TEACHERS' MANUAL

for Discovering with Science

SCIENCE TODAY AND TOMORROW

Gerald S. Craig
Beatrice Davis Hurley

Ginn and Company
Boston • New York • Chicago • Atlanta • Dallas • Palo Alto • Toronto • London
Photographs on pages 77 and 81 were taken in the public schools of Fort Wayne, Indiana, by D. Oswald Jones through the courtesy of Miss Anne Hopman, formerly Assistant Supervisor, Elementary Education, Fort Wayne Public Schools.

Drawings are by Foster Caddell and Hugh Spencer.
Contents

FOREWORD

Children and Science 1
I The Seasons 19
II Animals and the Seasons 27
III Plants and the Seasons 37
IV Where Plants Grow 46
V The Earth 56
VI The Air We Live In 66
VII The Sounds We Hear 75
VIII How Plants Grow 83
IX Learning about Animals 92
X Working with Electricity 103
XI The Waters of the Earth 115
XII Studying Rocks and Minerals 126
XIII Using Materials Wisely 134

APPENDIX

Minimum Science Equipment 142
Additional Science Equipment 143
Equipment Supply Houses 143
Directory of Publishers 144
Film and Filmstrip Distributors 146
National Film Rental Agencies 147

INDEX 149
Science Today and Tomorrow

During the last twenty-five years, science has grown steadily in the elementary schools of the United States, Canada, and various countries of Europe, Asia, and Africa. This is no ordinary event, for new areas are not easily established in the elementary school, owing to the tremendous pressure of various groups to gain the attention of children.

Science in the elementary school has to a large extent been developed by classroom teachers. They have experimented with new activities, new content, and new methods. Many of them have constructed curriculum materials and developed reading materials in science for the elementary school. As a result of this work, instruction in science in the elementary school is uniquely designed for use by classroom teachers.

The new elementary-school program with its emphasis on science is a feasible program because it recognizes that the classroom teacher has many professional tasks; teaching science is but one of them. The teacher is a specialist in the education of children and not necessarily a specialist in science. There is no need for classroom teachers to feel any responsibility for specialized science tasks, such as naming all the objects in the environment, animate or inanimate, or serving as a field naturalist, a laboratory technician, or a general bureau of information.

It is evident that only those subjects that are in keeping with the basic purposes of the elementary school succeed in maintaining a permanent place in its curriculum. The American elementary school is a unique institution. It has been called at times "the great common school," in that it is the school for all the people. It was established by the early forefathers as the one institution that would be common to everyone, regardless of race, religion, economic status, and future occupation. It has become the basic institution dedicated to the task of the education of all people for citizenship in a democracy. A significant part of the success that science has had can be accounted for by the fact that elementary-school workers have been concerned that science be developed in the interests of all boys and girls. This pattern for science in public elementary education is being adopted by a number of democratic countries.
Science from the Developmental Point of View

Science in the education of children should be considered wholly from a developmental point of view. Recognition will then be given to the fact that children do not come to school for the first time at zero in science learning.

They have had a wide range of rich experiences with physical and biological phenomena. They may have a variety of experiences including those with friction, momentum, inertia, magnetism, static electricity, simple electric circuits, snow, ice, water, steam, melting, boiling, freezing, conditions necessary to certain living things, care of animals, seasonal change, the sun, the moon, stars, clouds, mirrors, magnifying glasses, evaporation, condensation, varieties of kinds of locomotion found in the animal world, animal mouths, ears, noses, coverings, balance with building blocks, wagons and tricycles, heat and cold, effects of seasonal change, different animal habitats in the community, solution of solids in liquids, molds, the large number of seeds produced by some plants, and so on. They may bring with them misconceptions and superstitions, or they may come to school with a good attitude conducive to learning and the development of intelligent and resourceful behavior.

Many teachers of children find it useful to accept a point of view of dynamic psychology for understanding children. Their ideas may be stated simply in such words as these: A child lives in a dynamic universe which is new to him. He is challenged by his many experiences. This universe is filled with a great variety of objects. He is impressed by the events (phenomena) small and large occurring about him, such as rusting, rain, weathering rocks, electrical shocks, thunder, wind, and falling objects. He finds himself in normal circumstances tremendously stimulated and turns naturally to exploring and learning.

A young child is naturally egocentric. He is not to be condemned for being so; his egocentricity grows out of his great potentialities for ceaseless drive and for adjustment and understanding of his environment and himself. As a result of the great drives and yearnings, he feels inside himself a whole gamut of emotions which are to him discoveries about himself. He may display grief, irritability, anger, restlessness, impatience, and disappointment. Although such expressions are not to be condoned or encouraged in children, they are
not to be considered in themselves evil, for out of these emotional drives have come many of the great constructive developments of mankind, such as democracy, better living conditions, religious freedom, and improved health.

A child is an energy system and in all the universe we do not find its equal. It is remarkable that out of the use of his energy, a child is becoming intelligent in a universe filled with a vast variety of living and nonliving objects, an almost kaleidoscopic array of events and changes. Within his rapidly widening universe, the child attempts to identify himself and his inheritance. Viewing children from this dynamic point of view assists parents and teachers to understand that the drives of children, which are so frequently annoying to the adult, are potentially constructive traits.

A child learns about his environment whether he is taught science or not, although some of his learning may be negative in value. The kind of science learning considered in this Manual begins in the cradle. As a child begins to separate himself from his environment, he begins to develop learnings based on these experiences. Parents and teacher must recognize that there may be learning about the environment even though a child is unable to state meanings in words. For instance, a child is experiencing something with the rattle he places in his mouth although he has no words with which to shape thought. He is learning something about the earth and its gravity as he pushes his weight against it in taking his first steps. Were the earth like a suspended rubber balloon that bounced away from him, or if the gravity were not constant and pulled him with greater force at some times than at others, he would develop a different set of attitudes and behavior. In considering science in the program of elementary education, it is well to conceive of science experiences as beginning with birth. In a real sense, the adjustment to the environment can be traced back to the prenatal stages.

In a very real sense, we might say that the potentialities of science are inside human beings. To make it more personal we may think of these potentialities as being in such human beings as ourselves—teachers and children in the classroom. This is true because science has grown out of a tremendous urge on the part of mankind through the long centuries to come to an understanding of the universe.

Man, from the remote past, has sought explanations for the things that happen in the world about him. The rainbow, birth,
death, life, lightning, and other events challenged him. He frequently used great ingenuity and much fancy to develop explanations for the phenomena about him. The myths and legends of many peoples indicate men have felt that if they could understand the world about them they might know more about themselves, their origins and history. The fact that primitive people frequently associated their explanations with their religious beliefs demonstrates how important such explanations were to them. In fact, these explanations had much to do with man’s adjustment to the environment. Sometimes man’s explanations made him fearful and superstitious; at other times they filled him with confidence, calm, and resourcefulness.

According to the developmental point of view, the origin of science is in man’s distant past. An implication of this for teachers in the elementary school is that science need not be thought of as something foreign to them or to the children they teach. Science as we know it today, with its discoveries and inventions, is the result of urges in men and women through the ages. We can see these same urges in children as they follow their natural drives and as they attempt to secure adjustment and equilibrium in a dynamic universe. They use the senses of smelling, tasting, feeling, seeing, and hearing, the kinesthetic sense, imagination, curiosity, energy, irritability, restlessness, play, response to external conditions, and other partly understood drives deep within their natures to project themselves into the areas of the environment. They depend upon impulse, fancy, creative activities, and logical thinking just as their ancestors did.

From the developmental point of view not all of science is difficult. On the contrary, from this point of view science is part of the earliest learnings of children. Furthermore, the technical, vocational, and specialized aspects of science have no function in elementary education. Elementary science is closely related to the experiences of children and to the kind of thinking they can do, so that teachers need have no fear of science. The teacher can learn the science that is needed while teaching science at any level in the elementary school. The fear of science felt by some adults is not usually found in children. The adult may have been conditioned to a dislike of science in part by previous contacts with science instruction at high school and college levels, whereas children, having felt no such condition-
ing, are still following their natural impulses. Teachers can free themselves from their negative reactions if they will attempt to see the environment and science through the eyes of children. Encouraging children in a classroom to express themselves freely about their ideas of natural events has assisted many teachers to understand children and at the same time to gain a new look at the world for themselves.

**Using Science in a Democracy**

There has grown up a conviction that the free nations must remain strong if they are to remain free. There is also a realization that there is power in science, and therefore that science is an essential element in maintaining and improving the democratic way of life. It will not be enough to have a small portion of the population educated as scientists; to be truly strong, an entire nation must be conversant with science. To realize this goal, science must be placed in the curriculum as one of the fundamentals. Making a whole nation conversant with science is a task uniquely suited to the elementary school since this is the institution of all the people. It is the institution which has in its enrollment not only the future scientists but laymen as well (everyone is a layman outside his special field).

Strength for free peoples is secured through the development of good living conditions as well as military defense. Through the use of science man can do much to shape his own future, since science has tremendous potentialities for the improvement of living conditions for all.

The children now in the elementary schools will live in a world of tomorrow. Our boys and girls will live in a time of great decisions. They will need to make certain that science will be used for good and not for evil. They will need to determine how democracies can be kept secure. There will be great problems concerning the use of new and old sources of energy. Theirs will be the problems of wise utilization of natural resources, the distribution of new synthetics, medicines, and drugs, provision for health and well-being, development of materials from new sources, establishment and maintenance of research agencies dedicated to public welfare, the establishment of a balance of nature that will provide ample food and recreation for all, and the creation of a stable economy based on the natural
resources and other problems to be solved, all within a democratic framework. Through all of this there will probably be a consideration of problems of international and world co-operation.

As we seek to determine what shall be the basis for our instruction in science in the education of children, we find we must look to something more permanent than a mere teaching about objects. We make this decision because in a few decades we ourselves have witnessed a vast array of new inventions displace objects which once seemed permanent. Kerosene lamps have given way to electric lights in many places. We have observed the transition from telegraph to television. Our familiar world is in constant transition. So, although we may utilize objects in teaching children, we cannot base our curriculum on objects. We must look deeper for our basic purposes.

Some might say that our major purpose is giving children content. But the content of science, important as it is in the education of children, does not constitute the fundamental purpose of including science in the elementary curriculum. This is true, first, because our basic purpose must be in terms of children and society, and consistent with the dedication of the public elementary schools to the principles of democracy. Second, as we shall see later in this introduction, we must recognize that the content of science is not absolute; what we think is reliable information today may need revision tomorrow.

What we can be certain of is that boys and girls will need to be resourceful and democratic in the decades ahead if their and our way of life is to survive. Therefore, we are concerned with the development of resourceful and democratic behavior. If we succeed, we shall not need to be unduly concerned for the future, for with the development of resourceful behavior in accordance with the high purposes of democracy, our boys and girls can use science to shape the future with complete confidence.

It is to be noted in this discussion that science is considered as a tool for humanity. There is no intent in the education of children to develop science for its own sake or to defend science as a vested interest. Only as science serves in the development of children and in the welfare of humanity can it be defended as essential in the education of elementary-school children.

It is most important that we recognize that boys and girls need to do much more than talk about science. If democracies are to
preserve their way of life, there must be in their populations the ability to operate intelligently and resourcefully with the materials and energy of the universe to the best interest of mankind.

Social studies, however valuable they may be, are not sufficient in themselves to help children meet and solve the problems of today and tomorrow. Teachers and school systems are likely to miss the great contributions of science to children and through the children to the larger goals of democracy when they place science in the curriculum as a segment of the social studies. Science grows out of the tremendous urges of the human organism and does not have to be motivated through social studies. Many students of children think that science by its very nature is more challenging to young children than social studies. This is not to be interpreted as an argument against the social studies. It is, however, an appeal that curriculum workers thoroughly think through the concept that science is a part of the development of children. If properly guided, children can grow in intelligent and resourceful behavior just as they can grow physically if properly nourished.

Some have suggested that the primary purpose of science in the education of children is to develop "little scientists." Such an idea is not consistent with the fundamental purpose of the elementary school and the origin and nature of science in society. There should be no hero worship of scientists except in so far as an individual scientist deserves it. Democracy will be weakened if a society is created with a distinct scientific class. Scientists serve, but so do soldiers, senators, artists, carpenters, barbers, farmers, doctors, and everyone else. Scientists now and then outside their own special fields are somewhat naive, and at times exhibit traits of gullibility and dogmatism, thus violating the fundamentals of science. Scientists are human beings like other people. We should not set up the lives of scientists as ideals for children to follow, regardless of how much we may appreciate the contributions of science.

The Nature of Modern Science

In science we do not view knowledge as absolute. Any statement of science can be challenged, revised, or refuted with suitable data. There is no room for dogmatic attitudes. There can be no dictator for science.

Through science, man strives always for a better understanding
of the world. Unfounded prejudices, opinions, gossip, rumor, astrology, myths, intuition, and superstition cannot be considered reliable sources.

Science is an active, dynamic field, constantly demanding willingness to make new observations, to repeat experiments, to consider new facts, and to challenge earlier conclusions. Science is far from a finished subject; in fact, it is likely that it is only in its beginnings. All the areas of science are undergoing changes as a result of continuous study. New ideas are being added and old ideas revised about stars, ventilation, living things, diseases, nutrition, and other areas of science.

Man learns through experiences by means of his senses. Science has produced new instruments, such as telescopes, microscopes, and others, that extend man’s range of observations and experience. Nevertheless, to explain many happenings in nature, even everyday occurrences, is exceedingly difficult in spite of many new technical tools. So scientists have been forced to develop provisional explanations, or hypotheses, to guide them in further study of some things. But scientists must abandon any hypothesis as soon as it is found to be unsatisfactory. There is much that scientists have not satisfactorily explained. Many times a scientist must say he does not know even about problems within his own field of specialization, and even though he may by all rights be the world’s leading authority on the problem involved.

Since man is continuously in the process of making new discoveries and revising his information, accuracy is not an exact status. This means that we do not teach a fact as though it must be true for all time. It indicates, also, that we cannot teach all the truth to a child about any single subject. We may, however, attempt to make certain in the classroom that the way in which a child learns is consistent with scientific attitudes.

We cannot hastily call an item correct or incorrect. Instead it is essential that in all our discussion, reading, experiments, and so on we determine what is the most reliable information at a given time. It may not be as serious a matter to be mistaken in the information we may have at any time, as to assume that there may be no need to secure new information on all important matters throughout our lives. It is also a serious matter to pass along information as if there were no question about its accuracy when we are not sure of its re-
liability. The nature of modern science is thus entirely consistent with the idea that learning takes place through the continuous growth and development of large concepts. It also indicates how necessary it is to view education as a process which takes place from the cradle to the grave.

Accuracy is a direction toward which man in his best efforts strives. It is also a goal toward which teachers and children can move in teaching and learning; it calls for growth for both teachers and children. A child’s ideas gained from science can be accurate in so far as they go, but as a child proceeds through the school, his knowledge about any one subject increases in amount and detail. In other words, we may not be able to teach children all the reliable information in science about a given subject, but what we do teach can be consistent with what is reliable. Authoritative books such as those in the Science Today and Tomorrow series can be most useful to both children and teachers in maintaining a high standard of accuracy and a sound development of attitudes.

**Science and Behavior**

This condensed description of the nature of science has been provided because it has many implications for the teacher and can provide him with a sense of security and adequacy in teaching children. The teacher has the right according to science to play an honest role in the classroom. He has a right to admit that he is learning; that he makes mistakes sometimes; that sometimes a child with a special interest and concentration may be learning faster than he is. In a real sense, the scientific method is a method of honesty, and neither teacher nor child should be penalized in any way for being honest. The learner should never be humiliated for the admission of ignorance. The implications of science for mental hygiene and human relations are profound.

It would be well for the teacher to consider the implications of science in the development of such behavior patterns as open-mindedness, critical-mindedness, and the avoidance of gullibility. There is no greater educational factor operating in the modern world than the attitudes that teachers and parents utilize while working and living with children.

In science it is important to state the source of one’s comment in explaining a phenomenon, such as evaporation of water, hibernation...
tion of animals, erosion of soils, and so on. For instance, one might say, "I read an explanation in . . .," or "It may be . . .," or "My father said . . .," or "On my way to school I saw . . .," or "I think it might have been," or "I used my imagination," or "I think I am right," or "I can do an experiment to show . . ." This is preferable to giving such information as if the statements were unquestioned facts. We have sometimes called this identifying the source of a comment. The teachers and children should develop the behavior pattern of identifying the source of a comment.

Both teachers and children have a right to use their imagination, to speculate, to repeat information as long as they distinguish between reliable and unreliable information. Such a behavior pattern is in the direction of assuming responsibility for one's own speech. It is quite different from the behavior of gossip, loose talk, and rumor spreading.

This type of development should not be allowed to harm the good human relationships of children. Frequently children use parents' opinions as reliable information. It would be well for the teacher to handle such comments in a manner that will in no way decrease the child's respect for his parents. In a sense, the attitude of the teacher may be that we are glad to have what the parent has said, and indicate that further development of the statement is given in authoritative books. Perhaps the comment might be "What do persons who spend their lives studying this kind of thing say?" Science instruction should be utilized to improve the human relationships of children, those of children with children, children with teachers, and children with parents.

It is obvious that the great behavior patterns growing out of science are not built in a finished manner in a day or a year or a decade. For instance, critical-mindedness and open-mindedness require time for development. Development of the patterns associated with resourceful, democratic behavior should be considered a continuous program throughout the elementary school.

There is considerable evidence that three great achievements of mankind—democracy, scientific method, and religious tolerance—developed contemporaneously and out of the same general struggles. An examination of these achievements will indicate that these three have much in common in basic meanings. In the opinion of many students, real science cannot exist outside a democracy.
The Content of Elementary Science

Almost everyone is impressed with the extensive nature of science; it has indeed grown tremendously in scope. No one can learn all of science in an entire lifetime. It is also obvious a teacher cannot teach it all. Only a very small portion of the total science will be taught to children, but that portion can be most important in the development of citizenship. The question of how much content of science is taught is not of nearly so great importance as is the question of what content of science is taught and how it is taught. With the world situation as it is today, it is most important that the content and procedures of science suggested to teachers and children in such a series as Science Today and Tomorrow be those designed for the preservation and advancement of democracy.

Because of the extensiveness of science, there has been a tendency to develop what might be called encyclopedic instruction. Under this method students have been required to learn wide areas of content. Comprehensive instruction has been developed about animate and inanimate objects and about topics in the environment with little sensitivity on the part of curriculum makers as to the value of the content to the teacher and children involved. In the encyclopedic type of instruction the purposes of science in elementary education became lost in small content and busy work.

A traditional trend in nature study has been to make science instruction dependent upon an incident approach. If a child brings in an object, such as a rock, a feather, or a flower, or if he can relate an interesting experience, then there is instruction in this field about the object or incident. If there is no object or no incident, there is no science instruction in such classrooms. Science becomes incidental and accidental in the classrooms of teachers holding to this point of view.

But science is no incident in the lives of children. In fact, it is and probably will continue to be one of the most dominating and decisive factors in the lives of children. Schools developing science on an incidental basis will not provide boys and girls with the education they need for the great decisions they must make for themselves, their country, and the world.

This is not to say that incidents have no place in teaching-learning situations. Natural incidents can be used as experiences for concept-
formation and for the development of understanding of phenomena. But science with its profound and challenging ideas has a great contribution to make to the formation of concepts and important ideas. If our democracy is to survive, we must make certain that the potentialities of science in our way of life will be developed. This instruction must not be incidental.

Since the best information scientists have at any one time will need to be revised in keeping with future discoveries, a content of science in the elementary school cannot be considered as set and fixed for even a few years. There are, however, certain patterns for the universe which seem to persist as profound descriptive principles for all time, in spite of revisions and modifications that follow new discoveries. These patterns are described in the following statements:

- The universe is very large.
- The earth is very old.
- Many changes are going on in the universe.
- Living things are interdependent and interrelated.
- Living things which are living today are the results of adaptations that have been made in the past.
- There is a great variety among living things.
- There is evidence of a tendency toward balance among the forces and living things.

For the sake of brevity, we can speak of these patterns as principles of space, time, change, interrelationships, variety, adaptations, and balance.

These patterns seem to be guide lines for instruction through the elementary school. A child can continue to grow along the lines of these great principles or patterns. The experiences an individual has throughout life can enrich his understanding of these principles. Man must recognize these patterns if he is to adapt his civilization to this universe. A knowledge of these basic patterns is necessary to the understanding of the world's problems and life's experiences in our modern democratic world.
The Large Patterns of the Universe as Guide Lines for Teaching-Learning

The Universe Is Very Large—Space

As man has studied the universe that surrounds the earth, he has become impressed by the immensity of space. The earth which he thought was very large and the center of everything is small compared with many other objects in the universe. This earth is one of several bodies which revolve about a star known as the sun. The sun is one of millions of stars which compose a vast galaxy of bodies which is called the Milky Way. Man has learned that there are many other galaxies within range of the modern telescope.

While a complete understanding of the immensity of space is undoubtedly beyond the mental capacities of any one individual, it can become a guiding factor in the interpretation of the experiences of children at all levels. The young child may begin his growth in the understanding of space as he begins to associate with himself the rooms in his home and the yard or immediate vicinity about his home. Later, he learns the location of the nursery school or kindergarten when he is taken there by adults or by school bus. Still later, he goes to school by himself and learns where the homes of his relatives and friends are in relation to his own home. As he travels to neighboring communities, his world becomes larger. He may be intrigued by the observation that the sun and moon seem to follow him as he moves about.

A child's early contact with this pattern may merely teach him that the earth is a very big place compared with his familiar neighborhood. He may become acquainted with the appearances of the day and night sky. Later, his learning will reveal that the earth is very small in comparison with the stars and space. About the same time he will also learn that the stars are suns which are very, very far away. In later years he increases his understanding of the vastness of space by learning about the extent of the solar systems, the Milky Way Galaxy, other galaxies, radio stars, cosmic rays, the light year, and so on.

Any adult who has read modern astronomy, has attended lectures in this field, visited an observatory or planetarium, or considered the possibilities of space travel knows that his conception of...
space continues to change after childhood. There are new, challenging thoughts for all levels—the junior high school, senior high school, and college levels—and, for that matter, many new discoveries still to be made by the astronomer. Some comprehension of this conception is essential to an appreciation of the significance of science in its revolutionary effect on modern thought. It is important that children should be started properly along this path rather than allowed to absorb inaccurate and unscientific ideas of the universe and astronomical bodies and to grow up with earth-centered conceptions in an age of modern science.

The Earth Is Very Old—Time

The conception of the great age of the earth and of the universe has come to mankind as a revolutionary idea. Not only has it profoundly influenced scientific understanding, but it has altered man's attitude toward his own place and function in the universe. It was natural for primitive man to think that the earth had been formed just a short time before the advent of his people. Much of this primitive belief came down into modern times and still controls thought in scattered areas. Children in their early years may learn that soil is made from rocks, and through activities, observations, and experiences discover that the process of soil formation took a long time. They may also learn something about the forces which operate upon the earth to produce changes; that it was a long time before the earth became a suitable place for plants and animals; and that many kinds of animals have lived on the earth and have become extinct. These ideas furnish him useful content in constructing his understanding of the great age of the earth.

Children may have a variety of interesting experiences with earth forces: for example, they may examine pavements broken by water freezing in winter; feel rocks softened by the action of weathering; observe erosion after a rainstorm; note how plants keep soil from eroding; examine different kinds of soil with a magnifying glass.

Time is something to be learned. Children must learn the concepts of yesterday, today, and tomorrow; the meaning of a second, a minute, an hour, a week, a month, a season, and a year; the sequence of seasons; the varied lengths of life of living things. A tree may be several hundred years old, and on the other hand, a moth may live only a few weeks.
Time is relative to both children and adults. A half hour may be a long time waiting for a plane or train, but very short if we are playing. A year between birthdays can seem a long time, but it is short in terms of the centuries the Indians have lived in the Western Hemisphere. The teacher and the parent can greatly enlarge children's concept of time.

In later work children may learn something about what has happened to the earth, the causes of natural features in various localities, the long ages of prehistoric life, the struggle of life for existence, the forces operating on the earth, and some of the changes that have taken place on the surface of the earth. This comprehension of the great age of the earth is essential to an appreciation of the antiquity of man and of man's attempts to build social institutions for his own welfare. The goal is not the memorizing of a chronological sequence of events, but rather an approach to the modern conception of time. These ideas reveal to man the importance of building his social and political structure with the thought that he may live on this planet for some time to come, provided he uses his intelligence to assure survival. These concepts are fundamental to building an understanding of what is intelligent utilization of natural and human resources. This understanding is necessary for man's planning for his own future.

This background to an appreciation of the modern concepts of time and change should tend to inhibit chauvinism; it should teach each pupil that all life existing on the earth today is the result of a long succession of living things—a development involving a vast number of individuals and extending back to the beginning of life on the earth.

The mountains, rivers, valleys, plains, seas, and other physical features that we think of in connection with a given nation and that often come to be revered by the people of that nation have not always been there as they are now. The surface of the earth has changed its appearance many times in the past and is constantly changing today.

As the result of a long series of experiments in the art of living, man has become a dominant force in nature, and we have a right to feel a pride in the achievement of all mankind. It must be emphasized in our instruction that this achievement is restricted to no one race or nationality.
Changes Occur Continuously in the Universe—Change

The conception of change permeates all fields of knowledge, and man must consider these changes if he is to operate intelligently with natural forces. Modern geology reveals that our physical environment does not remain constant, that the history of the earth is a story of change—change in climate, in topography, and in the succession of living things.

The conception of change is manifest not only in geological history but in living things, as, for example, the changes produced by birth, growth, age, and death. There are also changes produced by the biological principles of struggle for existence; and these cannot be ignored by man in his striving to adapt the world to his needs. Then there are the changes produced by energy and movement. Astronomical bodies are seen to have changed position and character through cycles of time. The scientist learns to look for change in his explanation of phenomena; the layman must expect change as a condition of everyday life; the student of social studies and the citizen must anticipate change in the political, social, and economic structure. Information concerning changes produced by physical and chemical phenomena developed in terms of children’s own experiences can be introduced during early school years and continued through later levels.

Children see water disappear from a dish by evaporation. They pick up rocks which have weathered so much that the rock disintegrates into small pieces in their hands. They see the changes in the sky, in the weather, and in seasons.

Illustrations of change include such phenomena as rusting of iron, melting of ice, boiling of water, weathering of rocks, variations of weather and of seasons, and innovations produced by man’s discoveries and inventions.

School windows should be utilized more fully for the study of the succession of changes due to weather, to the seasons, to the time of day, and man’s activities in relation to these changes. Brief excursions around the school ground will provide varied experiences depending on the region. The children may see frozen, muddy, and dry soil; the growth of plants; and a variety of plant structure, such as roots, stem, flowers, and seeds. An outdoor thermometer may reveal temperature changes. Art work can be utilized in the study of changes.
A community of living things never remains in a strictly static condition. Children can observe the changes in a weed patch near the school, in a thicket, or in a garden. There is a continual shifting caused by weather, seasonal change, and just ordinary life and growth within the cycle of new life, maturing, and death. All around children are evidences of change.

There is no exception to the occurrences of change even when man is involved. Natural forces are always present and working in an environment. Perhaps man can never control the natural forces. Rather he must learn to work intelligently with these natural forces to bring about changes which are advantageous to his best interest.

In addition, there are the great changes brought about by man’s inventions and man’s discoveries. Of course, children are not so aware of the significance of these changes as adults. However, the school must prepare children to meet change, for the next generation may need to be prepared for even greater changes than those met by the present generation of adults.

Man has lived through revolutionary changes in his social living because of the introduction of new forms of energy and of ways to utilize that energy. The discovery of fire, the introduction of animals to carry man’s burdens, the steam engine, the electric generator, and the internal-combustion engine greatly changed man’s social and economic conditions. The utilization of atomic energy is bringing and will continue to bring tremendous changes. Children should gain a feeling of confidence in the fact that they are not the first of the human race to witness revolutionary changes in energy. Furthermore, it might be well for us to know how man’s discoveries of new forms of energy have brought about great potential supplies of energy for everyone. The advances in the field of agriculture and soil culture may have significant impacts on the future course of world events.

Changes brought about in a community also may be significant. What did the country look like before the earliest settlers came in? What changes have been brought about by man?

There are only about one hundred elements which enter into combinations and form the multitude of substances about us. Chemists find that some of these elements combine in so many different ways that to date they have been able to make but a small proportion of all the possible combinations. Chemists are learning to build
out of cheap sources substances which in their natural states have been very rare. They have also learned how to make new substances, such as new drugs, insecticides, medicines, plastics, synthetics, and so on. In this way, science contributes greatly to an improved health, finer recreation, and a higher standard of living.

Life Is Adapted to the Environment—Adaptation

Adaptation is a pattern which permeates the entire realm of living things, for wherever there is life there is adaptation. This is a conception of great significance in the modern world. Indeed, man’s problem today is to adapt his social, economic, and political structure to the conditions of the environment and his own needs. In the early grades children can learn something about the homes of some animals and their adaptation to life in various places. They can be introduced to the idea that animals’ structures have become modified to fit their environment. Later they can learn how plants and animals, including man, are adapted to seasonal changes. The study of prehistoric life is a story of adaptation, and can be supplemented by a study of how animals are protected against their enemies, how animals take care of their young, and how plants continue to live on the earth. Man adapts himself through community life. The advantages and disadvantages of this form of adaptation, along with a study of solitary animals, may be considered on intermediate levels. As the child matures, the scope of his concept of adaptation is further broadened through a study of prehistoric modifications, of the weapons which animals use, and of the struggle for existence.

The conception of this pattern, like the conceptions previously outlined, may influence an individual at all levels of his development. It may modify the child’s interpretation of simple observations of the effect of seasonal change on plants and animals. It may give substance to the youth’s understanding of the structural variations of living things, and to his consideration of problems of public welfare. It may determine the adult’s participation in politics and in public forums. The scientist finds much that remains to be discovered concerning adaptation. The significance of this conception in the social studies can scarcely be overemphasized.

Some of the more general facts involved in understanding the concept of adaptation are the relationships of living things to tem-

xxii
temperature, water, food, light, gravity, and certain gases found in the atmosphere; the effect of some of the limitations of these conditions upon life; the narrow range in these conditions on the earth as compared with those found in the universe as a whole; the adaptations imposed upon plants and animals that live under these conditions; the prolificness of life; and the interchange of energy and substance between plants and animals and between the physical environment and living things. Through experimentation, discussion, and reading, children learn that living organisms need light, oxygen, nitrogen, carbon dioxide, heat, water, and other conditions in order to exist and to produce young. When some of these things are scarce or too abundant, life may suffer.

The implication for international understanding is that man frequently is limited by the physical conditions of the environment to which he adjusts himself. Some people must live in inhospitable places, such as swamps, deserts, and arctic regions. These people must utilize the materials that are available for shelter, food, and clothing. It is not surprising, therefore, to find among the peoples of the earth a wide variety of customs. Many of these customs which seem foolish to others may be the results of the experiences of many generations in a given environment and may be necessary to the survival of that people.

International co-operation has become a necessary adjustment on the part of mankind if our culture is to survive.

In science studies in the elementary school, children have an opportunity to realize that man is only one of a multitude of living things, and that, like these other things, he has survived because he has made adjustments and adaptations to the environment.

The Variations of Living and Nonliving Things—Variety

On the earth there are wide varieties of climate exhibiting differences in mean temperature, in the range of temperature, in the length of the growing season, in the amount of rainfall and its seasonal distribution, as well as differences in exposure, in slope, in drainage, in elevation, and in soil. These factors create many kinds of environments and require adaptations to these environments. All around us we see in nature a variety of forms, differences in structure, sizes, habits, and life histories of plants and animals. They range from the ultramicroscopic organ-
isms to the gigantic forms of the redwoods and whales. The life span of some living things is very short, while that of others covers several hundred years.

When we see how many different kinds of living things there are, it is not surprising to find that there are also so many different kinds of people. Man has wandered about the world for thousands of years, living in many habitats widely separated from each other. We should expect, therefore, to find different races, languages, and customs, but a concept that science may teach is their interdependence despite their differences.

No two living things are exactly alike, although they may be of the same species. We cannot, therefore, judge all people of any nation on the basis of one or two we may have known.

Variation is manifested in the physical world as well as in the biological. There are many systems of organization in the physical world—the atom, the element, the molecule, the compound, the substance, the planet, the solar system, the galaxy. There are many kinds of minerals, soils, and rocks. There are only about one hundred elements, but there are thousands of different compounds. There is variety in the manifestations of energy. Man, too, tends to develop variety of forms in his inventions, discoveries, engineering, and arts.

Children should become acquainted with this theme by being introduced to the range and scope of certain obvious characteristics in the physical and biological aspects of nature. Instruction should be chiefly concerned with the theme rather than with mere identification of animate and inanimate objects.

Each child has two parents. Each parent brings to the child a diverse inherited background. When we consider that this means for each child four grandparents, eight great-grandparents, and so on, the tremendous potentialities working for variation in the human race become apparent. When to this observation we add the fact that each child has a different environment, the tremendous variations found in children in any classroom are understandable. Every individual is a result of success through a long span of years in that each of his ancestors is the result of two parents reaching maturity in spite of sometimes hazardous conditions.

The concept of individuality, that each individual is unique and different from all other individuals, is a part of the larger pattern of
variety. Williams,¹ a biochemist, has recommended that we should start teaching children in the kindergarten that they possess individuality. His recommendations merit serious consideration by elementary-school workers. They point to one way in which science can contribute to mental hygiene. Each individual has a right to be different. He should not be amazed to learn he is superior to some of his classmates in some ways and inferior to others in other abilities. This pattern can be used to develop a feeling for the dignity of the individual, a feeling so important in a democracy.

Following are some of the aspects of variations that are illustrative of those found in the environment of children:

a. Changes that take place in the out-of-doors.
b. The many different kinds of animals.
c. The variety of animal noses, eyes, tails, mouths, legs, coverings.
d. The variety in prehistoric animals.
e. The different ways in which animals move about.
f. The differences in animal homes, such as those on the desert, in the arctic, in swamps, underground, in fresh water, on the seashore, in the ocean depths, in the forest, in the meadow, in trees.
g. The variety in locomotion, food-getting, breathing, and protection of animals.
h. Different ways in which animals grow up.
i. The different kinds of plants, such as those that develop from spores, those that develop from seeds, those that are annuals, those that are biennials, those that are perennials.
j. The animals that are social, and those that are solitary.
k. The animals that are cold-blooded, and those that are warm-blooded.

Interdependence of Living Things—Interrelationship

A theme which is practically universal in character is interrelationship. We see the significance of interrelationships as an integrating theme in many of the forces operating on the earth, for example, in the description of astronomical bodies, weather, and other physical phenomena; in the interdependence and interrelation of living things to each other and,

¹Roger J. Williams, Free and Unequal: The Biological Basis of Individual Liberty (Austin, University of Texas Press, 1953), p. 177.
in turn, to their physical environment; in the causes of ill health; and in the relation of pests and parasites to economic loss in the agricultural world.

Space does not permit a full discussion of how the idea of interrelationships in physical and biological phenomena may be developed. In the early years children gain experiences which lead to an understanding that some plants and animals in the garden are harmful. In later work they learn the value of certain other plants and animals and what people are doing to protect them. Attention should be focused in later elementary school work on the problem of conservation and on preparing pupils for a more comprehensive study of the biological principles involved in the struggle for existence, in the balance of nature, and in the interdependence of life. Some of the relationships of scientific discoveries and inventions to man’s progress and welfare should be considered. Man does not live to himself alone. He lives in a world of interdependencies and interrelationships. He is dependent upon earthworms and plants for the fertility of the soil. He is dependent upon the birds to keep the insects in check. He needs snakes, owls, hawks, and other animals to keep rats and mice in check. Spiders serve to control the number of insects. An animal which seems rather insignificant to us may play an important role in the development of conditions suitable to man.

The interdependence and interrelationships of living things to other living things and of living things to the physical environment is basic to the understanding of social issues. Physical and biological forces do not recognize national borders. A wind blowing in one country may be due to world-wide atmospheric conditions and the pressure of air in regions within the borders of other nations. Animals do not necessarily stop at national borders unless those borders are natural barriers, and even then certain animals are known to cross many such barriers.

In science the earth must be considered commonly as an entity; a disturbance in the physical or biological world in one part of the earth may have significance to many other parts. In a community a fire in one section is the concern of the entire community. A disease or a pest in one section of the world may become the concern of all peoples. Nations, therefore, should learn to work together in an intelligent way for the welfare of all peoples of the earth.
The natural resources of a country, such as soil, oil, coal, gas, forests, and pastures, are the result of natural forces operating for millions of years. People have not created them, but they frequently waste them through carelessness and mismanagement. Man can waste in a generation or two what has been the result of titanic natural forces operating over long periods of time.

Man, if he is to remain civilized, must disturb the original balance of nature, for only savagery can exist where man does not attempt to make changes. But it is man’s task to use the natural processes and resources in such a way that he secures what he needs for a high standard of living without hazarding the welfare of future generations. Man need not return to savagery nor disregard natural resources; he now has science to use in planning for the years ahead. It is incumbent upon the public schools to develop a generation with ability to meet its problems, both personal and social, with intelligence, co-operation, and resourcefulness. This calls for an appreciation of the interdependence of living things, and of the interrelations of living things and the physical forces and materials.

Balance and Imbalance—The Interplay of Forces

As one observes the many events or phenomena in his environment, one is impressed by the dynamic flow of events and the energy involved in them. If one could be an observer over centuries, one would be aware of the titanic forces in operation; but seen one day at a time over the short span of a human lifetime these forces often pass unrecognized. Some, such as evaporation, seem small, yet scattered over the face of the earth, evaporation is tremendous and results finally in rain, snow, dew, frost, weathering, erosion, floods, blizzards, and other events.

There seem to be tendencies toward equilibrium and balance in the operation of forces. In a normal atom it is thought the positive electrical charges balance the negative electrical charges. It is thought that a static electrical charge is the result of an imbalance in these electrical charges. The shock we feel or the lightning flash we see is the resulting establishment of equilibrium of these charges. Even the thunder can be thought of as a clap caused by air rushing in where the air was expanded by the heat of lightning.

We have already spoken about the balance of nature. Man has
been ruthless at times with this balance and has experienced economic loss from the resulting dust bowls, soil erosion, waste of resources, epidemics, plagues, and pests.

There are forces operating also in the structure of the earth. It is thought by some geologists that in maintaining balance these forces have caused the formation of mountains, continents, and oceans. We witness earthquakes and volcanic eruptions as a part of the balancing of the earth’s structures.

It should be kept in mind that the sun is a great source of energy and that it shines on the earth all the time. It shines on the other side of the earth while we are having night. It shines, when it is cloudy, although there are clouds between us and the sun. The sun then is like a great solar engine which furnishes energy for green plants to grow and make food, for water to evaporate, and for the movements of air currents or wind and of ocean waves. The movements caused by the sun’s energy are checked and modified by the earth’s gravity, its rotation, and to some extent by friction. There is a tremendous interplay and interaction of the forces in the universe.

