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Science: Grade 5 provides the teacher with specific materials and suggestions for organizing effective learning experiences in the science area. It is based on the concept that learning occurs when the learner attempts to solve a problem which he finds meaningful. Both science knowledge and science processes are stressed. Significant findings from national projects have been incorporated. Evaluation activities are included for each of the major topics. Drawings, figures, charts, and graphs are used extensively to illustrate concepts. Listings of films, filmstrips, transparencies, and references are provided. (DS)

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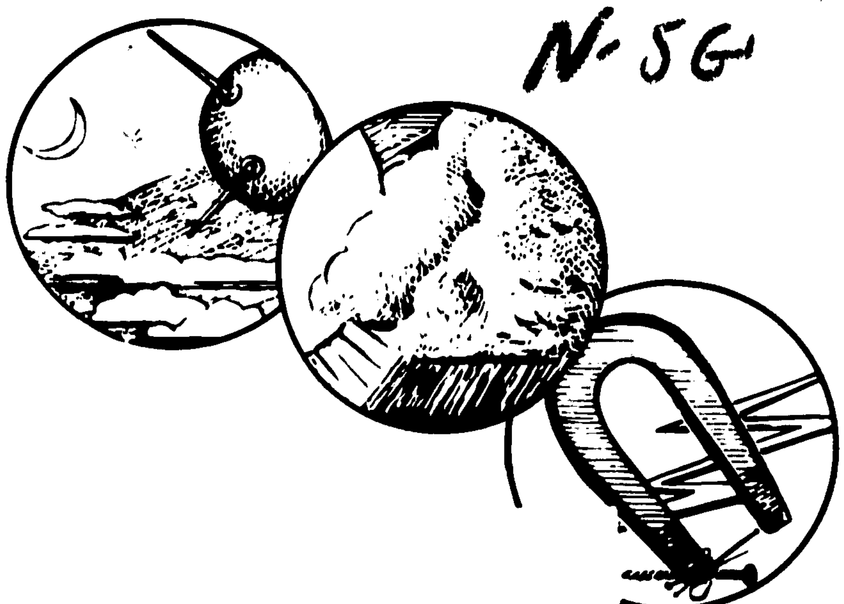
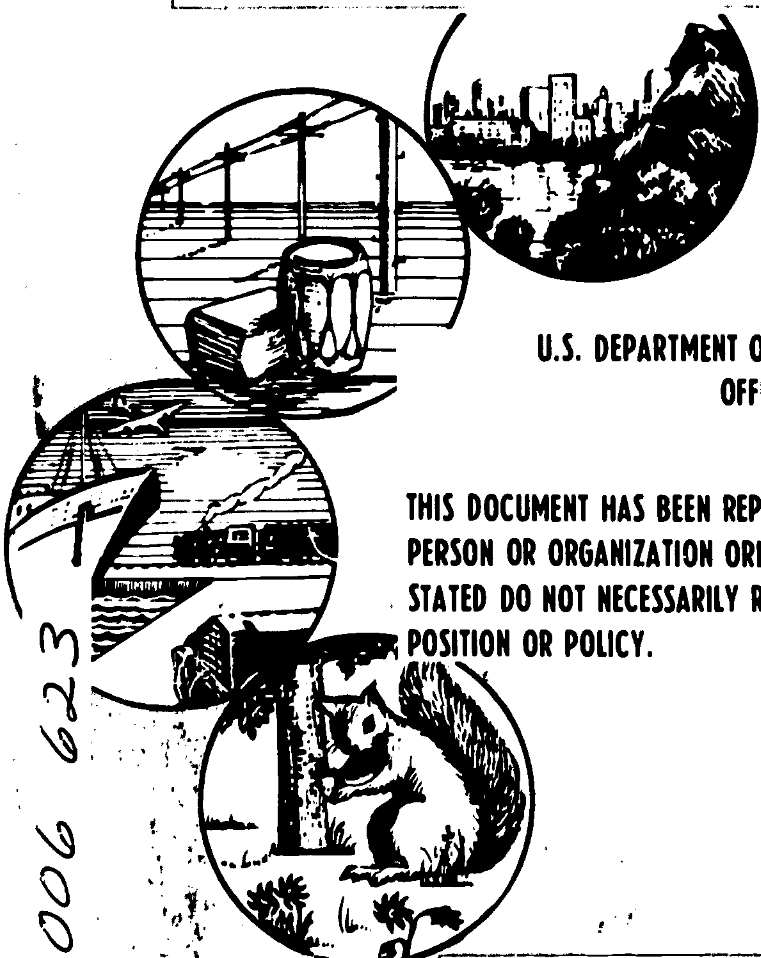


SCIENCE
Grade 5



BUREAU OF CURRICULUM DEVELOPMENT
BOARD OF EDUCATION • CITY OF NEW YORK

CURRICULUM BULLETIN • NUMBER 6 • 1968-69 SERIES

SCIENCE
Grade 5

BUREAU OF CURRICULUM DEVELOPMENT
BOARD OF EDUCATION OF THE CITY OF NEW YORK

FOREWORD

In the past decade science instruction has become an integral part of the elementary school program, from the prekindergarten through the sixth grade. Science has a unique role in the curriculum because it offers opportunities for all children to explore and to discover the what, the how, and the why of the world around them.

The science program is based on the concept that learning occurs when the learner attempts to solve a problem which he finds meaningful. *Science: Grade 5* provides the teacher with specific materials and suggestions for organizing effective learning experiences in the science area in harmony with this concept. Both science knowledge and science processes are stressed. Significant findings from national projects have been incorporated. Among the new features which merit special attention are the evaluative activities which follow each of the major topics.

In behalf of the school system I wish to express my appreciation to the Bureau of Curriculum Development, the Office of Science Education, superintendents, directors, elementary science coordinators, and to the hundreds of teachers and supervisors who have made this publication possible by tryouts in the classroom, by designing of materials, and by their participation in the preparation of this handbook.

October 1968

SEELIG LESTER
Deputy Superintendent

ACKNOWLEDGMENTS

This handbook was developed under the direction of Helene M. Lloyd, then Acting Deputy Superintendent of Curriculum, as a joint venture of the Office of Elementary Schools, Truda T. Weil, Assistant Superintendent; the Bureau of Curriculum Development, William H. Bristow, Assistant Superintendent; and the Office of Science Education, Samuel Schenberg, Director.

The preparation of this handbook was a cooperative enterprise which enlisted the efforts of hundreds of teachers and supervisors in the Elementary Science Revision Project. The general coordinating group for the Revision Project consisted of William H. Bristow, Samuel Schenberg, Harry Milgrom, and Julius Schwartz.

Julius Schwartz, Consultant in Science of the Bureau of Curriculum Development, was the principal researcher and writer for *Science: Grade 5,* and chairman of the Revision Committee.

Muriel Green, Science Consultant, Bureau of Curriculum Development, was the assistant chairman of the Revision Committee and researcher and writer of science curriculum materials for this handbook.

The following district science coordinators, members of the Revision Committee, participated in the writing, testing, and evaluation of the handbook materials for *Science: Grade 5:* George Barr, Rose Blaustein, Mary Graeber, Anna M. Rosenblum, Joan Rosner, Thomas G. Vinci. Steve Fisher, Bureau of Audio-Visual Instruction; Elliott Blaustein, physics teacher, Brooklyn Technical High School; and Tessa R. Harvey, Intermediate School Coordinator, District 5, also served on the Committee at various times.

The following members of the Office of Science Education reviewed the materials at different stages of its development: Harry Milgrom and Sam Fried, Assistant Directors; Joan Rosner, Acting Assistant Director; and Martin Bloom, Evaluator, Ninth-Year Science Curriculum.

Acknowledgment is due also to the many teachers, supervisors, science coordinators, curriculum assistants, and specialists from institutions outside the Board of Education who assisted in the preparation of the seven handbooks in the original series, *Science: K-6,* which has served as the basis for the current revision program.

Steve Fisher, Bureau of Audio-Visual Instruction, assisted the Revision Committee in preparing the list of films and filmstrips. Lucia Engels, Bureau of Libraries, assisted in the preparation of the bibliography. Thanks are extended to Edward G. Bernard, Director of the Bureau of Audio-Visual Instruction, and to Helen R. Sattley, Director of the Bureau of Libraries, for their cooperation. Richard R. Kinney, Supervisor of School Gardens, prepared the draft of *The School Garden in the Science Program.*

This publication was designed and produced by the Bureau of Curriculum Development. Aaron N. Slotkin, Editor, supervised printing production; Lillian B. Amdur edited and proofread the manuscript; Jan Margo did the drawings; and Ruth Eriksen was responsible for the layout. Simon Shulman cooperated on the art work.

DEVELOPMENT OF THE SCIENCE PROGRAM FOR THE ELEMENTARY SCHOOLS OF NEW YORK CITY

The science program for the elementary schools stems from a series of projects that have been under way for almost two decades to give the study of science full status in the elementary curriculum in New York City.

One project, originating in two districts, resulted in the preparation of *Science in Everyday Living* (Curriculum Bulletin No. 6, 1947-48 Series). This publication, reporting early childhood activities and experiences in the classroom, was distributed to all elementary schools in New York City.

Material developed in other districts for the intermediate grades was published as *Source Materials in Elementary Science* (Curriculum Bulletin No. 3, 1949-1950 Series). This publication, outlining science materials, experiences, and units, was also made available to all schools.

To meet the need for broader consideration of the overall K-12 science program, exploratory studies and conferences were conducted in 1950, culminating in the appointment and work of a science advisory panel which established a set of goals and principles later accepted as a working program by the Curriculum Council.

Another step was taken in 1950 when the Curriculum Council of the Board of Education designated a Science Advisory Committee to coordinate the development of a 12-year science program for the New York City Schools. This committee consisted of: *William H. Bristow, Director, Bureau of Curriculum Research (now the Bureau of Curriculum Development), Chairman; Alfred D. Beck, Science Supervisor, Junior High Schools; Francis X. Carlin, Science Supervisor, Vocational High Schools; Harry Milgrom, Science Supervisor, Elementary Schools; Samuel Schenberg, Science Supervisor, High Schools; Jacob H. Shack, Assistant Superintendent, Division of Curriculum Development, Secretary.

*The positions indicated are those which were held in 1950.

Concurrently, committees of teachers and supervisors were set up to prepare courses of study in science for the elementary, junior high school, and senior high school levels.

The work of the elementary school committee was directed first by the late Isaac Bildersee, Assistant Superintendent, and then by Herman Schneider, former Science Supervisor, Elementary Schools.

During 1953, a committee under the chairmanship of Harry Milgrom which included Ruth Berken, Allen Burnham, Frances Harmon, and Martha Shapp prepared a *Course of Study in Science for the Elementary Schools, Grades K-6,* which was adopted by the Board of Superintendents and the Board of Education in July, 1954. This gave the elementary schools the first approved framework on which to build a science program, and completed the process of organizing a science sequence from the kindergarten to the twelfth grade.

A program of curriculum development and implementation was approved by the Board of Superintendents at its meeting on January 4, 1955, and became known as the Elementary Science Project. This project was a joint undertaking of the Bureau of Curriculum Research and the Office of Elementary Science.

Thirty-one pilot schools in seventeen districts participated in the development of materials. To facilitate organization of production, committees were designated to develop materials in each of the seven areas of the program: Magnetism and Electricity, The Earth in Space, Living Things, Sound and Light in Communication, Weather, Motion and Force in Transportation, and Earth and Its Resources. Each committee consisted of teachers and supervisors from pilot schools, district science chairmen, curriculum assistants, science coordinators, and in some cases, representatives of cooperating institutions in New York City.

The work of the seven committees was under the direction of Harry Milgrom, Supervisor of Science for the Elementary School Division, and coordinated by Julius Schwartz, Consultant in Science of the Bureau of Curriculum Research.

The reports of the committees were prepared for publication by an editorial committee consisting of Allen Burnham and George Barr, Office of Elementary Science, and Julius Schwartz, Chairman. Jan Margo, a teacher in the All-Day Neighborhood School program at P.S. 108M, served as a consultant and illustrator for the handbooks.

Between the years 1958 and 1962 the seven handbooks, *Science: Grades K-6,* (Curriculum Bulletin No. 2, 1958-59 Series), each dealing with a separate area of science from Kindergarten to Grade 6, were distributed to all of the elementary school teachers of New York City. During this period, an intensive program of teacher training was instituted to implement the use of the handbooks in the schools. Under the leadership of Harry Milgrom, the staff of science coordinators assigned to the twenty-five district superintendents conducted workshops, demonstration lessons, in-service courses, and faculty and grade conferences to familiarize the teaching staff with the new program.

In-school television programs for children, based on the handbooks, were cooperatively developed by WNYE, the Bureau of Curriculum Research, and the Office of Science Education. These programs served both for direct pupil instruction and for teacher training.

After-school television programs for the training of elementary school teachers were initiated by Samuel Schenberg, Director of Science, and supervised by Harry Milgrom, Assistant Director, with the active cooperation of WNYE, the Bureau of Curriculum Research, and the Division of Elementary Schools. Teachers' guides for these purposes were prepared and distributed. These television courses for teachers were held at the end of the school day and were received in school centers throughout the city. Each telecast was followed by an intensive workshop, using the materials presented on the program. In a later period the same course was presented to teachers who wished to view it at home, and a special guide was prepared for that purpose by Muriel Green, Science Consultant.

The emerging elementary science program was accompanied by an expansion of science fairs, clubs, assembly programs, and trips. More and more, science became part of the daily experience of all elementary school children.

In 1963, the Bureau of Curriculum Research and the Office of Science Education launched the present revision program. One reason for the revision is to bring together science content formerly presented in seven handbooks so that a teacher may find all of the instructional materials for her grade in a single publication. In addition, the revision reflects recent advances in science and in the methods of teaching science. While retaining intact the basic scope and sequence of the original series, the experiences are enriched, and the number and variety of activities are increased. More suggestions are given to the teachers to stimulate the teaching of science as inquiry, through approaches which place children in the role of innovators, explorers, and discoverers. The teacher is given more assistance in planning, in using equipment, and in meeting the needs of children with varying abilities and interests. New introductory materials are incorporated to highlight modern developments, trends, and emphases in modern education. Integral to the revision is a series of items to assist the teacher and the children in evaluating the effectiveness of the teaching and the learning.

A panel of principals served as advisors to the Revision Project. The panel included Paul J. Fitzgerald, 164K; Thea S. Klein, 59M; Irving Kreitzberg, 41M; Sidney Levy, 92X; Maude E. McGrath, 29R; Hermine J. Nelson, 99K; Pearl Newman, 16K; Emil Soskind, 188K; Dirck Stamler, 75M; and Mary E. Vogt, 134Q.

A Revision Committee, staffed with district science coordinators, worked on the new handbooks during the period 1963-1968, including the summers of 1964 and 1965. A kindergarten team, consisting of Muriel Green, Alice Harwood, and Julius Schwartz, had the special responsibility of planning, researching, and writing the original kindergarten topics. These topics were then tried out in eighteen pilot schools. This project is described fully in *Science: Grades K-2*, which was published in the spring of 1966.

Because of the urgency of the fast developing *Operation Headstart*, the kindergarten team was assigned to write a science program for the pre-kindergarten curriculum. This science material appears in the *Pre-Kindergarten Curriculum Guide*, which includes all the curriculum areas, and should now be considered a part of a Pre-Kindergarten — Grade 12 science program of New York City.

Science: Grades 3-4 was published in the fall of 1966. Present plans call for the publication of the revised materials of *Science: Grade 6* in 1969.

CONTENTS

MEETING THE NEEDS OF ALL CHILDREN

Science meets the needs of all children since it offers them endless opportunities to explore, to manipulate, and to discover, as they try to find the what, how, and why of the world around them. The science program is designed to provide a variety of experiences in the form of trips, experiments, constructions, and projects which will appeal to children of varying backgrounds, interests, and capacities.

The unit *Climate,* for example, begins with a discussion of the previous day's weather. The children move from a personal recollection of the weather condition to a verification of the facts by consulting the daily newspaper. They go on to a comparison of New York City's weather for a given day or month to the weather of other large cities in the country. They then move to a comparison of New York's climate to that of other major cities. Some children will enjoy researching this information in the *World Almanac,* and preparing charts and graphs of their findings. Other children will plan the wardrobe they would need for a make-believe trip to cities in various parts of the country.

As the topic progresses, children experiment to find how the angle at which the sun's rays strike an object affects the amount of heat they produce. They prepare charts to record the findings of their experiments. They link the results of their experiments to the large-scale climate differences found in different latitudes. Through their continued investigations they find answers to such questions as why people find the mountains or seashore such comfortable places for summer vacations. By the completion of the topic, they have begun to understand the factors which influence the climate in which they live, and other climates throughout the country.

Science lessons come in many "sizes" and "shapes." Characteristically, children may be experimenting, constructing, discussing, reading, observing, making drawings, making measurements, making exhibits, taking care of plants and animals. Science lessons may take the form of a planned trip in or around the school building, to the school garden, in the neighborhood, or to a nearby park. A science lesson may be the spontaneous reporting by children of what the windstorm did the previous night. A science experience may last two minutes, five minutes, an hour, or more. It may be part of an interrelated series of experiences and activities, or it may stand uniquely by itself.

There are many roads to science learning and there are many settings for science teaching. The developmental class lesson, led by the teacher, is only one of the shapes that a lesson may take. On different occasions, children may work in small groups or by themselves. Since children learn at different rates and in different ways, there must be many opportunities for individual work. Children need time to think, time to work things out for themselves without pressure from their classmates or teacher. Not all children will necessarily be working in science at the same time.

Using This Handbook to Meet the Needs of All Children

In the Approaches and Learnings for the Child, you will find, for each topic, the significant concepts which all children should learn. Following these are suggested problems. For example, in *The Sun's Family,* Topic A, Planet Earth in the Solar System, is developed through such problems as the following:

1. Where have spaceships gone?
2. What planets are there in our solar system?
3. Can we see a planet in the sky?
4. How can we tell a planet from a star?
5. How do planets get their light?
6. Do planets appear to move in one night?
7. What paths do planets follow?
8. How do planets compare with each other?
9. How much would you weigh on another planet?
10. What else can we find out about the planets?
11. How does planet Earth appear from space?
12. What are asteroids?

For each topic the teacher *will use those problems that best serve the needs and interests of her group*. The problems should also be selected so as to develop adequately the basic concepts stated in the introduction to the topic. The teacher should feel free to extend the investigation of the topic along lines suggested by the children.

Following each problem in the handbook is a list of understandings which the children may be expected to gain. *It is important that the understandings be formulated by the children on the basis of their experiences and be expressed in their own words. It is not intended that all children or all classes will arrive at all of these understandings, or be limited solely to these.*

In summary: When we approach science as an exploration, we invite each child to make his own contribution to this unique enterprise, and to share in the learnings of all.

SCIENCE AS PROCESS AND AS KNOWLEDGE

"Science means various things to different people. Many accept it as an organized body of content to be studied from a science textbook. Some think of it as a new kind of magic. Others consider it to be an absolute authority.

"An increasing number believe it is something to be feared. Comparatively few recognize science for what it is — an enterprise created, designed, and managed by human beings. . . . We must make every effort to help our young people understand science in this light. To do this we must keep in mind the two basic components of science.

"One component has to do with science as a way of investigating the world of nature. . . . But science is more than a way of finding out. It is what the scientist finds out, not only the method. It is the tested knowledge of our environment that has come from using the methods. . . . At the pinnacle of this knowledge, however, are the grand ideas that have been forged in the creative, informed minds of scientists. . . . Both process and product are inextricably involved in the scientific enterprise. Both represent human activity. . . .

"As teachers we properly refer to the process part of science teaching as problem-solving. In order to teach science as problem-solving, we must get children involved in the process. They must be encouraged to ask questions; but more important we must help them develop the ability to ask thoughtful questions. Children must be encouraged also to speculate about answers to their questions. . . .

"We cannot give children the science ideas which they are supposed to understand. Each child 'catches,' or comes to understand, an idea on his own. Our job is to set the stage for this to happen and guide the process once it is under way."*

The material in this handbook is designed to combine the two components of science, process and knowledge. For example, the observation and measurement by children of the angle made by the entering and departing beam of light with a mirror (process) leads them to the generalization that when a beam of light is reflected, the angle of strike equals the angle at which it bounces off (knowledge).

The understandings listed at the end of each problem in this handbook, and the broader concepts found in the introduction to each topic, represent *knowledge* that should flow from the children's investigations. Interwoven in the development of each problem and implicit in the question which triggers each problem is the *process*.

Following are some of the processes in science investigations. The listing given here is not intended to suggest the order in which the investigation is to proceed. Nor is it essential that all of these be included in any one investigation. *And we should keep in mind that while children are discovering, they should be finding out something which, for one reason or another, they want and need to know.*

1. *Asking Questions.* This handbook is designed to encourage the asking of questions. The posing of a question is an invitation to children to engage in a scientific enterprise. Of course, the most significant questions are those which children ask. See *The Role of Questions* on page 7 for further discussion of this topic.

2. *Experimenting.* An experiment is a way of finding out; it is not an end in itself. In an experiment the materials are carefully selected and the conditions are carefully arranged. This is different from an *experience* in which the materials and events are observed in the

* J. Darrell Barnard, "What Is Science?" *Elementary School Science Bulletin*, No. 63 (Sept. 1961).

natural world. An experiment is a technique through which man tries to discover nature's secrets.

For example, if children are investigating why we use yeast in bread-making, they may prepare a yeast dough, place it in a warm place, and observe the dough rise. To establish that the yeast actually caused this action, they must prepare, as a control, a similar dough, *without yeast,* and observe its behavior under identical conditions.

Children should be encouraged to devise their own experiments. It will be helpful for the teacher to ask frequently, "How can we find out . . . ?" Indeed, the children's involvement in planning an experiment is just as important as the doing of the experiment. They should plan, if possible, to test a single factor at a time.

For example, if they wish to find out whether cans are coated with tin to prevent iron from rusting, they will scratch some cans down to the underlying iron, and leave other cans unscratched. They will then plan to keep both sets of cans under moist conditions, and observe them at regular intervals.

3. *Predicting.* Children should be encouraged to predict results, to propose explanations, and then to test them. Predicting results will help children focus their thinking on a problem. Checking results will help them evaluate their thinking. The process of predicting also adds excitement and a sense of "playing a game" to the learning of science. In the study of *Batteries and Bulbs,* children predict whether or not certain arrangements of batteries, wires, and bulbs will produce a working circuit; they predict whether certain circuits will make a bulb burn more brightly. They then experiment to test their predictions.

4. *Observing.* This involves making use of the senses to gather information. Children use their muscles and other parts of their bodies to make observations as they push, pull, put things together, and take things apart. The teacher encourages them to use all their senses when they investigate, and to report what their senses indicate. Sometimes they extend what they learn from their senses by using an instrument. A hand lens, for example, helps them see a tiny insect in greater detail.

5. *Interpreting.* This involves, for example, identifying the crystal, left after the evaporation of salt water. It includes identifying odors of familiar substances, and distinguishing and naming the end products

of combustion when a candle burns. It involves comparing size, textures, weights of common objects, and noticing changes in color, size, odor, state, shape, and position of different substances.

Children should be helped to distinguish between an observation and an interpretation. For example, in *Oceans and Climate,* children place a dish of water and a dish of soil outside on a cold day. They read and record the temperature of each at regular intervals. Their *observations* will be the temperature recorded on the thermometer; for example:

soil — 70 degrees; 67; 64; 60
water — 70 degrees; 69; 67; 67

Their *interpretation* will be that soil loses heat more rapidly than water.

6. *Measuring.* Observation may include measurement. Rough measurements come first, and then instruments are used to refine these measurements. Children have always used mirrors to reflect beams of sunlight. They know that by holding the mirror in different positions they can change the position of the spot of reflected light. By turning their attention to the angle of the incoming and outgoing rays, they begin to understand the relationship of the two.

7. *Keeping Records.* Records are kept in many ways: in written words, maps, photographs, tape recordings, numbers, drawings, graphs, and in collections of objects. When children gather data and look at it, they begin to understand that many examples make generalizations more valid.

   For example, in the study of *Little Environments,* children make a large map of the school yard and keep it in view for a period of time. They enter on the map its physical condition (fences, drains, cracks) and plants and animals which are observed during the period of the study. Similarly, in the same study, in this case of the soil, each child makes an intensive study of a square yard of the area and reports on the animals observed. A map is made of the total area studied by the class, and animals seen in this area are drawn or recorded in some other way.

   Gathering data, of course, is not enough. It has little value unless the data are examined and interpreted.

8. *Classifying.* This involves collecting and organizing objects or information. It may mean separating objects to find likenesses or differ-

ences. It involves comparing things and grouping them. Children should be guided to an awareness of the reasons for classifying objects: to simplify, to discover underlying or basic similarities and differences. Children should be encouraged to classify objects for their own reasons, and to use their own basis for classification.

Children compare relative sizes of earth, moon, and sun by drawing circles on the chalkboard. They compare the distance of the sun with nearby stars by using the *light year* as a basis for measuring the immense distances involved.

9. *Generalizing.* At the end of each problem in the handbook, there are some of the understandings or generalizations that children may suggest. These are based on their observations, experiences, and experiments. Throughout the work in science, children should be encouraged to generalize in their own words. This will make the process of forming generalizations one which involves careful, critical thinking.

THE ROLE OF QUESTIONS IN TEACHING SCIENCE

Good questions are the keys to good teaching in all curriculum areas. In science, questions have a special role since they are the starting point for children's investigations. In spirit, this is essentially the way in which scientists initiate research. Questions give purpose and direction to activity. Therefore, the science program outlined in this handbook is developed through problems that are posed as questions.

Children ask questions naturally. An important goal in science teaching is to encourage and cultivate this questioning attitude. *Children should feel that school is the place to ask questions, that their questions are important, and that questions often trigger exciting explorations.* The teacher helps set the stage by arranging for situations which provoke questions. By the kinds of questions he asks, the teacher also serves as a model for the children as they develop and improve their skill in questioning.

Answers are found in a variety of ways. Occasionally, the teacher, a book, or other children may provide answers. However, answers become more meaningful when children find them in the course of their own investigations.

Questions serve many purposes. Some useful question starters are:

"What would happen if . . . ?"
"How can we find out . . . ?"
"How could you be sure that . . . ?"
"How can we (do) . . . ?"
"How many ways can we (do) . . . ?"
"Where could we find . . . ?"
"What happened . . . ?"

And let us not forget to ask children, "What questions do you have?" and to counter children's questions frequently by asking, "What do you think?"

Children should come to understand that there are many questions for which there are still no answers. We are uncertain about the cause of the earth's magnetism. We do not know whether life exists on Mars although before the next edition of this handbook appears, we may have the answers. As children go on with their science studies, they will understand that all answers in science are man-made, hence subject to error and subject to change. There is no final and absolute authority in science. This does not, however, deny the importance of the principles and theories which scientists construct to explain phenomena. But most significant principles and theories in science lead to the discovery of new principles and theories.

The significance for the teacher of this approach to science "answers" is that children's ideas and proposals should be considered, and that the teacher need not become *the* authority or a spokesman for *the* authority. Rather, science in the classroom should be an adventure in which children and the teacher participate. Children should come to regard science as an endless quest rather than a finite body of information.

Following are some typical questions related to the work in *Science: Grade 5,* grouped to indicate their special character.

Questions which draw on children's experiences

Why is baking powder used for cake-making?

How do tools help our muscles?

What was yesterday's weather like?

Questions which lead to trips and surveys

Can we see a planet in the sky?

Is the school yard level?

What plants grow under a tree?

Is the temperature of the water in the pond higher or lower than that of the air?

Questions which lead to close observation

How does a mirror change the direction of a beam of light?

Does the amount of air in a jar affect the burning of a candle in it?

Do planets appear to move in one night?

Questions which provoke experimentation

Why do we coat cans with tin?

Why is yeast used in bread-making?

Why does the latitude of a place affect its climate?

How can you separate a mixture of salt and sand?

Questions which help children group and classify

How does the winter climate of coastal cities compare with that of inland cities of the same latitude?

How do the planets compare with each other?

What kinds of organisms live in the soil?

Questions which lead to measurement and collecting of data

How does this month's weather in New York City compare with that of other cities?

How much difference does the slant of the rays of sunlight make in the amount of heat received?

How does the temperature of the pavement in a sunny spot compare with that in a shady spot?

How much does a mirror change the direction of a beam of light?

Questions which challenge children to propose ways of finding out

How can we get fresh water from salt water?

How can you separate a mixture of salt and sand?

What happens to a substance when it is burned?

Does the amount of air in a jar affect the burning of a candle in it?

How can you connect two bulbs in a circuit?

Questions which ask children to predict

What would happen if we continued boiling a pan of salt water until all of the water evaporated?

What will happen to a burning candle in jars of different sizes?

What would happen to the bulb if we hooked up two batteries in the circuit?

Questions which challenge children to propose explanations

Why do the earthworms come out of the soil after a rain?

How did weeds get on the school lawn?

How do planets get their light?

THE ROLE OF THE EXPERIMENT

The classic way through which man tries to discover nature's secrets is by experimenting. When children experiment, they are intrigued by the elements of surprise and discovery that are a part of such investigations. They begin to develop patterns of thinking and working which are characteristic of scientists. In the context of science teaching, we differentiate *experience* from *experiment*. Experiences may include the child's observing goldfish in an aquarium, examining a rough surface with a magnifying glass, or identifying a planet in the night sky. An experiment, on the other hand, is usually a cooperatively developed enterprise (teacher and children) with appropriate materials set up for the purpose of finding the answer to a particular problem.

The significance of the experiment is that it helps to find something out rather than to prove something. *Its character is more "Let's find out whether . . ." than "Let's prove that. . . ."* The teacher sets the stage by providing situations which stimulate children to raise problems. In a real experiment, there should be some doubt about the outcome in the investigator's mind. The experimenter may consider a certain outcome to be most probable but he is unsure of it.

Although an experiment is conducted to solve a problem, every research scientist has had the experience of finding new problems during his experimentation. In their experiments, pupils also will open up many new lines of thinking; as they attack one problem, additional problems will be disclosed. Where feasible, therefore, the program of experimentation may be extended to include some of these new problems.

Guidelines for Experimentation

1. *The Setting*

The setting is provided by situations which may develop from asking the "trigger" questions in the science handbook, from children's individual experiences, from class trips, from provocative materials, from previous experiments. All of these may result in problems or questions. For example, after children "play" freely with a battery, two bulbs, and wires, they find that there are a number of different ways of making the bulbs light. Later they experiment to discover which way makes the bulb burn more brightly.

2. *Getting into Action*

The children should be given an opportunity to design the experiment and to decide on and gather the appropriate materials. Depending on the availability of the materials, physical conditions, and safety considerations, the experiment should be performed by pupils individually, by groups working together, or by one group in the class. It is important that children have opportunities to manipulate the materials and to work at their own pace. Before proceeding with the experiment, the children should understand how the experiment is related to the problem to be solved.

3. *Making It Scientific*

Wherever possible, use a *control*. This is simply a method of providing a basis for accurate comparison. When children try to find out why yeast is used in bread-making, they make one dough with yeast and one without. They set both jars in a warm place and compare them after several hours.

Test only *one* variable at a time. For example, when children experiment to find out whether the amount of air in a jar affects the burning of a candle in it, the only variable is the *size of the jar*. The candles should be identical in size. If, on the other hand, the children wish to find out whether a fat candle "uses up" air more quickly than a thin candle, then the size of the jars they burn in should be identical. In this way, they can arrive at a conclusion that has validity.

Take advantage of the fact that you have a number of children who may perform the same experiment. It may be found that variations in the results that children get are due to differences in the *techniques* used, variations in *observational skills,* differences in ability to *report* their observations, or differences in the *materials* being used (the use of a weak dry cell as compared to the use of a fresh dry cell). Discuss these variations with the children; do not avoid them. This is the heart of science! As one scientist said, "Cherish your exceptions."

Results of experiments should be recorded, reported, and summed up to help the children gain the most understanding from the experiments. The greater the number of experiments and observations, the greater the possibility of arriving at a basic explanation or generalization.

4. *When the Experiment Does Not "Work"*

In a sense, every experiment "works," that is, what happens is a result of natural influences. For example, when children experiment with two dry cells connected in series, they may find that the bulb does not light at all. *This is not a failure; it is an opportunity.* For here is a *real* problem — not one predetermined by the teacher. Asking the children how to solve this *real* problem leads to the highest level of experimentation because children are actually cast in the role of scientists. Something *is* working here — but not what is expected. Perhaps the bulb was blown out by the extra voltage. Perhaps one of the dry cells is "dead." Encourage the children to suggest why the experiment is working the way it does and to test their theories. Since, during a school year, many of the investigations suggested in the handbook will lead to situations in which something appears not to "work," it is essential that the teacher capitalize on these opportunities for involving children in science learning.

MATERIALS FOR ELEMENTARY SCIENCE

For effective learning of science, children must have as many first-hand experiences with real materials as possible. To assist you in planning this, the handbook includes lists of materials that are necessary for each unit in Grade 5. In general, the lists are based on the assumption that children will work in groups of four, although there will be many occasions when the teacher may depart from this arrangement. The E-1 *Science Supply List* and the G-1 *General Supply List* contain the items which may be ordered at requisition time (usually in the fall).

Sources

In addition to the standard type of science materials provided by the school, such as magnets, magnifying glasses, and thermometers, the teacher has many other sources to draw from. These include materials found in the classroom such as the window pole, paper, paper clips, drinking straws, and empty milk cartons.

Much of the equipment normally found in the kindergarten, such as blocks, paints, and toys, are useful for science teaching in Grade 5. Children can contribute science materials such as empty spools, leaves, pebbles, plastic containers, and shoeboxes. The local hardware, variety, and pet stores are sources of science materials. Other sources of science materials are museums, the ASPCA, botanical gardens, zoos.

Since we continually emphasize conservation, children should be made aware of the need to discriminate when collecting science material outdoors. Whereas removing a fallen leaf from beneath a tree does no harm, leaves ripped from branches may injure a tree. Specimens on private property are not to be collected. Small wild creatures, taken briefly to the classroom, should be housed and fed properly and eventually returned to the environment from which they had been removed. Children in early grades should be accompanied by an adult on any field trip.

Storage

It has been found that no one method of storage will be convenient for everyone. Shoeboxes or other containers may hold many materials for a particular unit such as the one on electricity. This may be part of the permanent equipment for your room. Expensive equipment should be stored centrally and be available, on order, to classroom teachers. Schools may order cabinets containing tote trays for the storage of science equipment. Each school will select a method that best meets its needs.

Safety

The bulletin *For Greater Safety in Science Teaching* is in all schools and should be consulted. The following rules apply particularly to the teaching of science in the elementary schools.

1. Materials must be safe for children. For example, plastic containers instead of glass containers should be used when possible.

2. Pupils are to be under the direct supervision of a teacher at all times.
3. Devices or equipment brought in by a child should be pretested before use with the children.
4. Cautions in handling potentially dangerous materials, even if the teacher is demonstrating them, should be discussed. The science principles involved in safety should also be discussed. For example, water and sand should be available whenever we are working with fire.
5. Wherever possible, the safety application of science principles should be taught. In the study of wheels and ball bearings, for example, a basis is developed for understanding the hazards of leaving round things on floors and stairs.
6. House current (110 volts) is NOT to be used. Only dry cells (1½ volts) are to be used for experiments with electricity.
7. Children are NOT to carry laboratory equipment or apparatus through the halls when classes are moving about.
8. Children are NOT to taste chemicals or other materials. The only exceptions are foods purchased and handled under sanitary conditions.

SCIENCE AND THE READING PROGRAM

Children are fascinated by explorations in science, and this interest may be utilized in many ways to improve reading ability. The teacher can guide children in the use of newspapers, magazines, and books to satisfy their curiosity, and to enjoy the excitement of adventuring in science. In the early school years, youngsters become familiar with the elements of their environment which they can see, hear, feel, smell, taste, and touch. They add to their speaking and reading vocabularies the names of these elements and the words which describe impressions made by them: hot, cold, wet, dry; loud, soft; high, low; rough, smooth. From year to year, as new experiences introduce new science words, their speaking, reading, and writing abilities grow rapidly. For example, when planning a garden, children consult planting instructions to find out how to sow and care for their plants. They become familiar with the names of many common seeds, vegetables, flowers, and gardening tools. Educationally disadvantaged children and those to whom English is a second language increase their English vocabulary as they learn words describing concrete objects and their use in science experiences.

Making Experience Charts, Oral and Written Reports, Graphs

Pupils are encouraged to describe in their own words what they want to investigate through their experiments, what they propose to do and to use, what they observe, and what they learn. The teacher may print an experience chart as the children dictate the story of each experiment. Once a child grasps the significance of such a statement it will not take long before he can read the words of which the statement is composed. Gradually, he will gain the ability to write and read his own reports, thus further strengthening both science and reading skills.

Step by step, as children pursue their simple investigations, they are taught to prepare, read, and interpret charts, tables, and graphs which show the results of such measurements as weight, time, temperature, rainfall, and sunspot number.

Preparing Exhibits

In the preparation of hall and classroom displays, children practice the skills required in writing and reading titles, captions, labels, and descriptive text. Much of this work may require that pupils read and follow specific directions. Through all of these science activities, reading is needed and used.

Implementing Reading in Science

Children should be given an opportunity to select reading material. The teacher should make available a variety of suitable books and other references in anticipation of a topic that may be studied, or as a source of information after a question. In this way, children begin to develop the habit of using many sources; they begin to appreciate the role of references in research. Printed matter in elementary science mostly falls into the following groups: textbooks, trade books, reference books, magazines, and free materials.

Since New York City has its own well-defined curriculum in science, no single textbook provides the readings essential in our program. Texts are used as references, for supplementary reading, for useful illustrations, or for techniques. For this purpose children should have available the texts of different publishers and of different grade levels.

Trade books, with their great diversity of subject matter, reading levels, styles, and formats, are excellent aids to the teacher in meeting the needs of individual children. On pages 247-264, grouped according to science areas, is an annotated *Bibliography* for children of Grade 5.

Reference books, such as encyclopedias, should be available, if possible, in the classroom and in the school library. Children need help, of course, in using these references properly.

Many manufacturers print material that may contribute to science learnings in elementary schools. Their public relations departments are cooperative in sending supplementary material to the schools. The usefulness of each publication must be carefully assayed before making it available to the children.

AUDIO-VISUAL MATERIALS IN THE SCIENCE PROGRAM

Since a large variety of audio-visual materials is available in our schools, the teacher can utilize a multisensory approach in the development of science concepts. These materials also motivate learning and make it more pleasurable. Thus stimulated, the pupils become more curious and begin to investigate, read, explore, and experiment.

Some aids, such as the chalkboard, the felt board, and the bulletin board, appeal to sight. The chalkboard, particularly, is available to every teacher and has great potentialities. To illuminate an idea, a large clear sketch, in colored chalk if appropriate, is a fine teaching aid. The value of the chalkboard is enhanced if the teacher develops the drawing with the help of the children. The drawing grows as ideas grow, as children contribute to its lines and labels. The chalkboard makes it possible for all children in a group to center their attention on the same drawing while they discuss a problem. The pupils should be encouraged to use the chalkboard to explain and clarify their own ideas.

Motion pictures, filmstrips, and transparencies are used in various kinds of projectors found in the schools. Magazines and newspapers are good sources for pictures that may be hung in the classroom and viewed in greater detail by using the opaque projector. Charts and models that children make are often more meaningful than commercial ones.

Other aids appeal to hearing. These include radio, tape recordings, phonograph records, sound films, and filmstrips. They offer the teacher additional opportunities for meaningful science lessons.

Television is a valuable teaching aid and can do much toward furthering the objectives of science teaching. The teacher should consult the TV guides provided by the Board of Education, and plan to use television as an *integral part* of his science program.

A teacher occasionally may use audio-visual materials to introduce a new unit or topic. Such use serves to stimulate the interest and curiosity of the children and helps them formulate the problems they will try to solve. Audio-visual materials may be used during the exploration of a unit or topic to supply information needed, to reinforce knowledge or skills, to stimulate research, and to encourage follow-up activities. These aids may also be helpful at the end of a unit to provide a review or as part of a unit's culmination.

Audio-visual aids in science are primarily for instruction. Films and filmstrips are most effective when they can contribute specifically to the topic which is being studied. It is most important that they be within the understanding of children of the grade and age level. It is not necessary that filmstrips be shown in their entirety; only those frames that are pertinent to the unit need be used. Projectors should be tested ahead of time to make sure that they are in working order.

If the children are adequately prepared for the material to be presented, and are stimulated to be active participants, the learning is more effective. There should be ample opportunity for language training, oral and written. Children should be prepared for the new words anticipated by the teacher.

A follow-up program reinforces the knowledge and skills learned from the film, filmstrip, or other audio-visual material. This may take the form of creative writing, art work, trips to zoos and museums, making collections, reading in science books, and making reports.

A list of films and filmstrips appropriate for the science topics in Grade 5 will be found in pages 228-246 of this handbook.

USING NEIGHBORHOOD RESOURCES

New York City is a wonderful laboratory for the study of natural science. Within the five boroughs such places as an ocean front, a bay, a waterfall, a river, and a swamp may be explored. Almost any neighborhood has a valley, a vacant lot, rocks, soil, plants, and animals. The school building itself with its natural and man-made stone reveals how man uses some of nature's resources. The schoolyard, exposed as it is to the sun, wind, and rain, is an exciting place for observing the forces of nature at work. The trees on the street announce the changing seasons. The street becomes a "rainshed area" and the gutter a "river bed" whenever it rains. Sparrows, gulls, squirrels, and insects are among the wildlife that may be observed. A host of others abounds in nearby parks and beaches. The city's surface reveals its past; its rivers, lakes, rocks, and stones bear evidence of the glaciers which advanced over it until some 25,000 years ago. Placed as it is on the great Atlantic flyway, one of four main paths taken by migrating birds, New York City is a stopover for many of them.

In keeping with the principle that science for children should be rooted in firsthand experiences in the real world, neighborhood trips form an essential part of the science program. In this real world children see *real* buildings going up, *real* machines at work, *real* changes in the seasons, *real* sun and clouds, *real* hills and valleys.

The following guidelines for trips are suggested:

1. There should be a good reason for making the trip, and children should know the reason.

2. There should be planning for safety, transportation, time schedule, collecting, note-taking, permissions.

3. The teacher should make a preliminary trip to determine the suitability of the place to be studied.

4. There should be group discussions about conduct and courtesy on the trip.

5. There may be some division of specific responsibilities for observing, collecting, and other simple duties.

6. Do not hurry children. A second trip to the same locale is often essential.

7. Follow-up after the trip may include discussion, displays, and reports.

Many trips are suggested in this handbook, particularly in the section *Little Environments*. The Curriculum Report *Operation New York* gives fuller descriptions of walks which may be taken to explore neighborhood resources.

THE SCHOOL GARDEN IN THE SCIENCE PROGRAM

The school garden is an outdoor classroom for science education. Here children can observe living plants in a natural environment of soil, sunlight, air, and water. It is a laboratory where children discover what plants need in order to grow, how plants change as they grow, how long it takes different plants to mature, how plants grow under different conditions, what happens when plants are too crowded, how plants change as the seasons change.

For city children especially, the school garden is a place for many surprises and delights. Foods such as beans and peas, which may have been seen only from a can or a frozen-food package, are now seen growing and ripening on living plants. A salad made in the classroom from radishes and lettuce freshly harvested by children from their own garden is a rare treat. Carrots, turnips, Swiss chard, spinach, and peanuts are some of the other food plants which are easily grown in school gardens. There may be a harvest of the spring planting in June or of the summer planting in September. Not to be ignored are the exotic aromas and rich colors of garden flowers.

As children work with garden tools, they learn about their proper use and care. They find out about the value of the hoe in breaking lumps of soil, of the rake for removing pebbles and stones and for smoothing the soil, of the sprinkling can (younger children) or hose (older children) for watering it.

Areas other than science are enriched by gardening experiences. One of the most valuable experiences is that which leads to improved interpersonal relationships. Recognition and understanding of a fellow planter's needs and desires grow as a gardening project develops. The school garden is also a laboratory in language arts, providing as it does a common basis for interchange of ideas, for discussion and writing of plans, and for recording the observations that follow. Some mathematics is used in planning and laying out the rows and measuring the growth of plants.

The school garden is a place where children observe the forces of nature at work. A downpour of rain makes gullies and washes away some of the precious topsoil; a drought dries the soil, makes it dusty, and causes the plants to wilt and droop. Children note that plants in the sunny part of the garden grow differently from those in the part which has less sunlight.

The school garden is a great teacher. Here children learn the dependence of man on plant and animal life and on the relation of this life to air, sun, soil, and water. And when children see that what *they* do makes a difference, they have learned one of the prime concepts of conservation.

EVALUATION

Evaluation is an integral part of the learning process. It starts when teaching starts and goes on long after a lesson or unit is completed. "Success" is revealed to the teacher by many signs. It may be simply the gleams in children's eyes or the smiles on their faces. In early childhood, it may be the painting and blockbuilding that children engage in following a science experience. It may be children's capacity to put a science principle to work in a new situation. It may be the number and kinds of questions that children ask. It may be their answers to such questions as, "What are we trying to find out?" or "What did we learn?" It may be their skill in manipulating materials, or their involvement in long-range projects. It may be what children do after they leave the school building: hobbies they pursue, games they play, books they read, radio and television programs they select.

Science is both knowledge and process. It consists of *knowledge* in the form of facts and principles; it consists of the *process* employed by scientists: hypothesizing, experimenting, and generalizing. Science teaching is concerned with both of these characteristics. We are concerned, for example, with a child's knowing *that* a planet appears in different parts of the sky with the passage of time and with his knowing *how to find out* that it does. It follows that our evaluation of science teaching must take both of these facets into account. Since it is difficult to conduct tests for the *processes* of science, it is necessary for the teacher to employ other methods of evaluation, as indicated in the foregoing paragraph.

At the end of each topic in Grade 5, there is a section entitled *Evaluative Activities*. Teachers may use these questions and activities as models, selecting appropriate ones and adapting others. *The answers which are provided are typical and suggestive; the teacher should expect and accept other words and other ideas as well.* The illustrations suggest how questions and answers may be adapted for children with language difficulties.

It should be emphasized again that evaluation takes place all the time, not merely at the completion of a topic. *Evaluation serves as a sensitive instrument to guide the process of learning, moment by moment.* This handbook is designed to foster evaluation as a built-in characteristic of teaching and learning.

Some significant objectives and goals of the science curriculum are:

Objectives	**Goals**
Can children:	*Are children:*
1. set up experiments	1. increasing their interest in science
2. state the problem	2. increasing their awareness of their environment
3. suggest ways to solve a problem	3. reading science periodicals and books
4. manipulate materials	4. engaging in science activities on their own
5. record data	5. developing keener observation
6. interpret data	6. seeking answers to their own questions
7. generalize from the results of an experiment	7. distinguishing fact from fancy
8. state new concepts	8. beginning to expect order and predictability in relation to natural phenomena?
9. apply these concepts?	

For the purposes of evaluation, *objectives,* as used in the preceding, may be defined as the short-term and limited aims of a single topic or portion of the curriculum. *Goals* are here defined as the long-term and broad-scope aims of the entire science curriculum.

PLANNING FOR YOUR YEAR IN SCIENCE

Many teachers have asked for suggestions in planning their year in science. There can be no *one* way of scheduling that will apply to all teachers and children, since the placement, depth, and duration of any science topic depends on many variables: on pupil interest, maturity, experiential background, language difficulties, on unexpected and unusual happenings. Thus an eclipse of the sun or the moon will certainly influence the scheduling of the Grade 5 study of *The Sun's Family.*

There are, however, certain constants which the teacher can depend on in planning science: the logical sequence of science concepts, the sequence of themes which have been planned in other curriculum areas, the changing seasons, holidays, and other special days.

The sample schedules shown here reflect some of the constant factors which enter long-range planning. The teacher may use these as a guide, but should design her own so as to include the variable factors that enter into her own situation. Note that a topic may be taught in its entirety, without a break, or that it may be subdivided into several subtopics to be taught at different times during the school year. It should also be noted that science lessons may occur without formal scheduling.

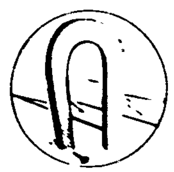
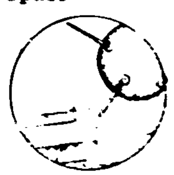
To summarize, the science schedule planned for the year should be structured to serve as a useful framework, but flexible enough to meet the special needs of children, and to make the most of the unexpected and the unusual.

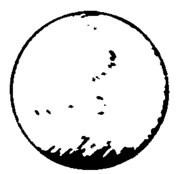
SAMPLE SCIENCE SCHEDULE

GRADE V	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
How Man Changes Materials	X	X								
Little Environments		X	X							X
The Sun's Family			X	X	X					
Climate					X	X				
Mirrors and the Reflection of Light						X	X			
Making It Go							X	X		
Batteries and Bulbs								X	X	

*SEQUENCE OF SCIENCE TOPICS IN PREKINDERGARTEN, KINDERGARTEN, GRADES 1, 2, 3, 4, AND 5

The following table indicates the specific topics which are developed in the Prekindergarten, Kindergarten, Grades 1, 2, 3, 4, and 5 in seven areas of science

Area	*Prekindergarten*	*Kinder-garten*	*Page*	*Grade 1*	*Page*	*Grade 2*	*Page*	*Grade 3*	*Page*	*Grade 4*	*Page*	*Grade 5*	*Page*
Magnetism and Electricity 		A Magnet Holds On	80			Magnets	196	Electricity in Everyday Life	27	Finding Direction with a Compass	157	Batteries and Bulbs	189
Earth in Space 		Spaces and Places Light and Dark	28 71			Sunlight and Shadows	187	The Earth and the Sun	41	Our Nearest Neighbor in Space: The Moon	174	The Sun's Family	77
Living Things 	Science in Food Moving Your Body All Kinds of Pets	What's Alive? Discovering With Our Senses Seeds and Fruits Discovering with a Magnifying Glass	32 38 54 44	Animals and Plants in Our Neighborhood	135	Animals and Plants in the Classroom	171	The Needs of Plants and Animals	54	Getting New Plants	194	Little Environments	50

Sound and Light in Communication 		Sounds Around Us		Making Sounds	149			How Sounds Are Made	75	Sounds Travel: Sounds Can Be Recorded	206	Mirrors and the Reflection of Light	138
Weather 	All Kinds of Weather			Weather from Day to Day	106			Observing and Measuring Weather Changes	91	Weather and Climate from Season to Season	225	Climate and Weather	106
Motion and Force in Transportation 	Science in Wheels Science in Block-building	Uphill and Downhill Seesaws and Balances	48 95	Moving on Land and Water	156	Moving in the Air	236	Friction, Gravity, and Motion	115	Moving Things More Easily	225	Making It Go	158
Earth and Its Resources 	Science in a Sandbox Science in a Pan of Water	Heat Changes Foods Getting Wet and Drying Water Mixes with Foods After It Falls Blowing Soap Bubbles	59 75 84 90 100			Water, Soil, Rocks, and Air	211	Rocks and How We Use Them	134	The Water We Use	277	How Man Changes Materials	26

* Pages indicated for topics in Kindergarten, Grades 1, and 2 refer to *Science: Grades K-2;* for topics in Grades 3 and 4 to *Science: Grades 3-4.*

How Man Changes Materials

A. SEPARATING SUBSTANCES

Background for the Teacher

Man's control of his environment has depended on his ability to use the substances around him and to create new ones. When primitive man smashed a rock and chipped a fragment of it into a serviceable spearhead, he was fashioning a tool which extended his arms and his legs and his hands to give him new power over his environment. Later when he learned how to heat sand with limestone and ash to make glass, he created a new substance, one which was destined to have many uses.

The first of these two examples, the making of a spearhead, we may think of as a *physical change*. The shape and the size of the rock were altered, but not the makeup of its molecules. On the other hand, in the making of glass, molecules were altered and a new substance produced. This is a *chemical change*.

In the topic *Separating Substances* we are concerned with physical changes only. *Filtering* or *straining* separates materials of different sizes because only smaller particles can pass through the openings in the filter or strainer. When a mixture of sand and salt is put into water, the sand sinks to the bottom and the salt dissolves in the water. The process of *dissolving*, then, is a way of separating substances. When a salt solution is heated, the water boils off but the salt remains. *Evaporation*, in this case, is the method of separation. To extract starch from a potato we begin by grating it, but we also use filtering and evaporating in the starch extraction process. When, however, we test the starch with iodine and obtain a blue-black color, we are making use of a chemical change to identify a substance. Other chemical changes will be considered in *Topic B*.

Approaches and Learnings for the Child

Children are challenged to invent procedures for separating various substances and to try out their "inventions" for obtaining fresh water from sea water, and clean water from muddy water; for extracting starch from a potato; for separating a mixture of salt and sand into its components.

From the activities suggested, children learn:

Fresh water may be obtained from salt water by the processes of evaporation and condensation.

When water evaporates from a saltwater solution, the salt remains.

Filters and strainers separate particles of different sizes by allowing the smaller particles to go through and by holding back the larger particles.

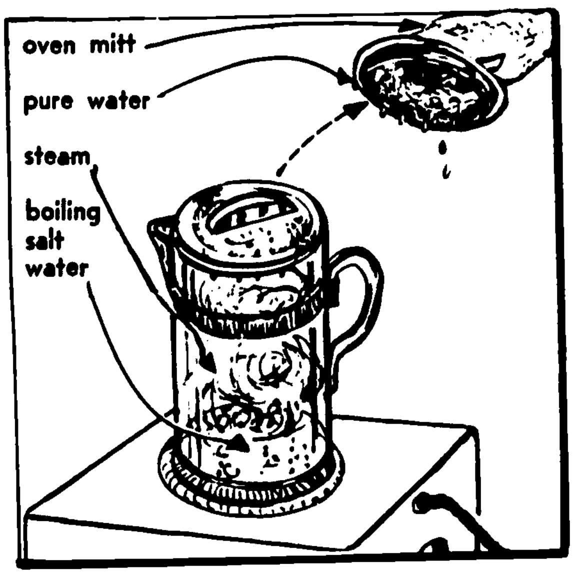
Solids which do not dissolve can be separated from liquids by using a filter or strainer.

Some liquids which do not mix with each other can be separated by allowing them to stand.

1. How can we get fresh water from salt water?

Discuss water shortages around the world. Why are we turning to the oceans as a source of water?

Ask children to suggest a procedure for extracting fresh water from salt water. Have class evaluate and possibly try some of the suggested methods.



Heat speeds the evaporation of pure water from salt water.

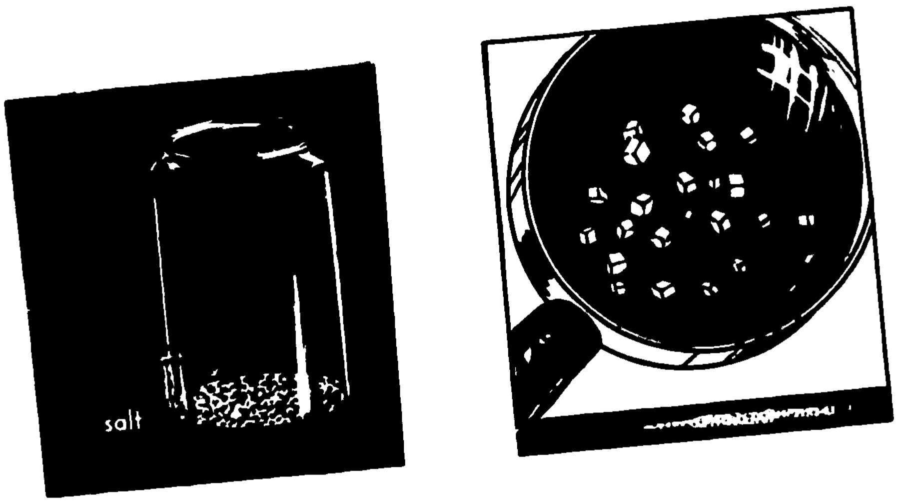
One way is to use heat. Boil sea water. (Artificial sea water may be made by stirring 1½ level teaspoonfuls of salt into a glass of water.) Use a hot plate and a Pyrex coffeepot and cover if available. An enamel or Pyrex saucepan with a metal lid or heavy earthenware plate to put over the steam when the water is boiling may also be used. (Leave a small opening so that pressure does not build up under the cover. Take care that the steam does not reach your hand.) Remove pot from heat after water has boiled a minute or two. Have children observe the drops that form on the lid. Try to collect some by allowing them to run into a spoon. Have one child taste the evaporated liquid. Does it taste salty? (No.) Compare with the water in the pot after it cools.

Many areas of the earth suffer from a shortage of fresh water. One of the ways being considered for obtaining fresh water is to extract it from sea water. The chief problem has been to obtain an economical source of heat for this purpose. Have children investigate other ways of obtaining fresh water from salt water. Some may experiment with the use of sunlight to provide the heat for evaporation.

- *Fresh water can be extracted from salt water by heating it and then cooling the steam.*

2. How can we get salt from salt water?

What would happen if we were to continue boiling salt water until all of the water evaporates? Children may predict that salt will remain in the dish. Try boiling salt water and see if this occurs, but avoid scorching the saucepan or the salt. Allow the water to boil down but do not allow all the water to evaporate. Instead, pour the remaining water into a number of clean flat dishes, such as saucers or plastic con-



Salt remains when ocean water evaporates.

tainers. Allow to evaporate slowly, or hasten the process by placing the containers in sunshine or over a radiator.

What happens? Children will observe white crystals form in the dish; on tasting, these are found to be salt. Look at the salt with a magnifying glass to observe the cube-shaped crystals.

Most salt is mined from the earth. However, in some tropical areas, sea water is trapped in long shallow ponds near the coast and allowed to evaporate. In this way salt is obtained. Ocean salt is made up of not one but a number of chemical compounds. The principal one is table salt, sodium chloride, which accounts for 78% of the salts in sea water. Magnesium chloride and magnesium sulfate are some of the other salts in sea water.

- *When water evaporates from salt water, the salt remains.*
- *Salt forms cube-shaped crystals.*

3. How does evaporation help to separate different substances?

In the two previous problems, children have seen how evaporation separates salt from water. The purpose in one case was to obtain fresh water; in the other, to obtain salt.

The word *solution* should be introduced here: it is the name given to the liquid and the material dissolved in it. (The material dissolved in the liquid is known as the *solute;* the liquid in which the solute is dissolved is called the *solvent.*)

To obtain fresh water from salt water, it was first necessary to heat the water, evaporate it, cool the resulting water vapor, and condense it. The water obtained in this way is called distilled water; the entire process is known as *distillation*.

The material that does *not* evaporate, (or does not evaporate easily) is left behind as the liquid evaporates. Instead of being scattered in the liquid, it is now *concentrated*. To see this happen quickly, place a few drops of tincture of iodine on a plate or on a glass (microscope) slide and allow it to evaporate. In this case the evaporating liquid is *alcohol;* the substance which remains is the chemical element iodine. When the alcohol has evaporated, look for iodine *crystals* with a magnifying glass, microscope, or microprojector (bioscope).

As a substitute for tincture of iodine, food coloring or Easter egg dye may be used, dissolved in half a glassful of hot water. When the dye has been completely dissolved, pour the solution into a shallow bowl, saucer, or pie plate. Leave it undisturbed for several days. Children will observe that as the water evaporates the coloring material is left behind on the sides and bottom of the dish. Evaporation has separated the water from the dye.

Try dissolving in water other substances, such as sugar and Epsom salt which children may suggest, and then use evaporation to recover the dissolved material.

- *Evaporation helps separate a liquid from the material dissolved in it.*
- *Evaporation helps separate substances when one substance evaporates and the other does not.*

4. How do we get powdered milk?

Have children taste some powdered milk in dry form. Dissolve the powdered milk in water, pour some into paper cups, and give to children to taste. Ask children to describe the difference in taste before and after water was added. How does the taste of dissolved powdered milk compare with the taste of "fresh" milk?

Direct children to read the label on a box of powdered milk. They will learn that powdered milk is milk with almost all of the water removed. Some children may want to research how this is done. They will find that the water in milk is removed by evaporation (not boiled) until the milk is very thick and almost dry. This thickened milk is then sprayed into a chamber through which are blown blasts of hot air. The hot air does the final drying; the milk is now in its final dry state. Sometimes the fat in milk is removed and then the powdered milk is called fat-free milk. Ask children to find out how other foods are dried or powdered.

- *Powdered milk is milk with its water removed.*
- *The water is removed by heating fresh milk.*
- *Liquid milk can be made from dry milk by adding water to milk powder.*
- *Milk is mostly water.*

5. How can you separate a mixture of sand and salt?

Have children mix a level teaspoonful of salt with a level teaspoonful of sand, and place the mixture in an aluminum pie plate. Ask them for suggestions on how to separate the sand from the salt. *(This is an excellent opportunity for encouraging creative thinking.)* List all suggestions on the chalkboard and assign groups of children to try them. Some children may suggest picking out each grain of sand with a toothpick and pushing it out of the pile; others may say to blow carefully on the mixture so the lighter salt grains will be moved more easily; and some may say to pour the mixture through a fine strainer, one which allows the salt to fall through but not the sand. (A salt cellar might do the job.)

Another suggestion may be to dump the mixture into a glass of water and stir. This will cause the salt to dissolve, but the sand will fall to the bottom of the glass. If the water is poured carefully into a second glass, the sand will remain in the first. Is the job finished? No, because the *sand* is now wet with salty water, and the *salt* is now mixed with another substance (water). How can we complete the job of separating the original ingredients and getting each back? Children will probably suggest that, in order to obtain any salt that may have been left on the sand, we add some fresh water to the sand, stir, and then pour the water into a dish to evaporate. The sand can then be spread in another dish to dry. With respect to the salt mixed with water, have the children recall and use the method for obtaining salt from water which is described in Problem 2.

Whichever method is used, ask the children to save all the sand and salt that are left. If the work is done carefully, they should have approximately the same amount of salt and sand that they started with. If they do not, ask them to offer an explanation. It is important for them to understand that none of the sand or salt is destroyed, although some may be lost, because this is an instance of the *Law of Conservation of Matter* which states that the amount that comes out of a mixture equals the amount that went into it.

- *We can separate a mixture of sand and salt in a number of different ways: picking out grains of sand, straining the dry mixture, blowing the dry mixture, dissolving the salt.*

  Note: Add others that children may have discovered.

- *The amount of each part of the mixture we end up with equals the amount we started with.*

6. How can we clean muddy water?

Ask children to suggest ways in which to clean muddy water. List all the suggestions on a large oaktag or the chalkboard, and have children try them.

Note: This problem is also included in Grade 4, *The Water We Use.* However, this method is different:

Line a kitchen strainer with a piece of clean cloth or paper toweling. Pour muddy water into the strainer and allow it to drip into a glass. Compare the color of the water coming through the strainer with the muddy water. Observe the materials stopped by the filter. This kind of separation is called filtration. Explain the fact that the filter helps separate the *solids* (soil particles) from the *liquid* (the water). Discuss the use of filters in some coffee makers, in fish tanks, and by druggists and chemists.

- *Solids can be separated from liquids by using a filter.*
- *A filter has tiny openings which allow the liquid, but not solid particles, to go through.*

7. How can we separate oil from water?

Pour 1/4 cup of oil, such as peanut or mineral oil, into a jar. Add 1/2 cup of water, cover the jar, and shake. Ask children to predict what will happen if the mixture stands for awhile, and have them record their predictions. As children observe the mixture, they will note that the oil rises to the top of the water. Why? They may suggest that oil is lighter than water.

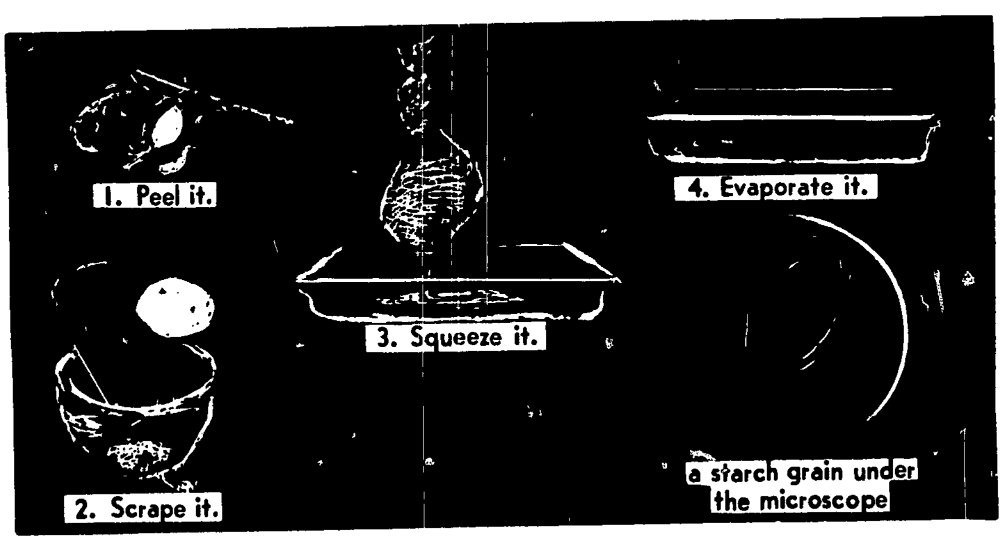
How can the oil be separated from the water? Children will probably suggest pouring off the oil into another container, thus leaving only the water in the jar.

- *Two liquids that do not mix well can sometimes be separated by allowing them to stand and then pouring off one.*
- *Oil is lighter than water.*

8. How can we get starch from a potato?

Discuss with children the fact that one of the important food substances in a potato is starch. Potato starch is sold in dry form in markets. How can we obtain starch from a potato? The method which follows uses two of the separation techniques which children have used in the preceding problems, namely, filtration and evaporation, and a new one known as grating.

