the size of the particles. Write the number on each specimen next to what you believe to be the correct description for it. Check with the teacher.

2. Close the box of igneous rocks and open the box of sedimentary rocks. Using the headings shown below, prepare your own key which will enable you to identify similar specimens you may find.

SEDIMENTARY ROCKS

Specimen Number	Name of Rock	Size of Particles	Color of Rock	Result of Acid Test	Other Special Characteristics

3. Close the box of sedimentary rocks and open the box of metamorphic rocks. Using the headings shown below, prepare your own key which will enable you to identify similar specimens which you may find.

METAMORPHIC ROCKS

Specimen Number	Name of Rock	Color	Mineral Components	Banding (Presence or Absence)	Result of Acid Test	Texture	Other Characteristics

4. As an assignment, gather at least six specimens of rocks from the neighborhood (this may be done during Lessons 22-23 — a field trip) and identify them, using the following chart to list their characteristics. Number each of your specimens.

ROCK SPECIMENS COLLECTED BY: .... (NAME)

SPECIMEN NUMBER	WHERE FOUND	COLOR	SIZE OF PARTICLES	BANDING (if any)	RESULT OF ACID TEST	TYPE OF ROCK	IDENTIFIED AS NAME

Summary:

1. Are your keys exactly like those of another group? If not, why not?
2. Why are there many different kinds of keys?
3. What difficulties did you have in using or making keys?
4. Besides identification, what other uses can you see for keys?
5. Which of the rocks you studied today have you seen in or near New York?
6. For what purposes were these rocks used?

Our Changing Earth

OUTCOMES **Suggested Time Allotment: 9 Periods**

- The earth's surface or crust is continually changing.
- Forces acting vertically and horizontally are producing such changes.
- Igneous activity, earthquakes, faulting and folding are constructive or up-building activities changing the earth's surface.
- Weathering and erosion are destructive or wearing-down processes modifying the earth's crust.
- Among the agents of erosion are rivers, winds, glaciers, oceans.
- The agents of erosion are also responsible for deposition of the materials eroded.
- Weathering is the sum total of chemical and mechanical processes which disintegrate and decay the rocks locally.
- All these activities affect the economic status and well-being of mankind.

6. HOW IS THE SURFACE OF THE EARTH CHANGED BY MAN AND THE FORCES OF NATURE?

a. Elicit from the pupils a list of illustrations which furnish evidence of ways in which man causes changes in the surface features of the earth. A starting point for this discussion can be an inspection of a display of man-made rocks and pictures of earth-moving equipment. There is even the possibility of using nuclear explosions to move mountains and to divert the flow of rivers. Include outstanding examples of changes man's engineering ability has achieved.

b. Raise the question, "Are the changes produced by man always beneficial?" and have the pupils discuss the cutting down of forests, the building of man-made lakes like Lake Mead, the leveling of elevations, and the filling in of marshes and swamps. The pupils should be lead to see the need for control of potentially destructive changes.

NOTE: In constructing dams, large areas are often placed under water with consequent loss of land and eviction of living things.

c. To illustrate the changes wrought by nature upon the earth's surface, show and discuss pictures, transparencies and diagrams of:
   - Volcanic eruptions
   - Earthquakes
   - Sandstorms
   - Floods
   - Sea fossils in mountain areas
   - Folded strata

   NOTE: These phenomena are treated in detail in subsequent lessons.

d. From the discussion, have the pupils conclude:
   - The earth's surface is constantly changing.
   - Some changes are man-made; others are caused by nature.
   - Man can control some of nature's destructive forms to a limited extent.
   - Some forces are wearing down the earth's surface.
   - Other forces are building it up.

e. Have pupils prepare a list of the natural forces that change the earth's surface. This list will include: volcanoes (vulcanism); earthquakes; changes in temperature; erosion by water, wind, and waves; glaciers; and miscellaneous factors. Discuss instances of these forces at work which may have made newspaper headlines.

f. Select pupils or rows of pupils to prepare reports, including dates and damage, on each of the three types of volcanoes:
   1) Mt. Pelee or Krakatoa (explosive type)
   2) Mauna Loa or Kilauea (quiet type)
   3) Mt. Shasta or Stromboli (intermediate type)

17. HOW HAVE VOLCANOES AND VULCANISM CHANGED THE EARTH'S SURFACE?

a. Have the selected pupils report briefly on the famous volcanoes assigned (lesson 16), stressing the characteristics of the three volcanic types:
   1) Explosive, which emits fragmented materials violently.
   2) Intermediate, which is sometimes quiet and at other times violent.
   3) Quiet, which oozes a steady flow of lava.