Wherever we look we witness the operation of forces and the many evidences of balance. In our own efforts to maintain balance and equilibrium, we also experience the operation of natural forces in and on our own bodies. Many psychologists explain learning at all levels as a process of attempting to gain intellectual balance in the face of a new situation, a problem, or a challenge.

**Conservation as a Pattern for Behavior—Developing Responsibility for Our Environment**

As children develop a better understanding of the basic patterns of the universe, they also may acquire more intelligent behavior with reference to natural resources, including human resources.

Some courses of study help to establish undesirable kinds of behavior, as when children are encouraged to develop collections which in turn can rob the environment. Sometimes they are instructed to bring to school collections of leaves, twigs, flowers, rocks, minerals, and bird nests.

We need to develop in children a feeling of responsibility for the environment. Conservation, or intelligent use of natural resources, consists of a kind of behavior as well as a body of content. Before moving objects, animate or inanimate, out of the environment and
into the classroom, there are many major considerations which the children may discuss. To whom does the object belong? Do I have the right to take it to school? Do I disturb the environment if I remove this object from it? Am I destroying the natural beauty of the environment by removing this? Is the study I am going to make of the object one which merits its removal from the environment? Should I plan to return the object to the environment as soon as the study is completed? Can this object be studied properly if it is removed from the environment? Can I care for it properly in the classroom? If it is alive, does it have a chance to live in the classroom? Am I prepared to give it the care it needs to survive? One should keep in mind that living things are usually found in an environment to which they are more or less well adapted.

Developing Behavior Consistent with Health, Economy, and Safety

Many schools are now integrating health entirely with science and the social studies. Science provides the necessary background for the teaching of health information and the development of good health habits; therefore, a program of science in terms of problems and meanings should offer opportunity for the integration of science and health.

The relation between science and economy has too long been neglected. Because of his own ignorance of the operation of biological and physical principles, man is at present beset by a host of problems concerning international economy. Recent projects in a number of countries are helping to solve these economic problems in local environments by re-establishing in the natural forces a balance in favor of man’s interests and welfare.

The relation of science to the economic problems of man is well exemplified in his struggle with pests. Man has carelessly introduced exotic plants and animals into almost all regions of the world. Many of these transplanted plants and animals, unchecked by their natural enemies and competitors, have multiplied so rapidly that they have brought havoc to the economic life of the nation. Control comes not alone from the work of fact-finding public or private scientific agencies, but also from the intelligent co-operation of the entire population. Much can be done to secure this intelligent co-operation through an integrated program of education in the public schools.
Foreword

Mankind cannot afford to have another generation ignorant of the elementary biological principles of nature.

Another similar problem is to find ways to prevent loss of soil through erosion. In almost any section of the world we can find examples of the terrific loss of natural resources resulting from the lack of soil conservation. Creating an awareness of this problem in order to bring about intelligent individual and community action concerning it is no small part of science in the elementary school program.

Many species of our indigenous plants and animals have become extinct because of man's ruthlessness and ignorance. Still others are in danger of being destroyed. Man cannot continue to be ignorant of the web of life in which he is by nature involved. The elementary school, as the tool of the common people, should work toward developing a generation concerned with the wise utilization of natural beauty and resources.

We cannot fully anticipate the environment of the future. New inventions may eliminate present hazards and create new ones, making it impossible for us to develop a code of conduct in safety instruction which will be functional for an entire life span. It may be well for us, then, in safety instruction, to place more emphasis upon scientific principles which are basic to safe conduct. Children at all levels should be encouraged to enter into planning with the teacher for safety on all excursions, including the short excursion, even though it may be only to the edge of the school ground.

Consideration should be given to what one should do in case of fire or other disaster so that the behavior is automatic. Classroom teachers and parents can have a powerful influence over the destiny of whole regions and nations by developing in children a willingness and ability to base their conduct and behavior upon sound information. Safety education, as one aspect of the goals of conservation, can well be integrated into the development of responsibility for one's own behavior and for the environment.

A Variety of Procedures

The teacher should look to a variety of procedures in teaching science. It might be well to avoid dropping into routine methods. Discussion, instructional excursions, observations, experiments, reading, use of visual aids, group work, and planning all play a part
in the teaching-learning situations in science education. The teacher should consider her own interests, tempo, and rhythm along with those of the children. It is important that the teacher be happy with the procedures. It is well for the teacher to be present as a participant in all the procedures. He should be a learner, for good teaching in science involves learning.

If there is one term that can be used to specify the kind of instruction appropriate to all phases of science teaching in the elementary school, it is "developmental." In this case it is developmental from the point of view of children and teacher, both as learners. It means the instruction develops, using the experiences and knowledge children may have or that can be provided for them. It is developmental in that children may participate in the development of the planning for the use of experiences, experiments, discussion, and authentic materials to provide solutions to problems. The new learning is made acceptable to the children by the nature of its development in instruction. Children are given time to internalize new learning, integrating it with their experiences and ideas. It is important in this development to provide opportunity for an idea to be tossed about in the thinking of a group, to be tested through simple experimentation, if appropriate, or through observation, to be talked about at home, and to be checked against authoritative books.

In any consideration of teaching methods, the primary concern in elementary education is what kinds of boys and girls are being developed. All of us need to be cautious that our procedures do not become devices and ends in themselves. Therefore, evaluation should be an integral part of instruction rather than something done at the end of a period of instruction.

At all times in teaching it is well for the teacher to know at what point the children are in a given development. In this Manual suggestions are given the teacher as to ways in which he can secure this information. It is well also to find out how the children think, that is, the type of thought structure they have. Such questions as "What do you think?" "Do you think so? Why?" "Why do you say that?" "How would you get the information?" "Do you think that is information we should accept?" will give the teacher evidence as to how children think and where they are in their development.

Regardless of how the instruction at any point is initiated, vital teaching recognizes the concepts children may have on a subject or
problem. So it is well for the teacher to provide opportunity for them to express their ideas, however incomplete or inaccurate, in order that misconceptions may be brought into the open. It is most important that they be allowed to express themselves without the fear of censure or ridicule, although at times there can be the enjoyment of childish humor and fun without personal damage.

Very frequently children's concepts have originality and imagination. Their concepts also provide opportunities for evaluation of preceding work and reveal the kind of instruction needed for the clarification of ideas. The authors of this series have profound respect for the natural ideas developed by children. Every child needs an adult who will sympathetically and intelligently listen to him. If such a person could be provided for more children, we would need fewer corrective institutions.

**Studying Children while Teaching Science**

Teachers will find their teaching enriched if they will study children as they teach. Science with its challenging content and its rich contribution to the attitudes and behavior of both adults and children offers unique opportunities for the study of children.

The greatest concern in studying children is not how much information children have secured, important as that may be. Rather, the main emphasis should be on what kind of boys and girls we have. What kind of thinking do they do? What are their outlooks upon the world? Are these outlooks constructive and democratic? Do the children think for themselves? Are they developing good ways of thinking? Are they learning to be resourceful?

At all times teachers should be alert to the kinds of behavior changes that children are making. The teacher may ask: "Are the children developing dogmatic attitudes, or are they willing to consider new ideas? Are they tending to accept every idea they hear without hesitation? Do they look for further evidence before drawing conclusions? Are they learning to use authoritative books? Do they report on out-of-school experiences in a wholesome way? Do they propose explanations? Are they learning to plan? Will they work with others?"

In this kind of study it must be recognized that behavior may reflect the home and the general background of the children. A dogmatic parent may cause a child to be gullible.
It should be kept in mind that it is the behavior in which a child has had some degree of freedom of choice which is the most useful for evaluation. The closely worded or directed question of the quiz program and the rigid recitation have little significance in evaluating behavior. In a sense it is the spontaneous behavior of children—the proposal of something to do, the inquiry, the choice of language in indicating open-mindedness, the critical-mindedness, poise, resourcefulness, the challenge of a statement, the willingness to consider new ideas and to take on new duties, the use of old learning in new situations and learning—which is useful in evaluation. All of this seems to favor a type of discussion in science instruction which allows for freedom of expression and thinking.

It is recognized in this that teachers need to study children as individuals and as groups and from a total, rounded-out point of view of education. The contention here is that science with its profound meanings offers unique potentialities in studying children from this view. Children should not be evaluated as if the development in behavior relating to science were isolated from all other aspects of their lives. Science, as the interpretation of the environment, should be thought of as an intrinsic part of the life of children in the modern world, a part that may be an important factor in building desirable behavior.

A Dynamic Education for Children

The preservation and advancement of democracy depends to no small extent on the behavior patterns developed in children. We do not know what the future will be. In a sense we must educate children for uncertainty. This does not imply that we need be pessimistic about the problems these children will face in the future. Rather, we can be confident that if we assist them to develop democratic and resourceful behavior, they will make their own future.

It is the contention here that the outlook of children toward their environment and universe is the very core of the development of a resourceful adjustment to the future. While incidents play an important part in making learnings meaningful, science should not be incidental in the lives of children. Instruction limited to talking about science and a description of objects and events is not in keeping with the dynamic urges of children and will not serve to help them cope with the problems of today and tomorrow.
There is a need for a positive and dynamic program for children, one which develops a feeling on the part of children of being needed by our democracy, in times of peace as well as war. Children are needed not alone for their own nation but to assume responsibility for work toward a better world.

There may be opportunities for children and teacher to work to improve conditions in the classroom, in the school, on the school grounds, and in the community. In this way, they can see how science is used.

Science will continue to play an important role in the lives of our children. It is a powerful tool which can be used for good or evil; and children, the adults of the future, will have to decide which way it shall be used.

It is most important to the success of our way of life that children have a favorable attitude toward science. Science should not seem foreign or exotic to them. Science viewed as the result of the age-old drive of man to adjust himself to his environment and to maintain his own equilibrium in the welter of biological and physical forces carries with it a larger point of view than a purely vocational one. Science is the result of man’s experience and logical thinking through the centuries. Science, like democracy or the mother tongue, belongs to all who wish to make use of it. Children should be made to feel that science belongs to everyone.

Science instruction should be a pleasant experience for both teachers and children. Teachers should feel relaxed with children while teaching it. Interest in science should be maintained at all levels. The instruction should be freed from assignments involving busy work and meaningless drudgery. Exhaustive and overly specialized units should be avoided.

Boys and girls must learn to handle and to experiment intelligently with the forces and materials of the universe. Unintelligent tampering and carelessness bring disease, ugliness, waste of natural resources, unemployment, poverty, war, and widespread unhappiness. Children must develop a poised, well-balanced, yet realistic outlook upon the modern world. They must learn that by working resourcefully and intelligently they can create their own world.
This Teachers' Manual has been prepared to help you as you work with your children in the solution of their everyday problems. It is designed to help you as you and your children use the science textbook, Discovering with Science.

The authors of Discovering with Science have had long experience in teaching children. They have taught in both public and private schools. They have taught at various grade levels. Out of their broad background of teaching experience they have chosen to include in their book Discovering with Science content dealing with many aspects of children’s environment. They have sought to present the content in such a way as to stimulate each child to seek knowledge and insight for himself.

Each chapter in Discovering with Science has a parallel chapter in this Teachers' Manual. Each chapter in the Manual has been carefully prepared to help you help children clarify their ideas about the world in which they live.

The information in the Teachers' Manual goes beyond that given in the children's book. It contains additional information which will be helpful to you. In this sense the Manual becomes more than a guide for teachers. It becomes, in fact, another source of additional information for you. It extends your own knowledge of science. It strengthens your grasp of ideas about science.

The Manual does more than supply additional information. It suggests additional activities and experiences in which your children may engage. It develops ways that subject matter may be presented and enriched. It provides ways to help you improve your techniques of teaching. It also suggests ways to evaluate your own teaching of science. You will find the Manual of great help as you use Discovering with Science with your children.

The Middle-Age Child

The children who will be using Discovering with Science will be, roughly speaking, beginning the middle age of childhood. They have already lived some eight, nine, or ten years. During these years they have faced and solved a good many problems. They have acquired at firsthand a body of knowledge about the air, sea, sky, land, rocks, electricity, weather, and other aspects of their environment.
They learned these many things as they touched, smelled, tasted, looked at, and listened to what was going on around them.

Now, as they arrive at the middle age of childhood most children are eager to extend their knowledge of their world. They will ask you searching questions. They will want to experiment to see what happens. They will want to read to find out more than they now know. You will be eager to help them learn.

As you work with your children you will be conscious that some have matured well, and that others have met obstacles which have made their adjustment to living less successful. You will be impressed with the wide array of individual differences. Some will be excellent readers. Others will find the going difficult. Some will be very independent, preferring to move under their own steam. Others will cling to you for an unusual amount of help and support. Most will be eager to know the what, the when, the how of things. Some will push hard for details. Success in acquiring practical, objective data will be important to many of them.

Most of your children will be vigorous and healthy. By and large, these years are healthy years. Your class will be a group of individuals, each of whom needs your respect and your affection. Each wants to achieve with his own age group and to win the esteem of his classmates. They will welcome your advice when they see that it helps them to achieve this esteem. They want to be in the swim of things. They want to be “in” not “out” of activities that are going on in the classroom.

**Science in the Program of Childhood Education**

Knowing as you do how vast is your task as a teacher and how important is your role, you will doubtless seek help. All areas of the elementary curriculum can assist you, and among them you will find that science makes specific contributions.

Science can be so taught that it can make the everyday environment of children ever so much more meaningful. You will want to think of science in this way. As your children inquire about their world you will want to help them find their answers.

In providing this assistance you will work with them. You will help them learn *how* to search for truth. You can do this best when you enlist their active co-operation in planning where to look, what to do, how to work. You will refrain from giving quick answers to
their questions. Rather will you say when a question is asked, "Where do you think we can find the answer to John’s question?" or you will say, “How do you think we might go about solving that problem?” or, “How can we prove whether this is true or false?”

In other words, you will avoid short-cutting children’s opportunity to learn for themselves by refraining from telling them the answers to many of their questions. You will help children develop successful ways of working as they solve problems. You will, at times, lead them to source materials, of which books are one kind. Among books children can search for data they need to help solve their problems.

*Discovering with Science* has been carefully prepared. It has been checked and rechecked for scientific accuracy. It has been written in an easy running style which children find interesting. The content has been selected on the basis of a broad knowledge of children’s concerns and interests at this age level.

The book is not meant to be used as you might use a reader. It is not intended to be used as a story book. Rather is it written to assist you to stimulate your children to think, to wonder, to try out ideas, to observe carefully, to come to tentative conclusions. It emphasizes the value of testing conclusions by further research and by referring to authorities in the field of science.

Science taught in this manner helps children better to understand their world; but it does more than that. It establishes a fruitful way of working. It builds habits of thinking as the scientist thinks, and of working as the scientist works. It encourages children to gather and weigh evidence. It promotes holding an open mind until a body of data has been carefully studied and its implications considered. It discourages "jumping the gun" and coming to hasty conclusions upon too little evidence. It develops a love for discovery and a joy of achievement which the scientist feels as he tries and fails, tries and fails again and again, until he finally succeeds.

A child and a scientist have many things in common. Each has a keen imagination. Each has an unusual amount of curiosity. Each has a desire to try out, to invent, to experiment. Each is willing to try another method when the previous one has failed. Each feels the thrill of discovery and the deep satisfaction of achievement.

As you work with your children, helping them solve their problems, you will lead them to an awareness that they are using the
methods of scientists. You will encourage them to do the same kind of careful observing, experimenting, and testing that the true scientist does.

In so doing you will be helping children develop a way of working which has been called the scientific method. The value of helping children grow in this respect can scarcely be overestimated. We live in a democracy where straight thinking, or the lack of it, matters greatly. It is our privilege and our challenge as teachers so to teach the generations to come that they will accurately evaluate the necessity for and the ability of the common man to solve his problems in ever better and better ways. Providing early opportunities for the application of scientific methods to the solution of problems promises to be an important step toward this goal.

Setting Up Your Program of Science in Childhood Education

All of us know that there is much more knowledge in the world than any one of us can ever learn. This makes choice of what we teach important. In setting up a program of science the exercise of choice is an important consideration. What will guide you in making your choices?

One way to test the value of the study areas you select will be to note their effect on the interest and pleasure children show in their surroundings. Usually a child’s growth in awareness of his environment parallels his opportunities to participate in activities concerning it.

What is in this environment? Each year your children have experiences with the earth, its rocks, its soil, its air, its water. Each year children have experiences with the bodies in the sky. Each year they deal with some aspects of plant and animal life. They note the effects of air, water, light, and heat upon all living and nonliving things around them. They become conscious of ways man has put to use such things as gravity, light, magnetism, electricity, and sound. They also become concerned about ways to improve the use of their environment.

This, then, is the body of science content from which to select areas of study for you and your children. The basis for your selection is the fact that the science program should grow out of children’s need for experiencing their whole environment.
Discovering with Science presents thirteen areas of study which the authors hope will serve as a framework within which you and the children may find these experiences. The units need not be studied in the sequence of their appearance in the book. In fact, the logical order would be one based on the children’s interests as they are influenced by current school experiences, neighborhood events, and other timely and local conditions.

You would, of course, avoid limiting children to the study of only one or two areas during the year when you have ample evidence of a fascinating broad field of science at their doorstep. Children deal with all of these science areas wherever they live. Choosing the order of topics for study is, then, the proper concern of you and your class.

Each year as children grow older they have additional experiences with all areas of science and thus they keep enlarging their concepts about their world. They build their concepts out of the experiences they have. Each child must build his own concepts. You cannot teach concepts to him. He builds his own ideas for himself. That is what is meant by saying experiences have a unique meaning to each child. The science program of any school, then, is concerned with helping each child build true and accurate concepts about the world in which he lives.

Ways of Working with Children

When you and the class have chosen the area of science you wish to study, you will plan the activities that will present the maximum opportunities for learning. Along with the factual information the children will acquire, you will want each child to grow in his awareness, initiative, appreciation, power to do clear thinking, co-operation, and responsibility. One way to achieve this growth is to set up rich problem-solving activities.

You will want to help children formulate and express the questions they have concerning the area they are to study. To do this you might begin by listing the ideas they already have on the subject. In this manner misconceptions needing correction will be revealed.

Well-guided discussions about such matters as "Where can we find answers to our questions?" "How shall we plan our work?" "What materials do we need?" "Are there places to visit which will
help us find out what we want to know?” “What books can we use?”
“Are there experiments we can perform?” are certain to be fruitful.

A variety of opportunities will present themselves for stimulating
group thinking and learning. These include experimentation, read-
ing, discussion, taking excursions, using audio-visual aids, and invit-
ing speakers to come to talk to your class. You will employ some of
these procedures in all your work in science. If there are places to
visit, you will take your class there. If you know someone in the
community who has a suitable set of slides or a movie dealing with
the current interest, you will invite that person to share his slides or
film with all the class. Likewise you will encourage your children to
use experiments when such experiments will help them learn the
truth. They will read books and discuss the contents at frequent
intervals.

You may wonder why a teacher should bother with all of these
activities. Why not just read about stars or the earth or electricity.
The answer is simple. Each child learns in many ways, through many
approaches, by traveling many paths. Therefore, you will employ
various techniques. Some will learn better by one kind of experience.
Others will gain more from quite a different approach. By the use of
many techniques, you will widen the opportunity for all of your
children to learn.

There is perhaps need here for a word of caution. The activity
itself is not the all-important thing. Activity for activity’s sake can-
not be justified. What you are after are wider opportunities for
children to build understandings, to broaden concepts, to solve
problems. Activities which aid in these respects are priceless. Let
us be sure that the activities we use are meaningful to our children.

Selecting Your Approaches to Science

There are many ways to teach. At various times teachers use
different techniques. Some promising techniques used by many
teachers will be discussed in this section.

Listing Children’s Questions • Children, as well as adults, find it
easier to focus on exactly what it is they want to find out if one or
two questions are written down. Stating the questions also helps you
to know how to proceed in the organization of subject matter. It
affords guidance as you gather books, films, filmstrips, and other
teaching aids. It helps to keep the class "on the beam," should interest and attention begin to wane. It sometimes serves as a terminating and evaluating yardstick.

**Discussion** - Discussion can play a vital part in the study of science, for it serves to clarify the problem, the experiment to be carried out, the questions to be answered. It serves to bring each child's experience with the subject to be studied into clearer relief and therefore tends to make the phenomenon meaningful to him. Such a procedure aids first in planning the method of study and later in evaluating the method used.

However, discussion has shortcomings in that it cannot of itself produce reliable explanations. In the end we must secure assistance from other methods to get at truth. Teachers should strive through discussion to encourage growth in thinking.

**Observation** - Through the use of their senses children can experience many things. In fact, the young child learns primarily through sensory experiences. Feeling the texture of soil that is ready for planting or the heat that comes from a glowing reflector gives children firsthand learning experiences which are not readily forgotten. Noticing the length of shadows at evening time or the thickness of a dog's hair in winter enhances and makes more real their awareness of seasonal change. When children are using their senses accurately by looking, tasting, hearing, smelling, watching, finding, or feeling, they are observing at firsthand true characteristics of their world. Careful observation by the children helps them increase their ability to draw accurate conclusions. The classroom should be amply supplied with many interesting things to observe. Time and encouragement should be given for careful observation.

**Excursions** - There are numerous possibilities for science activities in every community. In fact, it would be difficult to exhaust the possibilities for science teaching in any one community.

At one time of year the children may go outdoors to observe the signs of spring. At another time they may look for signs of preparation for winter. After a heavy rain the class may take a walk to see evidences of erosion.

One group of children who were interested in studying the natural habitats of plants and animals went on several field excursions to
nearby woods, fields, and streams. They looked for the relationships that existed between plant and animal life. They studied the structural adaptation of plants to their environment. They noted how plants and animals were adapted to seasonal change.

Another group studied the geological formation of the earth. They went to an eroded stream bed to see the layers of rock that were exposed there.

Still another class had a garden plot which they cared for during the year. They watched it being plowed. Then they chose and planted the seeds, kept the garden weeded, cultivated, and watered. They harvested the lettuce and radishes in the spring and prepared them for luncheon. In the fall there were tomatoes from which they prepared tomato juice.

Whenever possible, children should be taken out into the neighborhood to observe the natural phenomenon about which they are concerned. The authors feel that too often children are permitted only to read about the objects of nature or to make models or pictures of them when a short excursion to park or stream or meadow would add much reality to their learning.

Whenever you take children on excursions you should have a definite purpose in mind. The trip must be carefully planned so that children will discover what you want them to learn. Trips in and around your school can be just as important as a jaunt that takes you miles away.

Someone may want to know how your classroom is heated. A trip to the furnace or engine room at that time can be important. Out of your examination of a coal-burning furnace might grow the class study of "Rocks and Minerals." Watching motors forcing hot and cold air through the right pipes might stimulate questions to be answered in the study of "Working with Electricity" or "The Air We Live In." At another time a child may ask, "Are there buds on the trees even in winter?" A trip into the schoolyard to examine the different trees that grow there will be one good way to answer that question.

Field trips can be valuable, but they must be a real part of the ways of finding out what children want to know. Going on a trip "just for the ride" has little, if any, justification. Trips are valuable when they are carefully planned ahead of time, and when children spend time after the trip to ponder upon what they saw and learned.
Trips usually serve as a way of answering some of the questions children have asked. They also open up new areas to explore. Many activities in the classroom can grow out of an excursion. These may include discussions, reading, making pictures, and writing reports.

Experiments - Experiments too are meaningful to children when they furnish an answer to their questions. Obviously, when a child asks "What will a magnet attract?" that is the time he will learn the most readily from an experiment using a magnet. Another child might ask, "How can I find out where bulbs grow best?" This query would seem to call for freedom to try growing bulbs under various conditions of light, heat, and moisture. By so doing the child can find his own answer to his question.

Experimentation may be of great assistance in finding solutions to problems. Many times, however, inaccurate and totally wrong answers are obtained from experiments by those who are not trained to make them. Too much confidence should not be placed in the results of experiments performed in the classroom. Conclusions should be checked by authentic sources. Experiments should be accompanied by discussion and reading.

Experiments in the elementary school should not be used as mere demonstrations of the traditional type, in which the problem, method of procedure, and conclusions are established by the teacher with little or no intellectual participation by the student. The children should see the relation between the method and the conclusion.

In other words, experiments are of value when they help children find out the truth. Their value is increased when the children do most of the experimenting. They should come to conclusions after careful consideration of what happened. And then they should check their results with authorities to be sure they have drawn valid conclusions.

This is an opportune time to emphasize the importance of verifying results, not only by careful rechecking of procedures, but also by consulting authorities in the field. If easy reference books can be provided, children will enjoy making their own verifications. Discovering with Science is one authentic source the teacher may use. Ability to use reference books will give children added opportunity to practice another phase of the scientific method.
Visual Aids • Everything children see or feel or hear is a visual or an auditory aid. Firsthand concrete experiences with real things are the finest visual aids possible.

Frequently children cannot have firsthand experiences with the area of their study. For example, they cannot go to Africa to see gazelles, zebra, elephants, and other animals gather at the water hole to drink. In such instances, films, filmstrips, and slides or other still pictures are of inestimable value. The illustrations used in Discovering with Science provide visual examples of the information contained on the printed page. Children receive clearer ideas from both the words and pictures when they are discussed together.

There are now many fine films and filmstrips appropriate for use in the elementary school. The Manual suggests appropriate visual aids to be used with each chapter of the textbook. You will want to use all visual aids as an extension of your own teaching rather than as a substitute for it. You will prepare the children to see a film by telling them something about what they are going to see. Discussion of the film or filmstrip after they have seen it helps children grow in their understanding of the topic being studied.

You will want to use whatever visual materials, museums, abore-tums, zoos, libraries, or other facilities are available. Dioramas, habi-

Children are introduced to the principle of simple harmonic action by this exhibit of the “Sand Pattern Pendulum.” Like the pendulum of a clock, this sand-filled pendulum always follows a definite course. The pattern of its motion is traced by the sifting sand on the black table.
tat groupings, real and mounted specimens of animals, color plates, diagrams, models, collections, and exhibits are among the visual aids you may find in your community. All of these avenues multiply ways for children to learn. Thorough familiarity with community resources is important. You will want to use every resource which your community offers in your teaching.

Children like to collect all kinds of things. Many teachers make use of this interest by encouraging children to bring to class objects dealing with school science interests. The suggestion that the class may want to build an exhibit of its own may encourage the children to select their contributions thoughtfully. (See pages xxviii and xxix.)

At first the exhibit may be only a table or a window ledge set aside as a place where a few children may share their treasures. As more children become interested and more space is needed the children may want to build an exhibit cabinet of their own. They may use a discarded cupboard, such as is often stored in the basement. If the interest is strong enough the children and teacher will find a suitable place to house the exhibit. Some of the objects may help to solve problems and verify points raised by other groups of children.

Activities such as identifying, labeling, describing, and arranging objects for an exhibit are among those which the children find worth while. They take great pride in showing their exhibit to children in other rooms and to mothers and other classroom visitors. You will, of course, be careful to help children realize that bringing objects from their natural habitats into the classroom should be done only when it is difficult to study those objects outdoors.

The exhibits which do find their way into the classroom vary in character and permanence according to the interest of the group. Some exhibits, such as seed pods or autumn leaves, are temporary and will remain in the classroom only a short time. Others, such as a well-labeled rock collection, are of a more permanent nature and will need a more permanent place in the school.

It often happens that there are such fine exhibits of a permanent nature in the various classrooms that it seems advisable to promote and house a school museum. If there is a science laboratory in the building, cabinets or shelves in this room can be used to house the exhibits. Such a room brings to it at one time or another all the children in the building. It has the added advantage of unifying the school program of science.
Many new school buildings have lighted display cases along the corridor walls. These cases are often used to display the school science exhibits advantageously. Various classes may have charge of labeling, arranging, and changing the exhibits that reflect the interests and activities of the different groups of children in the school.

Loan exhibits from nearby museums, from state museums, and from parents or other local citizens may well be made part of the school museum. There is no danger of having a static school science museum if teachers and children use it to display their many science activities. When children and adults cease to linger at the cases, the danger signal has been given. Teachers may then well inquire of themselves and the children: What about the school museum? Why are people not looking at it any more? What shall we do about it?

Some schools have the good fortune to be near state and city museums. In this event the teacher should early familiarize herself with the possibilities offered there for further enriching her program of teaching. She should go to the museum frequently to keep up on all the new educational material which the museum offers.

A teacher may use the museum in a variety of ways. Sometimes it is advisable to take an entire class to the museum on an exploratory trip, just to see what is there. The teacher may wish to use such an experience to study the reactions, attitudes, and emerging interests of the group. At other times the entire group may go to study intensively one small section or exhibit in which they are interested. At still other times it may seem advisable for small groups of children to go to the museum and bring back reports to the rest of the class. Frequently teachers encourage children to go with their parents or friends and to bring reports of their visits to the class.

Many museums maintain a splendid film-and-slide library which they are eager to have schools use. Such libraries are catalogued so that the teachers may have ready access to the offerings. Good educational films and slides are now being made in many museums. Surely schools having the equipment necessary and the opportunity to use such museum materials should avail themselves of these effective aids to teaching.

Some museums maintain an excellent library of collections of pictures dealing with various topics. These loan collections often cost nothing but the time necessary to get and return them. They are
excellent supplementary teaching materials and should be used as frequently as possible.

Someone has said that one seeing is worth a hundred tellings. This may be an exaggerated statement, but many a teacher has had experiences with children which make her realize how eye-minded they are.

It has already been suggested that the teacher is fortunate indeed who has access to the good film-and-slide library of a local museum or other institution and who has the school equipment necessary for its use.

Many school systems are now including in their annual budgets an appropriation for purchase and rental of visual-aid materials for their schools. Some schools already have the beginnings of a good film library. The authors know of schools that have purchased a camera and are building a film library by means of motion pictures taken by staff members. This plan, however, requires that the person taking the pictures be more than an amateur photographer. Considerable skill is needed to produce good educational films, and when it is not available among the staff it may be wiser to use professionally prepared materials. The necessary adaptation of nationally distributed films to local conditions may actually heighten the class's interest in discussion and research.

Many state departments of education, as well as state universities, have started film libraries. The teachers in every school should have access to a catalogue of visual aids available from these sources. Educational films and filmstrips are available also from commercial distributors and rental agencies listed in the Appendix.

The Federal government also maintains a visual-aid service. Catalogues telling how materials may be obtained are available by writing the Superintendent of Documents, Government Printing Office, Washington, D. C.

Many commercial companies make available without cost excellent teaching films. Caution must be exercised in selecting these films, however, because the nature and amount of advertising used in some of them makes their showing inadvisable.

**Auditory Aids** • Auditory aids include records, tape recordings, sound films, and radio and television programs. An increasing amount of auditory teaching materials is being produced. These
furnish valuable supplements to books, pictures, and other visual materials. For example, listening to recordings of such sounds as the noises made by deep-sea animals or to the songs of common birds adds much to children’s pleasure in activities connected with the study of animals.

You also will find it interesting to make tape or wire recordings of discussions, speeches, and reports so that you may listen to them again. Tape recorders are becoming common equipment in schools. Teachers can make good use of them as auditory aids. If there is a recorder available for your use, experiment with it. However, excellent programs of science do not depend upon a tape recorder.

Planning for Science Activities in Your Classroom • Every teacher who has worked in the field of science knows that certain materials must be accessible for children to use. Because some of these materials are bulky and unsightly they may require a special place for storage.

Many teachers have found it advantageous to fit up a science table or miniature laboratory in the room. The center of the laboratory may be an old card table which a parent donates, or it may be a rough work table that the children make for themselves. At any rate, it should not be a table that will be spoiled by a few drops of water or vinegar or the contents from a dry cell. Temporary shelf space for the bulkier supplies, provided by orange crates if necessary, will leave the table top free for experiments.

A piece of linoleum, several thicknesses of discarded newspapers, or a zinc top on the table will allow children to experiment without being hampered by too many precautions.

What belongs on this table depends entirely upon what the children need for their science experimentation. At one time there may be dry cells, bell wire, electric push buttons, bells, tweezers, insulating tape, and the like. Such assembled materials suggest activities in which children might engage during a study of electricity. At another time there may be materials for making blueprints of leaves and flowers. At still another time, rocks, minerals, and shells may be found there.

You will want to make sure all the materials needed for experimentation are at hand. Orderliness will be important only to the extent that it helps or hinders the carrying out of experiments.
Many children have had their science interests broadened by working in such a classroom laboratory.

**Bulletin Board** • A bulletin board will be an outstanding aid to science teaching if its exhibits are planned as an integral part of the whole science activity. It can be used to call attention to the latest achievements in the area being studied, or it can present the historical view. In either case, it can stimulate further reading, observing, and experimenting.

The bulletin board may at one time reflect the special interests of an individual. At another time it may represent the work of an entire class. Often it is concerned with only one large interest, and its space is reserved for pictures, drawings, and clippings dealing with that topic. At other times it is used to display a miscellaneous collection of science information. The bulletin board may also be a clearinghouse for questions and answers of children. Sometimes the carefully written reports of the various members of the class can be posted for all to read and admire.

A good bulletin board reflects the time and effort spent on it by the teacher and her pupils. There must be first of all an interest on the part of both to have such a bulletin board. There must be an understanding of the responsibilities involved in the enterprise. Delegation of these responsibilities accomplishes two purposes. First, it helps to make sure they will be carried out. Secondly, the more participation there is in the maintenance of the bulletin board, the more interest there will be in its exhibit. Accordingly, the whole class may plan the exhibit. Then selected groups can take over the special responsibilities for selection, arrangement, and taking down of the materials contributed by the class. Many a good start has come to a sudden end because the teacher has failed to provide for the physical details of keeping a bulletin board alive. All too often the teacher herself assumes the responsibility and finds not only that she does not have time to do justice to it, but that she rather than the children learns from the experience.

**Reading** • One purpose of reading science books and other materials is to stimulate children to think, to wonder, to try out ideas, to come to tentative conclusions. Reading here is done to obtain information. Just as it proves helpful to state in advance the questions to
which an experiment is expected to provide answers, so too it is helpful to formulate beforehand one or two questions to be answered by reading. Reading to gain new ideas, therefore, profitably follows a discussion period in which information on the subject already at hand is summarized, and that which the class is seeking is stated in the form of specific questions.

As was pointed out in the section on "Experiments," reading of science materials also is done to verify tentative conclusions. These conclusions may be the result of information received from class discussions, experiments, or experiences outside the classroom. Reading for verification encourages resourcefulness in selecting information from books, magazines, leaflets, bulletin board exhibits, and other materials. It offers an opportunity for children to follow individual interests. You may encourage reading more than one reference, but try to leave the selection of the references to the child as much as is advisable. You may need to help the child apply what he reads to his conclusions.

Still another type of reading is called for when the child follows directions for doing an experiment. The success of the experiment may depend on his ability to concentrate and to read accurately. Such opportunities offered by science books and other reading materials provide real incentives to improve reading skills, as well as to learn more about science.

The best statement of truth is secured from people who are authorities in the field. The authors of Discovering with Science have gone to these competent authorities to secure their materials which provide a reliable reading source for science information, for verification of experiment conclusions, and for directions for carrying out experiments.

**Appraising Your Teaching of Science**

Evaluation is an important part of the learning process. Both teachers and children should consciously take part in evaluation, for in no other way can they really know what has been accomplished.

Evaluation may be done in various ways. From time to time, the whole group, or a small group, may pause to take stock of their progress. They must determine whether their original plans are working satisfactorily. They must decide if any changes should be made. They must think about which of their experiences have been
valuable, which ones should be repeated, and what new experiences are needed.

Here again you are invaluable. You will help them to be truly discerning of their ways of working. You will raise questions that cause them to reflect upon their procedures. If they have encountered failure, as sometimes happens, you will give them heart by suggesting possible new ways to go forward. There is often much learning when things turn out badly. You will substitute challenge for disappointment and temporary defeat.

The keeping of records aids in evaluation. Such records include individual and group reports, folders of work done, and notebooks with illustrations and explanations of activities pursued. Help the children grow in ability to locate information, organize data, and share information. Encourage co-operative enterprises as you de-emphasize competitive tendencies. Keep using the term WE in such questions as: What have WE accomplished? How have WE failed? What next steps should WE take?

You will want each child also to assess his own growth as he reflects upon the WE aspect of each situation. He may ask, "How well did I achieve? How helpful was I in this group venture? What did I contribute for the good of others?"

To arrive at your own estimate of the values to your children of each science experience you will want to ask yourself:

Are the children growing in ability to think straight, to plan effectively, and to draw appropriate conclusions?

Are the children applying more and more of the scientific methods as they work toward solving their problems?

Are the children learning to make sensible and appropriate generalizations in the face of ever widening experiences and to apply these generalities in problem-solving for life’s needs? For example, are there evidences that children are appreciating the need to enjoy objects where they find them in their natural habitats instead of bringing them into the classroom?

Are they enlarging their concepts about many aspects of the world in which they live?

Are the experiences they are having in science contributing to their total social, intellectual, and emotional growth?

Is science a meaningful, beneficial, and joyful experience to the
children? For example, are there evidences that children are using what they know about the orderliness of the universe to allay their own fears?

If you can answer affirmatively most of these questions, you should indeed feel proud of your part in the education of children.

**Using This Manual to Help You**

The purpose of this Manual, then, is to guide you as you use *Discovering with Science*. As part of your preparation for the class study of each unit you are strongly urged to read all the manual material on that chapter. You will then understand clearly what purposes the authors had in mind and their suggestions for procedure, and can profit from their guidance in selecting activities and experiences which are appropriate to the content of the unit.

There is no desire to limit your own creativeness in teaching. Everything in the Manual is suggestive. It is hoped that no teacher will slavishly follow the suggestions given here to the exclusion of other projects and activities. It would be deadly to do so. Each teacher is encouraged to work with her children in a natural and creative fashion. The local environment will afford numerous ways to proceed with each science interest. By all means make use of the local leads. They are real and concrete. Capitalize upon them. Make the local environment your laboratory for learning.

At times and in some situations, however, the suggestions and procedures set down in the Manual will greatly enlarge the teacher’s vision of what might be done. Making use of the additional content given in the Manual may frequently mean enriching the program significantly. Use it to help both you and the children achieve better science understandings. The more opportunities you afford for children to learn through activities and experiences, the more likelihood there is that deeper meanings and clearer understandings will result.

At the ends of chapters in *Discovering with Science* there are “things to think about,” “problems to solve,” and added suggestions of “things to do.” The Manual supplies, in each case, answers to the questions asked and gives ways to do what the text suggests. By turning to the corresponding section of the Manual, you can readily find the information you need.
The Seasons

There are changes taking place on the earth all the time, and among the most easily observed are the seasonal changes. The four seasons have characteristic weather changes which affect both plant and animal life and call for human adjustment as well. A study of the seasons helps children become increasingly aware of changes taking place all around them.

"The Seasons" has been placed at the beginning of Discovering with Science because it seems to be a natural and likely way to begin using the book. Children can easily be led to observe seasonal change and to become conscious of changes going on in the out of doors wherever they live. Also, teachers are frequently hesitant to let children begin their science work in an area that seems to be complicated and difficult. It should be made clear, however, that no teacher should feel that this chapter must come first. Each chapter is a complete unit in itself. No one chapter has to be preceded or followed by any other.