Peel and wash a potato. Then grate it into a bowl. Squeeze the gratings through cheesecloth. In a flat dish, evaporate the liquid that passes



Obtaining starch from a potato.

through the cheesecloth. Potato starch is the dry material which remains in the dish. (The mass left in the cheesecloth contains the gluten from the potato.)

Add a drop of iodine to a small amount of the potato starch. The starch will turn a blue-black color. This color change is used as a test to determine the presence of starch. Some children may wish to test other foods for the presence of starch. If a microscope is available, place a bit of starch in a little water on a glass slide, and examine it. Find starch grains.

- *Starch can be separated from a potato by straining and by evaporation.*

- *Iodine turns starch a blue-black color.*

EVALUATIVE ACTIVITIES

1. How would you separate a large amount of coal into lumps of *three* different sizes? (A number of answers is possible. One way is the following: First use a sifter with larger holes which holds back only the large lumps. Then use a sifter with smaller holes to separate the rest.)
2. If a pot of salt water is heated, the evaporated vapor coming from it

   a. is pure water. b. is pure salt. c. is salt water. (Answer: a.)
3. Complete the following statement.

   Salt water is poured through a paper-towel filter. The water coming through is salty because . . . (The salt particles in the water are small enough to go through the tiny holes in the paper.)
4. A teaspoonful of salt is dissolved in a cup of water. The water is then heated until it evaporates entirely. How much salt will be left in the cup? (One teaspoonful.)
5. A solution of salt water is poured into two pots. One pot is heated for 10 minutes, one for 20 minutes. Which will taste saltier? (The one boiled for 20 minutes.) Why? (More water has evaporated.)
6. Challenge students to "invent" a solar evaporator which would use the heat of sunlight to evaporate fresh water from salt water, and which would then condense the water vapor into water.

B. CHEMICAL CHANGES

Background for the Teacher

In a chemical change the *molecules* of substances are altered. (A molecule is the *smallest* particle of a substance that has the properties of that substance.) As a result new substances are formed. The souring of milk, the action of yeast on dough, the rusting of iron, the burning of a candle, are all chemical changes.

Consider, for example, the burning of a candle. The common candle has two kinds of atoms in each of its molecules, carbon (C) and hydrogen (H). When the candle burns, the carbon atoms of the candle combine with the oxygen atoms of the air to form carbon dioxide, while the hydrogen atoms combine with oxygen atoms to form water. To express this in chemical symbols:

$$C + O_2 = CO_2$$

$$2H + O = H_2O$$

Both the carbon dioxide and the water escape invisibly into the air.

Note: The soot that is formed on the bottom of an object heated by a candle is composed of *unburned* carbon atoms, that is, carbon atoms that have not combined with oxygen atoms.

What the preceding two equations do *not* show is that, in the process of combining carbon and hydrogen atoms with oxygen (oxidation), energy is released in the form of heat and light.

The fact that the candle is finally "used up" might lead one to conclude that in burning there is destruction of matter. This is not so. *Every atom is accounted for.* Every carbon and hydrogen atom is now part of a new substance — in a different place and in a different state — but *not one atom* has been destroyed.

In rusting, iron undergoes a chemical change. The new substance produced is rust. The chemist calls it *iron oxide.* Iron atoms in a nail join with oxygen atoms in the air to form molecules of iron oxide, rust. Rusting, like burning, releases energy in the form of heat, but this happens so slowly that the increase in temperature is small (but still measurable).

In the making of bread, chemical changes play an important role. Living yeast (one-celled plants) acts on the sugar in dough to produce carbon dioxide and alcohol. The atoms in the sugar molecule, carbon, oxygen, and hydrogen, are "juggled" to produce alcohol and carbon dioxide molecules. The carbon dioxide "blows up" the dough, making the bread light and spongy. The small amount of alcohol produced evaporates in the baking.

Approaches and Learnings for the Child

Opportunities are provided for introducing children to the nature of chemical change. They make cheese from milk, and vinegar from apple juice; they observe the action of yeast on dough and of bleach on colors; they make invisible ink; they make charcoal from wood and detect the products from a burning candle.

From the activities suggested, children learn:

Tiny living things, such as bacteria, yeasts, and molds, make changes in foods.

The action of bacteria on milk sugar causes souring.

Certain yeasts change sugar into alcohol and carbon dioxide.

Certain bacteria change alcohol into vinegar.

Carbon dioxide gas is made when baking powder is mixed with water.

Household bleach releases oxygen which combines with a dye and changes it.

Rust forms when iron combines with oxygen.

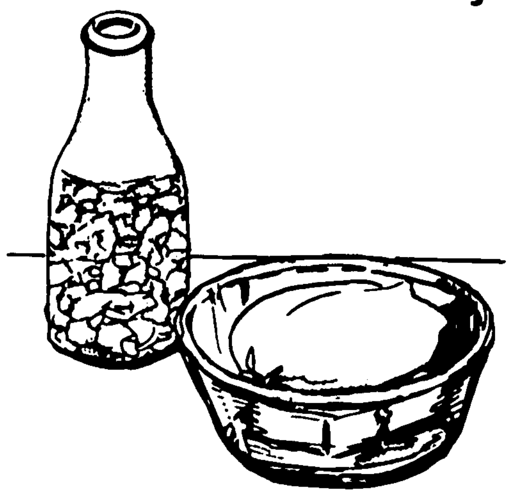
Fuel, sufficient air, and heat are needed for burning.

When a candle burns, water and carbon dioxide are produced.

Fires are prevented or put out by removing the fuel, cutting off the air supply, or lowering the temperature.

When a different substance is made, a chemical change occurs.

1. How can we make cottage cheese?



Making cheese from milk.

Cheese-making is one of man's oldest ways for preserving milk. In various parts of the world, cheese is made from the mil' of cows, goats, mares, camels, llamas, reindeer, buffaloes and other animals.

Children can easily make a palatable cheese from cow's milk. Allow a container of fresh milk to stand at room temperature until it sours and forms curds naturally. The souring of milk is due to the action of certain harmless bacteria on the sugar in milk. The sugar is changed to acid. When there is enough acid, the milk curdles: it separates into a liquid called whey and little chunks called curds. (Curd contains a protein called casein, much of the mineral salts, and the butter fat of the milk.) Next, add salt and separate the curd from the whey by pouring off as much of the whey as possible. Then tightly wrap the salted curd in muslin or cheesecloth. Allow the remaining liquid to drip out. The result is cottage cheese.

Introduce the idea of *chemical change*. In the previous topic *Separating Substances*, nothing really *new* was made; substances were separated from each other by evaporation, filtration, and other methods. In the making of cheese a number of chemical changes occur, that is, new substances are made. One of these is the making of an acid from the sugar in milk. This is the process which makes milk sour. The idea of *chemical change* will be reinforced in the problems which are developed in this topic.

Have a cheese party. Serve different kinds of cheese on crackers to the class. Find out how different cheeses are made.

It is interesting to note that the basis of cheese—the curd of milk—may be aged by adding, for varying periods of time, different molds and bacteria which give it particular flavors.

- *Cheese-making is one of man's oldest ways of preserving milk.*
- *Cheese is made from curdled milk.*
- *When enough acid is in milk, it curdles.*

* *Sour milk is obtained through the action of bacteria on milk sugar, resulting in the formation of an acid. This is a chemical change.*

* *The action of molds and bacteria give cheeses their flavor. This is also a chemical change.*

2. How can we make vinegar?

Allow children to smell and taste several kinds of vinegar, such as apple, tarragon, and wine vinegars. Read labels, and consult recipe books to learn how to make vinegar.

Grind some apples in a meat grinder and press the juice out of them. Pour this juice into several containers. Store some of the apple juice in a warm place, and some in a cool place. Encourage children to observe changes in odor and color over a period of a few days. Compare the samples kept at different temperatures. (Changes will occur sooner in the samples that are kept in a warmer place.) The apple cider that is forming may bubble. A chemical change is taking place.

The *first* change that occurs is that the sugar in the original apple juice is changed to alcohol and carbon dioxide. (Carbon dioxide is the same gas that makes the bubbles in carbonated drinks.) This change is due to the action of *yeasts* that came from the skin of the apple or from the air. We say that the yeasts *fermented* the apple juice into hard cider. Have children sniff to detect the odor of alcohol and look carefully to see the bubbles, which are carbon dioxide gas.

The *second* change that occurs is that the alcohol is changed into vinegar. This is due to the action of *bacteria* which are in the juice. Children may notice a thick film forming on the top of the juice as it ferments. This film is full of vinegar bacteria. (It is called "mother of vinegar.")

In summary, two important changes have occurred.

Sugar was changed into alcohol and carbon dioxide.

Alcohol was changed into vinegar.

These are chemical changes; something new was produced. Have children try making vinegar with grapes and other fruits.

* *Yeasts change sugar into alcohol and carbon dioxide.*
* *Bacteria change alcohol into vinegar.*
* *Both of these are chemical changes.*

- *The changing of apple juice into cider and then into vinegar occurs more rapidly in a warm place than in a cool one.*

3. Why is yeast used in bread-making?

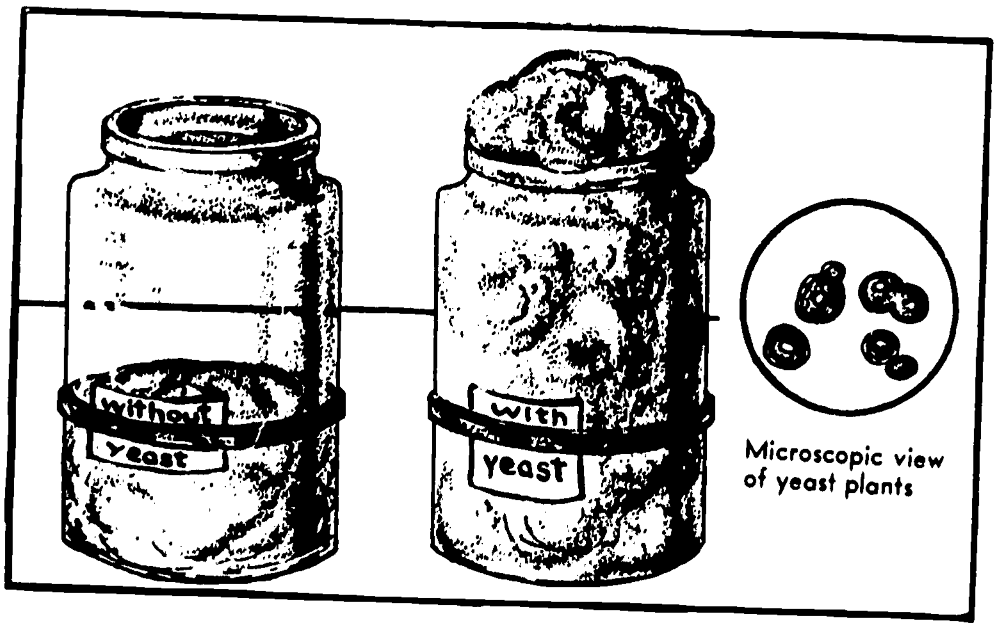
Find out what your pupils know about bread-making. Place a cupful of lukewarm water in a jar. Crumble yeast into it and stir in a spoonful of sugar. Stir in flour to make dough. Into a similar jar, place another mixture of the same ingredients minus the yeast. Mark both jars as shown in the illustration and set them in a warm place. Compare them after several hours.

Yeast consists of millions of tiny plants. As the yeast acts on the sugar, gas is given off which causes the dough to expand. This gas is carbon dioxide. (Alcohol is also produced, but it evaporates rapidly during break-making.) Baking expands the gas even more, making the bread "light," and causing the dough to become firm around each of the bubbles of gas.

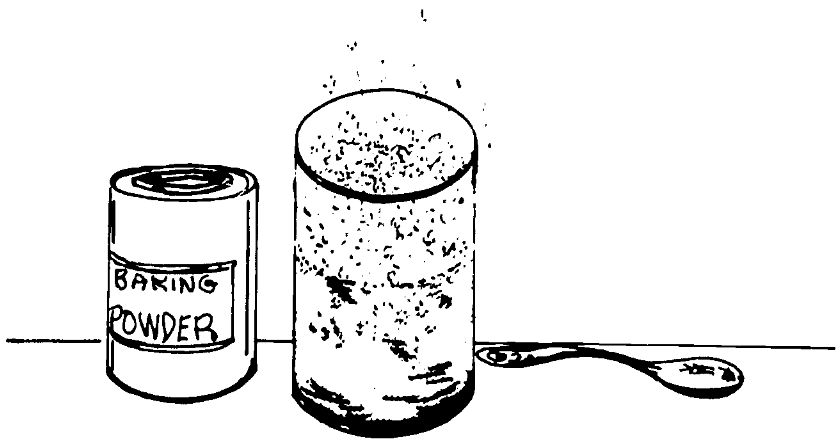
Experiment with yeast action at different temperatures (cold, warm, moderate). Compare the rising of the dough in each case.

Examine a drop of yeast in water, under the high power of the microscope, to see individual yeast plants.

- *Yeast is used to make bread rise.*
- *Yeast is a tiny plant.*
- *Yeast breaks sugar into alcohol and carbon dioxide. This is an example of a chemical change.*



Microscopic view of yeast plants



Baking powder and water produce bubbles of carbon dioxide gas.

4. Why is baking powder used for cake-making?

Baking powder gives off a gas that raises the dough as it bakes. To see this gas, drop a pinch of dry baking powder in a glass half filled with water. As soon as the baking powder dissolves, chemical activity begins. Small bubbles of carbon dioxide gas form. This is the same gas that forms bubbles in bottled sodas. In cake-making, the bubbles cannot escape from the dough and they blow it up into a sponge-like mass.

Water is one of the tools which a chemist uses to bring about chemical action. Baking powder is a mixture of dry chemicals which are inactive when dry. However, when these chemicals are dissolved in water, they react chemically with each other, producing new substances. One of these substances is carbon dioxide gas.

If there are suitable facilities available in the school, bake two cakes, one with and one without baking powder. Have the children compare the cakes for texture, size, firmness, and fluffiness.

- *Baking powder makes dough rise because of its chemical action.*
- *When baking powder is mixed with water, carbon dioxide is produced.*
- *Water helps bring about chemical action.*

5. What does household bleach do to some colored materials?

Mix a little liquid bleach, such as Clorox or Purex (sodium hypochlorite solution), with water. (Be careful that bleach is not spilled on any clothing.) Into a glassful of this mixture dip pieces of paper stained with blue and black ink, pieces of construction paper, and pieces of differently colored cotton cloth. Let the papers soak for a few minutes, and the colored cloths for a few hours. Have children observe what happens and have them record their observations.

The chemical in bleach releases oxygen which combines with the ink or dye to form another substance which is colorless. The color is changed because the chemical nature of the ink or dye is changed.

In summary, two important chemical changes occur in bleaching.

The bleach (sodium hypochlorite) releases oxygen.
The oxygen combines with the dye.

- *Bleach changes the color of some inks, dyes, and other colored substances.*
- *Bleach releases oxygen which combines with the dye and changes its color. This is a chemical change.*

6. How can we make invisible ink?

Two methods are suggested here.

a. Paper that does not contain any starch is needed for this experiment. If the paper does not turn blue-black when tested with tincture of iodine, it does not contain starch. Paper from a bag or newspaper will usually serve this purpose. Invisible ink can be prepared by thoroughly mixing a teaspoonful of starch in ½ cup of cold water. Write a message with a small paint brush dipped into the mixture and let it dry completely. To make the writing appear, place the paper in a flat dish or pan containing a solution of water and iodine (a few drops of iodine in ½ cup of water). Iodine turns starch (the invisible ink) blue-black.

b. Stir a tablespoonful of granulated sugar into ½ cup of water until it is completely dissolved. Dip a small paint brush into it and write a message on a piece of unglazed (non-shiny) paper. Let it dry. To make the ink visible, warm the paper by holding it with tongs over an electric oven, electric bulb, or other source of heat for a few moments. (Do not allow it to burn!) The sugar combines with oxygen in the air to form a new chemical which has a brown color. This method can also be done with milk, lemon juice, or vinegar.

- *Invisible ink can be made by using a chemical which is colorless when applied to the paper, but which turns color when something is done to the paper.*
- *Invisible ink becomes visible because a chemical change occurs in it.*

Making and using charcoal.

7. Where does charcoal come from?

Put some toothpicks in an aluminum pie plate and heat over a hot plate or other source of heat. Note what happens to the color of the wood as the heat increases. Note also the smoky gas coming from the heated wood. When the wood has turned black, turn the heat off. Remove the wood carefully and examine it.

Compare the color, shape, texture, and hardness of unheated and heated toothpicks. Heat causes the wood to change into another substance, charcoal. The chemist tells us that heat caused water (and some other chemicals) to leave the wood. These things went up in the smoke. The charcoal left in the plate was mostly black carbon. Heat produced a chemical change in the wood which resulted in the making of new chemicals.

Scientists believe that much of our coal was formed in a similar way. Millions of years ago the wood from trees was crushed by layers of earth. Heat and pressure slowly turned the wood into coal.

- *Charcoal is made by heating wood.*
- *Heat produces a chemical change in the wood.*
- *Millions of years of heat and pressure change plants into coal.*

8. Why do we coat cans with tin?

Encourage children to bring in clean, empty cans with smooth edges. Scratch some down to the underlying metal (iron). Leave others unscratched. Wrap all the cans in moist towels. Keep moist. Examine the cans every day. Note which cans rust, and where. Rust forms when oxygen in the air joins with iron to form an iron-oxygen chemical (iron oxide). Discuss the fact that this kind of change, which results in a new substance, is a chemical change. Discuss methods of preventing rusting, such as painting and oiling iron surfaces.

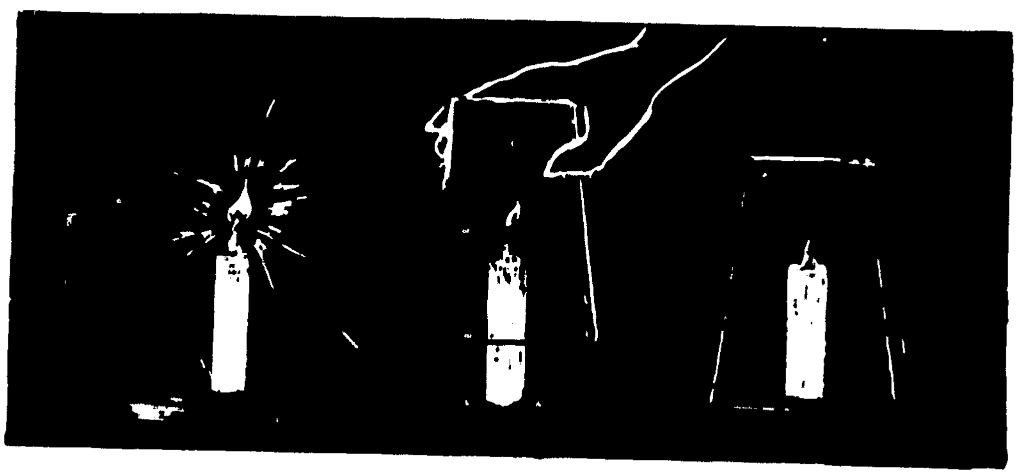
- *"Tin cans" are made of iron that is coated with tin.*
- *Tin keeps the oxygen of the air from reaching the iron in the cans. In this way, tin prevents rusting.*
- *Rust is formed by a chemical combination of iron and oxygen.*

9. What do we need for burning?

From children's own experiences, they will know that some kind of fuel is needed for burning. Show the children a candle. What else is needed? Children will say that the candle must be lighted. Another way of saying this is that enough heat must be supplied to start it burning. Light the candle. Is anything else needed for burning, something that is present but not seen?

Hold a glass over a burning candle until the light almost goes out; then raise the glass until the flame is strong again. Do this several times. Observe that a supply of fresh air is needed for burning. (The part of the air that supports burning is oxygen, which is about 20% of the air.)

Note: In any experiment involving burning, conduct the experiment on a nonflammable surface, such as an asbestos pad, or a metal sheet. Also have ready a supply of water, or sand, or both.



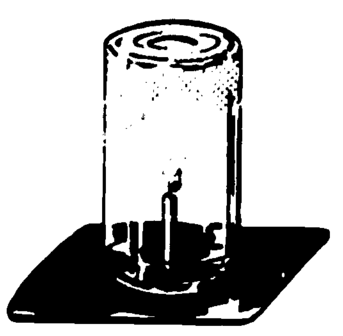
The flame goes out when the supply of fresh air is cut off.

Is burning a chemical change? Is anything different produced? These questions are answered in the next problem.

- *We need fuel, enough heat, and air to start a fire.*

10. Is burning a chemical change?

What happens when something burns? Encourage children to speculate on this. Of course, light and heat are produced. But what happens to the substance of the fuel — the candle, for example — when it is burned? Is it destroyed? Or is it changed into something else? How can we find out? One way is to try to "catch" everything that comes out of the burning candle.

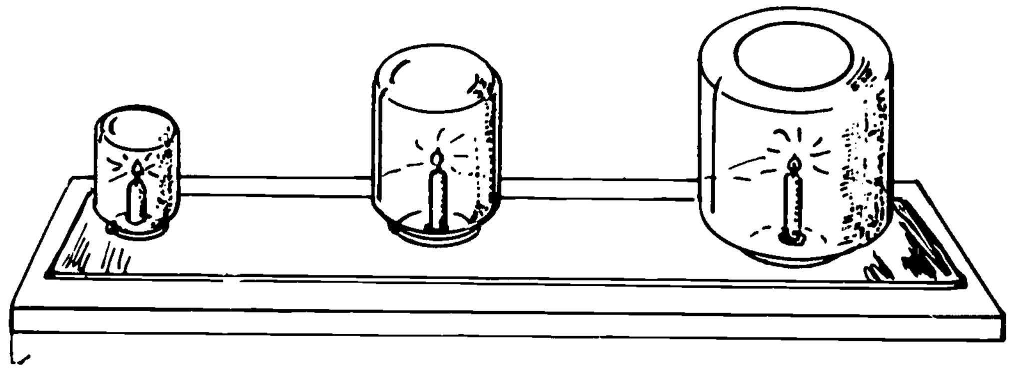


Water is produced when the candle burns.

Let us place a large *dry* jar over a candle. Children will note that as the candle burns, the glass fogs over. Remove the jar from the candle and have one child rub a finger over the inside of the jar. He will find that the fogging is due to moisture, water. Evidently, water is produced when a candle burns. Anything else? Hold a mirror or the bottom of a glass tumbler in the flame of a candle *for a few seconds*. Repeat a number of times. Children will observe that there is a black deposit on the glass. This is carbon (commonly called soot or lampblack). Evidently, as a candle burns, some carbon is produced. Anything else?

To find out, we would have to catch some of the invisible gas, which rises from the flame, and test it. Scientists have found that one of the gases made when a candle burns is carbon dioxide. To test for this gas, obtain some limewater from a druggist or other source. Use some candle drippings to stand a candle firmly upright in a saucer. Pour the limewater into the saucer and light the candle. Invert a wide-mouthed jar over the saucer and candle so that it rests on the table. Observe the surface of the limewater. A milky color indicates the presence of carbon dioxide.

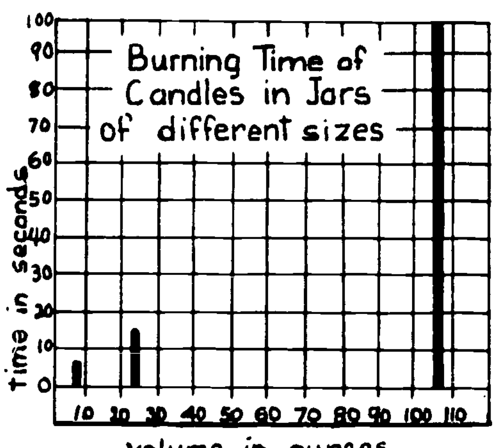
- *When a candle burns, water, carbon, and carbon dioxide are produced.*
- *Burning is a chemical change.*



Which candle will burn longest?

11. Does the amount of air in a jar affect the burning of a candle in it?

One way to find out is to use jars of different sizes. Use three jars — small, medium, and large. Ask children to predict what would happen to a burning candle confined in each of these jars. Ask for help in setting up the experiment. Something like the following may be tried.



Attach 3 candles of the same size by their own drippings to a flat pan or aluminum sheet. Light the candles. Three children invert the jars, one over each candle, at the same time. Each child announces when his candle goes out. A fourth child, equipped with a stopwatch or a wristwatch with a second hand, keeps a record of the burning time of each candle.

What is the relation of the amount of air to the burning time? (The more air, the longer the candle burns.)

How can we find out how much air is in each of the jars? One way is to fill each with water and then pour the water into a measuring cup. If the jars are perfect cylinders, their volume can be calculated by the formula: $v = \pi r^2h$, or volume = 22/7 times the radius of the jar squared, times the height of the jar. If the first method is used, the volume will be expressed in fluid ounces; if the second method is used, in cubic inches.

Have children make a graph to show the relationship of volume of air to burning time, as shown in the illustration.

- *The more air that is available, the longer a candle will burn before going out.*

12. How are fires put out?

What is needed to start a fire? Children will recall that to have a fire we need air, fuel, and heat. Then how can we put out a fire? (If any one of these three is removed, the fire should go out.)

a. *Removing air*

Cover a lighted candle with a drinking glass. The flame goes out because of the lack of fresh air. Other examples of removing air are stamping on a fire, throwing a blanket on it, or putting a lid on a pot in which the food has caught fire. *Some* kinds of fire extinguishers work by covering the fire with a layer of a nonflammable gas or foam which keeps the air away from the burning material.

b. *Cooling the fuel*

Pour water over a burning piece of paper in a metal pie plate. The water cools the paper (the fuel), and the flame goes out. The water in some fire extinguishers serves to cool the fuel below the temperature needed for burning. (To some extent, it also prevents air from reaching the fuel.)

c. *Removing the fuel*

Place several pieces of crumpled paper in a pie plate. Light one of them. How can we prevent the others from catching fire? One way is to remove them (or the burning piece) from the plate. Use tongs for this purpose.

Removing the fuel, or cooling it, will stop a fire.

Sometimes trained fire fighters will start a backfire to check a forest fire. In doing this, they are creating an area where the forest fire will be stopped because the fuel has already been burned. A *fire lane* in a forest is a place where trees have been permanently removed to *prevent* the spread of a fire. A fire lane also makes it possible for fire-fighting equipment and men to operate effectively.

Children should be cautioned *not* to experiment with fire. They should know that the first thing to do in case of fire is to call for help. Children should be cautioned never to attempt to put out an oil fire with water. Since the oil will float on the water, the water will *carry* the burning oil and spread the fire over a larger area.

Emphasize the need for preventing fires. Have students become familiar with these rules:

Don't play with fire.

Keep matches away from young children.

Use stoves and electrical devices properly.

- *To start a fire and keep it going, fuel, heat, and air are needed.*
- *Fires are prevented or put out by removing fuel, cutting off the supply of air, or lowering the temperature.*

EVALUATIVE ACTIVITIES

1. Which of the following are chemical changes?

   a. A pot of water is boiled until all the water evaporates into the air.

   b. Gravel is sifted to separate large pieces from smaller ones.

   c. Milk sours.

   d. An iron nail rusts.

   e. Sugar is stirred into a glassful of water.

   f. A lump of sugar is heated; it turns black and water bubbles out of it.

   g. In a mixture of oil and water, the oil rises to the top.

   h. A piece of wood burns.

   (Answer: c, d, f, h)

2. How would you set up an experiment to find out whether temperature makes a difference in the action of yeast on dough? (Add yeast to a dough mixture in two identical jars; place one in a cool place and one in a warm place. See what happens after a period of time; measure rate of "rise" of dough.)

3. A boy sets up an experiment, as shown in the diagram, using three candles of different sizes – small, medium, and large.

   a. What do you think he was trying to find out? (How long each kind of candle would burn; or, better, whether the size of the candle or the size of the flame makes a difference in how long it would burn in a confined space.)

   b. What do you think will happen?

      (The smallest candle will burn longest;
      the medium candle for a shorter time;
      the largest candle for the shortest time.)

   c. Why will this happen? (The faster a candle burns the more quickly the fresh air – or oxygen – is used up.)

BASIC SUPPLY LIST
FOR HOW MAN CHANGES MATERIALS

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

- * 1 hot plate
- 2 magnifying glasses
- 2 microscope slides
- * 1 microscope
- * 1 microprojector
- * 1 pkg. sand
- 1 large, plastic basin
- 5 candles
- 1 mirror
- 1 measuring cup

G-1: General Supply List

- 2 teaspoons
- * 1 pyrex saucepan
- 2 saucers
- * 1 tincture of iodine
- 2 glasses
- * newsprint
- 1 strainer
- * cheesecloth
- 1 flat dish
- 2 plastic containers
- * jars of assorted sizes
- * 1 pkg. unlined paper
- * blue ink
- * black ink
- * 1 pkg. construction paper
- * 1 pkg. graph paper
- * paper towels

Miscellaneous:

- * salt
- 1 pot holder
- 1 metal pot cover
- * 1 pkg. food coloring
- * sugar
- * Epsom salts
- * powdered milk
- * 1 box toothpicks
- * lemon juice
- 2 aluminum pie plates
- 3 small, empty juice cans
- * limewater
- * peanut oil
- * potatoes
- * assorted vinegars: apple, tarragon, wine
- * apples
- * 1 meat grinder
- * yeast
- * flour
- * baking powder
- * liquid bleach
- * starch
- * milk
- * pieces of colored cotton cloth

Little Environments

Background for the Teacher

New York City is a wonderful laboratory for the study of natural science. Within the five boroughs such places as an ocean front, a bay, a waterfall, a river, and a swamp may be explored. Almost any neighborhood has a hill, a valley, a vacant lot, rocks, soil, plants, and animals. The school building itself, with its natural and man-made stone, reveals how man uses some of nature's resources. The schoolyard, exposed as it is to sun, wind, and rain, is an exciting place for observing the forces of nature at work. The trees on the street announce the changing seasons. The street becomes a "rain-shed area" and the gutter a "river bed" whenever it rains. Sparrows, gulls, squirrels, and insects are among the wildlife that may be observed. A host of others abounds in nearby park and beach areas. The city's surface reveals its past; its rivers, lakes, rocks, and stones bear evidence of the glaciers which advanced over it until some 25,000 years ago. Placed as it is on the great Atlantic flyway, one of four main paths taken by migrating birds, New York City is a stopover for many of them.

One of the valuable outcomes in the study of natural and man-made resources in New York City should be the development of positive attitudes of conservation. Too often conservation is taught from books and without relationship to the lives of children. To develop meaningful concepts, it is essential that children be provided with enjoyable outdoor experiences with rocks, water, soil, plants, and animals. Through an understanding of and interest in these phenomena, children will want to preserve them. They will also see for themselves the harm that can come from neglect and carelessness.

A tree, a schoolyard, a lawn, the soil, a pond, are miniature environments. Although all of these settings can be found within the boundaries of New York City, they vary considerably in a number of ways — in their temperature, humidity, water, light, minerals, air, and in the plants and animals living in these settings. The environment under a tree is obviously different from that on the concrete surface of the schoolyard.

The physical characteristics of a particular environment — its temperature, light, and the other factors named in the preceding paragraph — influence the kind of plant and animal life that can live in that environment. Land plants generally need stiff stems to support them; aquatic plants often have more delicate stems and leaves which are supported by the water. A crack in the concrete of a schoolyard is a different environment from the rest of the pavement. Dust and soil may be blown or washed into the crack; rainwater may be held there after the rest of the yard has dried up. Grass or weed seeds blown there may germinate and thrive.

Living things influence the physical environment. A tree cools and humidifies the air around it; it intercepts the rays of sunlight and casts a shadow; its falling leaves and its roots change the soil under it.

Living things influence each other. Algae (small green plants, many of which live in ponds) manufacture their own food from the carbon dioxide and water in their environment, using sunlight as a source of energy for this process. The algae also serve as food for many pond animals, from microscopic protozoans to tadpoles. In turn, the algae-eating animals are eaten by other animals, such as crayfish and fish, in the pond.

This "who — eats — whom" relationship is called a *food chain.* The algae and other green plants are the *producers* in this chain. They are the organisms which manufacture sugars, starches, and other foods from the raw materials, water, carbon dioxide, and certain minerals. Animals such as the tadpoles that feed directly on the algae are the *primary consumers.* A water snake, which eats tadpoles, is a *secondary consumer.* Not all plants and animals are eaten by animals. Some die and decompose. The breaking down of the tissues of dead organisms (or of the wastes of living organisms) is the work of bacteria and fungi. They, also, are consumers, but because of their unique role in the food chain they are called *decomposers*. The decomposers help in the return of the minerals from dead organisms to the environment — water or land — where they again become available to the food producers.

Thus the food chain is an endless one: producer — consumer—decomposer—producer, and so on.

We have looked briefly at the relationships of plants and animals with each other and with their environment. This relationship is the content of the study known as *ecology*.

Approaches and Learnings for the Child

Five "little environments" have been suggested for investigation. The teacher will select those which are appropriate to the environment of the school, and those which may be reached on planned trips to nearby parks. Within each of the environments the activities most appropriate to the particular class should be selected for study.

It may be that an environment not given here may be chosen. A school may be near a river, an ocean beach, a wooded area, a stream, or other natural or man-made environment. These may be substituted for or added to those discussed here.

These questions may be helpful in exploring a "little environment."

1. What living things are found here? (Make a census of plants and animals.)
2. What kind of an environment is this? (Temperature, air, water, light, minerals, wind.)
3. What do living things require from their environment? (Minerals, warmth, light, moisture, air.)
4. What do living things require from each other? (Food, support, shelter.)
5. In what ways are the plants and animals adapted to their environment? (Water lilies have large leaves on the surface of the pond; fish have streamlined bodies for easy movement through the water.)
6. How do living things change the environment? (Earthworms aerate soil by making burrows in it; trees alter the surrounding temperature.)

7. How does man change the environment? (Plants trees, pollutes air.)
8. What food chains are found in this environment? (Owls eat field mice which eat grain.)

Many trips are possible in and near the school building, as well as longer trips farther afield. The methods used on trips include observing, measuring, collecting, interviewing, and discussing. Agreement should be reached in advance on how to do these things without violating the rights of others. Equipment such as the following may be useful on a trip: magnifying glass, knife (the teacher's), paper bags for specimens, ruler and tape measure, jars, net, string, pencil and notebook, compass, thermometer, and camera. The spirit of exploration of the teacher and the pupils is the most essential equipment needed for this work. In this connection the filmstrip *A Discovery Walk in Natural Science* is most useful in orienting pupils. One outcome of such an inventory may be the making of a map and guide to one or more of the "little environments" selected for investigation. Another outcome may be the development of a constructive attitude by children toward their own environment leading to a consideration of the question, "How might we maintain or improve it?"

A local project involving children, teachers, parents, and other interested individuals in the community may have as its objective the study of the neighborhood for such resources.

The children's use of library references for this enterprise is most essential. Many useful books will be found in the bibliography of this handbook. *Operation New York,* on file in each school, also has many relevant suggestions. Parks, zoos, museums, and nature centers may be helpful. Parents' and community organizations may be interested in developing and supporting a more extensive study of the local environment.

From the activities suggested, children learn:

Many kinds of plants and animals live in New York City.

Some of these are large; some are microscopic.

There are many "little environments" in New York City. Each kind of environment has its own conditions of heat, moisture, wind, light, minerals, air.

Each kind of environment has its own kinds of plants and animals.

Plants and animals depend on each other and their environment for food, warmth, shelter, air, and water.

Green plants are producers; animals are consumers; certain microscopic bacteria and fungi are decomposers.

Living things change the environment.

A. IN THE SCHOOLYARD

The schoolyard is thought of as a place in which to gather or to play rather than as a place in which to learn science. However, it has many qualities which make it suitable for this purpose. Pupils experience a novel change in viewpoint when using the schoolyard for science study.

The paved yard suggests an extreme form of environment. Generally it is, or is thought of, as hard, dry, level, barren of life, unchanging. If however, we go out into the schoolyard and look around with curiosity, we may find many examples of change, and even of life..

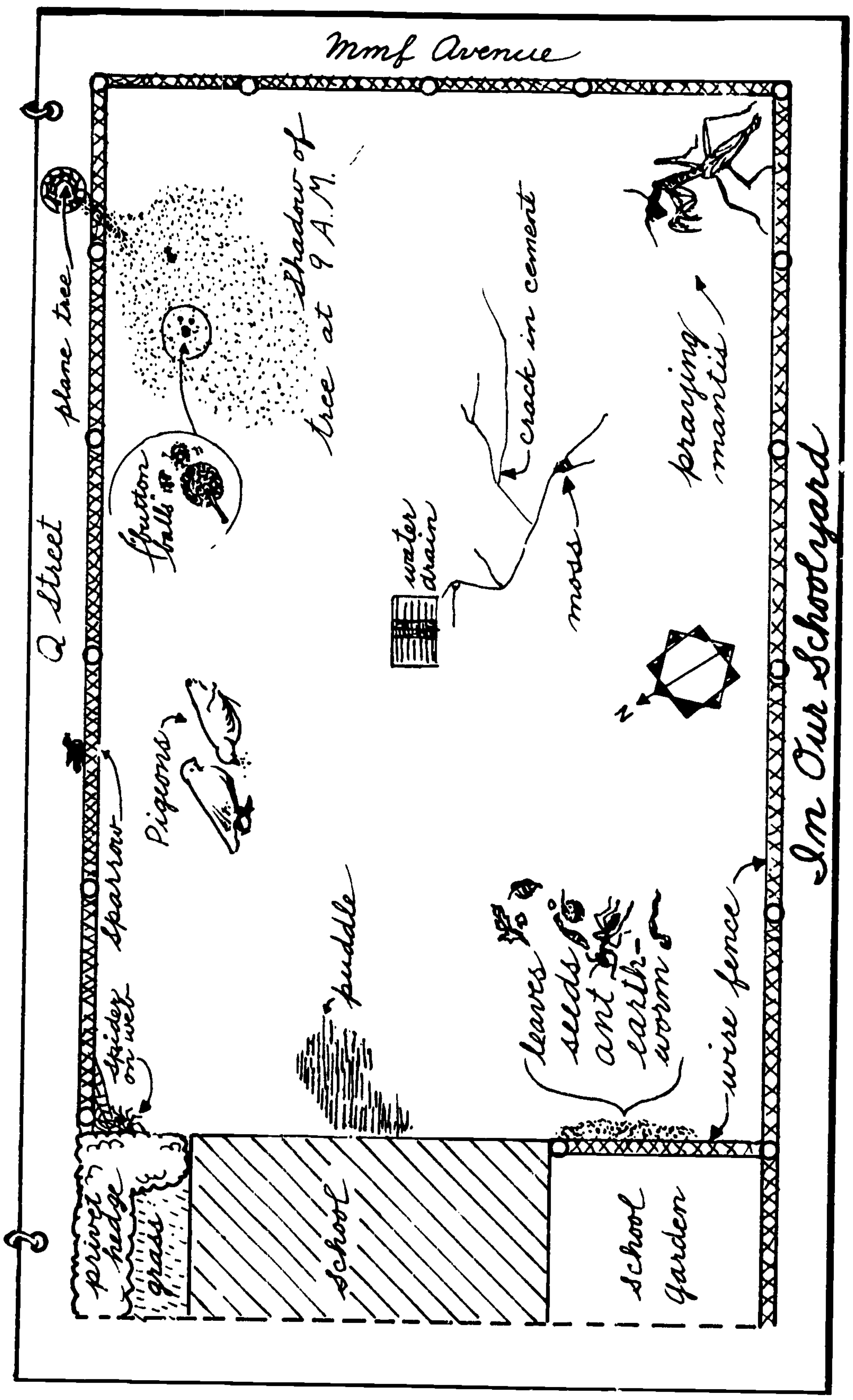
1. What are the physical conditions in the schoolyard?

   a. How does the part that is shaded compare with the part that is sunny? Use a thermometer to test the difference. *Note:* In taking the air temperature in a sunny area, shade the thermometer.

   Is the *air* temperature very different? (No.) Why not? (Air circulates and equalizes the temperature.) Which way is north? (Find north by using a compass or by the position of the sun in the sky.) If permitted, paint an arrow on the pavement showing north, and indicate the other directions, too.

   How about the temperature of the pavement itself? Place a thermometer on the part of the pavement that is in the sun, but shade the thermometer. Compare with the temperature in the shade. Is there any difference? (The pavement in the sun is warmer.)

   b. Are the wind direction and speed the same in all parts of the yard? Use a weather vane and a pinwheel or anemometer (See *Science: Grades 3 - 4)* to compare with wind direction and speed, respectively. Does proximity to a wall make any difference?


In Our Schoolyard
Mmf Avenue
Q Street
plane tree
Shadow of tree at 9 A.M.
button balls
Pigeons
Sparrow
Spider on web
privet hedge
grass
School
School garden
puddle
leaves
seeds
ant
earth-worm
wire fence
water drain
crack in cement
moss
praying mantis
N

c. Is the schoolyard level? Without using instruments, survey the surface of the schoolyard. It is often possible to see that certain sections are higher or lower than others. Notice, after a rain before all the water has dried up, where the puddles accumulate. (In the low places.) Look for rain drains that have been set in the yard. Does the water run down the drain as expected? If it does, the area around the drain is lower than nearby sections. Pour some water from a watering can or jar on different places in the yard. Which way does it run? If it spreads about equally in all directions, you may assume that these areas are level. If it runs off in one direction, you may assume that this section of the yard slants that way.

d. Do the differences in temperature, in light, in wind speed and direction, in moisture, and in any other conditions make a difference in the number and kinds of plants and animals seen in different parts of the yard? (The answer to this question will take a period of time. The following sections suggest some methods of study.)

2. What living things can we find in the schoolyard?

Ordinarily we think of the schoolyard as having living things in it only when pupils and teachers are there. There are, however, sure to be other living things at all times. It is interesting to look for them, find them, and explain how they got there.

a. Examine any cracks in the pavement of the schoolyard. You may find *moss* growing in some of them. Have the children notice the low, even growth of moss, and feel the velvet-like texture of its surface. Note that it just about fills the crack, and grows almost level with the surface of the pavement. You may also find, here and there in the cracks, *grass* and different kinds of *weeds*. The question then arises: How did they get there? Probably soil particles carried by the wind and water gradually accumulated in the cracks. Probably little specks (called *spores*) from moss plants were carried by the wind and fell or dropped into the soil between the cracks. Probably *seeds* from grass and weed plants were carried by the wind or water, and were caught in the cracks. The fact that plants like these are growing in the soil in the cracks suggests that seeds of plants are scattered everywhere, and that they grow when conditions are right. Probably seeds may be dropped from time to time all over the pavement, but since there is no soil there and nothing to hold moisture, they cannot germinate; therefore no plants grow on the bare pavement.

b. Look in the corners and along the edges of the schoolyard fence. You may see little piles of soil, leaves, seeds, and other debris which fell in the schoolyard and were carried by the wind to the edges and corners, where they were caught.

c. Look for little plants growing in these piles of material. You may find grass, weeds, or other small plants of many kinds, including seedling trees.

d. Early in the spring take some of this soil-like material (debris, soil, leaves), in which no plants are growing, into the schoolroom. Put it into a jar and moisten it. Keep it moist but not wet. Seeds that have been dormant in it, when given warmth and moisture, may germinate and develop into plants. See if little plants come up.

e. Let the children search for different types of animal life. They may find minute *insects* on the plants, or their *pupa cases* attached to plants, the fence, or building (look carefully on the underside of any cross bars or projections); *spiders,* or spider egg cases; or *ants* looking for food on the surface to take back to their homes in the soil. *Birds* may fly over or perch on the fence. Have children list and describe all the animals they find. Place spiders or other small forms of life in jars with soil, leaves, and twigs from the place where they were found. Try to keep them alive in the classroom for several days; then return them to their original environment or one like it.

3. Do any animals put in an appearance after a rain — *earthworms,* for example? Where did the animals come from? (Possibly nearby soil.) What made them come up? (Possibly there was too much water and not enough air in the soil for them.) Are any animals seen after a heavy windstorm — *caterpillars,* for example? Where did they come from? How did they get to the yard? (Possibly blown from nearby hedges or trees.)

4. Make a large map of the schoolyard and keep it in view for a time. Include on the map such features as fences, drains for water, hedges and trees, if any, prominent cracks, places where puddles form after a rain. On the map place drawings or cutouts of animals and plants which are observed during the period, such as grass, weeds, seeds and leaves, earthworms, caterpillars, sparrows, pigeons, ants, and

other visitors or residents in the yard. Mark north on the map. Indicate the area which is always in the shade.

- *Living things can be found in a schoolyard.*
- *Some forms of life in the schoolyard come from nearby soil, trees, bushes; some may be carried there by the wind.*
- *The light, temperature, wind, and moisture are not the same in different parts of the yard.*
- *The conditions in different parts of the schoolyard make a difference in the kinds of living things found in these parts.*

B. ON AND UNDER THE TREE

More than a million trees are growing along the streets in our five boroughs. Street trees are a particularly valuable resource for the city's children. They will enjoy observing the trees that grow in front of the school or in their neighborhood: how they change with the seasons, how each species can be recognized. They will learn why certain kinds of trees have been chosen for certain locations, what care they need, and what animals are associated with them. The filmstrip *Trees on Our Streets* provides an excellent orientation to this study.

1. "Adopt" a tree near the school. A good time to begin this is in September so that the children can see a complete seasonal cycle. Visit the tree regularly to watch its changes.

   What is the name of the tree? In congested areas, the tree will probably be one of the following:

   Norway Maple *(Acer platanoides):* Note leaf and winged seeds ("pollynoses").

   American Elm *(Ulmus americana):* Note leaf and shape of tree.

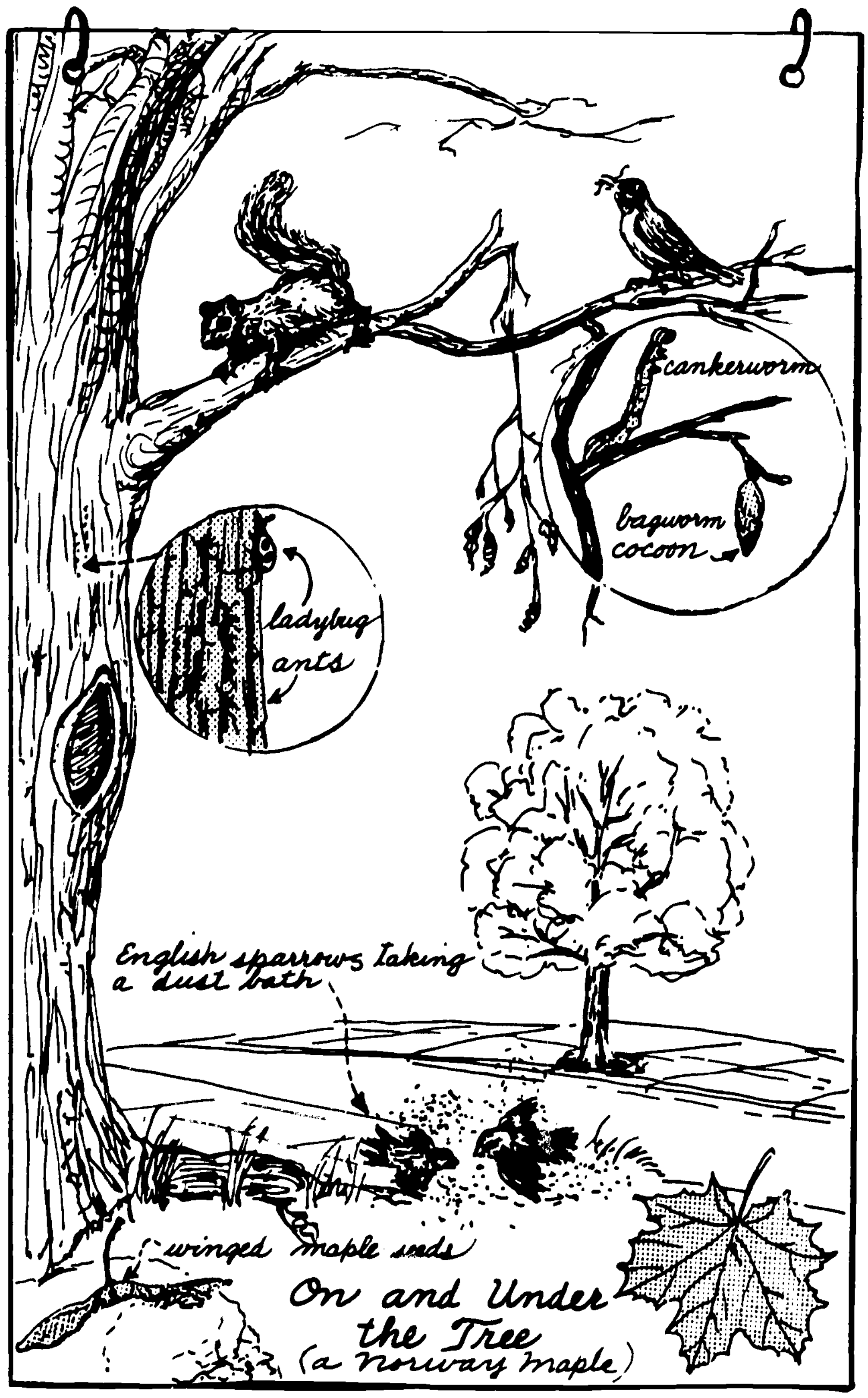
   Honey Locust *(Gleditsia triancanthos):* Note leaf and seed pod.

   Pin Oak *(Quercus palustrus):* Note leaf and acorn.

   London Plane. Tree *(Platanus acerifolia):* Note bark, leaf, seed-ball.

   Gingko *(Gingko biloba):* Note leaf.

   Do any insects feed on its leaves? What color are the leaves in autumn? When do the leaves fall? What happens to the leaves



cankerworm
bagworm cocoon
ladybug
ants
English sparrows taking a dust bath
winged maple seeds
On and Under the Tree
(a Norway maple)

that fall? When does the tree have seeds? What becomes of its seeds? Do birds roost in the tree? Do birds nest in the tree? Do any insects live in its bark? How is the tree affected by rain, snow, ice? When do the leaves come out? How much shade does it give? Compare the temperature of the air and soil under the tree with that in an unshaded area. (In taking the temperature in the sun, shade the thermometer.) To secure the soil temperature, place thermometer bulb into the soil, if possible. Is it cooler under the tree than beyond its shadow? How is the tree affected by lack of rain?

2. Look for signs of *animals* that may depend on the tree. Birds may be perching on its branches or searching for insects to eat; squirrels may be running among the branches (they may be on oaks, collecting acorns); insects may be feeding on its leaves or bark, pupating in crevices of the bark, or spending the winter in cocoons dangling from the branches; bees and other insects may be collecting nectar from the flowers and at the same time transferring the pollen that has caught on their bodies as they move from flower to flower; ants may be going up or down the trunk carrying food; spiders may have stretched their webs from one branch to another, trying to trap an insect to eat; aphids may be found on some trees.

   Make a large outline drawing of the tree being studied. On it, mount in appropriate places reproductions or drawings of animals observed from time to time.

3. What plants, if any, are growing *under the tree?* If no plants are present, relate this to the amount of shade and to the condition of the soil.

4. Relate the *shape* of the tree to its location. Few large trees can maintain their characteristic shapes on narrow streets. They grow toward the light, and become more or less one-sided, with few branches on the side which gets little light; low branches that would interfere with pedestrians or traffic have been pruned; higher branches may have been removed to avoid interference with buildings, overhead wires, or other trees.

5. Observe the condition of the *bark*. Has it been broken by cars or trucks or damaged by dogs? Bark is the protective layer; when it is injured, insects, bacteria, and fungi which cause diseases can attack the wood of the tree. Find spots where rot has gotten in. It may cause the death of the tree unless the wound is treated.

6. Look for old wounds that have been properly treated and are healing. On street trees this work is done by Park Department employees who have been trained to cut out the damaged part, smooth the surface, and cover the wound with special paint to protect the wood until the new bark and wood can grow over it. Find a wound which has been treated recently and one which has started to heal. Observe the ring of bark which gradually covers the wound.

7. Note the condition of the *branches*. Branches may have been broken by trucks, storms, or people swinging or climbing. Like any other break in the bark, these may admit insects and disease. Find examples where broken branches have been cut off and the wound has been treated; find other examples where rot has set in.

8. Note the condition of the *leaves*. Green, healthy leaves indicate plentiful moisture and minerals; curling or drooping leaves may mean the roots are not getting enough water. Have the children look at the soil under the tree. If it is hard-packed, it is not admitting water. Test by pushing a bottomless can one inch into the soil. Fill it with water. How long does it take the water to disappear into the soil? Classes that wish to improve the growing conditions of the trees *in front of their schools* can break up the top two inches of soil (going deeper might harm the roots) so that water can seep down to the roots. Test again with a bottomless can. This soil should be kept loose during the entire growing season. The children might also water the trees. Newly planted trees should have three pails of water twice a week, unless it rains. Older established trees might need as much as six pails twice a week during dry spells. When the tree has had enough water, puddles form and stay on the surface; adding more would force the air out of the soil and injure the roots. The Park Department does not allow us to water the trees with a hose, since the flow from a hose might wash the soil away from the roots.

   Some classes may want to compute how many quarts of water each pupil should carry to give the tree enough water for a week.

9. Is there any evidence that *air pollution* has affected the tree? Is it located near a bus stop? Do the fumes from buses seem to affect the trees? Compare with similar trees away from bus stops.

10. Consider *planting* a tree on the street in front of the school for Arbor Day. Write to the Park Department office in your borough to ask the cost of a tree, and how to apply for a permit.

11. Have the class make a survey of the neighborhood to locate streets on which trees are growing. Visit one or more of these streets to note the beauty and interest the trees add to it. On a hot, sunny day compare your feeling of comfort on such a street with any difference in your sensations on a street having no trees.

12. Look up the country of origin of the trees you are examining. (For further information and pictures of six species commonly planted in congested areas, see filmstrip *The Trees on Our Streets*. The filmstrip *Spring Flowers of New York City — Cultivated* also includes material on tree flowers.)

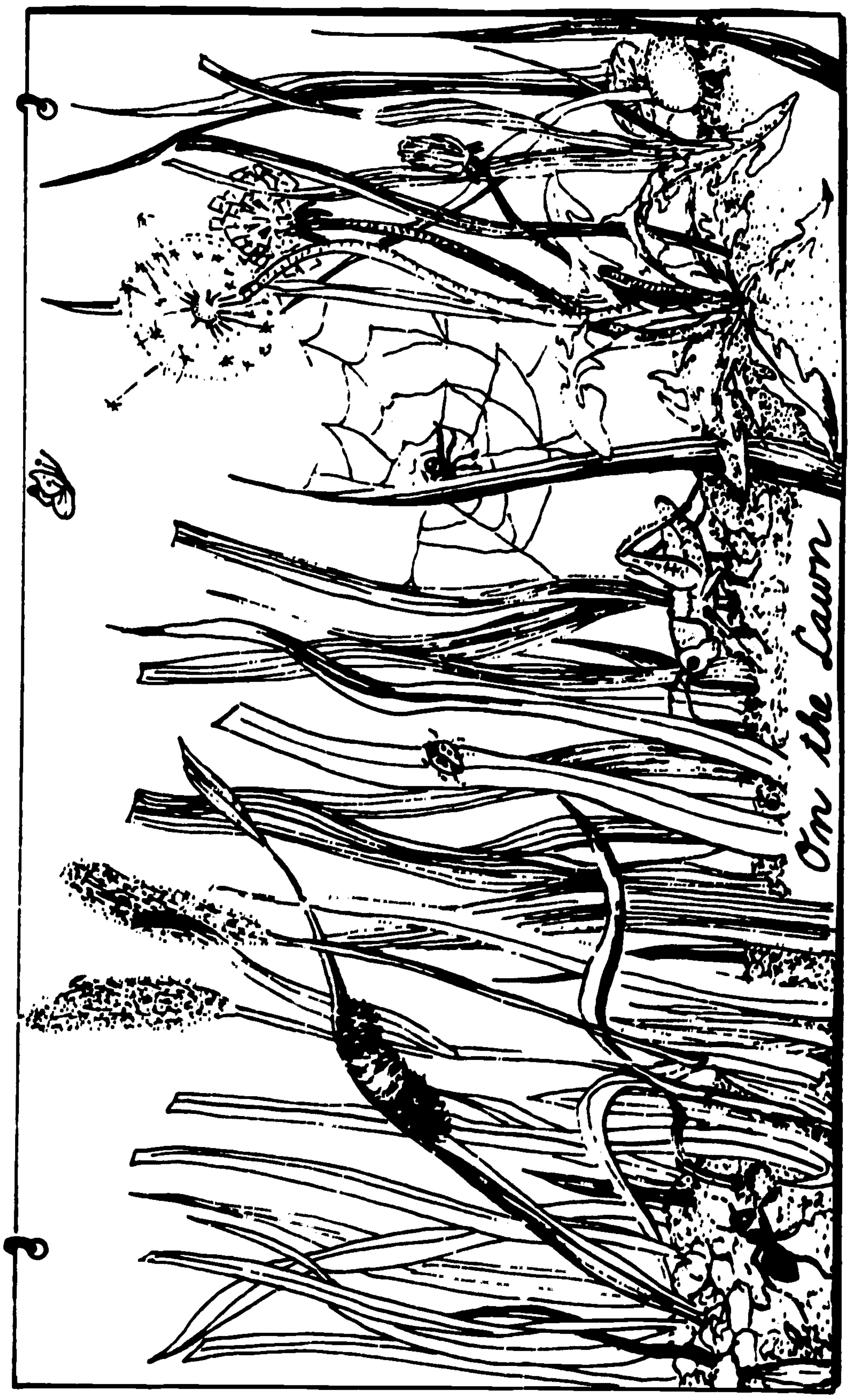
    Make sketches or photographs of trees, or parts of them that are particularly interesting; collect these through the school year. At the end of the term, arrange an exhibit which shows the trees in different seasons. Label each picture with the date it was made, the subject, the reason it was made, and the pupil's name.

    - ***Many kinds of animals are found on a tree.***
    - ***Some animals use a tree for food, some for protection, some as a "home" for young, some as a place to trap other animals.***
    - ***When the bark of a tree is injured, insects and organisms causing diseases may attack the tree.***
    - ***Trees are affected by air pollution.***
    - ***The kinds of plants growing under a tree are affected by the shade and condition of the soil there.***

C. ON THE LAWN

Lawns are a distinct kind of planting, and may be used to illustrate and develop learnings about the adaptation of living things to their environment, about seed dispersal, and about erosion.

It should be kept in mind that lawns vary in many ways — in their location, care, and the frequency and closeness of the cutting. Therefore, some of the statements made here may not apply at certain times to a specific lawn, but many of them will apply to the lawn you may


On the Lawn

find on your school grounds, nearby in front of a house, or in the neighboring park.

Temperature

On a hot, sunny day, it is more pleasant to sit or stand on a lawn than on a sidewalk or a piece of bare ground. Why? (The lawn is cooler and softer.)

1. Feel the surface of the sidewalk with the palm of your hand. Then, similarly, feel the lawn. Which feels cooler?
2. Find the temperature of the sidewalk and that of the lawn, choosing two equally sunny places for comparison. This can be done by placing one of two similar thermometers face down on the grass. Place the other face down on the sidewalk. Shade both thermometers. After two or more minutes, which has the higher temperature? Also compare with temperature of bare soil.

Flowers

We do not think of a lawn as a place where flowers grow, but there are flowers on lawns despite frequent cutting. These may be found in almost every month of the year. Have the class examine a lawn, looking at different times from early spring through fall, to see what flowers they can find.

1. In March, children might see many little white flowers, perhaps only $1/16$ of an inch across. These are probably *chickweed*. Later in the spring the *dandelion* blooms, and still later, the white *clover*. The children might also find other flowers, such as that of *plantain*.
2. Other plants have flowers that are not so obvious and are commonly passed by. Careful observation at the right season will reveal that grass itself has flowers.
3. Keep a record of the months in which particular flowers are found.
4. Find out if any of the plants in the lawn never have flowers. Although they are not typically lawn plants, flowering plants like *mosses* and *toadstools* sometimes grow on lawns.
5. If the grass is not cut, tiny inconspicuous flowers will appear on the grass plant. Later seeds are produced. Examine grass flowers with a magnifying glass. Can you see any *grass seed?*

Plants That Are Not Wanted

The caretaker of a lawn is interested in growing grass. Other plants grow which he may not want, and these he calls "weeds." A lawn, then, is a fine place to learn about the competition of plants for growing space, the adaptations some plants have for surviving under adverse conditions, and the dispersal of seeds.

You may wish to try out some of these suggestions on your school lawn or on another one nearby:

1. Make a rough estimate of how much of the lawn is occupied by grass, how much by other plants. How many different kinds of plants, in addition to grass, are growing on the lawn? List those you recognize; look up the names of others.

2. See if you can find *clover* growing in the lawn. Ask the caretaker of the lawn if he wants the clover there. Some people object to clover in the lawn; others plant clover seeds. From this discussion the pupils will realize that a weed is a plant that is growing where it is not wanted; a plant may be considered a weed by some people but not by others. Find different kinds of clover and compare their leaves and flowers. Discuss why clover is valuable as forage and how its roots add nitrogen to the soil.

3. Look over the lawn to see if certain kinds of weeds are more concentrated in one part than in another. A number of seeds of the same kind may have dropped in one section, but that is not necessarily the whole explanation of the success of the weeds in that location. The light, soil, and moisture must have been suitable for them to germinate and grow; perhaps it was not suitable for grass, or perhaps the weeds crowded out any grass that may have started there. Some plants are adapted to growing in rich soil; others in dry, gravelly places.

4. Compare weed plants growing in the lawn with others of the same kind growing nearby, where they are not mowed. Notice that those in the lawn are often stunted or bushy and low compared to those which are growing naturally. Only plants which are low, compact, or spreading, or can take that form, can survive repeated mowing. *Dandelion, plaintain,* and *clover* are all good examples of this.

5. Find out why dandelions and plantain are common on lawns.
   a. Observe the number of flowers and seeds produced by each plant; the children should use a hand lens to see the individual florets, each of which may produce a seed. Relate the large number of seeds to the "invasion" of lawns by these plants.
   b. Look under the rosettes of the dandelion leaves to note that there is not enough light for other plants to compete there with them. Their large leaves "shade out" the grass and in that way eliminate competition.
   c. Note that the rosettes of leaves are too low to be cut off by the mower.

Seed Dispersal

How did the weeds get there? No one planted them. Even though weeds are continually pulled out or killed by chemicals they reappear, the same season or the next.

1. Have children find plants with seeds on them. Look for the dandelion in April, May, and June. The yellow flowers ripen into the silvery globes which contain the seeds. Let pupils blow on one of these globes, watching the seeds as they parachute away on the wind.
2. Find the winged *maple* seeds which were carried by the wind. Look for seeds which are germinating and growing into little maple trees on the lawn in April, May, or June. Look for nearby maple trees which may have produced the seeds.
3. Watch for little wild *cherry* trees. Birds may have carried cherries off to eat, consumed the fleshy part, and dropped the hard seed which then sprouted.

Erosion

The children might like to take a walk on a rainy day to see that plant roots and leaves help to hold soil.

1. Compare a lawn, a nearby paved area, and an area of bare soil.
2. In the grassy area note that water is seeping down into the soil, or, if the soil is saturated, that any water which runs off is clear. (It is not eroding the soil.)
3. In the paved area note that water runs off the pavement.

4. In the bare soil area, note that the water running down may be brownish (colored by the soil it is carrying) and it may be carving erosion gullies into the area. If possible, collect some of this water and let it settle in a jar. How much soil does the water carry?

Animals on the Lawn

When looking for a lawn on which to study animals, suggest that children follow the procedures listed below.

1. Approach the lawn quietly and slowly to observe birds which may be feeding on it, such as *flickers* getting ants, *robins* getting worms, *starlings* getting grubs of beetles, *song sparrows* getting seeds or insects, or *grackles* getting insects or crumbs. How are the structures of birds (beak, feet, etc.) adapted for their feeding habits? The filmstrip *Exploring New York City for Birds* is useful as an introduction to or a summary of this study.
2. Watch squirrels search for food, and note that they do not eat grass or clover. Some classes enjoy feeding squirrels and take nuts along for that purpose.
3. Watch for *ants* carrying food to their homes; compare with activities seen in a classroom antcase.
4. Find insects which may live among the plants; examine them with a hand lens.
5. Is it difficult to see some insects in the grass? Why? (They are small; their color camouflages them; they do not move much; they are quiet when people are around.)
6. If possible, sweep the grass with an insect net. Place the contents in a large jar. Observe and try to identify the insects. After study, release insects on lawn.
7. Make a map of the lawn area. Attach to it drawings of animals seen over a period of time.

   - *The temperature of the surface of bare soil or pavement on a sunny day is usually warmer than that of grass-covered soil.*
   - *Different kinds of plants grow in a lawn.*
   - *Different kinds of animals are found on a lawn.*

- *Seeds of unwanted plants ("weeds") may be carried to the lawn by wind or by animals.*
- *Weeds growing on lawns often have low, spreading leaves, which enable them to escape the lawn mower.*
- *Soil covered by grass is not washed away by heavy rains as easily as bare soil in the same location.*

D. IN THE SOIL

By observation, children can discover many interesting facts about the soil and what is in it. Of course, digging in most places is not permitted. Samples of soil may be obtained from the school garden; with permission, from neighborhood gardens and from other sources.