b. As the reports proceed, draw the cross sectional profile of each volcano on the blackboard. Have the pupils analyze the *slope* of each cone along with its activity and emitted material to understand that:
   - The more explosive the volcano, the steeper its slope.
   - The slope depends upon the nature of the ejected material.
   - The greater the proportion of fragmented material, the steeper the slope; the greater the amount of liquid lava, the gentler the slope.

c. Develop the mechanism of the formation of a volcano and a dome mountain as follows:
   1) Draw a diagram (see below) of a typical area of volcanic activity. If possible, show photographs to illustrate each land form. If there are outcrops of rock in the vicinity of your school, you may be able to point out the types of igneous intrusions known as sills and dikes during the field trip (lessons 22-23).

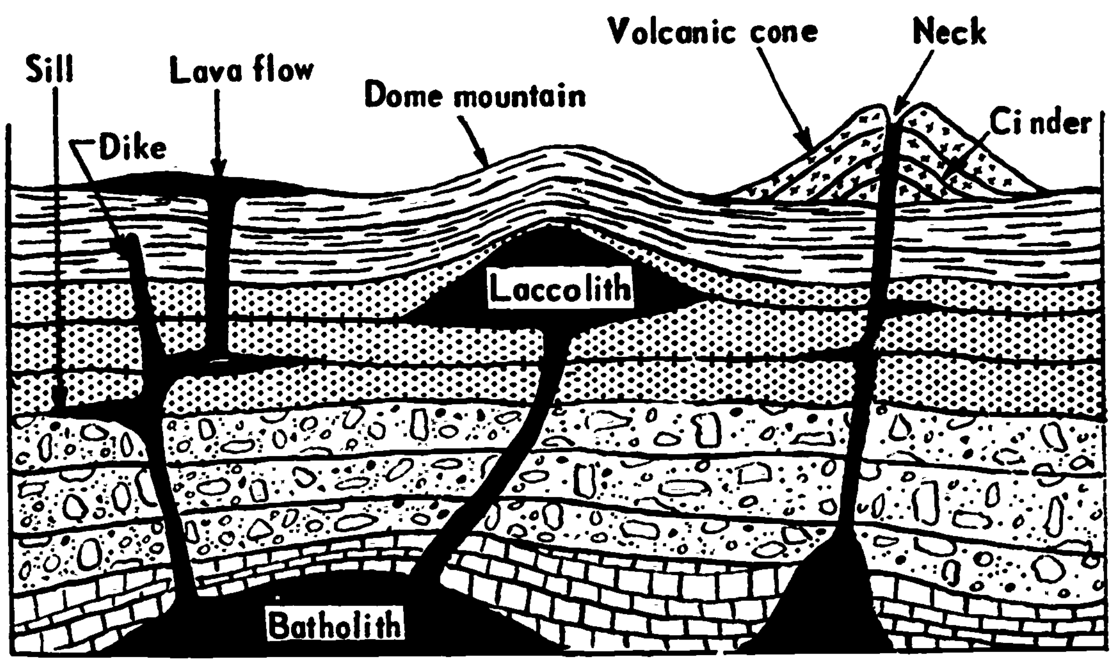
      Show pictures, diagrams or transparencies of:

      1) a dome mountain such as the Black Hills of South Dakota;

      2) a sill such as a cross section of the Palisades;

      3) a dike like the Giant Dike of New Mexico.

      Have the pupils consider the question of how volcanoes have changed the earth's surface such as the rise of the Hawaiian Islands from the sea, the destruction of Pompeii by Mt. Vesuvius, and other similar instances.



2) Explain the tremendous heat and pressure in the laccolith and the presence of an enclosed liquid (magma) where the pressure is transmitted equally in all directions.

3) Discuss eruptions as due to the oozing of lava out of weak spots, like cracks or fissures, in the earth's surface. If the pressure becomes too great, the plug in the neck of the crater may be blown out in a violent explosion.

4) The magma in the laccolith did not reach the earth's surface, probably because no weaknesses leading to the surface could be found. The rising magma met layers of rock which it could not penetrate and forced the overlying layers into a great circular dome. This formation on the surface of the earth is called a *dome mountain*.

5) Other magma flows intruded themselves between layers of sedimentary rock. Explain that this formation on earth is known as a *sill*.