Science Meanings for Children

As children read the first chapter of Discovering with Science they will become aware of several truths about the seasons. Among them will be the following:

The seasons follow each other in regular order: autumn, winter, spring, and summer.

Seasons have characteristic weather conditions.

Seasons differ in different places.

Distance from the equator affects the kinds of seasons all places have. Generally speaking, places far away from the equator have cooler summers and colder winters than places near it, and places near the equator have hotter summers and warmer winters than places farther away from it.

Wherever you live in North America your summer weather is warmer than your winter weather.
I - The Seasons

The number of hours the sun shines on any place affects the temperature of that place.

The angle at which the sun’s rays strike any place affects the temperature of that place.

Days and nights at the equator are about of equal length all through the year. Days and nights are of increasingly unequal length as you travel farther away from the equator. Winter days are shorter than summer days.

When it is summer north of the equator it is winter south of it. When it is spring north of the equator it is autumn south of it.

Information for the Teacher

Among all things on the earth there are constant changes taking place. For example, growth and aging may occur unnoticed amid the more obvious daily, yearly, and seasonal changes. Among the readily observed seasonal changes are the characteristic weather variations. Children can easily see many characteristic changes as they study the seasons.

As you prepare to teach your children more about the seasons, you will want to keep in mind your opportunities to help children become aware of changes. This increasing awareness of the constant changes occurring in all things is one of the concepts that should underline work in science all through the grades. It is a concept that requires time to develop and teachers will need to assist in its development.

In whatever section of North America you teach, each season has its characteristic weather and growth phenomena. You will want to call attention to the fact that when you speak of weather you are talking about the temperature, the humidity and precipitation, and conditions of sun and wind. By using the weather where you are as a point of comparison, you can help children visualize the weather and seasonal changes taking place in both warmer and cooler sections of the country.

Climate may be thought of as the average weather conditions that have prevailed in an area over a long period of time. Climate, even more than weather, affects the activities of living things, as will be brought out in the chapters to follow.

As you work with children you will want to be sure they understand that not just one but several factors determine the kinds of
seasons that occur at the various sections of the earth. It is easy to give the impression not only that distance from the equator but that the equator itself has some influence over seasonal climate. Because the area known as the equator is where the sun shines the most hours of the year and where the sun’s rays are most direct, it is the hottest section of the earth. As you move away from these long hours of direct sun rays, either to the north or to the south, you will find cooler climates.

Children may need help in understanding how the length of days and nights affects seasons. You might point out that at the equator there are twelve hours of sunlight every day in the year, and at that place there are no changes of season. It is always hot. But as you travel away from the equator, the hours of daylight change from day to day. When the days are longest, when the area is receiving light more hours of the day than it is dark, then there is summer. When the opposite is true, when the area is dark more hours of the day than it is light, then there is winter. During the change from one extreme to the other, the milder days of spring and fall occur.

The longer hours of sunlight noticeably affect the growth of plants. Orange groves in central California, for example, have an earlier ripening season than those in southern California because they have more hours of sunlight during the summer days. Many summer flowers and vegetables grow larger in parts of Canada and Alaska than in areas farther south for the same reason.

Your children will be interested in knowing that places near the equator have almost no twilight or dawn, and that the farther from the equator you go, the longer the twilight and dawn periods become. In places near the equator, day changes quickly into night at all seasons of the year. As you move toward the Poles the twilight periods lengthen, owing to the angle of the sun’s rays.

Along with the hours of sunlight is another factor affecting climate. This is the angle of the sun’s rays as they reach the earth’s surface. It is important to help children understand clearly how the angle at which the sun’s rays strike a given place affects its temperature. Straight rays are warmer than slanting ones. Therefore, although slanting rays spread over a larger area, sometimes giving longer hours of daylight, they do not warm the area as much as straight rays do.

By using the globe you can help children become aware of the
relationship between the distance from the equator and straight and slanting rays. Without getting too deeply into the causes of seasonal change, you can help children begin to understand that the tilting of the earth affects the angle at which the sun’s rays strike the earth.

Altitude can alter the effect of the sun’s rays in specific areas. An example of such an area is Mexico City. Although this city is near the equator, the summers are cooler than in many cities farther north. Its elevation of nearly eight thousand feet makes the difference.

Seasonal temperature changes of oceans and large lake surfaces are much less than those on land. Air coming across these bodies of water is tempered, and as it blows over the nearby land it causes the climate to be less extreme. Therefore, shore areas are usually warmer in winter and cooler in summer than adjoining inland sections. Contrasting off-shore ocean currents may alter this pattern in specific areas. For example, warm ocean currents near the coast of Alaska give a milder year-round climate to the southern part of the peninsula than would normally be expected at that latitude.

**Ways of Working with Children**

There are many possible ways to work with children. No doubt you will encourage your children to talk about their own experiences with seasonal change. You will encourage them to relate seasonal experiences in various other parts of the world where they may have traveled. You will allow ample time for children to ask questions and to seek answers.

Frequent use of a globe or wall map will be invaluable as you attempt to help children become aware of the factors affecting seasonal change. By imagining they are packing in anticipation of taking trips, children clarify their ideas of the several factors that affect weather conditions in each season. They may use the first chapter of *Discovering with Science* to find answers to the questions they raise regarding seasonal change.

Help the children to notice changes in the length of day and night as they experience each season. By keeping a record of the time the sun rises and sets each day during a month they will become acutely aware of the fact that the number of daylight hours varies from day to day during each season. Perhaps they will also want to keep a record of changes in the temperature throughout the same month.
In this way they can see the interrelationship between hours of sunlight and the daily temperature.

Use pictures that you and your children collect to show the effects of seasonal change upon the activities of people, other animals, and plants. Ask the children to study the pictures on pages 6 and 8 of *Discovering with Science*, and discuss the differences in them.

Four color films entitled *Spring on the Farm*, *Summer on the Farm*, *Autumn on the Farm*, and *Winter on the Farm* would be excellent to show as each season passes. (See audio-visual list on page 26.) The same farm is shown as it appears during each season. Seeing how the seasons change the landscape and affect the farmer’s activities brings into sharp focus the effects of seasonal change.

### Materials Needed

- daily paper showing time of sunrise and sunset
- flashlight or lamp
- standard school globe or wall maps of the world and North America

### Some Things to Think About and Do

Suggestions for teachers corresponding to those for children, page 19, *Discovering with Science*.

1. Answers depend upon your children’s experiences.
2. If you live in Australia the winter months essentially are June, July, and August; the summer months, December, January, and February. More specifically the dates would be June 22 to September 22 for winter, and December 22 to March 20 for summer.
3. The Land of the Midnight Sun is that part of the earth that is in the Arctic Circle. During the summer months in the Northern Hemisphere there is a period of about six weeks when portions of Alaska and Norway within the Arctic Circle have full daylight all twenty-four hours of the day. Have your children read about these places in other books. If you have access to an encyclopedia you might share its information about the Land of the Midnight Sun. The illustration on page 24 of the manual shows one way to set up the experiment which explains the phenomenon of the midnight sun. The source of light may be either a flashlight or a lamp.
In the Land of the Midnight Sun the sun shines for six weeks each summer.

4. You would go during the latter part of December, all of January, and February, and until the latter part of March. These are the summer months in the Southern Hemisphere.

5. The story should bring out how seasons affect the clothing children wear, the foods they eat, and the games they play.

Further Activities

1. Ask the children to make a collection of pictures that show different seasons in different parts of the world.

2. One group of children might make a chart showing the months comprising each season in the Northern Hemisphere and a similar chart for the Southern Hemisphere.

3. Take photographs of your schoolyard during each season. Ask the children to compare them to note changes from one season to another in such things as trees, grass, shrubs, insects, birds, play equipment, and games. Close-up pictures are better for this purpose.

4. One group of children might keep a weather chart during part of each season. The whole class would be interested in comparing the hottest day and the coldest day of each season. Help them find out the yearly temperature range as the seasons pass.

5. Take as many walks outdoors as possible at different times to watch changes that occur throughout the seasons. Keep going back to familiar haunts and then try to recall how they looked on the previous trip. Keeping a record of such walks adds accuracy to this activity. Pictures taken on the walks help to show seasonal changes.
Once an area has been studied, there remains the problem of finding out the effects this body of content has upon the children you teach. The goal is not to determine what facts children can remember. It is to find out, if possible, how children have increased their understanding, appreciations, and attitudes as a result of the facts they have acquired. Questions teachers ask should be asked in such a way that thinking is necessary to arrive at an answer. Questions beginning with "How do you know—" or "How could you try to find out—" stimulate children to think.

Check the feelings of children against the meanings listed on pages 19–20 in the Manual. Allow for a wide range of interpretations. Encourage individuals to interpret the meanings in their own ways.

Occasionally children will bring objects into the classroom that indicate they are thinking about the changes brought about as seasons change. Sometimes burrs, seeds, nuts, or autumn leaves are brought in. You will not encourage children to bring in objects that will upset the environment. One of the responsibilities that children need to learn is that of conserving objects as they are found in their environment. They should enjoy most things where they find them in their natural environment.

Through discussion try to ascertain how much children have learned about geographic location as a result of the frequent use of the globe. Encourage them to project their ideas concerning climate, seasonal conditions, and activities of the people of definite geographic regions on the basis of facts acquired in studying "The Seasons."

Use the questions on page 19 of the text to further check on the meanings children have gained as a result of reading the chapter on "The Seasons."

Bibliography

For the Teacher


For the Children

Films
AUTUMN. (ALF) 1 reel, b/w. Pictures the changing season with busy creatures doing what nature instinctively makes them do.

THE SEASONS OF THE YEAR. (Cor) 1 reel, color & b/w. The concept of four seasons is developed by activities through spring, summer, autumn, and winter.

SUMMER ON THE FARM. AUTUMN ON THE FARM. WINTER ON THE FARM. SPRING ON THE FARM. (EBF) 1 reel each, color. Four films showing weather during the four temperate-zone seasons. Typical activities on a farm during these seasons are depicted.

WHAT CAUSES THE SEASONS? (YAF) 1 reel, b/w. Shows how the inclination and revolution of the earth cause our different seasons.

Filmstrips
CLIMATE. (FH) b/w.
CLIMATE. (JH) color.
CLIMATES. (YAF) color.
NATURE IN THE FOUR SEASONS. (EGF) color.
THE SEASONS. (YAF) color.
SPRING, SUMMER, AUTUMN, WINTER. (FH) b/w.
THE SUN AND OUR SEASONS. (JH) color.
WHY THE SEASONS? (SVE) b/w.
WORKERS IN THE FOUR SEASONS. (EGF) color.
Animals and the Seasons

This chapter deals with the concept of adaptations to seasonal change. Adaptations are made throughout the year. Children will have information concerning those animals that live in the local environment. Start the study of "Animals and the Seasons" by drawing upon the knowledge your children already have about what happens to animals in their local community as the seasons change.

The second chapter of Discovering with Science may be used independently of other parts of the textbook and at any season of the year. Or it may be used in connection with the third chapter, "Plants and the Seasons."

Science Meanings for Children
As children read the chapter on "Animals and the Seasons" you will help them become aware of the following science meanings:

- Many animals show adaptation to seasonal change.
- Some animals hibernate during all or part of the cold season.
- Some animals migrate to warmer climates during the cold months of the year.
- Many animals grow thicker coats during the winter season.
- Many insects undergo change of form during their lifetime. This change protects insects from cold weather.
- Some animals store food for the winter.

Information for the Teacher
Animals exhibit various methods of adaptation to seasonal change. As far as is known, animals do not consciously adapt themselves, but instead they become adapted to changes through no conscious action on their part. This is in contrast to man, who consciously adapts himself to many aspects of seasonal change.

Animals with fur or feathers often have thicker coats in winter.
Horses, cows, dogs, cats, chickens, and ducks are examples of animals that keep warm during the colder months by having thicker coats.

Some animals change colors during the winter months. The bright colors of some animals would make them easy prey to their enemies in winter. If an animal lives in a cold region its winter coat is often white or dull in color. Certain foxes are blue-gray in summer and have white coats in winter. Some weasels change color, too. In summer their coats are brown and white. In winter they are all white.

Insects, such as butterflies and moths, also undergo change. In their life cycle the resting, or pupal, stage often occurs during the colder months of the year. During this time the insect may rest in a cocoon or a chrysalis. It may also rest in the ground. Many insects die during the cold weather. Many bees, wasps, and flies die almost as soon as cold days arrive. In some cases only the queen bee and queen wasp survive the winter months. All the rest of the bees and wasps die.

Migration is another phenomenon of adaptation. This subject interests children a great deal. Many animals migrate. Some travel great distances over land and in water. Others travel short distances up and down the slopes of mountains.

No one really knows just why animals migrate, although much study has been given to solving this riddle. Nor does anyone know just how animals find their way back to the same places year in and year out.

Some birds are examples of migrators. In fact, many birds travel great distances in the spring and again in the fall. The second chapter of the text tells about the travels of the golden plover, Arctic tern, and robin.

Some birds travel only at night. These tend to be the smaller ones. They gather in flocks and travel together. Some people believe that by traveling by night these birds escape many of their enemies. But live wires kill some, and lights of lighthouses and cities often confuse them, causing them to fly head on against buildings, as evidenced by those found dead nearby in the morning.

Larger birds tend to travel by day. They stop and eat and rest along the way. During their flight also many casualties occur.

Not all birds migrate. Some remain in the same place all year
around. These birds are called permanent residents. They are suited to living in the same place during all four seasons.

Children may not know of the migratory habits of animals other than birds. Fish, such as salmon and eels, also migrate. Pacific salmon migrate from the fresh water streams where they are born to the salt water where they grow and live for a time. When they are six or seven years old they migrate from salt water back to their birthplaces in fresh water. Here they spawn and lay their eggs. After laying their eggs in the fresh water the adult salmon die.

Eels migrate in the opposite way. They are born in salt water, then they migrate to fresh water as young eels and spend most of their lifetime there. They return to the deep, salty ocean water, however, to lay their eggs.

Shad migrate, too. Each spring thousands of mature shad seek fresh water places to lay their eggs. The remainder of the year they live in salt water. The young fish of these species migrate, too. They travel from fresh to salt water, where they grow up, then travel back to fresh water at spawning time.

Elk and reindeer migrate, too, as do polar bears, walruses, and seals. Elk go up into the high altitudes during the summer months and return to the valleys for the winter. Polar bears travel southward on floating icebergs. Here they bear their young. Then as winter time comes they migrate northward over the frozen wastes.

It is assumed sometimes that both food supply and weather conditions have a relationship to the migrating habits of animals. However, these cannot be the sole reasons for migration, for birds leave their summer homes long before the food supply is exhausted or the cold weather sets in. Some scientists have advanced the idea that migration is the result of habits of adjustment made during earlier extreme climatic changes upon the earth. At that time the habit of traveling for food and to escape cold may have become so firmly fixed that it is now an instinctive pattern of behavior. Others believe that the number of hours of daylight may be a factor influencing migration.

Hibernation is often spoken of as a sleeping period. It is more nearly correct to speak of it as a resting time or a quiet time, for hibernation is not sleep as children think of it. The body functions and processes of hibernating animals slow down tremendously. Hibernating animals appear almost to be dead, they are so quiet.
Breathing and heart action slow to a minimum. As children discuss hibernation you will want to help them use the term quiet time or resting time rather than sleeping time.

Many animals hibernate during colder times. Among these are cold-blooded animals, such as frogs, toads, turtles, and snakes. The blood temperature of cold-blooded animals varies with the temperature of the air or water around them. So in places where temperature changes between summer and winter are great, these animals hibernate. If they did not, when the air or water surrounding them became colder than the freezing point of water (32° F.) the cold-blooded animals would perish.

Some mammals hibernate all winter. Woodchucks do this. They eat and grow fat during the warmer months. As cold days come they hibernate. The layers of fat stored in their bodies furnish energy for the quiet period. When the woodchucks wake up or become active again they are very, very thin as well as very, very hungry.

Some mammals hibernate only part of the cold season. They rest for a few weeks then become active and gather food. Then they rest again. Chipmunks, skunks, some kinds of bats, bears, and opossums are partial hibernators. That is, they rest part of the time, and on other occasions become active and seek food.

Seasons in the temperate and colder parts of the world affect animals greatly. The same kinds of animals may hibernate in a cold climate but remain active most of the year in a warm climate. In the warm climate some animals reverse their hibernation habits and rest during the hottest or driest season of the year.

### Ways of Working with Children

In a temperate climate during autumn and spring children can watch birds leaving or returning to their communities. In the spring they can look for moths and butterflies emerging from a cocoon or a chrysalis. They can find woolly caterpillars crawling across the sidewalk or grass. In the fall they can watch squirrels storing food for winter.

If children bring any of these observations into their conversations, you will use them to open the discussion of “Animals and the Seasons.” You will call attention to the coats of birds and mammals. You will direct the children’s thinking to include a discussion of such questions as the following:
Where do you think our birds are going?  
Why do you suppose the butterfly is coming out of its cocoon now?  
What do you suppose would happen if toads, frogs, and turtles did not hibernate?  
How do you think these animals live all winter?

These and other appropriate questions usually lead children into reading, as well as further observational activities.

Short walks to see a cocoon hanging on a wire fence or bushes are to be encouraged. It is better to go outdoors to see plants and animals than to disturb them by bringing them indoors. Whenever possible encourage children to form the habit of reporting what they observe outdoors rather than ask them to bring outdoor living things into the classroom. Each year many living things die and conservation measures are violated by bringing living things indoors where the environmental conditions necessary to life are not appropriate. As you work with your class, go outdoors with them to observe and study life where you find it.

The pictures on pages 23, 24, and 25 of Discovering with Science may well be used to stimulate reading-to-find-out and thoughtful discussion periods. You will encourage children to ask about parts of the story they do not entirely understand. You will be readily available to help those who may be immature readers so that you may assist them in study reading.

A group of children may wish to take charge of finding pictures of animals and arranging them for the bulletin board. They may decide to place migrators in one group, hibernators in another group, and permanent residents in still another.

A group of mature readers might wish to go to the library, if there is one, or to search through other books in the classroom to find more information about animals and their seasonal adaptations.

Perhaps a caution is needed here. We would not want looking at pictures and reading about animals to hinder as much firsthand observation as possible of the animals themselves as they exhibit adaptations to seasonal change.

It is hoped also that it will be possible for you to use one or more of the films or filmstrips listed on pages 35–36 of the Manual. They help children visualize what they have been reading and serve to stimulate further questions, discussion, and reading.
II • Animals and the Seasons

Materials Needed

- animal cage made from fine plants for cage
- wire screen and square soil for cage
- cake tin, or glass aquarium, or plastic container

Some Things for You to Do

Suggestions for teachers corresponding to those for children, pages 32–33, Discovering with Science.

1. Answers will depend upon the region in which you live.

2. Start the diaries during the season at which you are studying “Animals and the Seasons.” As each season passes bring them up to date. You might keep the diaries for the children so that they will not get lost.

3. Make a suitable home for the animal to be kept in your classroom. Consult the diagram on this page. Set the animal home in a cool-to-cold place so that the animal will hibernate.

4. The bird chart should show local birds whose habits children can observe.

5. No directions needed.

6. Go to the index of science books and encyclopedias that are available for your use. Locate material on eels and ask some of the children to read about them and report their findings to the group.

7. Use local animals for observation. Go outdoors as often as pos-
Possible to see the animals in their natural habitats. Among the signs of the season you may observe thickness of coat, change of color, fatness of many animals just before hibernation, cocoon cases, winter homes, and absence of certain animals during some seasons.

Further Activities

1. Some children may enjoy drawing pictures of animals found in the local environment showing how they look in summer and in winter.

2. Help the children design a diorama scene showing one season as it comes to their community. Model animals of clay or papier-mâché. Model trees and shrubs from pieces of sponge and pipe cleaners. Paint a background. A ladies’ oval hat box makes a good diorama box. Cut out about one third of the oval so that you can see what is arranged inside. You may put cellophane over this cut-away part after all the items are arranged inside the hat box.

3. Go to a zoo, if there is one near you, and see how animals there become adapted to seasonal change.

Evaluation

As you know, it is difficult to assess the effect that a given set of experiences has upon each child in your classroom. You may be sure that each individual is likely to learn something quite different from that learned by others as a result of participating in what appear
to be identical situations. Therefore, you will watch for evidences of such individual learnings as you talk with your children and as you watch them work. You will guard against judging the success of your program in terms of only the few outstanding children.

You will look for understandings of the world in which the children live. Watch for evidences that the theme of adaptation was appreciated as they learned about animals and the seasons.

Watch for evidence that children are furthering their abilities to do scientific and critical thinking as they work in science and other curriculum areas.

Try to ascertain whether they are more aware of the meanings behind their firsthand observations of the environment.

Look for growth in relationships with classmates. For example, do the children share materials, disagree and not get angry, give turns to others?

Sometime when you want to test the extent of vocabulary growth, play a science game. Ask children to write or tell the meaning of such science words as hibernator, migrator, permanent resident, spawning, partial hibernator. Let each child keep his own score of correct answers. As children read their statements to each other there will be an opportunity to clear up any uncertainties and misconceptions.

Bibliography

For the Teacher


For the Children


**Films**

**Animals in Winter.** (EBF) 1 reel, b/w. A study of various wild animals as they prepare for and live through the winter season.

**Birds in Winter.** (Cor) 1 reel, color & b/w. Pictures the seasonal aspect of bird life, the interdependence of living things, and the food-getting adaptations of birds in winter.

**Butterflies.** (EBF) 1 reel, b/w. Shows life history of the cabbage butterfly and the swallowtail butterfly, including ways they cross-fertilize flowers.

**Camouflage in Nature Through Form and Color Matching.** (Cor) 1 reel, color. Shows how nature’s cloak of camouflage protects animals, birds, and fish from their natural enemies.
FLIGHT OF THE SEA BIRDS. (WLF) 1 reel, b/w. Story of the yearly migration of countless sea birds to mountain lakes.

THE FROG. (EBF) 1 reel, b/w. The life cycle of a frog is shown from egg to adult.

GRAY SQUIRREL. (EBF) 1 reel, b/w. Follows the growth and daily activities of the young squirrels from spring to midwinter.

MAMMALS OF THE ROCKY MOUNTAINS. (Cor) 1 reel, color & b/w. Observation of how animals typical of each mountain zone adapt themselves to the changing seasons.

SNAKES. (Cor) 1 reel, b/w & color. Develops the life habits and adaptations of representative snakes, showing their equipment for locomotion, sensation, nutrition, and self-protection.

SNAPPING TURTLE. (EBF) 1 reel, b/w. Presents life history of snapping turtles and their natural habitat.

WONDERS IN YOUR OWN BACK YARD. (Churchill-Wexler) 1 reel, b/w. Shows boy and girl finding a worm, spider, millipede, sow bug, and snail in their own back yard.

Filmstrips

ADAPTATION OF BIRDS. (JH) b/w.

ANIMALS AND SEASONS. (Curr F) 6 filmstrips, color: AIR MIGRATION, LAND AND WATER MIGRATION, HIBERNATION, ADJUSTMENT TO SUMMER, SEASONAL BODY CHANGES, and SEASONAL HABITS.

ANIMALS FIT THEMSELVES TO THEIR SURROUNDINGS. (EGF) color.

ANIMAL HOMES. (Curr F) 5 filmstrips, color: NESTS, CAVERNS, BURROWS, HOLLOW TREES, and LODGES.

ANIMALS IN THE FOUR SEASONS. (EGF) color.

BEHAVIOR OF SIMPLE ANIMALS. (Curr F) color.

THE MIGRATION OF BIRDS. (JH) b/w.
Plants and the Seasons

The three science themes dealt with in this chapter are change, adaptation, and variety. The material here and in the text illustrates what a wide variety of plants there are, how plants change, and how they become adapted to the changing seasons. Although you will not preach these concepts, you will help children gain some awareness of the existence and operation of each of them.

"Plants and the Seasons" might well be used at any season of the year. You may, however, wish to use this chapter during the spring months when many plants are changing rapidly and when gardening is an exciting activity.

Science Meanings for Children

The following science meanings are your concern as you help children explore the area of plants and the seasons:

- There are many varieties of plants.
- Plants are adapted to living in a variety of places under a variety of conditions.
- Plants change as seasonal conditions change.
- Some plants live only one year. These are annuals.
- Some plants live two years. These are biennials.
- Some plants live more than two years. These are perennials.
- In warm climates some plants grow and flower, store food, and produce seeds throughout most of the year.
- In temperate and colder climates some plants grow and flower, store food, and produce seeds during only part of the year.
- In temperate and colder climates perennials and biennials rest, or become inactive, during the colder months.

Information for the Teacher

Although children will have seen plants growing in their homes, in the school, and in the out-of-doors, they may have taken them for granted. This is often the case of objects around us
that are abundant. Children's appreciation of growing plants will increase when you help them to see interrelationships which exist between plants and their environment. You will want to help children observe how plants have become adapted to living under the changing conditions of each succeeding season. Whenever possible point out that plants have a variety of ways of growing, changing, and reproducing their own kind.

There is identifiable material in the chapter on “Plants and the Seasons” to fit several sets of environmental conditions. Children who live in warm climates will find the descriptions of plants that grow most of the year include those in their locality. Children who live in temperate and cold climates also will find plants of their regions described. It would be well for children to learn there are other kinds of regions than the one in which they live.

Plants are hardy living things. There are very few places on earth where some form of plant life is not found. High up on the mountains, in cold Arctic regions, and in hot dry deserts some kinds of plants survive. They become adapted to their habitats.

Here, as in the chapter on “Animals and the Seasons,” keep in mind the distinction between “becoming adapted” to seasonal change and “adapting” to it. Plants become adapted, while humans adapt to seasonal change. There is no evidence in the plant kingdom of conscious preparation to adapt. There is evidence that humans plan for and adapt themselves to seasonal change.

Some plants keep growing during all seasons of the year in regions where there is no killing frost and where conditions necessary to growth prevail. Moisture, as well as heat and light, is one of these
important conditions. For example, the presence of moisture is the chief reason for the lush growth of the tropics in contrast to the barrenness of equally warm but dry deserts.

In temperate climates where the temperature range is wide between winter and summer seasons, plants have become adapted to these conditions by having growing and resting periods. In the warmer areas, during hot dry periods many plants go into a resting state. They may even lose their leaves, just as plants in the less temperate areas do in extreme cold periods.

Many plants are annuals. They live during only one growing season. After forming seeds the parent plant dies. Other plants, the biennials and perennials, live more than one year. Many biennial plants die down to the ground in the fall, but the roots and bulbs which are underground remain alive all winter. In the spring and summer, new plants grow from these roots or bulbs. They will produce flowers and seeds. Other types of plants, such as bushes and trees, go into a resting state during the winter months. These are perennials.

A deciduous bush or tree loses its leaves every autumn. Before the cold weather comes, a separation layer forms where each leaf joins the twig upon which it grows. When this layer is completely formed, no sap can get into the leaves. Then the leaves begin to lose their green color because they can no longer manufacture chlorophyll. At that point other colors which were present in the leaves before the green faded become visible. We say the leaves turn color. Actually what happens is that the yellows, reds, and oranges which were obscured by the chlorophyll can be seen.

Soon after the separation layer keeps sap from reaching the leaves they dry and fall off. All winter the leaf buds that formed during the summer and early fall survive the severe cold. In the spring they start to swell, and with the coming of warm weather burst open. Often before the green chlorophyll becomes active the young leaves exhibit the same yellows and reds that are seen in the fall. As the warm weather arrives, the plants go into another period of active growth. Sap flows freely up the trunks or stems, leaves grow, flowers bloom, and food is manufactured for growth and storage.

Some perennials are evergreens; they do not lose their leaves at any particular season of the year. There are green leaves on these trees all the year through. The needles or leaves can be shed at al-
most any time. Even so, the evergreens grow most rapidly during the spring and summer months. They are not active during the wintertime. You will point out to the children the evidences of their growth in the spring. The lighter color at the ends of evergreen branches indicates the new growth.

Annual, biennial, and perennial are terms designating the length of life of plants. Children will know some of each kind. Biennials are least familiar because of our habit of eating most garden biennials in their first-year cycle. Beets, carrots, parsnips, and turnips would live in the ground all winter and grow new stems, leaves, and flowers the second year. But since they are used for food, children do not often have an opportunity to observe the second-year cycle. During the first-year cycle of growth, biennials do not flower and form seeds. This happens only in the second year.

Ways of Working with Children

Many times children will notice changes that are taking place in plants. They will see blossoms on plants in the spring. They may bring in seed pods of milkweed, cockleburs, or colorful leaves that have already fallen off trees in the fall. This gives an excellent opportunity for you to launch a study of how plants are adapted to seasonal change. You will again use concrete illustrations of what is happening in your local environment as a starting point. Later you will help children know about what happens to plants in other kinds of environments.

The best place to study seasonal changes in plants is outdoors. This does not mean taking elaborate trips. A walk around the school grounds, out into a nearby field, or down the road to an orchard is preferable. You can keep going back to the same places to study plant changes as each season progresses. You can see the place where separation layers are being formed, notice leaf and flower buds all winter, see new growth come in the spring, and observe fruit or seeds form on trees as seasons pass. You can have a school garden or visit one in the neighborhood and learn about how plants change with the seasons.

If your school is in a city where it is difficult to have outdoor gardening experiences, you can grow garden plants in window boxes in your room. No matter where your school is located, it is possible for children to have some firsthand experiences with growing plants.
You can help them have this experience by providing the opportunity to plant beans, beets, and other vegetables, indoors or out.

Do not encourage children to bring wild plant seeds or flowers or twigs indoors. Enjoy beauty where it is. Get in the habit of going out to the garden, over to the park, or down to the pond to enjoy various stages of plant life. Conservation of plants is important. Help children grow in awareness of their responsibility to conserve by enjoying plants where they are, rather than to destroy them by picking or breaking or pulling them up and bringing them indoors. Upon rare occasions when conditions outdoors do not permit careful scientific study, one branch or seed or plant may be brought indoors. The children should, in this case, however, understand why you departed from the usual practice of studying plants where they grow.

Try to arrange to show as many of the films and filmstrips listed on pages 44–45 of the Manual as possible. A film never substitutes for good teaching; correctly presented, however, it effectively supplements good teaching. Careful discussion with children beforehand of the contents of the film and the reasons for seeing it, and an evaluation afterward are steps in the effective use of films in your classroom.

If you have a camera, the children will enjoy having you take pictures of plants throughout the year. These might be used on the bulletin board or as a sort of plant calendar or diary in a booklet entitled “Plants and the Seasons.” Pictures drawn by children might be used in the same way.

**Materials Needed**

- blueprint paper
- cardboard, 2 pieces, 6 to 8 inches square
- dishpan
- flowerpots or other containers for planting seeds
- glass, 2 pieces, 6 to 8 inches square
- seeds, vegetable, and fruit and shade tree
- soil

**Things to Think About and Do**

Suggestions for teachers corresponding to those for children, pages 47–49, *Discovering with Science*.

1. Be sure to soak acorn or chestnut seeds overnight if you plant them. This softens the outside skin. Tree seeds are not so easy to
grow as vegetable seeds. Plant enough of them so that some will surely grow. Detailed help will be found in Play with Trees by Millicent E. Selsam listed in the bibliography on page 44 of the Manual.

2–3. If you examine leaf and flower buds on trees nearby, you can go out to see them at different periods of the year. Mark branches which you intend to watch. Let children draw what they see.

4. Purchase blueprint paper at a camera shop. Because the paper has been chemically treated, it must be carefully kept in a dark place until you are ready to use it. Placing separate sheets inside a large magazine works well. Then you can take one piece out as you need it. Directions given on page 48 of the textbook should be followed carefully. The drawing above illustrates exposure to sunlight, washing, and finished print.

5. The illustrations on pages 49 of the textbook and 43 of the Manual indicate the way children’s charts might look. However, allow children to design their own if they desire. Be sure they are accurate in their choices.

6. The annual plant must depend on one year’s crop of seeds to perpetuate the species.

7. Perhaps the custodian already has a compost heap that you can see. If not perhaps you can help start one. Be sure that you talk to him before you send your children to him. He will need to understand just what the nature of his co-operation is to be.

Further Activities

1. Divide your class into four groups, and have each one do a mural painting of your schoolyard during one of the seasons.

2. The groups might keep a written record of changes they see in plants as each season passes. Again, one group of children might record “Changes We See in the Trees.” Another might record “Changes We See in the Garden.”
3. There may be an opportunity for your children to have an outdoor garden or flower bed. This would be an important activity that would permit children to become actively aware of seasons as they affect plants. Such activities as determining hours of daily sunlight, temperature of the soil and air, amount of rainfall, kinds of soil, and need for fertilization would greatly enhance children’s opportunities to learn.

**Evaluation**

To evaluate what children have learned from reading the chapter on "Plants and the Seasons" you will first think "What learnings are there to be gained?" They might be stated in some such way as:

- Seasons greatly affect plants on the earth.
- Plants become adapted to seasonal change.
- Some plants become adapted to warm climates.
- Some plants become adapted to great changes in climate.
- Some plants live only one year, some live two years, and some live many years.
- Plants that grow in a certain environment have become suited to growing in that place.
You will also observe, of course, whether your children are growing in ability to express their ideas clearly, think scientifically, and work with others in a more mature manner.

Another important observation to make pertains to children's conscious effort to enjoy their environment without disturbing it. Watch to see if children (1) appreciate the effects of seasonal change upon plants, (2) understand that plants become adapted to living where they are, (3) take responsibility for caring for plants in their local environments.

Bibliography

For the Teacher


For the Children


Films

FLOWERS AT WORK. (EBF) 1 reel, b/w. Animation and time-lapse photography show the parts and the physiology of flowers, types of flowers, and methods of pollination.
Growth of Flowers. (Cor) 1 reel, color. Time-lapse photography shows the growth action imperceptible to the human eye.

Leaves. (EBF) 1 reel, b/w. Structure, functions, and types of leaves. The process of food-making is seen in animation.

Life of a Plant. (EBF) 1 reel, color. Shows growth of a flowering pea plant by means of time-lapse photography. Animated drawings reveal processes going on inside plant.

Seasonal Changes in Trees. (Cor) 1 reel, color & b/w. Compressed into a few minutes of film time, this picture presents the seasonal story of the changes in trees.

Filmstrips

Trees and Flowers in the Four Seasons. (EGF) color.

The Woods in Autumn. (EGF) color.

The Woods in Spring. (EGF) color.

The Woods in Summer. (EGF) color.
Where Plants Grow

As you work with the material in the chapter on "Where Plants Grow" you will be aware that the main theme is adaptation. Plants have become adapted to various conditions. These include heat and cold, dryness and wetness, sandy and rich soils, varying hours of sunlight, and fresh and salt water. The fact that plants are found in so many places indicates that they are able to become adapted. Here again they do not consciously "adapt to" conditions. Rather they become adapted to varying conditions.

Although children will have seen plants growing all around them, they will need help in becoming aware of the extensive adjustments and adaptations plants have made for survival. Many plants withstand adverse living conditions for surprisingly long periods. Plants are adapted for living.

The fourth chapter of the text may be used at any time of the year. You might use it following the chapter on "Plants and the Seasons." Or you might use it along with, before, or following the chapter on "How Plants Grow."

Science Meanings for Children

Throughout the chapter "Where Plants Grow" the following science meanings are developed:

- There are many different kinds of plants.
- There is a wide variety of some of these kinds of plants.
- Plants live in many places on the earth.
- Plants have become adapted to the various conditions existing where they live.
- Some plants live in hot, dry places.
- Some plants live in hot, wet places.
- Some plants live where the temperature range from one season to another is great.
Some plants grow fast and reproduce their kind in one short growing season.
Some plants grow slowly and reproduce their kind in one continuous growing season.

Information for the Teacher

You will help your class to become aware that some kinds of plants are to be found in most places on earth. There are plants, such as the arctic poppy, that grow in cold regions. There are plants, such as cactus, that grow in desert regions. There are plants, such as the rubber plant, that grow in the jungle regions.

Within any one kind of plant, such as wheat, or apples, or walnuts, there are a number of varieties. The wheat that grows in Montana, for example, is different from wheat that grows in warmer places. The corn that grows in Canada is not the same variety as that grown in Texas. In order to survive, each variety becomes adapted to the weather conditions that exist where it grows.

The plants that grow on hot dry deserts are adapted to living without much water and to withstanding intense heat. Many of them have thick stems that expand for storage of water inside. The leaves of cactus plants are small. Some varieties of cacti actually have no leaves at all. Since plants lose water through their leaves, evaporation from cactus plants is kept at a minimum, and economical use is made of the water absorbed by the roots.

The roots of cactus plants are adapted to getting every bit of water possible during the short rainy times. Some spread out, while others grow deep down into the ground.

Desert plants remain inactive for much of the year. They can grow fast when rainy times arrive. They blossom and form seeds in a few weeks.

Plants that are suited to living in the jungles are very different from plants that are found on the desert. There is abundant rainfall in jungles. It rains part of almost every day, and it rains all year around. Lush green growth is characteristic of tropical jungles. Many of the plants that thrive there grow tall and close together. They have large leaves arranged for catching as much sunlight as possible.

Plants living in jungles are adapted to giving off moisture rapidly. The water inside these plants evaporates readily through their
broad leaves. In this manner jungle plants are able to survive the wet conditions that prevail where they grow. Orchids, rubber trees, giant ferns, and palms are examples of plants adapted to surviving jungle conditions.

It is important to know that there are many, many kinds of plants that thrive in temperate climates. They include a great many kinds of grains: wheat, rye, oats, barley, buckwheat, and corn. They include many kinds of fruit: plums, grapes, apples, pears, peaches, and cherries. They include a great many kinds of vegetables: peas, beans, potatoes, lettuce, celery, onions, and asparagus.

Farmers plant the kinds of crops that will mature during the growing season where they live. Some plants take a long time to grow. Others grow more rapidly. Farmers know about how long the growing season is for their vicinity. They select the kinds and varie-
ties of plants that can mature during that time. When frosts come, the growing season is over. The water in plants freezes at that time.

Weather conditions at different elevations on a mountain vary considerably. Down at or near sea level, temperature and rainfall may be suitable for grass and trees and many other plants. Higher up the side of the mountain, as the temperature and soil conditions change, the variety of plants decreases. Finally there is the timber line. This is a region above which trees cannot grow. Most evergreens do not grow well above an altitude of two miles or so. Above the timber line only a few small plants, such as lichens and mosses, can grow.

Mosses and lichens are adapted to grow in places where there are extremes of temperature. Since they can withstand not only intense heat but also intense cold, they are found above the timber line in many places.

Children may not associate plant life with water. Yet the waters of the earth, both fresh and salt, sustain a great many plant varieties. The seaweeds thrive in salt water because they are adapted to conditions of life that maintain there. Iodine kelp, the giant seaweed of the Pacific, grows to the tremendous length of several hundred feet. Smaller varieties of seaweed grow in the Atlantic Ocean.

The Gulf Stream abounds in plant life. Sargassum weeds are brown algae that live attached to rocks along the West Indies and Florida coasts. Each year as these plants are torn away by storms, they float out into the Gulf Stream and then drift northward toward the Sargasso Sea. Plants that reach the Sea live on almost endlessly. As parts of the plants break off they form new plants. They need no roots or hold-fasts for attachment. It is estimated that some ten million tons of seaweed grow in the Sargasso Sea.