1. Select an area of soil for study. This may be a part of the school garden, a part of a "vacant" lot, an area in a nearby park, or a part of the school grounds not covered with concrete. Assign groups of children to study one square yard of the area. Have them report on the animals observed in this limited space.

   Look for *earthworm casts,* little piles of earth left on the surface as the earthworm makes its tunnels. Earthworms are valuable soil conditioners. They take plant material down into the earth where it breaks up to help form soil. The tunnels of earthworms admit air and moisture to the soil.

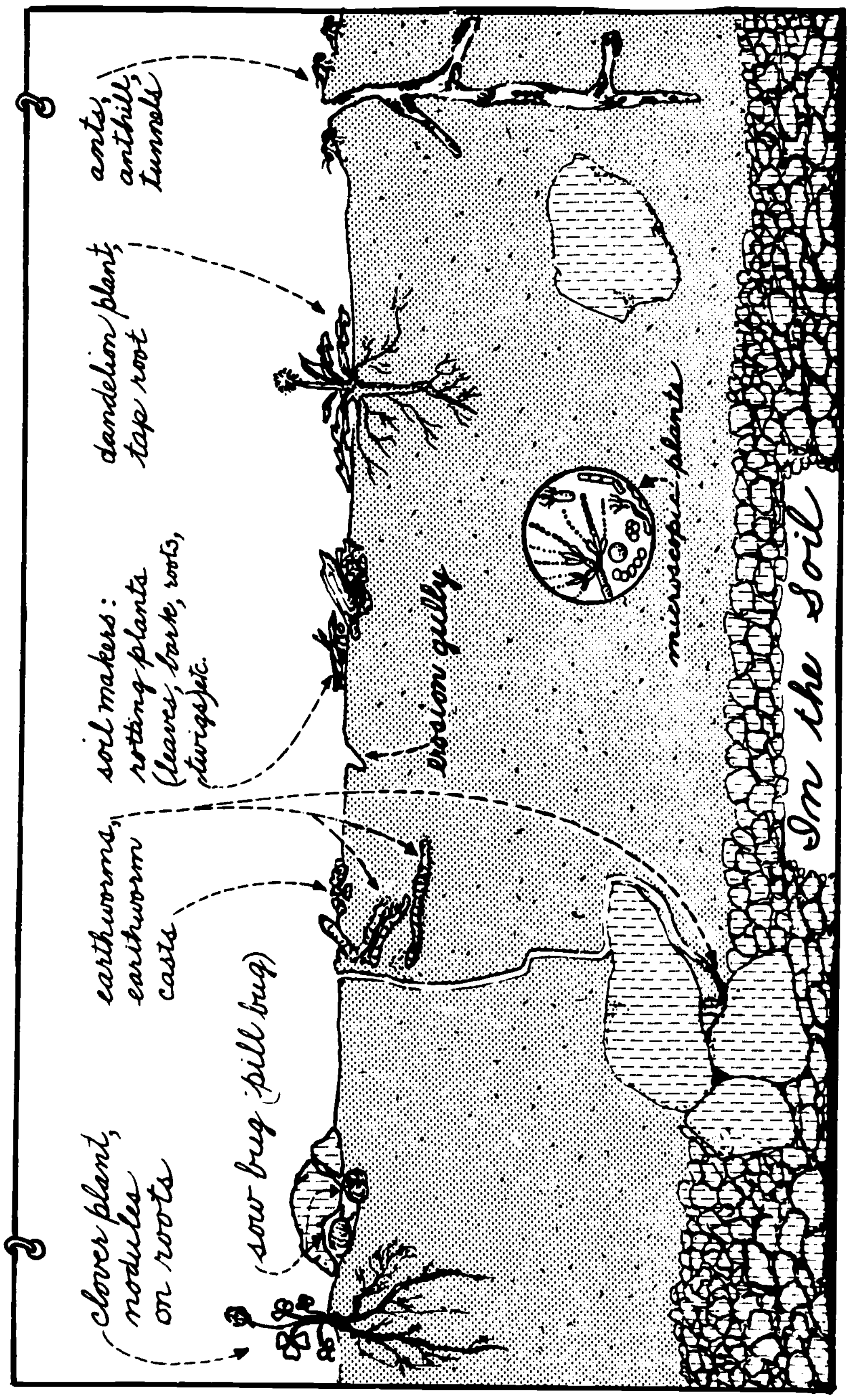
   Look for signs of mammals: holes, burrows, or trails.

   Turn over large stones to observe animals living under them. You may find *pill bugs, ~~snails,~~ centipedes, ants,* and other animals. Replace the stone before you leave. Point out that some animals are adapted to living in the conditions which exist under such stones.

   Look for *anthills.* If you note the color and texture of the grains of soil the ants have carried to the surface, you will know something about the subsoil there.

   Make a map of the area studied. Indicate compass directions on the map. As animals are seen, add drawings of them to the area of the map corresponding to where they were seen.

2. Examine any pieces of wood that are rotting, becoming *humus.* Use the hand lens to see the *fungi* or the termites and other


clover plant, nodules on roots
sow bug (pill bug)
earthworms, earthworm casts
soil makers: rotting plants (leaves, bark, roots, twigs) etc.
erosion gully
dandelion plant, tap root
ants, anthill, tunnels
microscopic plants
In the Soil

insects that are breaking down the wood. This will help the children to realize that rich earth is "alive": materials are used over and over again as plants and animals live and die; fungi and insects which break down these materials are performing an essential service by making minerals available for future growth.

Examine leaves piled up by the wind at the base of a hedge or a fence. If they have been there any length of time, the bottom ones will be disintegrating. Have the children remove the dry leaves on top until those that have been pressed against the damp soil are exposed. See if these leaves are decomposing, turning into humus. Sometimes earthworms can be found feeding on leaves at the bottom of the pile.

Use a jar to demonstrate the soil "profile" found outdoors.

3. Look for signs of *erosion.* Water may have washed topsoil from high spots to lower ones; gullies may show where running water carried this soil down the slope. Stones may stand on little pedestals of soil which they have protected from the force of raindrops while the bare earth next to them has been washed away. Tree roots may have been exposed as soil washed down a slope. On a breezy day, dry powdery soil may be picked up and carried by the wind. This miniature dust storm may be compared to the dust storms out West.

   Watch for soil on the sidewalk and find out where it came from. Probably a gully, large or small, has formed as rain washed soil down from a bare spot above the walk. Also note places where roots and leaves protect soil from erosion.

   A sample of soil *from the sidewalk* may be brought back to the classroom for further study.

4. With the permission of the owner, dig up a cubic foot or less of soil, and place it in a box. Back in the classroom let the children spread it on a sheet of paper. Note the humus and mineral particles and examine the plants and animals that are living in the soil. After this investigation, place the soil in a number of jars and in any unused aquaria. Keep it moist, but not wet. A piece of glass laid over the top will prevent evaporation; if water condenses on the glass, allow a little air to enter by temporarily removing the glass or leaving an opening. Do not disturb this soil, but observe it daily for signs of animal and plant life.

5. Place a sample of soil (about $\frac{1}{2}$ inch) in each of a number of small screw-top jars. Add tap water up to one inch of the top of each jar. Cover with cap. After several days or weeks observe appearance of *algae* (a fuzzy green growth) and any other forms of life. Examine with a magnifying glass; place a drop of the water on a glass slide and observe under the microscope. Is there any evidence that the soil contains microscopic plants and animals? Could the plants and animals have come from the glass jar or the tap water? (Possibly.) How could you avoid this possibility? (Place jar and cover in a pot of water and boil. Allow to cool. Use the cooled boiled water and jar to repeat the experiment with some of the *unheated* soil.)

Soil contains many tiny organisms: *bacteria, protozoa* (one-celled animals), *algae* (simple green plants), *molds,* certain kinds of *worms.* These organisms help in the breakdown of dead plant and animal material, as a consequence of which valuable minerals are returned to the soil.

Soil, then, is partly made of *living plants and animals.*

- *Many plants and animals live in the soil. Among these are bacteria, protozoa, algae, fungi, many insects, and various kinds of worms.*
- *Earthworms plow the soil; their burrows admit air and moisture into the soil.*
- *The rotting of wood and leaves helps make soil.*
- *Soil is made of minerals from rocks, of decayed material, and of living plants and animals.*
- *Wind and water may erode the topsoil and carry it from high places to low places.*

E. IN THE WATER

A pond or lake in a park is a place where children can learn conservation at firsthand. Such a lake may be natural or artificial, or a combination of both; it will certainly be different from a lake in the wilderness if only because many people are constantly visiting it. In any case, children can find out about the interrelationships of water, soil, animals, and plants. A park lake should be revisited to see how it changes in the different seasons. The following activities are suggested:

1. Make a large vertical-section "map" of the pond or lake. As animals and plants are seen, place drawings and cutouts of them on the map.

   Some living things which may be found in a pond are numbered in the following illustration and listed below.

1. water flea (daphnia)	10. water lily
2. spirogyra	11. snail
3. paramecium	12. dragonfly nymph
4. cyclops	13. dragonfly
5. water beetle	14. frog
6. cabomba	15. water strider
7. sunfish	16. turtle
8. catfish	17. mallard duck
9. elodea	18. cattail

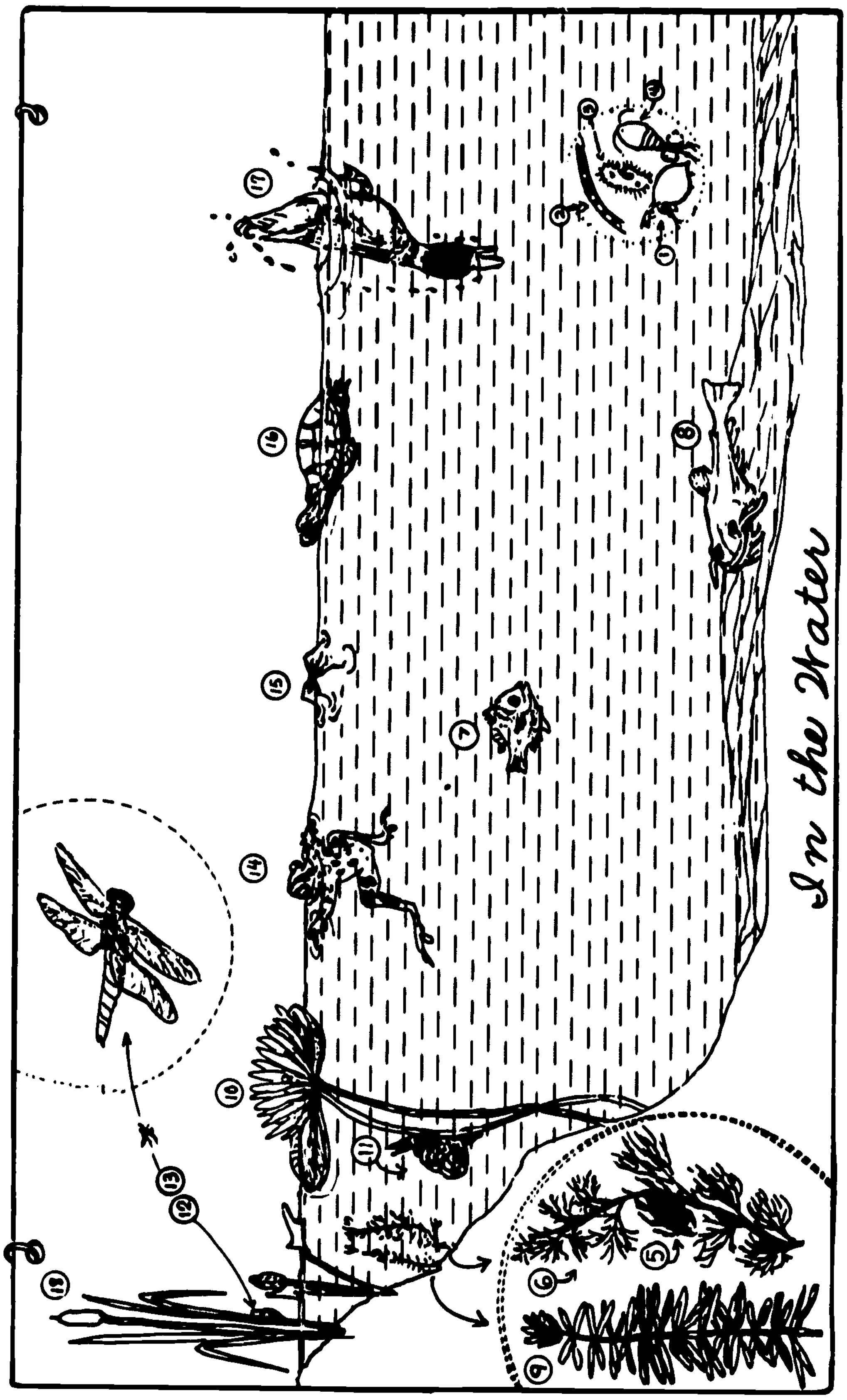
2. Examine the water at the edge of the lake. After a heavy rain it may be brownish from soil that has eroded into it. It may be green due to the presence of algae (tiny plants).

3. Scoop up several jars of water. Leave them uncovered in a sunny place in the classroom. Examine the *algae* which may grow in it; note soil that settles to the bottom. Examine the water with a magnifying glass or microscope to see if you can find tiny water plants and animals which may be living in the pond. Keep for a long period to see if any new forms emerge. If one or two cooked rice grains are added, it will encourage the multiplication of animals in the culture. (The food chain in this case is rice-bacteria-protozoa.)

   To determine the role of sunlight in the growth of algae, compare samples of pond water kept in sunlight with samples kept in shade or darkness.

4. Notice any litter in the lake. Develop in the children a realization that litter detracts from the beauty of the spot and adds impurities to the water.

5. Note any plants growing in the water at the edge of the pond. It may be possible to find *pond lilies* or other water plants.


In the Water

6. See how many birds can be identified on the water, flying over it, or bathing or feeding at the edges.

7. Look for *gulls, kingfishers, swallows,* and other birds; note what they eat and how they get their food. How are they adapted for obtaining food?

8. Watch *mallard ducks* on the lake; they may be getting food by scooping mosquito larvae from the surface, ducking for plants on the bottom, or picking up food thrown in by people. What shape are their bills? Distinguish between the brightly colored male and the drab female.

9. Notice if the parent ducks lead their young away from the shore. Why might they do this? (Probably to get them out of danger from rats or other animals.)

10. Look for insects on, above, or just below the surface of the water. You may see *dragonflies* (darning needles) darting and hovering. They feed on other insects such as mosquitoes. *Water striders* or *water boatmen* may be observed in the pond. Notice how each of the insects moves.

11. Look for *fish;* note their species and size. Find out how the lake was stocked. What food do they eat?

12. Try to trace the source of the water. It may be artificial; it may be a spring or stream; or it may be rain water draining in from surrounding hills. In the latter case, point out that these surrounding hills constitute a *watershed.* Look for gullies where soil has been eroded by running water.

13. Examine the trees and other plants around the lake. Notice that some kinds grow where the earth is constantly wet; others grow on higher, drier ground. Let the children use a reference book to identify some of the trees.

14. Take the temperature of the water in the pond. Is the water warmer or cooler than the air? (Generally cooler in warm periods of the year; generally warmer in cold periods.) (*Note:* See *Climate,* page 125.) Where are greater extremes ot temperature experienced, on land or in a pond? (On land.) Why? (Water does not heat up or cool down as quickly as land.) Visit the pond from time to time and take the air and pond water temperature. Note also plant and animal life on each occasion. What happens to pond life in the wintertime?

15. Look at any seeds floating on the lake. Water currents carry some seeds from one place to another, thus distributing them. On a windy day these may be carried considerable distances by surface currents, showing one way in which some seeds are distributed. If possible, pick up one of these seeds and examine its coating; if a variety of seeds can be found, let the children put them into a jar of water in the classroom to see how long they float. Place them in a pot of soil; water them. Do any plants come up?

- *A drop of pond or lake water contains many tiny living plants and animals.*
- *Some animals live on the surface of a lake; some under the surface; some near the bottom.*
- *Greater extremes of temperature are found on land than in water.*
- *Some pond animals are active all year.*

EVALUATIVE ACTIVITIES

Do the children

1. evidence greater interest in their neighborhood environment?
2. report voluntarily on changes which they see in plant and animal life?
3. revisit, on their own, the "little environments" which were studied by the class and report on changes in these?
4. express attitudes of conservation: concern for trees affected by air pollution, for plants affected by drought, for animals brought into classroom?
5. suggest new "little environments" for observation and study?
6. read more about plants and animals?
7. visit parks, zoos, museums, nature centers?
8. participate in making a nature trail in the neighborhood of the school?
9. make suggestions for improving the neighborhood?
10. go on trips with their friends or parents after school to have more experiences with living things?

BASIC SUPPLY LIST
FOR *LITTLE ENVIRONMENTS*

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

1 magnifying glass
1 compass
1 thermometer
*5 lbs. soil
*1 box microscope slides
* microscope
* microprojector
1 net, water dip

G-1: General Supply List

1 ruler, 12″
1 ball of string (warp, thread-white)
2 pencils
2 notebooks
1 saucepan
*4 sheets large oaktag

Miscellaneous:

paper bags
jars with screwtops
cameras
2 pinwheels
* anemometer
*1 sprinkling can
sidewalk soil
*1 shovel
pond water
1 insect net

*Assorted Drawings or Cutouts:

grass
weeds
seeds
caterpillars
leaves
earthworms
sparrows
pigeons
ants

A. PLANET EARTH IN THE SOLAR SYSTEM

Background for the Teacher

Solar system is the name we give to our sun and the nine planets that revolve around it. The solar system also includes the satellites of the planets, such as our moon, asteroids which travel in an orbit around the sun between the orbits of Mars and Jupiter, and comets.

The planets vary considerably in size. Mercury is the smallest with a diameter of 3,000 miles; Jupiter, the largest, with a diameter of 87,000 miles. Jupiter is so large that all the other planets can be contained in it.

Planets differ from stars in the following respects:

a. Stars radiate their own light, whereas planets are illuminated by sunlight.

b. Stars are *suns* outside our solar system; planets are part of the solar system.

c. Over a period of weeks or months, planets change their position in relation to the background of stars. (The word *planet* means "wandering star.") Stars maintain the same patterns in relation to each other.

d. Our planets are much smaller than most stars.

In distinguishing stars from planets in the night sky, three visual differences may be helpful.

a. Planets generally do not appear to twinkle although stars do. (The effect we call "twinkling" is caused by the distortion of the light as it passes through the earth's atmosphere. In outer space the stars do not appear to twinkle.)

b. Seen through a telescope, the planets appear as discs; stars are so distant that they always appear as points of light.

c. At times some of the planets such as Venus, Mars, and Jupiter are very bright in comparison to the stars.

The planets move at different speeds in their orbits around the sun. The planets closest to the sun move the fastest. Mercury orbits at the greatest speed (108,000 miles per hour) and Pluto at the slowest (11,000 miles per hour).

The orbits of the planets are elliptical; consequently, the planets are at different distances from the sun in different points in their orbits.

As a planet's distance from the sun changes, its speed changes too. It moves faster when it is closer to the sun. For example, in December, when the Earth is closest to the sun, it moves more rapidly than it does in July, when it is most remote.

Approaches and Learnings for the Child

In our Space Age there is great interest in the planets of our solar system. The moon, Venus, and Mars have been reached, studied, and photographed by spaceships. By making models and charts, children get a clearer idea of the size and position of the planets and learn some significant facts about them. *However, it is most important that the children see at least one planet in the sky.*

From the activities suggested, children learn:

The earth is one of nine planets which orbit around the sun.

Planets differ from each other in many ways.

Planets are illuminated by light from the sun.

Planets move in elliptical orbits around the sun.

The distance of a planet from the sun varies during its revolution.

Planets are at different distances from the sun.

The planets closest to the sun move the fastest.

Asteroids and comets are part of the solar system.

There are many unsolved mysteries about the planets. Spaceships and satellites are helping us solve some of these mysteries.

1. Where have spaceships traveled?

The purpose of this question is to invite the children to recall past and current space thrusts and to reveal their knowledge of the solar system, which is the present arena of space exploration. They will recall orbits around Earth made by the astronauts, and the many vehicles launched to the moon, to Mars, and to Venus. Some spaceships are now circling the sun.

In the course of the discussion, the children will reveal the extent of their knowledge of the stars, the sun, and the members of the sun's family. Questions for further study may be listed and plans for projects and trips can be made.

The *Space* focus will be helpful in all of this: the solar system is not only something to be studied or viewed — it is a region to be explored.

Some of the questions that may be raised by the children are:

What is it like on Venus?
How big are the other planets?
How can we see a planet?
How does Earth look from the moon?
How long would it take to travel to Mars?

Some of the plans for investigation may include:

looking at the night sky for a planet
visiting the planetarium
making a model of the solar system
reading the newspapers for news about space thrusts
reading books to find out more about the planets.

These questions and plans may serve as a basis for the activities in Problems 2-12 which follow.

- *Spaceships have circled Earth, landed on the moon and Venus, flown by Venus and Mars, and circled the sun.*
- *The solar system includes the sun and a group of bodies which revolve around it.*
- *Earth is a member of the solar system.*

2. What planets are there in our solar system?

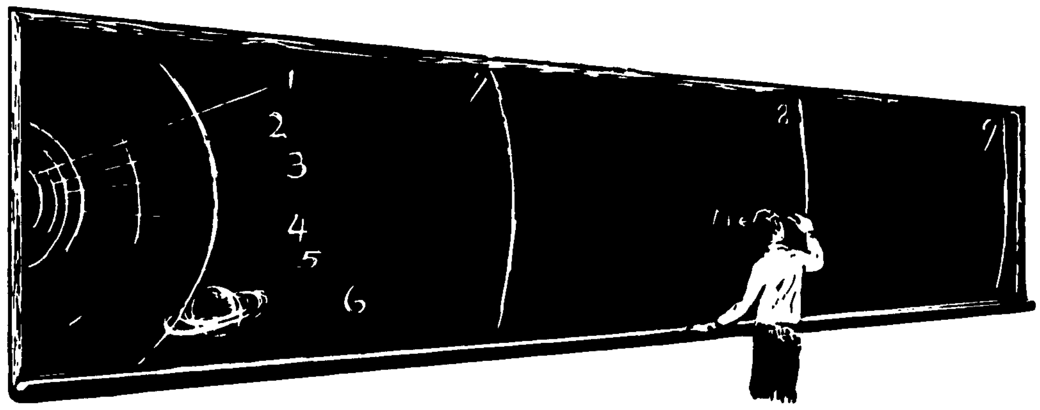
Children have learned that Earth (one of the planets) is shaped like a ball. Use photographs taken from spaceships and artificial (man-made) satellites to show the curvature of the earth's surface. Discuss with children the fact that Earth is a planet which revolves around the sun in a regular path.

Children find out and report on what other planets there are in our solar system. They learn how these are related to the sun and to each other. They make a "chalkboard planetarium" using the facts given as a basis for showing the relative distances of the planets' orbits from the sun.

FACTS FOR A CHALKBOARD PLANETARIUM

Number and Name of Planet	*Average Distance from Sun in Millions of Miles (approximate)*	*Distance to Be Measured from Left Side of Chalkboard (Scale: 1 inch = 20 million miles)*
Mercury	36	1¾ inches
Venus	67	3¼ inches
Earth	93	4¾ inches
Mars	140	7 inches
Jupiter	480	2 feet
Saturn	890	3 feet 7 inches
Uranus	1800	7 feet 5 inches
Neptune	2800	11 feet 6 inches
Pluto	3700	15 feet 3 inches

- *The earth is a planet, shaped like a ball that travels in a path (orbit) around the sun.*
- *There are other planets moving around the sun. These are Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.*
- *Planets differ in size.*
- *Planets are at varying distances from the sun.*



Making a chalkboard planetarium.

3. Can we see a planet in the sky?

The planets Venus, Jupiter, Mars, and Saturn are very conspicuous at certain times and are easily seen with the naked eye. Since the position of a planet during a given month varies from year to year, it will be necessary to consult one of these references for the current position:

a. *Science News*

b. *World Almanac*

c. *Natural History* (published by the American Museum of Natural History)

d. *The Observer's Handbook* (on sale at the Planetarium).

When a planet is visible in the sky at evening, the teacher can tell the class where and when to look for it. For example, directions for finding the planet Venus may be to go out about dusk and look in the western sky. Pick out the brightest object in the sky (except for the moon). It looks like a very bright star. *This is Venus.*

A unique service for those interested in the current night sky is provided by *Sky Information,* a recording prepared by Hayden Planetarium which may be heard by dialing 873-0404. For the price of a phone call, one is given information about each of the planets visible that night including its appearance, position in the sky, and time for viewing. Other news includes the position of the visible satellites (Echo, for example), the program at the Planetarium, and special celestial events such as eclipses and meteor showers. A most useful assignment is to ask students to dial the phone at home, watch the sky that night, and describe what they found the following day in school. As an alternate, the teacher may dial the number sometime during the school day and then relay the information to the class as a basis for their viewing the same night. Again, ask the children to report the next day what they have seen.

- *Some planets can be seen easily with the naked eye.*
- *Sometimes a planet can be seen before the stars come out in the evening.*
- *We see different planets at different times.*

4. How can we tell a planet from a star?

Some of the children will raise this question after trying to find a planet as outlined in Problem 3. Ask the children to report on how the planets looked. They may discuss their brightness and the fact that they do not appear to "twinkle" as some stars do. These characteristics, however, are not reliable guides for distinguishing between planets and stars. How can we be sure?

Examine star maps in books or charts. Why can't the positions of the planets usually be included on these maps? The answer is that planets are not "fixed" in position in relation to the stars: they change their positions from week to week and month to month.

Some children may be able to identify and observe a particular planet for a period of a month or longer and to report its relative position with respect to a particular group of stars.

- *Planets change their position in relation to the stars in the sky.*
- *Planets generally do not appear to twinkle.*

5. How do planets get their light?

The preceding problem developed the concept that planets change position with respect to the more constant "pattern" of stars. The point of Problem 5 is to introduce a second characteristic of planets: that they are illuminated by the sun.

In Problems 1 and 2, children learned that Earth is one of nine planets. Ask the children how planet Earth gets its light. (From the sun.) How would Earth appear from the moon? From television and their readings about the latest space probes, which include photographs taken of the Earth, they will be able to say that the Earth appears like a partly illuminated ball or sphere.

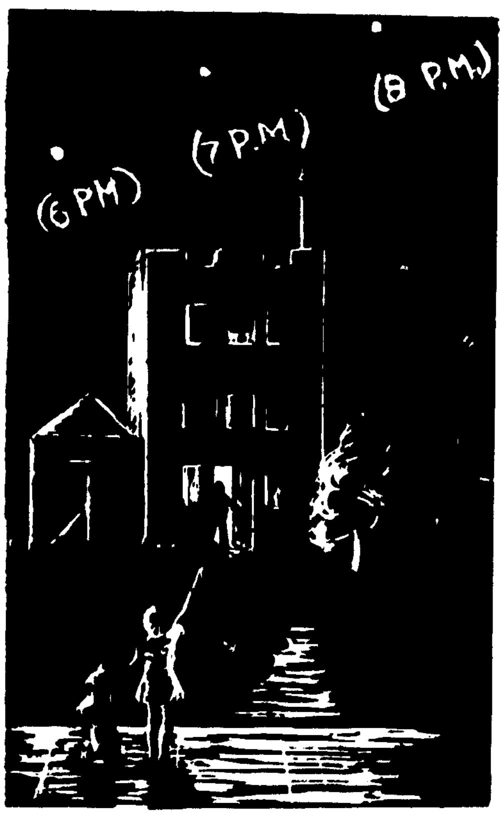
How would Earth appear from farther out in space — as from the planets Mars and Jupiter? Children will realize that it would appear smaller, but still be an illuminated body in the sky.

After discussing with the children the appearance of Earth from outer space and its source of light, they may suggest that the planets are like Earth: they also are bodies in space illuminated by the sun.

The following demonstration will reinforce children's understanding of how planets get their light: In a darkened room, use a flashlight to represent sunlight. Shine the light on a globe or ball which is then seen by reflected light.

- *Planets do not emit light themselves. They can be seen because they reflect light received from the sun.*

6. Do planets appear to move in one night?



Seeing a real planet in a real sky.

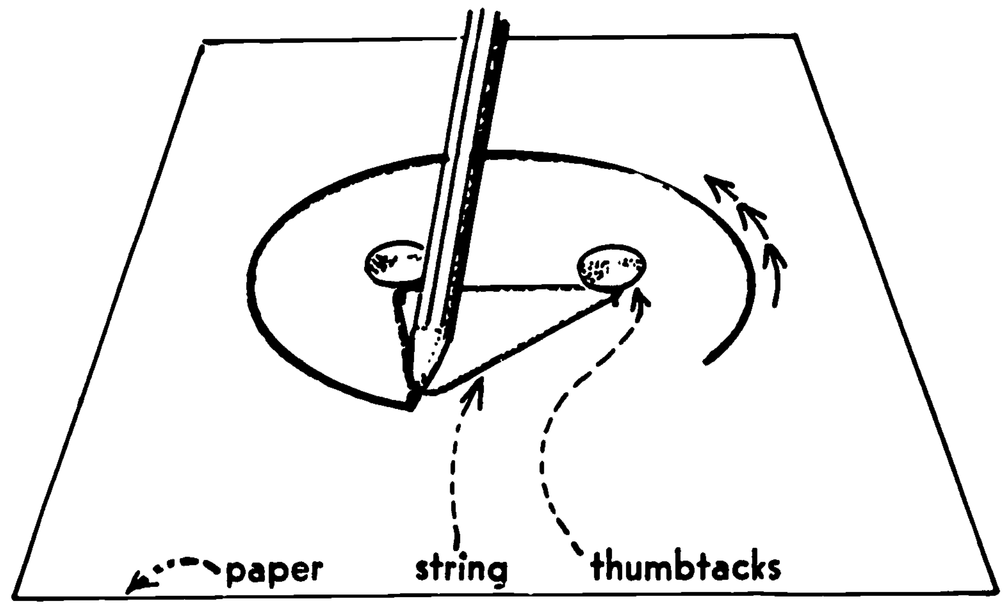
Direct the children to observe a visible planet at hourly intervals from the same observation point. Several observations should be made, but each observation will take only a minute or so. For example, observations might be made at seven, eight, and nine o'clock. Publications listed in Problem 3, and *Sky Information,* the telephone service of the Hayden Planetarium, will indicate which planets are currently visible.

After reports on these observations are made, discussion should stress that the apparent movement of the planet from east to west is due to the turning of Earth from west to east. The explanation for the apparent movement of a planet in one night is the same as the explanation for the daily apparent movement of the sun across the sky.

- *Planets appear to move from east to west in one night.*
- *This apparent movement is due to the rotation of Earth from west to east.*

7. What paths do planets follow in space?

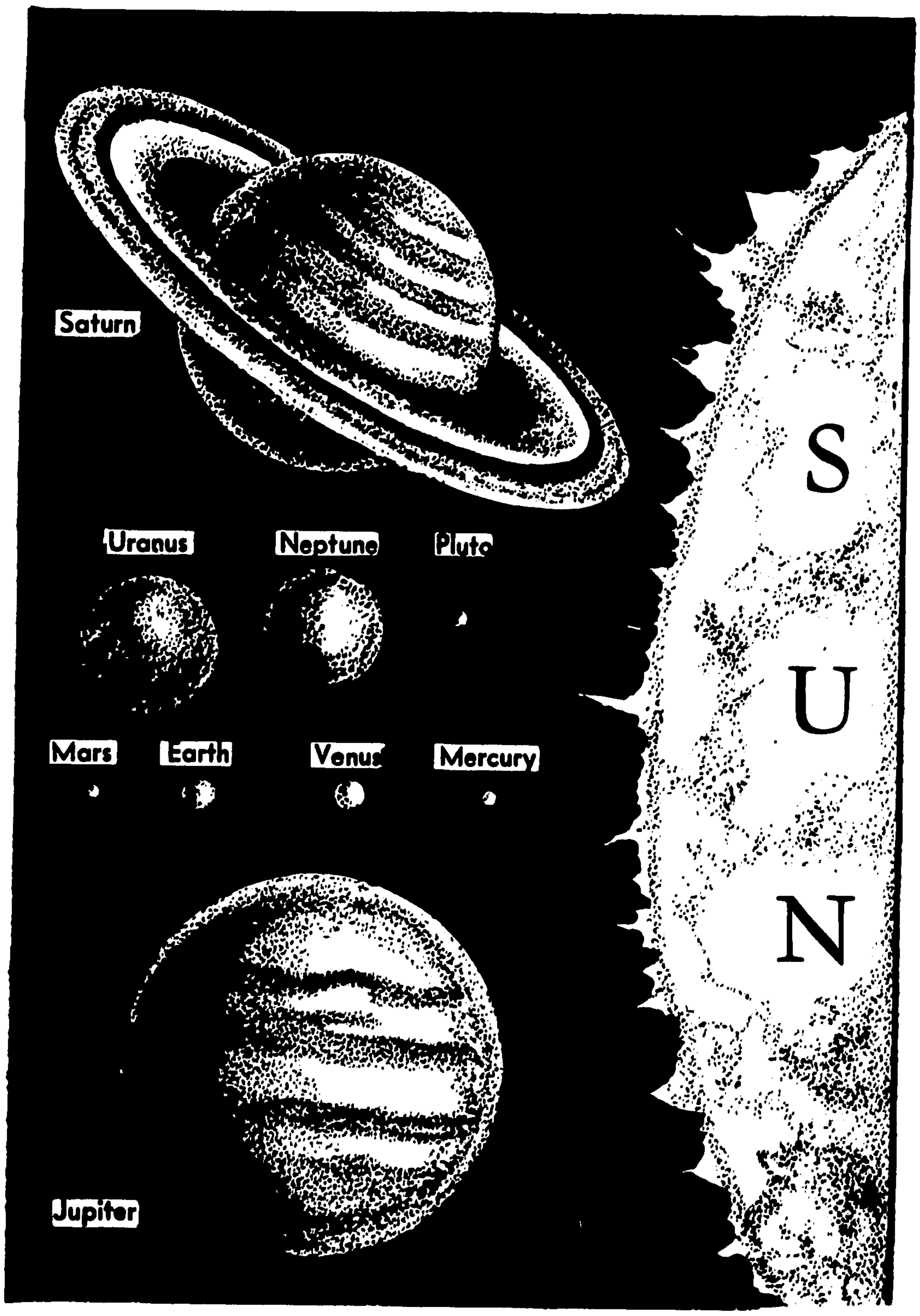
Ask the children to draw a diagram on the chalkboard showing Earth revolving around the sun. Most children will draw a circular orbit. Elicit from the children that if our orbit were circular, Earth would always be the same distance from the sun. All planets, including ours, have elliptical orbits. How can we draw ellipses?



Drawing an ellipse.

Have the children draw ellipses of different sizes and shapes by partially sticking two thumbtacks into a piece of cardboard as shown in the illustration. Attach a string to the tacks, leaving some slack. Now have the children put the point of their pencil inside the loop and draw a figure, keeping the string taut all the time. The figure they draw will be an ellipse.

Have the children repeat this experience, but with the thumbtacks at different distances from each other. What kind of an ellipse results when the tacks are far apart? When the tacks are very close together?



Relative sizes of planets.

When the two tacks are close together, the figure is almost a circle. This is true for Earth's orbit. When Earth is closest to the sun, the distance is $91\frac{1}{4}$ million miles; when it is at its farthest, as much as $94\frac{1}{2}$ million. Mercury, on the other hand, departs more from a circular orbit: Its distance from the sun varies between $28\frac{1}{2}$ million and $43\frac{1}{2}$ million miles.

- *The orbits of planets are elliptical.*
- *Because of its elliptical orbit, the distance of a planet from the sun varies during its revolution around the sun.*

8. How do the planets compare in size and in other ways?

Two procedures for illustrating the size of the planets are suggested. Children draw circles on large oaktag with the diameters indicated to illustrate the comparative sizes of the planets and the size of the sun.

Sun	5 feet	Jupiter	$6\frac{3}{4}$ inches
Mercury	$\frac{1}{4}$ inch	Saturn	$5\frac{1}{2}$ inches
Venus	$\frac{5}{8}$ inch	Uranus	$2\frac{1}{4}$ inches
Earth	$\frac{5}{8}$ inch	Neptune	$2\frac{1}{4}$ inches
Mars	$\frac{3}{8}$ inch	Pluto	$\frac{1}{4}$ inch

The size of the sun and the planets can also be illustrated by using the following familiar objects:

Sun	— A gigantic balloon	Jupiter	— A basketball
Mercury	— A marble	Saturn	— A soccer ball
Venus	— A tennis ball	Uranus	— A baseball
Earth	— A tennis ball	Neptune	— A baseball
Mars	— A ping-pong ball	Pluto	— A marble

Children may want to discuss facts about the nine planets given in the following chart. *Note:* It is suggested that this table be reproduced and given to the children. It is *not* intended that they memorize it but that it be used as a basis for comparison and discussion.

Planets	Average Distance from the Sun (Approximate)	Diameter (Approximate)	Period of Revolution Around the Sun	Period of Rotation	Number of Satellites	Average Orbital Speed (Miles per Hour)
Mercury	36 mill. mi.	3 thou. mi.	88 days	59 days	0	108 thou. mi.
Venus	67 " "	8 " "	225 "	247? "	0	79 " "
Earth	93 " "	8 " "	365¼ "	24 hours	1	67 " "
Mars	140 " "	4 " "	687 "	24½ "	2	54 " "
Jupiter	480 " "	87 " "	12 years	10 "	12	29 " "
Saturn	890 " "	71 " "	29 "	10 "	10	22 " "
Uranus	1800 " "	29 " "	84 "	11 "	5	15 " "
Neptune	2800 " "	28 " "	165 "	16 "	2	12 " "
Pluto	3700 " "	4(?)" "	248. "	6 days (?)	0	11 " "

Ask the children to familiarize themselves with the table above and to use it to answer and discuss the following questions. The questions listed here are not all inclusive but may serve as a guide.

a. *Distances of the planets*

Which planet is nearest the sun? (Mercury.)

Which planet is farthest from the sun? (Pluto.)

Which planets are inside Earth's orbit? (Mercury and Venus.)

Which planets are outside Earth's orbit? (All the others, from Mars to Pluto.)

b. *Sizes of the planets*

Which is the largest planet? (Jupiter.)

Which is the smallest planet? (Mercury.)

What other planet is about as large as Earth? (Venus.)

What is the diameter of Earth? (Approximately 8,000 miles.)

c. *Period of revolutions around the sun*

Which planet travels around the sun in the shortest time? Mercury, 88 days.)

Which planet travels around the sun in the longest time? (Pluto, 248 years.)

How long does it take Earth to travel around the sun? (365¼ days or one year.)

d. *Period of rotation*

How long does it take Earth to make one full turn? (24 hours or 1 day.)

What other planet takes approximately the same amount of time as Earth to rotate? (Mars, 24½ hours.)

Which planet takes the shortest time to make one rotation? (Jupiter, 10 hours. Note: According to the chart, Jupiter and Saturn both take 10 hours. More exactly, Jupiter takes 9 hours and 52 minutes, while Saturn takes 10 hours and 14 minutes.)

e. *Number of satellites*

How many satellites does Earth have? (One, the moon.)

Which planet has the largest number of satellites? (Jupiter, 12.)

Which planets do not have any satellites? (Mercury, Venus, and Pluto.)

f. *Orbital velocity*

Which planet travels at the fastest speed? (Mercury, 108,000 miles per hour.)

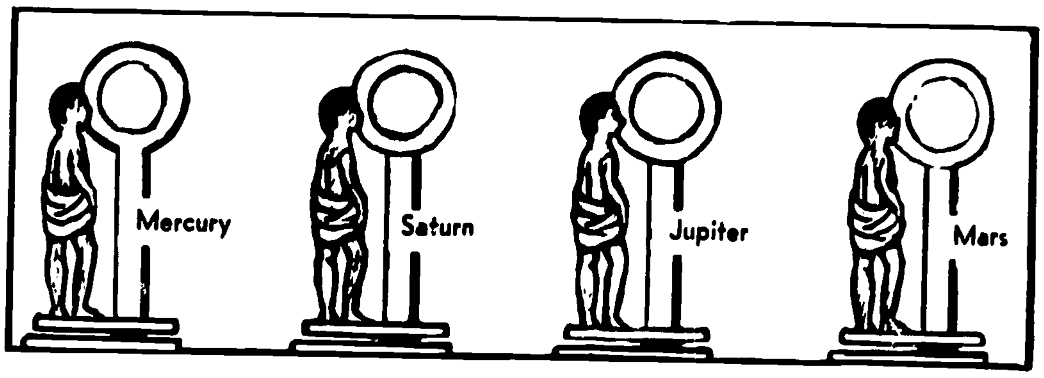
Which planet travels at the slowest speed? (Pluto, 11,000 miles per hour.)

How fast does Earth travel in going around the sun? (67,000 miles per hour.)

- *Planets are of different sizes.*
- *The sun is larger than any planet.*
- *The planet Earth is about the same size as the planet Venus.*
- *Planets are at different distances from the sun.*
- *Planets revolve around the sun at different speeds.*
- *Planets closer to the sun take a shorter time to go around the sun.*
- *Some planets take longer to rotate on their axes than others.*
- *Some planets have many satellites; some have few; others have none.*
- *Measurements of time are based on Earth's revolutions around the sun (one revolution = 365 days or one year); and Earth's rotation on its axis (one rotation = 24 hours or one day).*

9. How much would you weigh on another planet?

Ask the children how much they think they would weigh on the moon, Mercury, Jupiter, and the other planets. Discuss with them that without Earth's gravity, we, our atmosphere, the oceans, and anything not firmly attached to the earth would fly away. It is Earth's mass (material) which, by exerting a pull towards its center on all objects, gives us weight. (Weight is the measure of the force of gravity.) On another planet with less gravity, we would weigh less than we do on Earth. The surface gravity on the moon is about 1/6 that on Earth. Therefore, a child whose weight is 90 lbs. on Earth would weight approximately 15 lbs. on the moon.



The boy's weight is 100 lbs.
What does he weigh on each of these planets?

Have the children convert their weight (in round figures) on Earth to their weight on the moon and the planets. The following chart gives the gravity of these bodies as a decimal in relation to the gravity of Earth:

Planet	*Surface Gravity (approximate)*
Mercury	.4
Venus	.9
Earth	1.0
Mars	.4
Jupiter	2.5
Saturn	1.1
Uranus	1.1
Neptune	1.4
Pluto	?
Moon	.17

It may be surprising that some of the large planets, such as Saturn, have a surface gravity that is not much greater than that of Earth. However, the surface gravity of a body depends partly on its mass (roughly the weight of the material in it). Some of the large planets are not as dense as Earth; their material is "lighter."

A *spring* scale would be needed to show any difference. On a balance scale (one which uses weights), the weights would also be affected by a change in gravity. On a balance scale our weight would *appear* the same on all planets. If *your* weight is reduced from 90 lbs. to 15 lbs. on the moon, the 90 lb. balance weight is similarly reduced to 15 lbs. Show the children a balance and a spring scale and ask them to compare them.

Example: John weighs 103 lbs. on Earth. How much would John weigh on Jupiter?

Procedure: (a) Round off 103 to 100.
(b) Multiply by surface gravity of Jupiter.

	100 lbs.	weight on Earth
	x 2.5	surface gravity on Jupiter
Answer:	250 lbs.	weight on Jupiter

Note: If children cannot multiply by decimals have them first convert the decimal into a fraction.

- *The weight of anything depends upon the surface gravity of a particular planet on which it is being weighed.*
- *Your weight would be different on different planets.*
- *Weight is the measure of gravitational pull.*

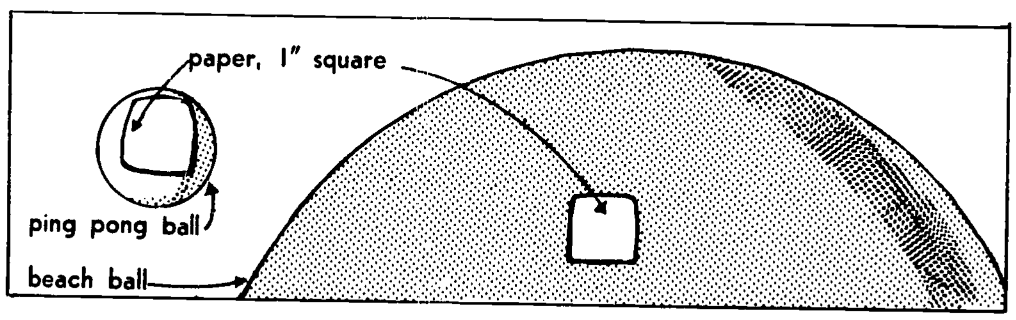
10. What else can we find out about the planets?

Individuals or committees refer to publications and report to the class on each of the planets. Reports might include the following: temperature, kind of atmosphere, possibility of life, satellites, unusual features (like the extreme temperature of Mercury, the dense layers of Venus's clouds, the "canals" and white caps of Mars, the great pull of Jupiter's gravity, the beautiful wide rings of Saturn, the poisonous methane atmosphere of Uranus, the "wrong-way" orbit of one of Neptune's moons, and the coldness of Pluto).

- *The planets differ from each other in many ways.*

11. How does the planet Earth appear from space?

Encourage children to use their knowledge and their imagination in answering this question. Some may wish to paint or sketch their answers.



A 1" square of paper on the surface of a ping-pong ball is curved more than one on the surface of a beach ball. A small part of the surface of a large sphere looks flat.

From space we would see our round Earth turning once every 24 hours. The reason Earth doesn't look round to us is that we don't see enough of it at one time. A small part of the surface of a very large sphere looks flat. Have the children bring in balls of various sizes, such as a beach and a ping-pong ball. Cut out one-inch paper squares. Dampen and press the paper square firmly against the ball. Have the children notice how much flatter a square appears on the larger ball.

From space, Earth would seem to be seen speeding along on its orbit at 67,000 miles per hour, making a complete trip (orbit) around the sun in one year.

A closer view of the Earth from space would reveal that some parts of Earth are having winter, while others are having summer. We would see clouds in the atmosphere. A closer examination of Earth would reveal a surface made up of lands and waters, valleys and mountains, arid and tropical regions. We might call Earth the "water planet" since almost ¾ of its surface is covered with water.

- *Earth is a sphere traveling at great speed around the sun.*
- *From space, we could see Earth having summer and winter at the same time.*
- *Half of Earth is in daylight; half is dark.*

12. What are asteroids?

Discuss with the children that in addition to the sun, planets, and many moons, there are more than 2,000 midget planets that "fill" the gap between the orbits of Mars and Jupiter. Some of these midget planets (asteroids) are as small as houses, others the size of mountains, and others 100 to 500 miles in diameter.

- *The solar system also includes asteroids, which revolve in an orbit between Mars and Jupiter.*

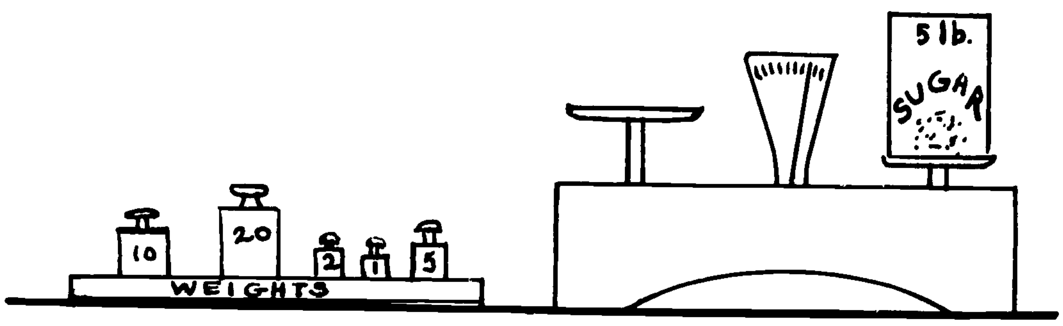
EVALUATIVE ACTIVITIES

1. Distribute copies of the chart on page 87 and select questions from pages 87-88 to determine how well children have learned how to use and interpret facts presented in chart form.

2. Why can't we always see all the planets in the night sky? (Here are some of the many answers to this question: Some planets are too far away; some are too dim to see. Some planets may be too close to the sun. It might be too cloudy. Some planets might be in the daytime part of the sky, at night we are facing away from them.)

3. You are a grocer on the moon where gravity is one-fifth that of the earth.

   a. If you placed a 5 lb. box of sugar on one pan of a balance scale, such as the one shown in the illustration, what weight would you have to place on the other pan to balance it? (5 lbs.)



b. What weight would be indicated if you put the sugar on a spring scale? (1 lb.)

c. Why is there a difference between the two scales? (The pull of gravity is less on the weights, as well as on the sugar on the balance scale.)

4. If you looked at Jupiter through a telescope, you would see that it has its own moons or satellites. Why might you see a different number of satellites at different times? (The satellites orbit around Jupiter; sometimes fewer or more are on the other side where we cannot see them.)

5. We can see the planets because

   a. they make their own light.

   b. they reflect light from the sun.

   c. they reflect light from the earth.

   d. they are very hot and glow. (Answer: b.)

6. Light travels about 186,000 miles a second. How long does it take light to reach us from the moon?

   a. About 1 second.

   b. About 1 minute.

   c. About 1 hour.

   d. About 1 day. (Answer: a.)

B. OUR STAR, THE SUN

Background for the Teacher

The sun influences Earth in many ways. The gravitational attraction of the sun keeps Earth in its orbit. Radiation from the sun provides light and warmth. Certain rays of sunlight are absorbed by green plants; the energy in these rays is stored in the food molecules made by the plant. The sun is thus the source of energy for all living things. The sun is also the source of energy that drives the "weather machine" of Earth. The topic *What Makes It Go,* on page

158, presents the role of the sun in providing the basic source of energy for driving man's machines.

The sun is our closest star. It is 93,000,000 miles away. This distance is more than 11.000 times the length of Earth's diameter: 11,000 Earths could be lined up between Earth and the sun. This distance varies during the year because of Earth's elliptical orbit. When Earth is closest to the sun, the temperature zone of the Northern Hemisphere is having its winter, and the temperate zone of the Southern Hemisphere is having its summer. When Earth is farthest from the sun, the opposite is true. The next closest star to Earth is almost 240.000 times farther away than the sun is to Earth.

The sun is a medium-sized star. The sun's diameter is about 108 times as large as Earth's. The temperature of the sun varies from about ten thousand degrees Fahrenheit on the surface to many millions of degrees in the center. Atomic-like explosions in which hydrogen atoms are changed to helium atoms produce great amounts of heat, light, and other forms of energy.

Although the sun may be regarded as a fixed point in relation to Earth's movement through space, it, too, is moving. The sun, and the entire solar system with it, are hurtling through space at fantastic speeds. In Grade 6 we will learn about the vast movements of stars, constellations, and galaxies through space.

Distance in space is so vast that measurement in miles would run into very large numbers. Scientists have, therefore, introduced the use of the *light year* as a unit of measurement. The light year represents the distance that light travels in one year. Expressed in miles, a light year is about six trillion miles.

Approaches and Learnings for the Child

With the continuing interest in space, children want to know more about the sun and its "control" over our solar system. In dealing with this topic, a word of caution must be given. *Never have the children look at the sun through a telescope, binoculars, any glass lens, or with their naked eyes.* Even a hazy sun can badly damage their eyes through the penetration of invisible ultraviolet rays.

By building models, drawing charts, making observations, making arithmetic computations, children will get a clearer idea of sizes and distances in the solar system. Readings selected from the bibliography on pages 254-255 will also be helpful.

From the activities suggested, children learn the following:

The sun is a nearby star; stars are distant suns.
The sun shines by virtue of its own atomic activities.
Life on earth would be impossible without the sun.
The sun rotates on its axis.
Over a million Earths could be placed inside the sun.
It takes light about 8 minutes to travel from the sun to Earth.
The entire solar system moves in space.

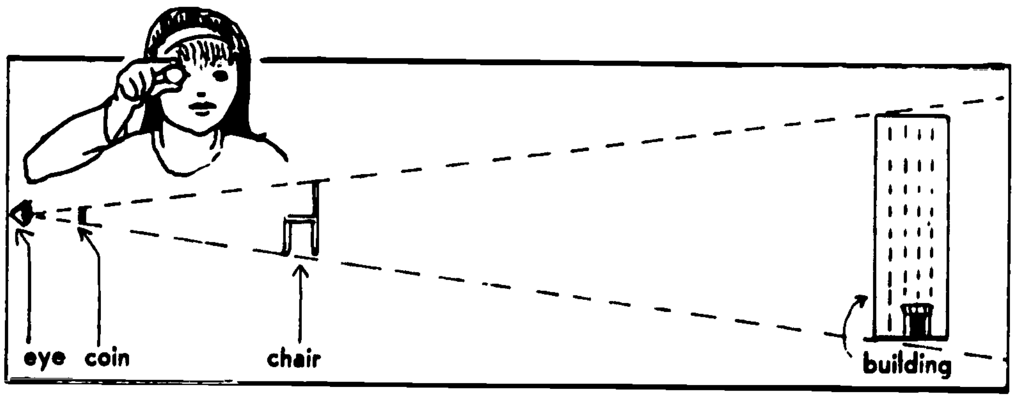
1. How big is the sun?

Children will answer this question in different ways, some by attempting to give the diameter of the sun in miles, and some by comparing it to other bodies, such as Earth and its moon.

Which *appears* larger, the sun or the moon? (They appear about the same size.) Are they really the same size? (No.) Can objects of different size *appear* to be the same size? (Sometimes, when one is farther away.) How can we show this?

Have children hold a small object, such as a coin, by its edge. Hold the coin about 6 inches from one eye and close the other. What objects around the room can be hidden by the coin? (Ceiling light, book, etc.) Look out the window and repeat the observation. What can be hidden now? (Lamppost, street sign, building.) Is a lamppost the same size as a book? Why does the same coin hide both? (Book is closer.)

In the same way, the sun and moon appear to "cut" the same size piece out of the sky. The sun is much larger than the moon but *appears* the same size because it is much farther away. The sun is about 93



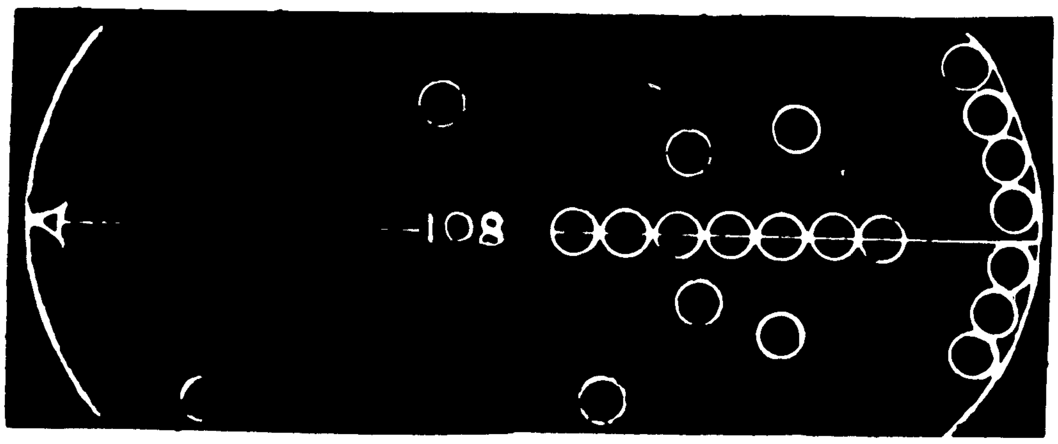
The greater the distance, the smaller an object appears.

million miles away from Earth while the moon is only about ¼ million miles away.

To give children an idea of relative size of Earth and sun, draw on the chalkboard a circle 1 inch in diameter to represent Earth. Have the children predict how large we will have to draw a circle to represent the sun. After several predictions draw on the chalkboard a diameter of 108 inches, indicating the arcs of the circle at each end.

The moon can also be represented in this diagram by drawing a circle with a ¼″ diameter.

- *The sun has a diameter 108 times greater than that of Earth.*
- *The sun and moon appear to be the same size because the moon is much closer than the sun.*



Filling the "sun" with "earths" on a chalkboard.

2. How many "Earths" can we fit into the sun?

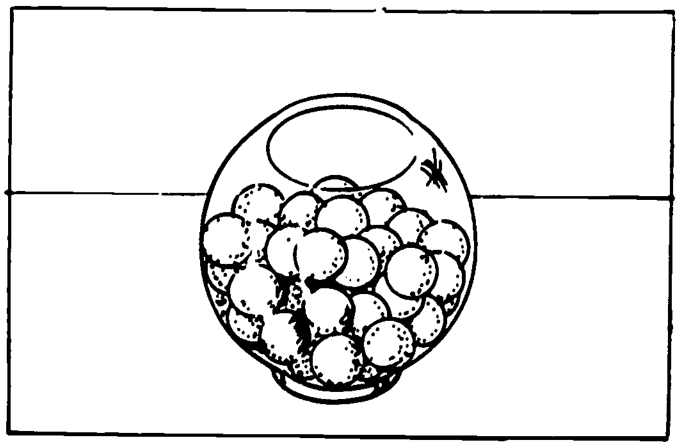
When compared to Earth, the sun is a giant. Although Earth has a diameter of almost 8,000 miles, the diameter of the sun is 864,000 miles or 108 times greater (see Problem 1). We could fit more than 1,000,000 "Earths" in a space the size of the sun with room to spare.

Have the children guess how many "Earths" will fit into the sun, remembering that its diameter is 108 times greater than Earth's. Some children will give 108 as the answer to this question. Illustrate this on the chalkboard.

Discuss with children that many more "Earths" can be placed along the circumference and in the other "empty" spaces in addition to those lined up along the diameter. Finally, they should realize that the sun is not a flat object as represented on the chalkboard, but rather a sphere. (It might be helpful to ask: How many marbles could we fit into this bowl? Try it.)

The following is optional. There is a mathematical procedure we can use to do this kind of computation.

When we compare the volume of two spheres, such as Earth and the sun, we must *cube* the diameter of each (multiply one number by itself and then multiply the product by the original number). The sun's diameter is about 100 times that of Earth but its volume is 100x100x100 or 1,000,000 times that of Earth.



Filling the "sun" (a fish bowl) with "earths" (marbles).

The sun is so large that it makes up over 99.87 per cent of the mass (the amount of material) of the solar system. It would require over 330,000 planets, each with Earth's mass, to equal the weight of the sun. Why not 1,000,000 planets? (Because the sun is gaseous and less dense, on the average, than is Earth.)

Discuss with the children that the sun's circumference is larger than the orbit of the moon around Earth. Ask them to make a drawing to show this.

- *A million "Earths" could fit into the sun.*
- *Over 333,000 "Earths" would equal the sun's weight.*
- *The sun makes up more than 99% of the material in the solar system.*

3. How big is the sun in comparison to other stars?

As we have learned from the previous problem, our star, the sun, is huge in size when compared to Earth. Yet the sun is an average-sized star. Some are smaller.

Other stars have diameters hundreds of times larger than our sun. Why then does the sun seem so much larger than all the stars? (The sun is relatively near us, whereas the other stars are very far away.)

Betelgeuse (a red star in the constellation of Orion) has a diameter of about 500 million miles — almost 600 times as large as the sun's. And Betelgeuse is not the largest! The smallest star known to astronomers has a diameter of only 1,000 miles, which is only ½ the length of the moon's diameter.

- *The sun is a star.*
- *The sun is larger than some stars and smaller than others.*

4. How long does it take the light of the sun to reach Earth?

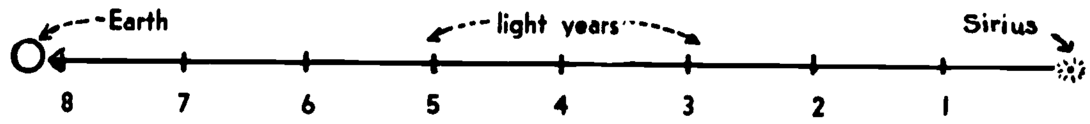
The distance from the sun to Earth is 93,000,000 miles. Light travels at a speed of 186,000 miles per second.

By dividing the speed of light (186,000 miles per second) into the distance of Earth from the sun (93,000,000 miles) children will discover that it takes 8⅓ minutes for this light to reach us. Discuss with the children that light can travel about 7½ times around Earth in *one second.*

The purpose of this discussion is to introduce children to a new unit for measuring distance — *time.* The American Indians used time when they said that a certain hunting ground was two moons away from their village. They meant, of course, that the distance was such that it would require two months of journeying to reach it, with their limited means of travel.

In astronomy, a new unit was needed because if we use miles the numbers become too large and unmanageable. We have found that it takes 8⅓ *minutes* for light to travel from the sun to Earth. We could say that the sun is 8⅓ *light minutes* from Earth. If we measure distance this way, the moon is about 1⅓ *light seconds* from Earth.

The standard used by astronomers is the *light year,* the distance light travels in one year, approximately 6 trillion miles (6 followed by four sets of 3 zeros.) The star Sirius is 8 light years away from us. (Compare this with 8⅓ *light minutes* for the sun's distance.) The closest star to us except the sun, Alpha Centauri, is about 4⅓ light years away from us.



It takes 8 years for light to travel from Sirius to Earth.
We say Sirius is 8 light years away from Earth.
We might also say that Sirius is 48 trillion miles away.

- *The distance of the sun from Earth is about 93,000,000 miles or 8 light minutes.*
- *A light year is an astronomical unit of measurement of distance.*
- *Stars are at great distances from Earth.*

5. How important is the sun to us?

List the children's answers on the chalkboard. (Many ideas will come from the study of this topic *Making It Go* on page 158 of this handbook.) Some of the important ones are given in the understandings which follow.

- *The sun warms Earth.*
- *The sun lights Earth.*
- *The sun supplies the energy for food-making in green plants.*
- *The sun causes the water cycle.*
- *The sun causes our weather.*

- *The sun was responsible for the building of Earth's reserves of fuel: coal, oil, and natural gas.*

6. Does the sun really burn?

The sun makes its own light and heat. This light and heat are not produced by burning, but by atomic action which fuses hydrogen atoms into helium atoms. This process of fusion is what also happens in the hydrogen bomb.

Using a magnifying glass, children may see evidences of atomic activity in the flashes in the radium dial of a watch or clock, seen in a dark room or closet after allowing sufficient time for the eyes to accommodate to darkness.

The surface of the sun consists mainly of hydrogen (79%), helium (20%), and small amounts of calcium, etc. Helium was found to exist on the sun before it was discovered on Earth.

The temperature of the sun's surface is approximately 10,000° F. How hot is this? Ask children to describe their experiences with hot objects. Have them compare the sand on the beach on a cool and hot day, and two automobiles, one in the shade and one in the sun. Have them compare familiar temperatures (which may vary from 100° F. to 212° F.) to the temperatures on the following chart.

Temperature of Surface of Sun	*10,000° F.*
Carbon melts	6,700° F.
Chromium melts	3,430° F.
Steel melts	2,822° F.
Aluminum melts	1,220° F.
Water boils	212° F.
Highest temperature (air) recorded on Earth	136° F.

- *The sun's heat and light are produced by atomic action, not by burning.*
- *On the sun, hydrogen is changed to helium, with a resulting release of energy.*
- *The temperature on the sun is thousands of times greater than that on Earth.*

7. What are sunspots?

Note: Warn children never to look at the sun directly through any filter, film, or with any optical device.

Sunspots were first observed by Galileo through his primitive telescope.

Sunspots appear dark because they are cooler in contrast with the hotter and brighter areas around them. Most sunspots last for a few hours or days; others have been known to last for months. Some sunspots are larger than the entire surface of Earth; some as large as ten Earth surfaces.

There is a cyclical rise and fall in the number of sunspots; each cycle persists for approximately eleven years. (See the following sunspot table.) Have the children make a graph showing the number of sunspots in the years 1937-1967. What years were peak years? Ask children to predict when the next peak years will come.

Sunspots are associated with magnetic disturbances on the sun. These disturbances upset shortwave radio reception on Earth.

PERIODS OF SUNSPOT ACTIVITY

Year	*No. of Sunspots*	*Year*	*No. of Sunspots*	*Year*	*No. of Sunspots*
1937	114	1947	152	1957	190
1938	110	1948	136	1958	185
1939	89	1949	135	1959	159
1940	68	1950	84	1960	112
1941	48	1951	69	1961	54
1942	31	1952	32	1962	38
1943	16	1953	14	1963	28
1944	10	1954	4	1964	10
1945	33	1955	38	1965	15
1946	93	1956	41	1966	54
				1967	43(?)

- *Sunspot activity happens in 11-year cycles.*
- *Sunspots are not as bright or hot as the surrounding surface of the sun.*
- *Sunspots may last for as little as a few hours or as long as several months.*

8. How do we know that the sun turns?

The sun, like Earth, turns on its axis. How can we tell? How would the study of sunspots help? (Spots mark definite places on the sun which can be observed by astronomers. They can determine how long it takes for a spot to make a complete turn.)

A study of the sunspots reveals that the sun turns unequally: the equator requires 25 Earth days for one turn while the polar areas drag behind, taking 34 days to make one complete turn. This is possible because of the *gaseous* nature of the sun. Not all of it has to turn together, as would be necessary if it were a solid body such as Earth.

- *The sun rotates on its axis.*
- *Parts of the sun turn faster than others.*
- *Astronomers discovered this by observing sunspots.*

EVALUATIVE ACTIVITIES

1. Are there any stars within the solar system? (Yes, one: our sun.)
2. Sunspots appear to move because
   a. the sun turns on its axis.
   b. they are storms which travel across the sun.
   c. the earth is turning.
   d. the earth revolves around the sun. (Answer: a.)
3. The number of "Earths" that could fit inside the sun is
   a. 100.
   b. 1,000.
   c. 1,000,000.
   d. 1,000,000,000. (Answer: c.)