6) Another type of intrusion cuts *across* either sedimentary rock layers or metamorphic rock and is called a *dike*.

7) Have pupils compare parts of the diagram to understand that:
   - In a dome mountain, the flow of magma is internal and below the earth's surface. This type of flow is referred to as an igneous *intrusion*.
   - In a volcano, the magma becomes lava when it flows externally and is then called an igneous *extrusion*.

d. Consider the question, "Since igneous intrusions occur below the earth's surface, how do we know they actually exist?" to explain that:
   - The overlying strata are often worn away exposing the intrusions below, as in the Palisades or the Black Hills, or in New York City (exposing many dikes).
   - Hot springs and geysers occur because water is heated by the recent, still-warm igneous intrusions below.
   - Demonstrate a model of a geyser as follows: Place a short-stem glass funnel inverted in a glass beaker. Add water until the bowl of the funnel is covered. Place the beaker over the Bunsen flame and note the bubbles of steam which push the water up the stem as they expand, thereby causing the water to spout out of the stem like the action of a coffee percolator. The principle of the geyser is the same as the action of a coffee percolator. NOTE: Poor circulation of convection currents results in geysers.

e. Calling upon information from the chemistry and physics units, have pupils discuss the origin of the vast amount of energy needed for volcanic action:

- Release of potential energy by chemical reactions of the exothermic type.
- Nuclear reactions in radioactive materials present beneath the earth's surface provide vast amounts of heat energy.
- All magma contain gases under high pressure. Volcanic explosions are caused by pressures built up by these gases.

f. Assign selected pupils or rows of pupils to report on some famous earthquakes: San Francisco, Japan, Bolivia, etc.

18. HOW HAVE EARTHQUAKES CHANGED THE EARTH'S SURFACE?

a. Have the selected pupils report on several famous earthquakes to understand that they are:

- Sudden and unpredictable
- Responsible for great damage
- The cause of many changes on the earth's surface.

b. To determine the principal effects of earthquakes, show pictures, diagrams or transparencies of the San Andreas Fault, displacement of buildings or fences by earthquakes and cracks or fissures. Have the pupils summarize the causes of earthquakes:

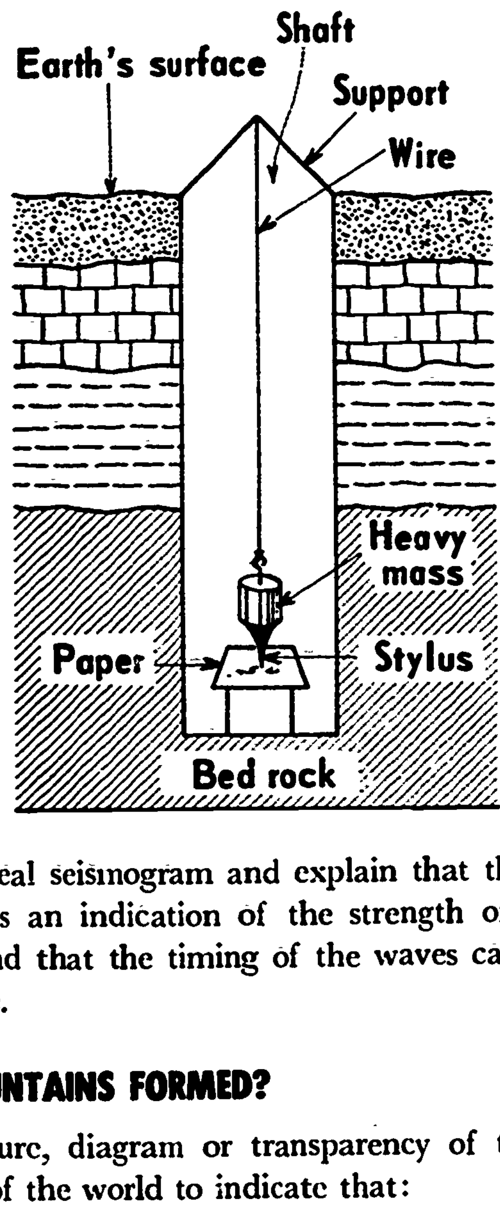
1) When the earth's surface cracks or slips at weak spots far below the surface, sudden movements may occur resulting in earthquakes. This is called *faulting* and is the principal cause of earthquakes.
2) Violent explosions of volcanoes may shake the earth and cause earthquakes.
3) Tremors or minor quakes may be caused by landslides, cave-ins or nuclear explosions.

c. Raise the question, "Can earthquakes occur at sea and if so, why?" Have the pupils realize that:

- More volcanoes rise from sea floor than from continents.
- Faulting and volcanic action occur also on the sea floor.
- Seaquakes may produce gigantic waves which may travel thousands of miles at speeds of hundreds of miles per hour and reach distant coastal areas.
- These waves are called "tsunamis." The origin of the word suggests the frequency of such sea waves on the isles of Japan.

d. Consider the matter of detection and location of earthquakes to reduce damage and render assistance to distressed areas.