A variety of plants live in fresh water. Fresh-water plants found rather commonly include pond lilies, elodia, eel grass, duckweed, water cress, water hyacinth, bladderwort, pitcher plant, plantain, sundew, cattails, and bog moss. The pictures on page 61 of Discovering with Science with the key illustration in the Manual will help identify some of these plants. Many of them have long waving stems with roots that attach to the bottom and flat leaves that float on the top of the water. Some that grow on the shore line, like the cattails and plantain, have spikes or stems that are partly under water and partly above it.

Algae, the green scum often seen on fresh water, are microscopic plants. They are visible only because there are so many millions of them. Algae often form in the schoolroom aquarium, especially if the aquarium is in a place that receives a great amount of sunlight.

Ways of Working with Children

Many children of today travel about from place to place a great deal. It may be that your children have had interesting journeys to parts of the earth that represent widely different conditions. If so, you may capitalize on these journeys by asking the children to tell their experiences. You will encourage them to describe the kinds of weather they encountered and what kinds of plants they saw growing.

When you have exhausted these individual experiences, have the children read those of other children whose travels are described in Discovering with Science, pages 52–61. These descriptions will bring out facts related to adaptation of plants for living in hot dry places, in jungles, in frozen deserts, in temperate climates, and in fresh and salt water.

Trips to nearby places to see plants that grow under a variety of conditions will be worth while. Through questions that promote thoughtful observation you will lead children to an awareness of differences in plants that live under different conditions. Some have broad leaves. Others have thick stems. Some have shallow roots. Others have deep roots. Some grow in sandy soil. Others grow in rich dark soil. Children can broaden their understanding of conditions necessary to life if you help them by the questions you ask.

Sometimes you may put a few leading questions on the blackboard. Then ask the children to read in Discovering with Science to find the answers. Do not attempt to read the entire chapter at once. Study it part by part. Allow ample time to explore children’s ideas.

The pictures in the chapter “Where Plants Grow” will stimulate discussion, too. Allow time to study them thoroughly. Encourage children to look for pictures appropriate to this study for the bulletin board. Discuss the contents of these pictures, too.

Throughout the chapter there is evidence that plants are persistent living things. They grow in a bit of earth, in the cracks of rocks, on top of high mountains, deep down in the water. If you come upon plants growing in unusual places, bring them to the attention of the
class. They will then become more aware of the persistence and adaptability of plants.

Materials Needed
daily newspaper giving local weather record
thermometer

Think and Talk about These Things
Suggestions for teachers corresponding to those for children, pages 62–63, Discovering with Science.

1. You might write on the chalkboard the names of a few common plants that grow nearby. Make a second list of those that could not grow there. This device might help children stick to the discussion of how plants differ in different places.

2. Discussion of leaf, stem, and root structure would be important to stimulate thinking about how the desert and water plants differ. Water plants must be able to get oxygen from the water. Desert plants get oxygen from the atmosphere around them. Roots of water plants do not always need to be in soil, as desert plants do.

3. Daily temperature records are given over the radio and in the newspapers. Keeping a record of temperatures for a short while helps children see that temperatures change as seasons change, and also brings out the relation of plant growth to freezing times.

4. Here again records of seasonal high and low temperatures will lead children to want to write the local weather bureau for the record high and low temperature of the last ten years. Farmers must know the length of the growing season and the extremes of temperature in their areas before they can choose what crops to grow.

5. The weather bureau keeps a record of rainfall for each area. This information helps the farmer choose his crops more wisely. Ask one child or group to get from the weather bureau information regarding rainfall in your area.

6. Plantain grows in shallow water; saguaro in the desert; arctic poppies in cold northern climates; iodine kelp in the Pacific; fir trees in temperate climates.

7. Have children use the symbols being used in the picture at the top of page 63 of the text or adapt ones of their own. Use the daily paper for temperature records and rainfall data.

8. Annual amount of rainfall is important, but the distribution
of it throughout the year is significant, too. In places where the rainfall is spaced rather evenly, the kinds of plant life are different from those where there are predominantly rainy and dry seasons. Man changes these conditions affecting plant growth when he irrigates the fields.

9. Take temperatures of air and soil in different parts of the yard, e.g., in the sunniest place, the shadiest place, the wettest place, the driest place. Then record what plants are growing in each of these places. These records could help you know where to place plants in your garden.

Further Activities

1. Showing one or more of the films or filmstrips listed on pages 54–55 will help enlarge children's concepts about where plants grow.

2. Reading from several books listed on page 54 will stimulate discussion, experimentation, and thinking.

3. Invite adults to come and talk to your class about plants. The 4-H Club leader and the Agricultural Extension agent are sometimes available. Or you might invite a person who has traveled widely and perhaps has taken movies or still pictures to show your class what faraway places are like.

4. If possible, help the children to grow plants under a variety of conditions so they may observe what happens. If planting must be done indoors, you may use wax paper cartons, florist plant jars, and odds and ends of containers. Have sandy soil for some planting. Use rich soil for others. See that some plants are watered more than others. Have the children place some plants in the dark and keep others in the sunshine. See that they keep a record of what happens as they experiment. Be sure they read to verify their ideas as to why things happened as they did.

Evaluation

The teacher should have as her goal, in addition to the acquisition of facts: (1) the development of meanings, such as the effects of climate on plant life; (2) the development of an appreciation of the interrelationships of science and everyday life; (3) the development of the habit of scientific thinking. Such developments depend upon the acquisition of facts; but the facts are learned because they are essential to the realization of these broad over-all values.
Sometimes listing on the chalkboard the understandings which children say they have gained helps emphasize the meanings which the chapter "Where Plants Grow" attempts to fix. Compare their list with "Science Meanings for Children" given on pages 46-47 of the Manual.

Bibliography

For the Teacher


For the Children


Schneider, Herman and Nina.  *Plants in the City*.  The John Day Company, 1951.


Selsam, Millicent E.  *See through the Jungle*.  Harper & Brothers, 1957.


Films

**Arctic Borderlands in Winter.**  (Cor) 1 reel, color & b/w.  Adaptations of plants and animals to an environment of unusually difficult living conditions is dramatically shown.

**Life in an Aquarium.**  (YAF) 1 reel, b/w.  Explains how fish breathe under water; that all animals need oxygen.

**The Seashore.**  (Barr) 1 reel, color & b/w.  Pictures plant and animal life found at seashore and its adaptation to the habitat.  Shows sea animals and plants in tidal pools.
What Is Soil? (IF) 1 reel, b/w. Emphasizes that while soil is essential to all living things, they in turn, after their life is done, contribute to the formation of soil.

Filmstrips

A Vegetable Garden. (EGF) color.
How Living Things Respond. (Curr F) color.
Life on the Desert. (SVE) b/w.
Plants and Animals. (SVE) 4 filmstrips, color: Of the Mountain, Of the Desert, Of Swamps and Marshes, Under the Sea.
Plants in Home and School. (EGF) color.
Plants in My Garden. (EGF) color.
Plants in the Park. (EGF) color.
The Earth

Children are interested in their earth, its size, shape, and motions, and how these factors affect them. The earth is part of children’s environment just as surely as are animals and plants. The explorations children have been making of their world started long before they came to school. The purpose of the chapter “The Earth” is to extend children’s concepts about their planet.

Teachers have but to listen to casual conversations of children to learn of their interest in the earth. They wonder about many aspects of the phenomena they see about them. They wonder what causes day; what causes night; how the earth travels. Adults often learn that some children have misconceptions about their planet. Study of “The Earth” should help children clear up any false impressions they may have. The chapter may be studied during any part of the year.

Science Meanings for Children

The following meanings are ones which the chapter “The Earth” attempts to develop:

The earth is round.
The earth spins on its axis once each twenty-four hours.
The earth travels once around the sun in about 365 days.
The spinning or rotation of the earth causes day and night.
The revolution of the earth around the sun causes our year to be about 365 days long.
The inside of our earth is hot in many places.
Geysers, hot springs, volcanoes, earthquakes, all help us to know about the inside of our earth.

Information for the Teacher

The children will have learned that the earth is round. Actually it is not exactly round. It is slightly flattened at
Planets in the solar system:

- Jupiter
- Saturn
- Neptune
- Uranus
- Earth
- Venus
- Mars
- Pluto
- Mercury

Orbits and times:

- Jupiter: 248 years
- Saturn: 165 years
- Neptune: 84 years
- Mercury: 88 days
- Venus: 225 days
- Earth: 365 days
- Mars: 687 days
- Sun: 295 years
both poles. But for children’s purposes it is entirely proper to speak of the earth as round.

You will want to build the concept of space and distance as children think and talk about the earth. The earth is 25,000 miles in circumference at the equator. It is about 8000 miles in diameter. These figures will not mean much to children until you develop them a bit. Perhaps someone in your class has had a trip that was a thousand miles long. Then twenty-five such trips would be the length of the trip around the earth. Talking about how long it takes an airplane to circle the globe today and how long it took early explorers like Sir Francis Drake and others to make the trip will also help children feel the meanings of distance and space.

You will also need to know that the earth is not the only object traveling around the sun. There are eight other planets, each traveling in an elliptical orbit. The earth is approximately 93 million miles away from the sun. Two of the other planets are nearer the sun. They are Mercury and Venus. The rest are farther away. They are Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. The diagram on page 57 of the Manual shows their relative orbits.

The length of time it takes our earth to travel once around the sun is $365\frac{1}{4}$ days. This time makes an earth year. We call the movement of the earth around the sun the revolution of the earth. We say the earth revolves around the sun once every $365\frac{1}{4}$ days.

Other planets have years, too. Some planets make the trip in a shorter time. Mercury, for example, requires eighty-eight days. So Mercury’s year is only eighty-eight days long.

The rotation of the earth on its imaginary axis profoundly affects the life upon it. Once each twenty-four hours the earth spins completely around. We speak of this movement as rotation. The rotation of the earth marks the length of our day and night. At the equator, day and night are of equal length. As one moves away from the equator days and nights are not of equal length. Days are longer in summer and shorter in winter.

The earth rotates from west to east. When you use the globe, be sure you help children rotate it in the correct direction. The question of time is tied into this rotation from west to east. Places east of any given point see the sun rise earlier. For each fifteen degrees of longitude there is one hour’s difference in time. Traveling around the earth eastward, one loses an hour every fifteen degrees of longitude.
Traveling westward one gains an hour every fifteen degrees of longitude. To ensure a consistency in the reckoning of time at various degrees of longitude, zones, or belts, have been established around the earth. In North America there are four time zones: Eastern, Central, Mountain, and Pacific. For information concerning time at various locations, you may consult the map on page 75 of Discovering with Science, which gives the time zones for the United States, and the world map below, which shows the time zones around the world.

To meet local needs, half- and quarter-hour zones have been set up.

Regarding the inside of the earth we have yet a great deal to find out. But observations that have been made give us something to go on. Samples from deep mines and oil wells have been brought to the surface and studied. Geysers and hot springs make us know that at least parts of the inside of the earth are very hot. Volcanoes and earthquakes tell us also that rocks deep inside the earth become hot enough to melt and move about.

Scientists believe that the interior of the earth is very hot. Temperature readings taken from borings increase at the rate of approximately 1° F. for every 60 feet as the earth is penetrated. This rate probably does not hold near the center of the earth. The core of the
earth is thought to be nickel-iron in a semirigid mass. Geologists believe the center of the earth is very hot.

The pools of molten rock materials which form inside the earth are known as magma. It is hot enough to flow and it moves upward in its flow.

Pockets of natural gas are often found near pools of magma. Oil is found in porous rock materials, also.

**Ways of Working with Children**

It is our belief that focusing attention upon specific questions to be answered before sending children to their books ensures more careful attention to the printed page. They approach their reading material with greater purpose. They want to find information relating to their questions.

For this reason it would be wise for you to allow rather free and rambling conversation to flow back and forth as children begin their study of the earth. As they talk they will reveal correct conceptions as well as incorrect impressions. Be alert to both aspects of their present learning. After a time, begin to help them sharpen, first, what they already know with some degree of certainty, and, second, what they do not know and wish now to try to find out. A typical list of questions asked by nine-year-olds follows:

1. What is the earth like way inside?
2. How do scientists learn about the inside of the earth?
3. How do we know the earth is round?
4. Why doesn’t the earth stop spinning and revolving?
5. Why do we have day and night?
6. Why is a year $365\frac{1}{4}$ days long?

This list of questions and others your children will ask will help you get started. Each child might make himself responsible for trying to find information about one question as he reads. Children then go to the book *Discovering with Science* with a real purpose. They read to learn!

We have found that making the transition from story material to straight factual material is difficult for many children. Early reading experiences are with story material that goes forward around an interesting plot situation. Factual material has no plot. The reader must concentrate upon getting the facts. This type of study reading
is often difficult for children to handle. By using questions like the ones mentioned above, children’s interest and attention are stimulated. Creating a desire to read to find out is the emphasis that seems to be appropriate here, as in all factual reading.

Not all of your children will read equally well. Some may have made a slower start in learning to read than others. You know which of your children read rapidly and which ones read more slowly. The children who read slowly should be responsible for questions answered early in the chapter. Those who read more rapidly can take questions answered farther along in the text. Through thorough discussion those children who read more slowly will learn from others who can cover all of the assignment.

Discussions about the earth will be made clearer by frequent use of the globe. Encourage children to use it as they explain the movements of the earth. Doing the experiments suggested on pages 69, 70, and 71 of the text will aid children in really understanding rotation and revolution and their effects.

If you have no globe, let the children dramatize the movements of the earth. One child can be the sun, and another the earth. While the “earth child” keeps spinning round and round, have him also keep walking around the “sun child.” Be sure he spins from west to east just as the earth spins.

Children will need help in understanding time belts. For convenience these time belts have been established where they are. Actually there is not an abrupt one-hour difference in time at these exact places. As the earth rotates there is a difference in sunrise and sunset time with each degree of longitude. But since it would be awkward and complicating for people living within the same city, for instance, to operate on different times, arbitrary time zones have been established. Make considerable point of this as you use the map on page 75 of Discovering with Science.

Sometime during this study you should try to show the film listed on page 65 of the Manual entitled What Makes Day and Night? It will clarify greatly the children’s concepts of rotation of the earth. Full, free informal discussion of the film may indicate that some points still need to be clarified. If this is so, a reshewing of the film might be desirable. Educationally this second showing may be extremely valuable. As children see the film again they look for details they missed in the first viewing. A good film usually improves in
value with the second showing. Other films and filmstrips listed may serve as substitutes for "field trips around the earth."

On pages 72 and 76 of the textbook the children are asked to find out time relationships between several places. For your convenience in checking the accuracy of their work, the following chart has been included:

<table>
<thead>
<tr>
<th>When It Is:</th>
<th>It Is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00 A.M. in St. Louis, U.S.A.</td>
<td>12 NOON in Paris, France</td>
</tr>
<tr>
<td>8:00 P.M. in London, England</td>
<td>10:00 A.M. in Fairbanks, Alaska</td>
</tr>
<tr>
<td>12 NOON in San Francisco, U.S.A.</td>
<td>12 MIDNIGHT in Stalingrad, Russia</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>When It Is:</th>
<th>It Is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 MIDNIGHT in Memphis, Tennessee</td>
<td>10:00 P.M. in Seattle, Washington</td>
</tr>
<tr>
<td></td>
<td>11:00 P.M. in Albuquerque, New Mexico</td>
</tr>
<tr>
<td></td>
<td>1:00 A.M. in Buffalo, New York</td>
</tr>
</tbody>
</table>

Materials Needed

- baseball
- bowl or pan
- chalk box or other square object
- flag, small paper
- flashlight
- globe or big ball
- map of North America showing time zones
- modeling clay or gum
- paper bag
- tin can
- top

More for You to Talk About and Do

Suggestions for teachers corresponding to those for children, pages 84–85, Discovering with Science.

1. The sun rising in the east and setting in the west made it appear that the sun moved around the earth rather than that the earth moved around the sun.

2. The earlier peoples believed (1) the earth was flat, (2) there were serpents out at the edge of the earth to gobble anyone up who traveled that far, (3) the earth was held up by a strong man, a turtle, or an elephant.

3. No comment needed.

4. Jane's radio should be tuned in at 5:00 P.M.

5. The earth has gone around the sun as many times as each child is old, plus the part of the year since the latest birthday. If the child
is eight and a half, then the earth has made eight and a half revolutions.

6. A description of how to do the experiment is given on page 70 in Discovering with Science.

7. The shadow the sun dial triangle casts on the dial denotes the time.

8. No comment necessary.

9. No comment necessary.

Further Activities

1. Perhaps a group of children might like to make several clock faces. Each clock might be placed on a time-zone map indicating the comparable time in each zone. The maps on page 75 in the text and page 59 of the Manual will be helpful.

2. One group might try to find out about the oil that is being pumped from under the Pacific Ocean along the western coast of North America. Ownership of tideland oil has been a subject of great concern. See what the class can learn about this question.

3. Individuals might try to find out as much as they can about any of the following volcanoes and report their findings to the class: Vesuvius, Parícutin, Mauna Loa, and Krakatau.

4. Others might try to find as much as possible about the following geysers: Old Faithful, Giant, Giantess, Excelsior, and Castle in Yellowstone National Park; or the Great Geyser in Iceland; or the North Island, New Zealand geysers. Reports could be given to the class.

5. Facts about other planets in our solar system, such as their size, distance from the sun, and lengths of their day and night and year, would be interesting subjects for reports.

6. Perhaps a group could construct an oil derrick from a toy building set. It would be fun to make several derricks and set up an oil field.

7. Someone might read about the Big Inch pipeline that brings oil from Texas and the Southwest to the northeastern part of North America.

Evaluation

The underlying purpose of the chapter on “The Earth” is to give children a feeling of the vastness of the planet on which they
live and something about what is inside it. Sometimes it is helpful for children to make a list of their learnings. Such a list might include the following:

1. The earth is round.
2. The earth spins around once every twenty-four hours.
3. The earth revolves around the sun.
4. Day and night are the result of the earth spinning.
5. A year is the time it takes the earth to revolve once around the sun.
6. The inside of the earth is very hot.

Another way to evaluate learnings might be to make a list of what people long ago believed to be true and then ask your children how they could prove that these beliefs are not true. Beliefs such as that the earth is flat, that the sun goes around the earth, and that there are serpents at the edge of the earth are examples of early beliefs now known to be false.

It is important to listen to children's informal conversations. Frequently they reveal a child’s feeling of confidence or lack of it in the orderliness of the happenings of the universe. You will be alert to ascertain whether your children have such assurances as:

Day will surely follow night.
Spring will surely follow winter.
Many plants that look dead in winter start growing in the spring.
The world is not going to come to an end in any foreseeable future.

There is no need to fear such a thing when others talk of it.

Bibliography

For the Teacher


For the Children


Films

**The Story of Time.** (Cornell) 1 reel, color & b/w. The story of man's ingenuity and inventiveness in devising ways and means, and instruments for the measurement of time.

**What Makes Day and Night?** (YAF) 1 reel, b/w. Demonstrates the alternation of day and night as caused by the rotation of the earth.

Filmstrips

**About Our Earth.** (Curr F) color.

**Day and Night.** (YAF) b/w.

**Day and Night.** (FH) b/w.

**How Our Earth Began.** (Curt F) color.

**How We Think Our Earth Came to Be.** (JH) b/w.

**Night and Day.** (UW-Educ) color.

**North, South, East, and West.** (JH) color.

**Our Changing Earth.** (Curr F) color.

**Our Earth in Motion.** (JH) color.

**Our Earth Is Moving.** (Curr F) color.

**The Story of Glaciers.** (SVE) b/w.

**The Story of Ice and Glaciers.** (EBF) color.

**The Story of Mountains.** (EBF) color.

**The Story of Volcanoes.** (EBF) color.

**Up and Down.** (JH) color.
The Air We Live In

Everyday experiences of children often reveal to them the fact that air surrounds them. They feel the air in motion in the wind. They know how hard wind pushes on them as they walk along the street on a windy day. They see the branches of the trees sway in it.

Children know that they breathe air. They know that air is necessary to life. They know that all animals breathe air. Many children wonder how far the air extends out into space. They wonder how high airplanes can fly into the air. They wonder what keeps the air down to the earth. They wonder what air really is.

You will find it stimulating to let children talk freely about this ocean of air that is all around the earth. They will ask questions. These questions, together with your own ideas, will point the way for the study of "The Air We Live In."

Science Meanings for Children

- Air is an invisible, odorless, tasteless mixture of gases which surrounds the earth.
- All living things need air.
- Air presses against all sides of everything it touches.
- Man has learned many ways to use this air pressure.
- Moving air helps to keep us comfortable.

Information for the Teacher

Having in mind the following facts will be helpful as you work with children on the chapter about air:

- Air surrounds the earth. It forms a blanket that goes all around the earth.
- The air extends out into space for 10,000 miles or more. No one knows just how far air extends.
The air is thicker near the surface of the earth. It gets thinner and thinner as one goes farther out into it.

Aviators who fly high into the air need to wear oxygen helmets in order to breathe normally.

Gravity holds the air to the earth.

Air is necessary to all plants and animals.

Air is a mixture of gases. About one fifth of the air is oxygen. About four fifths of the air is nitrogen. There are also some carbon dioxide, dust, and water vapor, and a little neon and other rare gases in the air.

Fire uses oxygen when it burns.

Air expands when it becomes warm.

Warm air is pushed up by heavier, cooler air. This movement of air causes wind.

Air presses against everything at sea level with a pressure equal to about fifteen pounds on each square inch.

Air can be compressed a great deal. Compressed air is used in automobile tires, bicycle tires, and air brakes on trucks and trains.

Every day of their lives children are having experiences with air; but because air is invisible, they observe and question little about it. It is the purpose of the chapter "The Air We Live In" to furnish children with experiments to do and with information about the atmosphere that will make them aware of this factor of their surroundings and the importance of it.

Many areas of science lend themselves readily to experimentation. The study of air offers rich possibilities for children to learn through experimenting. The firsthand experiences described hereafter offer other ways by which children may learn about the world around them.

We believe that the more experiences children have at firsthand with science, the better their learning will be. Therefore, in those areas where experimentation can be done by children, we recommend that you allow them the pleasure and thrill of learning the truth by trying things out for themselves. This does not mean that they may not need your help. On the contrary, they probably will need some assistance. However, it is important that children do as many of the experiments as they can by themselves.
One caution is necessary for all teachers at this point. Children often draw incorrect conclusions about what happens in an experiment. You will need to be sure that the conclusions they come to are the correct ones.

Most nine-year-olds have used fountain pens. They know that many of these pens are filled by pressing a lever on the pen. Most children will not know the principle involved in filling a pen. Let them listen to the noise the pen makes as it is being filled. Ask them what they think causes the noise.

Before telling them what is inside the fountain pen, let them experiment with an eye dropper or a nose dropper. Let them squeeze the rubber bulb, then release the pressure on it while holding the glass tube in water, and then watch the glass part of the dropper fill with water. Let them force the water out of the glass tube again by squeezing the rubber bulb. Now go back to the fountain pen. Fill and empty it several times. Can the children explain what happens in each case? Of course you know that air pressure is responsible for the result in each case. When you press on the rubber bulb of the dropper, air is sent out of it down into the tube, and some escapes. Then when you release this pressure, the water enters the tube again. This is because there is now less air inside the tube and therefore less pressure inside it. Outside air pressure forces the water into the tube again.

Let the children do all the experiments mentioned in the chapter on "The Air We Live In." All of these can be done easily in your classroom. They require very little equipment. Perhaps someone will be able to bring kitchen or bathroom scales from home, if the school owns none. Piling books on the scale one by one until there are fifteen pounds of books, and then allowing each child to lift the pile will give an experience that will impress itself upon each member of your class. It takes time to give each child his turn, but the time will be well spent. For only by lifting fifteen pounds will they really have the feel of the amount of pressure of the air.

Some simple experiments described in the textbook may leave children completely at sea as to the correct explanations. Some will guess at answers. Many will say, "It's magic." The teacher then has an opportunity to say that magic is not the answer, but that there is a scientific explanation for each phenomenon.

You will always be sensitive to opportunities which experimenta-
tion offers to help children use the scientific method. Too frequently in our teaching we tend to think for the children rather than to allow them to think for themselves. We forget how difficult it is at times to work new ideas into our thinking. We become impatient when children take so long to see a truth that is obvious to us. Let us remember that we cannot push children at this point. They must have time to work new ideas and truths into the fabric of their knowledge and experience. In no other way will the new information really become part of them.

If skillfully guided, as children do experiments they learn constantly to check their own findings and conclusions with those of authorities. Teachers need to lead children to be aware that this careful checking is one of the essentials of the scientific method.

The question "What is the truth about this phenomenon?" is a question which stimulates thinking and discussion. Teachers who help children get at the truth about the things around them are doing those children a great service. They are training them in the method of scientific thinking, which has become so essential to effective promotion of human and material progress.
We have dwelt upon this analytical aspect of experimentation because it is the crux of the whole science-study situation. Little would be gained by merely letting children experiment haphazardly in science. In fact, to do so might encourage careless habits of doing and thinking rather than develop scientific habits. The wise teacher makes use of experimentation to help children work for the best statement of truth by employing critical thinking and the scientific method.

Materials Needed

- balloons
- bottle, quart milk
- bottle, Pyrex nursing bowl
- candle
- cork
- egg, hard boiled
- eye dropper
- fountain pen
- glass, to cover top of wooden box
- matches, long handled, or wooden splinter
- metal pan
- paper bag
- scales, to weigh 15 pounds
- Sterno stove or other source of heat
- thermometer
- tin cans, 2
- tumbler
- wooden box

Some Things to Think About and Do

Suggestions for teachers corresponding to those for children, pages 104–105, Discovering with Science.

1. Sand cuts off the supply of oxygen to the fire.
2. Oxygen is the gas in the air that is used when fire burns.
3. The air inside the balloon expands and the balloon might burst.
4. No one knows just how far out into space air goes. There is thought to be no air on the moon. The gravitation of the earth has probably pulled all of the air away from the moon. It is correct to say the air is around the earth like a blanket. You might also say the air is heavier near the earth than farther out into space.
5. Follow the directions carefully as given on page 105 of the text. A long-handled wooden match may be used for the splinter of wood.
The smoke moves away from the tin can with the candle underneath it. The air moves into the can without the candle. This air is colder air. It is heavier. The smoke shows the direction of the air currents.

Further Activities

1. Perhaps some child might like to make carbon dioxide. He can do so by following these directions: Place about two tablespoons of washing soda (sal soda) in a tall tumbler—the taller, the better. Place the tumbler inside a larger container. Pour half a glass of vinegar, a little at a time, into the tumbler. Cover the container with a plate. Leave it for a few minutes. Test the carbon dioxide by lighting a glowing splinter or a long kitchen match and putting it down into the container. It will go out immediately because the carbon dioxide will not support fire.

2. A barometer measures air pressure. Your school may own one. Some barometers look like thermometers. On these you find the pressure by reading the number beside the column of mercury, or red liquid. Some barometers look like clocks. You read these by observing where the hand points. Many people use red water in a glass swan or bottle with a spout as another kind of barometer. The water rises and falls in the neck of the swan or in the spout as the pressure changes.

Barometers are useful in predicting weather. They forecast weather changes before these conditions actually come to pass. Barometers can forecast weather changes from four to six hours in advance. Dropping pressure usually indicates approaching storms; rising pressure usually precedes fair weather. Children can read barometers several times a day and predict the coming weather. Keeping careful records of readings and weather conditions on a calendar for a month is instructive and interesting.

3. Children like to make use of a siphon when emptying their aquarium. They can use rubber tubing or a piece of garden hose about three feet long. Help them carefully fill the entire tube with water. They should hold their thumbs over both ends of the filled tube. Then put one end down into the full aquarium and the other end down lower so that the water will empty into a pail. When they release both thumbs, the water will flow from the aquarium through the tube and into the pail. Let the children explain how air pressure makes the siphon work.
4. Have the children make a chart showing all the ways they know to put out a fire. The chart might include:

   Roll in a blanket when clothing catches on fire.
   Cover other fires with sand.
   Pour water on the fire.

5. Children might make a list of some of the things air does for us. The list might include:

   Air makes picnic fires burn.
   Air keeps a parachute from falling too rapidly.
   Air keeps us alive.
   Air helps plants stay alive.

6. Children might prove that there is air in water by filling a glass with water and letting it stand for a few minutes. Some of the air in the water will form in small bubbles along the inside of the glass.

7. Each child might hold his breath for a few moments to feel what happens when his body is deprived of air. Air is necessary to life.

8. If the weather is warm, fill a glass with cold water and let it stand long enough to permit the water to condense on the outside. Children sometimes think this water comes through the glass. Help them see that what really happens is that the air around the cold glass becomes cooled. As the air cools the water vapor in it condenses on the outside of the cold glass.

9. Put a thermometer outdoors in the sun. Put another one in a place that is shaded. Have the children read the temperatures and see the difference between the temperature of the air in the sun and in the shade.

Evaluation

Children like to keep records. Since this chapter has been concerned in a large part with helping children to learn through experimentation, it might be fun to make a "Book of Experiments about Air." In this way you will be able to evaluate the nature of their understanding of scientific principles and knowledge. Allow each child to choose what experiment he or she will write about for the book. Help each child to write the story simply and clearly. Perhaps the entire class could write several composite stories to help
set the standard as to organization and clarity. Some of the titles might be:

**Air Takes Up Space**

**Air Expands When Heated**

**Air Presses**

**Air Does Work for Us**

**Carbon Dioxide Puts Out Fires**

If there are mimeographing facilities in your school, such a booklet recording children's experiences could be mimeographed and used as a gift for parents and friends.

Good teaching does not merely consist of **telling** children something. It does not consist only of helping children read the contents of a book. Good teaching helps children have meaningful experiences and to learn through them. So, as you think about your teaching think in terms of what children can do with what they have been learning. Think about how well they carried out activities described in the text. Think in terms of how interested the children are in what they have been studying. Remember that becoming familiar with content in itself is not your goal. The important thing to consider is knowing how this content can be used. Children may need help in seeing the applications of newly acquired science meanings.

**Bibliography**

**For the Teacher**


**For the Children**


**Films**

AIR ALL AROUND US. (YAF) 1 reel, b/w. Classroom demonstrations illustrating concepts concerning air pressure, contraction and expansion of air, and compressed air.

NOTHING BUT AIR. (IF) 1 reel, b/w. A boy learns that, though invisible, air is very real.

SOLIDS, LIQUIDS, AND GASES. (YAF) 1 reel, b/w. Explains the characteristics of solids, liquids, and gases, and identifies the common forms of each.

WINDS AND THEIR CAUSES. (Cor) 1 reel, color & b/w. The great winds of the earth are explained.

**Filmstrips**

THE AIR ABOUT US. (SVE) b/w.

AIR AND ITS PROPERTIES. (YAF) b/w.

AIR AND LIFE. (EGF) color.

ALL ABOUT AIR. (VS) 5 filmstrips, color: What Air Is, What Air Does, What Air Pressure Is, Using Air Pressure, Using Compressed Air.

NOTHING BUT AIR. (EBF) b/w. Instructional Films production.

OUR OCEAN OF AIR. (SVE) b/w.

THE STORY OF THE AIR. (EBF) color.

WHY DOES THE WIND BLOW? (SVE) b/w.

WIND. (FH) b/w.
The Sounds We Hear

It is well for us to keep in mind the tremendous social significance of sound. By means of it communication among the peoples of the earth is possible. By means of it we make our desires, ideas, and needs known to others. With the mechanical aid of telephones, radio, and television we can now communicate simultaneously with one and with thousands of people, nearby and at great distances.

The authors have developed the materials in the chapter dealing with "The Sounds We Hear" largely through a series of experiences or experiments which children in almost any school can easily carry out. We urge you to use these or similar experiences with your class so that the children may learn about sound in concrete and meaningful situations.

Science Meanings for Children

Sound is caused by vibrating objects.

The pitch of sound can be changed by changing the length of the vibrating part and by tightening of that part.

Sound travels in all directions from its source.

Sound travels through gases, liquids, and solids.

Sound travels more easily through some substances than through others.

The ear is the organ through which sounds come to us.

Information for the Teacher

Sound is caused by waves which are produced by a vibrating body and which affect the auditory nerves of the ear.

Sound may be explained in the following way. When you strike a fork briskly against a chalkboard eraser or the rubber heel of your shoe, the prongs of the fork vibrate, or move back and forth. This movement sets the molecules of the air near the fork moving back and forth. These in turn set other molecules of air near them mov-
ing, or vibrating. The vibrations are communicated through the air in every direction and are known as sound waves. The outer ear collects the sound waves and directs them to the eardrum. As sound waves strike the eardrum they cause it to vibrate. Behind the eardrum is a chain of little bones which are set in motion. They in turn set little tubes of liquid vibrating. Inside the liquid tubes are the ends of nerves that lead to the brain. Impulses from these nerves reach the brain. We hear. If the sounds are familiar to us we understand.

Sound travels through air at the rate of about 1100 feet per second. The hotter the air, the faster sound travels. The figure given here is the rate at which sound travels through still air at 45° F.

Sound travels through anything made of molecules, including air, soil, water, and metal. Metal and water are better conductors of sound than air and soil.

Sound waves when reflected produce an echo. Therefore, when an echo is heard, we know that sound waves have been reflected, or turned back to us, by striking a solid object. Often a mountain, a hill, or the side of a tunnel will reflect an echo. Some solid objects reflect sounds better than others. Curtains are used in a school auditorium because they do not reflect sounds well. Instead they absorb sounds and help to stop echoes that make hearing a speaker difficult.

The pitch of a sound is determined by the number of vibrations per second that an object makes. The highest note on the piano is the effect of the most rapid vibration of the wire on the sounding board. Each key on the piano has a different pitch. You can change the volume of the sound by using more energy in striking the key; but you do not change the pitch by so doing.

Ways of Working with Children

It is suggested that you allow your class to do each of the experiments you find in the chapter "The Sounds We Hear." The values of firsthand experiencing are not new to you.

In answering the question "What is sound?" let children experience the feeling of vibration by doing the experiments suggested on page 108 of the textbook. Be sure they feel the vibration of the ruler, of the rubber bands, and of their throats. Let them feel the vibrations made by the ringing of a bell by touching the rim lightly with the finger. Let them feel the tingling sensation when they touch the strings of a violin which is being played. The more actual
vibrations they feel, the better will they understand that sound is made by vibrations.

Children will have fun making the toy tin-can telephone by following the directions on page 120 of the text. They will be surprised to find how well it works. See if they really understand why it works so well. Ask them how the sound travels and where it travels. Let them slacken the string and see if it works as well. Let them hold the mouthpiece a little away from the mouth and see what happens.

We have omitted any experiments with water because of the danger and inconvenience involved. Water is such an excellent conductor of sound that there is danger of injuring one's eardrum by experimenting with sound under water. Children have experienced loud sounds in a swimming pool. Let them tell about them.

All children have experienced echoes. Let them call loudly inside a tunnel, under a bridge, inside a barrel or a large pail, or in a large, empty room like the gymnasium or auditorium. They have heard their voices come back to them. Explain that sound is reflected, or turned back, when it hits a solid object, just as a ball bounces back to your hands when you toss it against the side of the schoolhouse.
Materials Needed

- bell, with clapper
- board, ½" x 2" x 18"
- box, cigar or other wooden box of similar size
- cardboard tubes, 2
- cork
- drum, or piece of inner tube and wooden keg or pail
drumstick
- fork, tuning or kitchen
- nails
- needle and thread
- pan of water
- pebble

More about Sound


1. If you use a tuning fork the experiment will be more satisfactory than with a kitchen fork.
2. The cork moves because the air around it is vibrating.
3. A cricket makes sound by rubbing its legs across a sort of comb. A bullfrog makes sound by letting a column of air out of his throat. A woodpecker makes sound by tapping a tree with its bill.
4. Cellos and harps produce sound as their strings vibrate. Flutes and trombones produce sound when a column of air inside the tubes vibrates. Changes in these sounds are made by lengthening and shortening the vibrating strings and columns of air.
5. Echoes are caused by sound bouncing back from a hard surface to your ears. A hill often reflects sound causing echoes to occur.

Further Activities

1. Invite your music teacher to talk to the class and show them what vibrates in each of the following musical instruments:

   - cello  drums  piano
   - clarinet  flute  violin

78
"Three Blind Mice"

3 2 1
Three blind mice
3 2 1
Three blind mice
5 4 4 3
See how they run
5 4 4 3
See how they run
5 8 8 8 7 6 7 6 5
They all ran after the farmer's wife
5 8 8 8 8 7 6 7 6 5
She cut off their tails with a carving knife
5 5 8 8 8 7 6 7 6 5
Did you ever see such a thing in your life as
3 2 1
Three blind mice

2. Try having the children tap many objects in the classroom and determine the pitch of each.

3. The children might like to make a set of musical glasses. Have them get eight tall glasses of the same size, and tune them to the scale of F on the piano. To do this, first add a little water to one glass. Then add water to each of the other glasses until the pitch of sound when each glass is tapped matches the piano scale of F. Each glass should be tuned to one note of the F scale. The children will
note that the pitch gets lower as water is added to the glass. Let
your music teacher help you, if your school has one. When the scale
is true, let the children mark the correct amount of water for each
glass by pasting a strip of tape on the outside at the water level.
Then if the glass is emptied or some of the water evaporates, the glass
can easily be put "in tune" again by adding water up to the tape line.
Number the glasses from one to eight, beginning with the lowest
note. Encourage the children to play and compose simple tunes on
their musical glasses. It is fun. The illustration shows how to play
"Three Blind Mice" by number.

4. Have the children try this: With their thumbs and forefingers
hold two pieces of paper together on opposite sides about an inch
from one end. Next, part the pieces at this end so that one piece
will cover the upper lip and the other the lower lip. Then blow into
the pieces of paper. They will vibrate with a squeal.

5. If you have a radio in school, suggest that the children put
their finger tips tightly to the plastic window over the dial. Then
turn on the radio. Ask them if they feel anything, if there is a tiny
shaking that goes very fast. Explain that it is vibration that they
feel.

6. If you have a saw blade or a ladies' shoe tree, have the children
try vibrating it against the edge of the table, as was done in the ex-
periment with the ruler described on page 108 of the text. They can
both see and hear the vibrations.

7. The children will enjoy this experiment: Tie one end of a string
around the middle of the handle of a silver teaspoon. Let the spoon
hang freely on the string. Now hold the other end of the string be-
tween two fingers and put it near your ear. Tap the bowl of the
spoon lightly with a pencil. You will hear a beautiful chime like a
church bell.

Evaluation

You might evaluate the learnings children have gained in the
study of sound by looking for the answers to any of the following
questions:

1. What evidences did you see that individual children were able
to read and carry out directions for doing an experiment?
2. What evidences did you see of the scientific method being used,
namely, stating a problem, gathering data, experimenting, observing, trying out, drawing correct conclusions in the light of data gathered and experiments tried?