4. The moon and sun *appear* to be about the same size because
   a. the sun is brighter.
   b. the sun is farther away.
   c. the moon is seen only at night.
   d. it takes light a longer time to reach us from the sun than the moon. (Answer: b.)

5. The action on the sun that produces light and heat is most like
   a. burning of coal.
   b. burning of gas.
   c. hydrogen-bomb.
   d. electric heater. (Answer: c.)

6. Light reflected from the moon takes 1⅓ seconds to reach Earth. How long would it take light to reach us from the sun?
   a. 8½ seconds.
   b. 8⅓ minutes.
   c. 8⅓ hours.
   d. 8⅓ days. (Answer: b.)

7. A *light year* is a measure of
   a. time.
   b. distance.
   c. weight.
   d. brightness. (Answer: b.)

C. FINDING OUT MORE ABOUT THE SOLAR SYSTEM

The following questions, problems, and suggestions are meant for children with an unusual interest or ability who may wish to pursue the subject further. It is not intended that the questions be specifically answered but rather that they serve as leads for additional research and discussion.

1. Take a time exposure photograph of the North Star.
2. Find out your weight on the different planets.
3. Using balls of different sizes, make a model planetarium.
4. Research and report on Ptolemy's and Copernicus' solar system.
5. Keep a graph of the time of sunsets for a one- or two-week period. Compare your findings with those of local newspapers.
6. Write a story about an imaginary trip to Mars.
7. Plan one evening meeting with some friends to observe the planets.
8. Make a large mural depicting the planets' orbits around the sun. Include a scale showing relative sizes.
9. Find out about the theories which attempt to explain the beginning of our solar system.
10. Report on ancient myths about our Earth and planets.
11. Report on comets in the solar system.
12. Report on meteors.

BASIC SUPPLY LIST

FOR *THE SUN'S FAMILY*

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

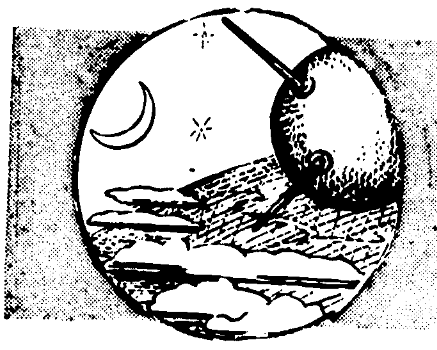
1 magnifying glass
*1 spring scale
*1 balance scale
* g graphic globe
*1 pkg. large balloons

G-1: General Supply List

- 1 flashlight
- *2 boxes thumbtacks
- 1 pencil
- *1 pkg. construction paper
- * ball of string (warp, thread white)
- * volley ball
- * basketball
- 1 large oaktag
- 1 oaktag 6"x6"
- *1 pkg. marbles

Miscellaneous:

- photographs of Earth's curvature
- star maps
- assorted coins
- clocks and/or watches with radium dials
- *2 tennis balls
- *2 ping-pong balls
- *1 soccer ball
- *2 baseballs
- *1 beach ball



Climate

A. CLIMATE AND WEATHER

Background for the Teacher

In considering both climate and weather, the same factors — temperature, precipitation and wind — are involved. However, climate and weather are quite different. Weather is the actual conditions existing at a given time and place. Climate is the average weather for a region over a long period of time.

Weather is a temporary condition. The severe cold of one or two days can be followed by a week of mild temperatures. A heavy rainfall might precede a long period of drought. No matter how bad today's weather might be, tomorrow's might be better — or worse! Such is not the case with climate. Patterns exist in different regions throughout a period of a year and they are fairly predictable. There is little likelihood of a white Christmas in Miami.

It is sometimes very important to know what the local weather will be in order to plan one's clothing or activities. However, daily weather fluctuations do not usually profoundly influence man or his livelihood. Climate, on the other hand, is an important factor for man, both economically and physiologically. Climate determines to a large extent the nature of the soil and vegetation of a given area, and, therefore, the agriculture of a region. The density of population that a given place can support is greatly dependent on its climate. In a similar way, man himself is influenced by climate. Cool or moderate climates tend to stimulate the physical activity of people, while hot and humid climates tend to slow down their physical pace.

There are many kinds of climates in the United States: hot and humid; hot and dry; cold and damp; cold and dry. New York's climate includes many extremes of weather from one end of the year to the other. Other cities in the United States might have similar average annual temperatures, but may have very different climates. Cities on the Pacific, for example, do not have the variety and extremes of weather experienced here.

The climate of a region is determined by its latitude, altitude, proximity to water, and the prevailing winds. How these conditions affect climate will be discussed in topics B, C, and D.

Approaches and Learnings for the Child

Children know that on any one day the weather is not the same in all parts of the United States. They listen to radio reports, watch weather programs on television, read newspapers, and discuss vacation plans. They know that some New Yorkers go to Florida during the winter because it is warm there, and that the Midwest has severe winters.

From personal experience they are aware that the weather in New York City varies from day to day and, more substantially, from season to season. They have observed that, allowing for daily fluctuations and unseasonable extremes, New York City weather follows a more or less predictable seasonal pattern. Building on this background, they will be helped to distinguish between weather (daily fluctuations of conditions in the atmosphere) and climate (average weather for locality over a long period). Discussions and experiments will also help to develop an understanding of climate in terms of their own lives.

From the activities suggested, children learn:

Climate is the average weather for a region over a long period of time.

There are many climates in the United States.

Temperature and moisture are the most important characteristics used in describing the climate of a region.

1. How does yesterday's weather in New York City compare with that of other cities?

Ask children to describe the previous day's weather. (Note: Two aspects of the weather picture likely to be stressed are *temperature* and *precipitation* (rain or snow). Children's descriptions may include such words as clear and warm; rainy and cool; snowy and cold.

How can we find out yesterday's exact temperature and amount of rain (or snow)? Some children may suggest calling the weather bureau; others may say to consult the newspapers.

Have children look at the weather page of *The New York Times* and consult the table (and/or map) which shows weather conditions in large cities. What are the headings of the different columns? What were New York City's temperature and precipitation yesterday? How do they compare with those of other large cities which are listed?

Encourage children to prepare charts similar to that illustrated. On the chalkboard and in their notebooks, have them record one day's weather for five or six widely separated cities. These charts may include columns for listing high temperatures, low temperatures, precipitation, and general weather conditions for each city.

Chart A

Weather in Some Cities on (fill in date)				
City	Highest Temp.	Lowest Temp.	Precipitation	Condition
Bismarck, North Dakota				
Denver, Colorado				
Honolulu, Hawaii				
Los Angeles, Calif.				
Miami, Florida				
New York, New York				
Fairbanks, Alaska				

Which city had the highest temperature? Which city had the lowest temperature? Which city had the most precipitation? Children will see that daily weather conditions vary greatly from one part of the country to another.

- *Temperature and rainfall are important features of daily weather.*
- *Daily weather varies greatly in different parts of the country.*
- *On any one day New York City is warmer than some cities and cooler than others.*

2. How does this month's weather in New York City compare with that of other cities?

Have children refer to the chart they made in Problem 1. Note that the temperature recorded for each city is for only *one* day. What would the weather be like in these cities for an entire month? How could we find out? One suggestion children may make is to record the day-by-day weather for each of the cities for a month, basing this on newspaper reports. To make comparisons, it would then be necessary to find the *average* for each of the cities for temperature and for precipitation. This would require adding the figures for each city and then dividing by the number of days.

An easier method is to consult the *World Almanac* for its table of the normal (average) temperatures for the month. (These are based on records for the thirty years between 1931 and 1960.)

Whichever method is used, enter the facts on Chart B.

Ask children to draw conclusions from the chart. Which city has

a. the highest average temperature?

b. the lowest average temperature?

c. the highest average precipitation?

d. the lowest average precipitation?

Chart B

Average Weather in some U.S. Cities for the Month of (fill in month)		
City	Average Temperature	Average Precipitation
Bismarck, North Dakota		
Denver, Colorado		
Honolulu, Hawaii		
Los Angeles, Calif.		
Miami, Florida		
New York, New York		
Fairbanks, Alaska		

Ask the children to assume that they were planning a visit to these cities for the month being studied. Based on the figures in Chart B, for which city or cities would it be wise to

a. bring a raincoat b. bring an overcoat c. bring ice skates

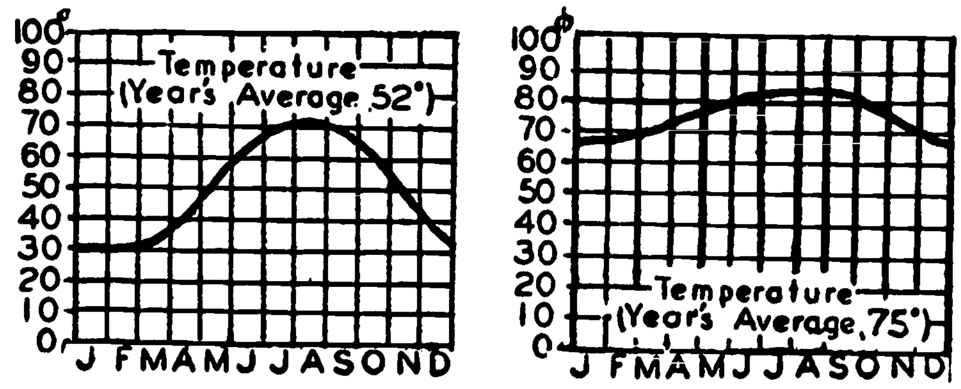
d. bring a bathing suit e. bring an overcoat *and* a topcoat f. bring snow skis?

Introduce the word *climate* for the *average weather* over a period of time. The climate of a city describes what to expect there for a month or a season.

- *Weather is the daily condition of the atmosphere.*
- *Climate is the average weather over a long period of time.*

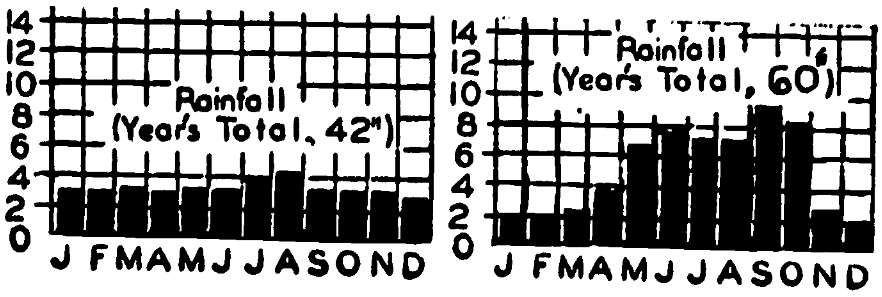
3. How does the 12-month climate picture of New York compare with that of other cities?

A graph of the monthly averages of temperature and rainfall tells the climate story effectively. The students might be furnished with statistics from the *World Almanac* and then guided into making such graphs, comparing New York with at least one other city in this way. As shown in the illustrations, both rainfall and temperature are included, each with its own graph for the same period.



New York Miami

AVERAGE MONTHLY TEMPERATURES



New York Miami

AVERAGE MONTHLY RAINFALL

It might be helpful to post large graphs of each of the cities around the room and to leave them there for several weeks. Children should be encouraged to draw their own conclusions from the graphs. Ask children to answer:

a. In which city would you need the least change of clothing during the year? The most?

b. Which city or cities would you select if you wanted a very dry climate? A rainy climate?

c. Which city or cities would you select if you wanted an average monthly temperature that would never be below freezing? Above 80° F.?

- *There are many kinds of climate in the United States.*

- *Climate affects the manner in which people live.*

4. Why are climates different in various parts of the country?

Encourage children to suggest those factors which they think might be responsible for the climate of a particular place. Some responses they may offer are:

"Some places might be farther south or farther north than others."

"Oceans may have something to do with the climate of a place."

"Mountains may have something to do with the climate of a place."

List all responses on a chart. Explain that subsequent topics will deal with those factors which influence climate. As children study these factors, have them check back with the chart.

- *There are a number of reasons why climates are different in various parts of the country.*

EVALUATIVE ACTIVITIES

1. In the chart below, which city had
   a. the highest temperature? (Los Angeles.)
   b. the lowest temperature? (St. Paul.)
   c. the temperature closest to New York's? (St. Louis.)
   d. the temperature least like New York's? (Los Angeles.)

CITY	HIGHEST TEMP. 3-1-67
Los Angeles	88°
Miami	84°
New York	43°
Phoenix	79°
Richmond	50°
San Francisco	63°
St. Paul	27°
St. Louis	44°

2. According to the newspaper on March 1, 1967, the *average temperatures* for the day of the following cities were:

Los Angeles	87°
Miami	83°
New York	44°
Phoenix	80°
St. Paul	28°

According to the almanac, the *average yearly temperatures* for these cities are:

Los Angeles	64°
Miami	75°
New York	54°
Phoenix	69°
St. Paul	46°

a. In which of these cities was the temperature on March 1st lower than the average yearly temperature? (New York and St. Paul.)

b. In which of these cities was the temperature on March 1st higher than the average yearly temperature? (Los Angeles, Miami, and Phoenix.)

c. In which of these cities might people be wearing lightweight clothing on March 1, 1967? (Los Angeles, Miami, and Phoenix.)

B. LATITUDE AND CLIMATE

Background for the Teacher

It is common knowledge that the regions of the world near the equator generally have a hotter climate than those farther north or south. For example, the average temperature near the equator is around 80° F., while at the North Pole it is about 5° below zero F.

Why does latitude influence climate? In any region, the amount of heat received from the sun annually depends on the angle at which the sun's rays strike the earth at that place. In general, regions near the equator receive the sun's rays directly. As we move away from the equator the sun's rays strike the earth's surface at more and more of a slant. We learned in Grade 4 that direct rays warm more than rays received at a slant. (Think of how warming it is to turn your face directly toward the sun when sitting on a park bench on a cool spring day.) Thus, the equatorial regions are heated more than the temperate regions, and the temperate regions more than the polar regions.

One result of this unequal heating of the earth's surface is the creation of winds. Cold polar air flows toward the equator, and pushes up the hot and, therefore, lighter equatorial air. A circulation is set up as the hot air flows toward the poles where it is eventually cooled and returned to the tropics.

The earth's rotation and the various topographical features on the earth prevent this cycle from being a simple, smooth flow from poles to equator and back. The various wind patterns which result from all of these factors play a large part in causing the different climates of the world.

Approaches and Learnings for the Child

Most children know that, in general, the climate gradually becomes cooler as one travels away from the equator and toward the poles. The latitude of a place — its distance from the equator — has a great influence on its average temperature.

Inspection of a globe of the earth will indicate why latitude makes a difference. Children will see that the equatorial regions receive the sun's rays directly, while regions farther from the equator receive the sun's rays at a slant. By simple experiments, children discover how slant influences the amount of heat received from the sun by a surface; greater slant, less heat. They also find out that unequal heating causes winds.

From the activities suggested, children learn:

Latitude is the distance of a place from the equator.

The sun's rays strike the earth at a greater slant in higher latitudes.

The more slant to the sun's rays, the less heating results.

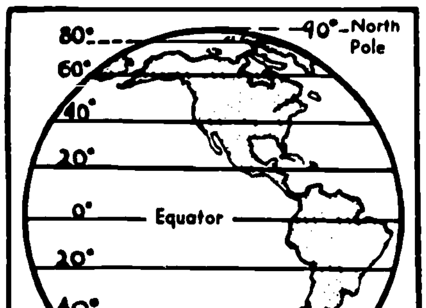
The latitude of a place is important in determining its year-round temperature.

Winds start blowing because of the unequal heating of the earth.

1. What is the latitude of some of the cities in the United States?

Review the responses offered by children in Topic A, Problem 3, as to why they think there are different climates in various parts of the country. One such response may have been that a place was "farther south." To comprehend what "farther south" means, it is necessary for children to understand the concept of latitude.

The terms *latitude* and *parallels of latitude* are taught in the fifth grade in relation to map and globe skills. Latitude, a means of finding positions north and south of the equator, is expressed in degrees.



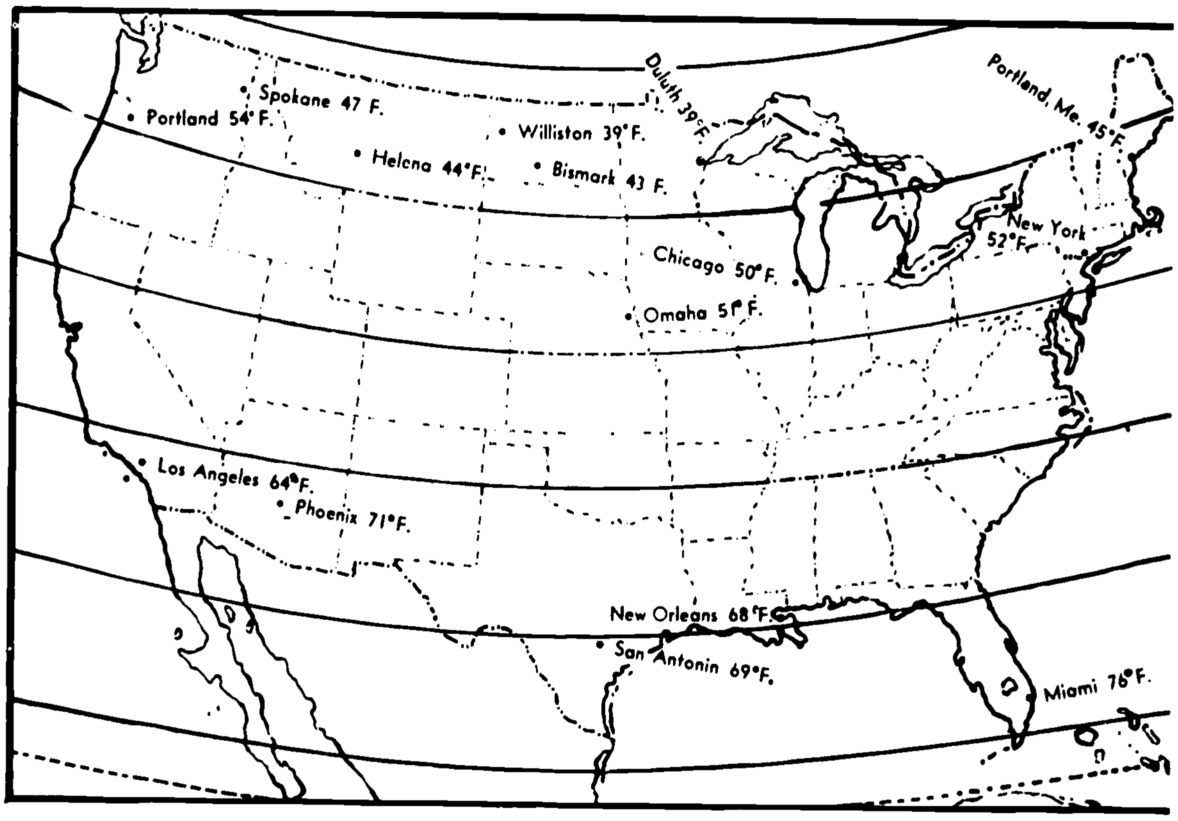
Parallels of latitude.

Have the children look at globes and find the equator. Point out that the circles above and below the equator are called parallels of latitude. They are imaginary circles, of course, and are measured in degrees north or south of the equator. The equator is at 0° Latitude; the geographic North Pole is at 90° North Latitude.

Note: The distance from the equator to the North Pole is ¼ of a great circle around the earth. A circle contains 360°: $\frac{1}{4} \times 360° = 90°$.

Have children find, and enter on a prepared outline or chalkboard map, the latitude of the cities studied in A - 1, page 00, and A - 2, page 00. For example, New York City is at about 41° North Latitude. Which city has the lowest latitude in the United States? Which city has the highest? (The U.S. lies approximately between 25° North Latitude and 50° North Latitude.) The students should understand that the higher the latitude of a city, the farther away it is from the equator.

- *Latitude gives the position of a place with respect to the equator.*
- *The higher the latitude, the greater the distance north or south of the equator.*
- *Latitude is measured in degrees.*
- *Each degree represents about 70 miles.*
- *The North Pole is 90° North Latitude.*
- *New York City is about 41° North Latitude.*



The average yearly temperatures in some American cities. How are they affected by latitude?

2. How does the latitude of a place affect its climate?

Have children add to the map made for Problem 1 the data for average yearly temperatures given in Chart C.

What is the relationship between latitude and average yearly temperature?

Chart C

Average Yearly Temperatures for Cities of Different Latitudes		
City	Latitude	Average Yearly Temperatures
Honolulu, Hawaii	21° N	
Miami, Florida	26° N	
Los Angeles, California	34° N	
Denver, Colorado	40° N	
New York, New York	41° N	52° F.
Bismarck, North Dakota	47° N (App)	
Fairbanks, Alaska	65° N (App)	

- *In general, the higher the latitude, the lower the average yearly temperature.*

- *In general, the higher the latitude, the lower the average yearly temperature.*

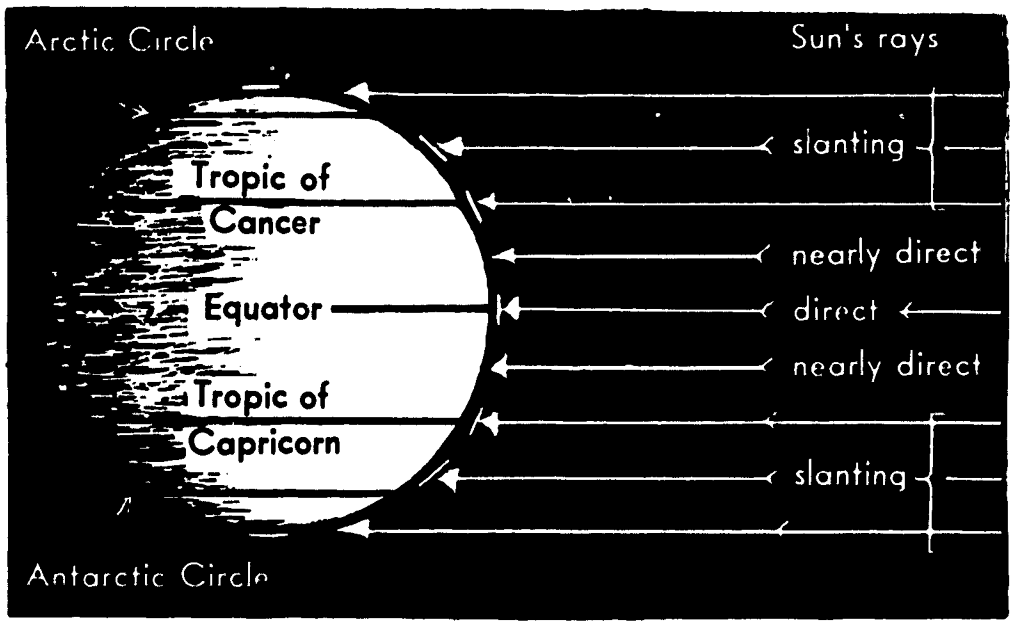
3. Why does the latitude of a place affect its climate?

Have children look at the chart in Topic B, Problem 2, above to recall the relationship between latitude and average yearly temperature. What might be the reason for this relationship? Some children may say that the sun "is hotter" in some places than in others. Is it the sun itself that is really hotter? (No.) Then what is it? Some children may suggest, from their recollection of the study of seasons in Grade 4, that

The sun's rays which hit Earth are almost parallel. (Not drawn to scale.)

the slant of the sun's rays may have something to do with the differences in heat. How could a difference in latitude affect slant of rays?

The following illustration may be drawn on the chalkboard to show how the sun's rays strike the earth. The sun is so far away that those of its rays which reach the earth are practically parallel. Discuss the angles at which the rays strike the earth. Where are the rays most direct? (Near the equator.) Where are they most slanted? (Toward the North and South Poles.) Suggest that children make similar drawings in their notebooks.



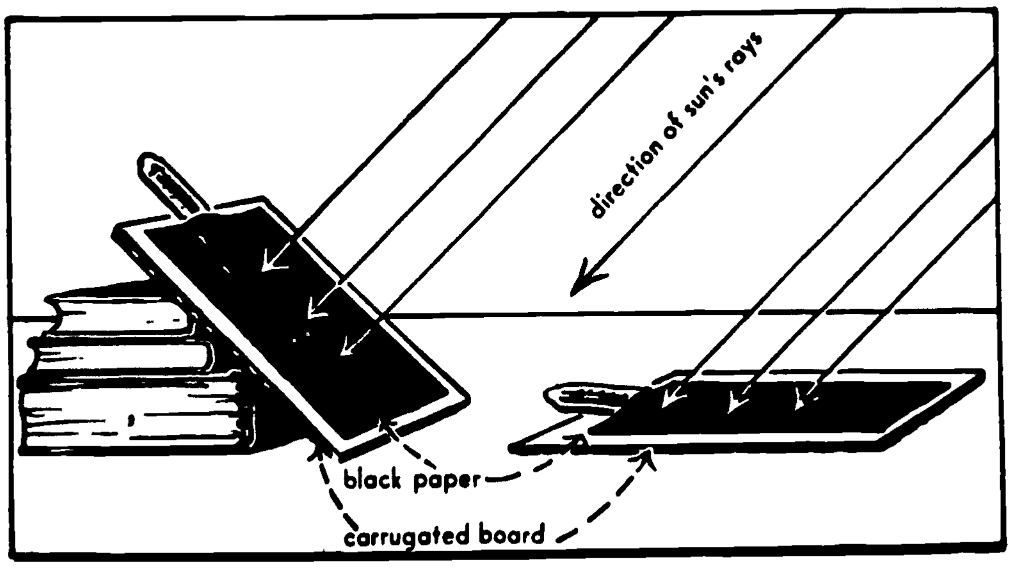
Latitude affects the angle at which the sun's rays strike Earth.

- *Near the equator, the earth receives direct rays from the sun.*
- *As the latitude increases, the slant of the sunlight increases.*

4. How much difference does the slant of the rays of sunlight make in the amount of heat received?

Encourage children to design an experiment to determine the difference in temperature when a spot is heated by direct rays and by slanted rays. Some children may suggest this experiment:

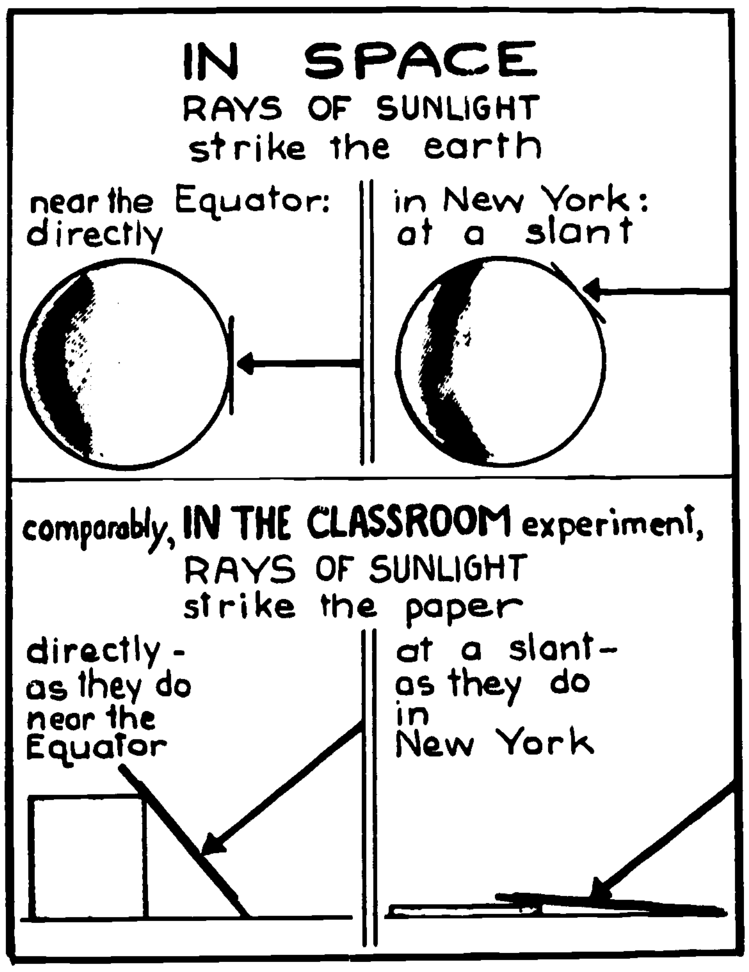
Staple a sheet of black paper to each of two pieces of corrugated board and leave room for a pocket in which to place a thermometer. (Black paper is used to absorb as much heat as possible, and the corrugated board serves as an insulator to keep in the heat.)



Direct rays warm more than slanting rays.

Place these boards in sunlight in the classrom, in positions that correspond approximately to that of the surface of the earth near the equator (at an angle of approximately 90°) and the earth near New York City (at an angle of approximately 45°). Record the initial readings of each thermometer. After five minutes feel each piece of paper. Is it warmer? Check thermometers and record readings. Additional readings can be recorded every five minutes for one-half hour. What do the readings tell you? (Slanted rays of sunlight give less heat than direct rays.)

- *Direct rays of sunlight heat more than slanting rays.*
- *Near the equator, the earth receives direct rays from the sun.*
- *As the latitude increases, the slant of the sunlight increases.*

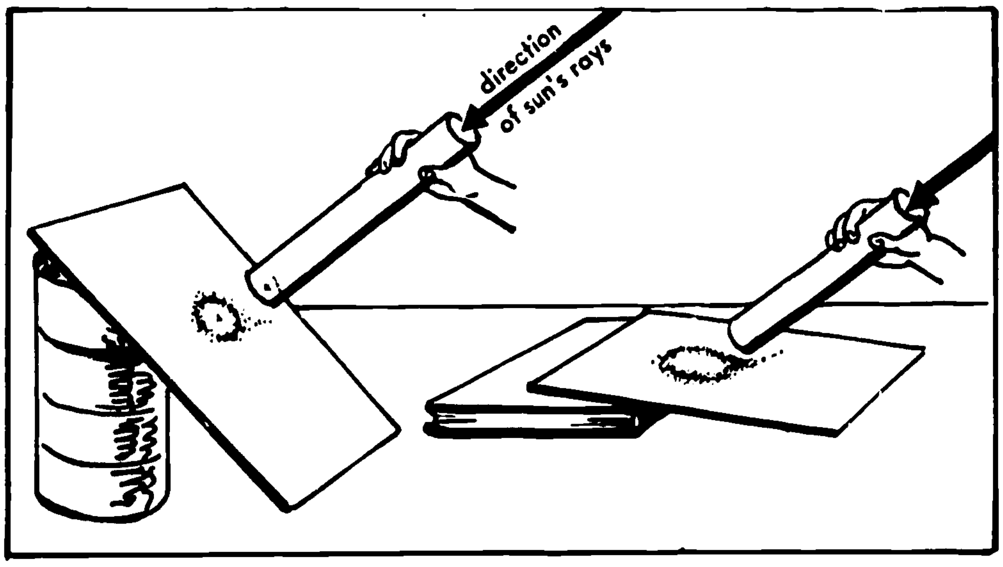


5. Why does the slant of the rays of sunlight make a difference in the amount of heat received?

Two demonstrations which children may conduct to find an answer are:

a. Obtain a cardboard tube (from a roll of paper towels, aluminum foil, or wax paper) and a sheet of stiff white paper. Hold the tube in a direct line with the sun's rays. Hold the paper at right angles to the light. What is the shape of the spot of light? (A circle.) This is the way light is received in the equatorial regions.

Now tilt the paper so that the light hits it on a slant. What is the shape of the figure it makes? (Oval or ellipse.) This represents the way the light is received in the regions distant from the equator. The children will observe that the light on the paper is dimmer. By concentrating attention on the size of the area within the ellipse, the children may suggest that the light is dimmer because the original amount is now

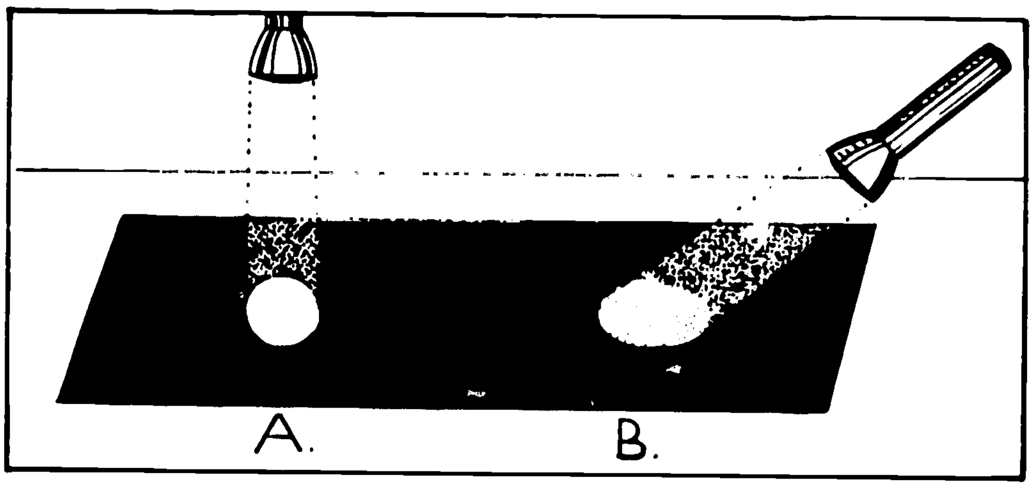


Sunlight that falls at a slant is spread over a wider area.

spread over a larger area. This is true. But sunlight also *heats* the earth. This means that both the amount of light and the amount of heat decrease when the sunlight spreads over a larger area.

In summary, where sunlight strikes the earth directly, its rays are concentrated and heat the earth strongly; where sunlight strikes the earth at a slant, its rays are spread and heat the earth less strongly.

b. Provide groups of children with a flashlight and a piece of dark construction paper. While one child shines the light *directly* on one half of the paper, another child draws the circle of light. Have the child with the flashlight hold it at a slant over the other half of the construction paper at the same distance from the paper as before. Ask another child to trace the shape of the illuminated figure (an ellipse) on the paper. Have children compare the two figures. What is their shape? (One is a circle, the other an ellipse.) Are they different in any other way? Some children may suggest that one is larger than the other. How can we tell? One way is to cut out each figure and place one on top of the other. Another is to place a number of pennies, 5 or 10, on each figure and see how many can be put into the areas. (A math "genius" in the class may know how to calculate the areas from formulas.) Encourage children to discuss how the area covered is related to the amount of light received from the sun.



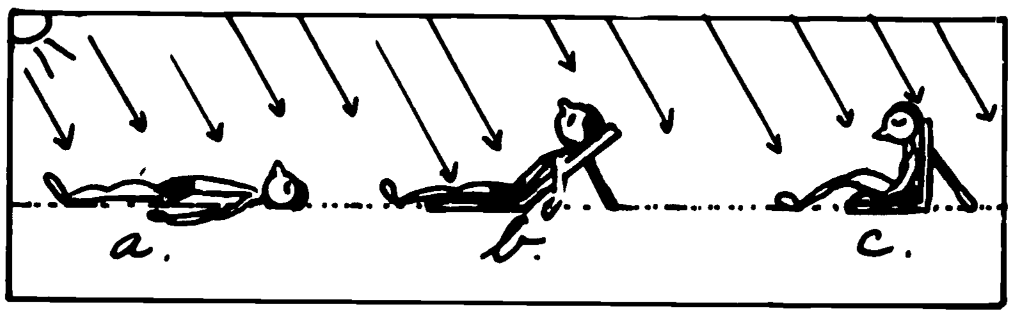
In A, the spot is round and bright.

In B, the spot is oval and not as bright.

- *The sun's rays are spread over a larger area when they strike the earth at a slant.*
- *Less light and heat are received when sunlight falls at a slant on a given area than when it strikes directly.*

EVALUATIVE ACTIVITIES

1. Would your face get a better tan at the beach if you were lying in position A, B, or C? (B.) Why? (The sun's rays would shine directly on your face; direct rays heat more than slanting rays.)



2. Listed below are some cities and their latitudes. Arrange these cities according to their distance from the equator. (Miami, Richmond, Philadelphia, New York, Boston, Portland.)

Boston, Mass.	42° N	Portland, Me.	43° N
New York, N. Y.	41° N	Miami, Fla.	25° N
Philadelphia, Pa.	40° N	Richmond, Va.	37° N

C. OCEANS AND CLIMATE

Background for the Teacher

The air surrounding the earth is heated by the earth itself. The sun's radiant energy is first absorbed by the rocks, soil, and water of the earth, and changed into heat. These warmed materials, in turn, heat the layer of air closest to the surface of the earth.

Land, however, gains and loses heat more rapidly than water. During the daytime, for example, the air above land at a summer seacoast is warmer than the air above the ocean. In the evening, however, land loses its heat more rapidly than water and so the air above the ocean is relatively warmer than air above land. For these reasons, coastal cities generally have a more moderate temperature than inland cities; they are cooler in the summer and warmer in the winter. (We will modify this statement somewhat in the material which follows.)

Inland areas in the temperate zones tend to have hot summers and cold winters *(continental climate)*, while areas near the sea tend to have cooler summers and milder winters *(marine climate)*. Small islands such as Hawaii have climates like those of their surrounding waters; these climates are equable (uniform). The interiors of continents, on the other hand, experience greater extremes of temperature, especially in middle latitudes.

Cities on the West Coast of the United States tend to have more moderate temperatures than cities on the East Coast at the same latitude and altitude. Why? The moderating effect of the ocean is more pronounced on the West Coast than on the East Coast because of the *prevailing westerlies*. These are the winds which blow from west to east most of the time.

The prevailing winds carry ocean air to the west coasts of continents in the middle latitudes. The climates produced there are known as *marine west coast climates*. The mild climate of Portland, Oregon, and London, England, are examples of this type.

On the East Coast, as at New York and Boston, the prevailing westerlies blow from the interior, bringing hot winds in the summer and cold winds in winter. This gives the East Coast a climate that resembles the continental climate of the interior. The Atlantic Ocean, although close by, has little temperature effect on the East Coast because the winds are usually "blowing the wrong way" — from the land rather than from the ocean.

Approaches and Learnings for the Child

In the study of climates of the United States, it is important to consider the influences of large bodies of water such as the Atlantic and Pacific Oceans, the Gulf of Mexico, and the Great Lakes. The Gulf Stream and the Japanese Current also play their part in influencing our climate.

In this section children continue their work with maps, and with records found in newspapers and almanacs. They also have opportunities to experiment with soil and water to discover the different rates at which these materials heat up and cool off.

From the activities suggested, children learn:

Coastal cities are generally warmer in winter and cooler in summer than inland cities at the same latitude.

Water warms up and cools off more slowly than land.

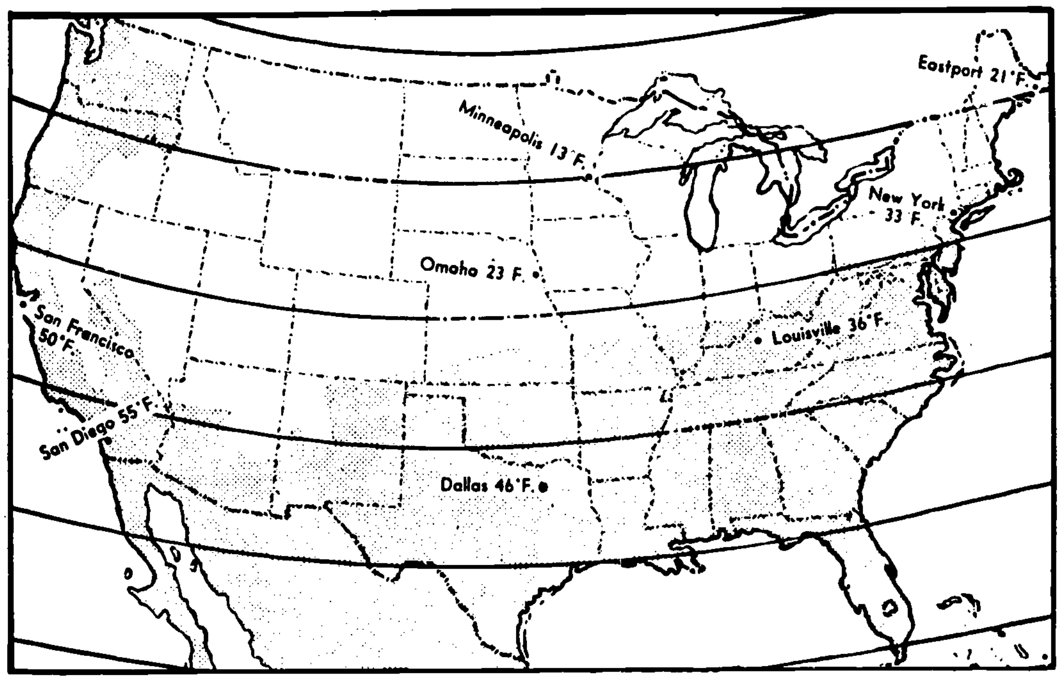
The West Coast climate is different from that of the East Coast because of prevailing westerlies (west winds).

There is a constant cycle of water from oceans to clouds to oceans.

1. How does the winter climate of coastal cities compare with that of inland cities of the same latitude?

Children consult a physical map of the United States and select several pairs of coastal and inland cities that have the same latitude and elevation, such as New York and Omaha, San Francisco and Louisville.

Children then consult an almanac to find average temperatures for the month of January for each pair of cities. This information can then be recorded on a map such as the one illustrated here.



Average temperature in January for some coastal and some inland cities. (Unshaded areas are below 32° F.)

- *At the same latitude, coastal cities are generally warmer in winter than inland cities.*

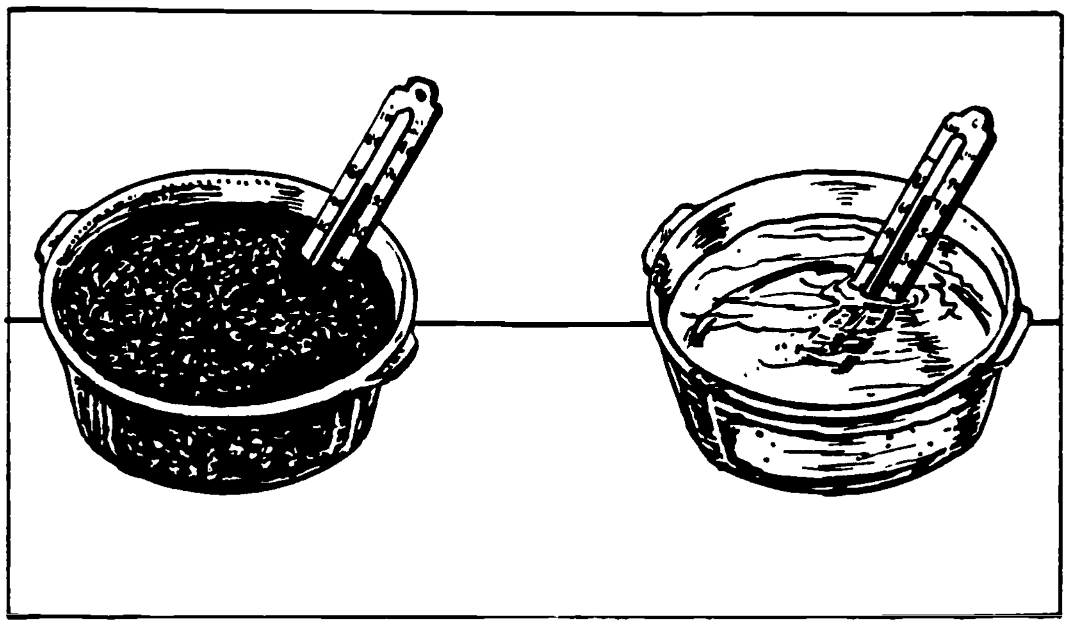
2. Why are coastal cities generally warmer in winter than inland cities at the same latitude?

Discuss the fact that both the land and the oceans warm up after being heated all summer. In the winter both land and water lose heat. Which stays warm longer — water or soil?

Ask children to suggest an experiment to help them find the answer to this question. This experiment might be used:

a. Place soil (to represent land) in one baking dish and water (to represent the ocean) in another. Use equal volumes of each. Allow them to stand until both are at room temperatures.

b. If it is a cold day, place both dishes outside (in the shade) and observe their temperature at five-minute intervals. The bulb of the thermometer should be about ¼ inch below the surface. (If the outdoor temperature is the same as that indoors, place both dishes in a refrigerator, if possible.)



Water remains warm longer than soil.

Make a table of the readings. (The following is given only as a sample. The observations children make will be different, depending on the particular conditions of their experiment.)

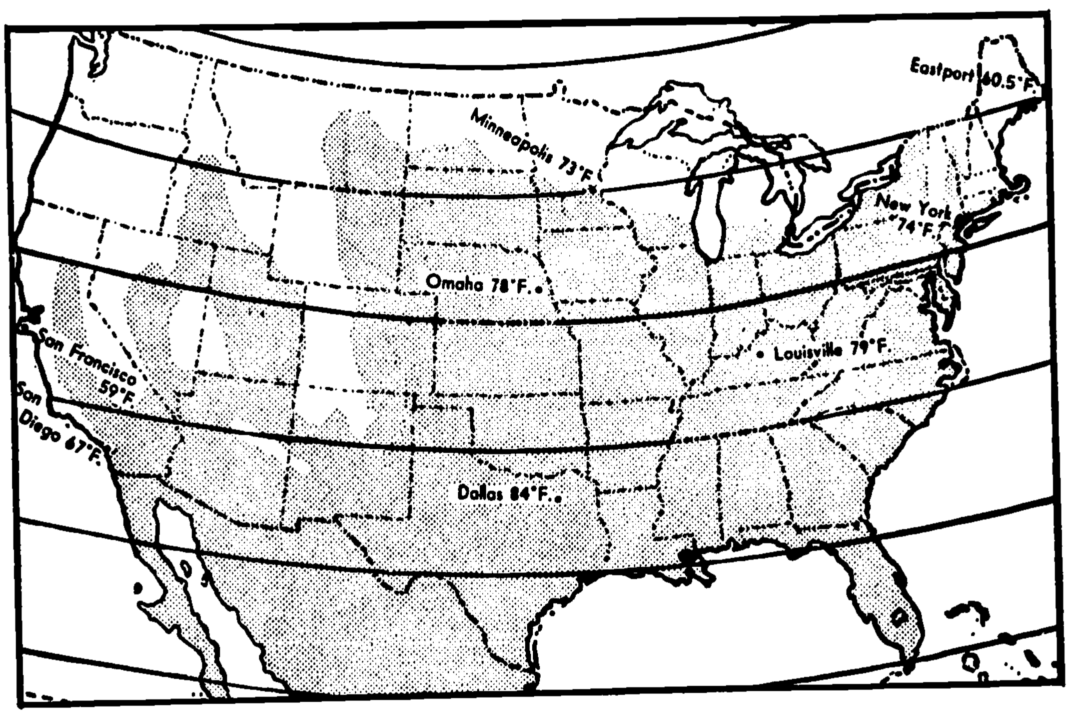
INTERVALS	SOIL	WATER
First reading	70°	70°
After 5 minutes	67°	69°
After 10 minutes	64°	67°
After 15 minutes	61°	67°

We find that, in the dishes, water cools off more slowly than soil. Help children to infer that, similarly, when winter comes, the ocean water retains its heat and gives it off *slowly* to the air near it. This helps to keep the air from cooling fast and explains why temperatures are higher near the ocean in winter.

- *A volume of water holds heat longer than an equal volume of soil.*
- *Coastal cities are warmer in winter than inland cities at the same latitude because the nearby ocean waters heat the air.*

3. How does the summer climate of coastal cities compare with that of inland cities of the same latitude?

Using the same pairs of cities as in Problem 1, page 00, children consult sources such as almanacs to find average temperatures for July for their pair of cities. They record their findings on a map.



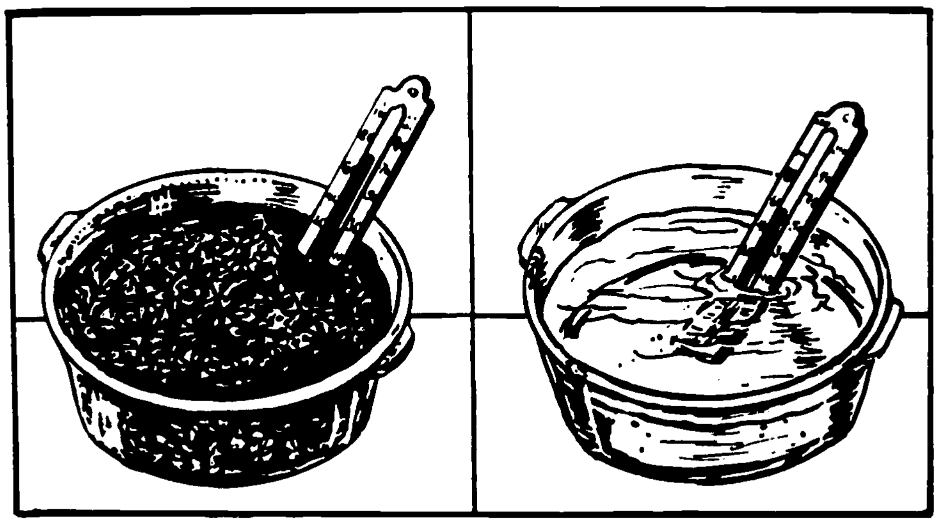
Average temperature in July for some coastal and some inland cities.
Note difference between West Coast and East Coast.
(Shaded areas are over 72° F.)

- *Coastal cities are generally cooler in summer than inland cities at the same latitude.*

4. Why are coastal cities generally cooler in summer than inland cities at the same latitude?

(See Problem 2, Topic C.) By the end of the winter, land and water have become quite cold. Both land and water warm up in the spring and summer. Which warms up more quickly? Ask the children to suggest an experiment to compare the warming up of water and soil. One way of doing this is to:

a. Place containers, one with water and one with soil (equal amounts of each), outdoors on a cold day or in a refrigerator for about an hour or until both are at the same temperature.



Water remains cool longer than soil.

b. Bring both into the room and take the temperature every five minutes. Make a chart of the readings. The following is given only as a sample. The observations *children make* will be different, depending on a number of conditions.

INTERVALS	SOIL	WATER
First reading	40° F	40° F
After 5 minutes	43° F	41° F
After 10 minutes	46° F	42° F
After 15 minutes	49° F	43° F

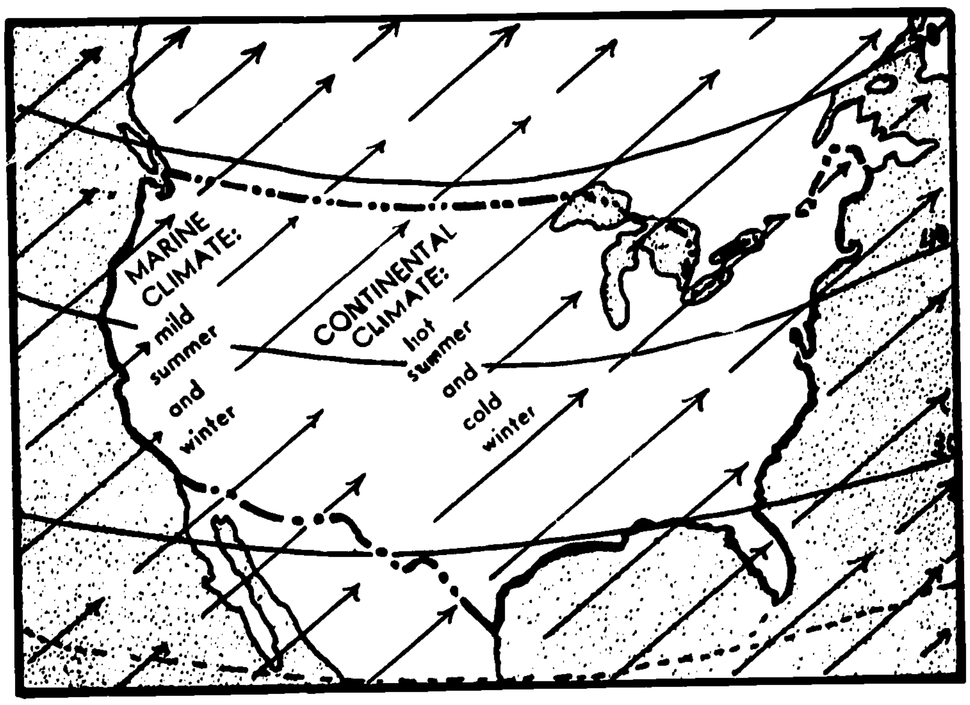
Children inspect the results and conclude that, in the containers, the water warms more slowly than the soil. Help them to infer that, similarly, the ocean in summer is cooler than the land and cools the air near it. This would explain why coastal cities are generally cooler in the summer than inland cities at the same latitude.

- *Water warms up more slowly than soil.*
- *Because the nearby ocean waters cool the air, coastal cities are generally cooler in summer than inland cities at the same latitude.*

5. Why does the West Coast of the United States have cooler summers and warmer winters than the East Coast?

Both the West and East Coasts are influenced by the proximity of oceans, as we have seen in Problems 1 through 4, Topic C. The oceans have a moderating effect, making summers cooler and winters warmer than in inland areas.

But why is the West Coast different? To answer this question one must consider the effect of the prevailing westerly winds. The term "prevailing" means these winds blow more often from one direction (west) than from any other. The prevailing westerlies blow in a generally west-to-east direction across the United States.



The prevailing westerlies affect our climate.

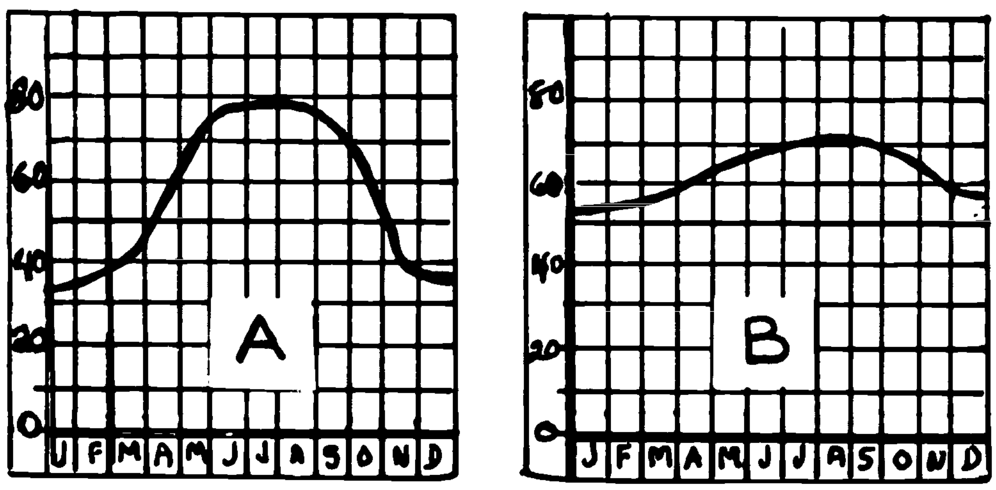
On the West Coast the prevailing westerlies carry ocean air to the land, thus affecting its temperature in the ways indicated above. On the East Coast, as at New York City and Boston, the prevailing westerlies blow from the interior, bringing hot winds in summer and cold winds in winter. This gives the East Coast a climate that more closely resembles the *continental* climate of the interior. The Atlantic Ocean, although close by, has less of a moderating effect on the coast because the winds are usually "blowing the wrong way," that is, from the land to the ocean.

- *The West Coast climate is different from that of the East Coast because of the prevailing westerlies.*

EVALUATIVE ACTIVITIES

1. (a) The graphs below show the average monthly temperatures for two cities. One is an inland city; the other is on the West Coast. Which graph might be for the coastal city? (B.)

   (b) What does the graph show that leads you to give the answer you did? (The differences of temperature between summer and winter are much less in graph B than in A.)



2. Which one of the following statements is true?

Coastal cities are generally

a. cooler all year than inland cities.
b. cooler in winter and warmer in summer than inland cities.
c. warmer all year than inland cities.
d. warmer in winter and cooler in summer than inland cities.

(Answer: d.)

D. MOUNTAINS AND CLIMATE

Background for the Teacher

The rays of sunlight pass through the earth's atmosphere without heating it very much. The sun's radiant energy is first absorbed by the rocks, soil, and water of the earth, and changed into heat. Those warmed substances, in turn, heat the layer of air closest to the earth. Most of this warming occurs in the lower, denser part of the atmosphere. Thus, the farther away one gets from the surface of the earth, the farther away one is from the place where the atmosphere is being warmed.

When air laden with moisture is brought toward the windward side of a mountain, it is deflected upward. The cooler temperature in the higher levels causes the water vapor in the air to condense into clouds; rain or snow may follow. The air which subsequently passes to the leeward side is drier. The climate on the leeward side of the mountain is generally sunny and dry, sometimes approaching desert conditions.

Approaches and Learnings for the Child

Children know from experience and from reading that it is cooler in the mountains than in other places which are at the same latitude. They may not be aware that mountains also influence climate by causing air to rise and lose its moisture through condensation and precipitation. Because of the proximity of mountains, some places in the United States are deserts and some have excessive rain.

From the activities suggested, children learn:

Mountains affect temperature and rainfall.

The higher the elevation, the cooler the region.

The side of a mountain facing the wind usually has more rainfall than the other side.

When moist air is pushed up a mountain, it cools; the water vapor in it may condense into clouds, and rain may fall.

1. What happens to temperature as we go up?

Discuss the reason some people take summer vacations in the mountains. The children may say that it is to escape the city heat. Some of them may recall enjoying cool nights in the mountains while New York City was sweltering in a heat wave. Pictures might be shown of mountains, even some near the equator, that are snowcapped in the summer.

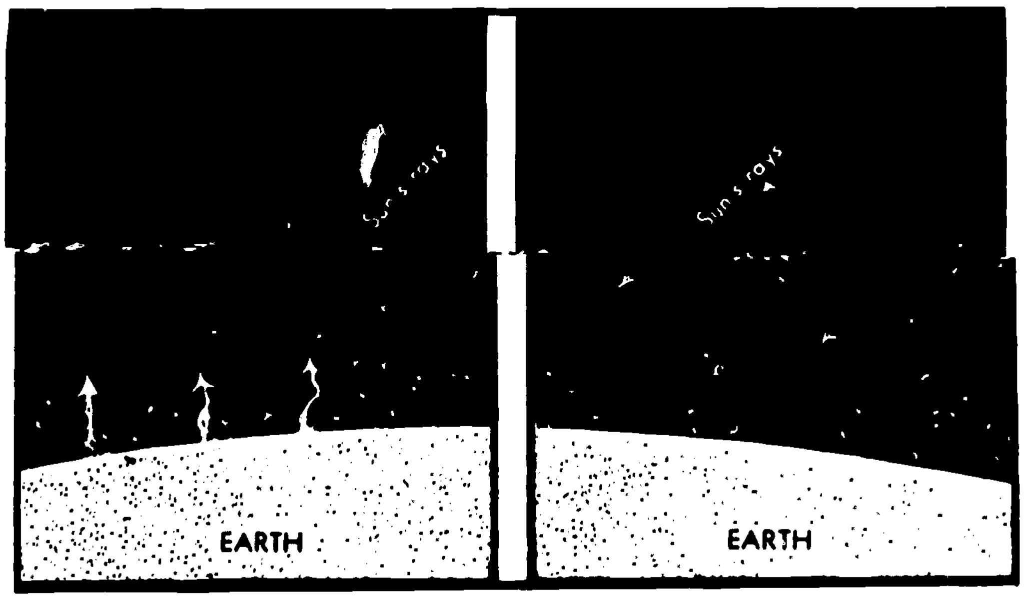
On maps of North America, ask children to find pairs of cities which are alike in latitude and proximity to water, but differ in elevation (altitude), such as Kansas City and Denver; Albuquerque and Oklahoma City. Have them look up the altitude and average annual temperature of these cities and record their findings on a chart. Is there any relationship between altitude and temperature? (The higher the altitude, the lower the temperature.) Children may be interested in the fact that the temperature drops 3½ degrees Fahrenheit for every 1,000 feet of elevation.

- *Elevation means the height above sea level.*
- *The higher the elevation of a place, the lower its temperature is likely to be.*

2. Why is air near the ground warmer than the upper air?

Discuss with the children the fact that the source of heat for the earth is the sun, which is about 93 million miles away. Why is air at the bottom of our atmosphere warmer than the upper air? There are two reasons for this:

a. The bottom air is heated *by the earth's surface.* The earth's surface of soil, rock, and water is heated directly by the sun. In turn, the earth heats the air in contact with it. This point may be illustrated by having children hold one pan on a hot radiator and hold a similar pan one foot above the radiator. They find that the pan in contact with the radiator is hotter than the upper one.



The sun warms the atmosphere in two ways.
Rays warm Earth; Earth warms air near it. **Rays warm air directly.**

b. The bottom air is heated by the sun's rays more than the upper air is. This is true because the bottom air contains more dust and molecules of water vapor, oxygen, and other air components which absorb the sunlight.

- *Air near the earth is warmer than the upper air because*

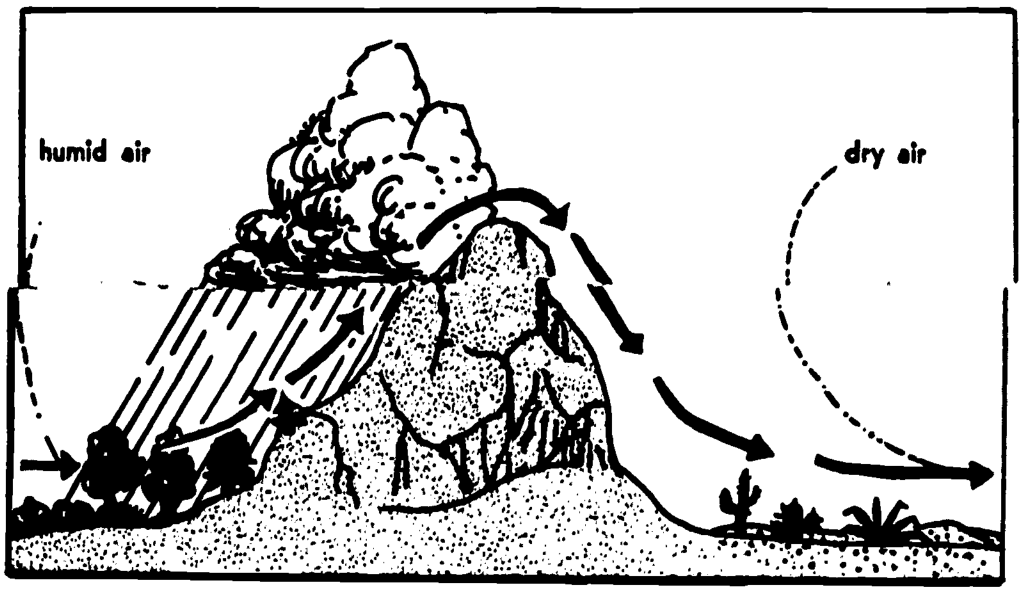
  it is heated by the earth

  it absorbs more of the sun's rays.

3. How can a mountain make a desert?

When a moisture-laden wind coming from the ocean blows against the side of a mountain, it is deflected upward into the cooler regions. Here condensation may occur and precipitation (rain or snow) may fall.

The air descending on the other side of the mountain is now drier. Often so little rain falls on that side that desert conditions may prevail. Have the children find the location of deserts in the United States and elsewhere and learn whether mountains helped in their formation. The dry, leeward slopes are in the "rain shadow" of a mountain. Great deserts in Nevada, Arizona, and Southern California are in the "rain shadow" of the Sierra Nevadas.



Air loses moisture as it rises over a mountain.

Since the United States has prevailing westerly winds, the western slopes of mountains usually have more rainfall than the eastern slopes.

- *Wind striking a mountain is forced to rise.*
- *When moist air moves up, it cools; condensation may then occur.*
- *The side of a mountain facing a moist wind has more rainfall than the other side.*
- *Deserts may be formed beyond a mountain range on the side away from the prevailing wind.*

EVALUATIVE ACTIVITIES

1. a. Show with an arrow the direction of wind that is probably blowing in the picture opposite. (Toward the right.)

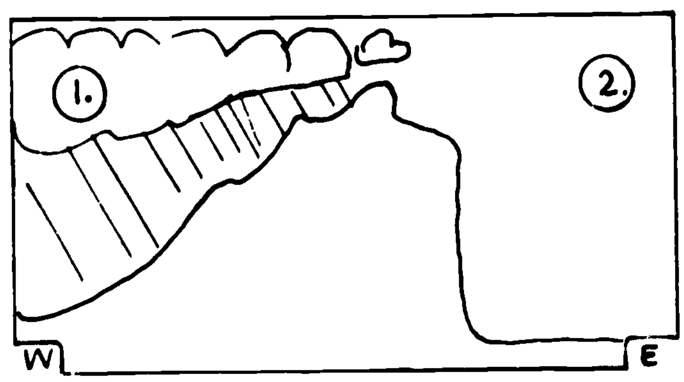
   b. What would we call such wind in the U.S.? (West or westerly.)

   c. How is the air in location 2 different from that in location 1? (Drier.)

2. Would the cabins of jets flying at high altitudes be more likely to

require heating or cooling? (Heating.) Why? (At higher altitudes it is cooler than at lower altitudes.)

3. If you wanted your car to be warm when you got into it on a sunny but cool spring day, would you leave the windows open or closed? (Closed.) Why? (Sunlight would come into the car through the windows. If the windows were closed, the heat from the sun's rays would be trapped inside the car.)



E. LEARNING MORE ABOUT CLIMATE AND WEATHER

The following suggested topics offer additional opportunities for students to conduct investigations on their own and report their findings to the class.