1) 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.



2) Show a real seismogram and explain that the height of the vibrations is an indication of the strength of an earthquake or tremor and that the timing of the waves can be used to locate the quake.

19. HOW ARE MOUNTAINS FORMED?

a. Show a picture, diagram or transparency of the principal earthquake belts of the world to indicate that:

- Almost 95% of all earthquakes occur in two great belts; the Pacific and the Equatorial (or Mediterranean) belts.
- These same belts also include most active volcanoes and young mountain ranges.
- These activities result in constant stress on the earth's crust in the regions of these belts.
- Because of these stresses, great fault lines or "lines of weakness" have developed.

b. Display pictures, transparencies, block diagrams and cross sections with arrows to show direction of movement of such *fault mountains* as: Sierra Nevadas, mountains of the Basin and Range area of Utah and Nevada, the Graben of the Rhine Valley flanked by the Vosges on one side and the Black Forest block on the other side, or the rift valleys of Africa with Lake Tanganyika and Nyassa. Lead the pupils to realize that:

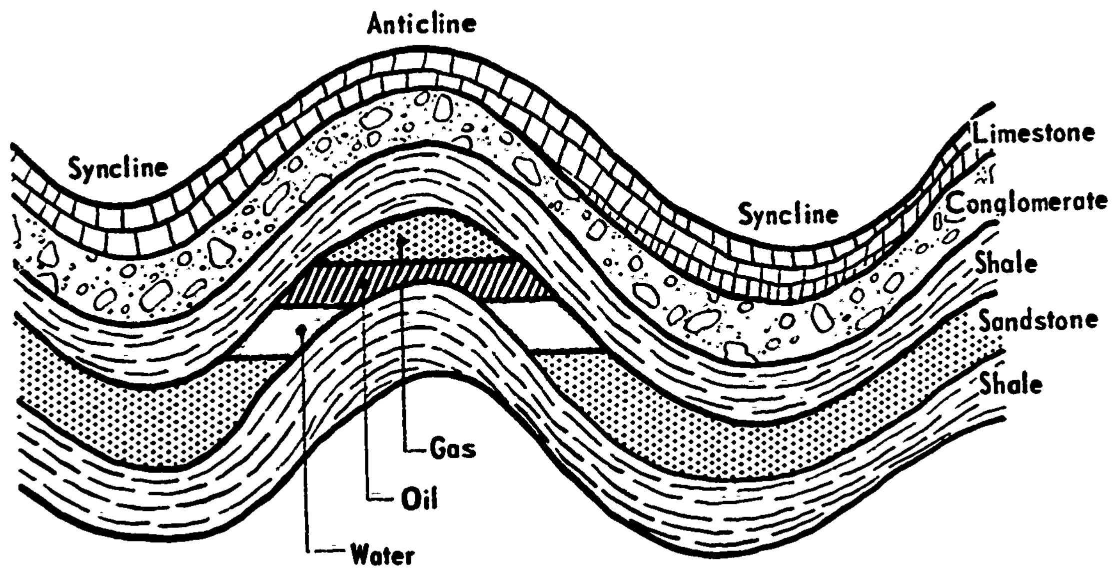
- Vertical forces must have pushed upward from somewhere below the earth's surface, or downward from above.
- The vertical forces probably were exerted slowly over a long period of time.
- The result was slow crustal movements along fault lines or "lines of weakness." The fault actually occurs in seconds, a few feet at a time. This process is repeated.
- Faults, over long periods of time, lead to the formation of fault or block mountains.

c. To demonstrate how such faulting may have come about, do the following: Balance two books close together on the two arms of a platform balance. The pages of the book will represent rock layers. On one book set a pan of sand to represent a mountain. On the other book set a pan of water to represent an ocean. Balance both sides. Point out that as the mountain is worn down, sediments are carried to the ocean. Represent this by taking a teaspoonful of sand from the mountain and dumping it into the ocean. This disturbs the balance of the earth's crust, and eventually may cause a fault.