3. What evidences do you find of individual children carrying on further study of sound on their own initiative, for example, doing other experiments or showing an interest in musical instruments or being more careful about the care of the ears?

4. What concrete instances can you recall in which you had an opportunity to watch children learn the give-and-take of social intercourse through this series of informal experiences? Were there any changes in behavior which indicate greater sensitivity to others?

5. Can the children explain just how the ear picks up sounds?

Bibliography

For the Teacher

For the Children


Films

**WHAT IS SOUND?** (YAF) 1 reel, b/w. An elementary presentation of the nature, source, and transmission of sound waves.

**THE WORLD OF SOUNDS.** (TFC) 1 reel, b/w. The importance of sound and the operation of sound waves on the human ear.

Filmstrips

**THE SOUNDS WE HEAR.** (EGF) color.
**THE WONDER OF THE MOTION PICTURE.** (EGF) color.
**THE WONDER OF THE PHONOGRAPH.** (EGF) color.
**THE WONDER OF THE TELEPHONE.** (EGF) color.
How Plants Grow

Children are usually interested in growing plants. They enjoy watching them grow. It is fun for them to plant seeds and care for the plants that grow from them. It is surprising, however, how many things about plants children take for granted. The chapter "How Plants Grow" will help them expand their present knowledge about this process. This chapter may be studied at any time during the year. If outdoor planting is to be done, most plants would start best in the spring season, and that is the time, too, when children would probably be most interested in working outdoors. If indoor gardening is to be done, this chapter would fit well into the winter science program.

Science Meanings for Children

Following are the main concepts with which the chapter "How Plants Grow" deals:

Plants grow in many ways.
Some plants grow from seeds.
Some plants grow from stems.
Some plants grow from roots.
Some plants grow from leaves.
Some plants grow from grafting.
Some plants grow from spores.

Information for the Teacher

Most children will know that plants grow from seeds. Many will think that all plants grow that way. As a matter of fact, a great many plants do form seeds as they mature. However, not all plants grow equally well from their seeds. Many times parts of the plant other than the seeds grow new plants that are healthier and stronger than plants grown from seeds.
There are not nearly so many kinds of plants as there are kinds of animals discovered thus far. At present we know about 325,000 kinds of plants as against approximately a million described species of animals.

Plants may be classified in several ways. One classification of plants is the seed-bearing group. Many common plants and trees found in any environment belong to the group of seed-bearing plants.

Seed-bearing plants appeared last of all plant groups upon the earth. They are at the top of the plant kingdom. They are divided into two groups, those that flower and those that bear cones. Within any local environment there are usually both kinds to be found.

The pine and spruce and many other evergreens are conifers, or cone bearers. Their seeds form inside the cones.

Among the flowering seed-bearing plants are deciduous trees. Children will need assistance in understanding that deciduous trees really are flowering plants. The blossoms of many of these trees do not have petals and are, therefore, not as conspicuous as the blossoms of most garden plants. The elm, oak, and maple do not have showy petals on their blossoms. The magnolias, horse chestnuts, and dogwoods do have.

Early in the spring the red maples flower. The tiny red flowers open before the leaves do and give the tree a reddish glow. The elm blossoms also open in the spring. They are small purple flowers which children may not even notice unless their attention is called to them. On the other hand, the magnolia, tulip, horse chestnut,
and dogwood will be noticed and appreciated by children who watch them blossom. Many children will have gone to Washington, D. C., especially to see the cherry trees in bloom.

The tiniest plant and the biggest tree may grow from a seed. Size of the plant has nothing whatever to do with the size of the seed. The giant sequoias grow from tiny seeds. Great oaks grow from acorns.

A seed is a wonderful thing. It is made up of a tiny plant, food for the tiny plant, and a seed coat for protection. The tiny plant is called the embryo. No other part of the seed can grow. If anything happens to the embryo, the seed will not produce a new plant.

Plants produce many, many seeds. They produce many more seeds than actually ever grow. Some are eaten by animals or are destroyed in other ways, and some fail to grow because they do not reach a favorable environment.

Seeds of many flowering plants grow inside the fruit of the plant. Sometimes there is only one seed inside the fruit, as in the peach, cherry, and plum. Sometimes there are several seeds, as in the apple, cucumber, and watermelon. The seeds of berries may be on the surface of the fruit, as in the strawberry. A raspberry is a cluster of fruit, as is a blackberry.

Children will need help to understand that the fruit of the plant
is that part where seeds grow. They will think of fruit that grows on trees—oranges, apples, peaches—when you first use the term "fruit." Help them to enlarge this concept. The pea pod is the fruit of the pea plant. The bean pod is the fruit of the bean plant. The tomato is the fruit of the tomato plant. The walnut is the fruit of the walnut tree. The acorn is the fruit of the oak tree. The ear of corn is the multiple fruit of the corn plant formed by a cluster of flowers grouped close together.

New plants can grow from roots, underground stems, above-ground stems or cuttings, leaves, and grafts. Examples of each way of growing new plants are familiar to most adults. A new white potato plant grows out of the eye, or bud, of the underground potato stem. A new onion plant grows from the bulb, or underground stem, of the onion. A cutting from a new variety of rose bush or fruit tree will grow if grafted on an old rose bush or fruit tree. African violets and rex begonias will start new plants from just the leaves.

Some plants belong to a group of plants that do not flower. They produce spores instead of seeds. These plants are reproduced by means of spores. The ferns reproduce in that way. You can see the clusters of spore cases on the underside of many ferns. These spore cases open when they are ready and the tiny, tiny spores scatter in every direction. Each spore can produce a new plant.

Other plants that reproduce from spores are mosses, mushrooms, toadstools, and puffballs. Mold also usually grows from spores.

Ways of Working with Children

"How Plants Grow" is a doing chapter. It consists largely of suggested activities, experiences, and experiments from which children can profit. They can truly learn by doing. Do not have the children just read about planting seeds or bulbs or cuttings. Take time for them to plant and grow these things.

One way that works well is to have small groups of children plant and care for different growing things. One group might plant flower seeds, such as petunias and zinnias. Another group might plant vegetables, such as Lima beans, peas, and carrots. Still another group might plant seeds of trees, such as horse chestnuts, acorns, beech nuts, and so on.

It is important to let children see how seeds grow. Follow the directions given on pages 132–135 of Discovering with Science. These
experiences will give children accurate knowledge about seeds, what they are, and how they grow. They will learn that some seeds grow rapidly and others grow slowly. They will see that the outside seed covering is a protection which slips off as the seed sprouts. They will find out that there is food for the tiny plant inside each seed.

Taking an excursion is an educational experience. If possible go on trips to truck gardens, to greenhouses, and to farms. Talk with the adults there about how various plants grow new plants. As you can see, this can be an interesting chapter, full of activity. Do not hurry through it. Allow children time to do, so that they may learn.

Materials Needed

- blotter
- bread
- cloth, small piece
- cotton, sheet 6 to 8 inches square, or large blotter
- flowerpots, 2-inch, or tin cans
glass, 2 pieces size of sheet of cotton
leaves, e.g., African violet, rex begonia, snake plant, walking fern
moss, ferns, mushrooms, or puffballs
roots, e.g., beets, carrots, dahlia, sweet potato
seeds, flower, e.g., petunia, zinnia; tree, e.g., grapefruit, lemon; vegetable, Lima bean and others, e.g., carrots, corn, onion, peas, potato, pumpkin; grass; cotton soil sponge stems, e.g., forsythia, geranium, ivy, potato, pussy-willow, wintergreen string window box or milk cartons

You May Want to Do These Things

Suggestions for teachers corresponding to those for children, pages 142–143, Discovering with Science.

1. No explanation necessary.
2. A wintergreen plant may be brought into the classroom, too. One is sufficient. Do not bring plants indoors except to study them. Allow them to grow in the out-of-doors.
3. Bring back a fern leaf with spores on it. Put it in the terrarium and watch to see if new fern plants grow. One leaf is enough. Do not disturb the others. Let them grow outdoors.
4. No explanation necessary.
5. Potato balls may sometimes be purchased at a seed store. New plants grow best from cut-up pieces of old potatoes.
6. No explanation necessary.
7. Follow the directions given.
8. Some seeds travel by wings, such as those of the dandelion, red maple, and thistle. Other seeds, such as those of the burdock and sandburs, are carried by animals. Others, such as those of witch hazel, are shot out forcefully when the seed pods open.

Further Activities

1. Take the children to a woods or a park and try to find spores on the underside of fern leaves. Also look for puffballs, toadstools, and mushrooms, all of which grow from spores.
2. Have groups of children make a series of charts to show “bits that grow into new plants.” One chart would show plants that grow
from seeds. Others would show plants that grow from roots, stems, grafts, and cuttings.

3. Have one group prepare a class diary of all the experiments done in relation to the ways plants grow. Other children might draw diagrams and write stories for the diary.

4. Another group might make a chart showing a variety of kinds of seeds in their cases as they grow in the fruit of plants.

5. Suggest that each child keep on the alert to see the blossoms of trees, bushes, and grain that he has never noticed before.

Evaluation

The chapter on “How Plants Grow” offers an opportunity for small groups and individuals to carry on a variety of worth-while activities under their own power. You will watch for clues which indicate the following:

Increasing Interest in the Environment · In this respect you may notice that children really take pleasure in protecting plants they find growing. You will look for increased responsibility in letting plants grow outdoors instead of bringing them inside except for study.

Increasing Interest in Sharing What One Is Learning · Children may want to discuss some of their expanding concepts, such as those concerning conservation, protection, and care of plants.

Increasing Awareness of the Responsibility for Group Enterprises · Children should be learning to work well in small committees. They should become increasingly able to assume constructive leadership of their group. They should also become able to fit into plans arrived at by group consensus.

Increasing Sensitivity to the Method of Scientific Experimentation · Children should learn to work with increasing carefulness on a project. This includes giving attention to ways of arriving at answers.

Increasing Attention to Accuracy in Observing and Recording Data · Do children become better able to see with accuracy the fundamental truths which are around them? Do they take responsibility for reporting and recording these truths accurately?
Increasing Skill in Use of Books to Check Accuracy of Conclusions. Do children constantly refer to accurately written material to verify their conclusions? In instances of disagreement concerning a point of accuracy, do they voluntarily refer to authoritative sources to settle their differences?

The study of science should influence behavior. How is science helping your children work more accurately and in more responsible ways?

Bibliography

For the Teacher


For the Children


Schneider, Herman and Nina. *Plants in the City*. The John Day Company, 1951.


Films

FLOWERS AT WORK. See listing for Chapter III.

FUNGUS PLANTS. (EBF) 1 reel, b/w. Reveals major types of mushrooms and other fungi, and describes their growth and method of reproduction.

GARDENING. (EBF) 1 reel, b/w. Explains how seeds start new plants, and how plants manufacture and store food.

THE GROWTH OF FLOWERS. See listing for Chapter III.

LIFE OF A PLANT. See listing for Chapter III.

ROOTS OF PLANTS. (EBF) 1 reel, b/w. Describes tap, fascicled, and fibrous roots, and explains how they hold the plant in place as well as absorb food elements from the soil.

SEED DISPERsal. (EBF) 1 reel, b/w. Shows ways the seeds of plants are scattered in order to insure the propagation of the species.

Filmstrips

HOW FLOWERING PLANTS GROW AND REPRODUCE. (SVE) color.

HOW TREES GROW. (PDP) b/w.

IDENTIFYING COMMON TREES. (SVE) color.

PARTS OF A FLOWERING PLANT. (Curr F) color.

TREES—THE OLDEST AND LARGEST LIVING THINGS. (PDP) b/w.
Learning about Animals

There are many, many kinds of living things. The chapter "Learning about Animals" tells about one large group of living things. There are many more known kinds of animals than plants. These two large groups, animals and plants, make up all living things upon the earth. You may wish to have the children study this chapter just before or just after they have studied "How Plants Grow." It might also be used along with the chapter on "Animals and the Seasons." However, the chapter stands as a complete section and may be used at any time during the year.

Science Meanings for Children

The following science meanings are developed in the chapter "Learning about Animals":

There are many, many kinds of animals.
Animals are alike in some ways; animals differ in some ways.
Some animals have no bones; they are soft-bodied animals.
Some animals have soft bodies inside hard coverings.
Some animals have bones. The backbone and bones attached to it make up the skeleton of these animals.
Animals may be divided into groups. These groups include mammals, birds, amphibians, reptiles, fish, and insects.
Some animals are one-celled animals. Others are many-celled animals.
Mammals, amphibians, reptiles, and fish are vertebrates.
Vertebrates are animals with backbones.
Insects do not have backbones.
Invertebrates are animals that do not have backbones.

Information for the Teacher

You will enjoy more working with your children in their study of animals if you have in mind certain basic information.
The Manual and Discovering with Science will furnish you not only with the essential facts, but will help you to enlarge upon the important ideas. The chart on "Groups of Animals" provides background information for you. It is not to be used with children.

In guiding children's experiences with animals, you will endeavor to extend and enrich their understanding of variety, change, adaptation, and interrelationship of animals to their environment.

**GROUPS OF ANIMALS**

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Number of Described Species</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protozoa</td>
<td>One-celled animals</td>
<td>20,000</td>
<td>Amoeba, paramecium</td>
</tr>
<tr>
<td>Porifera</td>
<td>Sponges</td>
<td>3,000</td>
<td>Fresh-water sponges, bath sponges</td>
</tr>
<tr>
<td>Coelenterata</td>
<td>Two-layered bodies</td>
<td>10,000</td>
<td>Hydra, jellyfish, coral, sea anemone, sea fan</td>
</tr>
<tr>
<td>Ctenophora</td>
<td>Comb jellies</td>
<td>100</td>
<td>Comb jellyfish, walnuts</td>
</tr>
<tr>
<td>Platyhelminthes</td>
<td>Flatworms</td>
<td>7,000</td>
<td>Planaria, tapeworms</td>
</tr>
<tr>
<td>Nemathelminthes</td>
<td>Roundworms</td>
<td>3,000</td>
<td>Hookworm</td>
</tr>
<tr>
<td>Rotifera</td>
<td>Wheel animals</td>
<td>1,800</td>
<td>Philodina</td>
</tr>
<tr>
<td>Bryozoa</td>
<td>Moss animals</td>
<td>3,000</td>
<td>Vulture-headed moss animal, comb moss animal</td>
</tr>
<tr>
<td>Brachiopoda</td>
<td>Lamp-shell animals</td>
<td>130</td>
<td>Magellania</td>
</tr>
<tr>
<td>Annelida</td>
<td>Segmented worms</td>
<td>7,000</td>
<td>Earthworms, leeches</td>
</tr>
<tr>
<td>Echinodermata</td>
<td>Spiny-skinned animals</td>
<td>5,000</td>
<td>Starfish, brittle star, sea urchin, sea lily, sea cucumber</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Soft-bodied animals</td>
<td>78,000</td>
<td>Snails, slugs, limpets,whelks, oysters, clams, mussels, scallops, squids, octopi, devilfish</td>
</tr>
<tr>
<td>Arthropoda</td>
<td>Jointed-footed animals</td>
<td>700,000</td>
<td>Crayfish, shrimps, lobsters, crabs, centipedes, millipedes, grasshoppers, crickets, praying mantes, termites, ant lions, dragonflies, bird lice, true bugs, cicadas, aphids, beetles, caddis flies, butterflies, moths, flies, mosquitoes, gnats, fleas, bees, wasps, ants, spiders, ticks, mites, scorpions</td>
</tr>
<tr>
<td>Chordata</td>
<td>Spinal-cord animals</td>
<td>70,000</td>
<td>Sea squirts, lampreys, fish, amphibians, reptiles, birds, mammals</td>
</tr>
</tbody>
</table>

*It is not intended that this chart be "taught." Children should not be required to memorize this material. The chart is presented only as background information which may be useful to you as you help children find answers to their questions concerning animals.
Facts in themselves unrelated to large concepts are unimportant. As your children learn more about many kinds of animals, help them see these animals in their natural environments, their relationship to other animals, and their importance to man.

Animals are of many kinds. Some are one-celled animals like the amoeba and paramecium. These belong to the group of animals known as protozoa. They reproduce by cell division. They are microscopic, and are soft-bodied living animals. The amoeba, the simplest form of protozoa, will be one children may have heard about.

More familiar to children, however, will be the greater number of many-celled animals. These include soft-bodied animals that live both on land and in the water; animals with soft bodies inside hard coverings; animals with backbones; cold- and warm-blooded animals; animals that fly; animals that crawl, hop, or swim; animals that feed their young from their own bodies.

One large group of animals includes the soft-bodied animals with no bones. The earthworm is an example of this group. Animals with no bones are invertebrates. Therefore, earthworms, which have no bones, that is, are soft-bodied, are invertebrates.

There are many soft-bodied invertebrates living in water. Clams, oysters, snails, and scallops are among this group. They have hard outer coverings or shells that protect the soft bodies. Some of these invertebrates have one part to their shells, some have two parts. The animals get food from the water when the shells are open. On the next page the identification key for the illustration on page 147 of the textbook identifies four soft-bodied invertebrates.

Insects are another kind of invertebrate. They have no bones. Some have hard coverings outside. Others have soft outside coverings. Insects are numerous. Beetles, flies, mosquitoes, grasshoppers, crickets, moths, and butterflies are common varieties of insects.

Another group of animals children will know are the vertebrates, or animals with a backbone which with the bones attached to it forms a framework called a skeleton. Fish, frogs, toads, lizards, alligators, birds, lions, tigers, and monkeys represent this group. It comprises the most conspicuous but far from the most numerous group of animals on earth today. Only about 5 per cent of all animals are vertebrates.

Some animals are cold-blooded. Fish, for example, are cold-blooded or variable-temperatured animals. They have no lungs but
breathe oxygen from the water through gill slits at both sides of the head. They cannot live long out of water. Most fish have scales on the outside of their bodies. Most fish lay eggs which the male fertilizes after they have been laid in the water by the female.

Reptiles are another kind of vertebrate. Crocodiles, alligators, snakes, lizards, and turtles are reptiles. The large ambling dinosaurs of earlier days were reptiles. Turtles are the only reptiles that have shells. Some turtles live on land, others in fresh or salt water.

Alligators and crocodiles are the largest reptiles alive today. They spend most of their lives in the water. Their feet are webbed and their bodies are covered with a tough skin. These animals cannot breathe under water. That is why they frequently are seen with just their nostrils above the water. Alligators and crocodiles are cold-blooded animals.

Snakes are numerous, too. There are over 2000 known kinds. In the United States alone there are more than a hundred kinds. Snakes are reptiles. That means they are cold-blooded, backboned.
creatures. Four kinds of poisonous snakes are found in North America—the diamondback rattler, coral, cottonmouth or water moccasin (found only in the southeastern part of the United States), and copperhead. Children should learn to recognize these snakes. They are pictured on page 163 of Discovering with Science. Most other snakes are helpful and should not be killed. They eat insects, rats, mice, and many other animal pests. Farmers are happy to have these pests kept under control.

Amphibians make up another animal group. Toads and frogs are common amphibians. They spend the first part of their lives in water and breathe through gill slits. Then they develop lungs and can live on land and in water. They are cold-blooded, backboned animals with a moist outer skin.

Birds are another group of vertebrates. Most of them can fly. Ostriches, cassowaries, and penguins are among the few that cannot. Chickens, ducks, turkeys, and geese are domesticated birds that fly very little. Birds are warm-blooded animals. They are covered with feathers. Birds lay eggs from which their young hatch.

Mammals are warm-blooded animals. They are well known to children. Cows, horses, dogs, cats, elephants, lions, tigers, monkeys, opossums, kangaroos, whales, bears, seals, walruses are only a few mammals that children will know. Mammals are covered with hair. The female feeds the young with milk from her body. The young of most mammals are born alive from the body of the female. Among some animals, for example the koala bear, opossum, and kangaroo, the young are born extremely tiny and undeveloped. They develop after birth inside the pouches of the female. Only two mammals, the duckbills and spiny anteaters, lay eggs.

Most mammals are land animals. Although whales, walruses, and seals live in the water, they must come to the surface to breathe.

Ways of Working with Children

Begin by talking about animals that children know well and have seen often. They will know something about the life cycle and food habits of some of these animals. About others they will know the kinds of homes they build, and whether the female lays eggs or bears her young alive, and if she feeds them with milk from her own body. With this start, you can lead children to learn about animals that belong together as a group. In this way the
various distinguishing characteristics between and within groups will come to be recognized.

There is no need at this age level to drill children in learning all the animals that are reptiles or mammals or amphibians. The emphasis here is that animals may be alike in some respects and different in others regarding their structure, covering, and manner of reproducing and caring for their young.

Help children know about snakes. Most snakes are helpful. The poisonous snakes in North America are pictured on page 163 of the textbook. These should be known. Children should know that they should not attempt to kill poisonous snakes. Instead, they should move away from them and go for adult help. Children should not kill other snakes either. Snakes play an important role in keeping in check many animals that might become too numerous if they were not eaten.

Read many stories about animals. Collect pictures of animals in their natural surroundings. Scrapbooks of each group of animals can be made. Take trips that will acquaint children with animals they do not frequently see. Whenever possible enjoy undomesticated animals in their natural habitat. Bring them into the schoolroom for study purposes only.

A recent study of children’s interests indicates that animals are high on the list. Many children, however, do not have an opportunity to satisfy that interest through having a pet of their own. For this reason teachers frequently have animal pets in the classroom. Sometimes children’s home pets visit school for a short period. In this way, children who have no pets at home have an opportunity at school to share with their classmates the fun of learning to care for them.

If your children have suitable pets, you might arrange for these to be brought to school for a short period where they can be easily observed. An animal pet should have a comfortable home. Your class could make a good cage without much trouble. It should be approximately 10'' x 10'' x 18''. The top, bottom, and sides can be made of fine wire mesh. The entire cage should be raised about an inch and a metal tray, such as a cake pan, put under it. This makes it easy to keep the cage clean. The dishes for food and water and the tray should be washed daily.
Such a cage is a good school home for white mice, hamsters, guinea pigs, white rats, chickens, or small rabbits. Snakes, if kept in school, should be kept in a glass terrarium with screen or wire mesh only over the top. Mesh on the bottom and sides might injure them. Turtles, frogs, and toads also should be kept in a terrarium.

Materials Needed

dishes for food and water for wire mesh, fine, for cage approximately 10" x 10" x 18"
metal pan or tray

More about Animals

Suggestions for teachers corresponding to those for children, page 163, Discovering with Science.

1. No explanation necessary.
2. In addition to the pictures shown here, Zim’s book Snakes contains a world of information about many kinds of snakes. Get it if possible.

Further Activities

1. If there is a zoo nearby, visit it during various seasons of the year. Try to take one trip to see an unusual baby mammal that has just been born.
2. Keep a lively bulletin board going. Have the children add and change pictures as they study this chapter.
3. Show some of the films and filmstrips listed on pages 100–102 in this Manual.
4. Buy or find a cocoon, only one, so the children can watch the insect emerge from it. Keep the cocoon in a cool place so that it will not come out too soon while the weather is too cold for it to live outside. Let the insect go as soon as its wings are dry and fully spread.
5. Take the children to a pond and look for frog and toad eggs. Do not bring the eggs into the classroom. Leave them in the pond to hatch. Later the children may catch one tadpole and put it in the aquarium to watch it grow. Toad tadpoles require about two years to change to toads. So unless you get a large tadpole, vacation time will interrupt your study.
Evaluation

Ask children to choose one animal to study. Have them prepare to give a rather complete report about it to the class. Help them make an outline of the various kinds of information they will gather for their report. Assist them in finding books, magazines, pictures, and whatever else they need as their informational sources. Develop various ways to help the children make their reports alive and interesting.

The interest shown by the children in preparing their reports and the degree to which they include significant descriptions may help you to determine how valuable the study of animals has been for them.

In order to test further children's understanding of the materials presented in the chapter on "Learning about Animals," you may wish to have them prepare a large chart showing the classification of animals. You would not want this to be an elaborate chart. Simple classifications such as the following are suggested:

- These Animals are Reptiles.
- These Animals are Mammals.
- These Animals are Fish.
- These Animals are Amphibians.
- These Animals are Birds.
- These Animals are Insects.

Bibliography

For the Teacher


For the Children

Adrian, Mary (Mary E. Venn). Garden Spider. Holiday House, 1951.
Buck, Margaret W. In Yards and Gardens. Abingdon Press, 1952.
Fenton, Carroll L., and Pallas, Dorothy Constance. *Insects and Their World.*
Goudey, Alice E. *Here Come the Whales!* Charles Scribner’s Sons, 1956.
Stevenson, Elmo N. *Pets, Wild and Western.* Charles Scribner’s Sons, 1953.

Films

*The Bear and Its Relatives.* (Cor) 1½ reels, b/w. A scientific and accurate zoological film offsets erroneous impressions about the bear family of animals.

100
The Beaver. (EBF) 1 reel, color. Illustrates ways in which the beaver’s teeth, feet, and tail help him in swimming, eating, felling trees, and repairing a broken dam.

Beneath the Sea. (TFC) 1 reel, b/w. Includes photographs of a variety of undersea life (Warner Bros. production).

Birds Are Interesting. (EBF) 1 reel, color. Colorfully presents some of the basic biological concepts concerning birds.

Birds of the Seas. (TFC) 1 reel, b/w. A sailboat trip to observe oceanic birds in various parts of the world (20th Century-Fox production).

Let’s Catch Reptiles. (IF) 1 reel, color & b/w. Identifies the general group of animals called reptiles (Simmel-Meservey film).

Mammals of the Countryside. (Cor) 1 reel, color & b/w. Students see the habits and characteristics of countryside mammals.

Mammals of the Western Plains. (Cor) 1 reel, color & b/w. Shows how the plant-eaters and meat-eaters of the plains illustrate the interrelationship of the wildlife in any area.

Nature’s Engineers. (WLF) 1 reel, color & b/w. Shows underwater scenes of beavers at work. Shows their complete life cycle.


The Sea. (TFC) (Battle for Life Series) 1 reel. Includes underwater photographs of many marine forms rarely seen by students.

Snakes Can Be Interesting. (YAF) 1 reel. Pictures the life cycle and the habitat of snakes, and their economic importance to man.

Thrushes and Relatives. (EBF) 1 reel, b/w. Shows the habitats, feeding habits, brooding, development, and activities of seven thrushes. Bird songs and calls are included.

Filmstrips


Animals of Far Away Lands. (EGF) color.

Animals of Our Continent. (EGF) color.

Butterflies and Moths. (SVE) b/w.

Fresh-water Shellfish and Amphibians. (JH) color.

Fresh-water Turtles and Fish. (JH) color.

How Birds Are Fitted for Their Work. (SVE) color.

How to Identify Moths and Butterflies. (SVE) color.

How to Recognize Birds. (SVE) color.

101
INSECTS AND THEIR WAY OF LIFE. (EGF) color.

MAMMAL SET. (SVE) 5 filmstrips, color: PRIMATES—MONKEYS AND THEIR RELATIVES; LARGE, HOOFED MAMMALS; BEARS, PANDAS, AND RACCOONS; RODENTS; CATS AND DOGS.


SMALL FRESH-WATER ANIMALS AND INSECTS. (JH) color.

SNAKES AND LIZARDS YOU SHOULD KNOW. (SVE) color.

THE STRUCTURE OF BIRDS. (JH) b/w.
Working with Electricity

The natural curiosity of children about many aspects of their world will lead them to be interested in the subject matter found in “Working with Electricity.” Electricity is a subject which deserves increased attention in the elementary school. A comparatively few years ago electricity was a mysterious awe-inspiring force, causing lightning and giving peculiar shocks at unexpected moments. Today electricity is our slave, doing a host of tasks which hitherto were done by human hands. It has undoubtedly become one of the most important factors in the social and economic life of today.

The children you teach take electric gadgets for granted. Many of them do not even vaguely imagine a time when there were no such things as electric toasters, vacuum sweepers, refrigerators, electric lights, and telephones. Yet these more modern conveniences are in a real sense newcomers in the sweep of time. The use we make of electricity may prove to be the most distinguishing characteristic of this century. “Working with Electricity” attempts to help children understand some of the elementary and fundamental facts known about electricity.

Science Meanings for Children

The following elementary meanings are developed in the chapter “Working with Electricity”:

Harnessing electricity to work for man is a recent and significant accomplishment.

Electricity is used every day in many ways.

The electric current which comes into buildings to light them is powerful. It can produce a dangerous shock.

It is safe to work with dry cells because they produce only a little electricity.

Electricity is not stored inside a dry cell. The dry cell changes chemical energy into electrical energy as it is used.

103
Electricity needs a complete path or circuit through which to travel.

Insulation prevents the electricity traveling inside the wire from taking a short circuit.

Some objects are good conductors of electricity. Others are poor conductors.

Electromagnets are made by using electricity.

Electromagnets are used by man in many ways.

You can be part of a circuit through which electricity may travel.

Learning the safe use of electricity is important.

**Information for the Teacher**

Children may ask "What is electricity?" The explanation of electricity is completely entwined in our understanding of matter, the materials out of which all substances are made. All matter is now thought of as electrical in nature.

The modern theory about electricity holds that each atom is made up of two kinds of particles of electricity. One kind is positive; the other is negative. The positive particles are called protons; the negative particles are called electrons. The simplest atom has one proton and one electron. The more complicated atoms have many protons and electrons.

The central part of the atom is believed to be positive. Around it rapidly revolve one or more electrons. The atom is normally neutral; that is, there are the same number of positive and negative particles in it, and we say they are in balance. As a result, the atom is neither negatively nor positively charged.

However, the electrons and protons in atoms can become unbalanced; that is, there can be more of one than the other. If there are more protons than electrons in an atom, it is positively charged. If there are more electrons than protons in an atom, it is negatively charged.

Some substances allow negatively charged particles, or electrons, to move through them freely. These substances are said to be good conductors of electricity. Many metals are good conductors. Copper is an excellent conductor of electricity and is used in electrical wiring. Water also is an excellent conductor of electricity. Therefore, be sure your hands and the children's are dry whenever they work with electrical equipment. Caution children to remove wet...
clothing and to dry their hands before turning on light switches. In case of defective wiring this will avoid any danger of electricity flowing through them as part of the easiest path or circuit.

Substances that do not permit free movement of electrical particles through them are called nonconductors. Paper, glass, cloth, air, rubber, and many plastics are poor conductors of electricity.

Current electricity is useful. It flows along conductors and is used to run motors, heat toasters, run vacuum cleaners, and light homes. The electricity that lights your school building and home is generated in power plants that may be far from you. It is carried to your schoolhouse through wires that are good conductors.

Children should not experiment with the ordinary house current. It is 110 volts and strong enough to produce severe shocks and even death. There is no danger, however, when working with dry cells. So, for your class study of electricity use No. 6 dry cells which are only 1.5 volts and entirely safe. Dry cells furnish only a little electricity at a time. They cannot give children a shock.

The outer metal covering of a dry cell is zinc. At the top of the cell two connecting screws, called posts, are attached. One post is the positive post, or pole; the other post is the negative one. One post is fastened to the zinc covering. It is the negative pole. The other is fastened to a black carbon rod inside the cell. It is the positive post.

All around the carbon rod inside the cell is a moist chemical mixture or pastelike substance. This substance dries out eventually
and then the dry cell is useless. Although children would not be expected to know the chemicals that make up the mixture, they are named here for your information. They are ammonium chloride, manganese dioxide, zinc chloride, coke, and graphite.

Lining the inside of the zinc container is a heavy pasteboard resembling blotting paper. It absorbs moisture and helps to keep the chemical mixture moist for a longer time. A dry cell is dry only on the outside. If it becomes dry on the inside it is "dead" and cannot furnish electricity.

Children often think there is electricity stored inside the dry cell. This is not true. The electricity that is furnished by a dry cell is the result of chemical action in which chemical energy is changed into electrical energy. One way of satisfying children's curiosity in this matter is to say that the zinc, the carbon, and the chemicals all acting together produce electricity.

Electromagnets are made by winding insulated wire around a piece of soft iron such as a nail or a spike. The two ends of the wire are then connected to a dry cell or some other source of electricity. The insulated wire makes a complete path, or circuit, through which electricity may travel. If the children do this experiment, you will want to suggest that they open the switch from time to time so that the wires will not become too hot. Electromagnets usually remain magnetic only so long as the electricity is flowing through the wire. However, if the electricity flows for a long time, the soft iron core will remain magnetic for some time after the electricity stops flowing. Electromagnets may be made stronger by increasing the number of coils around the iron core, or by adding another dry cell, or both.

The invention of the electromagnet was an important step in in-
increasing the usefulness of magnetism and electricity to man. It provided a magnet that could be controlled. It could be turned off and on as needed. Therefore it could be used commercially. For example, electromagnets are used in lifting devices needed by large industrial plants. Large quantities of metals are moved by electromagnets. They also made possible such electrical instruments as the telephone, telegraph, radio, and electric motor. All of these instruments use an electromagnet.

As children experiment with push buttons, lights, and bells they will need to learn that electricity travels along a circuit, or path. It flows from the dry cell along the wire attached to a post, or pole, and along the insulated wire into the bell or light. From there it travels back to the dry cell through the wire attached to the other post of the cell. If any part of this circuit is broken, the bell will not ring or the light will not light. Electricity needs a complete circuit along which to travel.

Electricity travels along the easiest path. This is often the shortest path. Wires are insulated to keep electricity flowing along the wire instead of somewhere else. Sometimes this insulation breaks. Then the bare wires may touch each other and the electricity will flow in the shortest, easiest path back to the dry cell instead of flowing out into the bell or light bulb. A short circuit is created.

It is important to keep all electric cords well insulated. Whenever insulation becomes broken or frayed, a new cord should replace the old one. This insures safe use of electrical equipment. It prevents short circuits and the possibility of fires which are frequently caused by overheating of faulty wires.

Not all materials conduct electricity easily. For this reason they
These boys have incorporated electromagnets into telegraph sets.

are called nonconductors. Rubber, cloth, and many plastics are nonconductors. Insulation around electric wires is often made of these materials. Rubber has the additional advantage of being waterproof as well. Therefore, where water is involved, rubber insulation is usually used. It is fortunate that air is another poor conductor of electricity. If it were a good conductor we would be in constant danger of receiving electrical shocks.
Ways of Working with Children

The text suggests that children may be curious as to what is inside many electrical devices, such as dry cells, electric bells, push buttons, and knife switches. The textbook starts with a discussion of the dry cell. Read carefully the directions for taking a dry cell apart. They are given on pages 166–167 of Discovering with Science. Be sure you help children as they cut the cell open. It is not easy for young children to cut through the zinc covering with a saw or a chisel. Perhaps this could be your part of the activity. The opening of a dry cell is messy, too. Be sure that there is an ample supply of newspaper available. It is recommended that a good dry cell be used instead of a dead one. It is important to see the inside of one that will produce electricity instead of one that will not.

"Working with Electricity" is a doing chapter. Your children will learn a great deal more about electricity if you have the materials at hand with which they may experiment. You will need two or three No. 6 dry cells, a push button or a knife switch or both, about ten feet of insulated copper wire, and a pair of large shears for cutting wire.

Some teachers assemble all of the electrical equipment on a science table or keep it in a cardboard carton so that children can use it freely. In this way many children may try out the experiments suggested. It is an excellent practice to allow free movement of small groups of children to the science table before school and during free periods throughout the day. In this way more children can have their turns at handling equipment.

Demonstrations of an experiment in wiring may or may not be fruitful. Follow-up periods where children "try it for themselves" are usually much more fruitful. Try to arrange your activities during the day so that these follow-up periods are possible.

Do not forget that children like to work alone sometimes, too. Some children are too shy or too fearful to work in a large group. They sit back and allow the more aggressive and secure children to have all the experiences. You will want to allow time for individuals who work better alone to use these electrical materials for experimenting.

Experimentation and discussion fit together quite naturally. Allow time for questions to be raised and discussed. Allow several
children to do the same experiment. It is not a waste of time to have an experiment repeated. Only in this way do children begin to sense the scientific aspects of careful, accurate experimentation. When children raise questions you will learn to wait before you give answers. There is a far better learning situation when children themselves think about the reasons, and come up with their own answers, than when you short-cut their thinking by giving them the correct answer. Needless to say, it is important that the children’s answers be checked for accuracy. Here they will need you and books and any other materials which will aid them to verify their conclusions.

You will also need to help them consider their data carefully as they come to their explanations of phenomena. Sometimes children “jump the gun” and draw hasty and inaccurate conclusions. Thoughtful, painstaking researchers train themselves not to jump to hasty conclusions. As long as children are sincerely considering a problem, time is never wasted. Good teachers treasure these periods when children are carefully considering a question and searching for reasonable explanations.

It is suggested that you look inside a push button and a simple electric motor. Take time for the children to point out the various parts, to try to identify them for themselves, and to discuss them. Let them trace the circuit. Let them push the button down and really see what makes contact with what. Let them release the button and see where the circuits are broken. These activities take time, but it is time well spent.

There might be one or two children who could make a simple telegraph instrument like the one pictured on page 180 of the text. Some children are more interested than others in trying things out for themselves. Allowing for differences in individual interests and capacities is important. Here is one among many opportunities suggested throughout the Manual for you to recognize individual differences and to make suitable provision for them.

Materials Needed

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>bell, electric</td>
<td></td>
</tr>
<tr>
<td>chisel</td>
<td></td>
</tr>
<tr>
<td>dry cells, 3 No. 6</td>
<td></td>
</tr>
<tr>
<td>flashlight</td>
<td></td>
</tr>
<tr>
<td>hammer or can opener</td>
<td></td>
</tr>
<tr>
<td>knife</td>
<td></td>
</tr>
<tr>
<td>knife switch</td>
<td></td>
</tr>
<tr>
<td>newspapers</td>
<td></td>
</tr>
<tr>
<td>110</td>
<td></td>
</tr>
</tbody>
</table>
Thinking about Electricity

Suggestions for teachers corresponding to those for children, pages 182–183, Discovering with Science.

1. No answer required.
2. Modern homes are equipped with many electrical instruments, including clocks, toasters, mixers, washers, ironers, refrigerators.
3. At first look it may appear that a flashlight does not have two poles or posts. But it does. The positive pole of a flashlight is at the center of one end of the cell. The entire zinc can is the negative pole. Help the children trace the circuit through the flashlight, the push button, the light bulb, and the dry cell.
4. Cars use wet cells as opposed to the dry cells you will be using at school. The mechanic in a garage can show children a storage battery and tell them about the chemicals in it and the water he adds to it.
5. Discussion here of all the other kinds of energy children experience is important. Energy is needed to do work. The energy from wind, water, animals, and people, as well as from chemicals and electricity, helps man work.
6. Good conductors include copper, silver, brass, and aluminum. Poor conductors include cloth, plastic, feathers, straw, glass, silk, rubber, and wood.
7. Safety posters will add interest to these discussions. The children might make them or obtain them from the Junior Red Cross or National Safety Council.
8. Fuses are safety devices installed in buildings. The passage of an electric current through wires may heat them. The stronger the current through a wire the hotter the wire becomes. Sometimes wires become hot enough to start a fire. Fuses are provided to safeguard the house wires in case of a short circuit or an overload of current. A fuse is essentially a short piece of wire which melts at low temperature. It is inserted into 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 house wires become dangerously hot. Thus the circuit is broken and
electricity cannot flow. A blown fuse is a signal that something is wrong. This fault should be located before a new fuse is inserted into the fuse box.