1. Look through a farmer's almanac which predicts weather a year in advance. Check the degree of accuracy over a period of a week or month. Should we rely on such almanacs?

2. Make a report on some recent findings of oceanographers about ocean currents.

3. Do an experiment to find out whether ocean water freezes. Place actual sea water in a metal cup in the freezer. Suitable "sea water" can also be made by dissolving 8 teaspoonfuls of salt in one quart of water.

4. How are icebergs formed? What are the dangers of icebergs? What is the Ice Patrol?

5. Study and report on the climates in Alaska and in the Hawaiian Islands.

6. What is meant by the *timber line* in mountainous territory?

7. Explain the reason for fogs around Newfoundland.

8. Write a report on the Gulf Stream. Explain why it has more of an effect on Northwestern Europe than on the United States.

9. What is the effect of the Japanese Current on the western part of our country?

10. How do tree rings give us clues to past climate?

11. How do vegetable growers solve their weather problems?

12. How do orange growers fight cold temperatures?

13. How does frost penetrate into the ground in different parts of the United States? Why is this information important to farmers?

14. Is our climate changing? Find out about the ice ages, and determine whether there is any evidence that our climate is changing.

15. What causes land and sea breezes?

16. What causes mountain and valley breezes?

17. What are microclimates? What microclimates can you find near your school or home? (Consult the Cornell Science Leaflet *Little Climates.*)

18. What is the "Greenhouse Effect"? How does it explain the heating of our earth?

BASIC SUPPLY LIST FOR *CLIMATE*

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

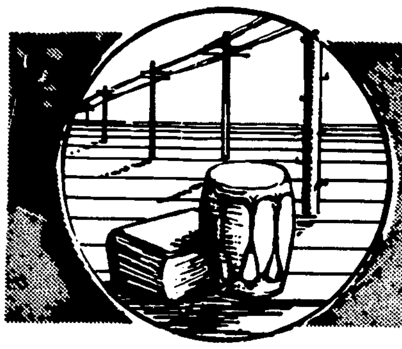
- 1 thermometer
- *10 lbs. soil
- 2 large plastic basins

G-1: General Supply List

- *1 pad graph paper
- 1 large oaktag
- *1 pkg. small oaktag
- 1 flashlight
- *1 pkg. black construction paper

Miscellaneous:

- 4 small outline maps of U.S.
- 2 pieces corrugated board
- 1 cardboard tube
- 4 small outline maps of North America
- 4 small physical maps of United States



Mirrors and the Reflection of Light

A. SEEING WITH MIRRORS

Background for the Teacher

Of the various means that man has of learning about the universe, light is one of the most important. It tells us almost everything we know about what is happening around us. Light is a form of energy which travels 186,000 miles per second. Light from the sun, which is 93,000,000 miles from us, reaches us in 8 minutes; from the moon, which is 250,000 miles away, in a little more than a second. The earth would be a dead planet without the sun's light. It warms and lights the earth and makes life possible.

Although scientists have been puzzling over the nature of light for hundreds of years, its exact nature is still unknown. It behaves like a wave, yet it also behaves like fast-moving particles of energy. What we do know is how to produce light, how to use and control it, and what it can do.

The path of a beam of sunlight passing through an opening in the clouds is made visible by the dust particles in the air. So, too, is the beam from a projector in a darkened theater and from a searchlight in the night sky. The edges of such beams are straight lines.

A beam of light may be thought to be made of an infinite number of imaginary straight lines, called *rays*. To a high degree of accuracy, light rays travel in straight lines. That is why we ordinarily cannot see around corners, and why we see objects only if they are in our line of sight. The usual straightness of the path of light (we will not discuss the exceptions, which are important) explains many common observations, including the reflection of light from a mirror.

We see things only when light from them is reflected to our eyes. Shiny surfaces reflect light better than dull ones; smooth better than rough; light better than dark. Many things in nature reflect light to a degree, but a mirror reflects almost all the light that strikes it. The light that is not reflected is absorbed by the atoms in the reflecting surface and converted into heat energy.

When light strikes a mirror, it passes through the clear glass and strikes the metallic substance (usually silver) on the back of the glass. The light is reflected back through the clear glass to our eyes. Shiny, smooth, and polished metals such as silver, aluminum, and stainless steel make good mirrors.

A mirror produces an image because it reflects light in a way called *regular reflection.* Each individual ray from the object is reflected from the flat, smooth surface of the mirror so that it is parallel to all the other rays. As a consequence, a perfect image of the object is carried to the viewer's eye. However, when rays of light are reflected from a rough surface, such as the page of this bulletin, they bounce off in many directions. The light is scattered in many directions and so is the image. This is called *diffuse reflection.* This kind of reflection is useful; otherwise you would see your image on this page instead of the print.

Approaches and Learnings for the Child

Children like to look at themselves in mirrors. They enjoy using a mirror to see what is going on behind them. This interest provides opportunities for learning about the role that light plays in forming images of the world around them.

From the activities suggested, children learn:

The image of an object is reversed in a mirror, left to right.

Tilting a mirror at different angles helps us see different objects.

A mirror works because it reflects light.

1. What can you see when you look into a mirror?

In this introductory exploration, pupils should be encouraged to explore freely and to describe their findings in their own words.

Each pupil is furnished with a mirror. "Look directly into the mirror. What do you see? Answers may include the following: "I see myself." "I see things behind me." "I see the window."

Introduce the words *object* to refer to themselves or the things observed and *image* for what is seen in the mirror.

"What happens when you turn the mirror sideways or tilt it?" Possible answers are: "I see only the top of my head." "I see only my chin." "I see the ceiling." "I see the floor." "I see the other wall." "I see the building across the street."

"What happens when you turn the mirror upside down?" (In a round or square mirror there will be no difference. In an oval or rectangular mirror children will report seeing more in one direction than another.)

"What happens when you move the mirror closer? Farther away?" ("I look bigger." "I look smaller.")

"What is the color of objects in the mirror?" ("The image is the same color as the object.")

"What happens to "right" and "left" in the mirror? Wink your right eye. Which eye is your image winking?" ("Left.") If children have difficulty in understanding this, have them put their mirrors down and face a classmate. Their classmate's left eye is on the viewer's right.

To reinforce the idea of left-right reversal, ask children to write the number 81 on a piece of paper and hold it up facing the mirror. "What does the image of the number look like? Copy it on a piece of paper." ("The image is 18." "The *eight* is on the right." "The *one* is on the left.") "Hold the '18' you have written in front of the mirror. It's 81 again!"

"What happens to a number such as 47?" (In addition to the previous observations, children find that the image of each digit is reversed as shown in the illustration.)

"What happens to your first name (printed) when you hold it in front of a mirror? Copy the image on a piece of paper. How can you see your name correctly in the mirror?" ("Hold the copy of the image in front of the mirror.")

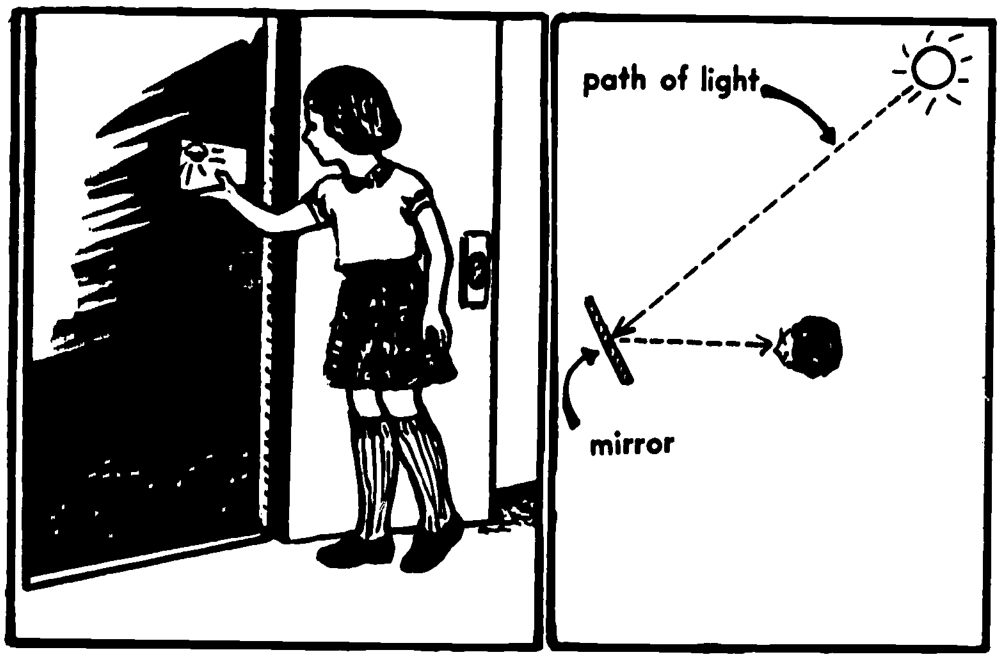
- ***When a mirror is tilted or turned, we see images of different objects.***
- ***When a mirror is moved closer to the object, the image is bigger; when it is moved away, the image is smaller.***

- *In a mirror, the image looks the same as the object, but is reversed left to right.*

2. How can we see objects behind us?

If this question has not been explored in the first problem, it may be taken up now. Pupils will find that by holding a mirror in front of themselves and tilting or turning it, they can see the images of various objects behind them. Ask them to name the objects they see. Discuss the use of rearview and sideview mirrors in automobiles.

- *A mirror can show objects behind the observer.*
- *Different objects behind the observer can be shown by tilting or turning the mirror.*



Using a mirror to see around a corner.

3. How can we see around a corner?

Ask a pupil to stand in the open doorway and, at the same time, hold a mirror out into the hall. Ask the pupil to turn the mirror until he can see the end of the hall in the mirror. Discuss the use of mirrors on highways to show approach of vehicles from an obscured side road; in elevator doorways to show the approach of a person.

- *A mirror can be used to help us see around corners.*

4. How can we see over a wall?

Provide a pupil with a hand mirror. Ask him to sit on the floor near a window with his back to the wall and try to see out the window by using the mirror. By holding the mirror above the level of the sill and by tilting the mirror, the pupil will be able to see over the wall and out the window. If the pupil cannot raise the mirror high enough, it may be necessary to seat him on a few books.

- *With a mirror, we can see over a wall or other obstruction.*

5. When can a pane of glass be used as a good mirror?

Ask children if they ever saw themselves in the glass windows of shops as they walked down the street. What were these reflections like Were they very distinct?

Give each child a rectangular piece of glass or a piece of clear plastic, such as the top of a food container (a coffee can). Ask children if they can see their images in the glass or plastic. As they hold it in different positions, they will discover that they can see themselves better when the background behind the reflecting surface is darker. A dark-colored book or a piece of dark paper will help them confirm this.

Why does covering one side of the glass make it a better mirror? (You are not confused by objects on the *other* side of the glass.) How does a *darker* background help? (The light is reflected by the smooth flat surface of the glass and not by the irregular surface of the background.) (See *Background for the Teacher,* page 138).

Ask children if they can explain why a window in their home or in a train is sometimes a good mirror at night. (It is dark outside, like the black paper, and there are bright objects inside.)

How is a mirror constructed? Examine several mirrors, including one or more pocket or purse mirrors. Scratch a little paint off the back of an inexpensive pocket mirror. Notice that most mirrors are made of glass, coated on one side; the coating is silvery on the side next to the mirror, and opaque on the back; the glass is smooth.

- *A pane of glass can be a mirror; it makes a clearer image when it is covered on one side.*
- *A window can be a mirror; it works best when it is dark outside.*
- *A glass mirror has a shiny, smooth backing.*

6. Do all mirrors make the same kinds of images?

Ask children to tell about experiences they may have had in "fun" houses when they looked into the mirrors. What happened to their images?

Have children observe their reflections from curved surfaces such as holiday-tree balls, metal coffee makers, spoons, and curved mirrors, such as a shaving mirror. How are their reflections different from those "in" a smooth flat mirror? Compare for size, shape. Is the image upright?

- *Curved mirrors produce images different from flat mirrors.*

7. How does a mirror work?

From their previous investigations or from their reading, children may offer different explanations, all of which should be accepted for the moment. They will probably suggest that *light* has something to do with the question. Is light really needed to make an image? How can we tell? Children may suggest turning *off* the light or eliminating it in some way. While children are looking at themselves in mirrors, darken the room by turning off the lights and pulling down the shades. What happens to their images? (Become fainter.) What would happen if there were no light at all? (Image might disappear.)

So far we have reduced the amount of light falling on both the object (the child) and the mirror. What would happen if we reduced the light on the object only? How can we do this? Children may suggest inverting a carton over their heads with a square cutout about the size of their faces. They place the carton over their heads as far back as possible from the opening. Another, simpler method is to curve a large dark desk blotter around their heads so that the child can look out at the mirror, but with as little light as possible on his face. In either case, the children see that as the light on their heads (the objects) is reduced, the image becomes dimmer and may disappear.

What happens if we reduce the (room) light falling on the *mirror?* The mirror is now placed inside the box or blotter. Children find that the image is still bright.

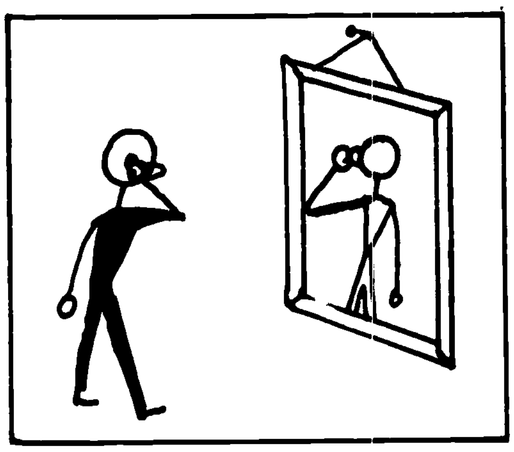
So far, children should have learned:

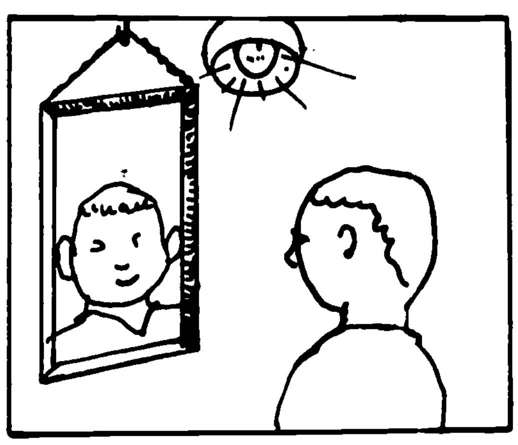
- *Light has something to do with the making of an image.*
- *When the amount of light falling on the* object *is reduced, the* image *becomes dimmer.*

Just how does this happen? Why should reducing the amount of light on the object affect the brightness of the image? In the previous discussion and in the discussion which ensues, children reach intuitively for the concept that *light travels* and *light is reflected*. This is an important turning point: children are shifting their attention from the object (their faces) and the image (seen "in" the mirror) to light itself, to the vehicle which carries "information" from object to mirror to the eye. Children should be asked to express *this* concept in words or to make drawings to show the *pathway* of light. The word *reflection* should be introduced here. Light falling on the object is reflected to the mirror; light from the mirror is reflected to the eye of the viewer.

- *A mirror works because it reflects light.*
- *We can see the object because light travels from the object to the mirror to the eye.*

EVALUATIVE ACTIVITIES



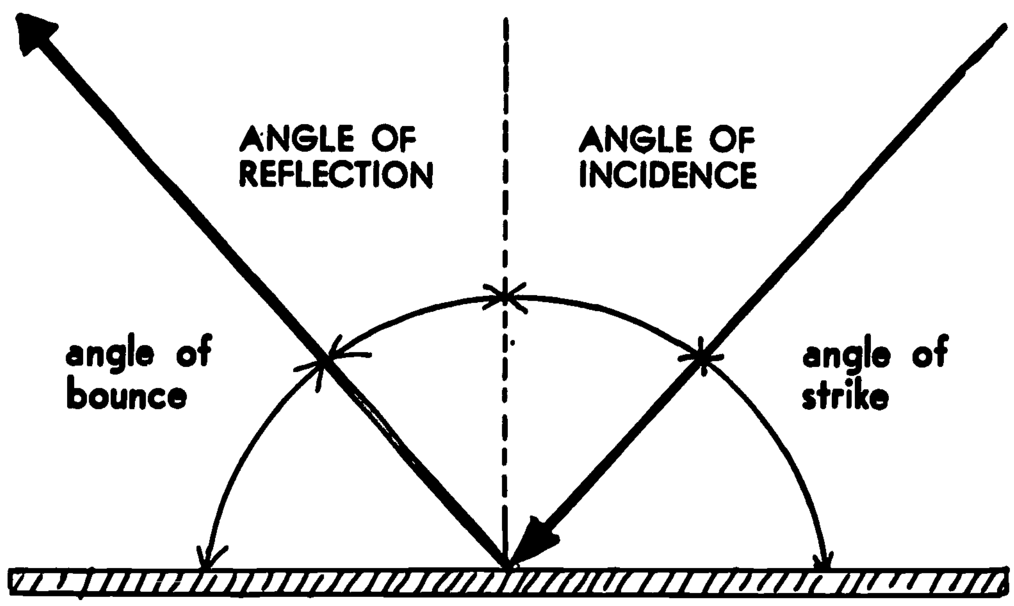


1. What is wrong with the picture on the left?
   (The boy in the mirror is touching the wrong ear.)
2. Which of these words looks the same in a mirror as it does on the page: HOOT, TUBA, HORN, BOOT. TOOT, NOON, MOM? (TOOT, MOM.)
3. (a) In the picture on the right, label object, light, image.
   (b) Draw three arrows to show the path of light which makes it possible for the boy to see his image. (Line from light to boy, from boy to mirror, from mirror to boy.)

B. MIRRORS REFLECT LIGHT

Background for the Teacher

When a ray of light falls on a mirror, it is reflected from it at the same angle at which it struck it. To measure the angles made by light rays, physicists conventionally erect a perpendicular at the point where reflection occurs. The angle formed by the entering ray of light and the perpendicular is called the *angle of incidence;* the angle formed by the reflected ray is called the *angle of reflection*. Experimentation shows that the angle of incidence is always equal to the angle of reflection.



The angle of incidence equals the angle of reflection; the angle of strike equals the angle of bounce.

For the purposes of *teaching* in the elementary school, it is simpler to consider the angles made by the entering and departing rays *with the mirror's surface*. This eliminates the need to construct an imaginary perpendicular, referred to above. However, it *is* necessary to "invent" new terms to describe the angles we wish to deal with. The *angle of strike* is the name we will use for the angle made by the approaching ray and the mirror; the *angle of bounce* for the angle made by the departing ray and the mirror. The angle of strike equals the angle of bounce.

Light leaving a mirror can be reflected by another mirror. This explains the operation of the periscope as an instrument for seeing over obstacles. When placed in certain positions, mirrors can bounce light back and forth an infinite number of times. In this way, multiple images of a single object are produced. In the kaleidoscope a number of mirrors are placed in such a way that the multiple images of a number of colored pieces of glass or plastic make symmetrical patterns.

Approaches and Learnings for the Child

Children have always used mirrors to reflect beams of sunlight. They know that by holding the mirror in different positions they can change the position of the spot of reflected light. By turning their attention to the angle of incoming and outgoing rays, they begin to understand the relationship of the two.

The analogy to a ball hitting a wall is a good one and helps them understand that the angle of strike equals the angle of bounce.

When children experiment with two or more mirrors, they discover the effects produced when light is reflected a number of times.

From the activities suggested, children learn:

A mirror changes the direction of light striking it.

The path of light reflected from a mirror can be changed by facing the mirror in different directions.

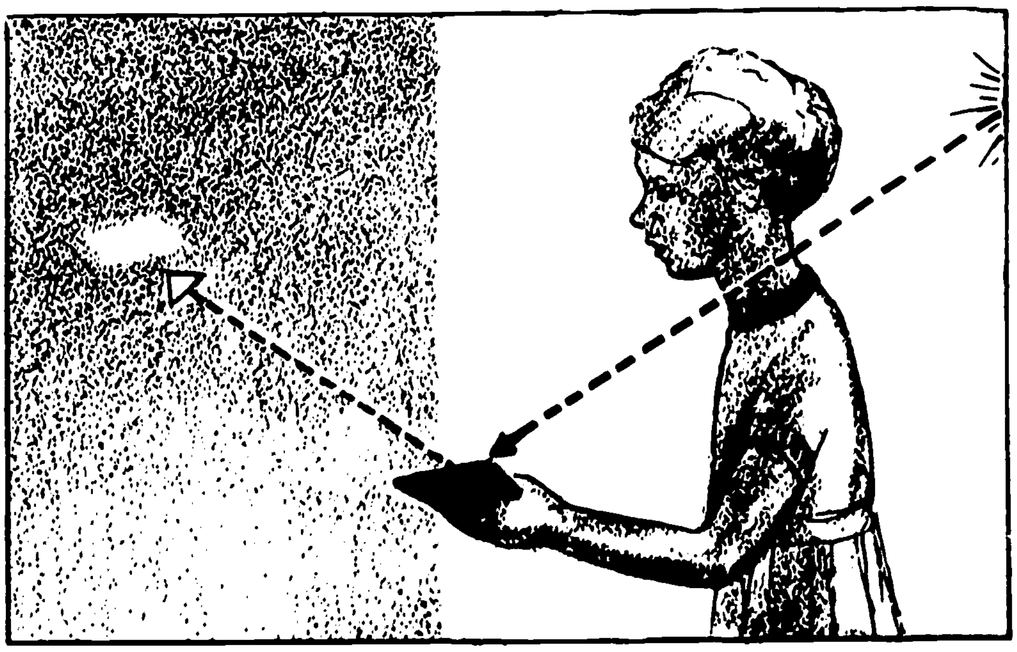
Light can be reflected many times.

The angle of strike of light on a mirror equals the angle of bounce.

1. How can we use a mirror to shine light in different places?

In a sunlit room or in a sunny hall or yard, provide as many pupils as possible with mirrors. Have the pupils catch the sunlight on their mirrors, and reflect the light to the ceiling or the walls by tilting the mirrors. Ask the children to make a drawing to show the pathway of light from the sun to the mirror to the spot on the wall.

At another time, darken the room by drawing the shades. Ask one pupil to shine a flashlight on a mirror held by another child. Ask the second pupil to reflect the light from one place to another in the room by tilting the mirror. Make a drawing to show the pathway of light.



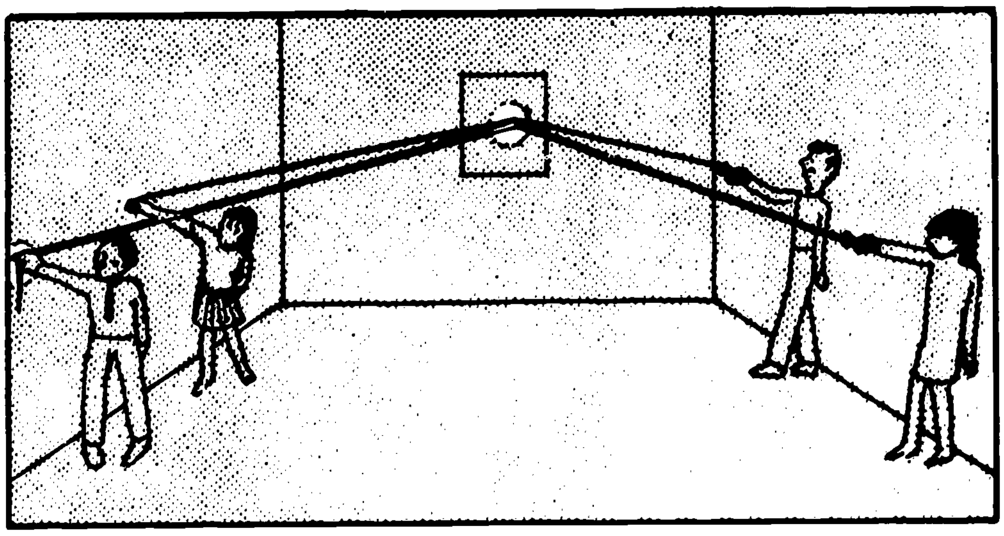
A mirror changes the direction of light.

Again in the darkened room, light a candle. Let a pupil see if he can reflect the light from the candle to another place in the room. He can do so by holding a mirror near the candle flame, and by tilting the mirror in various directions. Again make a drawing to show the pathway of light.

- *A mirror changes the direction of light striking it.*
- *The new path of light can be controlled by tilting the mirror in different positions.*

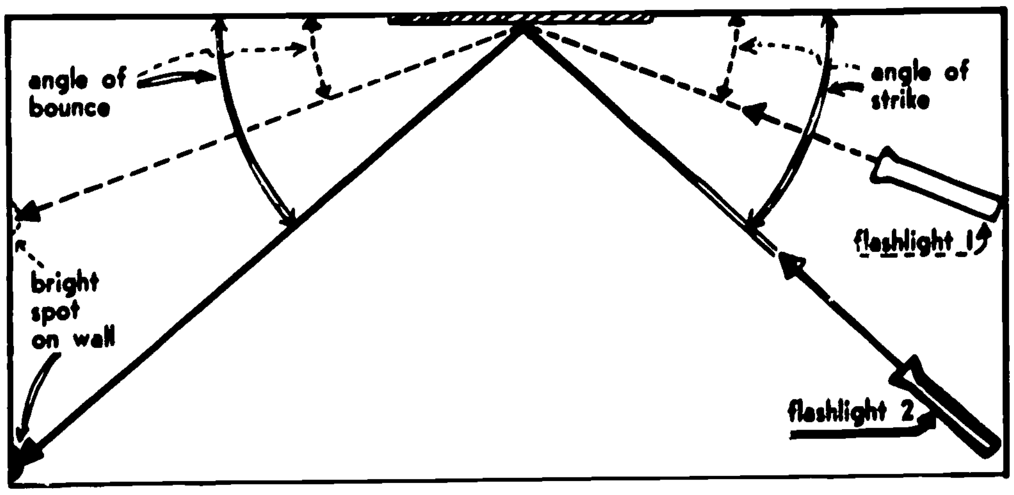
2. How much does a mirror change the direction of a beam of light?

The purpose of this question is to help children discover more exactly the relationship between the angle at which light strikes a mirror and the angle at which it is reflected. Place a large mirror on a wall. Darken the room. Have a child shine a flashlight (held at the same height as the mirror) on the mirror from the side. Mark the spot on the wall where the reflection falls. Turn on the light. With the help of two other children, extend a long string from the child to the mirror (attach with cellophane tape) and from the mirror to the reflected spot. What does the string show? (The path of light from the flashlight to the mirror and from the mirror to the spot.)



**Tracing the path of light:
flashlight to mirror to wall.**

Without disturbing the string or the children holding it, have another child shine a second flashlight from a new angle. Repeat the process of using string to show the path of light. How do the two paths compare? In various ways, children will describe the angle at which light strikes the mirror and the angle at which it is reflected. A chalkboard diagram will be helpful, especially if children participate in making it.



The angle of strike equals the angle of bounce.

On such a diagram ask children to compare the angle made by the entering and departing beam of light with the mirror. Call the angle made by the entering beam the "angle of strike" and that made by the departing beam the "angle of bounce." Children may discover that the angle of strike equals the angle of bounce.

To reinforce this idea, substitute a rolling ping-pong or rubber ball for the advancing beam of light, and a wall instead of a mirror. Ask a child to roll a ball on the floor directly to a marked spot on the baseboard in front of him. Ask children to describe what they see. (Ball comes back to the "roller.") Ask the child to stand off to one side and roll the ball again so that it hits the same spot as before. What happens to the ball after it strikes the wall? (Ball does not come back to the "roller"; it goes off in a different direction.) Try from other places. What happens?

How can we find out more exactly how large the angles are in each case? Draw two or three straight lines with white chalk on the floor to the marked spot. Have a child roll a ball as carefully as he can along one line (mark it "A") toward the spot. Make a mark to show where the ball is when it rebounds — about a foot from the wall. Draw a straight line from the wall spot through the floor spot. (Mark it "B.") How does the angle of bounce compare with the angle of strike? (Should be about equal.) Now try this for a number of different angles along the lines previously drawn.

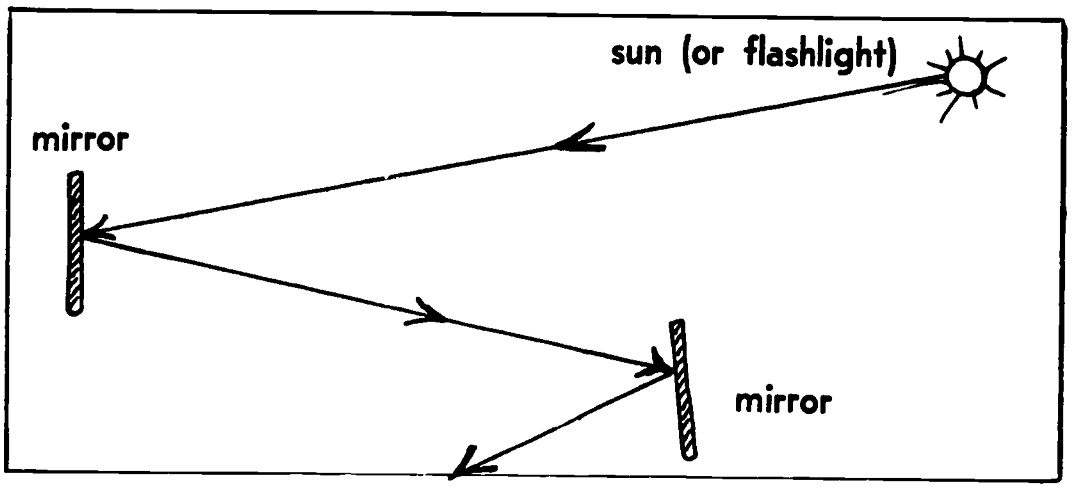
- *When a beam of light is reflected the angle of strike equals the angle of bounce.*

3. Why must you stand directly in front of a mirror to see your face?

Mount a mirror flat against a wall. If no large mirror is available, use the mirror inside the teacher's locker. Have a child stand directly in front of the mirror and tell what he sees. (His image.) Now ask him to stand at one side of the mirror. Can he see himself? (No.) What can he see? (Images of objects to one side of him.) Why can't he see himself? Have children recall Problem 2 where the ball was rolled on the floor at different angles against the baseboard.

Can the children explain and draw pictures to show what happens when they stand at one side of a mirror and look at it? (The angle of bounce equals the angle of strike. The image can only be seen along the angle of bounce.)

- *When we stand directly in front of a mirror, the light reflected from our face is reflected back to our eyes.*
- *When we stand at one side of the mirror, the light from our face is reflected away from our eyes.*



Light can be reflected many times.

4. Can we reflect light more than once?

Try to reflect light from one mirror to another, using a light source such as the sun or a flashlight. This can be done by having two pupils stand several feet apart, facing each other, one with his back to the light source, each child holding a mirror.

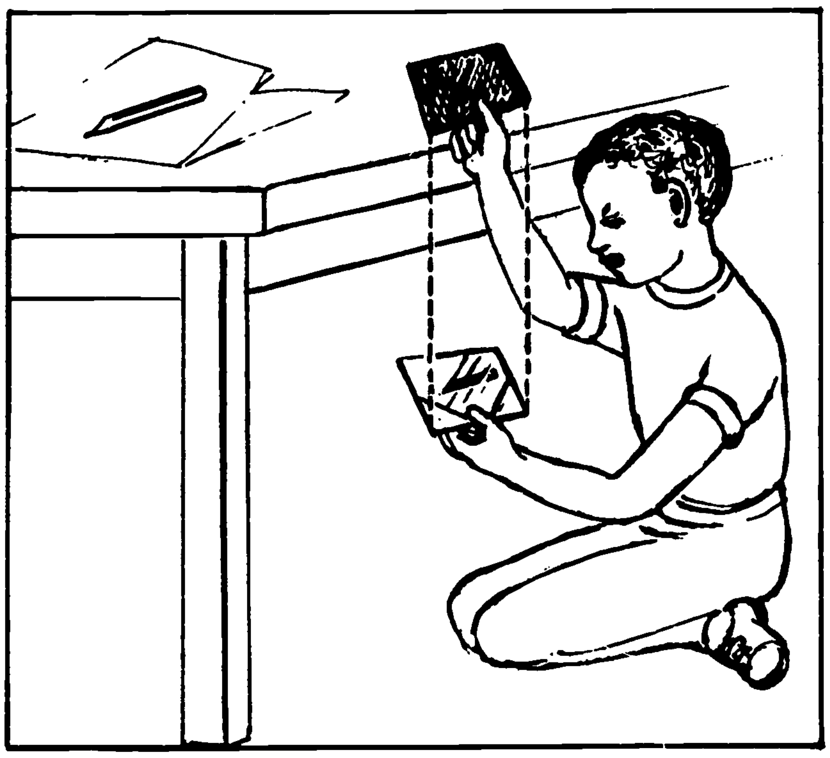
Let the light fall on the mirror held by the first child. He directs the beam to the mirror held by the second child. The second one then tilts his mirror to send the beam off again. The second child might direct the beam to a mirror held by a third child.

Make a diagram to show the pathway of light from source to first mirror to second mirror, etc.

- *Light can be reflected from mirror to mirror.*
- *Light can be reflected many times.*

5. How can we use a pair of mirrors to see over the top of an obstruction or around corners?

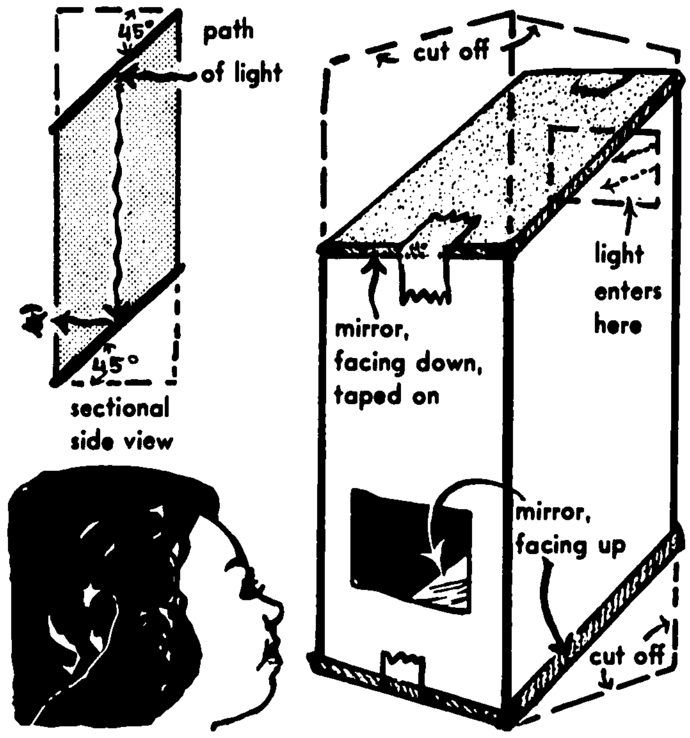
a. Have children sit on floor facing a solid wall of a desk or other solid object tall enough so that its top is higher than the top of their heads. Give them 2 mirrors each and ask them to experiment with them until they can see over the obstruction. They will find that they can do this by holding one mirror, shiny side up, near their laps tipped at an angle of about 45°. The second mirror is held above the top of the desk, also at a 45° angle parallel to the bottom mirror with the shiny side down. Ask the children to name the objects they see. Discuss the pathway of light from the object to the viewer. Ask children to make a drawing to show the pathway.



A pair of mirrors helps us see over obstructions.

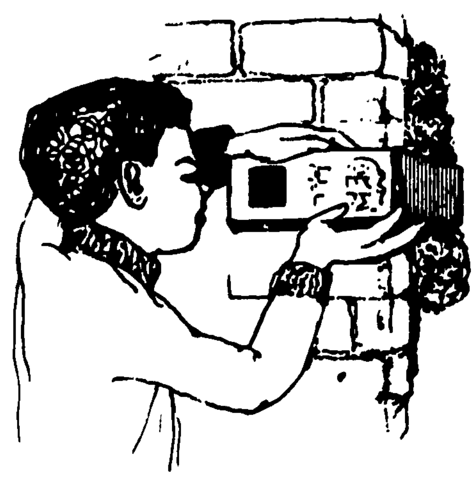
Ask children where mirrors used in this way can be of help to people. (In a submarine, in armored tanks and space capsules, and in an atomic laboratory where a scientist can watch dangerous materials he is working with while he sits safely behind a protecting wall.) Paired mirrors used in this way are incorporated in instruments called *periscopes*.

b. Children may build their own periscopes with a pair of mirrors, a rinsed milk carton (preferably plastic), and some transparent tape.



A periscope made from a milk carton.

Cut off the top and bottom of a quart milk carton. Attach the two mirrors with adhesive or tape, in the positions shown. Make two openings, each about one inch square, opposite the middle of each mirror. If the mirror does not fit over the cut end of the carton exactly, use strips of cardboard on which to cement the mirror. To use the periscope, have pupils hold it so that the lower opening is held below an obstruction and the top opening is held above the obstruction.



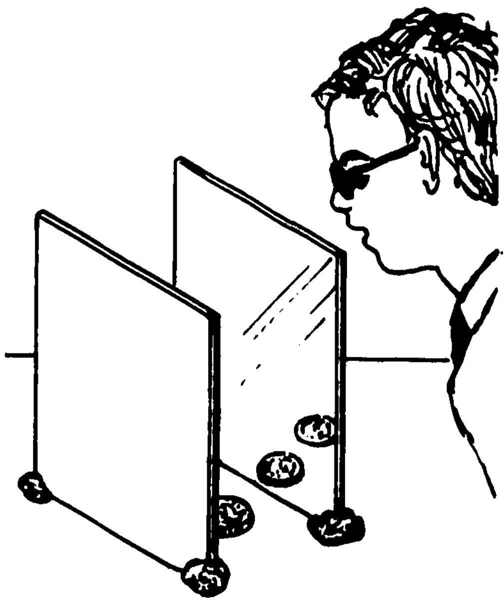
A periscope helps us see around corners.

To use the periscope to see around a corner, have child stand inside doorway of classroom and hold the periscope flat against the wall with one end extending out into the open doorway.

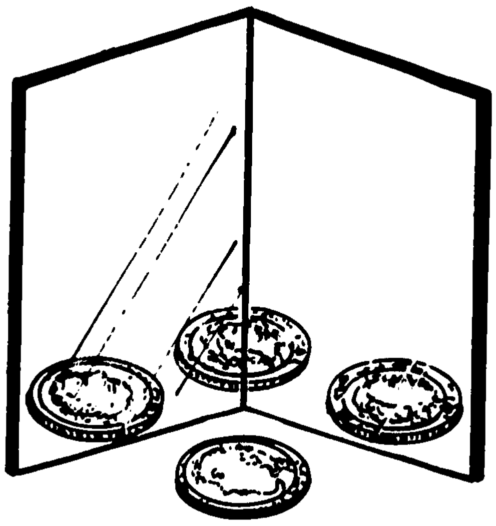
- *Pairs of mirrors can be used to see over obstructions.*
- *Pairs of mirrors can be used to see around corners.*

6. How can we "make money" with a coin and two mirrors?

a. Ask children to predict what they think they will see when they put a penny between two mirrors held parallel to each other with reflecting surfaces facing.



Mirrors can make images of images; they can "make money."



Mirrors can make patterns.

Give each child two small hand mirrors and a penny or other coin. Have pupils prop up one mirror against some books, facing the viewer. Hold the other mirror parallel to the first and facing it. Hold a coin vertically between the two mirrors, parallel to both of them. How many coins do they see? Children will see many images of the coin in the mirror they are facing. Why does this happen? (Images are reflected back and forth.)

Slowly move the coin in a small circle. Observe the simultaneous movement of all the images. Note also that the successive images appear to be deeper and deeper in the mirror, and smaller and smaller. Ask children to recall multiple images they may have seen in barber shops.

b. Give each child two small hand mirrors and ask him to hinge them together with a piece of tape so they can stand on the table like the covers of a book. Have him place a coin between the mirrors and observe the number of images formed. What happens when we spread the mirrors wide? What happens when we make the angle between the mirrors smaller? Ask children to count the number of coins as they change the angle. Have them keep a record. When do we "make" more coins? How does this happen?

- *Two parallel mirrors facing each other make images of images.*
- *Two mirrors held at an angle can make a number of images of an object. The number of images can be changed by changing the angle between the two mirrors.*

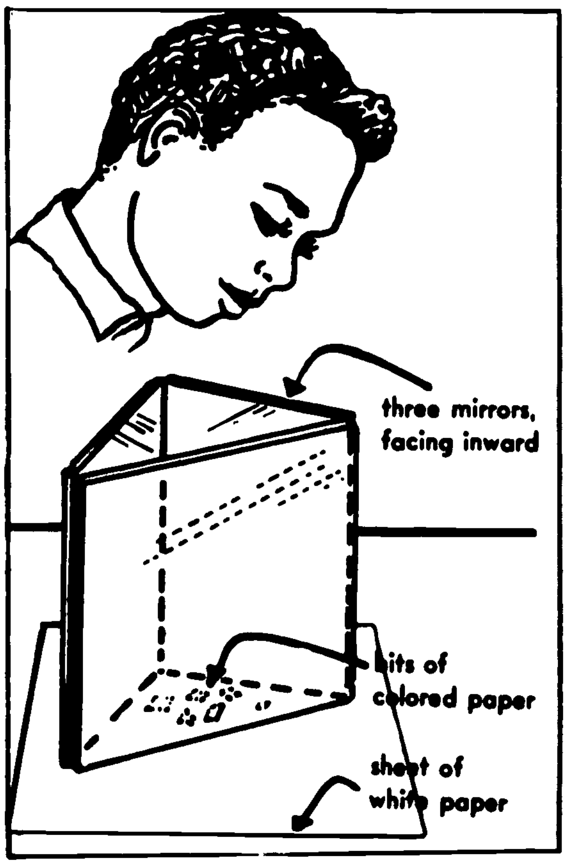
7. How does a kaleidoscope work?

Have children look through the kaleidoscopes (E-1 List) and try to explain how the changing designs are formed. If possible, take apart an inexpensive kaleidoscope to see what it is made of and how it is constructed. Ask the children to construct a kaleidoscope.

Provide children with 3 plane mirrors of same size, sheet of white paper, irregularly cut bits of colored paper, scotch or adhesive tape. Tape together three plane mirrors as shown in the illustration opposite.

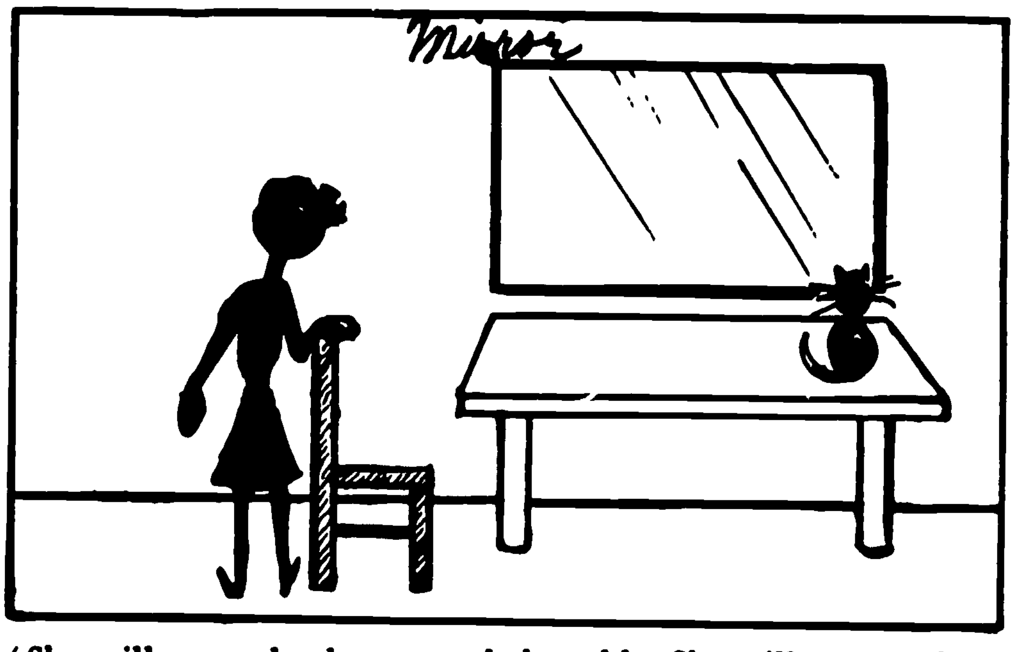
The reflecting surfaces should be inside the triangle thus formed. Have the children put the irregularly cut bits of colored paper inside the triangle on the white sheet of paper. What do they see? Ask them to jiggle the paper slightly from side to side, or to blow lightly into their kaleidoscope and observe what happens.

- *Kaleidoscope patterns are made by mirrors. The mirrors **multiply the** images of small objects.*
- *When the objects are moved, the pattern changes.*

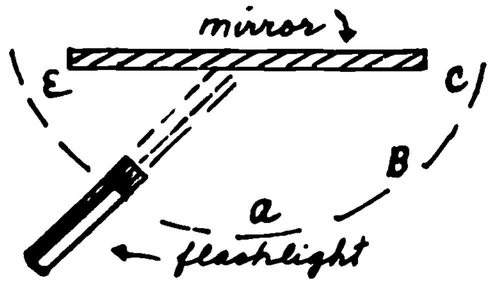


EVALUATIVE ACTIVITIES

1. Look at the picture below. Which things will the girl see in the mirror?



(She will see only the cat and the table. She will not see herself or the chair next to her.)

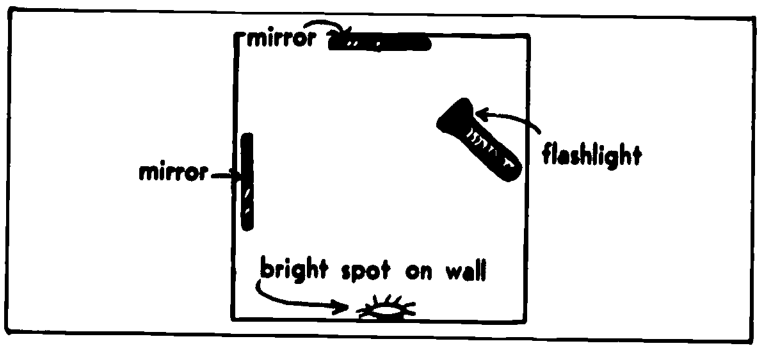


2. When the flashlight is turned on, towards which letter will its beam of light be reflected?

(B)

3. What is the path of light between the flashlight and the spot on the wall? Draw lines to show the path.

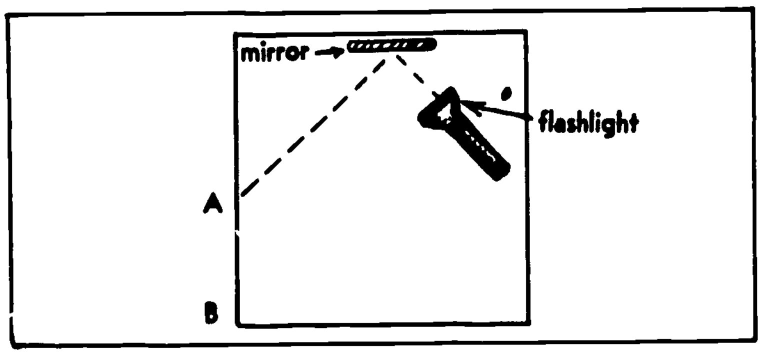
(Line from flashlight to adjacent mirror, to opposite mirror, to spot.)



4. In the picture opposite the path of light from the flashlight to A is shown correctly. How could you make light fall on B?

(Either turn mirror *or* move flashlight into new position so that its light falls on mirror at new angle, *or* turn flashlight directly on B.)

MIRRORS AND THE REFLECTION OF LIGHT



BASIC SUPPLY LIST
FOR *MIRRORS AND THE REFLECTION OF LIGHT*

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

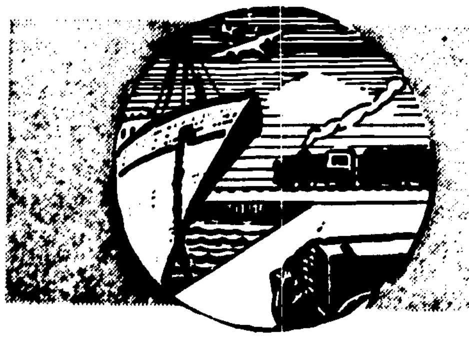
- 8 mirrors
- 1 kaleidoscope

G-1: General Supply List

- 2 pencils
- *1 pkg. colored construction paper
- 1 desk blotter
- 1 flashlight
- 1 box chalk
- 1 pair of scissors
- 1 candlestick
- 1 roll cellophane tape
- 1 ball of string (warp, thread-white)
- 1 pkg. unruled white paper

Miscellaneous:

- * pane of glass (approx. 3"x5")
- 1 metal coffeepot
- 1 metal spoon
- 1 shaving mirror
- 1 cardboard cover
- 1 mirror (approx. 8"x10")
- 1 plastic milk carton
- assorted coins
- 1 holiday-tree ball
- 1 ping-pong ball
- 1 clear, plastic food container cover
- mirrors of various shapes (round, square, oval, rectangular)



Making It Go

A. MUSCLES MAKE IT GO

Background for the Teacher

A muscle is a collection of hundreds of thousands of specialized cells capable of shortening when activated by a nerve impulse. The shortening of muscle cells produces the contraction of an entire muscle.

To cause movement of an arm or leg, or any bone, the muscles must be attached across a joint. Tendons anchor muscles to bones. For every movement there are antagonistic muscles, that is, one muscle works oppositely to another. For example, to move our forearm up, the biceps, which are attached across the elbow, are stimulated to contract. To straighten the arm again, the biceps must relax while another muscle, which extends across the elbow and behind the arm, the triceps, now contracts.

Approaches and Learnings for the Child

Primitive man relied principally on his own muscles for the work that had to be done. Later the muscles of domestic animals were used to help man pull and lift things. When he invented such tools as axes, hammers, knives, drills, and saws, man increased the effectiveness of his muscles. But even today hundreds of tasks are still performed by muscles.

Children learn about the work done by their muscles by using some simple machines. They observe their own muscles and learn how they move their arms and legs.

From the activities suggested, children learn:

Muscles move many tools and machines.

Muscles move arm and leg bones to which they are attached.

Muscles work in pairs, one opposing the other.

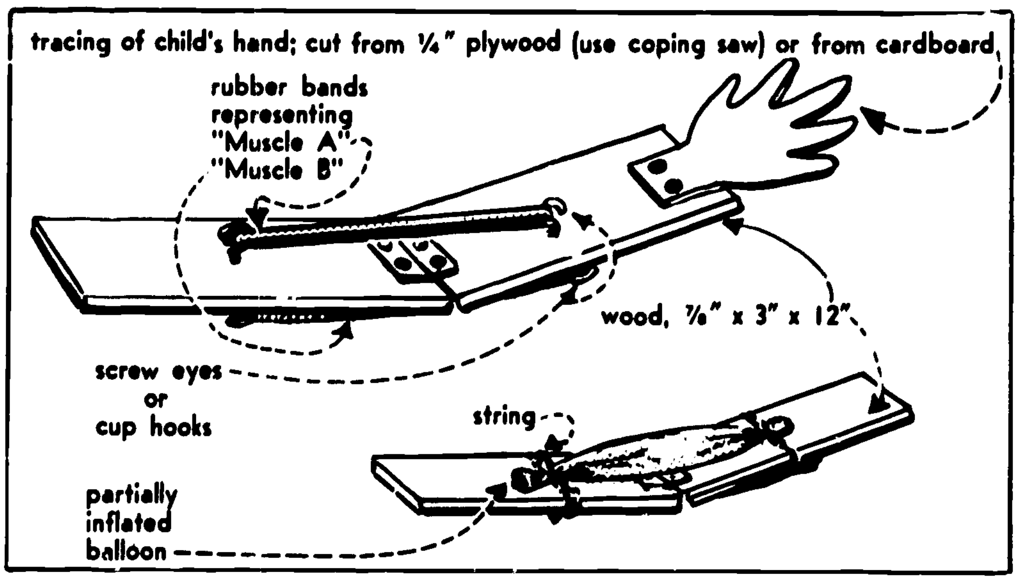
1. What makes your forearm move?

Let one arm hang loose, palm forward. Feel the long muscle in front (the biceps) that goes from the shoulder almost down to the bend of the elbow. A tendon connects this muscle to the forearm bone. Now lift the forearm slowly by bending the arm at the elbow. Feel the biceps become shorter and thicker. As this muscle shortens, it pulls up on the bones of the forearm, causing it to rise.

One muscle pulls the forearm up; the other pulls it down.

Most muscles work in pairs. A muscle which is paired with the biceps is in the back of the arm. It pulls the forearm down. To find this muscle, bend one arm and then straighten it while pushing against a wall. With the other hand, feel the muscle along the back of the arm tighten.

Ask children to report on muscles that move other parts of the body. Look for muscles (meat), and tendons which connect muscles to bone, in a chicken leg or in a shank of lamb.



Two models demonstrating muscle action.

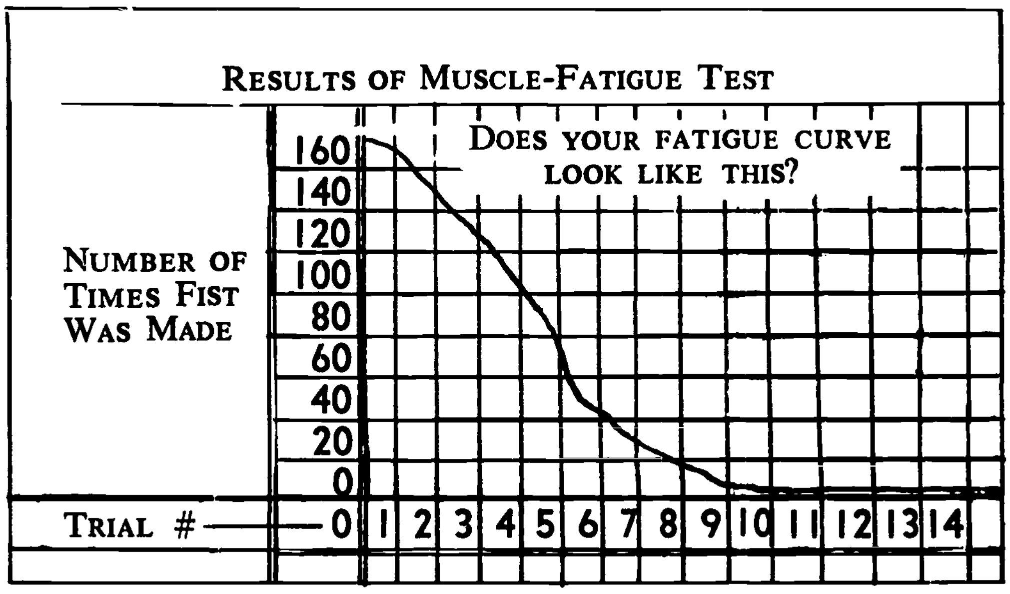
To demonstrate the idea of opposing muscles, an easily constructed model can be used in which one rubber band is fastened to the upper surface of a hinged board and another similar rubber band is attached to the underside of the board. Instead of rubber bands, partially inflated balloons may be used. The ends are tied and attached to the board by screw eyes or by string. This device clearly demonstrates how muscles A and B work in opposition — one shortening as the other lengthens.

Ask children to list the ways in which they use their muscles during a school day.

- *When muscles shorten, they pull on bones, making our arms and legs move.*
- *Muscles work in pairs; one muscle pulls in the opposite direction from the other.*

2. How fast do your muscles get tired?

Ask children if they ever experienced a stiff muscle (Charley Horse) in an arm or leg. How did it feel? When did it usually happen? How long would it take for the muscles in the hand to get tired? Have the children make a fist with the right hand; then open it as wide as possible. Close and open the hand again. Children continue doing this as rapidly as possible until fatigue makes it impossible to open the hand once more. While engaged in this activity, children should count the number of times the fist was clenched and record the figure on a chart under "Trial one." Wait exactly 30 seconds and repeat the opening and closing of the hand until fatigue stops "Trial two." Record the number of times the fist was clenched, wait 30 seconds, and repeat for "Trial three."



Have children repeat this procedure many times. In each series they will clench the fist fewer and fewer times, until complete exhaustion occurs. Let each child make a table of the results and graph them. Compare the fatigue curves of the children in the class. Ask children to suggest other muscles for fatigue tests. (Caution! Do not permit children to engage in whole-body activity, such as running, jumping, or bending, in a fatigue test.) Have them check how long it takes to recover full use of tired muscles in each of the tests.

- *Muscles get tired with repeated action and must be rested before they can work effectively again.*

3. How do tools help our muscles?

Ask children to name the different kinds of common tools they have seen used around the house (hammer, screwdriver, pliers, scissors), and to describe the uses of each.

Do tools make a task easier on the muscles? Ask a child to tighten a large nut or a bolt by hand. Now ask another child to try and loosen it. (It may be possible to loosen the nut by hand.) Now have the first child use a wrench or pliers to tighten the nut. Was it easier to do by hand or with a tool? Have the second child try to loosen the nut by hand. Can it be done? (Not usually.) Review Grade 4: *Moving Things More Easily* to remind children how many common tools and simple machines help to make it easier for the muscles to do jobs. See *Tools We Use*, page 221.

- *Many common tools and machines are moved by muscles.*
- *Tools make it easier for muscles to do a job.*

4. How do animals help man "make it go"?

Have children do research and report on how horses, camels, oxen, water buffaloes, elephants, and other animals throughout the world work for man.

Discuss what kinds of jobs each animal performs. How is each suited for the particular work?

- *Animals' muscles help men move things.*

EVALUATIVE ACTIVITIES

Put a circle around letter of the correct answer.

1. One of the first means used by ancient man to move things was
   a. water.
   b. wind.
   c. muscles. (Answer: c.)
2. Muscles work in pairs. This means that
   a. they work together for greater force.
   b. one pulls in the opposite direction from the other.
   c. one will work if the other fails. (Answer: b.)
3. When a person "makes a muscle" with his fist and arm, he is causing the bulging muscle to get
   a. longer.
   b. shorter.
   c. relaxed. (Answer: b.)

B. FLOWING WATER CAN MAKE IT GO

Background for the Teacher

The water flowing down a river, or pouring over a waterfall, can do work for man. Flowing water carries logs and rafts downstream. Waterwheels are turned by the force of moving water. Man used waterwheels to run machinery which ground his grain, sharpened his knives, operated his looms, sawed his logs, and hoisted his loads. Today giant waterwheels, turbines, turn the generators which produce electricity to do this work.

For water to flow and do work, it must start from a higher level than its destination. The water cycle in nature makes this possible. The heat of the sun evaporates water from oceans, lakes, rivers, from vegetation, and from the land. This water vapor is now buoyed high into the air where it is cooled and condensed into clouds. Some of the rain falling from clouds is deposited at a level higher than that from which it came. Thus the sun is the source of the energy of flowing water.

The moon also plays a role in lifting water, since its gravitational pull on Earth is responsible for tidal action. Recently, power plants have been constructed to trap the energy of sea water as it falls from its high-tide level to the low-tide level.

Approaches and Learnings for the Child

Children find out about the rafts used by early man, and make working models of dams and waterwheels. They experiment to determine the force of moving water, and to discover why it is easier to move something in water than on land.

From the activities suggested, children learn:

Flowing water can move heavy loads downstream.

Flowing water can turn wheels.

A dam is a wall built across a stream or river to raise the level of the water behind it.

Running water can exert a force.

Falling water can exert a force.

The sun is the source of energy for water flowing in streams and rivers.

The moon's pull on the earth makes tides.

Water lifted by the tides can be used to turn wheels.

1. How does water help men move loads?

Discuss how logs are floated downstream to the sawmill. What advantage does this have over methods of moving logs on land?

Children find out about the kinds of rafts which man has used in the past. They make models of these rafts and try them out in home-made "streams" and "ponds." They read about the voyage of the raft Kon-tiki and report on it. How may ocean currents have influenced the movements of men around the earth?

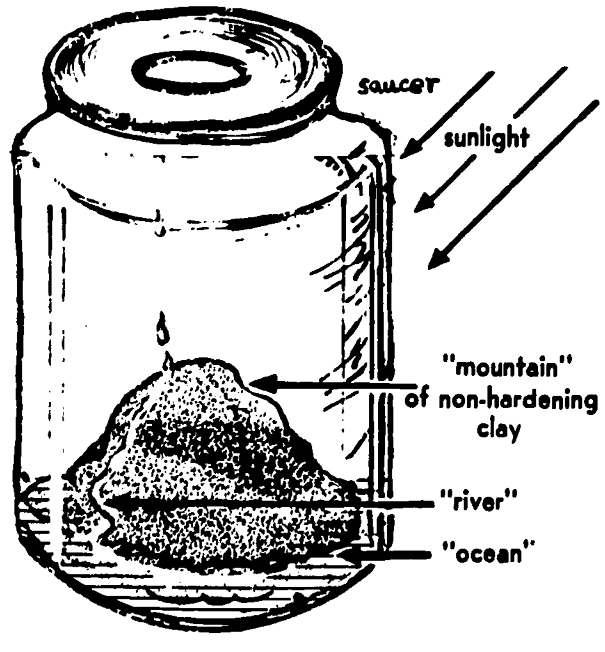
What are the disadvantages of using streams, rivers, and currents to move things? (The moving is in one direction only; one must get *to* and go *with* the water.)

- *A current of water can move heavy loads downstream.*
- *Some loads can be moved more easily on water than on land.*

2. Where does the water in mountain streams come from?

The water in a river is always falling from a higher part of the river to a lower part. How does the water get up to the higher part in the first place?

Discuss the water cycle. Emphasize the role of sunlight in causing water to evaporate from puddles, lakes, and oceans.

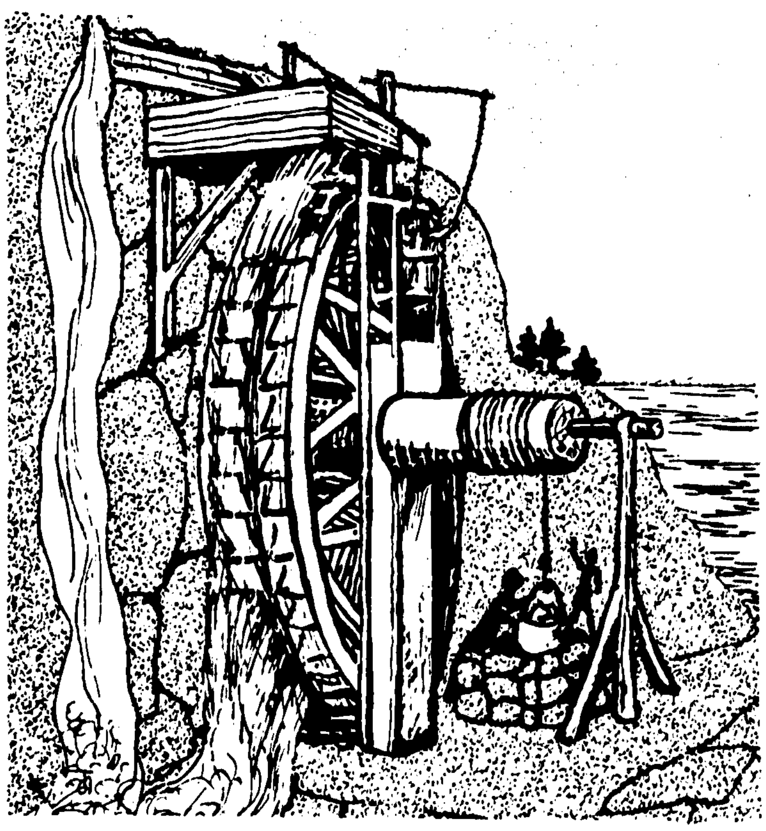


Sunlight "lifts" water.

To show the "lifting" of water caused by the sun's rays, make a model, as shown in the illustration, and place it in sunlight. Trace the cycle of water from "ocean" to air to "mountain stream."

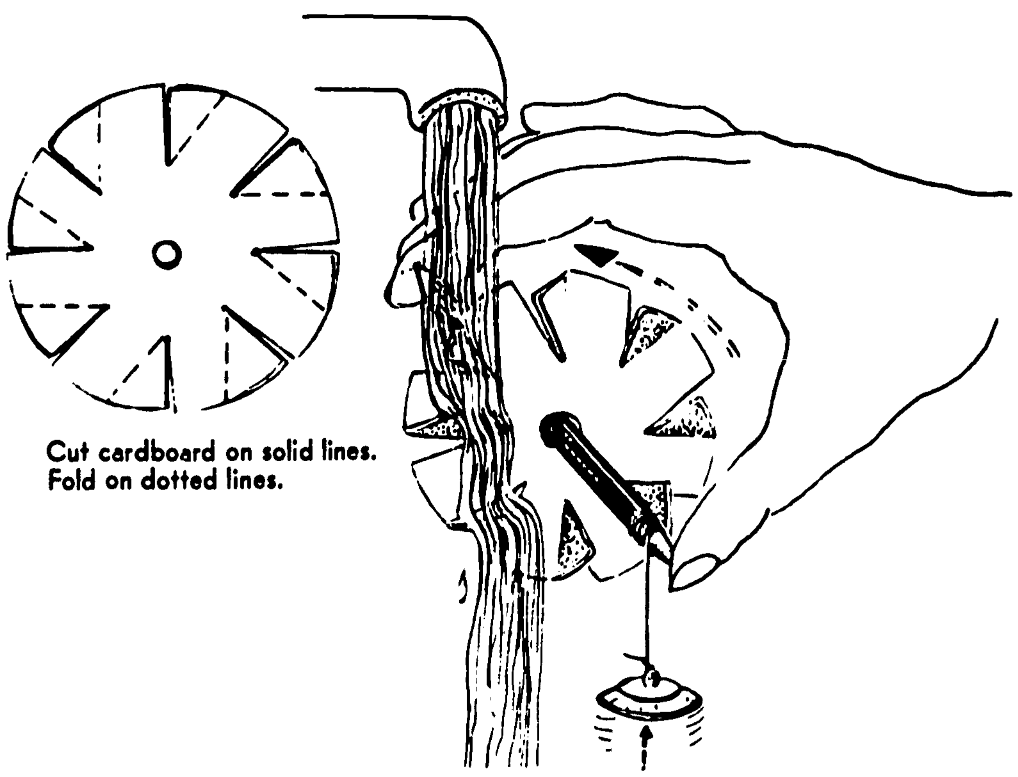
- *Sunlight helps water move into the air by causing evaporation.*
- *Rain from clouds falls on mountains and forms springs and streams.*

3. How do waterwheels help men do work?



A primitive water hoist.