d. Ask the pupils to predict what would happen to the rock strata of the earth's crust if the forces were directed horizontally, rather than vertically as in faulting:

1) Demonstrate how mountains are formed by compression, as follows: Cut several strips of foam rubber of various colors, or strips of colored paper or flannel cloth about 2 inches wide and 2 feet long. Superimpose one strip on another to represent several layers of rock. With hands placed at each end, push the strips equally toward the middle to form symmetrical folds that occur in folded mountains.
2) Repeat the performance, but this time push only with the right hand to produce folds that seem to topple toward the left.
3) Show pictures, diagrams or transparencies of folded mountains such as the Appalachians or the Jura Mountains of Europe.

e. Draw the diagram of a folded mountain (page 36).



Have the pupils observe that:

- The anticlines are rises in the layers (upfolds in the crust), while the synclines are downfolds. (Mnemonic: Have pupils note shape of an *A*nticline is like an "A".)
- Oil is often found in the porous sandstone in anticlines, if the anticlines are of the open type; i.e., the strata are only slightly folded.
- The trapped materials are separated in order of their densities, the heaviest being on bottom, as should be evident from the physics unit.

20. HOW DOES WATER CHANGE THE EARTH'S SURFACE?

NOTE: Prepare two wooden troughs or trays for showing erosion experiments, each as follows: Construct a wooden or metal trough 2 to 3 feet long and 3 to 4 inches high and 6 to 8 inches wide. Leave it open on top and at one end. Use putty or neoprene on the inside edges to make it watertight. With tacks fasten a piece of ⅛ inch mesh or fly-screen at the open end. At the closed end, place several handfuls of soil, gravel, sand, and clay (the coarser materials on the bottom). Be sure to place an overflow container of some sort, such as a pail or a funnel in a glass jug, at the open end to catch the overflow and to avoid clogging the drain. See the N.Y.S. *Earth Science Handbook*, pages 62-3, or the N.Y.S. *General Science Handbook,* Part 2, pages 140-1, for diagrams and details. In using these trays, be careful not to permit the dirt in the run off to enter or clog the drain in the laboratory sink.

a. Review the building-up forces of nature by showing a picture of a complex mountain, such as the Rockies, Alps or Himalayas, and explain that it is a complex mountain because it contains elements formed by folding, faulting and volcanic action. Point out that mountains are continually being worn down by a process called *erosion.*

b. Demonstrate the impact of water erosion by setting a jar lid or a saucer of soil in the center of a large sheet of paper. With a medicine dropper, release a few drops of water from a height of several feet, onto the soil, and notice the amount of soil that splashed out on the paper.

c. Have the pupils discuss how raindrops become great rivers:

   1) Rain falls on the hillside following the slopes, forming rivulets and streams.
   2) These rivulets and streams form larger streams, forming river systems.
   3) From the moment that the water started running downhill, it carried soil, sand and pebbles along with it.

d. Using the erosion trays, demonstrate erosion, transportation and deposition of sediments as follows:

   1) Set one tray at a steep slope and run a rubber tube with spray nozzle from the water tap to the closed end of the tray to provide a rapidly flowing stream in order to show deep valley formation and the activity of a young river.
      NOTE: It may be necessary to remove the spray nozzle to concentrate the stream and to achieve the desired result.
   2) Set the other tray at a slight slope and decrease the rate of flow of the water to demonstrate the activity of a mature or old river:
      - If one or two pebbles or a stick are buried along the course of the stream, meanders can be shown;
      - A dam of clay, deposited across the open end, will cause a delta to develop.

e. Based upon the foregoing demonstrations and upon pictures, have the pupils summarize each stage of the "Life Cycle of Rivers":

   1) Youth: Rapid flow of water, narrow V-shaped valley, and much erosion of rocks and soil, lakes and few tributaries.
   2) Maturity: Slower flow of water, lesser erosion of soil and deposition of flood plains, deltas and alluvial fans, many tributaries.

3) Old Age: Deposition of a very broad flood plain, formation of natural levees, and a meandering twisting course.