9. Use the books at hand to read about Thomas Edison’s work. If the children can read the books about Edison that are readily available, well and good. If not, perhaps you can read them to the children.

10. The bell is ringing because the circuit is complete.

11. The light is not on because the circuit is broken.

Further Activities

1. It is unlikely that anyone in your class will want to make the electric motor pictured on page 179 of Discovering with Science. However, should one of the children be interested in trying, you may wish to give him the following points about constructing it:

   a. Be sure to wind the wire around the large nails in opposite directions so that the heads of these nails will become opposite poles.

   b. Be sure that the insulation is scraped off the wires leading down the glass tube below the cork, and also off the wires leading from the small nails to the glass tube.

   c. Carefully fuse the end of the glass tube which fits up into the cork. This is the most difficult part of making the motor.

2. Perhaps a few children would enjoy trying to make a crude telegraph set such as the one pictured on page 180 of the textbook. They can do so by carefully studying that picture. Strips of metal cut from a clean tin can may be used to build the set. These are easy to cut and bend to the desired shape. Ordinary screws make good posts. Insulated wire such as the children have been using can be used to make the electromagnets in the telegraph set.

Evaluation

The materials in the chapter “Working with Electricity” lent themselves well to individual and small-group experimenting. Thus you were given an excellent opportunity for important observations. Did you find the children accomplishing the experiments satisfactorily for themselves? Did any of them tend to monopolize rather than share materials? Did you see progress in individual initiative and co-operation? Did you find opportunities to help children grow in their social relationships?
You may use a picture test to evaluate subject-matter learnings. Here are some sample problems:

a. Draw a light bulb. Show the path of electricity with a colored crayon.
b. Draw a cutaway dry cell. Label all the parts you know.
c. Draw a complete electromagnet circuit. Label the parts in your circuit.
d. Draw a cutaway electric socket. Show where electricity may enter and leave the socket.
e. Draw a picture showing an electromagnet circuit. Now draw another circuit showing a stronger electromagnet.

Probably you would not require each child to do all these things. It would take too long. But have them repeated enough times by different children so that you are pretty sure the children understand how to carry out these activities.

You may wish to have children make a large mural on brown wrapping paper which will show the uses of electricity. This will help you to evaluate the work of individuals. Before beginning the mural, let each child make a list of as many uses of electricity as he can. Everyone should be able to make such a list. All the children will be able to contribute to the mural.

Perhaps children will also indicate by their behavior that they are now more aware of safety factors relating to electric current. Do you hear them discussing such cautions as:

Do not go near wires that are blown down during a storm. They may be live wires.

Be sure that all electric cords in lamps, radios, toasters, and irons are well insulated.

Dry your hands before touching an electric switch of any kind.

Do not touch electric equipment, including light switches, when you are in the bathtub.

Bibliography

For the Teacher

**For the Children**


**Films**

**Electromagnets.** (YAF) 1 reel, b/w. Shows how the electromagnet is used in the doorbell, telegraph set, and many other everyday applications.

**The Flow of Electricity.** (YAF) 1 reel, b/w. Shows by animation the flow of electricity through a circuit in a home situation.

**Magnets.** (YAF) 1 reel, b/w. Temporary and permanent magnets are explained.

**Making Electricity.** (EBF) 1 reel, b/w. Provides a demonstration of how electricity is made by moving a coil of wire through the field of a magnet.

**Thunder and Lightning.** (YAF) 1 reel, b/w. Gives an introduction to static electricity.

**Filmstrips**

**Electric Magnets.** (SVE) b/w.

**Electromagnets.** (YAF) color.

**Magnets.** (YAF) b/w.

**Permanent Magnets.** (SVE) b/w.

**The Wonder of Electricity.** (EGF) color.
The Waters of the Earth

Three fourths of the earth's surface is covered with water. Some of it is salty. Some of it is fresh. No matter where children live they are curious about the ocean waters that rise and fall in ocean tides twice a day. These waters teem with life that fascinates young people. Whales, sea bass, marlin, crabs, oysters, seaweed, and coral are objects about which children often ask.

The chapter on “The Waters of the Earth” illustrates the variety of conditions in the ocean, the various forms of life that abound under different aquatic conditions, and the struggle for survival that goes on in the vast water regions of the earth. It develops the thesis that the waters of the earth grow a crop of both plant and animal life that represents a vast and largely untapped source of food supply. Harvesting an acre of ocean water would produce a crop of food just as does harvesting the crops on an acre of land.

Science Meanings for Children

“The Waters of the Earth” develops the following meanings for children:

Three fourths of the earth’s surface is covered with water.
The waters of the earth are either salt or fresh.
Oceans and some seas and lakes are bodies of salt water.
Streams, rivers, ponds, and most lakes are bodies of fresh water.
The waters of the earth support many kinds of plant and animal life.
Plants live in the upper six hundred feet or so of the ocean water.
The contour of the ocean floor resembles that of land not covered by water. It has hills, mountains, valleys, and large stretches of level plains.
The waters of the earth contain dissolved minerals.
The plant, animal, and mineral riches of the water parts of the earth are still largely untapped. These remain for future generations of men to explore.

**Information for the Teacher**

The four oceans of the earth are the Atlantic, Pacific, Arctic, and Indian. They are all joined to form one vast body of water. Islands and continents are high places on the earth’s surface. Sometimes they are tops of mountains surrounded by water. The floor of the ocean is uneven. It has valleys, plains, hills, and mountains just as the dry parts of the earth’s surface do. Most of the ocean floor is gently sloping, however.

The ocean is salty. Because of the ability of water to dissolve many substances, the ocean contains many kinds of mineral salts. Year after year waters from rivers, lakes, and ponds flow over rocks and minerals on their way to the sea. The minerals dissolve in the water and are carried on to the ocean. Since the ocean has no outlet, these mineral salts remain in the waters of the ocean. As ocean waters evaporate, the ocean slowly gets saltier and saltier.

The ocean teems with plant and animal communities, located according to the specific conditions of life to which each is adapted. Depth is one of the factors determining the character of marine communities. Some of the animals of the sea are the largest living creatures on earth. For example, they include the blue whale, the largest animal living today. The sea is also full of millions of tiny animals which can be seen only with the aid of a microscope. Among water plants, too, there are huge ones, such as the iodine kelp seaweed that grow to be several hundred feet tall. And at the same time there are the millions of microscopic plants that abound in the surface waters.

In the surface waters of the ocean there is a layer of plant and animal life called plankton. This layer is roughly 200 feet in depth and is the part of the water which supplies much of the food for all creatures living in the oceans. Plant life does not occur below the depth to which light penetrates. The plankton layer is thicker and life is more abundant in cool waters than in warm. There are places where plankton is so abundant that the sea is described as “soupy.” The Bering Straits is such a place.

Plankton is luminous at night. A beautiful description of this luminosity and of the entire plankton area is to be found in Chapter 2
of Rachel Carson’s book *The Sea around Us* listed in the bibliography. At night, the eerie glow from phosphorescent fires of billions of small and microscopic creatures is a sight not easily forgotten. By day, millions and millions of these creatures give the water its characteristic color.

Plankton is the main source of food supply for all sea life. The young of many sea creatures are born from eggs laid in the plankton region of the sea. The young feed upon the lush plant and animal growth found there. Many large fish come to this area to eat and in turn to be eaten. The life of all parts of the sea is unmistakably linked to the food supply found in the plankton region. Diatoms are the most abundant microscopic plants in the plankton area.

An endless battle for life and food goes on continuously in the waters of the ocean. Some animals live entirely upon plant life. Some live on both plant and animal life. The dwellers of the deepest ocean are carnivorous. No plants live in the dark, cold depths of the ocean. The creatures that inhabit these deep abysses have powerful jaws and luminous regions on their bodies.
The life of waters in the tide zones along sandy and rocky shores is described in separate sections of the chapter. Much of this life children have experienced and will be interested in discussing. Each region of the sea supports the kinds of plant and animal communities which are adapted to living there. Depth, temperature, degree of saltiness, and condition of the ocean floor affect the kinds of living communities found in the numerous regions.

Life in fresh water is plentiful, too. Fresh-water plankton is found in abundance in ponds, lakes, and slow-moving streams. Long-stemmed plants grow along the shores of fresh-water streams and ponds. Some have broad leaves which float on the water and roots that grow into the sand at the bottom. Still other plants are entirely

immersed in water. Some of these plants are shown in the illustrations on page 202 of the text. They are cattails, reeds, pickerelweed, marsh grass, bulrushes, and pond lilies. The outline drawing with identification key on page 118 will assist in identifying these plants.

The young of many insects hatch in or near fresh-water areas. They include water striders, dragonfly nymphs, and back swimmers pictured on page 203 of the text and in the outline drawing and identification key above. Frogs, toads, turtles, and many kinds of fish live in or near fresh water.

From a conservation point of view this chapter attempts to help children sense the importance of conserving through wise use the abundant plant and animal life of the waters of the earth. Stocking streams with fish, making fishing laws, and keeping water free from pollution are among the conservation considerations brought out in the chapter "The Waters of the Earth."

Ways of Working with Children

If your classroom is near a body of water, start your study by observing the kinds of living things that live and grow in it. Firsthand observation is fruitful. It raises points for
discussion. Reading to find the answers to questions raised also brings books into dynamic and worth-while use.

You may want to use the globe or a world map to locate the oceans, large lakes, and rivers as you talk about them. Help children to see that the oceans are all joined into one huge body of water.

If possible, get a cup of water, either fresh or salt, from the nearby ocean, lake, pond, or river, and examine a little of it under a microscope. You will see living organisms, not visible to the naked eye, moving in a drop of water. You might invite the high school science teacher or the school nurse or doctor to tell the children about these microscopic organisms.

Heyerdahl describes in his book *Kon-Tiki* the plankton and other sea life he observed on the long trip made in 1947 from Peru to the South Sea Islands. Try to get this book and read some of these descriptions to the class. It is interestingly written and will help children get a vivid picture of the life in the surface water of the ocean.

Carson’s *Under the Sea Wind* also describes beautifully many aspects of life in the sea. Chapter 2 is a wonderfully stimulating and magnificently written chapter to share with children of this age.

For information about fresh-water life have the children read carefully pages 202–205 of *Discovering with Science*. The section “Rivers Are Roadways” on page 208 also will help to stimulate discussion.

Encourage children to read stories from other books of the migrations of salmon, eel, polar bears, whales, walrus, and mackerel. Let them compare the migration habits of these different animals.

Whenever possible gather the shells of animals that live along the seashore. These shells once held live animals. Make a collection of them and notice how they differ. Try to find out all you can about the animal that once lived inside each shell. Talk about how these shells protected the soft-bodied animals that dwelt inside.

If possible, borrow a book or magazine containing color plates of shells found on beaches around the world. A bulletin board of pictures of sea animals makes an attractive display and helps children learn about life in distant waters.

Study the various ways that animals are adapted to living in waters in the tide zones, on the deep ocean floor, and in shallow waters off the shore.

Perhaps the children will write stories about various creatures
that live in the waters of the earth. These might be assembled for a book about the communities of plants and animals that exist in the different regions of the sea.

Some children may wish to make several murals depicting the kinds of life that abound in different regions of the sea. The pictures and text on pages 190–197 of Discovering with Science will be helpful here. The outline drawings and identification keys below for the illustrations on pages 194 and 195 also may assist in preparation of the murals.

![Illustration of marine life with numbers and labels]


Perhaps some of your children may have seen the beautiful marine gardens that exist in shore waters off the coast of Florida, Bermuda, Catalina, and the Virgin Islands. If so, give them ample opportunity to describe their beauty to the class. Refer to the pictures in the textbook, pages 192–195, which show some of the plants and animals found in marine gardens.

![Illustration of marine life with numbers and labels]

Materials Needed

- hand lens or microscope
- water from nearby ocean, lake, or stream

No other specific equipment is needed. If children have collections of marine shells encourage them to display the shells at school.

Some Things to Think About and Do

Suggestions for teachers corresponding to those for children, page 209, Discovering with Science.

1. Use the local environment. Discuss plants and animals that abound there. Gear the discussion toward the conditions for living that exist in the local water regions.

2. Point out the need to observe good regulations set up by the community. Keep in touch with local and state and province laws governing conservation.

3. Discuss with your children the garbage removal and disposal policies of your community. Find out about the water supply of your community. Inquire about commercial waste disposal from factories built along streams.

4. Examine with the children the pictures on page 209 of the textbook and any collections of shells the children may have. Point out the variety in color, shape, size, and parts of these shells. The following key to the illustration may assist you in identifying shells brought into the classroom.

Further Activities

1. Have your children make a close check on conditions of any bodies of water near their school. Find out what the provisions are for keeping the water clean and free from pollution so that it may continue to support plant and animal life.

2. Invite someone who has traveled widely to speak to your class about his experiences on an ocean voyage.

3. Have the children collect some pond water and look at it under a microscope.

4. Distilled water is used in batteries of cars. Ask a group of children to try to find out how it differs from rain and drinking water.

5. Suggest writing a story entitled "The Nursery of the Sea" and describe conditions that exist in the plankton region of the oceans.

6. Suggest that one group select one kind of sea plant or animal to read about and report the information found to the class.

Evaluation

One way to help children organize the knowledge they have gained in studying any area of science is to have each child choose some aspect of that unit and report on it. The following topics might be used for reports:
a. The ocean is a great storehouse.  
g. Life along sandy shores.
b. Life in the ocean varies greatly.  
h. Life in tidal pools.
c. Why the sea is salty.  
i. The plankton layer.
d. Life in the tide zones.  
e. Life along muddy shores.  
k. Life in fresh-water ponds.
f. Life along rocky shores.  
l. Life in fresh-water streams.
m. Using water wisely.

Another important outcome to observe is whether children seem to be really concerned about helping keep the oceans, lakes, ponds, and streams free from unnecessary pollution. Watch to see if they avoid throwing waste matter into local water areas. Watch to see if they are conscious of the need to leave living water plants and animals where they find them instead of disturbing them. Be alert to discussions about their own responsibility to keep harbors, beaches, and streams clean.

Bibliography

For the Teacher


For the Children

Films

KILLERS OF THE DEEP. (Cornell) 1 reel, b/w. Shows the suspense and struggle of life beneath the sea.

LIFE ALONG THE WATERWAYS. (EBF) 1 reel, color. Depicts the many forms of plant and animal life found near the streams, ponds, rivers, and marshes that make up a waterway system.

MARINE LIFE. (EBF) 1 reel, color. A vivid portrayal of some of the colorful forms of animal life found under the sea.

SALT WATER WONDERLAND. (Sterling) 1 reel, color & b/w. Pictures color and action of marine life around a coral reef in Florida.

SEASHORE LIFE. (EBF) 1 reel, color. Portrays life on three kinds of seashores—the sandy beach, the rock pool, and the mud flat.

SNAPPING TURTLE. (EBF) 1 reel, b/w. Life story of the turtle in its natural habitat, and its encounter with other animal life.

TIDE POOL LIFE. (IF) (Elem. Ed.) 1 reel, color & b/w. Story of the more usual species of marine life found near rocky shores and tide pools (Simmel-Meservey production).

TIDES. (ALF) 1 reel, b/w. The regular changing tides are shown by actual scenes and animated figures.

WATER CYCLE. (EBF) 1 reel, b/w. Tells the story of the endless cycle of water from earth to sky to earth.

WATER IN THE AIR. (IF) 1 reel, b/w. Two boys learn about water in the air by simple observation and experimentation.

WONDERS OF THE SEA. (TFC) 1 reel, b/w. Describes marine wonderland of the Great Barrier Reef in Australia (20th Century-Fox production).

Filmstrips

KEEPING AN AQUARIUM. (JH) color.

LIFE IN PONDS, LAKES, AND STREAMS. (JH) color.

PLANTS AND STRANGE ANIMALS OF THE SEA. (JH) color.

RAIN. (FH) b/w.

SHELLFISH OF THE SEASHORE. (JH) color.

THE STORY OF RIVERS. (EBF) color.

THE STORY OF UNDERGROUND WATER. (EBF) color.

THE TIDES. (FH) b/w.

WATER AND ITS IMPORTANCE. (EGF) color.

WATER AND ITS WORK. (YAF) b/w.

WATER CYCLE. (PDP) b/w.

WATER IN THE AIR. (EBF) b/w. Instructional Films production.

WATER RESOURCES. (Curr F) color.

WHY WATER IS IMPORTANT. (PDP) b/w.
Studying Rocks and Minerals

Children of all ages are interested in rocks. They fill their pockets with pretty stones. They clutter up museum shelves and window ledges with samples. They ask again and again, "What kind of stone is this?"

Undoubtedly, you will not know what many of their stones are. But let us reassure you. Many geologists have spent their whole lives studying rocks and minerals and still do not begin to know all there is to know about rocks.

We urge you to learn about rocks and minerals along with your class. Let them know you want to study with them. You might start your own collection. Ask them to help you identify your samples. Label them carefully, and put them in a cigar box or similar container. You will be surprised to see how much help children will give you when they realize you are a learner also.

Science Meanings for Children

"Studying Rocks and Minerals" attempts to develop the following meanings:

- Rocks were formed by forces that have been at work for a long time. These forces are still at work.
- Rocks can tell us many things about life on the earth at an earlier date.
- Most rocks and minerals can be identified.
- Rocks contain valuable minerals. Some rocks contain only a few minerals. Other rocks contain several minerals.
- We use rocks and minerals in many ways.

Information for the Teacher

Perhaps you will feel reluctant to let your children become involved in this area of science because there are so many facts to learn, and it is so difficult to become expert in this subject.
You need not hesitate, however, to begin with your children. You can learn as you help them to learn.

Scientists identify rocks by color, shape of crystals, cleavage (the way a rock breaks when pounded), and hardness. You can buy for about a dollar a sample kit of common rocks and minerals from any scientific supply house. (See pages 143–144 of this Manual.) That is one way to begin. We found real help in having such a kit. It gave us a useful leaning post when children asked, “What kind of stone is this?”

It is interesting to know the story behind rocks. A few of the facts which you are sure to find valuable follow.

The common minerals found in rocks are discussed on pages 216–219 of Discovering with Science. Read these pages carefully. They will help you help children learn about minerals. Quartz, basalt, mica, and feldspar are common minerals. They are found in many common rocks in many localities. Children can learn to find them in their samples.

Common kinds of rock are discussed on pages 220–232 of the textbook. By breaking sample rocks apart you can tell the colors of the minerals more easily. Look at the freshly opened surfaces. Compare them with sample rocks in your collection. Granite, mica, schist, gneiss, sandstone, and limestone are common rocks that you are likely to find in your neighborhood.

Children will ask how rocks are formed. Some rocks are formed by the laying down of small particles of sediment. These rocks are called sedimentary rocks. Limestone, sandstone, shale, and soft coal are sedimentary rocks. Most sedimentary rocks are formed under water. Some sediments are deposited by wind. Year after year sediment settles to the bottom of lakes and oceans. Finally it becomes pressed into layers of rock.

Some rocks are formed by intense heat or fire. Granite and quartz are examples of these igneous, or fire-made, rocks. They were once molten rock material. When the molten mass cooled it became igneous rocks.

Metamorphic rocks are sedimentary or igneous rocks that have been changed, or made over, by heat and pressure. Marble, gneiss, and hard coal are examples of metamorphic rocks.

The following table may help you to remember such rock metamorphosis, or change.
### Original Rock becomes Metamorphic Rock

<table>
<thead>
<tr>
<th>Original Rock</th>
<th>Metamorphic Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone</td>
<td>Marble</td>
</tr>
<tr>
<td>Sandstone</td>
<td>Quartzite</td>
</tr>
<tr>
<td>Shale</td>
<td>Slate, mica schist</td>
</tr>
<tr>
<td>Conglomerate</td>
<td>Gneiss, conglomerate schist</td>
</tr>
<tr>
<td>Bituminous coal</td>
<td>Anthracite coal</td>
</tr>
<tr>
<td>Basalt</td>
<td>Slate, schist, serpentine</td>
</tr>
<tr>
<td>Granite</td>
<td>Granite gneiss</td>
</tr>
</tbody>
</table>

### Ways of Working with Children

You may as well be prepared for requests to identify rocks and minerals. You can quite easily learn to tell a few of the common rocks of your locality. Encourage children to start making collections. They can put their specimens on cotton in cigar boxes or egg cases. Then they can paste a square of adhesive tape on each sample and number it. You can help them prepare a key of identification to paste on the lid of the box. Go slowly. Just a few samples carefully identified will satisfy most nine-year-olds.

Directions for obtaining mineral crystals are given on page 213 of the textbook. Examine these under a microscope or hand lens. Children may be surprised to learn that "grains" of sugar and salt are actually crystals. Let them examine these. They will enjoy
looking at quartz and mica crystals too. Make sure that as the children look at crystals they notice that each has a definite shape.

If there are outcroppings of rock near your school, go to see them. Look for evidences that the rock was made under water. No sedimentary rocks have crystals. Then look for evidences of crystals. Often you can see where one kind of rock has formed on top of other layers of rock. Point out that the bottom layers were no doubt made before the upper layers. Freshly cut roadbeds through the sides of hills and excavations for new buildings are good places to visit to see rock layers. Frequently evidences of rock folding and of magma having hardened between two layers of rock may be seen on such visits. These will help children understand better the flow of magma.

Look for rocks containing fossils, too. Discuss how geologists read the history of the earth by the fossils they find embedded deep in rock layers.

Children will need to know that fossils are found only in sedimentary rocks. Help them to understand that studying the kinds of fossils found in rocks helps geologists read the story of the earth in earlier times. Children will ask many questions about fossils in rocks. Help them find answers through reading and observation.

If there is a stone quarry nearby, visit it with your children. For this visit make arrangements in advance with the officials of the company so that all safety measures will be carefully carried out.

If any of your children have seen the Grand Canyon, Yellowstone National Park, Zion or Bryce Canyons, or any of the famous underground caves, such as Luray or Carlsbad, allow them to describe these places to the group. They may have pictures or slides or movies which they will be willing to share with their classmates.

Some children may own a View-Master and slides. You might obtain some of the beautiful color slides which are available with these viewers to show as children study the chapter on rocks and minerals.

Cormack’s The First Book of Stones gives considerable help in how to make rock collections. Encourage the children to refer to it as they make their own collections.

Another excellent book is Schneider’s Rocks, Rivers, and the Changing Earth. Good readers in your class might read this book and report on it to the group. If it is too difficult for your children to read, they will enjoy having you read all or parts of it to them.
If possible, show one or more of the films and filmstrips listed on page 133 of this Manual. Help to make children conscious of the many uses to which rocks and minerals are put, for example, in houses and public buildings, for bridges, as road ballast for railroads, in stone walls and walks, as jewelry, and for lamp shades.

Materials Needed

boiling water
hand lens or microscope
cup or tumbler
salt
dish, shallow
string
sugar

Some Things to Think About and Do

No suggestions for teachers necessary concerning page 235 of Discovering with Science.

Further Activities

1. If there is a natural-history museum nearby, take the children to see the collection of rocks and minerals there.
2. Ask the curator of your museum to help you classify rocks and minerals you have gathered for your own collection.
3. Invite interested parents who know about rocks and minerals to talk to the children about the fun they have had with their hobby collection. Perhaps they will have films or slides to show.
4. Metals are minerals. Someone may wish to find out about common metals and report to the group.
5. Suggest that children write stories which give the history of a certain kind of rock. Titles might be:

   How Quartz Is Formed
   How Granite Turns to Gneiss
   Why Fossils Are Found Only in Sedimentary Rocks
   Why Sedimentary Rock Has No Crystals

6. There are fascinating stories about famous precious stones. Try to find some of these stories and read them to the class.
7. Pupils may wish to construct a model volcano which can be
used to demonstrate volcanic activity. If so, they may use these directions: Nail several boards together to form a platform measuring 2 feet square. Mix 2 pounds of plaster of Paris with water, and quickly build it up into the shape of a volcanic cone. While the plaster of Paris is still soft, embed a Pyrex custard cup in the top of the volcano to simulate the crater. Leave it alone until it hardens.

Next you will need 4 ounces of ammonium dichromate. This can be obtained from a chemical supply house. It is an inexpensive and harmless chemical, crystalline in form and orange-yellow in color.

When the model volcano has hardened, fill the custard cup to the brim with the ammonium dichromate. It should not be pressed down. Then you will touch a match to the chemical to ignite it. Do not let children ignite the chemical. The ammonium dichromate seems to burn, giving off a slight flame. As the chemical change continues, the orange-yellow color disappears, leaving a green residue.

The important things in this demonstration for which pupils should watch are the building up of the cone, the spilling of the "lava" over the sides, and the "volcanic" dust which floats away from the eruption. While this demonstration is only an analogy of volcanic action, it fascinates children. If it can be done in a darkened room, the effect is heightened, for then the slight flame of the reaction becomes clearly visible. Several pupils may participate in this activity. After the demonstration is completed, the model may be cleaned and put away for future use.

**Evaluation**

You may evaluate children's learnings by asking yourself such questions as the following:

1. To what degree did this study help children to realize the age of the earth and changes that have gone on since it was formed?
2. How did the study of fossils help the children learn about the history of the earth?

3. How interested were the children in continuing on their own a search for new rock and mineral samples and in finding the story behind them?

4. To what extent do the children as they talk about rocks and minerals give evidence that they have enlarged their background and understanding of the concepts of time and change?

5. What evidences do I have that children have grown in the use of the scientific method at any point in this study?

6. To what extent have the children learned to use the tools of research to find answers to their questions?

Bibliography

For the Teacher


For the Children


Films

THE EARTH'S SKIN. (ALF) 1 reel, b/w. Pictures the graphic structure of our earth deep under the surface.

PARÍCUTIN—MOUNTAIN OF FIRE. (Pictorial) 1 reel, color. Shows the growth of this mountain in Mexico during six months.

THE STORY OF OIL. (YAF) 1 reel, b/w. Shows how a new oil field is located, how the oil well is drilled, and how the oil is stored.

Filmstrips

HOW ROCKS ARE FORMED. (JH) b/w.

SOIL RESOURCES. (Curr F) color.

THE STORY OF THE EARTH WE FIND IN THE ROCKS. (JH) b/w.
Using Materials Wisely

The recent census reveals a sharp rise in population on the North American continent. One of the implications of this fact is that an increasing number of people are using the natural resources of the earth. The last few years have brought forcefully to our attention also the fact that many people are wasteful of our precious natural resources. The salvage program of the Second World War did much to make us conscious of the need to conserve for wartime. We need to learn that it is just as important to conserve during peacetime.

During the entire history of the western world most people have given little thought to conservation problems. Forests have been slashed. Soil has been depleted. Grasslands have been overgrazed. Clear sparkling streams have been polluted so that fish no longer abound in them. Minerals have been depleted by careless use and inefficient mining methods.

Children of today are the grown-ups of tomorrow. They need help in becoming aware of the many conservation problems that will be theirs to solve. One of these problems deals with the wise use of natural resources. The chapter on “Using Materials Wisely” is designed to help them come to a fuller realization of such need.

Science Meanings for Children

At present North America is rich in natural resources.

For years these resources have been wastefully handled.

Our natural resources must be conserved, used wisely, because not many are known to be forming inside the earth today.

Our present-day world of machines and electric power depends on these natural resources.
We know many ways to make better use of our natural resources. All of us, children and adults, need to practice all the ways of conservation we know.

The stories in the text give the facts you need to know. They deal with the use and misuse of our great natural resources. These resources include good soil, forests, grasslands, animal life, and minerals, including coal and oil, and oil products. Some farmers waste much good soil by poor farming methods. Lumbermen and pioneers wastefully cut down forests. Factory wastes are permitted to pollute streams. As a result, damaging floods occur where forests have disappeared, dust bowls develop in barren fields, and unhealthful water supplies threaten city populations.

The modern meaning of conservation is the wise use of materials. "Using Materials Wisely" deals especially with the wise use of three of our natural resources: water, minerals, and metals. Emphasis should be placed upon helping children to practice using these materials wisely.

The economic importance of water can scarcely be overestimated. Without an adequate amount of water well distributed throughout the growing seasons of the year all plant life suffers. Children who live in places where there is no water shortage need to be helped to realize that in many areas there is an insufficient water supply.

It is a well-known fact that the water table in many parts of our continent is constantly lowering. The water table is the level of underground water. As this table lowers it affects plant life. A high water table brings plenty of water to the roots of growing plants. A low water table prevents lush growth of many plants. Farm land becomes less productive when the water table lowers.

Many sections of North America receive an insufficient amount of water during the growing season to produce a satisfactory harvest of crops. In these places, farmers may irrigate their lands. Huge dams have been built on rivers near many dry regions of the North American continent. These dams, in addition to furnishing electric power to places both near and distant, serve as a reservoir for storing millions of gallons of water which is piped to dry farm lands. In this way food is grown on lands that otherwise could not produce good crops. Irrigation is used on many thousands of acres of farm land.
A study of any local community will doubtless reveal wasteful and harmful practices concerning water. The story of John’s harbor as related in the textbook on pages 240–242 is a common story. Children can be made aware of what has and is happening in their local communities concerning stream pollution, garbage and sewage disposal, and harbor cleanliness. From this firsthand knowledge they can be led to study conservation problems concerning water in other places throughout the world. Study of polluted oyster beds, of diminishing satisfactory spawning regions for cod, mackerel, and other fish, and shell fish provides challenging evidence of our need to adopt better conservation practices.

Turning to conservation of minerals and metals of the earth, the emphasis again is upon using these supplies wisely. Experts in these matters indicate that there is little danger of depleting many of our mineral resources in the near future. This is, however, no excuse for continuing to use them wastefully.

The great coal-forming era of the earth’s history is past. Another may come in some future time in the earth’s history. But at present, coal is being formed in the Dismal Swamps of North Carolina and Virginia and in no other places that we know about.

Products made from coal tar are numerous. Discussion of ones commonly known and used are to be found on page 244 of the textbook. Reflecting upon the importance of these products will help children realize the economic importance of coal.

The discussion of the economic importance of oil and natural gas given on pages 245–249 will be important background reading for children as they learn about our need for these resources. The remainder of the chapter points out uses of important metals and reasons for their conservation.

Ways of Working with Children

Pupils may plan to make an intensive study of the waste of natural resources in their own community. They may wish to suggest methods for stopping wasteful practices. For example, they may note that wasting paper is actually a waste of forests; that a waste of clothing is a waste of soil, since most clothing is made from cotton, linen, and wool, each of which comes directly or indirectly from the soil. They may learn that the improper burning of coal is a waste of a resource which has been millions of years in formation;
that improper use of electricity is likewise a waste of coal, since much electric current is generated by coal-heated, steam-driven generators. They may conclude that iron ore is being wasted in discarded tin cans and rusting farm machinery and automobile junk yards.

One of the greatest causes of waste in America is fire. Hundreds of millions of dollars' worth of materials are lost annually through fires, most of which are preventable. In addition, thousands of persons perish in these fires. Pupils may wish to focus their attention on this problem, to study the fire hazards in their own community and recommend safety measures to be taken for prevention. They may be encouraged to begin by working on such problems in their own homes and thus to put their learning into effect. They may write to the National Safety Council for literature on this subject that will be helpful in their study.

### Safety Rules Chart

1. Keep paper in metal waste baskets.
2. Keep closets free of rubbish.
3. Use matches only when an adult is present.
5. Build camp fires in picnic grounds only in places provided for them.
6. Put out camp fires before leaving picnic grounds.
7. Report all fires quickly to the nearest adult.

Pupils may watch newspapers and magazines for articles on various phases of conservation. They may find articles on flood control, the construction of dams for impounding irrigation waters, forest fires, and many other topics related to the conservation of natural resources. These articles may be read and studied by the pupils who find them, reported in class, and discussed by the class as a whole. They may invite a fireman from the local community to talk with them about fire precautions. Out of such an experience a set of safety rules, such as those in the chart above, might well result.

Almost every part of North America contains some kind of mineral deposit. By writing to the state or province geologist, children may learn what minerals are to be found in any region. Important
information about the extent and value of local mineral deposits may be secured in this way.

It would be interesting and beneficial if members of the class were assigned the task of finding out additional information about big dams such as the Grand Coulee, Hoover, and others on the Columbia and Colorado Rivers. They could report their findings to the class.

Perhaps a group of children would like to set up a small irrigation system of side ditches and row ditches in a sandbox or outdoors on the playground. Rubber tubing leading from a pail of water could be used to represent the reservoir and irrigation pipes. If children are near enough to irrigation areas they might visit one of them to see just how the land is watered. Referring children to the illustration on page 239 of the textbook should also stimulate discussion concerning irrigation projects.

As they read about the uses of metals the children may wish to make a parallel study of the rise in the use of plastics and synthetic products. Literature for such a study might be obtained from large industrial plants near you that produce plastics.

Perhaps setting up a "Then and Now" exhibit of products would be interesting. For example, you might display products that used to be made of a special metal or mineral material with their counterparts of today that are now made from plastic materials. These might include many kinds of children’s toys and games, dishes for storing food, and containers for plants.

An exhibit of products made from coal tar and petroleum would also help children realize the vast uses to which these products are put. These might include mothballs, aspirin, asphalt shingles, and perfume.

A visit to a railroad yard, a building in the process of construction, or an airport will help children realize how extensively iron, steel, aluminum, and magnesium are used.

Discussions after using any of the films and filmstrips listed on pages 140–141 in the Manual will also stimulate thinking and help children clarify their ideas concerning our need to use materials wisely.

Materials Needed

No special equipment or materials are necessary.
Things to Think About and Do

Suggestions for the teacher corresponding to those for children, pages 253-254, Discovering with Science.

1. In addition to discussion of the items listed, encourage children to suggest others.
2. Use of local resources might be seen by visiting such places as quarries, aviation fields, irrigation fields, and dams.
3. Pulling together the meat of the chapter on 'Using Materials Wisely' to share with others in an assembly program will require group thinking and planning. You will need to help children list topics that will interest other children. They might include:
   a. How dams are built.
   b. Irrigating a field.
   c. Use of plastics as substitutes for metals.
   d. How our community disposes of its garbage.
   e. Products that are made from coal tar.
   f. How coal is formed.
   g. How oil is believed to be formed.
   h. The need for wise use of materials.

4. More use of plastics and additional use of natural resources in medicine are two examples.
5. Suggest that children look for material on formation of coal in books they have at home and at school.
6. Many minerals abound in sea water. At present it is expensive to get them out of the sea. Stories of 'mining the sea' may be found in newspapers, books, and magazines. Try to find them and use them with your children.

Further Activities

1. Children may wish to study about oil and mineral deposits in Canada, the Near East, East Indies, and other places in the world.
2. Transporting oil from the oil fields to refineries would be an interesting topic for a report. Material on the Big Inch pipeline would also present an interesting topic for discussion.
3. Reading to learn how coal tar and petroleum products are made would be interesting to children.
4. Some meteorites are iron. Children might read about some of the meteorites which have fallen to the earth.
5. Additional information concerning conservation of other natural resources not covered in the textbook might be read to the class. For example, you might read to them about conservation of soil, wild life, forests, or some other resource that is commonly used in their locality.

**Evaluation**

One good way to assess the value of the children's work with the chapter on "Using Materials Wisely" is to watch their behavior regarding wastefulness in the classroom. You might watch for increased evidences that the children (1) use paper wisely; (2) care for books they are using; (3) keep all metal tools, games, and toys in dry places; (4) turn faucets off directly after using; (5) report drips in faucets both inside and outside the school building; (6) keep materials and supplies in good condition for use.

Another way to assess children's learnings is to listen to their informal conversations concerning any aspect of conservation. During free discussion periods they may talk about a new dam, plastics, oil wells, coal products, or other present-day uses of resources. Through their discussions you can learn much about their overall understanding of the basic principles of conservation. If working with the material in this chapter has really helped your children to improve their behavior regarding the care of everyday materials, an important goal will have been achieved.

**Bibliography**

*For the Teacher*


*For the Children*


140
Films

LAND OF LITTLE WATER. (EBF) 1 reel, color. Tells the story of water—the lack of it, and the excess of it on our western land.

OUR COMMON FUELS. (Cor) 1 reel, b/w. & color. Shows how various natural and manufactured fuels are obtained. Stress the importance of fuels in our economy and need for their conservation.

SCIENCE AND WOOD UTILIZATION. (Cor) ½ reel, color & b/w. Shows how science is helping save the nation’s forests by use of small growth and waste products.

WATER WORKS FOR US. (YAF) 1 reel, b/w. Explains the concept of water pressure, including the factors which govern it.

Filmstrips

MINERAL RESOURCES. (Curr F) color.

WATER CONSERVATION. (VS) color.
Appendix

Minimum Science Equipment

This list of equipment will make possible carrying out the science experiences suggested in Discovering with Science. Most of the items can be obtained in your community. The children will enjoy helping to collect the articles and to put them in the place set aside for their storage, as well as using them in their experiments.

Balloon
Baseball
Bell, electric
Bell, with clapper
Blotter
Blueprint paper
Board, ½” × 2” × 18”
Bottle, Pyrex nursing
Bottle, quart milk
Bowl
Box, wooden, approximately 6” × 8”

Candles
Cardboard, 2 pieces approximately 6 inches square
Cardboard tubes, 2
Chalk box
Chisel
Cigar boxes
Cloth, small piece
Cork
Cotton, sheet approximately 6 inches square, or heavy blotter

Dishes, 2 cereal
Dishpan
Drum or piece of inner tube and keg or wooden pail
Drumstick
Dry cells, 3 No. 6
Eye dropper
Flag, small paper
Flashlight
Flowerpots or other containers for planting
Fork, kitchen or tuning
Fountain pen

Glass, 2 pieces approximately 6 inches square
Globe
Hammer or can opener
Hand lens
Jar, quart
Knife
Leaves, e.g., African violet, rex begonia, snake plant, walking fern
Map, time zone of North America
Matches, long-handled, or wooden splinters
Measuring cup
Measuring spoon
Measuring tape
Modeling clay or gum
Mosses, ferns, mushrooms, or puff-balls

Nails
Needle and thread
Newspaper, daily giving local weather records

Pans, 2, sizes of wire cages
Paper bag
Pebbles
Pencil
Piano
Plants, small for floor of cage

Roots, e.g., beets, carrots, dahlia, sweet potato
Rubber bands
Ruler
Appendix

Additional Science Equipment

Although this list of materials is not essential for a good science program, their availability will greatly enrich the science program.

Ammonium dichromate, 4 ounces
Aquarium
Boards, for platform 2' x 2'
Bulb, 1 ½ watt
Cellophane
Cocoon
Custard cup, Pyrex
Doorbell
Hat box, ladies’ oval
Modeling clay
Perfume atomizer
Pipe cleaners
Plaster of Paris, 2 pounds

Rock and mineral samples
Rubber tubing or 3-foot piece of garden hose
Saw blade or ladies’ shoe tree
Screws
Silver teaspoon
Socket, for 1 ½ watt bulb
Soda
Soils, rich and sandy
Terrarium, glass with wire cover
Tumblers, 8
Vinegar, ½ cup
Wire screening for pet cage,
18” x 10” x 10”

Equipment Supply Houses

CAROLINA BIOLOGICAL SUPPLY COMPANY, Elon College, North Carolina.
Living and preserved materials, plastic mounts, charts, and apparatus.