Have children read in encyclopedias and other sources about different kinds of waterwheels, and report their findings to the class. Waterwheels were widely used in early times to raise buckets of coal and iron out of mines. Such a machine is called a water hoist.



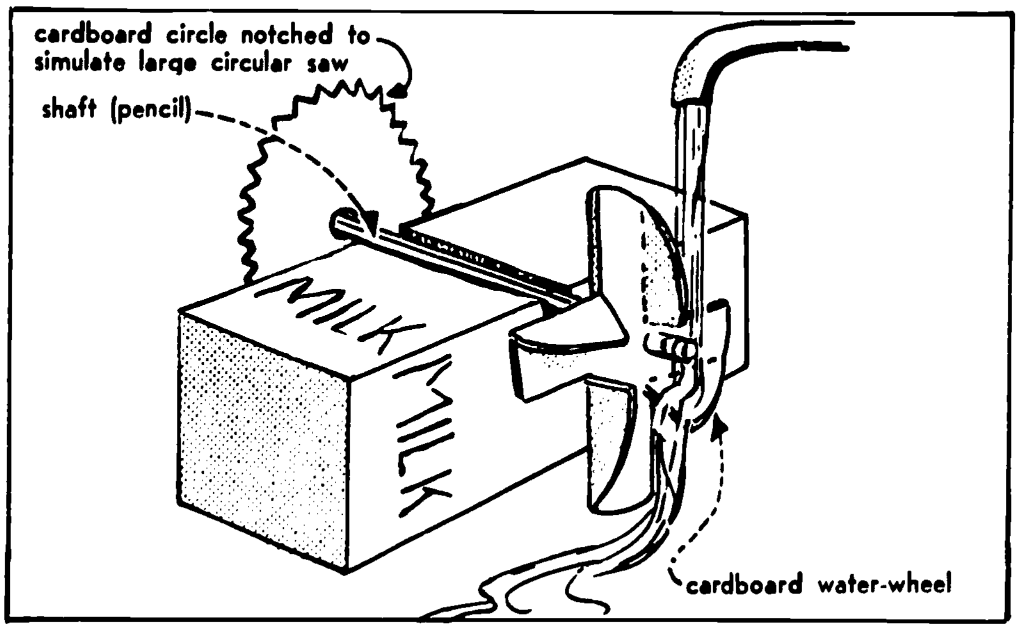
Making a model waterwheel and using it to lift a weight.

Have children make working model of a waterwheel. Hold it under a faucet with the water running very slowly. Watch the wheel turn.

How can we make the wheel turn faster? The first suggestion that children may make is to open the faucet more. Try it. How does this help? (More water hits the blades of the wheel, pushes it harder,. and makes it go faster.)

Is there any way of making the wheel go faster other than opening the faucet wide? Children experiment and find that when they lower the wheel, it spins faster. Why? (The water falls farther, increases its speed, and therefore pushes harder.)

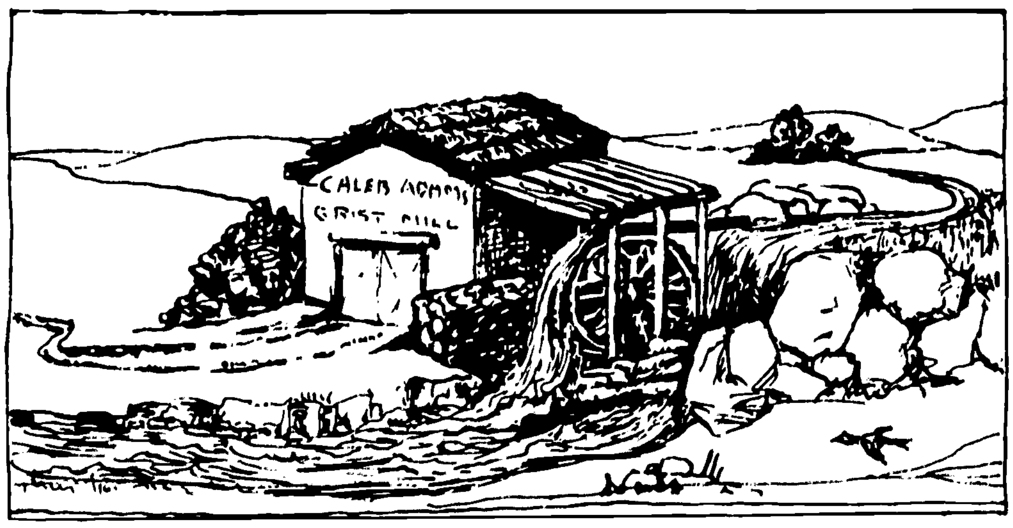
Two factors, then, affect the operation of a waterwheel: the quantity of water pouring on it and the distance the water falls. How does this affect the selection of a site for a waterwheel? (Select a place where there is sufficient flow and/or sufficient fall.)



Model of a waterwheel driving a saw.

How can a model waterwheel be used to do some work? Tie a small weight to one end of a piece of thread. Tie the other end of the thread to the shaft of the waterwheel. Hold under running water. The blades turn, the shaft turns, the thread winds up, and the weight is lifted.

Discuss the use of moving water in water mills (grinding grain, turn-

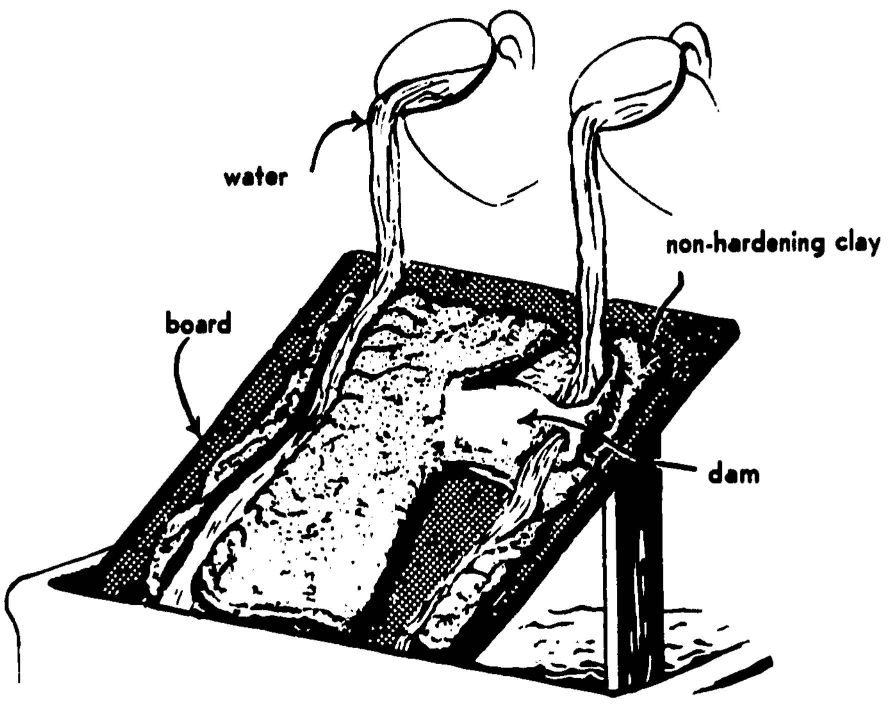


ing grindstones to sharpen knives and scissors, operating looms to weave cloth, and turning saws to cut logs).

- *Moving water can turn wheels.*
- *Waterwheels can turn machines that do many kinds of jobs.*
- *The speed of a waterwheel depends on the quantity of water falling on its blades and the distance it falls before it strikes the blades.*

4. How do dams help us use the force of moving water?

With nonhardening clay, build a "mountain." Make a groove down each side to represent rivers. Across one of the "rivers" build a dam.



A dam raises the level of the water.
When the water flows again, it will have greater force.

Now pour water in equal quantities down both rivers. What effect does the dam have? The children will observe that water builds up behind the dam and falls a distance after pouring over the top or through the locks (spills).

To show how the dammed-up water is used to turn a turbine, make a hole through the wall of the dam. Under the water which spouts out, hold a penpoint "turbine" and watch it spin.

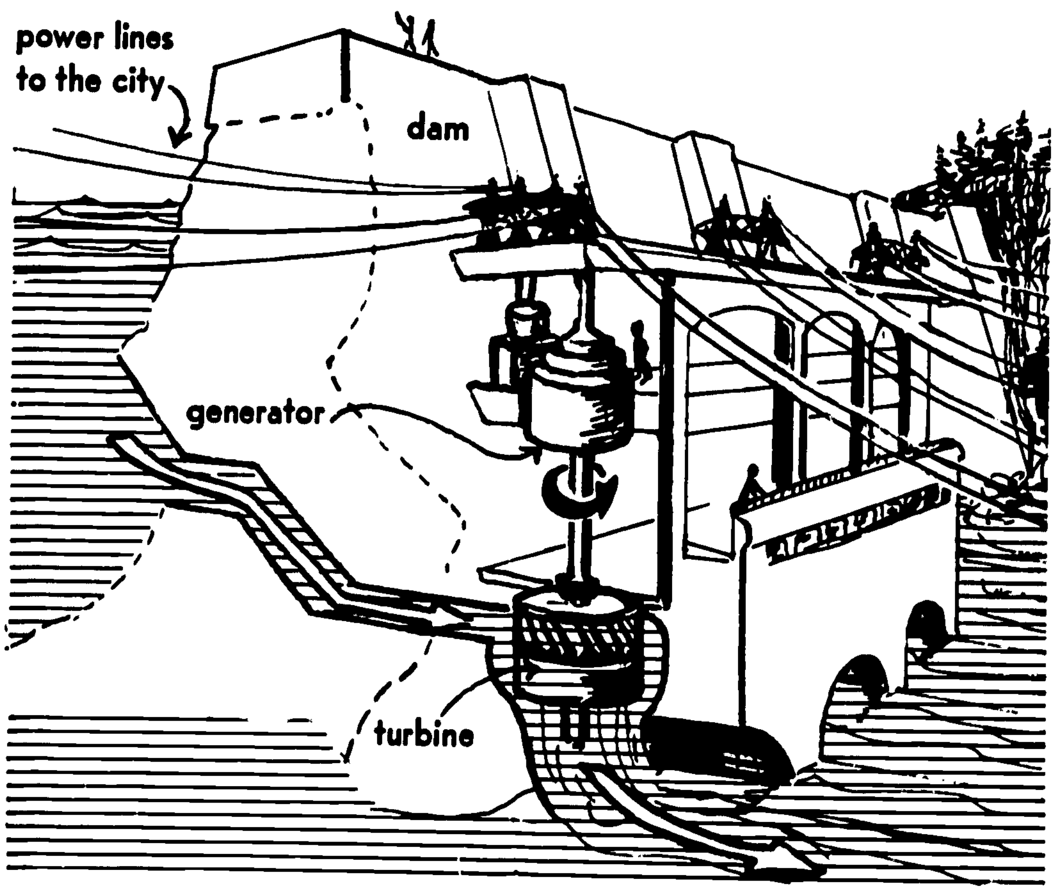
- *A dam is a wall built across a stream to raise the level of the water behind it.*

- *Falling water can exert great force.*

5. How can the force of moving water turn wheels in factories which are far away from the water?

Have the children find out about the huge waterwheels called turbines which turn electric generators. When a generator is turned, electricity is produced. To see this happen, have children light a bulb by turning the crank on a model generator. (Science E-1 Supply List.)

Electricity from water-driven generators goes through wires to factories hundreds of miles away from the flowing water. In the factories,



The power of moving water is changed into electric power.

electricity makes the motors turn. These motors drive many kinds of machines.

Some children may wish to report on the hydroelectric plants which have been built in the U.S. — (See encyclopedias and almanacs.)

- *In hydroelectric plants, water turns turbines connected to generators that send electricity through wires.*
- *Wires can carry electricity hundreds of miles from generators to factories.*

6. Can the tides be used to make electricity?

This question may be assigned to a committee of students for investigation. Encyclopedias are good resources for this topic.

Significant ideas and information that should be presented are:

a. Ocean tides lift water up. In some parts of the world the ocean tides push water into narrow bays and river mouths to a great height. (In Passamaquoddy Bay, where Maine joins New Brunswick, the tide backs up to a height of 26 feet. In River Rance, in Northern France, the water is lifted 44 feet above the low-tide level.)

b. A bay or river mouth can be cut off from the ocean by a dam to form a large basin. The basin is filled when the tide comes in through gates in the dam. When the tide is near its highest, the gates are closed. The trapped water is allowed to flow back to the ocean through water turbines which run electric generators.

c. The first tidal power plant ever put into operation is situated in France on the bay where the Rance River empties into the English Channel.

Some students may wish to build a model to demonstrate how tidal action can be used to turn water turbines.

The gravitational pull of the moon is mainly responsible for ocean tides. (The sun plays a role but a much smaller one.)

- *Tidal action can be used to turn turbines.*
- *The turbines turn generators which make electricity.*
- *The moon's pull on Earth lifts water to produce tides.*

EVALUATIVE ACTIVITIES

1. In order for water in a river to flow it must

   a. start from the north.

   b. start from the south.

   c. come from a higher level. (Answer: c.)

2. Beginning with "sun shines," rearrange the words in the correct order to show the water cycle:

   Sun shines.
   Rivers flow.
   Water evaporates.
   Clouds form.
   Rain falls.

   (Sun shines; water evaporates; clouds form; rain falls; rivers flow.)

3. Waterwheels turn faster when

   a. water falls from a greater distance to the wheel.

   b. more water falls on the wheel.

   c. both of these. (Answer: c.)

C. WIND MAKES IT GO

Background for the Teacher

Long ago, men learned how to use the force of the wind. They put up sails so that the wind would drive their boats. With windmills they used the wind to grind grain, to pump water, and to generate electricity.

Approaches and Learnings for the Child

Children observe the wind blowing smoke, papers, leaves, and other objects. They make and test model sailboats and windmills.

From the activities suggested, children learn:

Wind helps move boats by pushing against their sails.

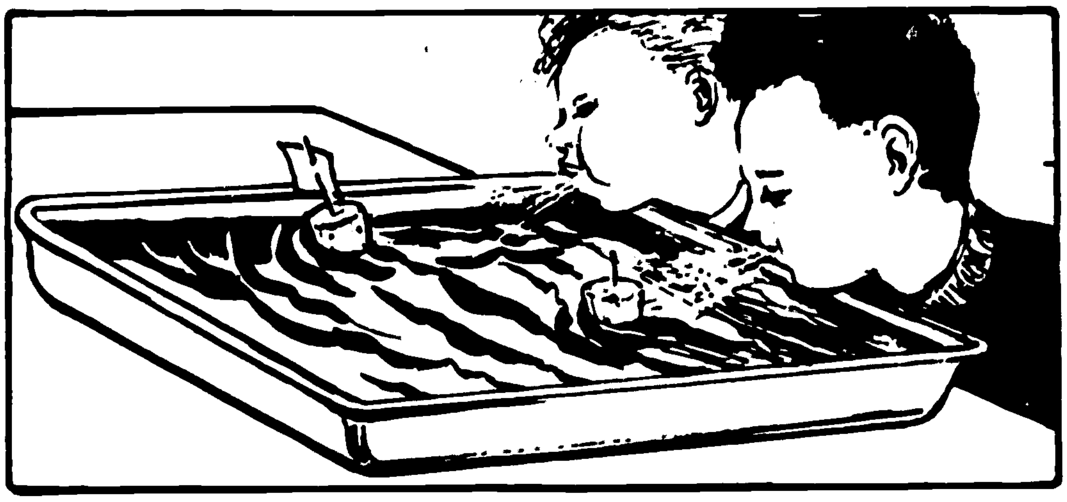
Wind turns the vanes (sails) of windmills to run many kinds of machines.

The heating of Earth by the sun makes winds blow.

1. How do we use wind to make boats go?

Read about sailboats, iceboats, and sailing vessels. Display pictures of sailboats which are famous in history. Discuss the advantages and disadvantages of using wind for making ships go. Find out how long it took for the ships of Columbus to cross the ocean. How long does it take an ocean liner today?

To demonstrate the effectiveness of sails, build two model boats, one with a sail, and one without. Have two children conduct a "race" by blowing on them.



A sail catches the force of the "wind."

Find out about windwagons, land vehicles with sails which were pushed by the wind. Find out about iceboats. Ask children to tell of their sailing experiences. What kinds of sails are there? How is it possible to sail against the wind? Why can't we depend on the wind?

- *The wind's force can be used by man.*
- *Wind moves boats by pushing against their sails.*
- *The wind cannot always be depended on because it does not blow steadily.*

2. How have farmers used wind to help them do their work?

Ask children to find out about windmills and the kind of work they do: pumping water, generating electricity, grinding grain. Make a model of a windmill and hold it in the wind. (The waterwheel shown on page 166 serves equally well as a windmill.)

- *The vaned sails of windmills are made to catch the wind.*
- *Windmills can run many kinds of machines.*

3. Where does the power of the wind come from?

Discuss how the unequal heating of Earth makes the wind blow. (See page 114.) Emphasize the role of the sun in heating Earth. Trace the movement of a sailboat to its source in the energy of the sun.

- *Unequal heating of Earth by the sun helps make winds blow.*

EVALUATIVE ACTIVITIES

1. Windmills are used less and less in the United States because

   a. electrical energy from power plants is now supplied to most farms.

   b. winds are not as strong as they used to be.

   c. farmers are replacing windmills with waterwheels. (Answer: a.)

2. Explain how the following statement can be true:

   The sun makes windmills turn.

   (Sun heats earth unequally; this causes winds to blow; winds turn windmills.)

D. STEAM MAKES IT GO

Background for the Teacher

Very early in history, men learned how to use flowing water and wind to move things. It was not until a few hundred years ago that they learned how to use steam for this purpose. When water is heated to steam, it expands more than 1000 times in volume. If the steam is prevented from expanding by being confined in a closed space, it can exert tremendous force. This force can be put to work. It can spin the blades of turbines to drive the propellers of ships or to turn electric generators. It can push against pistons to drive locomotives.

The heat needed to change water into steam is obtained by burning wood, coal, oil, or gas. Recently nuclear (atomic) energy has been used for this purpose in ships and in atomic plants which generate electricity.

Approaches and Learnings for the Child

Children have observed steam jiggle the lids of pots and teakettles. They make models of steam turbines and watch them spin in a jet of steam. They pop some popcorn to discover the explosive force of confined steam.

From the activities suggested, children learn:

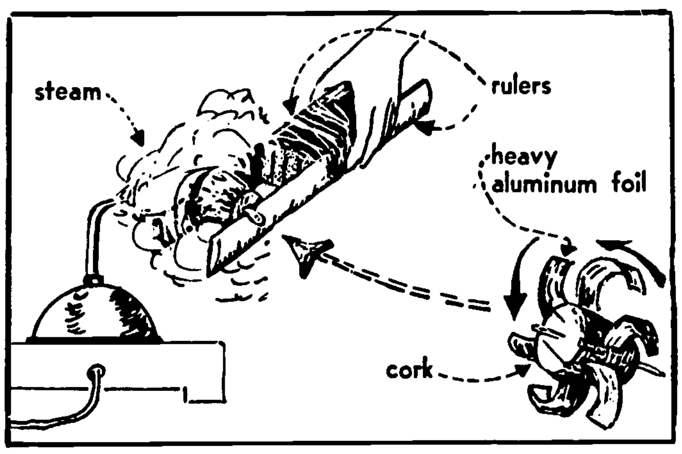
Steam from water boiled in a confined space can push very hard.

Steam can turn the blades of wheels which do work for man.

Steam turbines drive the propellers of ships.

Steam turbines drive electric generators.

Steam gets its driving force from burning fuel or from nuclear (atomic) energy.

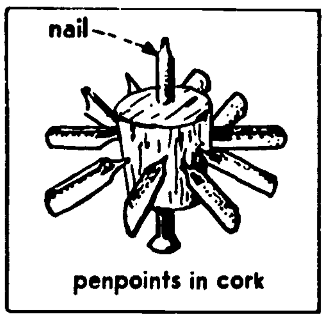


A model steam turbine, with wheel of metal foil.

1. How can steam turn a whee

One of the most motivating experiences for children is to get up a "head" of steam in the electrically operated steam engine. (E-1 Science

Supply List.) It is simple to operate: just plug in. Caution: Make sure there is water in the boiler. Water should be at the half-way mark in the glass water-level gauge. If the boiler is heated empty, then the metal seams split and this fine device is ruined. *Please do not allow this to happen.*

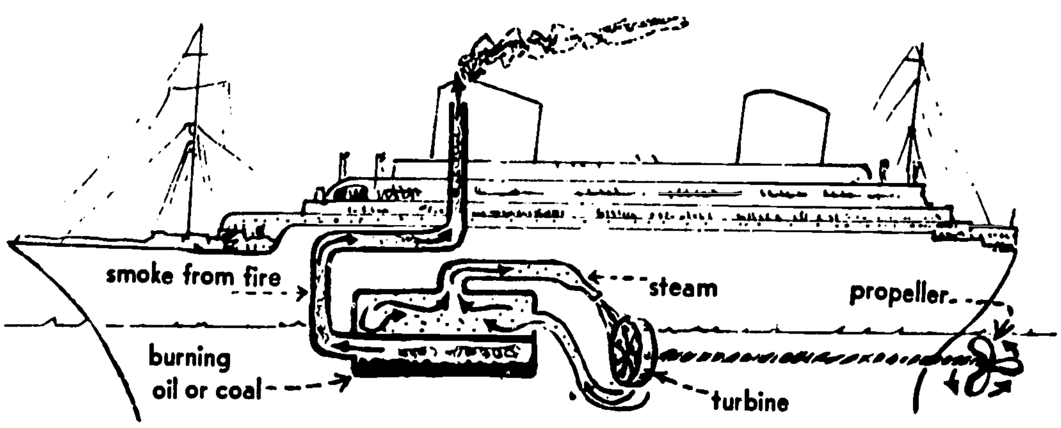


A pen-point turbine wheel.

Make a model steam turbine, using a needle, cork, and penpoints or use "heavy-duty" aluminum foil. Hold it over a jet of steam from a clean oil can which is partly filled with water.

Have children investigate the steam turbines which are used to drive ships and to turn electric generators. Compare these turbines with the model turbine. A real turbine has thousands of blades of strong steel and runs much faster than the model turbine.

Most ships are run by steam turbines. Very hot steam from a boiler pushes the blades quickly and powerfully, forcing the wheel to spin. The turbine wheel is connected to a propeller which drives the ship.



Steam makes the ship go.

In New York City, steam turbines drive the huge electric generators which make electricity for the city. Burning coal boils the water into steam.

- *Steam from water boiled in a confined place can push very hard.*
- *Steam can turn wheels to run machines.*
- *Steam can turn wheels to drive electric generators.*

2. How can steam make a locomotive go?

Children may recall watching the lid on a pot of boiling water. The lid jumps up as steam pushes against it and falls back into place after a puff of steam escapes.

In the piston type of steam engine, the hot steam enters a large tube called a cylinder. Inside the cylinder there is a movable part called a piston. The piston fits snugly in the cylinder, but not so snugly as to prevent its moving. Steam pushes against the piston. The piston pushes a rod which turns a wheel.

In the steam locomotive, now largely replaced in the United States by the diesel, moving pistons make the wheels go round.

Ask volunteers to find out about the work of Thomas Newcomen, James Watt, and others in harnessing the power of steam. Also find out about early steam automobiles.

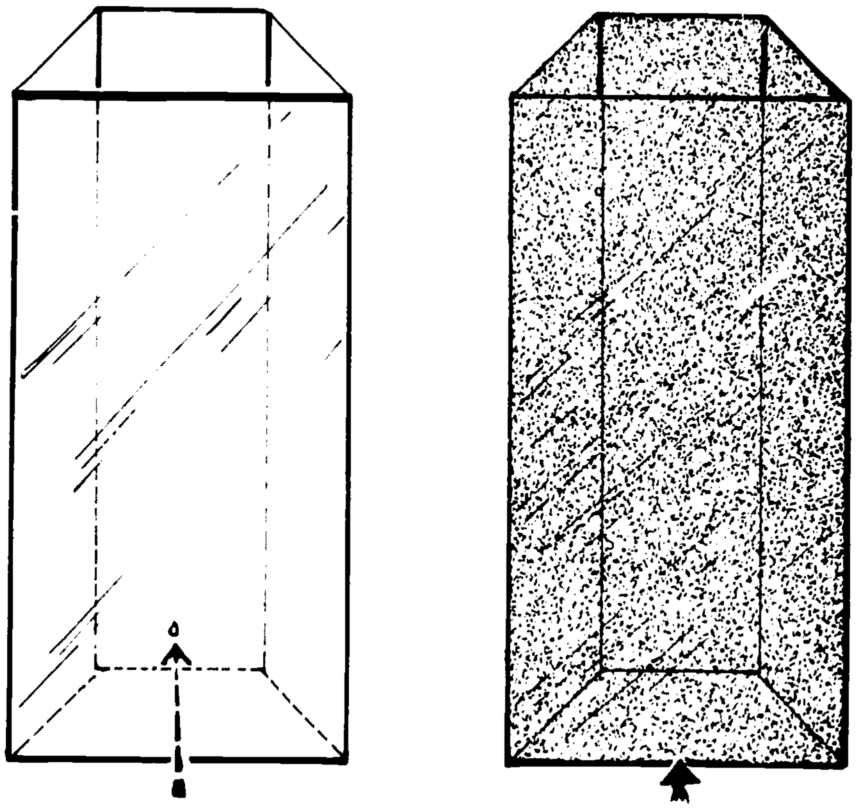
- *Steam can push a piston which moves a rod that turns a wheel.*
- *Steam piston engines are used in steam locomotives.*

3. Where does steam get its "push"?

Discuss the various fuels that are burned to heat water: wood, coal, gas, and oil. The burning of these fuels makes water change into steam. Steam has the force to spin a turbine or push a piston. Why?

When water is heated and changed into steam, the steam takes up more than 1,000 times as much room as the water from which it comes. As a result, steam pushes hard against anything that confines it. Because of this, it can push pistons and spin turbines.

Pop some popcorn in class. Compare the amount of space occupied by the original kernels with that of the popped corn. What causes the popping? Inside each kernel is a tiny bit of moisture, sealed in by the



This much water . . . becomes . . . this much steam.

tough kernel coat. Heat changes the water into steam. The steam exerts tremendous pressure and "blows up" the kernel. The force of this explosion actually turns the kernel inside out.

Find out how steam is made on ships run by nuclear (atomic) energy.

- *Heat from burning fuels changes water into steam.*
- *When water is changed into steam, the water expands more than 1,000 times.*
- *When steam is confined, it can push very hard.*

EVALUATIVE ACTIVITIES

1. When water changes to steam it

   a. takes up less space.

   b. takes up more space.

   c. takes up no space. (Answer: b.)

2. Arrange the following statements in the correct order to show how electricity may be made.

   a. Generator makes electricity.

   b. Water changes to steam.

   c. Turbine turns generator.

   d. Coal heats water.

   e. Steam drives turbine. (Answer: d, b, e, c, a.)

E. RAPID BURNING MAKES IT GO

Background for the Teacher

In steam engines, the heat produced by the burning of fuel changes water into steam. The steam then pushes to "make it go." In automobiles, planes, and rockets, however, the heated gases which result from the burning of fuel are used directly. These gases push hard enough to "make it go."

In the case of piston engines, the explosive burning of fuel in a cylinder pushes a piston to drive the wheels (as in the automobile) or propellers (as in the airplane). In a jet plane or a rocket, the explosive burning of fuel in a combustion chamber produces hot gases which are pushed out of the rear end. As a consequence, the jet plane or the rocket moves in the opposite, or forward, direction.

Approaches and Learning for the Child

Children take trips to garages to observe the "insides" of automobiles. They observe a simple demonstration which shows the push which is developed by rapid burning of fuels. They construct simple devices to show how the in-and-out movement of a piston is converted into the rotary motion of wheels. They release balloons to see how jet action makes them go. They read reports of current achievements of jet planes and rockets.

From the activities suggested, children learn:

Hot gases are produced when fuels burn.

In some engines, the hot gases push against the pistons.

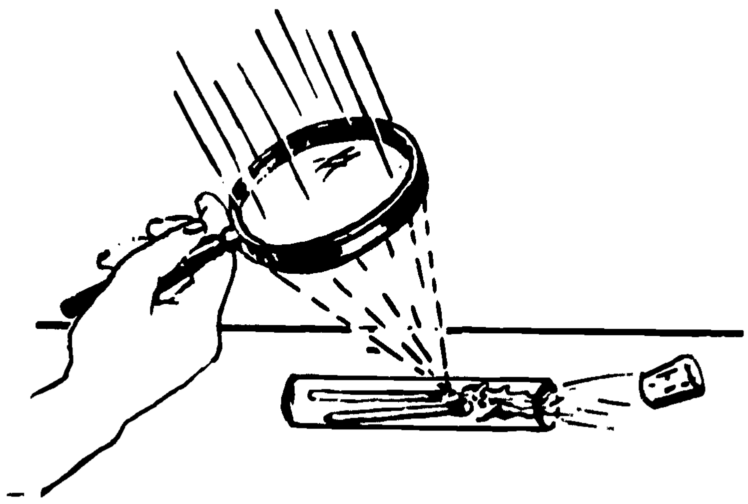
The pistons drive wheels or propellers which make the vehicle go.

In jets and in rocket engines, hot gases are blown out of the rear end. As a result the vehicles go forward.

Jets take in oxygen from the outside air; rockets carry their own supply of oxygen.

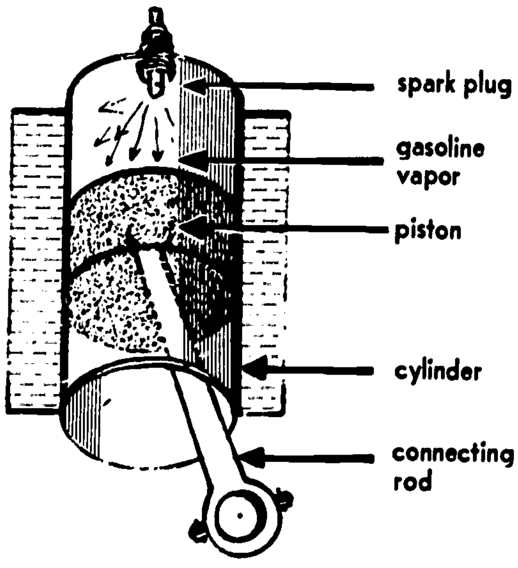
1. How can an automobile engine make a car go?

Ask children to tell what they think happens inside an automobile engine. The following activities and discussions will help clarify their concept of this internal combustion engine.



The sun's rays ignite matches; heated gases expand; the cork pops.

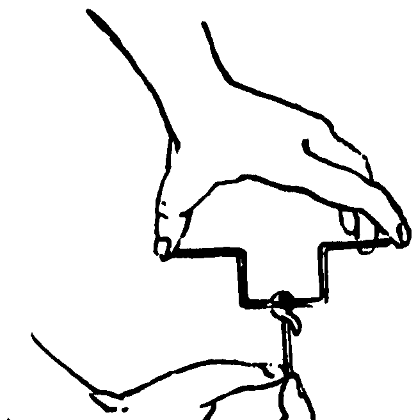
a. This demonstration should be performed by the teacher. Put two match tips together in a glass vial. Wet the stopper and put it in place, but not too tightly. Place the bottle in sunlight. Hold a large magnifying glass so that the sunlight comes to a focus on the match tips. If the sunlight is strong enough, the matches will catch fire after a short time and the cork will fly out of the bottle. (As a match burns, it gives off gases and heats the air near it. The new gases and the heated air push the cork out.)



Spark ignites gasoline vapor; heated gases expand; piston is pushed down.

b. Compare the preceding demonstration with what happens in a gasoline engine. A fine spray of gasoline is mixed with air inside a cylinder. The mixture is set afire by a spark from a spark plug. The gasoline burns rapidly (we call such rapid burning an explosion). As a result, the heated gases which are produced push against the piston and make it move.

c. The in-and-out movement of the piston makes a wheel turn. Each explosion makes the piston move outward. The piston pushes a connecting rod that turns a crankshaft. The turning motion of the crankshaft is eventually transmitted to the wheel.

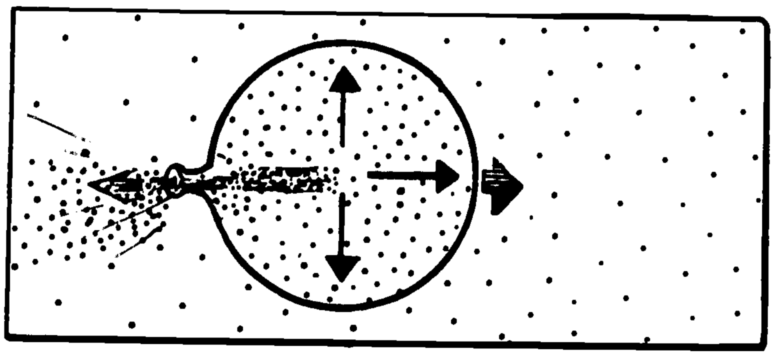


Up-and-down motion becomes rotary motion.

To show how an in-and-out motion can produce a rotary motion, have the children bend a piece of wire into the shape shown. Manipulate it to obtain a rotary motion. Also, recall how the downward motion of a foot on a bicycle pedal results in a rotary motion.

Take a trip to a nearby garage or auto repair shop where the parts of an engine may be observed.

- *The driving force of a car engine comes from the burning of gasoline.*
- *When gasoline burns, it gives off gases and heats the air near it. This causes the gases and air to expand and push.*
- *In a gasoline engine, the gasoline is burned inside metal cylinders. In each cylinder there is a piston that can slide back and forth.*
- *Each piston pushes a rod which turns a crank. The crank causes the wheels of the auto to turn.*



There is less push on the side of the balloon from which the air is escaping.

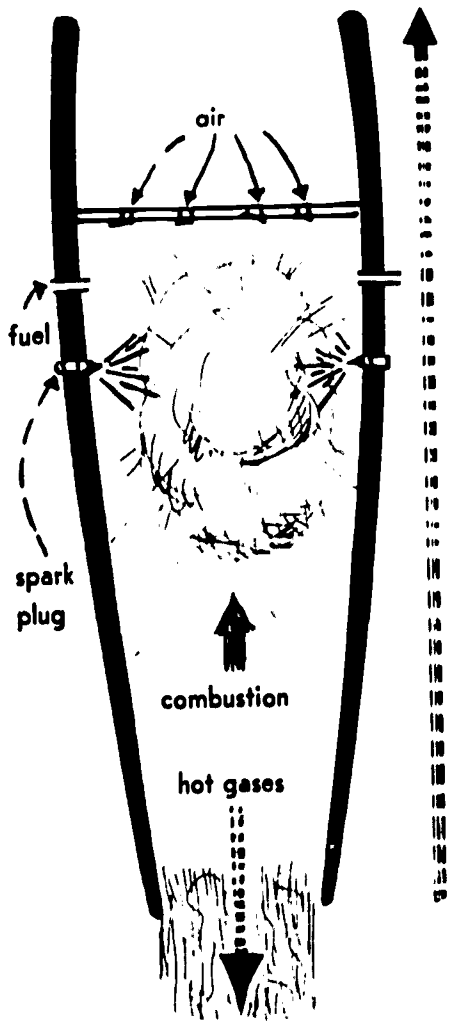
2. How does a jet get its push?

Have children fly a toy balloon by blowing air into it and then releasing it. Note that the balloon goes in a direction opposite to that of the air rushing out of it.

Note that the balloon keeps going until all of the extra air is gone. If we could keep a supply of air or some other gases blowing out of the balloon, the balloon would keep on flying.

There are a number of kinds of jet engines, but all work on the same principle. In all, an explosion is produced by the rapid burning of fuel in a large chamber. In all, the oxygen needed for burning is obtained by taking in air from the surroundings. In all, the explosion of fuel in a chamber causes a blast of hot gases from a rear opening, resulting in a forward push on the plane.

- *In a jet plane, gases blow out of the rear end. As a result, the plane goes forward.*



Jets use oxygen from the air.

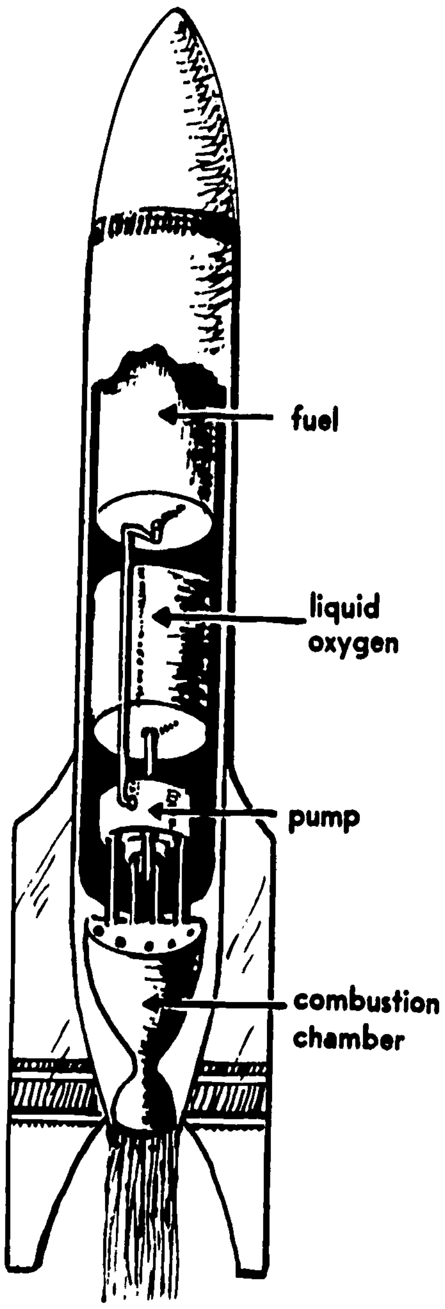
- *In a jet plane, the oxygen needed to help burn the fuel comes from the outside air.*

3. Why are rockets used for flights to outer space?

Have children discuss television broadcasts of the blast-off of rockets. Ask them to bring in pictures of rocket launchings. In the rocket, as in the jet, the burning of fuel blasts gas backward and causes the rocket to go forward. How does a rocket vehicle differ from a jet?

A jet engine takes in air from which it obtains the *oxygen* needed for burning. As we go higher into the atmosphere, the amount of air decreases until finally there is practically none. A jet engine, consequently, cannot operate at very high altitudes. A rocket engine, however, *carries its own supply of oxygen.* It does not depend on the outside air.

- *Rockets carry their own supply of oxygen.*
- *Rocket engines can work in outer space.*
- *The blast of gases from the rear end of a rocket makes it go forward.*



Rockets carry their own oxygen supply.

EVALUATIVE ACTIVITIES

1. An explosion is a very rapid burning which produces a tremendous amount of gases and heat. What substances are needed for the explosions in the cylinders of an automobile engine?
   a. Gasoline.
   b. Gasoline vapor and air.
   c. Gasoline vapor, air, and oil. (Answer: b.)

2. What starts the burning of the fuel in the cylinders of an automobile?
   a. A spark from a spark plug.
   b. A flame from a match.
   c. Heat from the electric heater. (Answer: a.)

3. Rockets
   a. carry their own supply of oxygen.
   b. use oxygen of the air around them.
   c. must have air to push against. (Answer: a.)

F. ELECTRICITY MAKES IT GO

Background for the Teacher

So far we have considered such basic sources of energy as muscle, flowing water, wind, steam, and burning. In many instances, as we have indicated, the energy in these sources is first converted into electrical energy, which then is used to drive machines.

We include a brief discussion on electricity here to complete the topic *Making It Go*, but specific activities on motors and generators are deferred until Grade 6.

Approaches and Learnings for the Child

Children observe many of the hundreds of electrical devices used in homes, schools, and industry.

From the activities suggested, children learn:

Electric motors are found in many everyday appliances.

Moving water, wind, or steam can be used to run electric generators.

1. What is moved by electricity?

Students make a survey of electrically powered devices and machines at home, in school, in transportation, and in industry.

- *Electric motors are found in many everyday appliances.*
- *Electric motors drive many of the machines of industry.*

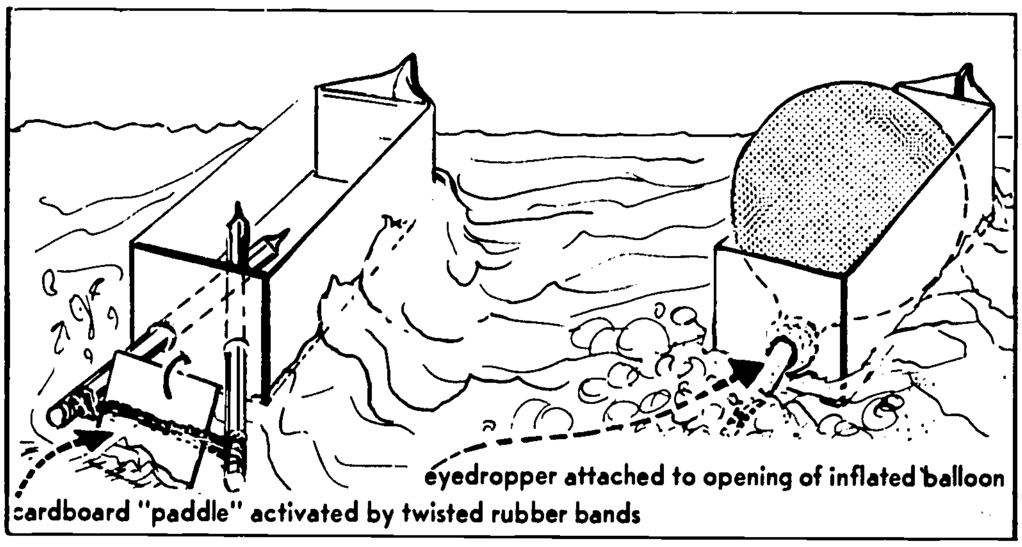
G. FINDING OUT MORE ABOUT MAKING THINGS GO

This section lists some suggestions for special projects for interested students. The children should be encouraged to present their findings and demonstrations to the class and to use them in school exhibits and science fairs. The library is a rich source of ideas and inspiration. Refer interested students to the books listed in the Bibliography.

1. Make reports on muscles in the human body. Include: illustrations; the use of different muscles; information about their care and development; and the treatment of sore muscles.
2. Report on and have actual demonstrations of common tools worked by man's muscles. Include: use, care, types, improvements, and the scientific principles involved in their operation.
3. Demonstrate operation of parts of a bicycle: brake, fork, ball bearings, spokes. Discuss operation of bicycles with gear shifts.

4

4. Make models of a rubber band-propelled boat and a jet-propelled boat, as in the illustration.



5. Find out about the various kinds of boats used in the past and in the present. What is a hydrofoil? What is the future of water transportation? How does a nuclear-powered ship operate?

6. How does a submarine work?

7. Make a chart showing how the sun is responsible for various forms of energy.

8. Demonstrate a toy boat operated by remote radio control. These are sold in most hobby shops.

9. How does the logging industry use moving water to transport logs to a mill? What techniques are used in this operation?

10. Report on atomic energy plants which produce electricity.

11. Make a plaster model of a dammed reservoir with hydroelectric generator.

12. Report on the large hydroelectric power plants in the United States.

13. Make a model of the action of a steam engine.

14. How can a sailboat go against the wind?

15. Can you invent a way of using the tides to turn a generator to produce electricity?

16. Design an experiment to show how the speed of a stream increases as the slope of the stream bed gets greater.

17. Design a technique or an instrument to measure the speed of moving water currents.

18. Read about the Passamoquoddy Bay and other projects to harness the force of the changing tides.

19. Find out about the large wind vanes one sees on tall towers in the country. Are they used to charge large electrical batteries or to pump water from wells up to water storage tanks?

20. Obtain a spring wind-up toy and also a watch with a second hand. Time how long it will take to run down completely when one turn is made with the winding key. Then try with two turns, etc. If the toy can move in a straight line, measure how far it moves. Complete a chart such as the one given here and make a graph. What conclusions can you draw from your data?

Number of turns of winding key	Number of seconds for spring to run down	Number of feet car moved
1	4	7

21. Report on and, if possible, make models of devices which use solar energy, such as: solar cookers, solar heat panels for heating homes, solar pumps, solar refrigerators, thermopiles, photoelectric cells, solar batteries.

BASIC SUPPLY LIST
FOR *MAKING IT GO*

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

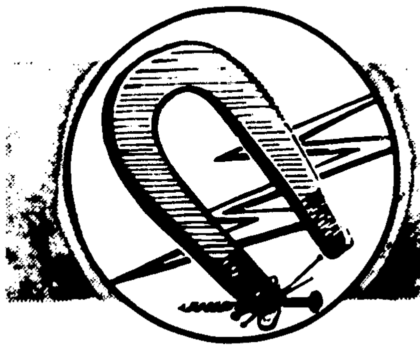
- *2 pkgs. balloons
- 1 large plastic basin
- *1 magneto (model generator)
- *1 pkg. corks
- * aluminum foil
- 1 oil can
- 1 magnifying glass
- *1 engine, steam model

G-1: General Supply List

- 4 rubber bands
- •1 box open screws and eyes
- 1 wrench
- 1 hammer
- 1 screwdriver
- 1 pliers
- 1 pair of scissors
- • pencils
- 2 nuts
- 2 bolts
- •1 pkg. oaktag
- •1 pkg. unlined paper
- •1 pkg. needles
- •1 box paper clips
- •1 pkg. plasticene

Miscellaneous:

- •1 spool of thread
- • buttons of assorted sizes
- •1 box toothpicks
- • penpoints
- 1 glass vial with cork stopper
- •1 pkg. enclosed aluminum container of corn for popping ("Jiffy Popper")



Batteries and Bulbs

A. BULBS IN DIFFERENT KINDS OF CIRCUITS

Background for the Teacher

Electricity must have a complete circuit in order to flow. The circuit is the path that the electrons follow from a source of energy (a flashlight battery), through the device to be operated, and then back again to the source of energy.

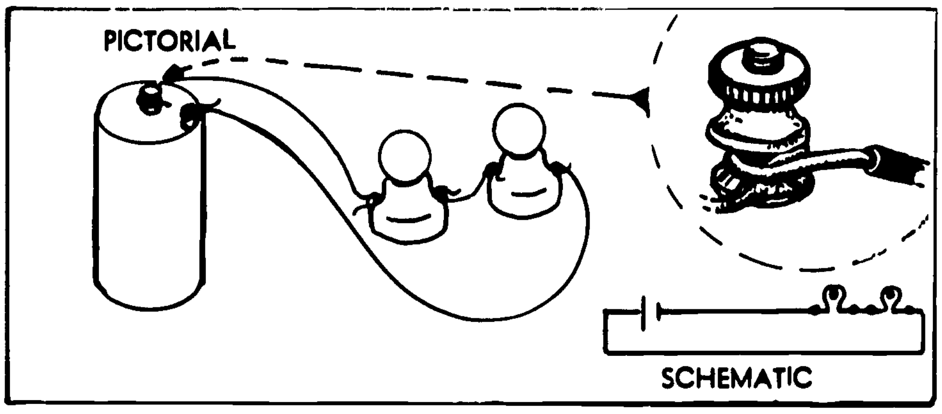
To understand electricity, it is essential to know something about electrons. Electrons are particles found in the atoms of all substances. In a basic sense, therefore, all substances are electrical in nature. Thus, it is not possible to "make" electricity; all that is needed is a "push" to start a flow of electrons in one direction. Current electricity, then, is a stream or a *flow of electrons*. This stream or current flows in a continuous path from a source of energy, through the device to be operated, back again to the source of energy, and so on. This complete path is called a circuit. The current will not flow unless the circuit is unbroken (complete).

When we say that electricity flows through a copper wire in a circuit, what really happens is that each atom of copper in that wire is passing some of *its* electrons on to neighboring atoms. The neighboring atoms do the same, and so on along the wire. An electric circuit may be compared to a circle of children, each child with pieces of chalk in his hand. Each child represents an atom in the wire; the chalk represents electrons of that atom. When each child passes a piece of chalk to his neighbor, a "current" is flowing. This analogy, however, is imperfect because the chalk is not really a natural part of each child in the sense that an electron is a part of each atom.

A "dry" cell, used as a source of electrical energy in the experiments in this topic, is not actually dry; some of its components are moist. When the cell is connected in a circuit, chemical action within the cell supplies the energy to give the "push" needed to start a flow of electrons around the circuit.

The word "battery" technically means a combination of cells. However, since "battery" in common usage is synonymous with "cell," it is sometimes used to refer to the "D" size flashlight cell.

Two basic types of circuits are the *series circuit* and the *parallel circuit*. Each type has its own characteristics and uses.

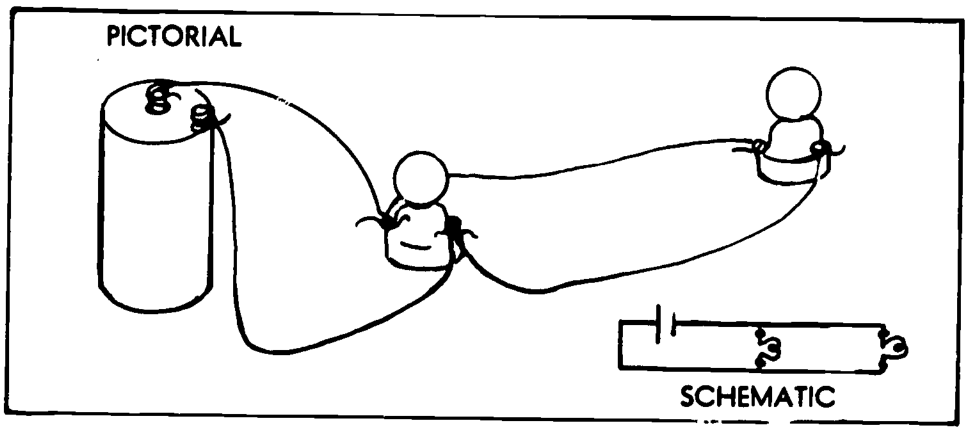


In a series circuit there is a single pathway for the electricity.

When electrical devices are connected in series, they form a *single* pathway over which the current flows between the two points of the circuit they connect. Thus, in order to light two bulbs in a series circuit, the electrons must flow from one terminal of the battery, through a wire, through one bulb, through a second wire, through a second bulb, and then through a third wire leading to a second terminal of the battery. Both lamps must be connected or no current will flow. If either bulb is removed or blows out, the circuit will be broken and the other bulb will not light.

When electrical devices are connected in parallel, they form *branches,* each of which provides a separate path whereby current can flow between the two points they connect.

If either bulb is removed or blows out, the other bulb will remain lighted because the electricity flowing through one lamp can complete its circuit without flowing through the other lamp.



In a parallel circuit there are a number of separate pathways for the electricity.

Approaches and Learnings for the Child

Many of the approaches used in this topic come from *Batteries and Bulbs,* a unit developed by the Elementary Science Study, a division of the Educational Development Center, Inc., Newton, Massachusetts.

Each child experiments with his own simple equipment (flashlight batteries, small bulbs, wire) and draws conclusions based on his observations. He finds out that there are several ways to connect a bulb to a battery and have it light up. He investigates ways of connecting two bulbs in a circuit. The experiments suggest questions which in turn suggest new experiments.

In the course of their experimentation, children construct their own "rules" to *describe* what happens and to *predict* what may happen. These rules are discussed, evaluated, and modified by other children on the basis of their own experiments.

Although the generalizations are worded in children's language, they express scientific truths within the context of the conditions of the experiments. Some examples are:

"A switch can be used to open or close a circuit."

"In some connections (parallel) each bulb has its own private circuit."

"In some circuits (series) if one bulb goes out, the other one goes out."

The teacher should allow one or two periods of free experimentation before asking children to draw conclusions. This allows for a good deal of communication among children and between the teacher and individuals or groups of children.

From the activities suggested, children learn:

Electricity flows in a circuit.

In a series circuit there is only one path for the current to flow.

In a parallel circuit there are two or more paths for the current to flow.

The bulbs in a parallel circuit glow brighter than those in a series circuit having the same kind of bulbs and battery.

If one bulb in a series circuit is removed or blows out, the others will not light.

If one bulb in a parallel circuit is removed or blows out, the others will remain lighted.

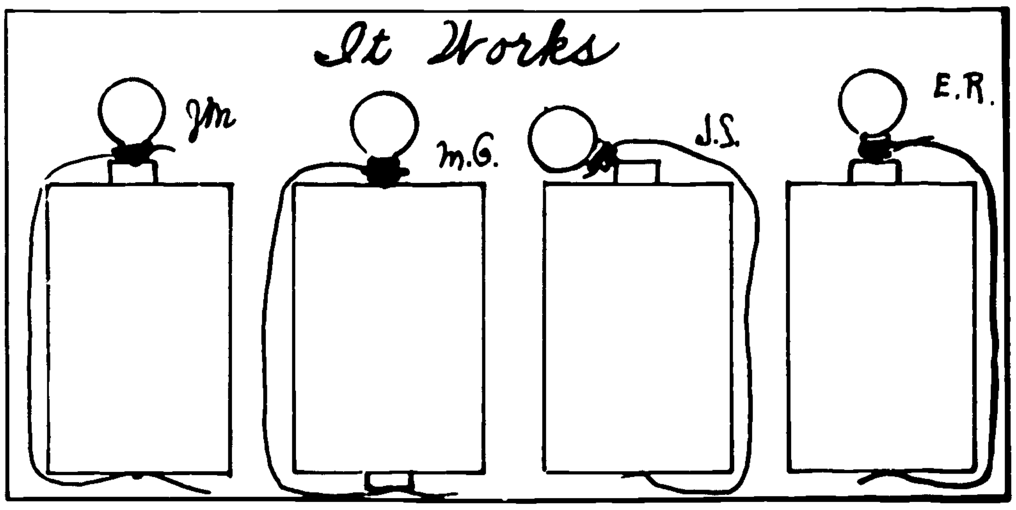
1. How can you make a flashlight bulb light with just a battery and a wire?

Distribute 1 bulb (1.5 volts), 1 flashlight cell, and 1 piece of wire (stripped at both ends) to each child. Invite the children to experiment with the materials until they get the bulbs to light.

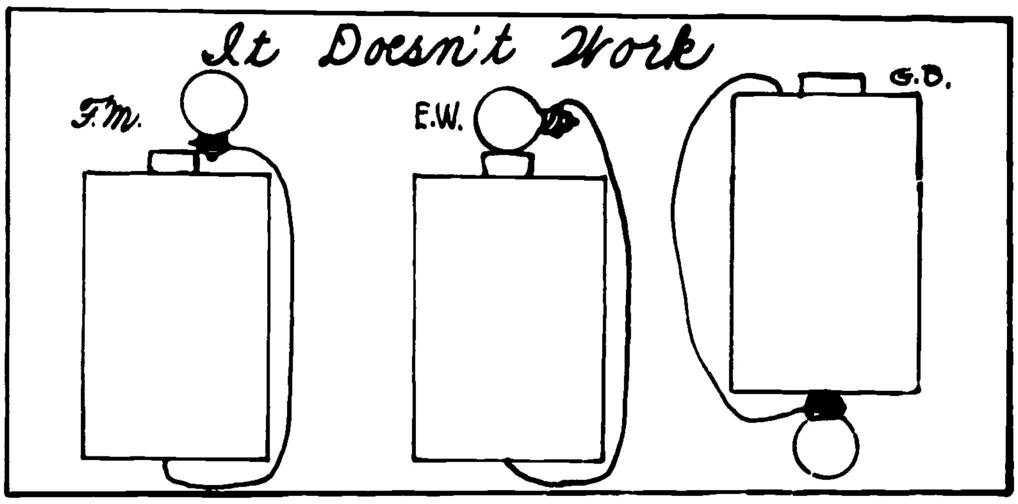
Some children may take twenty minutes to get the bulbs to light; others may do it in five minutes. Once one child manages to make the bulb light, his idea spreads fast. It is possible that only five or six children will light the bulb by themselves. The rest of the class may follow a neighbor's lead. This should not be discouraged because some children hesitate to investigate on their own. (It may be necessary to continue this activity in the next science period.)

What did you do to get the bulb to light? As each child demonstrates, have the others note that there are different ways to do it. How can we remember these different ways? Some children may suggest writing down everything that was done; others may wish to draw a picture showing how the materials are used to light the bulb.

Invite children to the chalkboard to draw the different ways they used to get the bulb to light. (They might want to initial their diagrams.) Label this section of the chalkboard "It Works."



Ask those children who did *not* get a bulb to light to show what they did. These ways are also important and should be included. Invite these children to draw on the chalkboard a diagram of what they did and label this section "It Doesn't Work."



Have children examine the diagrams of both chalkboard sections. Why did the bulb light in "It Works" and not light in "It Does Not Work"? Some children may be able to draw inferences by comparing the diagrams; others may have to work with the materials for verification. To help guide children in their thinking, ask:

Does the bulb have to touch the cell? (Yes.)

Does the wire have to touch the bulb? (Yes.)

To light the bulb, what special places must be touched on the bulb? (The tip and the "screw." These may be called "contact points.")

To light the bulb, what special places must be touched on the cell? (The tip at the top, and at the bottom. These may also be called "contact points.")

At this point, or later if the teacher prefers, there should be a discussion of the flow of electricity. (See *Background for the Teacher*, page 189.) The advantage of discussing it here is that the circuit is "stripped down" to its bare essentials in this simple circuit.

Develop these points:

a. The cell provides the "push" for the current.

b. Electricity (electrons) flow from the zinc container of the cell, through the wire, through the bulb, and back to the center post of the cell.

c. Each part of the circuit has two contact points, one for the entrance and one for the exit of the electric current.

d. Electricity flows in a circuit.

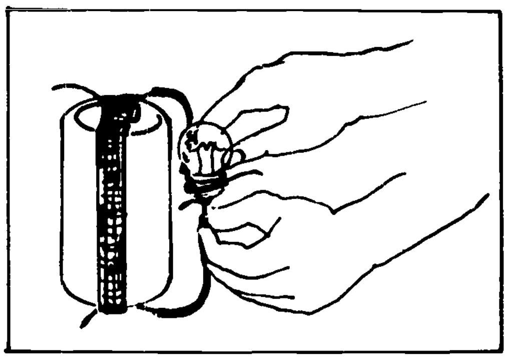
- *There are a number of ways of connecting a bulb to a cell so that the bulb lights up.*
- *To light the bulb, two places on the bulb and two places on the cell must be touched.*
- *Electricity flows in a circuit.*

2. Can you light a bulb if it does not touch the dry cell?

Distribute 1 flashlight bulb (1.5 volts), 1 flashlight cell, and 1 piece of wire (stripped at both ends) to each child. Invite the children to experiment with the materials.

As children work, they will become aware that another piece of wire is needed. Distribute a second wire (stripped at both ends) to each child to solve the problem.

Children experiment until they get the bulb to light without having it touch the cell. What can we do to help us remember how this was done? Children will suggest drawing a picture. Invite children to the chalkboard to make drawings of the different ways they got the bulb to light. Some drawings may look like those shown in the illustration.



Two wires make it possible to light a bulb at a distance from the dry cell. A rubber band helps.

In working with the materials, children will probably find it awkward and difficult to hold the materials while trying to light the bulb. What can we use to keep the materials together? Some children may be motivated to design their own holder.

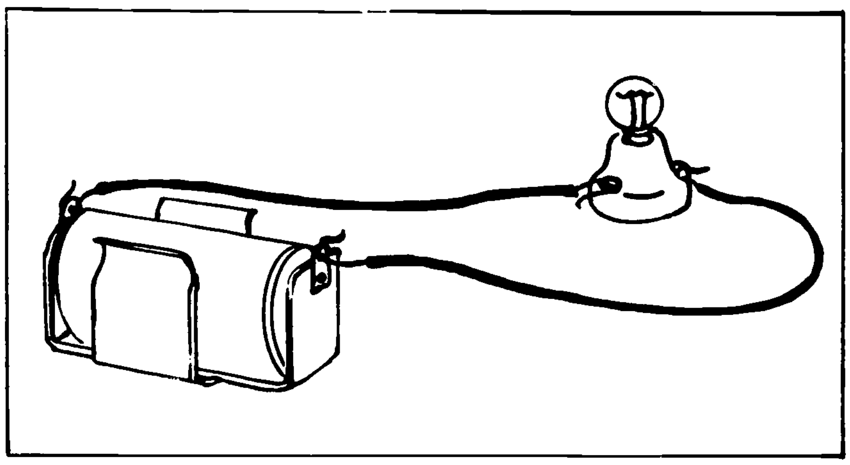
Distribute a thick rubber band to each child. How does the rubber band help? Children will find that it makes it possible to assemble circuits more easily.

- *If you use two pieces of wire in a circuit, a bulb need not touch the battery directly to light up.*

3. How can we use a holder, a socket, and a switch to make circuits?

Distribute the following materials to each child: 1 cell, 1 battery holder, 2 pieces of wire (stripped at both ends), 1 socket (1 knife switch will be distributed later).

How can you get the bulb to light, using all of these items? Allow enough time for children to examine the materials. As children place the cell in the battery holder, ask: Does the holder still touch the special places on the cell? (Yes.)



A "battery" holder and a lamp socket make it still easier to construct a circuit.

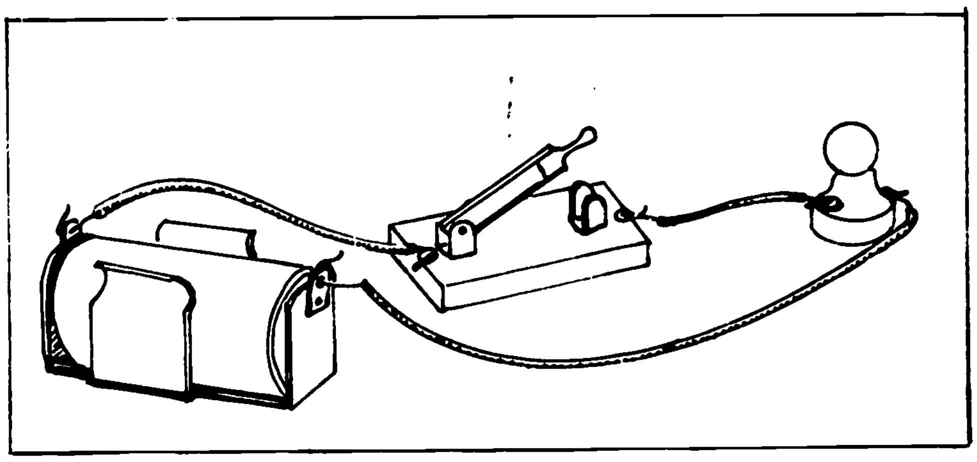
When children start to work with the bulb and socket, they will find that they need a screwdriver to attach a wire under each of the loosened screws in the socket. To guide children as they work, ask:

How does the socket work?

Are the contact points on the bulb still connected to the contact points on the battery?

Which parts of the socket touch which parts of the bulb?

How can you turn off the light? Some children may suggest unscrewing the bulb from the socket; others may suggest disconnecting one wire from the battery holder, or from one of the screws on the socket. Have children try the different ways mentioned. Which way was the easiest? (Children may differ in their answers, depending on their own experiences with the materials.)



A switch is used to close a circuit and to break a circuit.

Could we add anything to the circuit which would make it very easy to turn the light on and off? Some children may introduce the idea of using a switch. Give each child a switch. (There may be some who will want to make their own.) In what different ways can you now light the bulb? Children experiment with materials to connect a circuit, using a switch. When the switch closes the circuit, the bulb will light. When the switch breaks the circuit, the bulb will not light.

- *A battery holder, a bulb socket, and a switch make it easier to construct a circuit.*

- *A switch can be used to break or close a circuit.*

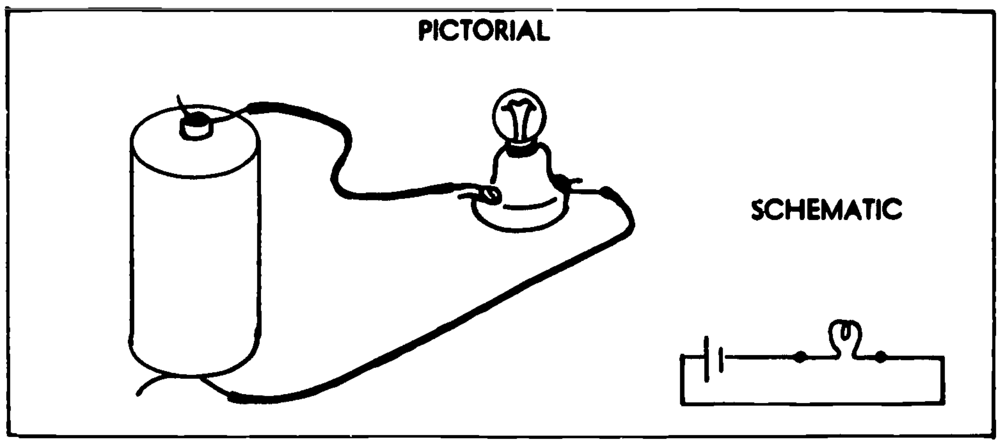
4. What is a quick way to make circuit drawings?