21. HOW HAVE OTHER ERODING AGENTS CHANGED THE SURFACE OF THE EARTH?

NOTE: In this and the following lessons, place particular stress on the evidences of these changes which may be seen in the New York City area. Encourage your pupils to visit locations other than those in the neighborhood of your school, for example: undeveloped beach areas, the Bronx River Valley, north of the Botanical Garden (for many evidences of glaciation), and the area along the west bank of the Hudson below the Palisades.

a. To evoke understanding of the erosion and deposition effects of *waves*:

- Show pictures or diagrams of wave-cut cliffs, terraces, banks, caves, stacks, and chimneys as examples of the erosion effects.
- Show diagrams and pictures of Sandy Hook, Coney Island and Long Beach to demonstrate the effects of longshore currents. NOTE: Longshore currents move at an angle or parallel to the shoreline and deposit loose materials into coves and bays, especially across the mouths of bays as at the Rockaways.
- Have the pupils discuss the effects of wave erosion on shorelines during a storm, often resulting in the creation of disaster areas.

b. Clarify erosion and deposition effects of glaciers by:

- Showing pictures or diagrams of glaciated valleys, mountain passes, glacial deposits, and moraines.
- Discussing the plucking action of glaciers, which removes soil and rock and which become eroding agents.
- Comparing the U-shaped glacial valley with the V-shaped one of a young river.
- Explaining that glaciers move slowly because of their solid and semi-solid state.

c. Demonstrate the action of the *wind* as an eroding and depositing agent by:

- Showing pictures of sandstorms, sand dunes, and desert areas
- Discussing how wind carries away topsoil which is blown against rock, wearing it down

- Pointing out that sand may be deposited as dunes which have a gentle slope.

d. Point out to the pupils that eroding agents change the surface of the earth not only by destructive activity, but also by constructive building of new land forms such as deltas and moraines which are made from the products of destruction. Distribute copies of the following chart:

GEOGRAPHIC FEATURES RESULTING FROM EROSION AND DEPOSITION

AGENT	EVIDENCES OF ERODING WORK (DESTRUCTIVE)	EVIDENCES OF DEPOSITIONAL WORK (CONSTRUCTIVE)
Rivers	Gullies V-shaped, narrow canyons like Ausable Canyon and Colorado (young rivers). V-shaped, wide valleys as exemplified by the lower Mississippi. (late maturity or beginning old age)	Flood plains Deltas Alluvial fans and cones
Waves	Cliffs Sea Caves Wave-cut terraces Chimneys or stacks	Wave-built terraces Barrier beaches Spits Hooks Baymouth bars
Glaciers	U-shaped valleys Matterhorns Hanging valleys Rock basins Cirques Roche moutonée (many in New York City area)	Moraines (unstratified angular-unassorted materials) Glacio-fluvial deposits (water from melting ice starts to sort out and stratify the materials)
Winds	Sand-blasting action of exposed inland regions and along seashores	Sand dunes

Suggest that pupils find illustrations of these evidences and/or take photographs of places they may visit (or have visited). These photographs and illustrations, with proper captions, should be mounted in the pupils' notebooks.

e. Demonstrate *weathering action* by:

1) Heating a glass rod and plunging it quickly into cold water to show the effect of temperature changes on substances such as rock.

2) Pointing out that roots of plants, freezing and expansion of water, and chemical action, as in rusting, will widen cracks and break rocks. This process is called *mechanical weathering.*

3) Explaining that chemically weathered rock is the parent of soils.

4) Comparing weathering with erosion to show that erosion involves a moving agent plus tools and produces transported mantle rock, not soils.

f. Instruct pupils as to preparations they are to make for field trip. It is suggested that the trip be introduced by showing all or selected frames of the Board of Education filmstrip called "Geology of New York," obtainable without charge from the Bureau of Audio-Visual Instruction. An excellent guide and script accompany the film.

22. and 23. WHAT CHANGES IN THE EARTH'S SURFACE HAVE TAKEN PLACE OR ARE TAKING PLACE NEAR OUR SCHOOL?

NOTE: Probably an excellent way to culminate the section on crustal changes of the Earth Science Unit is to have the pupils go on a field trip to observe some of the phenomena discussed. Among the observations possible are the viewing of evidences of weathering and erosion, as well as seeing specimens of rocks and rock formations. The work of man as an agent of modifying the Earth's surface.

Also of great value is the Board of Education curriculum resource bulletin entitled, *Operation New York,* which includes a wealth of suggestions in connection with this type of activity.

LABORATORY WORKSHEET #18

(May be duplicated for distribution to the pupils.)

Purpose: To study the geologic changes taking place in and around our school.