CENTRAL SCIENTIFIC COMPANY, 1700 Irving Park Boulevard, Chicago, Illinois; 79 Amherst Street, Cambridge A Station, Boston, Massachusetts;
237 Sheffield Street, Mountainside, New Jersey; CENTRAL SCIENTIFIC COMPANY OF CALIFORNIA, 6446 Telegraph Road, Los Angeles 22, California; REFINERY SUPPLY COMPANY, McKinney Avenue, Houston 3, Texas; CENTRAL SCIENTIFIC COMPANY OF CANADA, LTD., 146 Kendal Avenue, Toronto 4, Ontario, Canada.

General equipment: magnetism, heat, light, etc. Aquarium and terrarium supplies, living and preserved materials, charts, etc.

CHICAGO APPARATUS COMPANY, 1735-43 North Ashland Avenue, Chicago, Illinois.

General equipment: magnetism, heat, light, etc. Aquarium and terrarium supplies, living and preserved materials, charts, etc.

FISHER SCIENTIFIC COMPANY, 711-732 Forbes Street, Pittsburgh, Pennsylvania, and EIMER AND AMEND, 633-735 Greenwich Street, New York, New York; in Canada, FISHER SCIENTIFIC COMPANY, LTD., 904-910 St. James Street, Montreal, Quebec.

General laboratory appliances.

GENERAL BIOLOGICAL SUPPLY HOUSE, 8200 South Hoyne Avenue, Chicago 20, Illinois.

Aquarium and terrarium supplies, living and preserved materials, charts.

NEW YORK SCIENTIFIC SUPPLY COMPANY, INC., 28 West 30th Street, New York 1, New York. (Formerly New York Biological Supply Company.) Preserved and living materials, and chemicals.

PRACTICAL AIDS COMPANY, Estacada, Oregon.

General equipment.

SOUTHERN SCIENTIFIC COMPANY, INC., Atlanta 3, Georgia.

General Equipment.

WARD’S NATURAL SCIENCE ESTABLISHMENT, INC., 3000 Ridge Road East, Rochester 9, New York.

Living and preserved materials and apparatus, rocks, and fossils.

W. M. WELCH SCIENTIFIC COMPANY, 1515 Sedgwick Street, Chicago 10, Illinois; BRAUN, KNACHT-HEIMANN, 1400 16th Street, San Francisco 19, California.

General equipment.

Directory of Publishers

ABELARD-SCHUMAN, LIMITED, 404 Fourth Avenue, New York 16, New York.

ABINGDON PRESS, 810 Broadway, Nashville 2, Tennessee.

AMERICAN RED CROSS, National Headquarters, 17th and D Streets, N. W., Washington, D. C.

WM. C. BROWN COMPANY, Dubuque, Iowa.

CHILDREN'S PRESS, INC., Jackson Boulevard and Racine Avenue, Chicago 7, Illinois.

THOMAS Y. CROWELL COMPANY, 432 Fourth Avenue, New York 16, New York.
Appendix

The Dryden Press, 110 West 57th Street, New York 19, New York.
Garden City Books, Garden City, New York.
Ginn and Company, Statler Building, Boston 17, Massachusetts.
Harvey House, South Buckhout Street, Irvington-on-Hudson, New York.
Holiday House, 8 West 13th Street, New York 11, New York.
Little, Brown and Company, 34 Beacon Street, Boston 6, Massachusetts.
The Macmillan Company, 60 Fifth Avenue, New York 11, New York.
Julian Messner, Inc., 8 West 40th Street, New York 18, New York.
Rand McNally & Company, P.O. Box 7600, Chicago 80, Illinois.
Charles Scribner's Sons, 597 Fifth Avenue, New York 17, New York.

145
Appendix

SIMON AND SCHUSTER, INC., 630 Fifth Avenue, New York 20, New York.
STERLING PUBLISHING COMPANY, INC., The Sterling Building, 121 East 24th
Street, New York 10, New York.
25, D. C.
VANGUARD PRESS, INC., 424 Madison Avenue, New York 17, New York.
ALBERT WHITMAN & COMPANY, 560 West Lake Street, Chicago 6, Illinois.
WHITTLESEY HOUSE (McGraw-Hill Book Company, Inc.), 330 West 42nd
Street, New York 36, New York.

Film and Filmstrip Distributors

Film Distributors

ALF
Barr
Churchill-Wexler
Cor
Cornell
EBF
IF
Pictorial
Sterling

Almanac Films, Inc., 516 Fifth Avenue, New York 18, New York.
Arthur Barr Productions, 6211 Arroyo Glen, Los Angeles 42, California.
Churchill-Wexler Film Productions, 801 North Seward Street, Los Angeles 38, California.
Coronet Films, Coronet Building, Chicago 1, Illinois
Cornell Film Company, 1501 Broadway, New York 36, New York.
Encyclopaedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Illinois; 5625 Hollywood Boulevard, Hollywood 28, California; 7250 MacArthur Boulevard, Oakland, California; 277 Pharr Road, N.E., Atlanta, Georgia; 161 Massachusetts Avenue, Boston 15, Massachusetts; 4902 Argyle Street, Dearborn, Michigan; 7421 Park Avenue, Minneapolis 23, Minnesota;
202 East 44th Street, New York 17, New York; 463 West Main Street, Kent, Ohio;
2129 Northeast Broadway, Portland, Oregon; 1414 Dragon Street, Dallas, Texas.
Instructional Films, Inc., 1150 Wilmette Avenue, Wilmette, Illinois.
Appendix

Filmstrip Distributors

Curr F


EBF

Encyclopaedia Britannica Films, Inc. See addresses listed for EBF under Film Distributors.

EGF

Eye Gate House, Inc., 2716 41st Avenue, Long Island City 1, New York.

FH

The Filmstrip House, 347 Madison Avenue, New York 17, New York.

JH

The Jam Handy Organization, 2821 East Grand Boulevard, Detroit 11, Michigan.

PDP

Pat Dowling Pictures, 1056 South Robertson Boulevard, Los Angeles 35, California.

SVE


UW-Educ

Educational Film Department, United World Films, Inc., 1445 Park Avenue, New York 29, New York.

VS

Visual Sciences, Box 599-HW, Suffern, New York.

YAF

Young America Films, Inc., 18 East 41st Street, New York 17, New York.

National Film Rental Agencies

Association Films, Inc., 347 Madison Avenue, New York 17, New York; 799 Stevenson Street, San Francisco, California; 561 Hillgrove Avenue, La Grange, Illinois; Broad at Elm, Ridgefield, New Jersey; 1108 Jackson Street, Dallas 2, Texas.


The Bray Studios, Inc., 729 Seventh Avenue, New York 19, New York.


Ideal Pictures, Inc., 58 East South Water Street, Chicago 1, Illinois; 2161 Shattuck Avenue, Berkeley 4, California; 4336 West Sunset Boulevard, Los Angeles 29, California; 714 18th Street, Denver 2, Colorado; 1331
Appendix

North Miami, Miami 32, Florida; 52 Auburn Avenue, N. E., Atlanta 3, Georgia; 1108 High Street, Des Moines, Iowa; 422 West Liberty Street, Louisville 2, Kentucky; 1608 St. Charles Avenue, New Orleans 13, Louisiana; 102 West 25th Street, Baltimore 18, Maryland; 40 Melrose Street, Boston 16, Massachusetts; 13400 West McNichols, Detroit 35, Michigan; 1915 Chicago Avenue, Minneapolis 4, Minnesota; 1402 Locust Street, Kansas City 6, Missouri; 3743 Gravois Avenue, St. Louis 16, Missouri; 1558 Main Street, Buffalo 9, New York; 233–239 West 42nd Street, New York 36, New York; 137 Park Avenue, W., Mansfield, Ohio; 1239 Southwest 14th Avenue, Portland 5, Oregon; 214 Third Avenue, Pittsburgh 22, Pennsylvania; 18 South Third Street, Memphis 3, Tennessee; 1205 Commerce Street, Dallas, Texas; 54 Orpheum Avenue, Salt Lake City, Utah; 219 East Main Street, Richmond 19, Virginia; 1370 South Beretania Street, Honolulu, Hawaii.

Instructional Films, Inc. See addresses of branch offices listed under Encyclopaedia Britannica Films, Inc., above.

International Film Bureau, Inc., 57 East Jackson Boulevard, Chicago 4, Illinois.

Index

Figures in boldface indicate pages on which illustrations occur.

Adaptation
as a pattern of the universe, xxii–xxiii
becoming adapted vs. adapting, 27, 38, 46
of animals to seasonal changes, 27–30
of plants to climate, 46, 47–49
of plants to seasonal changes, 37, 38–40
to environment, vii

Air
and the earth, 66–67, 70
and gravity, 67, 70
characteristics of, 66, 67
density of, 67, 70
depth of, 66
experiments with, 68, 69, 71, 72
gases in, 67
movement of, 67
pressure, 66, 67, 68, 71

Algae, 51
Amoeba, 94
Amphibians, 92, 93, 96

Animals
adaptation of, to seasons, 27–30
birds, 92, 93, 94, 96
cage for, 32, 97–98
characteristics of, 92
cold-blooded, 94–95, 96
fresh-water, 119
groups of, 92–96
hibernation of, 27, 29–30
insects, 27, 28, 92, 94, 119, 119
in the classroom, 32, 97–98
invertebrate, 92, 94
mammals, 92, 93, 96
many-celled, 92, 94
microscopic, 94, 116–117, 123
migration of, 27, 28–29
one-celled, 92, 93, 94
reptiles, 92, 93, 95–96
salt-water, 116, 117, 118
soft-bodied, 92, 93
vertebrate, 92, 94, 95, 96
warm-blooded, 94, 96

Audio-visual aids, 10, 10–14, 15
See also Films; Filmstrips.

Balance and imbalance in forces of nature, xxvii–xxviii
Barometer, 71

Behavior
and conservation, xxviii
and science, xiii–xiv
and study of science, 89–90
changes in, xxxii
consistent with health, economy, and safety, xxi–xxx
evaluation of, xxxii–xxxiii
patterns of, xiv
reflection of home and social backgrounds on, xxxii
relationship of democracy to, xxxiii
undesirable kinds of, xxviii

Bibliography: For the Teacher; For the Children

Biennial plants, 37, 39, 40

Birds, 92, 93, 94, 96
migration of, 28–29

Blueprint
care of paper, 42
of leaf, 42

Bulletin-board displays, 15

Change
a universal pattern, xx–xxii
seasonal, 19–22, 27–30, 37–40

Charts
Groups of Animals, 93
of local plants, 43
of seasons, by months, 24
on fire prevention, 137
on reproduction of plants, 88–89
on ways to put out fire, 72
on what air does for us, 72
showing classification of animals, 99
showing seed varieties, 89
Three Blind Mice, 79
weather, 24
Climate, 20, 21, 22
and plant life, 37, 39
map, 48
Coal, 136
Community resources, 10, 12, 13, 137–138
See also Resource persons.
Conductors of electricity, 104, 105, 111
Conservation
as a pattern for behavior, xxviii–xxix
developing responsibility for, 124, 140
of balance of nature, xxvii
of natural environment, 25, 31, 41
of natural resources, xxvii, 134–136
through wise use, 119, 135
Content of elementary science, xv–xvi
accuracy of, xiii
encyclopedic approach to, xv
incident approach to, xv

Dams, economic importance of, 135
Deciduous tree, 38
Democracy
American elementary school’s place in, v, ix–xi
dependence on behavior patterns, xxxiii
problems of the future in, ix
relationship of science to, xiv
using science in, ix–xi
Developmental instruction, xxxi
points of view in, vi–ix
Diaries
of experiments, 89
using pictures, 41
Diorama
as visual aid, 10
how to make, 33, 33

Discovering with Science
content of, 3
plan and use of, 5
purpose of, 3
Discussion
and experimentation, 109–110
in teaching science, xxx–xxxii, 5–6, 7
Dry cells, 103
content of, 105, 105–106
electricity from, 105
in electric circuit, 107
Earth
interior of, 56, 59–60
motion of, 56, 57, 58
shape of, 56–58
size of, 58
time zones on, 58–59, 59, 61
Echoes, 76, 78
Economy
relation of science to problems of, xxix–xxx
task of elementary school in teaching, xxx
Egocentricity in children, vi–vii
Electric circuit, 104
short circuits in, 107, 111–112
with push button and bell, 107
Electricity
conductors of, 104, 105, 111
current, 103, 105
from dry cells, 103, 105
nonconductors of, 105, 107–108
protons and electrons, 104
safety with, 104–105, 113
Electromagnets, 104, 106
in telegraph sets, 108
uses of, 106–107
Electrons, 104
Elementary school science
basic purpose of instruction in, x
content of, viii, xi
developmental instruction in, vi–ix, xxxi
integration of health, social studies, and science in, xxix
teaching procedures in, xxx
Environment
adaptation to, xxii–xxiii
children's experiences with, 4, 44
conservation of, 25, 31, 41
developing responsibility for,
xxviii–xxix, 87
early adjustment to, vii
interrelationships in, xxii–xxiii
of the future, xxx
variations in children's, xxv

Equipment for teaching science
Additional Science Equipment, 143
Equipment Supply Houses, 143–144
Minimum Science Equipment, 142–143
See also Materials Needed.

Evaluation
[Numbers in parentheses indicate
the chapter to which the reference applies.] (I) 25, (II) 33–34,
(III) 43–44, (IV) 53–54, (V) 63–64, (VI) 72–73, (VII) 80–81,
(VIII) 89–90, (IX) 99, (X) 112–113, (XI) 123–124, (XII) 131–132,
(XIII) 140

Evaluation
an integral part of instruction,
xxxii
by observing behavior, 44, 81, 140
by observing conversations, 64
criteria for, 17–18, 34
goal, 25
of behavior, xxxii–xxxiii
of study areas selected, 4
through written stories, 72–73
using picture tests, 113
using science word game, 34

Excursions
as learning experiences, 7–9
concerning
animals, 32–33, 98
minerals, 130, 138
plants, 40, 87, 88
rocks, 129
seasonal changes, 24, 40

Exhibits
at museums, 10, 12
concerning
coal products, 138
minerals and plastics, 138
preparation and display of, by
children, 11–12

Experiments
analytical aspect of, 68–70
as learning experiences, 9, 67
concerning
air in space, 69
air in water, 72
air pressure, 68, 71
carbon dioxide, 71
electricity, 112
plant growth, 43, 53
sound, 77, 78, 79, 80, 81
sun's rays, 24
temperature, 72
vapor condensation, 72
repetition of, 109–110
verifying results of, 9

Films; Filmstrips
[Numbers in parentheses indicate
chapters for which lists are given.] (I) 26, (II) 35–36, (III) 44–45,
(IV) 54–55, (V) 65, (VI) 74,
(VII) 82, (VIII) 90–91, (IX) 100–102, (X) 114, (XI) 125, (XII)
133, (XIII) 141

Films and filmstrips
sources of, 12, 13, 146–148
use of, 10, 41, 61–62
Fish, 92, 93, 94, 95
Food chain, 117
Forces in the universe, interplay of,
xxvii–xxviii
Fossils, 129, 132
Fresh water life, 49, 50, 118–119,
118, 119
microscopic, 123
See also Keys to illustrations.
Frost-free zone map, 48

Further Activities
[Numbers in parentheses indicate
chapter for which the activities
are suggested.] (I) 24, (II) 33,
(III) 42–43, (IV) 53, (V) 63, (VI)
71–72, (VII) 78–80, (VIII) 88–89,
(IX) 98, (X) 112, (XI) 123,
(XII) 130–131, (XIII) 139–140

Fuses, electric, 111–112
Index

Geysers, 63

Group work
in teaching-learning situations, xxx–xxxi
stimulation of, 6

Health, integration with science and social studies, xxix

Hibernation of animals, 27, 29–30

Incident approach to science, xv–xvi, xxxiii

Individuality, concepts of, xxiv–xxv

Information for the Teacher

Insects, 27, 28, 92, 94, 119, 119

See also Keys to illustrations.

Insulation of electric wires, 104, 107, 108

Interdependence of living things, xxv–xxvii

Interplay of forces, as a pattern of the universe, xxvii–xxviii

Interrelationships
as a pattern of the universe, xxv–xxvii
between animals and environment, 93–94
between plants and environment, 38
of science and everyday life, 53

Invertebrates, 92, 94

Irrigation, 135

Keys to illustrations in Discovering with Science
[Figures in parentheses indicate pages in textbook on which illustrations occur.]
animals, fresh-water, (203), 119;
salt-water, (147) 95, (194–195) 121; shells of, (209) 122

plants, fresh-water, (61) 50, (202) 118

Land of the Midnight Sun, 23, 24

Magma, 60, 129

Mammals, 92
characteristics of, 96
that hibernate, 30

Materials Needed
[Numbers in parentheses indicate chapters for which lists are given.]
(I) 23, (II) 32, (III) 41, (IV) 52, (V) 62, (VI) 70, (VII) 78, (VIII) 87–88, (IX) 98, (X) 110–111, (XI) 122, (XII) 130, (XIII) 138

See equipment lists, 142–143.

Metals, 130, 135, 136

Middle-Age Child, The, 1–2

Migration of animals, 28–29

Minerals
conservation of, 136
crystals in, 128–129
in rocks, 126, 127
in the ocean, 115, 116, 139

Molecules, 75–76

Museums
as sources for visual aids, 10, 12–13
in the school, 11–12
state and city, 12
ways to use, 12

Natural resources
conservation of, 134, 135, 136
misuse of, 134, 135, 136

Nonconductors of electricity, 105, 107–108

Observation
an approach to science, 7
in teaching-learning situations, xxx–xxxii

Ocean
characteristics of, 115, 116
contents of, 116–118

See also Keys to illustrations.
Patterns of the universe, xvi, xvii–xxix
adaptation, xxii–xxiii
balance and imbalance, xxvii–xxviii
change, xx–xxii
interdependence and interrelationships, xxv–xxvii
space, xvii–xviii
time, xviii–xix
variety, xxiii–xxv
Perennial plants, 37, 39–40
Pets in the classroom, 97–98
cage for, 32
Pictures
for study of
animals, 31, 97, 120
seasons, 23, 24
to draw
for plant calendar, 41
for safety posters, 111
for time-zone map, 63
of animals in summer and winter, 33
of electric devices, 113
of leaf and flower buds, 42
Planets, 58
orbits of, 57
Plankton, 116–117, 118
Planning in teaching-learning situations, xxx–xxxi
Plants
adaptation of, 37, 38–40, 46, 47–49
annuals, 37, 39, 40
biennials, 37, 39, 40
classification of, 84
conifers, 84, 84
deciduous, 38, 39
embryo of, 85, 85
evergreen, 39–40
flowering, 84–85, 85
fruit of, 85–86
known kinds of, 84
microscopic, 116–117
perennials, 37, 39, 40
reproduction of, 83, 84, 85, 86
seed of, 83, 84, 85, 85–86
universality of, 47, 48, 49
variety in, 37, 46–49
water, 49, 118–119

See also Keys to illustrations.
Procedures in teaching science, variety of, xxx–xxxii
Protons, 104
Protozoa, 94
Publishers' directory, 144–146

Reading
factual vs. story, 60–61
in teaching-learning situations, xxx–xxxi
objectives of, 15–16

Recording
and evaluation, 17, 72
on wire or tape, 14
barometer readings, 71
seasonal changes, 22, 24, 42
Reptiles, 92, 95–96
Resource persons
Agricultural Extension agent, 53
fireman, 137
4-H Club leader, 53
high-school science teacher, 120
museum curator, 130
music teacher, 78
nurse or doctor, 120
school custodian, 42
Rocks, 126–128
collection of, 128
formation of, 127–128

Safety education
aspect of conservation, xxx
chart, 137

Science
aims in teaching, 3–4, 5
approaches to learning, 6–16
behavior, and study of, 89–90
children's concepts of, 5
children's experiences with, vi, vii
curriculum development in, v, x, xv–xvi
developing favorable attitudes toward, xxxiv
in a democracy, v, ix–xi
in elementary-school program, v, ix, xv–xvi
nature of, xi–xiii
origin of, viii
preschool experiences in, vi, vii
problems of the future in, ix–x
relation of economy to, xxix–xxx
reliability of information taught in, xii–xiii
Science instruction
incident approach to, xv–xvi, xxxiii
using scientific method in, xiii–xiv
Science Meanings for Children
[Numbers in parentheses indicate chapters to which summaries refer.] (I) 19–20, (II) 27, (III) 37, (IV) 46–47, (V) 56, (VI) 66, (VII) 75, (VIII) 83, (IX) 92, (X) 103–104, (XI) 115–116, (XII) 126, (XIII) 134–135
Scientific method
helping children use, 3–4
in teaching, xiii–xiv
Seasons, 19
effect on animals, 27–30
effect on plants, 37–40
factors affecting, 19, 20–22
See also Charts.
Seeds, 83–86, 84, 85
Selecting Your Approach to Science
auditory aids, 13–14
bulletin board, 15
discussion, 7
excursions, 7–9
experiments, 9
listing children's questions, 6–7
maintaining a science table in your classroom, 14–15
observation, 7
reading, 15–16
visual aids, 10–13
Setting Up Your Science Program, 4–5
Snakes, 95–96, 97, 98
Solar system
earth in, 58
planets of, and their orbits, 57
Sound
and vibrations, 75–76, 78, 80
conductors of, 75, 76
echoes, 76, 77
experiments with, 77, 78–80, 79, 81
pitch, 75, 76, 79, 79–80
traveling of, 75, 76
Source material
auditory aids, 13–14
identification of, xiii–xiv
reliability of, xii–xiii
visual aids, 10–13
See also Bibliography; Community resources; Films; Filmstrips.
Space, as a pattern of the universe, xvii–xviii
Spores, 83, 86
Summarizing activities
More about Animals, 98
More about Sound, 78
More for You to Talk About and Do, 62–63
Some Things for You to Do, 32–33
Some Things to Think About and Do, 23–24, 70–71, 122
Things to Think About and Do, 41–42, 139
Think and Talk about These Things, 52–53
Thinking about Electricity, 111–112
You May Want to Do These Things, 88
Teaching methods for science
developmental, xxxi
evaluation of, xxxi
incident approach, xv–xvi, xxxiii
in presentation of facts, xii
Telegraph set, 108
Three Blind Mice, chart of musical score, 79
Time, as a pattern of the universe, xviii–xix
Time zones, 59, 61
answers to questions on pages 72 and 76 of textbook, 62
map of, 59

Universe, patterns of, xvi, xvii–xxix
Variations
in biological world, xxiii–xxiv
in concept of individuality, xxiv–xxv
in physical world, xxiv
Variety
as a pattern of the universe, xxiii–xxv
in animals, 92, 94–96
in experiences of children, vi
in plants, 37, 46–49
of procedures in teaching science, xxx–xxxii, 6–16
See also Community resources;
Discussion; Excursions; Experiments; Observation; Reading;
Visual aids.
Vertebrates, 92, 94, 95, 96
Vibration
and sound, 75–76
experiments in, 79–80
Visual aids
in teaching-learning situations, xxx
sources of, 12, 13
ways to use, 10–13
See also Bulletin-board displays;
Films; Filmstrips; Museums.
Volcano, 63
model of, 130–131, 131
Waters of the earth, variations of, 115–116

conservation of, 124, 135–136
economic importance of, 135
life in fresh, 118–119, 123
life in salt, 116–118
Ways of Working with Children
[Numbers in parentheses indicate chapters to which the reference applies.] (I) 22–23, (II) 30–31,
(III) 40–41, (IV) 51–52, (V) 60–62, (VI) 67–70, (VII) 76–77,
(VIII) 86–87, (IX) 96–98, (X)
109–110, (XI) 119–121, (XII)
128–130, (XIII) 136–138
Ways of working with children, 5–6
developing problem-solving methods, 2–3, 4
discussion, 7
evaluation, 16–18
excursions, 7–9
experiments, 9
keeping records, 17
listing children’s questions, 6–7
maintaining science table, 14–15
observation, 7
reading, 15–16
using auditory aids, 13–14
using visual aids, 10–13
Discovering with Science

By Gerald S. Craig

Professor of Natural Sciences
Teachers College, Columbia University

and Beatrice Davis Hurley

Associate Professor of Education
New York University

Ginn and Company

Boston • New York • Chicago • Atlanta • Dallas • Columbus • Palo Alto • Toronto • London
SCIENCE TODAY AND TOMORROW

Science and You (Primer) · CRAIG-BRYAN
Science Near You · CRAIG-BRYAN
Science Around You · CRAIG-DANIEL
Science Everywhere · CRAIG-LEMBACH
Discovering with Science · CRAIG-HURLEY
Adventuring in Science · CRAIG-HILL
Experimenting in Science · CRAIG-ROCHE-NAVARRA
Learning with Science · CRAIG-AREY-SHECKLES
Facing Tomorrow with Science · CRAIG-URBAN

A Teachers' Manual accompanies each book

Illustrations by FOSTER CADDELL, JR., ELEANOR O. EADIE, MATTHEW KALMENOFF, CHRISTIE McFALL, A. GLADYS PECK, and TECO SLAGBOOM
## Contents

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Seasons</td>
<td>4</td>
</tr>
<tr>
<td>Animals and the Seasons</td>
<td>20</td>
</tr>
<tr>
<td>Plants and the Seasons</td>
<td>34</td>
</tr>
<tr>
<td>Where Plants Grow</td>
<td>50</td>
</tr>
<tr>
<td>The Earth</td>
<td>64</td>
</tr>
<tr>
<td>The Air We Live In</td>
<td>86</td>
</tr>
<tr>
<td>The Sounds We Hear</td>
<td>106</td>
</tr>
<tr>
<td>How Plants Grow</td>
<td>128</td>
</tr>
<tr>
<td>Learning about Animals</td>
<td>144</td>
</tr>
<tr>
<td>Working with Electricity</td>
<td>164</td>
</tr>
<tr>
<td>The Waters of the Earth</td>
<td>184</td>
</tr>
<tr>
<td>Studying Rocks and Minerals</td>
<td>210</td>
</tr>
<tr>
<td>Using Materials Wisely</td>
<td>236</td>
</tr>
<tr>
<td>Science Words</td>
<td>255</td>
</tr>
<tr>
<td>Index</td>
<td>260</td>
</tr>
</tbody>
</table>
Back to School

September days are here again. You are back at school. It is good to see all your friends once more. You will enjoy working and playing together again this year.

Yes, September is the month when many boys and girls all over North America go back to school. It is also the month when the fall season begins in North America. September 23 is the first day of fall. Wherever you live in North America, the last days of September, all of October and November, and the first part of December are the months of your fall season.

Heat and the Seasons

You probably live in a place that has four seasons. But the kinds of weather during each season where you live may be quite different from the kinds of weather during each of the seasons in other places.

You may live in a place where summer and winter temperatures are much alike. Or you may live in a place where summer and winter temperatures are very, very different.

If you live in the northern part of the United States or in Canada, you live where there is a great difference between summer and winter weather.

Summer days are usually warm or hot in the northern part of the United States and in Canada. Winter days are usually cool or cold.

You may live in the southern part of the United States or in Mexico. There the summer and winter days are different, too. But most winter days there are likely to be warmer than any winter day in Canada. Most summer days are likely to be hotter than any summer day in Canada.

How does the weather change through the seasons where you live? Are most of your winter days cool or cold? Are most of your summer days warm or hot?
Finding Out about Summer and Winter Days

Perhaps you are ready now to try to answer this question: Why are summer and winter days in some parts of North America warmer than in others? If you have a globe in your classroom, it will help you to find the answer to the question. If you do not have a globe, the map on this page will help you.
First of all, find the place where you live on the globe or map. Now find the north pole. Is the north pole a long, long distance from where you live? Next find the equator. The equator is an imaginary line making a circle around the middle of the globe. Is the equator a long, long distance from where you live? Your teacher will help you to find these places if you need help.

Ask yourself this question: Is the place where I live nearer the north pole than the equator? This is an important question. It makes a difference in the kinds of weather you have during your four seasons.

If you live near the equator, your summer season is hotter and your winter season is warmer than summer and winter seasons farther north. On the other hand, if you live near the north pole, your summer season is cooler and your winter season colder than summer and winter seasons farther south.

Winter in different parts of the world
Finding Out about Straight and Slanting Rays

The nearer you live to the equator, the straighter the sun’s rays shine on your part of the earth. The farther you live away from the equator, the more slanting are the sun’s rays. You can understand about straight and slanting rays by doing the following experiment in your classroom:

Hold a flashlight in your hand so that its light shines straight down on the floor. Have someone draw a circle on the floor where the light falls. Draw the circle lightly with chalk, so that it will wash off easily. You will notice that not much of the floor is lighted, but that the light is bright on the floor.

Now tip the flashlight so that the light hits the floor at an angle. Again have someone draw a line around the lighted part of the floor. You will notice that this lighted part of the floor is larger, but that it is not so bright as before.

Try the experiment over again. Have someone hold his hand near the floor each time as the light shines on it. Ask him which time the light warms his hand more.

The sun’s rays shine on the earth in much the same way that the light from the flashlight shines on the floor. The slanting rays of the sun spread out over more space as they hit the earth, just as the slanting rays of the flashlight do as they shine on the floor. The slanting rays of the sun heat and light a larger part of the earth, but this part is not heated or lighted so well.
On the other hand, the straight rays of the sun shine on a smaller space as they hit the earth, just as your flashlight rays do when you hold the flashlight straight. They heat and light this space better.

The closer you live to the equator, the straighter are the sun’s rays that shine there. This is one reason why places near the equator are warm or hot. Places far away from the equator are cool or cold because the sun’s rays that shine there are more slanting.

At some times of the year the sun’s rays slant more than at others. Wherever you live in North America, your winter season is cooler than your summer season. Perhaps the warmest day during the summer was 100 degrees where you live. Your warmest winter day will not be that warm.

One reason for this is that in winter the rays of the sun that shine on your part of North America are more slanting than they are in summer.

Summer and winter may be thought of as seasons of hotness and coldness. They may also be thought of as times of the year when the sun’s rays are straighter or more slanting.
Summer Days Are Not All Alike

Suppose your class takes an imaginary trip right now. Let's make believe you live in Mexico and that you are going to visit the city of Vancouver in Canada. Your trip will take you through the northern part of the United States and into southern Canada. It is June, and the weather is hot. The temperature on the day you are packing for your trip is 92 degrees.

What a hot day it is to pack! You keep on putting summer clothing into your bag. You can hardly believe that you will need any warm clothes. But you'd better look at that globe or map again before you close your suitcases.

Where is Canada? In what direction shall you be traveling? Shall you be going away from the equator or toward it? Remember what you have just been reading. Will the sun’s rays that shine on Vancouver be more slanting than those that shine on Mexico?
Of course you know by now that you’d better pack a sweater and perhaps a coat too. You’ll be sure to need them on some days as you travel north.

What fun you have on your trip! You travel by way of California, past orange groves there. You admire the tall evergreen trees in Oregon and Washington. Finally, you arrive in Vancouver, Canada.

It has taken you about two weeks to reach Vancouver by car. It is still June. Yet already you have used both your sweater and your coat. You are glad that you brought them along, for there were a few days when you needed them to keep you warm.

Let’s look again at the globe or map. Have your teacher help you to find Vancouver. Is it north of Mexico? Is it nearer the north pole than the equator?

You remain in Canada for a month. The weather there is comfortable. Many days are warm and sunny. It is often warm enough to enjoy a swim and to wear summer clothing. But even in summer the sun’s rays are slanting rays in Vancouver. It is cool enough to need a sweater sometimes, too.

Letters from home tell you how hot it is in the part of Mexico where you live. There the sun’s rays shine straighter. It is very hot there during the summer season.
Winter Days Are Not All Alike

Now suppose you live in Montreal instead of Mexico. Can you find this city on the globe or map? If you need help, ask your teacher to help you. What about straight and slanting rays there?

It is December in Montreal. The winter season begins there on December 22 and lasts for three months. You are in school, so you cannot take a vacation. But you don’t care, because you like winter in Montreal.

The days are cold. After school you hurry home to get your skates. Away you go to the pond! You glide and turn as you skate over the smooth ice. Skating is great fun on cold winter days.

On Saturday you bundle up in warm clothing. You pull your ear flaps down over your ears and put on warm, furry mittens. You are off with your sled for a ride.

The air is clear and cold. You stay outdoors for an hour or so. Then you decide to go indoors and warm yourself. Winter days are cold in Montreal. Winter days there are colder than winter days farther south.

Take Washington, D.C., for example. The children there also may have a chance to skate and to go sliding in winter. They bundle up in warm clothes. Children in Washington think of their winter as being cold. And many days are.
But many winter days in Washington are warmer than most winter days in Montreal. There are many more days for skating and sliding in Montreal than in Washington each winter.

Again, if you look at your globe or map, you will know why this is true. The winter rays of the sun that shine on Washington are less slanting than those that shine on Montreal.

Now suppose you live in New Orleans, Louisiana. What are the days like there in winter? Well, first of all most winter days there are warmer than winter days farther north. They are warmer than most winter days in Montreal or in Washington.

The children in New Orleans think of their winter days as cool. And compared with their summer days, they are cool. The children feel the difference between winter and summer days. Sometimes on a winter day in New Orleans it may freeze or even snow. But most winter days in New Orleans do not get that cold.

In New Orleans there are not many days when you could use a red sled or a pair of skates, even if you owned them.

Can you find New Orleans on your globe or map? Is it nearer the equator than it is to the north pole? Can you tell now why winters in New Orleans are warmer than winters in Washington?
Finding Out about Long and Short Days

Of course you already know that a day and a night are twenty-four hours long. You know, too, that during the summer season in North America days are longer than nights.

Think for a moment, and you will remember that this is true. In the summertime do you often play outdoors after supper? You may jump rope or play baseball or some other game. Perhaps it is light enough to play outdoors until as late as eight-thirty or nine o’clock where you live.

What about winter days where you live? Is it often dark when you eat your supper? You cannot go outdoors to play games after supper. You must play indoors instead.

If you lived right at the equator, there would not be such a difference. Days and nights are almost always of equal length there. Each day is about twelve hours long. Each night is about the same length.
As you travel north from the equator, days and nights are not equal in length. Summer days are long, and winter days are short. The sun rises earlier in summer in North America than it does in winter. The sun sets later in summer in North America than it does in winter.

Do you sometimes have a hard time getting up in the winter? Perhaps you open one eye, and everything is dark outside. You can’t believe it is seven o’clock and time to get ready for breakfast. So you shut your eyes and go back to sleep.

The sun rises later in winter in North America than it does in summer. Is it often still dark at seven o’clock in the morning in winter where you live?

The time of day the sun rises and sets is one reason why days are colder and warmer during the different seasons.

As you know, the earth gets its heat from the sun. The longer the sun shines on any part of the earth, the more hours it has to heat that place. There are more hours of sunshine each day in summer in North America. So there is more heat.

In winter in North America there are fewer hours of sunshine each day, and there is therefore less heat.

Remember this also: no matter where you live in North America, you receive straighter rays of the sun in summer than in winter. Remember that straighter rays mean more heat.
If you live in the northern part of the United States or in Canada, you know that there is a great deal of difference between the length of days in summer and the length in winter.

If you live in the southern part of the United States or in Mexico, there is not so much difference between the length of your day and night in summer and the length in winter. Even so, days there are longer than nights in the summer and shorter than nights in the winter.

Use your globe or map again. You can now compare the length of days and nights where you live with the length of days and nights in places north and south of you.

Plan to keep a record of the time the sun rises and sets each day where you live. Keep your record for at least a month. In this way you can see whether the days are getting longer or shorter during this time of year.

You may be able to find out from your daily newspaper the time that the sun rises and sets. You may also ask the nearest weather station to help you to get the time the sun rises and sets each day in your neighborhood.

After your record is finished, it might be fun to find out how much the amount of sunlight in your neighborhood changed during the month. Did you find that there were more minutes of sunlight at the end of the month, or were there fewer minutes of sunlight?
You have been reading about seasons in the continent of North America. The winter season begins here on December 22. The first day of spring is March 21. Summer starts on June 22, and autumn begins on September 23.

For children who live south of the equator the opposite is true. Find South America on your globe or map. Notice that most of this continent is south of the equator. While you are having summer where you live, children in most of South America are having winter. While you are having spring, children there are having fall.

Yes, if you lived south of the equator, the months of each season would be different. Something else would be different, too. As you travel south, away from the equator, winters would be colder and summers cooler.

You might keep on going south and finally reach the south pole. Winters there are very, very cold. Summers there are very cool, just as they are near the north pole.

As you grow older, you will learn more about the earth and its seasons. Now you have learned three reasons why the seasons change. Perhaps you will remember these three ideas better if you think of them in the following way:

1. The distance that you are away from the equator affects the kinds of seasons you have where you live.

2. The way that the sun’s rays hit your part of the earth affects the kinds of seasons you have where you live.

3. The difference between the length of night and the length of day affects the kinds of seasons you have where you live.
1. Really your globe is a very important instrument when you are learning to understand the seasons. If you have been using it, you know that this is true. You may wish to study it some more. You might like to find places that members of your class have visited. Let each person who has visited one of these places describe the kind of weather there. See if you can explain why the weather there is as it is. Ask yourselves these questions:

How far is this place from the equator?

At what time of year was this place visited? At this time of year, would the days be longer or shorter than the nights?

Would the rays of the sun that strike this place be straight or slanting?

2. If you lived in Australia, what months would be your winter season? What ones would be your summer season?

3. Have you ever heard of the Land of the Midnight Sun? Try to find out where this place is. See if you can find any reason why the sun would shine at midnight there. Your globe will help you again.

Suppose you place a flashlight on one end of the table where your globe stands. Can you place some books under the flashlight so that the part of the earth near the north pole is lighted even at night? This is summer at the north pole. Now can you change the position of the globe so that the north-pole area is dark even at noon? This is winter at the north pole. In summer at the north pole the sun shines day and night for almost six weeks. In winter at the north pole the sun does not shine at all for about six weeks.

4. Suppose that you wanted to be in South America during its summer season. When would you plan to go?

5. Think about how the seasons affect you. Write a short story telling some of the things you do in the summer season and some you do in winter.
Animals and the Seasons
Animals Change Their Ways

As the seasons change in your neighborhood, animal life changes, too. During the warm summer months there is much food for animals. Animals are busy eating and growing. Some of them eat more food than they need. This food is stored as fat.

As cooler days arrive, many birds fly to warmer places. Other animals bury themselves in the ground and spend the winter there. Still others find shelter in hollow logs or caves or old buildings.

As spring and summer days come again, insects can be seen almost everywhere. Many birds return from the south. Animals climb the mountains and graze. Fish seek shallow waters and raise their young.
Some Animals Hibernate All Winter

Did you ever wonder where toads and snakes and turtles and frogs go when cold winter days come? These animals find places that are protected from the icy wind and crawl into them. They may bury themselves in the mud or sand at the side of a pond.

We say that these animals hibernate, or seem to sleep. That is, they become quiet much as you do when you go to sleep. They have been active all summer and fall. Now they seem to sleep.