Distribute all the materials that were used in Problem 3. How can we record the different circuit arrangements? Children may suggest drawings. As they pictorially record the circuits, they will find that this kind of record keeping can be time consuming, and that sometimes the pictures cannot be understood.

How can we make simple diagrams that can be understood by everyone? Children may suggest using a "secret language" to communicate their ideas: signs or symbols can be used instead of pictures. Some children may want to invent their own symbols. At this point it should be explained that people who work with electricity use *standard* symbols to represent actual batteries, wires, and bulbs which make up the circuits. Symbols that are widely known and used are found in the following chart.

Why do you think the symbols are drawn the way they are?

Draw a simple circuit on the chalkboard in pictorial form. This is called a *pictorial* diagram.

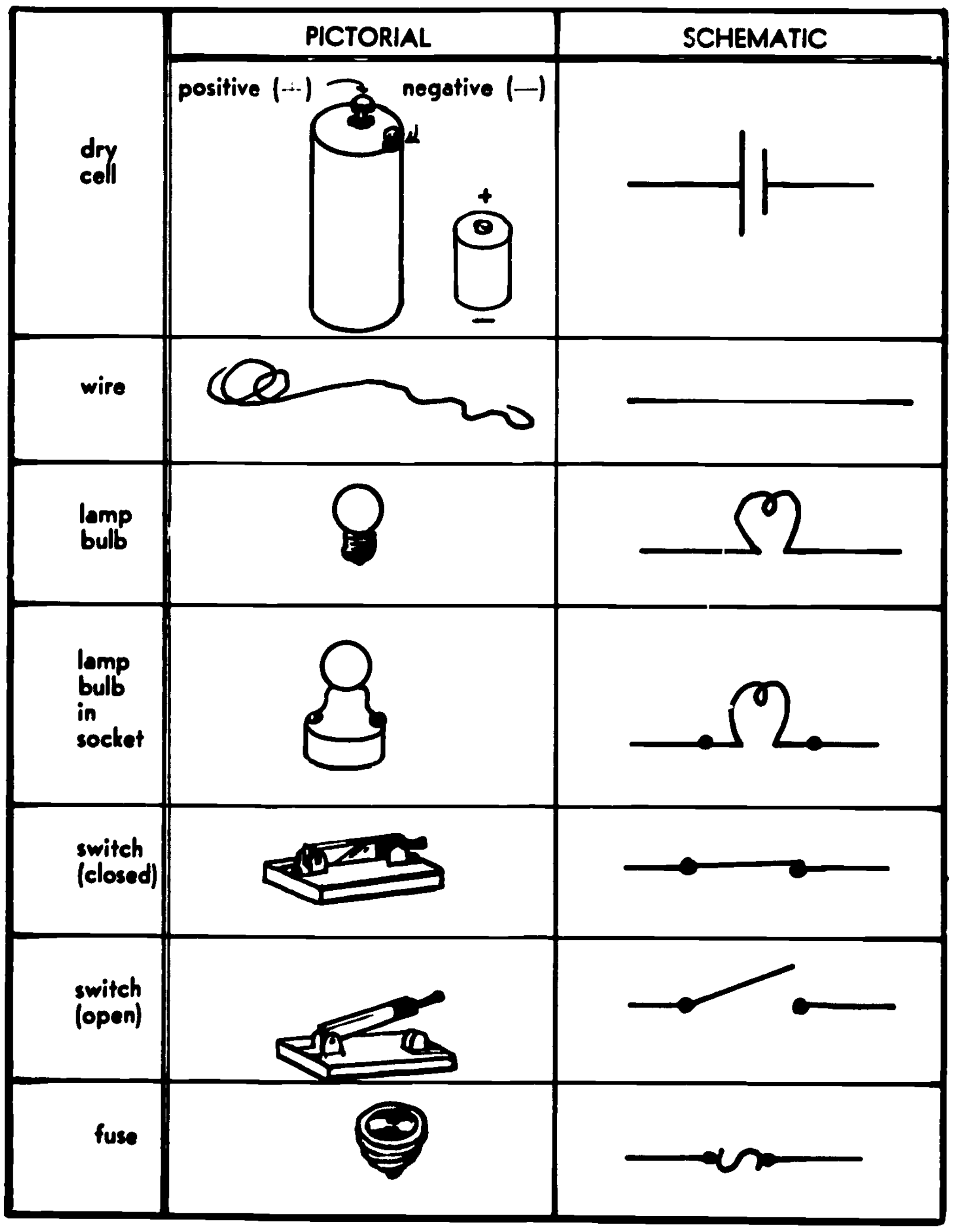


Two ways to draw a circuit.

Ask children to draw this simple circuit using the standard symbols of the "secret language." This is called a *schematic* diagram.

Next, have children examine the circuits they have constructed and make a diagram of it with the standard symbols. Do the symbols help you in the drawing of circuits?

Have different children, using symbols, draw various simple circuits on the chalkboard. Ask other children to predict what will happen. Children can check their predictions by constructing the circuits indicated by the diagrams.



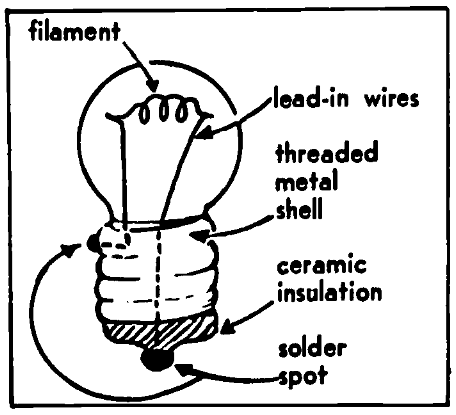
The "secret language" of electrical circuits.

• *It is easy to draw simple circuits with symbols.*

5. How does electricity travel through a bulb?

Distribute a battery holder, a switch, a socket, a bulb (1.5 volts), two pieces of wire (stripped at both ends), and a cell to each child. Have the children complete a circuit and light the bulb. Ask them to review the path of electricity.

How does electricity flow through the *bulb* to complete the circuit? Encourage children to hypothesize. List their ideas on a chart.



A bulb as seen through a magnifying glass.

Give out magnifying glasses to the class. Have children look at an unlighted bulb through the magnifying glass. What do you see? Direct children's observation to the continuous wire from the solder spot at the base of one side of the bulb up through the filament to the solder spot at the other side of the bulb.

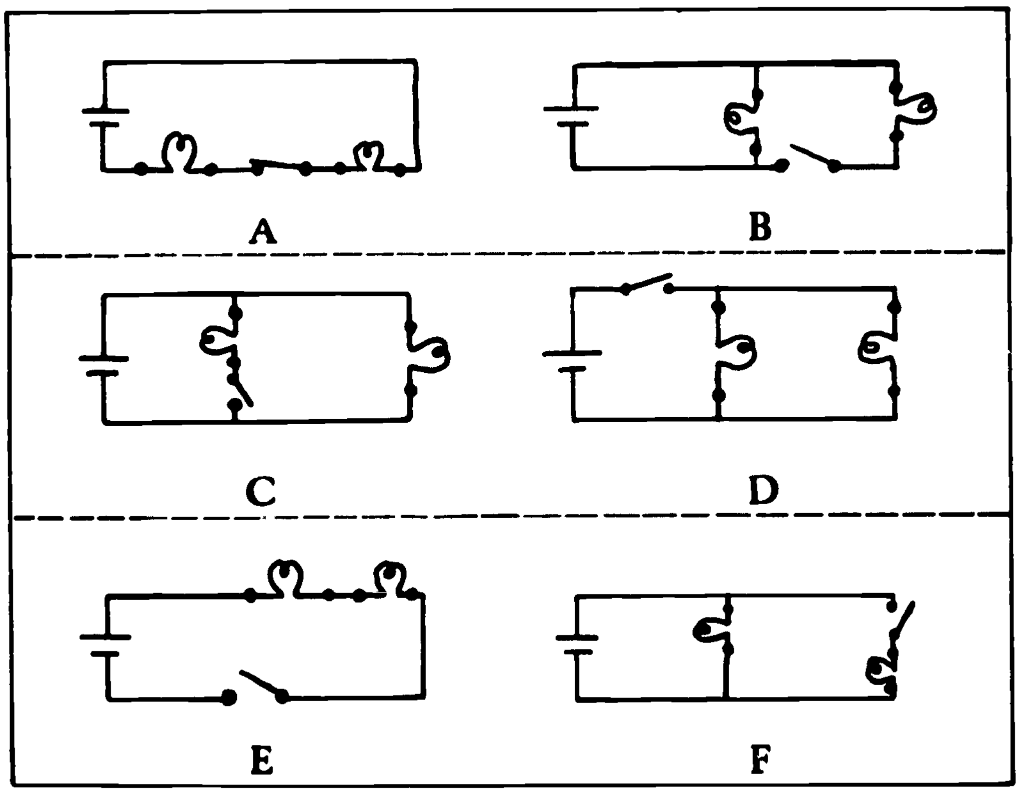
Have children light the bulb by completing a circuit. Look at the bulb through the magnifying glass. How does the bulb complete the circuit? Close observation will lead children to infer that the current flows from one contact point in the bulb up through a wire connected to the filament and then to the other contact point of the bulb. The filament is made of a special kind of wire (often tungsten) which gets hot and glows when electricity flows through it.

- *Electricity flows through a special wire in the bulb called a filament.*
- *Electricity makes the filament hot enough to give off light.*
- *The filament in a bulb is connected by wires to the two contact points on the outside of the bulb.*

6. How can we light two bulbs in a circuit?

Distribute 2 bulbs (1.5 volts), 2 sockets, a switch, 4 pieces of wire, a cell, and battery holder to each group of two children. How can we use one battery to light two bulbs? Allow time for children to examine and experiment with the materials.

What different ways can you light the bulbs? As groups of children succeed in getting the bulbs to light, invite them to go to the chalkboard and record their circuits using schematic drawings. Some of the drawings may look like those on the next page.



A and E are series circuits. B, C, D, and F are parallel circuits.

Ask children to look at all the schematic drawings. Are all the circuit arrangements the same? Are they all different? Are just some the same? Help children to see that there are really only *two* different circuit arrangements.

Focus children's attention on one of the two circuits. For example, have them look at a circuit that looks like this: (A, E.)

How does the electricity travel to light the two bulbs? Ask someone to trace the path of electricity. The others will observe that electricity leaves the cell, passes through one lamp, then through a second lamp, and back to the cell. This kind of arrangement is known as a *series circuit*. The electricity (the electric current) passes through first one lamp, then another. Let children arrange a series circuit using the materials distributed earlier.

Have all the children look at a schematic drawing of the second circuit arrangement. That drawing may look like the following. (B, C, D, F.)

Does electricity travel the same way in this circuit as it does in the *series circuit?* Ask someone to trace the path of electricity in the diagram. The others will observe that the electricity goes from the cell through a wire until it comes to the place where the first lamp is connected. At this point the current divides. Some of it goes through the first lamp and then back to the cell; some of it goes on to the second lamp, through the lamp, and to the cell. These lamps are said to be wired in parallel and so this arrangement is known as a *parallel circuit.*

Why are the words "series" and "parallel" used? Have children inspect the circuits to suggest why these terms are appropriate. Think, for example, of the World Series — one game after another. Parallel might suggest a pair of railroad tracks which resemble the wiring in a parallel circuit.

In addition to the way the bulbs are wired, is there any other difference between a series circuit and a parallel circuit? Children may note a difference in the brightness of the bulbs. This will be investigated in the next problem. Have all the children arrange a parallel circuit using the materials given them.

- *A series circuit arrangement will light two bulbs.*
- *A parallel circuit arrangement will light two bulbs.*
- *In a series circuit the current flows through one bulb and then through the other.*
- *In a parallel circuit the current flowing through one lamp is entirely separate from that flowing through the second lamp.*

7. Do the bulbs in a series circuit have the same brightness as the bulbs in a parallel circuit?

Distribute to each group of two children the same materials that were used in Problem 6. Have one group arrange a series circuit with its materials. Then have the group nearest to this one arrange a parallel circuit with its materials.

Look at the bulbs that are lit in both circuits. Can you see any difference? (Yes.) What? (The bulbs in the series circuit are dimmer than the bulbs in the parallel circuit.) What do you think might be the reason for this?

This is a difficult question. A full answer requires a background in physics which is not expected at this grade level. It is desirable, however, to have children invent explanations for the difference in brightness of the two lamps, even if these explanations are incomplete. Possible theories children may offer are:

"In a series connection, the electricity drawn from the cell has to be shared by the two bulbs. Each one is dimmer than it would be if it had *all* the electricity by itself."

"In a parallel connection, each bulb draws its electricity for its own private circuit; it gets enough electricity to burn brightly."

Another way of looking at this question is to think of it in terms of one of the electrical units — *volts*. The batteries used in our work are marked 1½ volts. The bulbs (#00) are also rated at approximately 1½ volts. Present this information to the class. What does this information suggest?

"In a series circuit the 1½ volts from the cell must be shared by the two bulbs. Each will get less than the 1½ volts it needs for full brightness."

"In a parallel circuit 1½ volts flow through each bulb; each lights up with full brightness."

- *The light of bulbs in a series circuit is dimmer than that in a parallel circuit (when both use the same source of electricity).*

8. What happens if one bulb is removed (or blows out) in a two-bulb circuit?

Distribute 2 bulbs, 2 sockets, 4 pieces of wire, a cell, a switch, and a battery holder to each group of two children. Have one group arrange a series circuit with its materials. Have the adjacent group arrange a parallel circuit with its materials.

Ask children to remove one bulb from a socket in each circuit. What happened in the series circuit? (In the series circuit the removal of one bulb caused the light in the second bulb to go out.) Why? (The flow of electricity was interrupted.) What happened in the parallel circuit? (The light in the second bulb remained on.) Why? (The removal of one bulb interrupted the flow of electricity only through that bulb.)

Put back the missing bulbs in the sockets. What happened in the series circuit? (The light came on in the second bulb.) Was there any change in the second bulb in the parallel circuit? (No.)

What circuit would you use to string up lights at an outdoor party or carnival? (Parallel.) Why? (If one bulb blows out, the others will still remain lit.)

Where else would you expect to find a parallel circuit? (In homes, offices, etc.) Why? List places that children mention.

- *If one bulb is removed from a two-bulb series circuit, the light from the second bulb will go out.*
- *If one bulb is removed from a two-bulb parallel circuit, the light from the second bulb will remain on.*

EVALUATIVE ACTIVITIES

1. In which examples in the illustration on the following page will the bulbs light? Predict and try! Write a Y for those which *will* and an N for those which *will not* light.

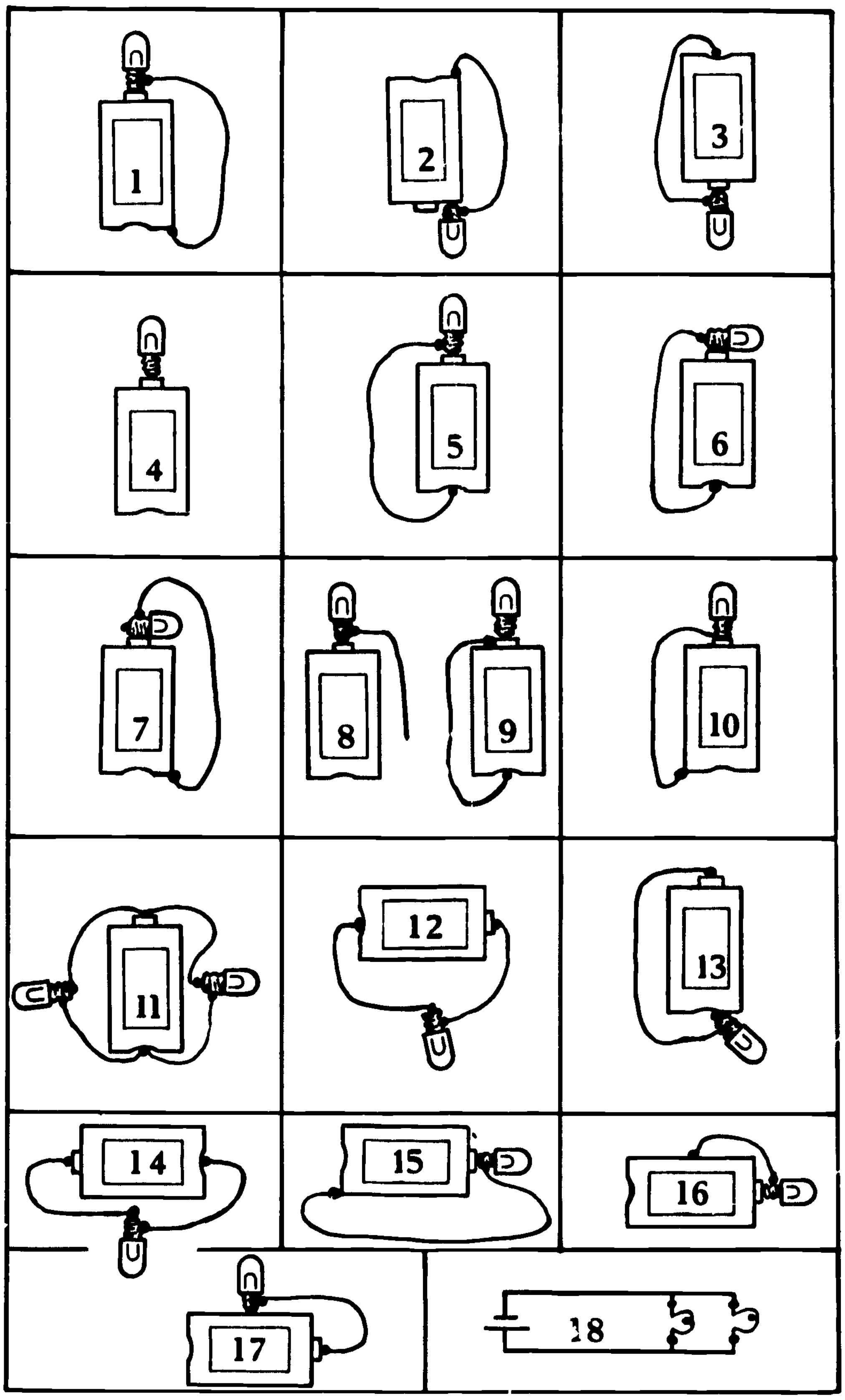
1. (N.)	2. (N.)	3. (Y.)	4. (N.)
5. (Y.)	6. (Y.)	7. (N.)	8. (N.)
9. (N.)	10. (N.)	11. (Y.)	12. (Y.)
13. (Y.)	14. (Y.)	15. (N.)	16. (N.)
17. (N.)	18. (Y.)		

2. A girl wired her dollhouse so that there were lights in all three rooms. When she closed the switch, all the lights went on. The day after she completed the job she found that in only one room would the lights go on. What do you think might have been the trouble in the other two rooms? (The bulbs may have burned out; the bulbs may be loose in their sockets; the connections are loose.) In what kind of circuit had she wired the bulbs? (Parallel.)

B. DRY CELLS IN DIFFERENT KINDS OF CIRCUITS

Background for the Teacher

A dry cell consists of a zinc container filled with a mixture of chemicals in the center of which there is a carbon rod. Although it is called a dry cell, there is sufficient water to dissolve the ammonium chloride, the most active chemical. Enough powdered charcoal and manganese dioxide are added to give the mixture a paste-like consistency.



Which bulb will light?

On any dry cell, the center terminal, which is connected to the carbon rod, is marked positive (+); the outside zinc container is marked negative (−). On a No. 6 dry cell, the outer binding post terminal is attached to the zinc container. However, the dry cells used in flashlights do not have a special terminal attached to the container. Instead, electrical contact is made with the bottom of the container itself.

A dry cell produces 1½ volts whether it is a penlight cell (about ⅜" in diameter), a "D" cell (usual flashlight size), or a large No. 6 dry cell. The size of the cell does not determine its voltage. When two or more cells are connected to each other, they form a battery.

If cells are connected in series, the total voltage is the *sum* of the voltages of the individual cells. When cells (similar) are connected in parallel, the total voltage is the *same* as the voltage of any single cell. In everyday use, the advantage of connecting cells in parallel instead of using a single cell is that they last longer. If the battery is in an inaccessible place, the advantage is obvious.

When a dry cell is worn out, the chemicals in the mixture may have been used up, or all the water may have evaporated, or the zinc container may be almost completely dissolved. In the latter case, the chemical mixture may leak out through holes that develop in the container. (See *Tips on Making Dry Cells Last Longer* on pages 212-213.)

Approaches and Learnings for the Child

With flashlights and transistor radios so much a part of children's daily lives, cells of various sizes are familiar to many of them. They are aware that a dim light on a flashlight or a weak sound from the radio means that cells have to be replaced. Some children may have flashlights that require only one cell, while others may have flashlights that hold two, three, or more cells.

The activities in this topic are designed to provide children with opportunities to learn how dry cells are arranged to form batteries, and how the voltage produced by a battery is the result of the type of arrangement and the number of dry cells. Children will be working with the large No. 6 dry cells instead of the flashlight "D" cells because No. 6 does not require a special holder. However, if there is an insufficient supply of No. 6 cells, the small flashlight cells may be used.

From the activities suggested, children learn:

A battery is a group of two or more dry cells connected to each other.

The voltage of a series arrangement of dry cells is equal to the sum of the voltages of the individual cells.

The voltage of a parallel arrangement of similar dry cells is equal to the voltage of any individual cell.

1. How can we make a circuit with two dry cells and a bulb?

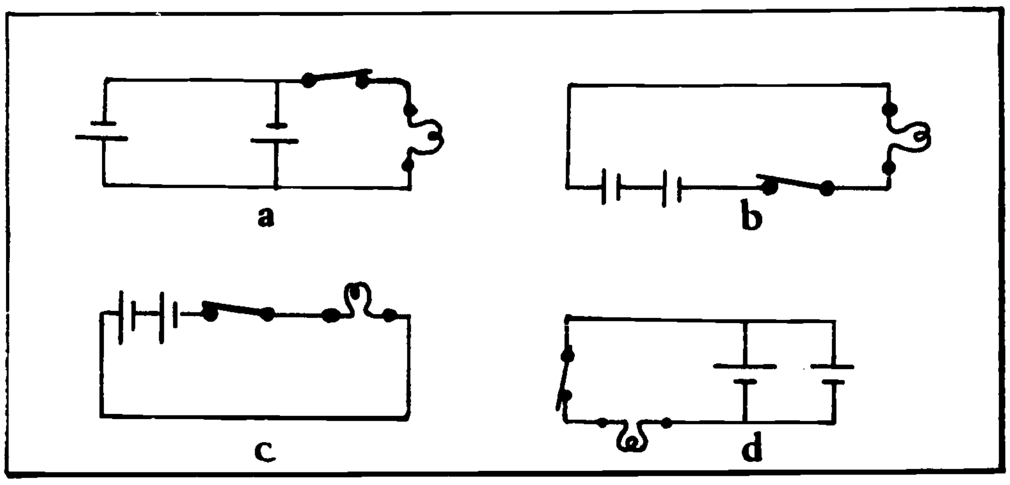
Distribute two No. 6 dry cells, 4 pieces of insulated wire (stripped at each end), a miniature socket, a switch, a screwdriver, and a *3-volt* bulb to each pair of children. How can you get the bulb to light using these materials?

Note: Children should be cautioned *never* to make a connection *across* the two posts of a cell without having an electrical device, such as a bulb or a bell, intervene. Electricity always tends to take the path of least resistance back to the place where it started. If it is able to get back without going through the bulb, it will do so. This path is called a *short circuit.* When this happens, the bulb does not light and the connecting wires get hot. If either happens, have children disconnect the wires at once in order to prevent damage to the dry cells.

Allow enough time for children to investigate and experiment with the materials. Some children may raise the question as to how the No. 6 dry cell differs from the "D" dry cell (the ones usually found in flashlights and used in Topic A). Show both kinds. Help children to see that the center terminal of the No. 6 dry cell corresponds to the tip at the top of the "D" cell; the outside terminal of the No. 6 dry cell corresponds to the bottom of the "D" cell. However, *each* kind of dry cell provided for classroom use produces 1½ volts, as marked on the wrapper of the No. 6 cell.

What did you do to get the bulb to light? Select two groups that have different dry cell arrangements and have them demonstrate how they got the bulb to light. Make a pictorial drawing of each group's arrangement. Invite one child from each group to go to the chalkboard and make a schematic diagram of his dry cell arrangement. The drawings may look like:

Which diagram matches your own arrangement? Children decide which drawing matches theirs. Is there any group with a dry cell arrangement different from that on the chalkboard? A careful check



In drawings a and d, the cells are connected in parallel; in drawings b and c, they are connected in series.

followed by discussion will lead children to see that there are *two* main ways of arranging the dry cells to get the bulbs to light. One is known as a series arrangement of dry cells (b, c); the other is known as a parallel arrangement (a, d). (Label the drawings on the chalkboard.)

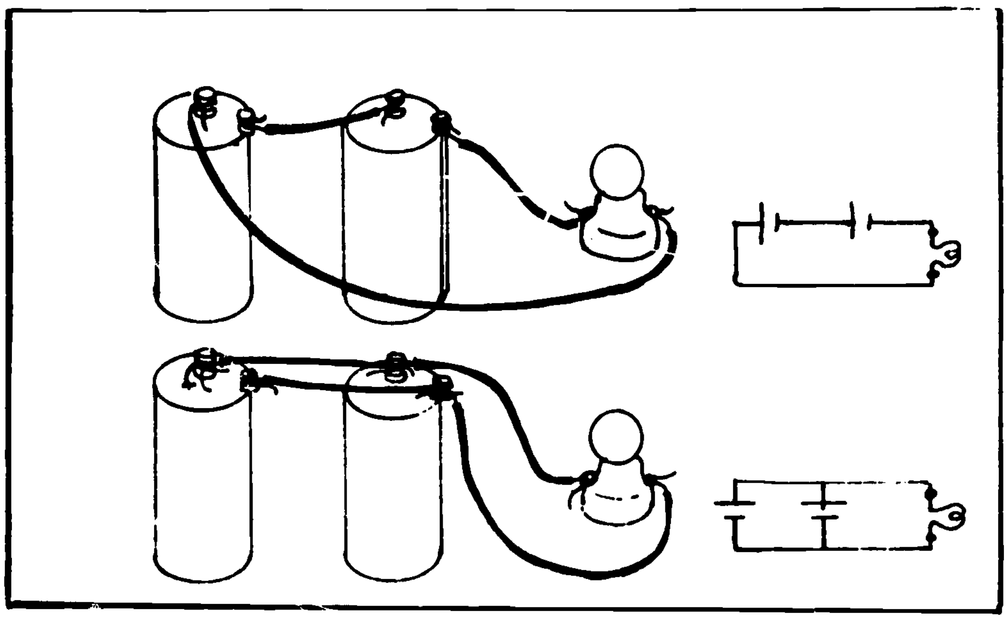
Have children disconnect their circuits and make a dry cell arrangement other than what they had. Let each child record the two arrangements with schematic diagrams. It might be noted at this time that when two or more cells are connected to each other, they form a *battery.*

- *There are two main ways in which dry cells can be connected in a circuit.*
- *Dry cells can be connected in series with each other.*
- *Dry cells can be connected in parallel with each other.*
- *When two or more dry cells are connected to each other, they form a battery.*

2. What is the difference in the connections between a series arrangement and a parallel arrangement of dry cells?

Distribute two No. 6 dry cells, 3 pieces of insulated wire (stripped at each end), a miniature socket, a screwdriver, and a *3-volt* bulb to each pair of children. Have one pair make a circuit using a series arrangement of dry cells while another pair nearby connects a parallel arrangement.

On the chalkboard make a pictorial drawing of a series arrangement of dry cells. Next to it, have a child draw a schematic design of the arrangement.



In the upper illustration, two dry cells are connected in series. In the lower illustration, two dry cells are connected in parallel.

How are the dry cells connected to each other? Have one child trace the connections while the others observe that the *outside* terminal of one dry cell is connected *to the center* terminal of the second dry cell. How is the bulb connected to the dry cells? Children note that the bulb is connected to the center terminal of the first dry cell and the outside terminal of the second. Ask those children with series arrangements to check their materials to see if the same connections are made.

Make a pictorial drawing of a parallel arrangement of dry cells on another section of the chalkboard. Next to it, have a child draw a diagram of the same arrangement.

How are the dry cells connected to each other? Have one child trace the connections while the others observe that a center terminal is connected to a center terminal and an outer terminal is connected to an outer terminal. How is the bulb connected to the dry cells? Children note that the bulb is connected to the center terminal ot one dry cell and the outside terminal of the other. Ask those children with parallel arrangements to check their materials to see if the same connections are made.

- *In a series arrangement, the outer terminal of one dry cell is connected to the center terminal of the other.*
- *In a parallel arrangement, the center terminal of one cell is connected to the center terminal of the other, and the outer terminal of one cell is connected to the outer terminal of the other.*

3. How does the type of arrangement of the dry cells affect the brightness of the light bulb?

Distribute to each pair of children the same materials that were used in Problem 2. Have one pair connect the dry cells in a series arrangement. Then have the pair nearest to this one connect the dry cells in a parallel arrangement.

Look at the bulb that is lit in both arrangements. Can you see any difference? (Yes.) What? (The bulb in the series arrangement has a brighter light than the bulb in the parallel arrangement.) What do you think might be the reason for this? Some children may say that it has something to do with the dry cells; others may say that it has something to do with the bulb; and some may say that it has something to do with both pieces of equipment.

Direct children's observation to the series arrangment of dry cells. How does the electrical current reach the bulb? (It flows *through* one dry cell to another to the bulb.) Have children look at the markings on the cover of *one* dry cell. How many volts does it have? (1½ volts.) If electrical current is flowing through one dry cell to another to the bulb, how much electrical current reaches the bulb? Children may infer that the total is 3 volts. Ask them to remove the bulb from its socket and look at the marking on the base of the bulb. How many volts does it have? (2.5v or 3v.)

Note: Some bulbs may be unmarked. If this is the case, tell children that the bulb is approximately 3 volts.

Is there any relationship between the amount of electrical current flowing through the bulb and the bulb itself? Guide children to see that the current flowing through the bulb is the *sum* of the voltages of each cell (1½v + 1½v = 3v.) This sum is equal to the 3 volts of the bulb. Does this affect the light from the bulb? (Yes.) How? (Gives off a bright light.)

Direct children's attention to the parallel arrangement of dry cells. How does the electrical current reach the bulb? (It seems to flow *from each* dry cell *to* the bulb.) *Explain* to the children that when bulbs are connected in this way, the voltage does *not* add up. The total voltage is only 1½ volts. Does this affect the light from the bulb? (Yes.) How? (Gives off a dim light.)

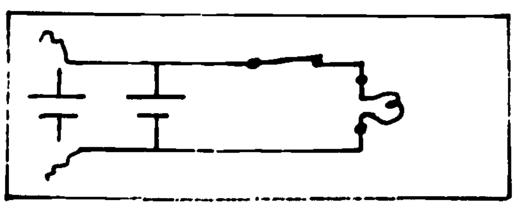
- *The light from a bulb in the series arrangement of dry cells is brighter than one in the parallel arrangement.*
- *The voltage of dry cells connected in series amounts to the sum of the voltages of each dry cell.*
- *The voltage of similar dry cells connected in parallel amounts to the voltage of one dry cell.*

4. What happens when you disconnect a dry cell in a series arrangement? In a parallel arrangement?

Distribute two No. 6 dry cells, 4 pieces of insulated wire (stripped at each end), a miniature socket, a switch screwdriver, and a 3-volt bulb to each pair of children. Have one pair make a circuit using a series arrangement of dry cells while another pair nearby connects a parallel arrangement.

Ask the children who have a series arrangement to disconnect one dry cell by removing the wires from its terminals. Did anything happen to the bulb? (Yes.) What? (The light goes out.) Why do you think this happened? (The circuit is broken.)

Is it possible to disconnect a battery in a parallel circuit without breaking the circuit? Ask the groups which have a parallel arrangement to disconnect the dry cell most distant from the bulb.



In a parallel arrangement, a cell may be disconnected without breaking the circuit.

Did anything happen to the bulb? (No.) Why do you think nothing happened? (The electrical current flows from the other dry cell to the bulb. Therefore, the removal of a dry cell did not break the circuit.)

- *If a dry cell is disconnected in a series arrangement of dry cells, the bulb will not light.*
- *If a dry cell is disconnected in a parallel arrangement of dry cells, the bulb may continue to light.*

5. Why did the bulb burn out?

Distribute to each pair of children two No. 6 dry cells, a switch, 4 pieces of insulated wire (stripped at each end), a miniature socket, and a screwdriver. Direct the children to connect the dry cells in a series arrangement.

Give *one* pair of children a 1½-volt bulb. Let the rest of the class watch. Have them place the bulb in the socket and observe. What happened? (A bright light flares; then the bulb burns out.) Why do you think this happened? Some children may say that it was a faulty bulb. Try the test again. Others may then say that the bulb was different from those used previously.

How could we find out if the burned out bulb is different from others used in the past? Distribute 3-volt bulbs to each pair of children. Have them examine both bulbs carefully. They may find that the bulbs differ in size; or they may find that some bulbs are marked 1.5v, 2.5v, or 3v. If there is no way for children to observe any differences, then they may be told which bulb is which.

Have the children place the 2.5-v or 3-v bulb in the socket. What happened? The bulb lit and continued to glow. Why? (The sum of the voltages of each dry cell is about *equal* to the voltage of the bulb. The electrical current produced was just right for the 2.5-volt or the 3-volt bulb.) Why did the 1.5-volt bulb blow out? (The sum of the voltages of each dry cell was *more* than the voltage of the bulb. Therefore, the electrical current produced was too strong for the 1.5-volt bulb.)

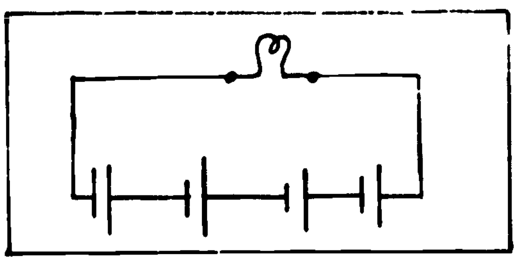
Some interested children may wonder what would happen if a 1.5-volt bulb was placed in a parallel arrangement of dry cells. Ask them to predict what would happen and to give reasons for their predictions. Have every other pair of children connect their dry cells in a parallel arrangement. Distribute a 1.5-volt bulb to place in the socket. What happens? (The bulb produces a bright light but does not blow out. The electrical current produced was just right for the 1.5-volt bulb.)

- *A bulb will burn out if the voltage is too strong for it.*

EVALUATIVE ACTIVITIES

1. Make an arrangement of 1½-volt dry cells that will light a 6-volt bulb at its correct voltage.

2. Eight 1½-volt dry cells are arranged in series. What is the lowest voltage bulb that can be lit by this arrangement without burning out? (12-volt bulb.)



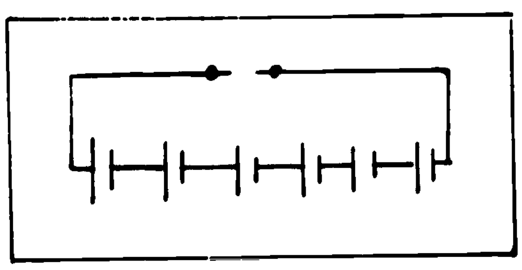
1.

3. To operate some transistor radios 9 volts are needed. Arrange enough 1½-volt dry cells to produce this voltage.

4. An automobile storage battery consists of a group of wet cells, each of which produces 2 volts in a 6-volt storage battery.

   a. How are the dry cells arranged? (In series.)
   b. How many dry cells are there? (3.)

5. Using symbols, show how you would connect two cells in parallel to a bulb.



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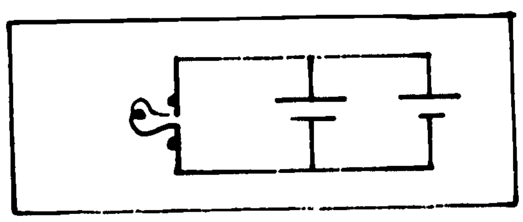


5.

TIPS ON MAKING DRY CELLS LAST LONGER

It is worthwhile to allow children to experiment with different arrangements when wiring bells or bulbs to dry cells. Unless precautions are taken, however, this activity could deplete the school's stock of dry cells quickly.

The teacher can help preserve the cells by explaining to the children that at no time should a wire be connected directly across the terminals of a dry cell. When bells and bulbs are properly connected to dry cells, the current in the circuit is limited by these devices.

Demonstrating a short circuit.

When a wire is placed directly across the terminals of the dry cell, a very large current flows through the wire. This is called a SHORT CIRCUIT.

To demonstrate a short circuit, a single strand of lamp wire is placed directly across the terminals of a dry cell. Note the heat and light produced. Do not allow the wire to remain across the terminals of the cell for more than a few seconds. This demonstration should be performed by the teacher, and only *once*.

Since a dry cell has only a limited electrical capacity, a short circuit can drain it severely. In addition, the excessive current will make the wire causing the short very hot. The wire should be disconnected quickly and carefully. Frequently, the rapid chemical action during the short eats holes in the zinc case of the cell through which the contents can leak out.

The two wires connected to the dry cell terminals may touch at some distance away in the circuit. This also results in a short circuit equivalent to the direct short circuit.

Children should be taught to recognize and avoid these "shorts."

During the children's experimentation, the teacher should move among them and call attention to possible short circuits. Good housekeeping also dictates that all dry cells should be disconnected at the end of the practice period.

Dry cells used in science fair exhibits will deteriorate rapidly, if excessive current drains and short circuits are not avoided. A good rule to follow to prevent such waste is to place switches in every circuit. For bells and lights, one may use knife switches or, preferably, pushbutton switches. However, since electromagnets give no audible or visible evidence of being activated, these should be controlled ONLY BY PUSHBUTTON SWITCHES. These switches are automatically in the OFF position when not in use.

C. FUSES

Background for the Teacher

If an electric wire is carrying too much current for its size (thickness), it will heat up considerably. If this happens in the wiring of a building, it may set fire to some combustible material near it. In order to prevent this, electric fuses are included in the wiring systems of buildings.

A fuse is essentially a short piece of wire which melts at a low temperature. It is inserted in the circuit in such a way that the current must pass through it on its way to the devices to be operated. When too much current flows, this wire becomes hot and melts before the building wires become dangerously hot. This breaks the circuit and stops the flow of electricity.

A blown fuse is a danger signal that something is wrong. Usually there is a defective wire, or else too many devices are being used. In either case, the fault should be found and corrected before a new fuse is inserted.

Fuses are marked on the base or on the rim with a number which tells how many amperes of current they can safely carry. A fuse of a higher capacity should never be substituted for one of a lower capacity because the building wiring may not be able to carry as much current as the fuse can. In such a case, the building wires may get red-hot before the fuse melts.

Approaches and Learnings for the Child

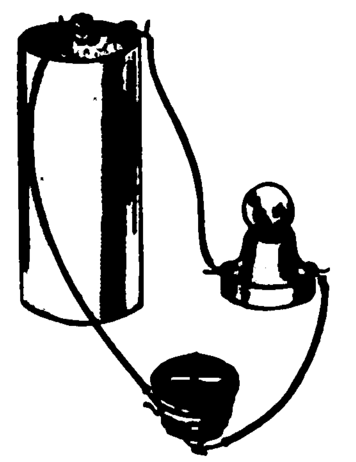
Children have experienced the excitement of a suddenly darkened house because of a "blown" fuse. They learn that house wiring has a limited capacity to carry electricity. If this capacity is exceeded, the wires become hot and may start a fire. A fuse is inserted in the circuit to prevent this from happening. To further their understanding of this topic, children make fuses and "blow" them, using a dry cell for current.

From the activities suggested, children learn:

A fuse is a special metal strip that is part of an electric circuit. When too much electricity goes through the fuse metal, it melts and breaks.

Fuses are a protection against fire: they break the circuit when the wires are in danger of being overheated.

1. What is the difference between a blown fuse and a good one?



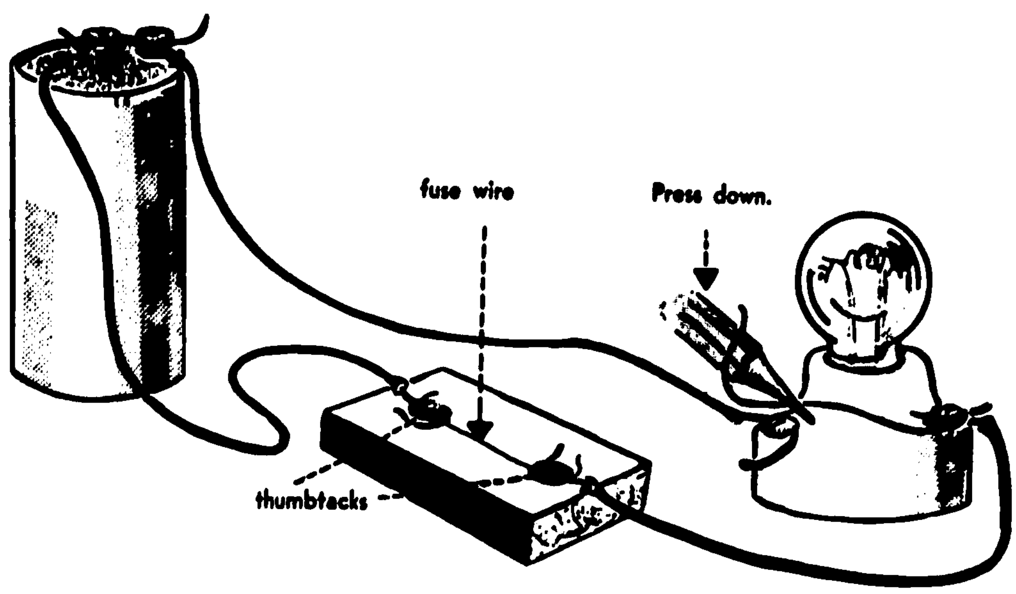
If the fuse is "good," the bulb will light up.

Children look at a few good fuses and some blown ones. They may notice spatters of metal on, or darkening of, the "window" in a blown fuse. To determine whether fuses are blown or good, they place them in a simple circuit as in the illustration.

- *A "blown" fuse has a break in its metal strip.*
- *A "blown" fuse does not allow electricity to pass through it.*

2. How can we make a simple fuse and learn how it works?

Set up the circuit shown in the illustration.



When a short circuit is made by pressing down on the loose wire, the fuse melts and breaks the circuit.

The fuse is made from a very thin strip of household aluminum foil. When set up as shown, the bulb will light. The fuse will not melt because not too much electricity is going through the circuit. When the two wires leading to the bulb touch each other (as is about to happen in the illustration), a short circuit will result. More electricity will move through this circuit and the fuse will get hot enough to melt.

Remove the wire used to make the short circuit. The bulb does not relight because the circuit is broken at the fuse. Replace the blown fuse with a new one. The light will go on.

NOTE: It is important to use a very thin strip of aluminum foil. Instead of foil, you may use a special "fuse wire," which is listed in the E-1 List of Science Supplies. It is also helpful to use a fresh dry cell, or two cells in series with a 3-volt bulb.

- *A fuse is a bridge of special metal in an electric circuit which melts when more than a certain amount of electricity passes through it.*
- *If we did not have a fuse to protect the circuit, the wires would get red hot. In a house this might cause a fire in the walls.*

3. Where are the fuses in our homes?

Children should ask their parents to show them the fuse boxes which contain the fuses for their homes. The adult might unscrew a fuse to show how the current is thereby interrupted in part of the house.

- *Each circuit of the home wiring is protected by a separate fuse.*
- *The changing of fuses should be left to grown-ups.*

EVALUATIVE ACTIVITIES

1. Distribute some good fuses and some blown fuses. Ask children to look carefully and determine which are good fuses and which are blown fuses.
2. Place adhesive tape over the windows of some good fuses and some blown fuses. Have children describe how they would test the fuses. Let them carry out the tests. Once they have decided which are the "blown" fuses and which are the good fuses, remove the adhesive tape and check with test results.
3. Explain what is meant by the statement, "A fuse is the weakest link in an electric circuit." (The fuse is the first part of a circuit to break when the circuit is overloaded.)

D. MORE THINGS TO DO WITH DRY CELLS AND BULBS

This section lists special projects for interested students. The children should be encouraged to present their findings and demonstrations to the class and to use them in school exhibits and science fairs.

(The library is a rich source of ideas and inspiration. Refer interested students to the books listed in the Bibliography, pages 247-264.)

1. Cut open an old dry cell. Investigate the physical and chemical structure of the cell. Locate the terminal connections.
2. Make switches from cut aluminum pie plates, wooden blocks, and thumb tacks.
3. Examine a voltmeter. Show how it is used.
4. Examine an ammeter. Show how it is used.
5. Test series and parallel dry cell arrangements with a voltmeter and ammeter.

BASIC SUPPLY LIST FOR *BATTERIES AND BULBS*

* Indicates quantity for entire class; other quantities specified are for each pair of children.

E-1: Science Supply Lists

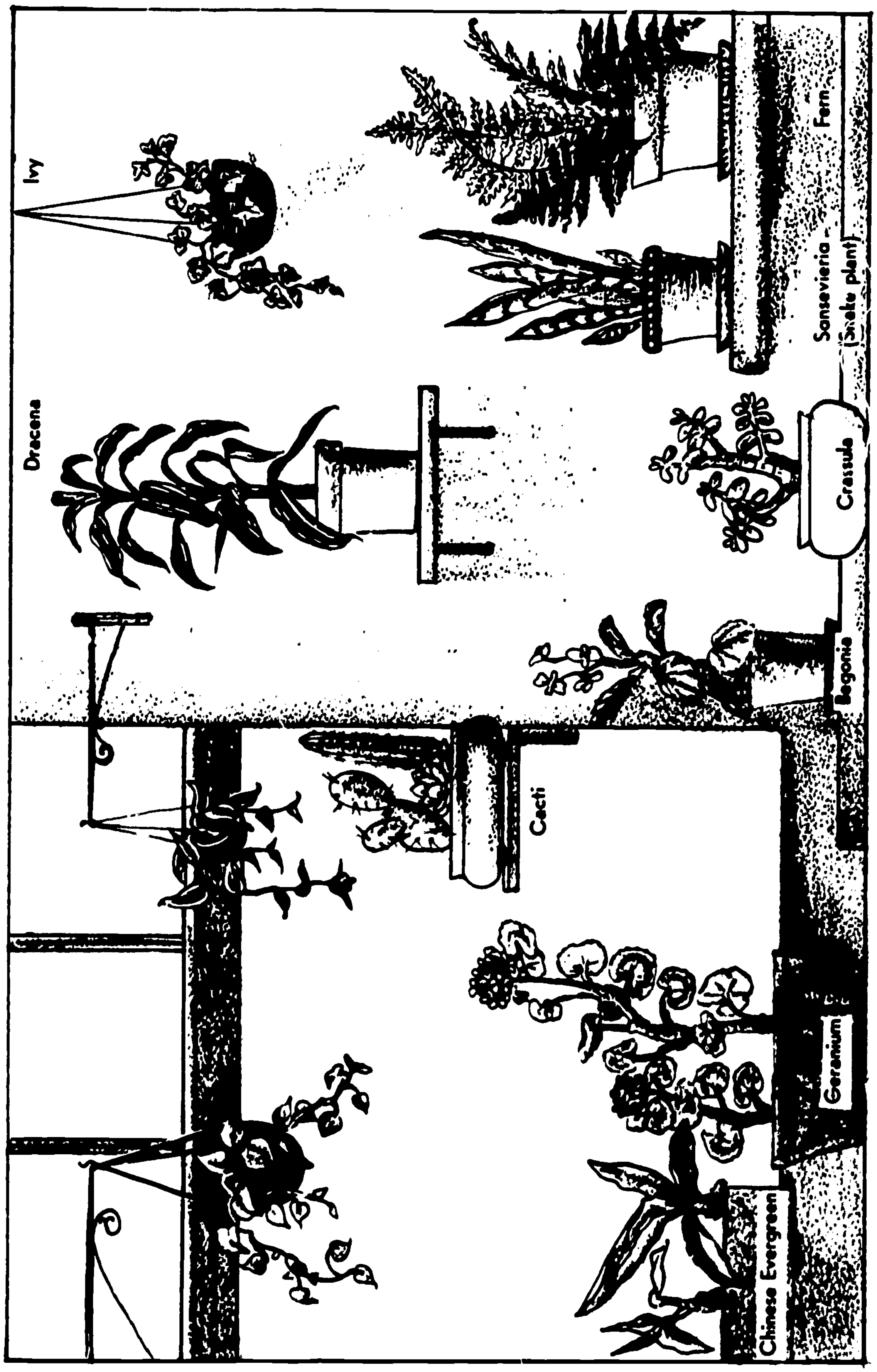
60 miniature lamps, 1.3 volts
30 miniature sockets
30 battery holders
15 knife switches
*1 roll aluminum foil
30 no. 6 dry cells
15 screwdrivers
15 magnifying glasses
*40 ft. annunciator wire
* 1 spool fuse wire

G-1: General Supply List

25 flashlight lamps 2.5 volts
30 flashlight cells
30 thick rubber bands
* 1 pkg. fuses, 15 amp.

Miscellaneous:

assorted, "blown" fuses


Ivy
Dracena
Sansevieria - (Snake plant)
Fern
Crassula
Begonia
Cacti
Geranium
Chinese Evergreen

A "Green Thumb" in the Classroom

The classroom is home for about one half of the waking hours of both teachers and students. It becomes more cheery and colorful with the addition of plants which children can care for. Teachers and children can acquire "green thumbs" by putting them into soil. If there are different kinds of plants in a room, there will be opportunities to meet the problems presented by each. Children should be encouraged to observe the plants, report on their growth, and try to find the best ways of caring for each kind.

The hardy plants used most often in the classroom are: geranium, ever-blooming begonia, coleus, tradescantia, philodendron, pothos, English ivy, grape ivy, crassula, ferns, cactus, snake plant, nephthytis, Chinese evergreen, dracaena, pick-a-back, peperomia.

Children can also grow sweet potatoes, beet and carrot tops, seeds of avocados, squash, watermelons, pumpkins, grapefruit, lemons, oranges, apples, peaches, cherries, lima beans, and sunflowers. See illustration on page 183 in *Science: Grades K-2*.

Bulb growing, of course, is a well-established custom in schools. See illustration on page 184 in *Science: Grades K-2*.

In the spring, marigold, nasturtium, or petunia seeds will produce attractive and hardy plants which can be grown in school.

Covered terraria can be made with gravel and soil in a fish tank or bowl or a large mustard jar obtained from the neighborhood delicatessen. See illustration on page 184 in *Science: Grades K-2*.

Plants will grow successfully if they have:

Sufficient water. Plants should be watered only when the soil feels dry. However, when adding water, soak the soil thoroughly.

Good drainage. The pot or box should have holes in the bottom to allow excess water to escape. (The roots of a plant require air. Water which remains may prevent air from entering the soil.) Saucers or aluminum pie plates under flower pots will protect the woodwork and catch drained water. One can water plants by adding water to the saucer until the top of the soil is moist. (Empty the saucer of any water which remains after the soil is moist.)

Suitable temperature. Plants should not be placed on hot radiators or in hot or cold drafts. Protect plants over cold weekends.

Proper light conditions. Experience is the best teacher. A geranium, for example, needs a good deal of sunlight. Cactus also thrives in sunlight. Begonias and some ferns, on the other hand, should not be kept in direct sunlight for many hours at a time. Most plants will grow with only a few hours of sunlight. Many will need only the light from the sky. No green plant, however, will do well in a dark area.

Good soil. While each plant has its own soil requirements, any good garden or potting soil will usually be satisfactory. The addition of sand will make the soil more porous. If the soil dries too quickly, peat moss or humus can be added. Commercial fertilizer may be used, but only according to the directions on the package. *Note:* When transplanting, take care to avoid injuring the roots.

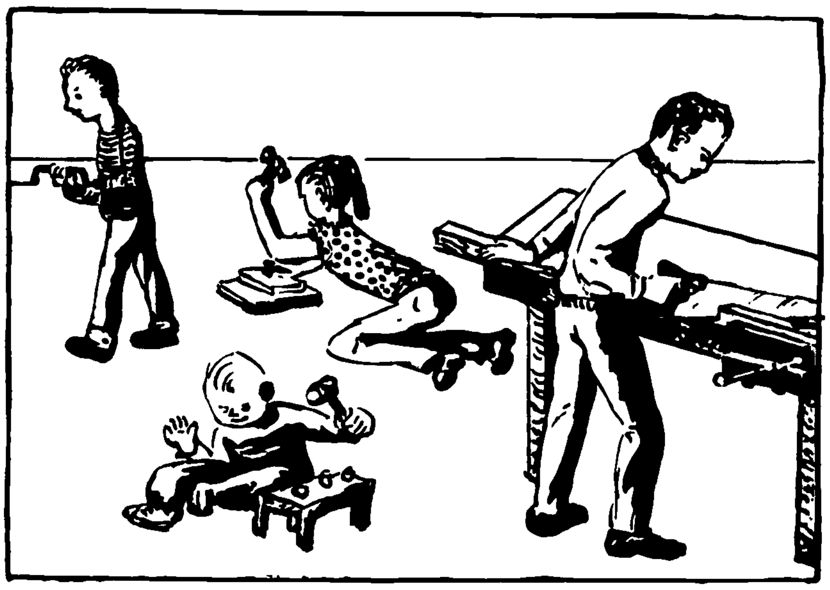
Other care. Leaves should be showered or washed with a sponge from time to time. Insect pests can be removed by washing or by using specific insecticides.

Children may interview a school or neighborhood person who has had notable success in growing plants and report to the class on the advice obtained. Further information on household plants can be found in any library.

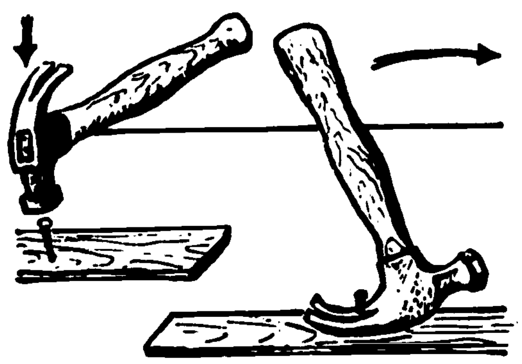
Tools We Use

In the course of constructing models and performing experiments in science, children use common tools such as hammers, screwdrivers, pliers, and saws. The teacher may use the opportunity that is thus presented for improving children's skill and understanding in the use of tools. The following supplementary material is intended to help children look more closely at tools, and to discover how they work and how to use them safely.

As they use tools for their own projects, children achieve a better appreciation of the role that tools play in everyday life. As they observe the tools more intently, they learn that tools are used because they give us greater force, greater speed, greater convenience, or greater accuracy. The following activities, possible learnings, and safety suggestions may be helpful in teaching about tools.

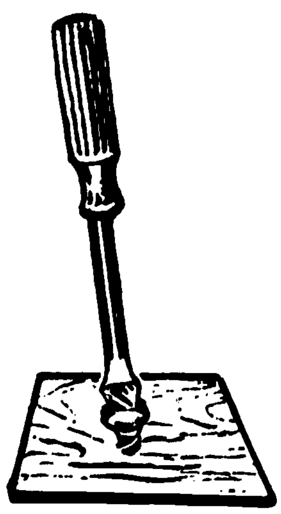


ACTIVITIES



HAMMERS. Children examine all kinds of hammers and mallets. They use the tools to hammer nails into wood and also to remove nails. They test the magnetized head on the upholsterer's hammer. They compare the weight of a heavy hammer with that of a lighter one.

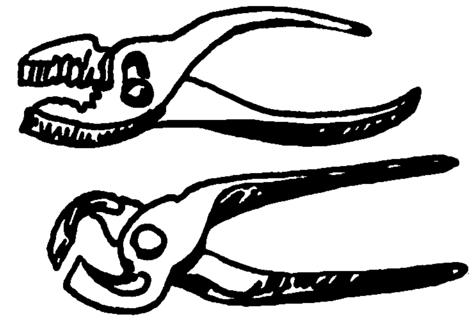
Children examine the handles on the hammers. They check to see how the handles are attached to the heads. They observe the materials in the hammer heads and handles and relate the materials to the use of that tool.



SCREWDRIVERS. Children may bring in all kinds of screwdrivers and use them to drive screws into a soft piece of wood such as pine. (The teacher may have to drive in nails beforehand to make holes so that it is easier for the children to practice driving in the screws. Soap on the screw threads also makes it easier to drive the screws.)

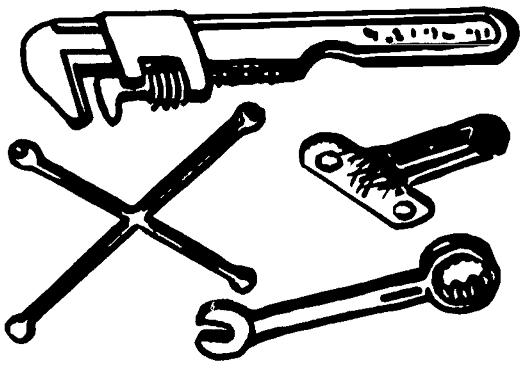
Children may experiment with joining two pieces of wood which have matching predrilled holes. Use nuts and bolts for fastening. Also, children may practice using a screwdriver to tighten nuts and bolts on their mechanical building sets.

Children conduct a survey to see where wood screws, nuts, and bolts are used in the classroom.

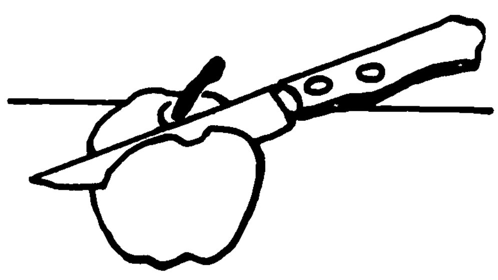


PLIERS. Children may bring an assortment of pliers from home and tell how the pliers are used. In class, they use the pliers to pick up objects, hold things tight, tighten bolts, and snip wire. They become familiar with all kinds of pliers and relate the shape of the tool to its use.

SOME POSSIBLE LEARNINGS	HOW TO USE THE TOOL SAFELY
1. There are many kinds of mallets and hammers. 2. Hammers are shaped for their jobs. 3. Some materials used in hammers are steel, wood, and rubber. 4. Handles are sometimes forced into the head of the hammer and kept there by wedges. 5. We can hit a nail hardest when we hold a hammer at the end of the handle. 6. We can pull a nail out with a claw hammer most easily when we hold the handle at its end.	1. Use the proper hammer for the job. 2. Use the hammer that is appropriate for your strength. 3. Do not use a hammer with a loose handle. 4. When nailing, hit gently at first, holding the hammer near the head with one hand, and holding the nail with the other hand until you get the nail started. Now take your hand away from the nail, hold the hammer closer to the end, and continue nailing.
1. Screwdrivers are made of many materials; most of them are steel with a wooden or plastic handle. 2. Screwdrivers are shaped differently to perform different jobs. 3. When we turn a screwdriver clockwise, we drive the screw or bolt in; when we turn it counterclockwise, we loosen the screw or bolt. 4. Most screws have points. They may be found holding pencil sharpeners, hinges, and window-shade pulleys to wood. 5. Bolts do not have points. They screw into metal nuts or threaded holes. They may be found on radiators, typewriters, switch plates, etc.	1. Use a screwdriver of the right length, with a head of the correct size to do a job. 2. Do not use a screwdriver as a pick, a chisel, or a crowbar.
1. Pliers are used to do many different jobs: to pick up, grab, twist, cut. 2. When we close the handles of pliers, the jaws close also. When we open the handles, the jaws open. 3. With pliers, we can hold things tighter than with our fingers alone.	1. Be sure that the jaws of the pliers do not slip off your work, or you may pinch your fingers between the handles. 2. Do not hold wire with pliers until you are sure that the wire is not connected to a source of electricity.

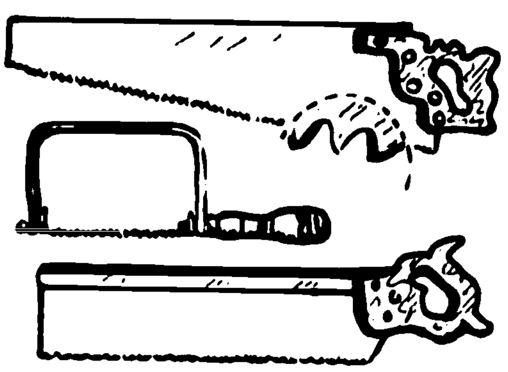


WRENCHES. Children tell where they have seen wrenches used. They learn to identify many kinds of wrenches and they associate the shape with its special use. Have the children use a wrench to tighten a large nut or a bolt to hold two pieces of wood together. (See section on screwdrivers.)



KNIVES. Children discuss the various uses for knives and other tools with sharp edges. They list the jobs done with these tools. They discuss how a good workman takes care of his fine tools to protect their edges and to be safe. They see a sharpening stone and wheel and learn how they are used.

The teacher may use a kitchen knife to cut an apple, using both the blunt edge and the sharp edge. The children compare the effort used to do the job in each case.

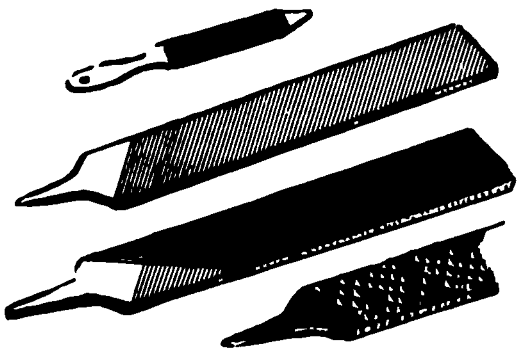


SAWS. Children examine many kinds of handsaws: crosscut saws, ripsaws, hacksaws, and coping saws. They examine the teeth with a magnifying lens and note the sharp cutting edges on the teeth. They also examine the blades and note that they vary in length and in the size and the shape of the teeth.

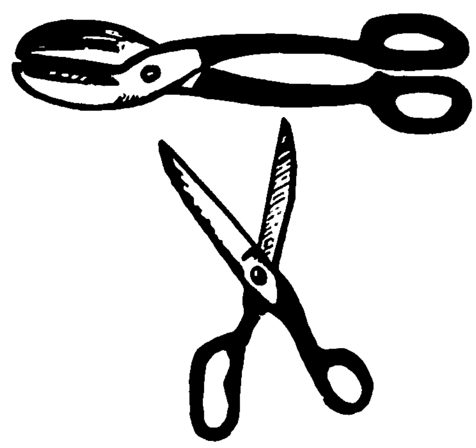
They use a coping saw to cut a thin piece of pine wood and they learn that the saw cuts best in one direction only. They compare the cutting action of a saw with the cutting action of a knife, and they consider the advantages of the saw. They compare a coping saw to a hacksaw in cutting aluminum or copper tubing.

SOME POSSIBLE LEARNINGS	HOW TO USE THE TOOL SAFELY
1. Wrenches are used to tighten or loosen nuts, bolts, pipes, and some pieces of machinery. 2. Wrenches are made in many sizes. Some wrenches are adjustable. 3. When we use a wrench with a long handle, we are able to turn nuts tighter than when we use a short-handled wrench.	1. Use the proper wrench for the job. 2. Use the correct-sized wrench, or it may slip when you turn it. 3. When using a wrench to tighten a nut on a bolt, do not turn it too hard, or you may strip the threads.
1. Knives have special shapes to do special jobs. 2. Knives should be kept in a safe place. 3. When a knife is sharpened, the rough stone rubs off pieces of metal from the blade to bring it to a sharp edge. 4. When a knife is sharpened on a grinding wheel, we sometimes see sparks, and the knife gets hot.	1. When you cut with a knife, watch your fingers and cut away from you. 2. Do not keep open knives or other sharp objects in your pockets. 3. Do not use knives or other sharp instruments as toys. 4. Do not use knives as screwdrivers or for prying.
1. A saw has tiny teeth with sharp edges which cut wood or metal when the saw is moved. 2. The tiny teeth work best when the saw cuts the wood in one direction only. 3. Different saws do different jobs. Some saws cut wood; others cut metal. Some saws cut in straight lines; others are better for cutting curves. 4. Sometimes the blade of a saw becomes hot when in use.	1. Hold your work firmly when sawing. 2. Keep your fingers out of the way of your saw. 3. Store your saws carefully. 4. Use the proper saw for the job.

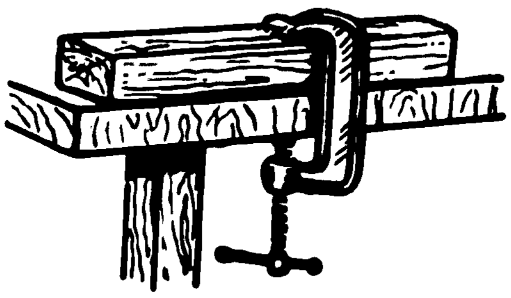
ACTIVITIES



FILES, SANDPAPER. Children examine all kinds of files. They see the teeth on coarse files and use a magnifying glass to examine the teeth on fine files. They feel coarse and fine sandpaper and dip the paper into water to loosen the sand particles. Children bring in nail files and sandpaper and use them to file various materials.