Procedure:

1. Locate any natural stones or rocks in or near the school.
   - Look for MARBLE near the door or staircase, or in the school lobby.
   - GRANITE is usually grey, speckled and granular in appearance. Large grains indicate slow cooling; small grains rapid cooling.
   - LIMESTONE is often grey, often cementlike in appearance. It is often used as window sills, breaks easily and may contain fossils.
2. Examine your school yard for evidences of weathering:
   - Rust stains on the concrete below the school gate. How did the stains get there?
   - Cracks and fissures in the pavement. What caused them?
   - Uneven surface of the yard. How does it slope and why? Of what is the surface made? Is concrete more durable than asphalt?
   - Repairs and patches. Why were these made?
   - Stains and gullies below a water pipe. How were they caused?
3. Look between the sidewalk and the curb for "islands of soil." What do they tell you? How did they get there?
4. Observe other areas near your school to identify geologic features and to note changes that are occurring such as:
   - an area of bare soil. Are there any gullies?
   - the gutter. Why is it higher in the middle?
   - the curbstones. Why is granite often used here?
   - excavations. What kind of bedrock is present?
   - outcroppings. Do you see any markings caused by glacial action?
   - hills and plains. What are the evidences of erosion?
   - vacant lots.
   - splashed mud and soil to show raindrop erosion. Often these may be found on the sides of buildings.
   - beach areas. How is the sand held in place? Show how the variations in color of sand are due to variations in mineral content.
5. Return to school with:
   a. materials for a geologic collection. (Be sure to obtain your teacher's permission.)
   b. a collection of weathered materials for comparison with non-weathered types.

Observations: Describe your observations, using the form below.

LOCATION	OBSERVATION	EXPLANATION (CAUSE AND/OR EFFECT)

24. WHAT ARE THE RESULTS OF WEATHERING AND EROSION?

NOTE: This lesson has been placed after the field trip to provide an opportunity to follow up the experience and to make sure that some of its outcomes have been achieved.

a. Begin with a ten-minute period during which the pupils should be allowed and encouraged to ask questions concerning things they saw on the trip. If possible, pupils should volunteer to answer other pupils' questions. If they cannot, the teacher should (or he should indicate a way to find the answer).

b. The teacher should then take his turn at asking questions, such as:
   - What evidences did you see of erosion caused by . . .?
   - What evidences did you see of weathering caused by . . .?

c. Since it probably will be impossible to find a complete assortment of evidences in the neighborhood of a particular school, it may be necessary to supplement the experience of the field trip with illustrations of various types. Here are some suggestions:
   - Results of chemical action:
     1) Have pupils compare stains of rocks with rusty nail and bathtub or sink which shows stains where the water drips.
     2) Show mica schist that has become crumbly because the iron in it has become oxidized.
     3) Show pictures of limestone caverns or weathered marble tombstones and demonstrate how acid reacts with these rocks.
     4) Show the effect of ground water upon deposits of rock salt.
   - Results of mechanical action:
     1) Show examples of exfoliation — this is common in sidewalks.
     2) Show pictures of Yosemite Royal Arches and Half Domes as scale examples of exfoliation.
     3) Show pictures of rock falls at Niagara Falls which are due in part to the wedge-work of ice. City streets in winter often show the effects of water which has seeped under the roadbed and frozen.
     4) Point out where pavements have been broken by the growth of trees.
     5) Show pictures of the talus deposits at the base of the Palisades. Call attention to the signs one sees along the highways warning of fallen rock zones.
     6) If there has been a recent rainfall, call attention to the damage that rain contributes to the earth's crust.

d. Up to this point, the attention of the class has been focused chiefly upon the effects of weathering and erosion upon the earth's surface. It is also important to draw attention to the effects of these forces upon the works of man, especially those things involving vast capital outlay or public safety (sometimes both are combined). Stimulate the pupils to recall instances in which buildings have collapsed because of washed-out foundations; in which roads have become hazardous; in which farm land has become a dust bowl; in which floods have been caused; and minor instances which have caused trouble to householders. Once you start the discussion, it should be possible for the pupils to contribute many anecdotes.

e. Another point of view which has been neglected should be discussed at this time. The focus has been upon geomorphology. This unit should not be concluded without mentioning the side effects, such as: the problem of water pollution, the problem of air pollution, the loss of crops, the danger to lives, and the effect upon wild life.

f. Finally, it will be well to conclude the unit with some constructive ideas on how to conserve resources of soil, water, and property. It is recommended that the teacher refer to three books published by the United States Department of Agriculture—*The 1955 Yearbook—WATER, The 1957 Yearbook — SOIL,* and *The 1958 Yearbook — LAND.* Each of these contains many ideas on conservation which should be brought to the attention of the pupils, especially those who may wish to read further on this subject.