SCISSORS AND SHEARS. Children examine scissors and shears. They observe how the motion of the handles affects the motion of the blades. Ask children for what purposes they would use scissors and shears. Experiment by attempting to cut sheet metal with an old pair of scissors, and then with shears. Have children relate the shape and the size of the tools to their uses.



CLAMPS AND VISES. Children may bring small clamps, vises, clamp-on lamps, and other devices to school. They also recall where these tools are used at home and in the neighborhood.

A small clamp can be used to hold two rulers securely against each other. Children then try to separate the two rulers and find that it is difficult to do so.

Hold a ruler in a clamp or vise and ask the children to remove the ruler. Compare the effort needed to remove the ruler when the vise is tight with the effort needed when the vise is not very tight.

SOME POSSIBLE LEARNINGS	HOW TO USE THE TOOL SAFELY
1. A file has teeth with fine edges which cut into wood and metal when the file is moved across the material. 2. Different files are used for different jobs. 3. A file works best when moved in one direction only. 4. The particles of sand on sandpaper act in the same way as teeth on a file.	1. Use a handle on the tang (pointed end) when using a file. 2. Do not use a file for prying things, since files are brittle and may crack.
1. Scissors and shears are used to cut various materials. 2. Scissors usually have proportionately longer blades and shorter handles than metal shears.	1. Always offer the handles of scissors when giving them to someone. 2. Do not put scissors into your pockets. 3. Do not use scissors for prying, since the blade may snap off. 4. Do not run with scissors in your hands.
1. The jaws of clamps and vises are tightened when a screw on the tool is tightened. 2. A long handle makes it easy to turn the screw on a vise. 3. The tighter the screw is turned in the vise, the tighter the jaws close.	1. A tight clamp can make a mark in soft wood. 2. Do not hammer on the jaws of a vise.

Films and Filmstrips

This list of sound film and filmstrip resources has been prepared to implement the teaching of *Science: Grade 5*.

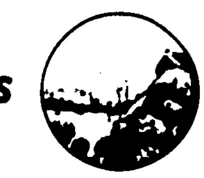
All listed films and filmstrips have been approved by the Board of Education. Annotations are based on evaluations by committees which have carefully screened the films and filmstrips for citywide use. Grade placement and utilization in individual schools should be based on local previewing and adaptation to specific needs.

Recommended filmstrips (and a few transparencies) have been selected from *List of Approved Audio-Visual Materials, 1963-67, Part III*. They must be purchased by individual schools since they are not available on loan. Board of Education item numbers, price, vendor, and expiration date are included with each annotation. When purchasing items with past expiration dates, order on a non-list basis or consult approved BAVI listing.

All films are sound motion pictures, 16 mm. width, and may be available from the BAVI loan collection. Consult the listings of the Bureau of Audio-Visual Instruction in *Instructional Films and Tapes* for borrowing procedures. Many of the films listed are also available at the local film centers. Schools should consult film center lists and direct their requests to these centers before requesting service from the BAVI Loan Collection.

For approaches to the use of films and filmstrips, see *Audio-Visual Materials in the Science Program*, on pages 16-17.

How Man Changes Materials



FILMS

SIMPLE CHANGES IN MATTER — **11 min., Coronet, 1952**

Discusses the physical and chemical changes that surround us every day, such as growth of seedlings, soil erosion, metal expansion, ice melting, leaves changing color, logs decaying, and metal rusting.

WATER AND WHAT IT DOES 11 min., E.B.F., 1962

Illustrates the nature and properties of water. The problem-solving approach is used in demonstrations and experiments to acquaint children with the methods of science. Shows the properties of water in its liquid, solid, and gaseous states.

WHAT ARE THINGS MADE OF? 11 min., color, Coronet

Defines and explains composition of matter and its three states: solid, liquid, and gas. Differentiates between an element and a compound and shows that matter can be changed chemically and physically.

YOUR FRIEND THE WATER: CLEAN OR DIRTY 16 min., E.B.F., 1954

Shows sources and value of pure water in contrast to the causes and wastefulness of water pollution. Presents both clean and dirty water in terms that young children will understand.

FILMSTRIPS

	Item No.	Price	Vendor No.	Exp. Date
FINDING OUT HOW THINGS CHANGE	36483.36	4.50	83.5	70

Deals with the effect of heat and cold on water, which things can be changed by air or water, what changes living things make. Many suggestions for discussion and things to do.

ALL MATTER HAS THREE FORMS	37022.12	4.00	62.5	69

Matter exists in one of three forms — solid, liquid, or gas; properties of each of these forms; simple experiments to show how each is affected by heat, cold, and other conditions.

SOME THINGS DISSOLVE	37025.15	6.50	62.5	68

Examples of dissolving, using salt and water and sugar and water. How the substances may be recovered by evaporation; importance of these changes in digestion; dissolved minerals and oxygen for water plants.

HEAT CHANGES THINGS	37248.13	5.75	58.5	69

How and why heat can change a solid to a liquid or a liquid to a gas; how and why cooling can cause matter to change form.

Little Environments

FILMS

ADAPTATION OF PLANTS AND ANIMALS — **15 min., Coronet, 1955**

Describes plant and animal adaptations to environment for protection and feeding. Animals shown are beaver, squirrel, camel, porcupine, etc.

ADAPTING TO CHANGES IN NATURE — **10 min., color, Journal**

Shows ways in which different animals and plants adapt to different types of environmental change and discusses the instincts that help them survive in the changing natural world.

ANIMALS AT NIGHT — **11 min., color, E.B.F.**

Tells the story of nocturnal animals and how they differ in their physical characteristics and behavior from animals that are active during the day. For grades 3-6.

ANTS — **11 min., E.B.F., 1949**

Shows four different types of ants (mound builder ants, black ants, household ants, and carpenter ants), their activities, and the kinds of nests they build.

BIRDS IN YOUR BACK YARD — **11 min., Barr, 1950**

Two brothers share the fun and responsibility of a project to attract birds to their yard. They observe feeding, drinking, bathing, and nesting activities of birds that visit their sanctuary.

CHANGING RIVER, THE — **17 min., color, I.F.B.**

An ecology film showing the changes in life, above and below the water, depending on the area. Shows region from the head waters to the mouth of a typical river. For grades 5-6.

LIVING THINGS ARE EVERYWHERE — **11 min., color, E.B.F.**

Helps children discover that living things can be found almost anywhere — in water, in the air, in a tree, on a blade of grass, or under a stone. For grades 3-6.

MAKING A BALANCED AQUARIUM — **11 min., Coronet, 1954**

Bob and Lynn make a balanced aquarium in a glass tank. They demonstrate the step-by-step procedures of collecting soil and gravel, greens and fish, to complete their aquarium.

PLANT-ANIMAL COMMUNITIES: PHYSICAL ENVIRONMENT
11 min., Coronet

Among the natural factors which influence any plant-animal community are altitude and atmospheric conditions, heat and light, water, and soil conditions. Four biomes are illustrated.

POND LIFE 11 min., E.B.F., 1950

Depicts the pond as an organized community in which plants and animals are dependent upon each other. Shows conditions which are necessary for life in the pond. Portrays representative animals at various levels of the water and explains why they live at those levels. Shows animals which live upon one another and keep the population of the pond in balance.

SEASHORE LIFE 11 min., E.B.F., 1950

Provides an experience in ecology through portrayal of life on three kinds of seashores: the sandy beach, the rock pool, and the mud flat. Shows ways in which representative seashore animals are adapted to survive in their special environments and how they feed, move, and compete with other kinds of animal life.

SECRETS OF THE POND 10 min., Almanac, 1953

The camera goes under water to show microscopic life as well as that of frogs and other animals and plants in the pond.

SOIL (Understanding Our Earth Series) 11 min., Coronet, 1953

Layers of soil and their characteristics. Formation of soil from rock, changes caused by roots, decaying vegetation and animals are considered. Role of top soil and the need for soil conservation are stressed.

STRAND BREAKS, A (The Web of Life) 16 min., color, E.B.F., 1950

Demonstrates the consequences of the unbalance in nature, and the dire consequences to man and the community when natural resources are abused.

STRANDS GROW, THE (The Web of Life) 15 min., color, E.B.F., 1950

Shows replacement of prehistoric communities of plants and animals due to failure of adjustment to changes in environment. Balance of nature is shown through development of the climax forest.

WONDERS IN A COUNTRY STREAM 10 min., Churchill, 1949

Shows a boy and girl as they walk along a stream where they discover a baby turtle, a frog, a salamander, a newt, a caddis-fly nymph, a damsel fly, and water striders. Close-up photography and slowly paced narration are used throughout.

FILMSTRIPS

	Item No.	Price	Vendor No.	Exp. Date
HOW ANIMALS LIVE IN THE AIR	35990.12	4.95	25	72

Basic principles of flight; how flying squirrel glides. Illustrates force and lifting power of air. Wings of birds, insects, and bats compared; structure of wing and feathers.

HOW ANIMALS LIVE IN THE DESERT	35990.13	4.95	25	72

Interdependence of plant and animal life; various kinds of vegetation; horned toad, gila monster, fringed lizard, rattlesnake, kangaroo rat, ostrich, lion, jackals, camels; special adaptation to desert living.

HOW ANIMALS LIVE IN THE FOREST	35990.14	4.95	25	72

Adaptations: climbing trees (squirrels, monkey, opossums, tree frogs); perching, short winged birds (owl). Animals of the forest floor; hunters (cat family).

HOW ANIMALS LIVE IN THE SEA	35990.15	4.95	25	72

Three life zones: shore, open sea, deep sea. Anchored animals (sea anemones, sponges, etc.); tidal bottom (star fish and crustaceans); adaptations (streamlining, fins, tails). Reptiles (tails and feet). Deep sea luminosity. Whale's adaptations.

HOW ANIMALS LIVE IN THE ARCTIC	35990.16	4.95	25	72

How some animals live in the Arctic all year, while others are there in summer only.

HOW ANIMALS LIVE IN THE GRASSLANDS	35990.17	4.95	25	72

Coloration to blend with the background; ability to run fast; use of horns and feet for defense; and living together in herds or colonies.

BALANCE OF NATURE	36400	6.00	42	68

How the many forms of life are adapted to perform within the community; how the delicate balance of nature can be easily overturned.

ADAPTATIONS IN PLANTS	36410.11	4.00	9	72

How plants are specially fitted to survive in particular environmental conditions.

BACKYARD COMMUNITY 36494.21 4.00 9 72

A community of people living in a city and a community of animals and plants living together in a backyard community.

CHANGING PLANT COMMUNITIES 36494.22 4.00 9 72

Changes that take place in biological communities with time and changing environments.

MAN AND BIOLOGICAL COMMUNITIES 36494.2 4.00 9 72

Balance among members of a natural community; how man uses and upsets these balances; problem of reestablishing the balance.

PLANT COMMUNITIES AND WATER 36494.25 4.00 9 72

Water, one of the major factors in the formation of different kinds of plant communities.

SEASHORE COMMUNITY 36494.26 4.00 9 72

How many seashore plants and animals must be able to live in and out of water because the water level changes with the tides.

THE FRESHWATER COMMUNITY 36494.27 -4.00 9 72

Life in a freshwater pond; basic food supply of the community.

DESERT 36769 18.00 3 71

How animals and plants have adapted themselves to desert living; how man, by mining and irrigating, has made the desert useful.

SOME WATER ANIMALS 36780.15 6.00 39 68

Some characteristics of fish, lobsters, crabs, barnacles, clams, sponges, coral; some examples of microscopic water animals

WATER AND ITS WORK 37022.11 4.00 62.5 69

Need for water for our food, clothing, homes, health, and industries; water power for hydroelectric plants; water for steam to drive turbines; water supply systems for cities and homes.

MEANING OF CONSERVATION 37025.12 6.50 62.5 68

Importance of topsoil in plant growth; erosion and how to prevent it; the value of fertilizers in soil improvement.

FUNGI — OUR NON-GREEN PLANTS	37028.1	6.50	62.5	68

Non-green plants — fungi: mushrooms, molds, yeast, bacteria, mildew, etc.

SOIL IS FOR GROWING	37028.13	6.50	62.5	68

Composition of soil; how it is formed; how rock particles and minerals get into the soil; composition of humus; types of soil (sand, clay, loam); restoring the balance of nature by adding minerals to the soil, rotating crops, replanting trees and grasses, strip cropping, and contour plowing.

LIFE IN A TERRARIUM	37041.3	6.00	73.15	71

The interdependence of life forms; the recreation of a natural environment; how to construct and maintain several kinds of terraria; the care of animal and plant life.

LET'S EXPLORE A FIELD	37210.51	6.00	83.5	69

Different kinds of fields; how to find animals in a field; how to make an insect zoo; how fields change with the seasons; soil erosion.

LET'S EXPLORE A GARDEN	37210.52	6.00	83.5	69

Many kinds of insects in gardens; how man controls plant pests; parts of different plants we eat; why we must protect all parts of a plant; mulching.

LET'S EXPLORE A LAWN	37210.53	6.00	83.5	69

Kinds of seeds commonly used in lawns; use of fertilizers and weed killers; types of weeds; enemies of lawns such as moles. Includes experiments children can perform.

LET'S EXPLORE THE POND	37210.54	6.00	83.5	69

How ponds form and why they disappear; how plants protect a pond and feed animals.

LET'S EXPLORE A STREAM	37210.55	6.00	83.5	69

How streams differ and how streamside vegetation affects water. What energy of moving water can do; how stream animals obtain food; how man pollutes streams.

LET'S EXPLORE A WOODLAND	37210.56	6.00	83.5	69

How decaying leaves and humus add to the soil; how dead leaves harbor caterpillars and spiders which are food for wood frogs, etc.

ANIMALS AFFECT MAN AND OTHER LIVING THINGS
37365.51 5.00 42 72

How animals provide food and other useful products; how animals get their food and how they defend themselves.

LIVING THINGS NEED OTHER LIVING THINGS
37365.56 5.00 42 72

Tells how we depend upon animals and plants for all our food; explains that we eat plants for their starches, minerals, and vitamins.

INSECTS: MAN'S GREATEST RIVAL
37591.34 6.75 55.3 71

Insects' adaptation to environment; ways in which insects are harmful and beneficial to man.

INSECT HOMES 37825.11 5.95 58.5 68

Different types of insect homes — natural and insect-built; homes of the bee, moth, mud dauber, beetles, etc.

OUR INSECT ENEMIES AND INSECT FRIENDS
37825.14 5.95 58.5 68

Insect enemies like the mosquito, housefly, termite, cabbage worm, coddling moth, potato beetle, tomato worm, and aphid, and the damage they do. Friends like ladybird, dragonfly, and honeybee and their contributions.

HELPFUL AND HARMFUL INSECTS
37826.1 6.00 39 68

Helpful insects: Bees, both for honey production and for pollination, silkworm, insects that eat other harmful insects which spoil crops and gardens.

Harmful insects: Flies, mosquitoes, lice, crickets, and those that destroy food and fiber.

HOT AND COLD 37840.11 5.95 58.5 68

Torrid, frigid, and temperate zones are shown with living conditions caused by temperature differences created by angles of the sun's rays.

LIVING THINGS NEED EACH OTHER
37901.14 6.00 39 72

Explains how plants and animals depend on each other for survival — food, shelter, and protection from enemies.

TREES	38210.15	4.75	83.5	70

Characteristics of trees, i.e., types of trees; where trees grow; how leaves make food; where food is stored; products from trees; value to man.

ANIMALS OF THE POND	38240.1	4.95	25	72

Describes the frog, toad, snail, and newt.

OUR FRIEND THE EARTHWORM	38390	6.00	25	72

How worms help the farmer soften and loosen the earth and help plants grow.

THE DESERT	38640.1	6.00	39	72

Adaptation of plants and animals to an environment with a minimum of water.

THE FOREST	38640.11	6.00	39	72

Areas in which trees, the largest of the plants, are the dominant and most influential members of the biological community.

THE GRASSLANDS	38640.12	6.00	39	72

Grasslands as a typical biological community.

THE POND	38640.13	6.00	39	72

Ecological succession of a pond — gradual change in a body of fresh water as it fills in and becomes a meadow or forest.

THE SEASHORE	38640.14	6.00	39	72

Life in an environment where, within the space of a few feet, living conditions vary and undergo continual change due to tides and waves.

THE SWAMP	38640.15	6.00	39	72

Life in waterlogged areas where the abundance of living things makes it easy to show how plants and animals have evolved ways of living together.

PLANT FACTORIES	38670.13	6.00	54	68

How all our food comes directly from green plants; how plants produce many materials other than food.

GREEN PLANTS ARE IMPORTANT TO US	38715.1	5.75	58.5	70

Step-by-step demonstration of how many of the necessities of human life have their origins in, or are affected by, green plants.

HOW ANIMALS LIVE 38755.23 6.00 73.15 71

Life habits of wild animals: means of feeding, shelter, and protection from enemies. Encourages child's interest in wildlife conservation.

SOIL AND ITS USES 39150.15 4.00 42 68

What soil is; how it is made; work of earthworms; erosion.

SOLAR STOREHOUSE: FOOD FROM THE SUN
39542 6.00 62.9 68

How the sun provides the energy to produce food for all living things, directly or indirectly.

BIRDS IN SPRING 39580.11 5.75 58.5 69

Various types and breeds of birds seen in the early part of the year: robin, sparrow, meadowlark, phoebe, towhee, hummingbird, creole, red-winged blackbird.

SPRING FLOWERS OF NEW YORK CITY (CULTIVATED)
39585 4.00 1.21 70

Flowers we enjoy in the spring in New York City.

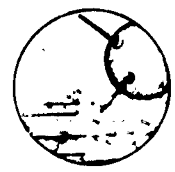
SOME USEFUL INSECTS 40900.18 5.00 42 72

Some insects helpful to man: silkworm, praying mantis, ant lion, ground beetle, and others.

NATURE'S HALF ACRE 40060.14 6.00 39 68

Plants and animals that can be found in a small natural area; interdependence and interrelationship among plants and animals, including birds, insects, small mammals, and insectivorous plants.

The Sun's Family



FILMS

ENERGY FROM THE SUN 11 min., E.B.F., 1956

How the sun acts as a source of energy utilized on the earth and how the sun's energy is converted to the energy of the clouds, winds, precipitation, and plants.

EARTH IN MOTION — 11 min., E.B.F., 1936

Presents evidence of earth's sphericity, its axis rotations, its revolution about the sun, and inclination of its axis. Permits simulated observation of the earth from the stratosphere, of earth and stars in motion, and of the earth's orbit movement, explaining the causes of night and day and of seasons.

ECLIPSE — 10 min., Almanac. 1950

Pictures an actual solar eclipse using time-lapse photography.

GRAVITY — 11 min., Coronet, 1950

Through everyday examples, students are made aware of the force of gravity and are helped to understand its principles.

GRAVITY AND CENTER OF GRAVITY — 11 min., McGraw-Hill, 1955

The principle of the center of gravity is demonstrated by a series of simple stunts using home equipment.

HOW WE EXPLORE SPACE — 17 min., color, F.A.C., 1958

Introduction to the instruments astronomers use and the methods by which they obtain information about the objects in space. Telescope, camera, spectroscope, and photocell are demonstrated.

HOW WE KNOW THE EARTH MOVES — 11 min., F.A.C.

Illustrates the reasoning by which scientists have established that the earth rotates on its axis and revolves around the sun.

MAN AND THE MOON — 20 min., Walt Disney

Shows a simulated trip to the moon and return by a rocket ship departing from a previously established space station.

MAN IN SPACE — 27 min., Walt Disney, 1957

Illustrates and discusses rocket development from ancient Chinese weapons to modern missiles. Shows a simulated manned flight into space and man's reaction to "weightlessness."

MARS AND BEYOND — 30 min., Walt Disney

Discusses the possibility of life on Mars and depicts a simulated trip to Mars and return.

PLANETS AROUND OUR SUN — 14 min., U.W.

This film affords a comprehensive view of our neighbors in space by means of the most modern astronomical instruments.

SHAPE OF THE EARTH (Planet Earth Series) **27 min., McGraw-Hill**

The study of the size and shape of the earth is presented from ancient times to present concepts derived from data from orbiting satellites. Determination of position and distances on the earth by astronomical means are examined.

SOLAR FAMILY **10 min., E.B.F.**

Presents an introductory study of the planets: their evolution, motions, sizes, and satellites. Describes, with animated drawings, the evolution of the solar system according to the planetesimal hypothesis and traces the real and apparent motions of the planets. Reveals special phenomena pertaining to certain planets and describes the planetoids. Halley's comet, and the movement of the solar system.

SOLAR SYSTEM **11 min., Coronet, 1951**

Two boys study the solar system with the help of their science teacher. A scale model shows sizes and distances and the effects of gravitation.

SPACE FLIGHT AROUND THE EARTH **11 min., color, Churchill, 1963**

Through this film children can go along on an actual space flight.

SPACE SCIENCE: THE PLANETS **16 min., Coronet, 1962**

Telescopic motion pictures, animation, and other special effects survey nine planets and their satellites. For 5th and 6th grade I.G.C. classes.

SUN'S FAMILY **9 min., McGraw-Hill, 1959**

Depicts the nature of the solar system, discussing the sun and planets that travel about it.

TRIP TO THE PLANETS, A **15 min., E.B.F.**

Illustrates an imaginary trip to the planets based on the most recent scientific facts known about the solar system. Reveals the size and appearance of the planets and what their surfaces are thought to be like. For grades 3-4.

WHAT DO WE SEE IN THE SKY? **12 min., Coronet, 1959**

A little boy's curiosity about the sky leads him to learn about the sun, moon, planets, stars, and constellations.

FILMSTRIPS

	Item No.	Price	Vendor No.	Exp. Date
FINDING OUT ABOUT THE SOLAR SYSTEM	36483.45	4.50	83.5	68

How our planets were named and their symbols developed. How our planets, asteroids, comets, and meteors differ from each other.

UNIVERSE AND SOLAR SYSTEM — 1	37000.12	6.00	22.8	68

Earth, four seasons, the moon, sun, and stars.

UNIVERSE AND SOLAR SYSTEM — 2	37000.54	6.00	22.8	68

Earth, one of nine planets, each traveling in its own orbit around the sun. Seasonal changes. Weather changes. Force of gravity and speed of earth's movement hold earth in its orbit.

UNIVERSE AND SOLAR SYSTEM — 3	37000.74	6.00	22.8	68

Our sun is a star and center of our solar system. All stars are suns. Planets rotate and revolve and shine by reflected light. Facts about orbits, constellations, galaxies.

UNIVERSE AND SOLAR SYSTEM — 7	37002.17	6.00	22.8	68

The members of the solar system, phases of the moon, tides, eclipses.

UP AND DOWN	37840.14	5.95	58.5	68

Up is discussed as away from the earth's center and down is shown as towards the center of the earth.

MOON, SUN AND STARS	38590.13	4.75	83.5	70

Simple concepts about the sun, the moon, and the stars.

SUN'S FAMILY	39480.12	4.95	58.5	69

Points out similarities and differences between planets, meteors, and comets.

INTERESTING THINGS ABOUT THE PLANETS	39480.13	4.95	58.5	69

The possibilities of life on other planets; comparison of the length of days and years with those of the earth; facts and legends about the discovery of planets.

CHANGING MOON	39480.15	4.95	58.5	69

Phases of the moon, eclipses, and moon's effect on earth's tides.

HOW WE LEARN ABOUT THE SKY	39480.16	4.95	58.5	69

Great leaders in astronomy and their contributions. The scientific method contrasted with the early practices of accepting opinions and superstitions as explanations of these phenomena.

SOLAR STOREHOUSE: LIGHT, HEAT, POWER 39542.1 6.00 62.9 68

Concept of the sun as the source of all energy with emphasis on light, heat, and power.

SOLAR SYSTEM 39542.5 6.50 62.5 68

Solar system, its members, planets, and its star, the sun, around which these planets revolve and rotate. The distances, sizes, and descriptions of the nine planets and other bodies in our solar system. Comparisons of night and day and length of year are indicated for each of the planets.

SUNSET AND ECLIPSE 40710.13 4.53 8.5 68

How the light from the sun is affected by the atmosphere at different angles causing sunsets and blue skies.

TRANSPARENCIES

ELEMENTARY SCIENCE — EARTH AND UNIVERSE UNIT I	Item No.	Price	Vendor No.	Exp. Date
ORBIT OF EARTH AROUND SUN	8267.5	4.00	73.15	70
OUR SOLAR SYSTEM	8267.5	4.00	73.15	70
REVOLUTION	8309	2.96	57.65	69
SIZES OF PLANETS	8310.4	2.21	57.65	69
SOLAR SYSTEM	8310.7	2.96	57.65	69
SOLAR SYSTEM	8460	5.00	87.3	70

Climate

FILMS

WEATHER SCIENTISTS 13 min., color, U.W.

Explains weather factors and instruments used to measure these factors. Describes how weather maps are constructed and then used in weather predictions.

WEATHER STATION, THE 14 min., McGraw-Hill, 1955

A young boy and girl take a tour of a local weather station where they see the instruments and are shown how weather is forecast.

FILMSTRIPS

	Item No.	Price	Vendor No.	Exp. Date
WEATHER MAPS AND WEATHER FORECASTING	37365.34	5.00	42	70

The various methods of forecasting weather and location of the weather stations in relation to weather map construction. The effect of weather upon plants, crops, and people, e.g., rain, cold, fog, and snow.

WHAT MAKES THE WEATHER	39150.13	4.00	42	68

Illustrates weather concepts: high altitude, cold, winter, thermometer use, nature of hurricanes, functions of moisture in air and clouds.

SEASONS — PART I	39280	6.00	89	70

Positions of the direct and indirect rays of the sun on the earth's surface; shifting of the heat zones with the shifting of the direct rays of the sun.

SEASONS — PART II	39280.1	6.00	89	70

As the earth revolves around the sun, different areas are presented to the vertical rays of the sun. The shifting of the heat zone shifts with the shifting of the vertical rays of the sun.

SUN, WEATHER MAKER	40260.13	4.50	25	68

Explains how the sun is a weather maker for the earth, accounting for temperature differences of night and day, during different seasons, at the seashore and inland.

Mirrors and the Reflection of Light

FILMS

LEARNING ABOUT LIGHT — 8 min., E.B.F., 1955

Deals with the fundamental concepts in the study of light: which objects are luminous; when objects are transparent, translucent, or opaque. What is reflection and what is refraction? Examples from the students' daily experiences are amplified with animation to achieve these objectives.

LIGHT AND WHAT IT DOES — 17 min., color, E.B.F.

Demonstrates, through a series of simple problem-solving experiences, how light travels; how it is affected by different materials; what causes reflection and refraction. For grades 5-6.

NATURE OF LIGHT 10 min., Coronet, 1948

Takes students on a fishing trip with two boys who study light as a form of radiant energy. Closely observes the principles of reflection and refraction.

SHADOWS AND ECLIPSE REFLECTION (LIGHT)
10 min., United World, 1951

A series of demonstrations illustrates some sources of light and the properties of light. Diagrams and photographs show formation of shadows and eclipses; the law of reflection is demonstrated.

FILMSTRIPS

	Item No.	Price	Vendor No.	Exp. Date
HOW LIGHT TRAVELS	37700	6.00	73.15	68

How light rays form images in mirrors. Fun with mirrors. How lenses work; explanation of color; how to make a telescope.

	Item No.	Price	Vendor No.	Exp. Date
LIGHT	37925	6.50	62.5	68

Story of light; how it travels and why we are able to see certain objects better than others. *Transparent, translucent,* and *opaque* are defined.

	Item No.	Price	Vendor No.	Exp. Date
LIGHT IN OUR DAILY LIVES	39150.16	4.00	42	68

Where light comes from, how it travels, how we see, etc.

Making It Go

FILMS

FUELS—THEIR NATURE AND USE (2nd Edition of "Fuels and Heat") 10 min., E.B.F., 1958

The various types of fuels, from wood through atomic, are discussed as to their nature and use.

HOW POWER DRIVES MACHINES 11 min., Coronet

From muscle power to atomic and solar energy, from waterwheels to gas turbines, a survey of applications of power in driving machines to do work.

HOW WE GET OUR POWER — 12 min., McGraw-Hill, 1955

Explains how all of our power comes from nature: from wind, water, fuels, explosives, and the atom.

OUR COMMON FUELS — 11 min., Coronet, 1954

The origins and uses of common fuels.

SUN'S ENERGY — 12 min., color, Cenco

Radio waves, infrared, visible light, and ultraviolet radiation from the sun supplies all the energy used on earth. This energy makes weather, plant food, fuel for heat, and the oxygen we breathe.

WATER WORKS FOR US — 9 min., McGraw-Hill, 1949

The many uses of water from cooking to driving steamships. The principles of the waterwheel and steam pressure are demonstrated and applications suggested.

WE USE POWER — 10 min., color, Churchill, 1956

Traces the history of the use and development of power. Uses simple models to demonstrate the use of wind, water, steam, electricity, and burning gases.

FILMSTRIPS

	Item No.	Price	Vendor No.	Exp. Date
MOTION AND FORCE	37040.41	6.00	73.15	71

How muscles, wind, flowing water, steam, rapid burning, and electricity make things move. Children are encouraged to experiment with motion and force, using easily obtained materials. The effects of gravity and friction on motion are explained.

OFF WE GO	37365.11	5.00	42	70

Shows progress in the area of transportation: walking, beasts of burden, rafts, boats, carts, chariots, wagons, and automobiles. Development of transportation in this country: the covered wagon, stage coach, pony express, steamboat, locomotive, automobiles, planes, helicopters, and rockets.

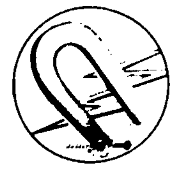
MACHINES HELP US TRAVEL	37365.31	5.00	42	70

Forms of travel aided by machines: the cart, auto, truck, rowboat, and steamboat; the use of gasoline as a fuel.

WHAT MAKES ENGINES GO	40345	6.00	73.15	68

How a steam engine functions; a simple model of a steam turbine and its operation.

Batteries and Bulbs



FILMS

ELECTRICITY: HOW TO MAKE A CIRCUIT (Using the Dry Cell)
11 min., E.B.F., 1959

Three children set up a simple telegraph and learn how to use dry cell batteries safely.

ELECTRICITY WORKS FOR US — **11 min., McGraw-Hill**

Just before dinner, the power goes off in the McMahon home. Tommy and Jane are made aware of the convenience of electricity. Their father takes them to the local power plant and they trace the wires from the street to their home.

FLOW OF ELECTRICITY — **11 min., McGraw-Hill, 1946**

Describes in a simple manner the flow of electricity by means of a simple demonstration in a home situation. Animation is used to demonstrate the flow of electrons through the circuit.

LEARNING ABOUT ELECTRIC CURRENT — **8 min., E.B.F., 1956**

Summary of the generation and use of electricity, including some elementary principles; wires in a home are traced to a generating station; simple experiments, such as a closed and open circuit; how to make an electromagnet.

SERIES AND PARALLEL CIRCUITS — **13 min., color, Cenco**

Dad explains to Steve the main parts needed in a simple electrical circuit, the differences, and the advantages of series and parallel circuits. Then Dad demonstrates the function of fuses in electric circuits.

THIS IS ELECTRICITY — **11 min., color, Cenco**

A father explains basic principles of electricity to his daughter. We learn about dry cells, generators, conductors, insulators, circuits, and switches. For grades 4-6.

FILMSTRIPS

	Item No.	Price	Vendor No.	Date Exp.
WE USE ELECTRICITY	37591.26	6.75	55.3	71

How electricity can bring us light, heat, power; how electric current is put to work.

	Item No.	Price	Vendor No.	Date Exp.
MAKING ELECTRIC CURRENTS	38591.42	6.75	55.3	71

Electron flow which produces electricity; electricity from magnets, heat, chemicals, and light energy.

FILMSTRIPS

	Item No.	Price	Vendor No.	Exp. Date
PRODUCING SMALL AMOUNTS OF ELECTRICITY	39945.13	5.95	58.5	72

How an electric cell can produce electricity; what instruments might be used to determine the flow of small amounts of electricity; the difference between dry cells and wet cells.

USING ELECTRICITY SAFELY	39945.14	5.95	58.5	72

Short circuits, overloading circuits, fuses, and circuit breakers; safety rules.

WHAT IS CURRENT ELECTRICITY?	39945.15	5.95	58.5	72

How electrons can become activated and force other electrons to move; how electric energy can be charged to heat, light, chemical, and sound energy.

TRANSPARENCIES

	Item No.	Price	Vendor No.	Exp. Date
DRY CELL AND CIRCUIT	8267.2	2.96	57.65	69

Science: General

FILMS

SCIENTIFIC METHOD — 12 min., E.B.F., 1954

Explains the elements of the scientific method, demonstrates the way this method of problem solving is applied by scientists, and discusses the value of scientific thinking in dealing with problems of everyday life. Features the discovery of penicillin by Sir Alexander Fleming and the work of Louis Pasteur.

USING THE SCIENTIFIC METHOD — 11 min., Coronet, 1954

Presents the scientific method in the context of an everyday problem through collection of information, formation of hypothesis, and experimental testing of hypothesis.

WHAT IS SCIENCE? — 11 min., Coronet, 1947

Designed as an introduction to the study of science, this film, in a simple story, presents the "scientific method" which begins with curiosity and proceeds, through observation, to the forming and the testing of the hypothesis, and then to a conclusion.

Bibliography

The publications for children listed in this Bibliography have been selected to:

provide good reading in science for children

convey the meaning and spirit of elementary science

provide science content related to the course of study

provide enriched material for children with special science interests

suggest valuable classroom procedures, experiments, and projects.

Most of the publications are on the current lists of the Board of Education of the City of New York: *Library Books for Elementary and Junior High Schools;* and *Textbooks: Elementary and Junior High Schools 1968.* The numbers which follow the annotation refer to the item numbers given in either of these publications.

For approaches to the use of books, see *Science and the Reading Program* on pages 14-17.

Following the list of children's books is a list of professional books on the teaching of science in the elementary school.

BOOKS FOR CHILDREN

How Man Changes Materials

BEELER, NELSON F., and BRANLEY, FRANKLYN M. *Experiments in Chemistry.* New York: Crowell, 1952. 152p.

Chemistry in everyday life with simple experiments using materials available in the kitchen, such as salt, soap, sugar, flour, milk, starch, and tea. 65-22-000

COOPER, ELIZABETH K. *Discovering Chemistry.* New York: Harcourt, Brace, 1959. 190p.

An introduction to the basics of chemistry, with instructions for setting up a home laboratory. A resource book for the teacher and for the especially interested student. 65-22-003

Gallant, Roy, and Schuberth, Christopher. *Discovering Rocks and Minerals.* New York: Doubleday, 1967. 127p.

An attractively illustrated guide to rocks and minerals, with methods of investigation. 65-38-040

Goldin, Augusta. *Salt.* New York: Crowell, 1965. unpaged.

An easy-to-read description of the importance, characteristics, and origins of salt. 71-12-382

Levy, Leon, et al. *Essentials of Merchandise Information: Non-textiles.* New York: Pitman Publishing, 1968. 320p.

Describes, in detail, many of the products sold in stores today. Designed to make students more knowledgeable and selective buyers of consumer goods. A good reference for the teacher.

Sander, Lenore. *The Curious World of Crystals.* Englewood Cliffs, N.J.: Prentice-Hall, 1964. 65p.

Everyday crystals and how to grow them. 65-38-026

Schwartz, Julius. *It's Fun to Know Why: Experiments with Things Around Us.* New York: McGraw-Hill, 1952. 125p.

How man obtains and uses iron, coal, cement, glass, rubber, wood, salt, bread, soap, and paper. Ideas reinforced by simple experiments with everyday materials. 65-00-067

Smith, Howard E. *From Under the Earth.* New York: Harcourt, Brace & World, 1967. 161p.

How we obtain and use materials from rocks, soils, coal, and petroleum. Highlights historical facts about the early discovery of many of America's metals, fuels, and minerals.

Wohlrabe, Raymond A. *Crystals.* New York: Lippincott, 1962. 128p.

The science of crystallography; simple methods for growing crystals; how crystals are used. For the interested student.

Little Environments

Anderson, Sydney. *The Lives of Animals.* Mankato, Minn.: Creative Educational Society in cooperation with The American Museum of Natural History, 1966. 144p.

Picture-text introduction to zoology and the impact of animal research on health and ecology. Touches on the problem of population growth and the balance of nature. 65-62-257

AUDUBON SOCIETY. *Audubon Nature Bulletins.* New York: The Society, n.d.

Attractively printed and illustrated bulletins written by authorities in natural history; nontechnical; easy to read and understand. Includes 60 bulletins under the following categories: animals with and without backbones, how they live, plant identification, conservation. Good teaching aids. Complete set of 60 bulletins: $5.00; 15¢ each; 10¢ each for 5 or more copies.

BARR, GEORGE. *Young Scientist Takes a Walk.* New York: McGraw-Hill, 1959. 160p.

Shows young readers how careful observations of plants and animals in an urban environment can lead to understanding of relationships in nature. 65-52-000

BEUSCHLEIN, MURIEL. *Free and Inexpensive Materials for Teaching Conservation and Resource-Use.* Reprinted from *The Handbook for Teaching Conservation and Resource-Use,* National Association of Biology Teachers. Copies of the bibliography may be obtained from: Richard N. Weaver, P.O. Box 2073, Ann Arbor, Michigan. (10¢). For teachers.

BLOUGH, GLENN O. *Lookout for the Forest.* New York: McGraw-Hill, 1955. 48p.

A conservation story, told through a boy's experiences, showing the value of forests and the animals in them, and the ways forest farmers and rangers protect our forest against fires. 63-25-002

———. *Who Lives in This House?* New York: McGraw-Hill, 1957. 48p.

Natural history for younger readers in an easy-to-read narrative about a peek into an old house to see the animals which have "taken it over." 65-62-015

———. *Who Lives in This Meadow?* New York: McGraw-Hill, 1961. 48p.

Variety of animal life in a meadow; how animals are suited to their environment. 65-62-016

BREVOORT, HARRY F., and FANNING, ELEANOR I. *Insects from Close Up.* New York: Crowell, 1965. 150p.

More than a hundred larger-than-life photographs of insects living in our own backyards, school lawns, and parks, with informative text.

BUCK, MARGARET WARING. *Pets from the Pond.* Nashville, Tenn.: Abingdon Press, 1958. 72p.

Exciting experiences for youngsters interested in learning how to find and keep fresh-water pets. 65-73-001

———. *Small Pets from Woods and Fields.* Nashville, Tenn.: Abingdon Press, 1960. 72p.

How to house and care for small plants and animals found in nature. 65-52-006

CADBURY, B. BARTRAM. *Fresh and Salt Water Community of Living Things.* Mankato, Minn.: Creative Educational Society in cooperation with the National Audubon Society. 1967. 128p.

Picture-text description of plants and animals in a water environment, and man's relationship to the whole.

CASSELL, SYLVIA. *Nature Games and Activities.* New York: Harper, 1956. 87p.

Construction of bird houses, feeders, terraria, displays, and collections. Simple games. 65-52-008

COLLINS, STEPHEN. *The Forest and Woodland Community of Living Things.* Mankato, Minn.: Creative Educational Society in cooperation with the National Audubon Society, 1967. 125p.

Picture-text description of plants and animals that make for a balanced forest environment and man's relationship to the whole.

COOPER, ELIZABETH K. *Science in Your Own Back Yard.* New York: Harcourt, Brace, 1958. 192p.

Introduction to accessible organisms and phenomena ranging from soil, earthworms, and plants to clouds, weather, and the stars. 65-52-009

CROSBY, ALEXANDER L. *Junior Science Book of Pond Life.* Champaign, Ill.: Garrard Publishing, 1964. 65p.

In conversational style, the author explores a pond and its wildlife. Brief descriptions of the habits of frogs, muskrats, snakes, turtles, and salamanders. 65-52-001

DARLING, LOUIS. *The Gull's Way.* New York: Morrow, 1965. 96p.

A most appealing book about the herring gull in an island setting. This gull is a resident of New York, too. 65-74-077

GREENBERG, SYLVIA S., and RASKIN, EDITH. *Home-Made Zoo.* New York: McKay, 1952. 256p.

A practical handbook on the care of small pets in the home or classroom.

HARRISON, WILLIAM C. *The First Book of Wildlife Sanctuaries.* New York: Franklin Watts, 1963. 48p.

Establishment and maintenance of refuges and sanctuaries for the preservation of America's animals.

HEADSTROM, RICHARD. *Adventures with Freshwater Animals.* New York: Lippincott, 1964. 217p.

Introduction to the amazing variety of creatures living in streams, ponds, lakes — even in a puddle; includes methods of investigation.

HIRSCH, S. CARL. *The Living Community: Adventure into Ecology.* New York: Viking, 1966. 128p.

Three biological themes are brought into focus: ecology, evolution, and conservation.

HOGNER, DOROTHY C. *Frogs and Polliwogs.* New York: Crowell, 1956. 68p.

The life cycle of the frog from egg to maturity; includes material on toads and salamanders. 65-73-012

———. *Grasshoppers and Crickets.* New York: Crowell, 1960. 61p.

Natural history of grasshoppers, locusts, and crickets. 65-72-023

HUNTINGTON, H. E. *Let's Go to the Brook*. Garden City, N. Y.: Doubleday, 1952. 90p.

A welcome book for young naturalists ready to explore out-of-doors. Many exceptional pictures taken through water. 65-52-024

HUSSEY, LOIS, and PESSINO, CATHERINE. *Collecting Cocoons*. New York: Crowell, 1953. 73p.

Describes the stages in the development of the moth; how cocoons are made: where and when to look for cocoons; how to collect and care for them. 65-72-027

KAVALER, LUCY. *The Wonders of Fungi*. New York: John Day, 1964. 128p.

Fungi are all around us. They play an important role in food chains as decomposers. Some fungi are harmful to man and his crops. Some are used to make antibiotics.

KIERAN, JOHN. *An Introduction to Trees*. New York: Hanover House, 1954. 77p.

Over 100 American trees described and illustrated so that identification is made easv.

KLEIN, STANLEY. *A World in a Tree*. New York: Doubleday, 1968. 64p.

The bird, mammal, and insect life that goes on in, around, and under the tree during the year. Simple introduction to ecology.

KLOTS, ALEXANDER S. and ELSIE B. *The Desert Community of Living Things*. Mankato, Minn.: Creative Educational Society in cooperation with the National Audubon Society, 1967. 126p.

Picture-text description of plants and animals that make for a balanced desert environment and man's relationship to the whole.

LAVINE, SIGMUND. *Wonders of the Anthill*. New York: Dodd, 1960. 64p.

The structure, life cycle, and habits of the ant are described and illustrated. 65-72-032

LEMMON, ROBERT S. *Parks and Gardens: Community of Living Things*. Mankato, Minn.: Creative Educational Society in cooperation with the National Audubon Society, 1967. 126p.

Picture-text description of plants and animals that make for a balanced garden environment and man's relationship to the whole.

LEOPOLD, ALDO. *A Sand County Almanac*. New York: Oxford University Press, 1966. 269p.

Inspiring essays presenting a sound basis for conservation of natural resources; a love and respect for the land. For teachers.

MATTISON, CHARLES W., and ALVAREZ, JOSEPH. *Man and His Resources in Today's World*. Mankato, Minn.: Creative Educational Society, 1967. 144p.

Picture-text review of man's use and abuse of natural resources with implications for urban conservation and the interdependence of rural and urban Americans.

McCormick, Jack. *The Life of the Forest.* New York: McGraw-Hill, 1966. 232p.
Ecological principles; the four seasons in the forest; many excellent photographs.

——————. *The Living Forest.* New York: Harper, 1959. 127p.

The forest as a constantly changing product of many influences — climate, soil, animal activity, natural and man-made hazards, and time.

Morgan, Alfred. *Aquarium Book for Boys and Girls.* New York: Scribner's, 1959. 180p.

Practical advice on starting an aquarium and caring for it. Includes amphibia and turtles as well as fish. 65-73-019

Morgan, Ann. *Field Book of Ponds and Streams.* New York: Putnam, 1930. 448p.

A valuable and detailed description of fresh water plant and animal life. For each form there is a discussion of basic life history characteristics.

Petit, Sid S. *The Web of Nature.* Garden City, N.Y.: Doubleday, 1960. 56p.

Various ecological complexes: marshes, prairies, deserts, forests, salt and fresh waters; need for conservation programs and practices. 65-52-038

Palmer, E. Laurence. *Field Book of Natural History.* New York: McGraw-Hill, 1949. 664p.

A teacher's mine of information about common plants and animals, helpful in identification and understanding their structure, habitat, life history, and economic importance. Answers the kinds of questions children ask. The author, for many years the editor of the *Cornell Rural School Leaflets,* has selected those forms found most commonly in "field, stream, or woodlot, in the grocery or fruit store, or behind the kitchen sink."

Raskin, Edith. *The Pyramid of Living Things.* New York: McGraw-Hill, 1957. 192p.

Explores adaptations of plant and animal life in a variety of settings from the Arctic to the tropics. Stresses ecological principles.

Reid, George K. *Pond Life.* New York: Golden Press, 1968. 160p.

Nature guide to pond life.

Ress, Etta Schneider. *Field and Meadow: Community of Living Things.* Mankato, Minn.: Creative Educational Society in cooperation with the National Audubon Society, 1967. 125p.

Picture-text description of plants and animals that make for a balanced field environment and man's relationship to the whole.

Rogers, Matilda. *A First Book of Tree Identification.* New York: Random House, 1951. 95p.

Identification facilitated by large, clear photographs of leaves and bark. Especially useful for young people. 65-59-024

RUBLOWSKY, JOHN. *Nature in the City*. New York: Basic Books, 1967. 152p.

The plant and animal life of the city. Includes a brief history of living things in cities, telling of the changes that have occurred from pre-Colonial days until now.

RUSH, HANNIFORD, and MORA, RAUL. *Backyard Trees*. New York: Rutledge Books, 1964. unpaged.

Common trees described and illustrated. The shapes of the trees and their leaves are well defined and will help in the identification of the trees. 65-59-030

SCHWARTZ, JULIUS. *Through the Magnifying Glass: Little Things That Make a Big Difference*. New York: McGraw-Hill, 1954. 142p.

Explores nature's wonders with a simple magnifying glass: includes flowers, roots, and stems of plants, bread mold, insects, and others. 65-00-069

SELSAM, MILLICENT. *How Animals Live Together*. New York: Morrow, 1963. 95p.

Many types of animal relationships and how scientists have studied them. 65-62-164

———. *Microbes at Work*. New York: Morrow, 1953, 95p.

The work of bacteria, molds, and yeasts. Simple, illustrative experiments are included. 65-61-004

———. *See Along the Shore*. New York: Harper, 1961. unpaged.

The wonders of nature to be discovered at the everchanging seashore.

———. *Questions and Answers About Ants*. New York: Four Winds Press, 1967. 75p.

A carefully developed question and answer format; attractive illustrations.

SPILHAUS, ATHELSTAN. *The Ocean Laboratory*. Mankato, Minn.: Creative Educational Society in cooperation with The American Museum of Natural History, 1967. 144p.

Picture-text description of oceanography and what the outlook is for farming, mining, energy, and other uses.

STERLING, DOROTHY. *Caterpillars*. New York: Doubleday, 1961. 64p.

The habits of caterpillars: how to catch, raise, and observe them; includes 50 common species. 65-72-056

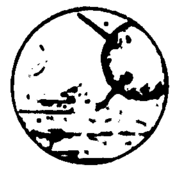
WEBBER, IRMA. *Thanks to Trees*. New York: William R. Scott, 1952. 60p.

Explains the balance of nature and stresses the interdependence of trees, animals, and human beings. 63-25-035

ZIM, HERBERT S., and others. *Golden Nature Guides: Birds, Flowers, Insects, Reptiles and Amphibians, Mammals, Seashores, Fishes*. New York: Simon and Schuster, 1950-57.

Each of these books provides a brief but useful guide to typical forms.

The Sun's Family



Adler, Irving. *The Sun and Its Family.* New York: John Day, 1958. 128p.
An historical approach to the study of the sun and planets. For interested pupils and teachers. 65-05-001

Asimov, Isaac. *Kingdom of the Sun.* New York: Abelard Schuman, 1963. 159p.
The story of man's growing comprehension of the sun and its relationship to the earth and the other planets begins with Babylonian astrology and ends with modern day astronomy. For interested students and the teacher.

——————. *Mars.* Chicago: Follett, 1967. 32p.
Simple presentation of present day knowledge of Mars.

Bova, Ben. *Uses of Space.* New York: Holt, Rinehart & Winston, 1965. 144p.
Presents arguments for going to the moon and the planets. For especially interested pupils.

Branley, Franklyn M. *Book of Mars for You.* New York: Crowell, 1968. 58p.
Discusses Mars and how information by Mariner IV has changed and expanded our knowledge.

——————. *Experiments in Sky Watching.* New York: Crowell, 1959. 112p.
Helps make the sky a laboratory for observation and discovery.

——————. *Mars.* New York: Crowell, 1955. 148p.
A clear story of Mars — its age, size, physical geography, and mysterious "canals." Recommended for interested pupils and teachers.

Chamberlain, Joseph, and Nicholson, Thomas S. *Planets, Stars and Space.* Mankato, Minn.: Creative Educational Society in cooperation with The American Museum of Natural History, 1962. 222p.
Picture-text introduction to astronomy. 65-05-010

Fogel, Barbara R. *What's the Biggest?* New York: Random House, 1966. 115p.
A book which may encourage reluctant readers. One section deals with Earth and the universe. 65-00-086

Forman, Robert. *Faster and Faster: A Book About Speed.* New York: Viking, 1965. 42p.
A picture-book presentation of the comparative speeds at which a variety of things travel, including the earth in orbit and light.

Freeman, Mae and Ira. *Fun with Astronomy.* New York: Random House, 1953. 58p.
The earth, moon, sun, planets, stars, time, seasons, phases of the moon, and eclipses explained with many suggestions for experimentation and model making. 65-05-015

Gallant, Roy A. *Exploring the Planets.* New York: Garden City Books, 1958. 123p.
A simple but comprehensive view of the solar system includes chart and tables for locating the planets. 65-05-020

———————. *Exploring the Sun*. New York: Garden City Books, 1958. 56p.

Presents the story of the sun from the myths of primitive people to the "death" of the sun billions of years from now. 65-05-021

KNIGHT, DAVID C. *First Book of Mars*. New York: Franklin Watts, 1966. 96p.

Includes latest findings about Mars in light of Mariner IV's historic "fly by." 65-05-066

LAUBER, PATRICIA. *All About the Planets*. New York: Random House, 1960. 139p.

The origin of our solar system; what astronomers know about the planets; the possibility of life on other planets. 65-05-028

LYON, JENE. *Our Sun and the Worlds Around It*. New York: Golden Press, 1957. 57p.

Factual information about the solar system for beginners. 65-05-060

MOORE, PATRICK. *The Solar System*. New York: Criterion Books, 1961. 127p.

An historical approach to the story of man's study of the solar system. The reader is introduced to the special characteristics of the various bodies of our solar system.

NEWELL, HOMER E., JR. *Space Book for Young People*. New York: McGraw-Hill, 1968. 160p.

Earth, our atmosphere, the moon, sun, planets, and steps to space flight. Supplies mathematics for understanding distance, size, and speed. Includes findings of such space probes as Mariner V and the lunar orbiters. 66-36-055

SAGAN, CARL; LEONARD, JONATHAN; and the EDITORS of *LIFE*. *Planets*. New York: Time, 1966. 200p.

Our knowledge of the planets and how we learned about them. Each chapter includes a picture essay.

SCHNEIDER, HERMAN and NINA. *How Big Is Big? From Stars to Atoms*. New York: William R. Scott, 1950. 48p.

With striking illustrations, the author helps the child to understand how he fits into the scheme of the universe, using size as the basis. 71-02-196

SHAPP, MARTHA and CHARLES. *Let's Find Out About the Sun*. New York: Franklin Watts, 1965. 47p.

A simple introduction to the sun and an explanation of the dependence of the earth and all forms of life on the emanations of solar light and heat.

SILVERSTEIN, ALVIN and VIRGINIA B. *Life in the Universe*. Princeton, N.J.: D. Van Nostrand, 1967. 48p.

An introduction to the forms of life on Earth and their support requirements; the rarity of these essentials on other planets.

Climate

ADLER, IRVING and RUTH. *Storms*. New York: John Day, 1963. 48p.

Discusses the various types of unusual weather around the world. 65-36-003

ADLER, IRVING. *Weather in Your Life.* New York: John Day, 1959. 126p.

Explores the ways we study, forecast, outwit, and change the weather. 65-36-001

BENDICK, JEANNE. *The Wind.* New York: Rand McNally, 1964. 80p.

How winds start; how they affect weather; what myths and superstitions they have inspired. 65-36-007

FENTON, CARROLL LANE, and ADAMS, MILDRED. *Our Changing Weather.* New York: Doubleday, 1954. 110p.

For the student who is interested in the whys and wherefores of weather phenomena. 65-36-011

FORRESTER, FRANK, *1001 Questions Answered About the Weather.* New York: Dodd, 1957. 419p.

A valuable reference in question and answer form. A treasure for anyone interested in the whys and wherefores of climate and weather.

HARRIS, MILES F. *Man Against Storm.* New York: Coward-McCann, 1962. 120p.

A good reference book for teachers. Good photographs explain the work of meteorologists. 65-36-018

HOLMES, DAVID C. *Weather Made Clear.* New York: Sterling, 1965. 128p.

Weather phenomena explained; includes methods of measuring and forecasting weather.

KIMBLE, GEORGE H. T. *Our American Weather.* New York: McGraw-Hill, 1955. 322p.

A comprehensive report of the weather in the United States. For the interested reader and the teacher.

NAMOWITZ, SAMUEL N., and STONE, DONALD B. *Earth Science: The World We Live in.* Princeton, N.J.: D. Van Nostrand, 1966.

This high school textbook has excellent chapters on weather and climate. A fine reference for the teacher. 477-591.1

PILKINGTON, ROGER. *The Ways of the Air.* New York: Criterion Books, 1962. 192p.

Interesting and easy reading. Valuable for the teacher who is interested in climate and weather.

SCHNEIDER, HERMAN. *Everyday Weather and How It Works.* New York: McGraw-Hill, 1961. 194p.

Updated edition of the new weather detection devices which explain the many elements that make up our weather. 65-36-033

SPAR, JEROME. *The Way of the Weather.* Mankato, Minn.: Creative Educational Society, 1957. 224p.

Picture-text treatment of weather observations which help in weather forecasting and in understanding relationship between weather and climate; conveys the feeling as well as the science of weather. 65-36-034

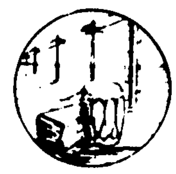
SPILHAUS, ATHELSTAN F. *Weathercraft*. New York: Viking, 1951. 64p.

Tells how to assemble a home weather station using easily available materials. Excellent for the weather hobbyist. 65-36-035

TANNEHILL, IVAN RAY. *All About the Weather*. New York: Random House, 1953. 148p.

An interesting presentation of many aspects of weather for good readers. 65-36-037

Mirrors and the Reflection of Light



BEELER, NELSON F., and BRANLEY, FRANKLYN M. *Experiments with Light*. New York: Crowell, 1958. 143p.

Clearly and accurately presents experiments for finding out about light. Fun and information. 65-17-002

BRUCE, GUY V. *Experiences with Light and Color*. Volume VII, *Science Teaching Today*. Washington, D.C.: National Science Teachers Association, 1951. 48p.

For the teacher.

FREEMAN, MAE and IRA. *Fun and Experiments with Light*. New York: Random House, 1963. 58p.

Using materials usually found around the house, the child performs experiments illustrating many of the principles of light. 65-17-004

HARRISON, GEORGE R. *The First Book of Light*. New York: Franklin Watts, 1962. 85p.

Answers questions about light simply. Suggests a variety of experiments using home equipment. 65-17-005

HEALY, FREDERICK. *Light and Color*. New York: Golden Press, 1966. 48p.

Tells where light comes from, how it works, what it does. Includes experiments a child can do. 65-17-006

JUPO, FRANK. *The Adventure of Light*. Englewood Cliffs, N.J.: Prentice-Hall, 1958. unpaged.

In word and picture tells how man brought light to his surroundings. Explores recent developments and things to come. High interest; low reading level. 65-17-008

MARK, STEVEN J. *A Physics Lab of Your Own*. Boston: Houghton Mifflin, 1964. unpaged.

The principles involved in experiments with reflection and refraction of light; experiences with color and optical illusions.

NEAL, CHARLES D. *Exploring Light and Color*. Chicago: Children's Press, 1964. 156p.

Attractive, clear print, well illustrated; diagrams easily interpreted; explores a wide area of light, color, mirrors, and lenses. 65-17-011

Pine, Tillie S., and **Levine, Joseph.** *Light All Around.* New York: Whittlesey House, 1961. 48p.

Basic facts about light, with simple suggested experiments. 65-17-013

Ruchlis, Hy. *The Wonder of Light.* New York: Harper, 1960. 154p.

Uses good photographs and diagrams; explains the how and why we see. Explores reflection and refraction and the instruments that show their application. 65-17-014

Sootin, Harry. *Light Experiments.* New York: W. W. Norton, 1963. 93p.

Each experiment accompanied by easily understood explanations of the principles and scientific history involved. Inexpensive and easily obtained materials are suggested. 65-17-016

Making It Go

Blackwood, Paul E. *Push and Pull: The Story of Energy.* New York: McGraw-Hill, 1966. 192p.

Discusses solar, mechanical, electrical, chemical, and nuclear energy.

Branley, Franklyn M. *Solar Energy.* New York: Crowell, 1957. 117p.

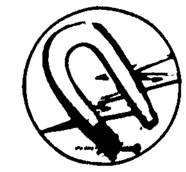
How solar energy may be harnessed and used for the benefit of mankind. Includes heat pumps, cookers, furnaces, water heaters, and generators. 66-21-000

Ress, Etta Schneider. *Transportation in Today's World.* Mankato, Minn.: Creative Educational Society, 1966. 144p.

Picture-text survey of many forms of energy used in transportation, with a look to future possibilities.

Schneider, Herman and **Nina.** *More Power to You.* New York: William R. Scott, 1953. 128p.

How man has put wind, water, fire, electricity, and the atom to work for him. Simple experiments included. 66-16-021



Batteries and Bulbs

Beasley, Rex. *Edison.* Philadelphia: Chilton, 1964. 176p.

The story of Edison and his invention of the electric light, the phonograph, etc.

Beeler, Nelson, and **Branley, Franklyn M.** *Experiments with Electricity.* New York: Crowell, 1949. 145p.

Safe experiments using simple, everyday materials to explain the how and why of electricity. Useful for science clubs and special projects. 65-19-000

BERRY, ERIC. *Charles Proteus Steinmetz: Wizard of Electricity*. New York: Macmillan, 1966. 41p.

The student days of the mathematician genius, his escape from Germany to Switzerland, and finally his arrival in New York. 69-66-022

DIBNER, BERN. *Alessandro Volta and the Electric Battery*. New York: Franklin Watts, 1964. 135p.

A biography of the Italian physicist, following the development of electricity from its inception to his own development of the "Voltaic pile" known as the electric battery.

EPSTEIN, SAM and BERYL. *The First Book of Electricity*. New York: Franklin Watts, 1953. 69p.

What electricity is; how it is produced in batteries and generators; how it is used in the home; explanations of meters, fuses, toasters, electric bulbs, sockets, and switches. Directions for making an electric current detector, a fuse, an electromagnet, and a telegraph set. 65-19-005

FREEMAN, IRA M. *All About Electricity*. New York: Random House, 1957. 141p.

Summary of basic principles, with emphasis on key historical discoveries in electricity. 65-19-007

FREEMAN, MAE and IRA. *The Story of Electricity*. New York: Random House, 1961. 79p.

An introduction to electricity and some of its uses, from rubbed amber to the electron tube. 65-19-008

MERRIAM, EVE. *The Story of Ben Franklin*. New York: Four Winds Press, 1966. 79p.

Relates many details of Franklin's life, including his inventions, scientific experiments, and years as elder statesman. Easy reading. 69-65-455

MORGAN, ALFRED. *A First Electrical Book for Boys*. New York: Scribner's, 1951. 263p.

Explains fundamentals of electricity with clear diagrams and simple explanations to older children. Also valuable to the teacher who wishes to understand electricity, magnetism, batteries, telegraphs, electric bells, telephones, fuses, lights, motors, generators, and radios. 65-19-011

PARKER, BERTHA M. *Electricity*. Evanston, Ill.: Harper, 1963. 36p.

A general nontechnical introduction to electricity and its uses.

PINE, TILLIE S., and LEVINE, JOSEPH. *Electricity and How We Use It*. New York: McGraw-Hill, 1962. 48p.

Explores the world of electricity; how electrons flow in a circuit; what electricity can do; safety rules.

PRINGLE, PATRICK. *The Young Edison*. New York: Roy, 1963. 126p.

Edison's career from "candy butcher" to that of telegraph operator, experimenter, and inventor. 69-64-259

ROSENFELD, SAM. *The Magic of Electricity.* New York: Lothrop, Lee and Shepard, 1963. 158p.

Describes how and why electricity works; includes experiments using inexpensive and easily obtained materials. Useful for the teacher. 65-19-013

SCHNEIDER, HERMAN. *Everyday Machines and How They Work.* New York: McGraw-Hill, 1950. 192p.

Describes many everyday machines using electricity and magnetism. 66-61-002

SCHNEIDER, HERMAN and NINA. *Let's Look Inside Your House.* New York: William R. Scott, 1948. 40p.

Contains a section about the electrical system in a house. Good diagrams; simple explanations. 65-13-009

SCHNEIDER, HERMAN and NINA. *Let's Look Under the City.* New York: William R. Scott, 1954. 71p.

A basic book on community utilities: water, sewage, electricity, gas, and telephone; how the home is linked by these utilities to the city. 66-28-008

SHEPARD, WALTER. *Electricity.* New York: John Day, 1964. 49p.

An introduction to a number of topics in electricity. Uses the water analogy in explaining the terms "volt," "ampere," and "short circuit."

YATES, R. F. *Boy's Book of Magnetism.* Harper, 1959. 166p.

Games, experiments, and constructions with magnets and electromagnets leading to an understanding of magnetism, compasses, and electricity. 65-20-005

————. *Boy and a Battery.* Harper, 1959. 120p.

Describes young experimenters, equipped with a battery, making electromagnets, current detectors, and fuses to discover principles of electricity.

Science: General

BARR, GEORGE. *Research Ideas for Young Scientists.* New York: McGraw-Hill, 1958. 142p.

Provides many ideas for science clubs and science fairs. Teaches newcomers to science how to make accurate measurements, record and interpret data, construct graphs, and use controls. 65-00-005

————. *More Research Ideas for Young Scientists.* New York: McGraw-Hill, 1961. 159p.

Contains many open-ended experiments which allow the child room for discovery in chemistry, astronomy, magnetism, electricity, and other fields of science. 65-00-003

DE VRIES, LEONARD. *The Book of Experiments.* New York: Macmillan, 1959.

This first book of three gives clear instructions for basic experiments with air, sound, heat, water, and other materials. Also by the same author:

The Second Book of Experiments. 1964

The Third Book of Experiments. 1965

LYNDE, CARLETON J. *Science Experiences with Ten-Cent Store Equipment.* Princeton, N.J.: D. Van Nostrand, 1955. 276p.

Describes many experiments briefly, using inexpensive material. 272-998.2

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Includes experiments leading to a better understanding of rockets, satellites, gyroscopes, submarines, turbines, motors, motion, and gravity. 65-00-050

————. *Further Explanations in Science: A Second Book of Basic Experiments.* New York: Dutton, 1963. 128p.

A variety of experiments, using simple materials, for exploring the physical world. 65-00-051

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WYLER, ROSE. *The First Book of Science Experiments.* New York: Franklin Watts, 1952. 69p.

Easy-to-understand directions for performing experiments with air, water, plants, electricity and magnetism, chemistry, and light. 65-00-079

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BLOUGH, GLENN O., and SCHWARTZ, JULIUS. *Elementary School Science and How to Teach It.* New York: Holt, Rinehart & Winston, 1964.

Combines a survey of science subject content with methods of teaching science in the elementary school.

CARRIN, ARTHUR, and SUND, ROBERT B. *Teaching Science Through Discovery.* Columbus, Ohio: Merrill, 1966.

Emphasizes planning and evaluation for a series of representative lessons.

CRAIG, GERALD S. *Science for the Elementary School Teacher.* Boston: Ginn, 1966.

Provides the teacher with a background in science and with methods of teaching it.

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GEGA, PETER C. *Science in Elementary Education.* New York: John Wiley, 1966.

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A description of the goals, content, and specific teacher roles of one of the national projects, namely, the Science Curriculum Improvement Study (SCIS).

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Teaching suggestions and subject matter.

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How to develop children's creative potential in science.

RENNER, JOHN W., and RAGAN, WILLIAM B. *Teaching Science in the Elementary School.* New York: Harper, 1968.

Discusses the contributions of science education to the objectives of the elementary school.

TANNENBAUM, HAROLD E.; STILLMAN, NATHAN; and PILTZ, ALBERT. *Science Education for Elementary School Teachers.* Boston: Allyn and Bacon, 1965.

Goals, methods, child development in relation to elementary school science.

VESSEL, M. F. *Elementary School Science Teaching.* New York: Center for Applied Research in Education, Inc., 1963.

Traces the history of elementary school science; includes curriculum organization and classroom procedures.

VICTOR, EDWARD. *Science for the Elementary School.* New York: Macmillan, 1965.

Teaching methods and outlines of content.

VICTOR, EDWARD, and LERNER, MARJORIE S. *Readings in Science Education for the Elementary School.* New York: Macmillan, 1967.

Readings on current thinking, practices, and innovations in elementary science education.