SUGGESTED REVIEW QUESTIONS

The questions that follow are not intended as a diagnostic tool or comprehensive measure of the outcomes of the unit. They may serve the teacher for review purposes, as a source of questions for a unit examination, or in any way deemed desirable.

Directions (1-20): Choose the *letter* of the term which best completes the statement.

1. The scientist who studies the earth history is known as
   a. mineralogist
   b. astronomer
   c. paleontologist
   d. seismologist
   e. petrologist

2. The "Moho Project" aims to penetrate into
   a. the earth's atmosphere
   b. the deepest ocean
   c. the earth's mantle
   d. a glacier
   e. the earth's core

3. Cleavage means that a mineral
   a. breaks unevenly
   b. breaks with flat, smooth surfaces
   c. shatters
   d. breaks with curved surfaces
   e. leaves a streak on porcelain

4. Conglomerate is formed of cemented beds of
   a. silt
   b. sand
   c. gravel
   d. volcanic ash
   e. lime

5. Granite is composed of the minerals quartz, feldspar and usually
   a. calcite
   b. mica
   c. talc
   d. gypsum
   e. apatite

6. The principal cause of earthquakes is
   a. folding
   b. faulting
   c. landslides
   d. oozing volcanoes
   e. tidal waves

7. Evidence that New York State at one time had an arid climate is based on the existence of
   a. limestone
   b. shale
   c. salt deposits
   d. glacial till
   e. erratics

8. The igneous intrusion that causes the overlying rock strata to form a dome is called a
   a. cone
   d. dike
   c. laccolith
   d. sill
   e. spine

9. Oil deposits are most commonly found
   a. synclines
   b. monoclines
   c. anticlines
   d. faults
   e. rifts

10. A 'U" shaped valley was formed by
   a. rivers
   b. winds
   c. glaciers
   d. waves
   e. gravity

11. An old river is usually identified by its
   a. "V" shaped valley
   b. rapids
   c. meanders
   d. many tributaries
   e. lakes

12. A sand dune has a gentle slope on
   a. its leeward side
   b. all sides
   c. its windward side
   d. its crest
   e. its southern side

13. The cracking of rocks by freezing water is called
   a. erosion
   b. weathering
   c. corrosion
   d. sedimentation
   e. deposition

14. The earth's history can best be studied from the
   a. age of a river
   b. stage of mountain development
   c. radioactive decay
   d. salt in the oceans
   e. carbon 14

15. Igneous intrusions compared to the rocks which they have intruded are
   a. younger
   b. older
   c. the same age
   d. not related in age
   e. none of the above

16. Fossils found in rocks of only one age are called
   a. casts
   b. index fossils
   c. imprints
   d. concretions
   e. inclusions

17. The opening at the top of a volcano is called a
   a. neck
   b. crater
   c. pothole
   d. sinkhole
   e. blowhole

18. The most abundant element in the earth's crust is
   a. nitrogen
   b. silicon
   c. oxygen
   d. iron
   e. helium

19. The ore from which lead is extracted is
   a. hematite
   b. bauxite
   c. galena
   d. chalcopyrite
   e. pitchblende

20. A person's thumbnail can scratch
   a. quartz
   b. gypsum
   c. a copper penny
   d. feldspar
   e. fluorite

Directions (21-25): Choose *the word* or expression from the group that *includes* or is most closely related to all the others in the group.

(Example: Earth, Mars, *Planet,* Saturn)

_____21. cleavage, fracture, crystal, shape, physical property, streak.

_____22. frost action, exfoliation, oxidation, weathering, solution.

_____23. delta, dune, deposit, drift, drumlin.

_____24. cast, mold, fossil, impression, petrified wood.

_____25. river, valley, pothold, meander, levee.

Directions (26-35): Give the word or expression that best completes the statement.

26. Lines that connect places having the same elevation are called ____________________

27. Fossils are found usually in ____________________

28. Wind erosion is most effective in those regions where the climate is ____________________

29. The chief mineral in limestone is known as ____________________

30. Waterfalls are characteristic of ____________________

31. Magma that cools very slowly is likely to form ______

32. Slate is usually metamorphosed from ______

33. The sum total of all the processes by which rocks are chemically and mechanically broken up into smaller pieces is called ______

34. A crack in the earth's crust along which there has been a movement of the rock is called a(n) ______

35. Erratics are deposits left by ______

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