But really their quiet time isn’t like our sleep. While they hibernate, the work that goes on in their bodies almost stops. They breathe ever so slowly. You might even think that the animals were dead. But they are still alive.

Snakes crawl under rocks and boards and old logs to hibernate. Here they are safe and warm while the cold winds blow.

You may wonder who brings them their food. No one needs to bring food to these hibernating animals. They do not need to eat during their quiet time.
All summer long they have eaten all they wanted. Layers of fat have been stored in their bodies. These layers of fat are used by the animals while they hibernate.

No one knows just why hibernating animals become active again. They may get hungry. At any rate, they crawl out of their winter homes and start hunting for food.

Toads and frogs, turtles and snakes are not the only animals that remain quiet during the cold part of the year. Some furry animals hibernate, too. Woodchucks find a hole to stay in during the winter. They too have layers of fat which they use as they hibernate.

The picture on this page shows you why woodchucks hibernate in deep holes. Can you see why they would not hibernate near the top of the ground? Would they be comfortable near the top of the ground?

When woodchucks start hibernating, they are round and fat. You should see them at the end of their long quiet time. They have grown very thin. Some of the fat in their bodies has been used as food. How hungry they must be when they wake up!

You may live in a part of the world where winter is not a cold time. Frogs, toads, turtles, and snakes that live in warm places do not hibernate. They stay active almost all the year through.
Some Animals Hibernate Part of the Winter

Many animals hibernate only part of the winter. This is true of chipmunks.

During most of the year chipmunks hunt nuts and seeds for food. How busy they are! You can watch them eating. You can also see them carrying nuts and seeds to safe hiding places in underground tunnels.

As the cold days come, chipmunks crawl into their underground homes and curl up. They seem to be sleeping. But they are only quiet. They are hibernating.

From time to time during the winter they wake up. If they are hungry, they have a little feast of nuts. They may even run about hunting for more food. Then they become quiet again.

Many other animals hibernate for only part of the winter. Some bats keep hibernating and waking up all winter long. When they wake up, they usually go out to look for food.

Meadow mice and squirrels hibernate during part of the winter, too. Perhaps you have been surprised to find them running about in winter.

When you see them out on cold winter days, you know they are hunting for a little bite to eat. Then they hibernate again.

Some kinds of bears hibernate part of the winter. They crawl into a hole or cave, where they keep warm. They wake up and then hibernate again several times during the cold weather.
Some Animals Travel Long Distances

“Honk, honk, honk!” There they go, flying high above in the shape of a V. Not airplanes! Wild geese! They are flying north. Can you guess what season of the year it is?

Wild geese and many other animals take long journeys in the fall and spring. We say they migrate. They travel south in the fall and north in the spring.

Do you live in a place where there are many cold winter days? If so, you may wish for the return of the birds to your schoolyard. Are robins among the first birds to return to your part of the country?

Sometimes robins arrive too early and are caught in the last snowstorm of the year. If that happens, they may need your help. You may have to feed them.

You are glad to do so. You know that the return of the robins and other birds means “Spring’s here at last!” Soon you will be jumping rope or playing baseball again.

Many, many birds fly north as the warm days come. They fly and fly. Finally, they find a place to build their summer homes. Do some of these birds that fly north build their nests near your home?
How busy robins are once they arrive! We see them carrying many things in their mouths. They use small bits of string, paper, leaves, feathers, and other things to build their nests. We know that eggs will soon be laid in these soft, round nests.

Day after day the mother bird sits on the eggs and keeps them warm. The male bird sometimes brings food to her. Some male birds sit on or near the nest while the female bird goes for food.

Before many days fuzzy heads stick up above the top of the nest. What a noise! Here come the grown-up birds with food for the hungry, growing ones. No wonder the young birds grow fast. They eat so much.

Some birds stay in the same place the year round. They do not migrate as the seasons pass. They live in the same region all winter and all summer.

You may be surprised to know that some birds are great travelers. Many birds build their summer homes miles and miles away from where they live in winter.

The golden plover is one of these birds. This bird builds its summer home in the northern part of North America. It spends the winter in South America.

Twice each year the golden plover flies miles and miles to get from its summer to its winter home and back again.

Arctic terns are great travelers, too. Twice each year they travel about 11,000 miles to reach their summer and winter homes. Their nests have been found in the northern part of Canada. But their winter homes are thousands of miles to the south.
As Birds Migrate

Birds meet many dangers as they migrate. They sometimes have to fly through heavy storms. They may run into ice and snow as they fly north. They may have to fly against a strong wind. Sometimes the wind blows them far out to sea, and they become tired and fall into the water and drown.

Each year many birds die because of bad weather. Often they bump into trees or high buildings or lighthouses. Lights may attract them toward the buildings. In the morning many birds may be found dead near these places.

Sometimes, on the other hand, the wind helps the birds on their long trips. We might say the birds ride on the wind when it is blowing their way.

Most birds stop to feed and to rest along the way as they migrate. Some travel only a few miles in a day. Others travel much farther.

Have you ever seen birds getting ready to migrate? They gather in large flocks. That is the way they travel. They go north and south in flocks.

The larger birds usually travel by day. They rest and find food on the way. The smaller birds usually travel at night. They are safer from larger birds when they travel at night.

You must have seen migrating birds resting on their long journeys. Sometimes hundreds of them will light on telephone and other wires. You may have frightened them away as you rode past in your car.
No one really knows just why birds migrate. Different people have different ideas about that.

Some people believe that birds migrate to get food. Yet this could hardly be the only reason. Many birds begin their journeys while there is still much food where they are.

Besides this, birds would not need to fly as far south as many of them do to get food. They could stay much nearer their summer homes in the north. There would be enough food for them to eat.

Some other people think that birds may migrate because of habit. Long ago birds may all have lived in warm places. The food supply may have become scarce, and some birds may have traveled north in search of food. Each year they may fly north because they have formed the habit of doing so.

Tell your classmates any ideas you have about why birds migrate in the spring and fall. After all, no one really knows just why. Your idea may prove to be the right answer to this question.
Some Other Animals Migrate, Too

Birds are not the only animals that migrate as the seasons come and go. But birds migrate in greater numbers than any other animals do. Perhaps they are better suited to migrating because they can travel so fast.

A few other animals do migrate, however. Alaska fur seals travel to the cold waters of the Bering Sea. Here they raise their young. As colder days arrive, both young and old swim farther south to warmer water. Here they stay until the next spring.

Polar bears migrate, too. They live on large pieces of floating ice in summer. Here they mate and have their young. The ice travels to the south in the summer and fall. The bear families float along on it. As the winter days arrive, the small pieces of ice freeze together. Then the polar bears travel north again over the solid ice.

Some fish migrate also. Salmon that live in the Pacific Ocean are great travelers. The grown salmon travel from the salty ocean waters to the fresh waters of rivers. Here they lay their eggs.

This trip upstream is a very hard one. The salmon sometimes leap many feet into the air to get over the waterfalls and rapids in the rivers. They travel only a few miles a day because they have to swim against the swift water.

Finally, they reach the places where the rivers are not so swift. Here they lay their eggs. They then float down toward the ocean again. But they do not ever reach it. They die on the way.

When the young salmon are 2 to 5 inches long, they swim down the rivers to the ocean. They stay in the ocean for several years before they migrate up the rivers to fresh water again.
Animals Change in Other Ways

You have been reading about animals that hibernate or migrate as the seasons pass. Many animals do neither of these two things. They stay in one place during all four seasons. But they change with the seasons.

Dogs and cats stay in one place the year round. They grow a thicker coat of hair in winter. This thick coat keeps them warm. In summer they lose some of their coat. Hair drops out of their coats.

Sheep grow thick, woolly coats, which keep them warm during the cold winter days. In the spring the farmer cuts off this woolly coat. If he did not cut it early in the spring, some of it would drop off. Then the farmer would not have as much wool to sell.

You may have wondered why there are so many duck and chicken feathers around the barnyard in the spring and summer. Ducks and chickens grow more feathers as winter comes. They lose some of their feathers in the spring and summer.

Horses and cows grow thicker coats in winter, too. You may have noticed how long and shaggy their coats are in the early spring. They lose some of the hair in their coats as the warm days come.

Some animals change color as the seasons pass. Perhaps you know that some foxes have a blue-gray coat in summer and a white coat in winter. Their clean, white coats match the clean, white snow. Hunters cannot see them easily.
Weasels change color, too. In summer weasels are brown and white. In winter most weasels are white except for black on the tips of their tails.

Can you see why a white weasel would be safer in winter? Its coat is the same color as the snow. Therefore enemies of the weasel cannot find it so easily.

Do you know of any other animals that change color as the seasons pass? Do any of the birds that live near you look different in spring and in fall?

Are there many insects where you live in the summer? Insects live in many, many places, and there are many of them. Bees, ants, flies, butterflies, and moths are insects. Can you name others that live near you?

All these insects are around in spring and summer. What happens to them when cold weather comes? Many of them die when the days grow cold.

In places where the winters are cold only a few worker bees and the queen remain alive. The queen bee is the bee that lays the eggs.

A queen honeybee may spend the winter with a few worker bees in a hollow tree.

A queen wasp often finds a warm place in an old building and spends the winter there.

Some other insects remain alive all winter in their warm homes. Some spin cocoons for themselves and spend the winter inside them. Others live in warm homes underground.

Yes, there are many ways that animals live through the seasons. How do some of the animals in your neighborhood live?
1. No matter where you live in North America, there must be some animals there, too. What animals live near your home? Make a list of them. Now watch these animals as the seasons change. Which ones leave your neighborhood as cold days arrive? Which animals stay active all winter? Can you find out which animals hibernate as cold winter days come?

2. Each member of your class may wish to choose one animal to watch. You might write a diary about the animal you choose to study. Your diary might have four chapters in it. One chapter might tell what your animal does in spring. Other chapters might tell what your animal does in the other seasons. Pictures would make your diary more interesting to others.

3. If you would like to watch an animal that hibernates, you can keep a frog or a small turtle in your classroom. Make a box of wire screen and set it in a metal pan. Put some soil on the bottom of the box. You can grow some plants in the soil. Now put your frog or turtle in the box and keep the box in a cool place. If your coat closet is cool, that will do. Be sure to give the animal food and water. Watch to see what it does in cold weather. Watch what happens on warmer days.
4. It is fun to keep a bird chart like the one above. You may keep it in the spring or in the fall or in both seasons.

5. You or your teacher may know someone living in another part of North America. You might like to exchange letters and learn about animals there.

6. Try to find out about eels. Eels are one of the few fish that migrate from fresh water to salt water to lay their eggs. They live most of their lives in fresh water. When they are full grown, they swim out to sea.

7. If you live in a place where the winter is cold, you will notice many changes in animals. Talk about some of these changes.
Plants and the Seasons
As Seasons Change

You know that you, your mother and father, and others plan for each season as it comes and goes.

You may wear different kinds of clothing as the seasons change. You may play different kinds of games, and your mother may cook different kinds of food. Yes, people do different things as the seasons change.

Plants change, too, with the seasons. They do not plan, as we do. But as each season passes, many of our plants change. Sometimes flowers are in bloom or trees are covered with fruit. At other times branches are bare.

Study the four pictures on these pages and notice how the growing plants change with the seasons.
Plants during the Summer Season

Unless you live at the equator or near it, summer is the warmest season of your year. If you live near the equator, your seasons change very little. It is hot at the equator the year round.

Summer is the season of the year when the greatest amount of sunshine comes to your part of the earth. It is also the season when the rays of the sun that come to you are straighter than at any other time of the year.

For many places on the earth summer is the time when plants grow very rapidly. They make food as they grow. Some of this food is used by the plants as they grow. Some of it is stored in the plants.

If you have a garden, you know how rapidly plants grow during the summer. You know, too, about some of the ways in which the growing plants store food.

Perhaps you have had white potatoes growing in your garden. Their stems and leaves grow large and spread out over the top of the ground. As the summer passes, the ground may crack around each plant.

It is fun to dig into the ground under the cracks and find the potatoes. The potato plants have been storing food in this way all summer. The white potato you eat is the underground stem of the potato plant.
Whenever you eat an onion, you eat food that the onion plant stored during the growing season. The onion plant stores food in the bulb. A bulb is really a stem.

When you eat a dish of rhubarb, you eat the food that the rhubarb plant stored in its stem during its growing season.

Yes, summer is the time of year when plants in many places grow rapidly and store food. This may not be true for every part of your country, however.

Your summer season may be the dry season of the year. Plants must have water, as well as sunshine, in order to grow well. If your summer season does not have enough rain, plants cannot grow well.

Many parts of the southwestern United States are dry in summer. In some of these places farmers have learned how to grow plants, even during dry times. They have learned how to bring water to their land.

Many fields are now watered by irrigation. Water is stored in reservoirs that are made by building dams across streams. The water is carried to the fields in ditches. Then farmers can use the water to make their crops grow well.

You may have seen one of these big dams. Millions of gallons of water are stored in the huge reservoirs above the dams. This water is used to make plants grow where no plants could grow before.
Plants during the Autumn Season

Autumn follows summer. This is the season when the earth and the air are beginning to cool a little. The hours of sunlight that reach you each day are getting fewer, too.

Autumn in many parts of North America is the season when plants of many kinds lose their leaves. You enjoy seeing the beautiful colors of autumn leaves as you walk along the street or ride along a country road.

Before long many of these beautiful leaves blow off the trees. They make a deep carpet upon the ground. As they become dry, they crackle under your feet.

You will want to help your father rake the leaves. These leaves should not be burned. They make good fertilizer for your lawn and garden.

Perhaps you can make a heap of them somewhere in your backyard where they will not blow away. During the winter the leaves will rot in the heap. They will break into little pieces.

In the spring they will be ready to spread over the garden. They should be worked into the soil. In this way they will make your garden a better place for plants to grow.
You may be wondering why the leaves on many trees change color before they drop off. They turn from shades of green to yellow, orange, and red. How beautiful they look! You wish they would stay that way for a long time. But within a short time they drop off and blow away.

During the spring and summer a tree takes water from the soil through its roots. The water passes up the trunk of the tree and into the leaves during food-making time. As summer passes, both food-making and growing slow up and finally stop.

Then the tree forms a thin layer of cork between the stem of each leaf and the twig on which the leaf is growing. This thin layer will prevent the sap from escaping when the leaf falls.

The green color in the leaf now begins to fade. As it fades, other colors that are also in the leaf stand out more clearly. You see red or yellow or orange instead of green.

As soon as the thin layer of cork is formed, leaves fall off easily. Even a gentle breeze blows them from the branches. A leaf that was once fastened tightly to a branch may fall when a raindrop touches it ever so lightly. It falls because of the thin layer that now separates it from its twig.

Not all trees drop their leaves in autumn. The evergreen trees form the tiny layers at any time during the year. So they keep losing some of their leaves throughout the year. For this reason there are always green leaves on evergreens, even in winter.
Perhaps you think of autumn as harvest time where you live. Farmers cut their corn and husk the big, ripe ears. They may also dig potatoes and put them into bags or crates for market.

If you have a garden, autumn may be harvest time there too. Pumpkins are large and round and orange. They are ready to be picked and made into pies. Beets and carrots and onions are pulled up and stored in a dry, cool place for winter use.

The leaves of some of the plants that grow in your garden have changed, too. All summer they were green. Now they are getting brown and dry. Many of them have already fallen off and blown away. Your garden looks very different in autumn.

Of course not all places are alike in autumn. You may live near enough to the equator so that plants keep on growing in autumn and winter too. You may even plant some new crops in autumn. But autumn in many places is harvest time for crops.
Plants during the Winter Season

Winter in many places is the season when plants rest. Many plants appear to be dead during the winter. But some of them are not dead. They are only resting.

As you look out of your window in winter, do trees around you appear to be dead? Does the grass look brown? Does snow cover the ground?

Perhaps you live in a place where the winter season is not very cold. It may almost never freeze, even in winter. Many plants may keep growing during your winter season. You may be able to see flowers in bloom almost all winter. The plants can keep on growing because there is no frost to kill them.

Nina spent last winter in southern California. Her home is in New Hampshire. Nina had never been in California before. What a change for her! In December Nina saw many flowers growing out of doors. Poinsettias were blooming in the yard. They were beautiful there. But it seemed strange to Nina that December days were warm. Winter in New Hampshire was not at all like winter in southern California.
Plants and the Spring Season

Spring in many places is the season of the year when seeds are planted and plants begin to grow.

Joan lives where spring is a season of much change. There are more hours of sunlight each day. The air and ground are warming up. Joan and her friends play outdoors in the warm sunshine. They like to have spring days come.

Joan’s mother and father are busy in the yard. They are digging in the flower beds and getting the ground ready for planting. They will soon plant flower seeds.

How carefully they dig around some plants that are already coming up! These plants have been in the ground all winter. Now, as the sun warms the ground, the plants start growing. Soon there will be lovely flowers in Joan’s garden.

The trees around Joan’s house are changing, too. Joan becomes interested in the buds that she sees on many twigs. Some of them are leaf buds. Some are flower buds. The buds have been on the twigs all winter. They were formed there last summer.
The buds were formed while the sun shone hot upon them. Joan did not see them there then, because the big leaves hid them.

The pictures on this page show some of the changes Joan saw as the spring days grew warmer. Buds changed to leaves or blossoms. Soon the trees that had been bare all winter were beautiful and green again.

Alan lives nearer the equator. Spring days where Alan lives are much like winter days. Alan has never seen snow. All winter long there has not been even a frost.

Flowers bloom in Alan’s garden all winter. In the winter there is fruit on many trees that grow near Alan’s home. The grass in Alan’s yard stays green, and vegetables keep right on growing, too.

Paul lives in Alaska. Here spring is a very short time. The warm sun melts the frost in the top of the ground. Then the seeds of the arctic poppy can begin to grow.

How fast they grow! The sun shines day and night. There are just a few weeks of spring and summer in Alaska. Arctic poppies and a few other plants grow, blossom, and form seeds in eight weeks.

The only kinds of plants that grow well where Paul lives are those that can grow fast. During the long, long winter the seeds that the plants make stay alive. They may be blown about by the winds and covered with snow. But in the spring and summer they can grow quickly.

What is spring like where you live? What is happening to plants around you?
How Long Do Plants Live?

Did you ever stop to think about how long plants live? As you look at a tall elm tree, you know that it has lived through many seasons. It has lived through summer’s heat and winter’s cold. Over and over again, it has lost its leaves in autumn and grown new leaves in the spring.

Trees are the oldest living things on our earth. Some of the giant sequoia trees in North America are three or four thousand years old. What stories these trees could tell us if they could talk! They have lived through forest fires and sleet and ice storms. Hundreds of animals have built nests in their tall branches.

Plants that live to be several years old are called perennials. Every tree that grows near your home is a perennial. These trees store food every year.

When winter comes, trees do not die. They may lose their leaves as summer passes. But they remain alive winter after winter.
Many bushes and shrubs are perennials, too. They may live several years. Do you have any shrubs growing in your schoolyard? Do they lose their leaves in autumn? In the spring and summer do they bloom and form flowers and seeds again?

Some flowers are perennials, also. The dandelion, which blooms in many yards, is a perennial. Its leaves and stems wilt as summer passes, but the roots stay alive all winter underground. As soon as the frost melts in the spring, new stems grow from the roots. Leaves form quickly from these. Before most other flowers are in bloom, yellow dandelions dot the fields and lawns.

Does your mother dig up some garden plants as fall days grow cold? She may put them in pots and bring them indoors, so that they do not freeze. These plants may be perennials, too. If they are, they live during several winters when they are taken indoors. The pictures on this page show you several common perennials. Do any of them grow near your home?

Some plants live only one year. Each year the plants grow from seeds. Each year they grow and blossom and form new seeds. Then they die. These plants are called annuals because they live only one year.
Many plants that grow near you are annuals. Corn and beans live only one year. They are annuals. Oats and peas are annuals, too. So are lettuce, cabbage, and tomatoes.

Next year annuals will grow from the seeds that formed this year. Your mother may plant some of these seeds in the flower garden around your house. Then you can pick flowers for your dining-room table many times during the summer.

Some plants live two years. These plants are called biennials. The first year they grow from seeds that are planted. They keep growing all that first summer. In the fall their tops die down.

The next spring they start growing again. This time they grow from the roots of last year's plants. The roots have kept alive all winter in the ground. This second year the plants blossom and form seeds.

Some of the vegetables you eat are biennials. Beets and carrots and turnips are biennials. If you did not pull them up and eat them the first year, they would grow again from their roots. During the second year they would form flowers and seeds.

You now know that plants that live only one year are called annuals. Plants that live two years are biennials. And those that live more than two years are perennials.
THINGS TO THINK ABOUT AND DO

1. You may want to plant the seeds of several trees in flowerpots or in a terrarium. Have about 3 inches of sandy soil at the bottom of your pot. A layer of pebbles under the soil is good, too.

   Plant several seeds of each kind of tree so that you may be sure that one or two will grow. Tree seeds are harder to grow than flower seeds.

   Poplar, maple, and elm seeds grow best if they are planted almost as soon as they fall from the tree. If you are planting acorns or chestnuts, it is best to soak them overnight before you plant them.

   Peach, apple, cherry, and pear seeds should not be planted right after you take them from the fruit. It is wise to keep them in damp moss in a cold place for several weeks before you plant them. They will be more likely to grow then.

2. After leaves have fallen from trees, you can easily see the tiny buds on the branches. They were formed during the summer as the trees made and stored food. Watch these buds during the winter months. See if they change any when the first warm days arrive.

3. Plan to watch buds of several trees in the spring. Tie a string around one low branch of each of several kinds of trees that grow nearby. Each day you can look at the branches with the strings on them. You can watch how the branches change. You will see flower buds and leaf buds. Keep a picture record of what you see happening. Draw a picture each day of what you see.
4. Have you ever made a leaf blueprint greeting card? It is fun to do. One or two leaves are all you need. This is the way you make a blueprint:

You can get blueprint paper at a store that sells camera supplies. This is a paper that has been treated so that it changes as light strikes it.

Select one leaf. Place it on a piece of glass. Now put a piece of blueprint paper over the leaf. Next place a stiff piece of cardboard over the blueprint paper. Hold the glass and cardboard tightly at their edges. Go out into the bright sunlight. Hold the glass toward the sun for three to four minutes. The blueprint paper will change color. It will become lighter.

Now go indoors again and remove the glass. Dip the blueprint paper into a pan of clean, cold water. Then lay it on a flat table to dry.

The leaf print will look pretty as the cover of your greeting card.
5. Make a chart of the kinds of plants that grow near your school. Put the names of all annuals in one column, of biennials in another column, and of perennials in another column.

6. Did you ever stop to think about how many, many seeds one annual makes in its short lifetime? Try to count the number of seed pods that one pea plant or bean plant forms. There are several seeds in each pod. Why do you suppose most annuals make more seeds each year than most perennials do?

7. You might wish to make a compost heap of leaves that fall in your schoolyard. Talk it over with the custodian. Find a place where the heap of leaves will be out of the way. Rake the leaves into a pile. In the spring help the custodian spread the rotted leaves over the lawn. In this way you will be helping to make the soil in your yard better.
Where Plants Grow
Plants Everywhere

Most boys and girls like to see what other parts of the world are like. It might be fun to make a list of all the places the children in your class have visited.

Have some of you visited cold places and hot places? Have some of you visited wet places and dry places? Were there plants growing in each of the places that you visited?

Plants grow in many places. They grow in hot and in cold places. They grow in warm and in cool places. They grow where it is wet and where it is dry. They grow on the tops of mountains and in valleys. Almost any place you go, there will be some kinds of plants growing.

The same kinds of plants do not grow in all places. Some plants grow best where it is dry. Other plants grow best where it is wet. Some plants grow best where it is warm. Others grow best where it is cool.
Plants That Grow in Hot, Dry Places

Peter and Jim drove across a desert in North America last summer. They found plants growing there. That was quite a surprise for the boys. They had thought that the desert was one place where no plants could grow. The picture on this page shows you some of the plants the boys saw.

Desert plants are different from plants that grow in other places. Many of them have large, thick stems. When the rains come, these stems stretch. Water is stored in these stems. The stems shrink as the plant uses the water.

Can you find the leaves of any of these plants? Many of them are hard to see. There are spines on some of the cactus plants. These are the leaves of the plants. Other cactus plants have no leaves at all. Their stems do the work of the leaves. Still other desert plants have leaves only when they are young.

Large leaves would not be good for cactus plants. The water stored inside the plants would evaporate too quickly from the leaves. Then the plants would not have enough water to use during the hot, dry days.
Some cactus plants have two kinds of roots. A few other plants do, too. One kind grows down deep into the ground. It soaks up the moisture there. The other kind of root spreads out near the top of the ground. These shallow roots are important when the short, rainy season comes. They can soak up much water in a very short time.

When Peter and Jim crossed the desert, plants were grayish brown and dry. The boys almost thought the plants were dead. Every plant they saw looked about the same color. If they had crossed the desert during the rainy time, they would have seen quite a different sight.

Instead of the dull, gray-brown color that the boys saw, this same desert is colorful when the rainy time comes. Then greenish-white, pink, orange, and other brightly colored flowers may be seen on many desert plants.

Desert plants are able to grow much more quickly than the plants that grow in our vegetable and flower gardens. Only plants that grow quickly can live in the desert. During the long, dry season they keep alive by using water stored in their stems. During the short, rainy season they grow quickly and blossom and form seeds.
Plants That Grow in Hot, Wet Places

Tom took a trip with his father last summer. They went to visit the Amazon jungle in South America. They went up the Amazon River by boat. The picture shows some of the plants they saw growing along the riverbank.

How different these plants look! What large leaves they have! This is a place where it rains almost every day all year long. It is also a very hot place.

Have you ever been in a hothouse during the middle of a summer day? If so, you know that the air inside is hot and very damp. You can even smell the damp, warm earth.

The jungle that Tom visited was hot and damp and full of smells. Tom said, "This place is a steaming jungle." And so it was.

Many of the plants in the hot, wet places grow very large. They grow very close together too. The leaves of many of the plants are broad. They shade one another. The plants grow tall. In this way they get as much sunlight as possible.
Much water evaporates from the big, broad leaves of the plants that grow in the jungle. But there is so much rain that it doesn’t matter. It is wet and rainy most of the time there.

How different this is from the desert! In the desert, plants must use every drop of water they get. But in the jungle, plants always have enough water. We learned that plants that grow in hot, dry places are the kinds that live without much water. Now we know that plants in the jungle are the kinds that grow well where there is a great deal of water.

We say that plants are fitted for living in whatever places they grow. Plants have different kinds of roots and leaves and stems to fit the places where they grow.

Rubber trees grow in the jungle. Prickly-pear cacti grow in the desert. Orchids grow in the jungle. Tree cacti grow in the desert. Each plant grows where it does because it is best fitted for living in that kind of place.
Plants That Grow in Warm and Cool Places

Mary and her family took an automobile trip last summer. They drove from the Pacific Ocean to the Atlantic Ocean. From the time they left home until they returned, they had driven over 10,000 miles.

What a fine trip they had! Mary said that there were plants growing everywhere she went. There was no place on the whole trip which had no plants at all.

Mary was right. There are many, many plants growing in the warm and in the cool parts of the earth. Plants that grow in these places are fitted for growing there.

Mary drove east through the northwestern part of North America. There she saw large evergreen forests.

As Mary drove farther east, she saw great fields of wheat and corn.

Mary and her family returned to the west coast by a more southern route. On their return trip they saw many fields of tomatoes, sweet potatoes, peanuts, cotton, rice, and tobacco.

Mary also saw many of the same plants which she had seen growing in other parts of North America. She saw wheat growing in Texas. It was a different kind of wheat from that which she saw growing farther north.

Mary said that she could not begin to list all the plants that she had seen on the trip. She said there were so many that the list would fill the blackboard.
As we learn more about plants, we come to know how wonderful they are. A few can live in very hot places. A few can live in very cold places. Many, many plants can live in warm and in cool places.

Farmers need to know which plants can grow well on their farms. On a farm where there are one hundred and fifty growing days before frost comes, the farmer plants crops that can grow and be harvested within that time.

Another farmer may have to choose crops which have much shorter growing times. He may live where the frost comes sooner.

A farmer in Arizona has a long growing season for his crops. But a farmer in Canada has to choose crops that need a much shorter growing season.

Think again about Mary’s trip across North America. Can you explain why she had seen some crops growing in the northern region that she did not see growing in the southern region? Can you tell why she saw plants in the southern region that she hadn’t seen in the northern region?

Mary saw some plants that looked similar growing in both regions.

There were apple trees in Canada and apple trees in Texas. But the apple trees were different. The corn Mary saw in Texas was not the same kind of corn that she saw in the north.

There are many kinds of apples, wheat, corn, and other plants. Each kind will grow better in some places than in other places.
Plants That Grow in Cold Places

Micky and his father drove to the top of Pikes Peak in Colorado for part of their vacation. What a trip that was! They made a round trip of 54 miles in order to get to the top and back.

Pikes Peak is not 27 miles high. No mountain on earth is that high. Pikes Peak is only about 3 miles high. But the road has to wind back and forth to reach the top of the mountain.

Micky began to feel cool when he was halfway up Pikes Peak. By the time he and his father reached the top, his teeth were chattering. The thermometer read 25 degrees at 2 p.m.
Micky could see snow here and there as they drove along. When they reached the top, his father stopped the car, and Micky made snowballs to throw at his father. Think of it! Snowballs in July!

Micky told the class about the plants he saw on Pikes Peak. There were many evergreen trees growing along the road as they started up the mountain. As they went higher, there were not so many trees. Right up at the very peak there were no trees at all.

The evergreen trees do not grow higher than about 2 miles up the sides of Pikes Peak. We call this point the timber line. Above the timber line Micky saw only bare rock and a few small plants. There is not enough soil for the trees to grow well. Also, it is cold at the top of Pikes Peak. It is much too cold for trees to grow well.

Although there are no trees, there are some other plants at the top of Pikes Peak. There are mosses and lichens above the timber line.

Both mosses and lichens can live through heat and cold. They can grow in the hot sun along the seashore. Here they grow on rocks and logs. They can grow on rocks at the tops of cold, cold mountains. They grow almost anywhere on the earth.
Plants That Grow in Water

There are still other places in which plants can grow. Some plants grow in salt water. These plants are called seaweeds. The picture at the top of the page shows you some of the seaweeds that grow in the ocean.

Tony's family visited Catalina Island on their vacation. They took a trip in a glass-bottomed boat and saw the beautiful undersea gardens. What a sight it was! Tiny plants grew on rocks. Tall, brown seaweed, called kelp, waved about in the salt water. Some of the kelp plants were 100 and more feet tall.

Beautiful blue, green, and orange fish swam about among the large brown leaves of the kelp. They could hide well there.

Plants grow in fresh water too. You may have some fresh-water plants growing in your aquarium at school. The plants that grow in your aquarium or in a fresh-water pond could not grow in the ocean, but they are able to grow well in fresh water.

The white and yellow pond lilies that grow in fresh-water lakes are very common. You often see them when you go fishing.
Most fresh-water plants have very long stems. Sometimes their leaves float at or near the top of the water. They can get more sunshine near the top.

Many kinds of plants grow in marshes and bogs. Some kinds of moss are found in marshes. Cat-tails grow in wet, marshy places near the shores of ponds. What kinds of plants grow in marshes near your home or schoolhouse?

The plants you see in the pictures on this page are ones you might find growing along the edges of streams and ponds or in bogs and marshes. Each one of them is well suited for growing in such places.

The next time you go walking near a stream or a wet, marshy place, notice the plants. See if you can find any of the ones there that you see in these pictures.
THINK AND TALK ABOUT THESE THINGS

1. Plants need warmth, light, moisture, and soil for growing. Talk about the plants you see growing near your school. How are they fitted for growing there? What plants that you know about couldn’t grow near your school?

2. Plants that live in the desert could not live in salt water. Discuss why this is true.

3. Plan to have someone in your class talk with the men in the weather bureau near you. They will tell you when hard frost is likely to come to your neighborhood. Why is this important information?

4. Try to find out from the weather bureau the highest temperature and the lowest temperature for your community for each year during the last ten years. Discuss how this information would help farmers and gardeners.

5. Try to find out how much rain falls on your school grounds in a year. Why is this information important?

6. In what kinds of places should you expect to find the plants growing that you see below?
7. Plan to keep your own weather chart for a month. Record the temperature each day. Find out how cold it gets each night by looking at the weather record in your daily newspaper. The newspapers often tell how much rain falls during each storm. Record this amount on your weather chart.

8. When you plan a garden, it is important for you to know the amount of rain that falls upon your region. You should also know another fact, too. You should know whether the rains that come to your region come rather regularly throughout the growing season. Perhaps the rains come all in one short time. How would this affect plans for your gardening?

9. Did you ever stop to think about what part of your garden or school grounds is the coldest or the warmest? You might take the temperatures of soil and air in a shady spot and in a sunny spot; in a spot where grass grows and in a place where there is only soil. You will be surprised at the differences you find. How would this record help you when you are ready to plant your garden?
The Earth
Finding Out about the Earth

Do you ever wonder about the big, round earth on which you live? Should you be able to explain to your class how you know the earth is round?

Perhaps you have never thought much about day and night. You know that day follows night, and that’s all. But do you know why day follows night?

Of course you know that you have a birthday once each year. You know that Thanksgiving Day and Columbus Day come once each year. But do you know why the earth has a year?

Science can help us to know why these things happen. Finding out about the earth will help you answer some of the questions you may have about it.
Our Earth Is Round

As you walk to and from school, you seem to be walking on flat ground. As you look ahead, you cannot really see that you are walking on a big, round ball. But that is just what you are doing, for the earth is shaped like a big, round ball.

It is little wonder that people long ago believed the earth was flat. As you look out across the city from a high place, the earth appears flat.

As you look out over the ocean on a calm day, it too appears to be flat. In the past some people thought the flat earth was held up by a huge turtle. Others thought that a very strong man held the earth on his shoulders.

No one dared travel far out to sea for fear he would fall off the earth. People believed that monsters waited out there at the edge of the earth to swallow anyone who fell off.
These ideas seem foolish to us now. But that is because we now know several ways of proving that the earth is round. Early peoples did not have such proofs.

Long ago there were no airplanes that could fly all the way around the earth. Furthermore, no one had ever traveled all the way around the earth. There were no maps, such as we have today, to tell people about the round earth.

Perhaps you have seen pictures of some of the old maps that Columbus and other early explorers used. If you have, you know that they were not like the maps in your geography textbook. They were very crude ones indeed.

Many people who watched ships disappear must have used what they saw as a proof that the earth is round. For, as a ship sails farther and farther away, the part nearest the water disappears first. The topmost part of the ship disappears last. If the earth were flat, would this be true?
Here is another way in which some people may have come to believe that the earth is round: They watched the eclipses of the moon. Each time the earth made a shadow on the moon, it was a round shadow. The round shape of the shadow may have helped them to decide that the earth is round.

You can try this for yourself. Place a globe or a ball in the sunlight. Look at the shape of the shadow on the floor. Now place your chalk box in the sunlight. Is the shadow it makes round?

It often happens that it takes many years to convince everyone that an idea is true. At first a few people believe in an idea. They keep working to prove that their idea is true.

After a while other people become interested. They may work on the same idea in a different way. Finally, many people become convinced that the idea is true.

You will want to learn to work on ideas in this careful way. You will want to use some of the methods that the scientists use as you work to prove that an idea is true.
Our Round Earth Spins

It is not strange that men came to believe that the sun went around the earth. Long ago they did not know that the earth is spinning around and around all the time.

They saw the sun rise in the east each morning. They saw the sun set in the west each evening. It looked to them as if the sun went around the earth.

Many stories were told to explain the sun. Some people thought the sun traveled across the sky in a chariot, starting in the east in the morning.

Today we know that the sun does not travel around the earth. It only appears to move around it.

In order to understand what really happens, try this experiment: Spin a top on your table. The earth spins around much as the top spins on your table. Only the earth does not rest on a table or any other object.

Now spin a baseball fast on the table. The earth spins around and around much as the baseball spins. The top and the ball soon stop spinning. But the earth never stops. It keeps spinning because there is nothing to stop it.

The top spins around many times in a minute. The earth spins fast, too. However, it is so large that it takes twenty-four hours to spin all the way around once.
Why Day Follows Night

Yes, our round earth spins. How does this fact help us to understand why the sun seems to travel through the sky from east to west?

Suppose you try this experiment: Pull down the shades. Place a lighted flashlight at one end of a table. Now place a globe at the other end of the table. If you haven’t a globe, a big ball will do.

Look carefully to see how much of the globe is lighted. Can you place the flashlight so that half of the globe receives light?

Now have someone turn the globe. Be sure to turn it toward the east because that is the way our earth turns. Do different parts of the globe become lighted as you turn, or rotate, it?

Place a small paper flag on the globe at the place where you live. First, paste the flag on a stick or a pin. Then fasten it to the globe with a little bit of clay or some gum. The globe should be turned so that the flag is on the dark side of it.

Now turn your part of the earth toward the flashlight, which is being used as the sun. It is morning where you live. But you can see that the sun is not traveling around the earth. Instead, your part of the earth is turning toward the sun.

Keep turning the globe until the flag is directly in front of the flashlight. Now it is noon where you live. It is time for you to eat your lunch.
Keep on turning the globe toward the east. Soon the flag begins to move out of the lighted area of the globe. It is sunset where you live. Your part of the earth is turning away from the sun.

Keep turning the globe until the flag is directly in line with the flashlight sun, but on the dark side of the globe. It is midnight where you live.

Let's see now if we know why day follows night. First, we know the earth is round. Second, we know our round earth keeps turning toward the east.

As your part of the earth turns toward the sun, you have morning and then noon. As your part of the earth turns away from the sun, you have afternoon and then evening. As your part of the earth keeps on turning toward the east, you have midnight and then morning.

Day follows night because our round earth keeps on turning. It turns all the way around once every twenty-four hours. That is why a day and a night is twenty-four hours long.

Only half of the earth gets the sun's light at one time. The other half is in darkness. Can you see that this is true of your globe?
While the city near you is having noon, another city, halfway around the earth from where you live, is having midnight. When it is morning in your city, it is evening in the city on the other side of the earth.

Suppose you live in St. Louis. It is 6 A.M. there. Look to see what time it is in Paris, France.

Suppose you live in London. It is 8 P.M. there. What time is it in Fairbanks, Alaska?

Suppose you live in San Francisco. It is noon there. Can you find a place on your globe where it is midnight?

When the children in Hawaii are having breakfast and getting ready for school, the children in Norway are having supper and getting ready to go to bed.

When the children in New Orleans are eating their noon lunch, what will the children in Italy be doing?
The Earth Is a Clock

We tell the time by our clocks. When it is about eight-thirty we hurry to school. When the hands of the school clock point to twelve noon, we hurry home for lunch.

The earth is a big master clock. It tells us the correct time. We set our clocks by it.

Long ago people did not have clocks in their homes. They had only the earth and the sun as their clocks. A farmer would look up at the sun overhead and say, “It’s time to eat.” When the sun was low in the western sky, he would say, “It’s time to rest.”
Many kinds of clocks were made before our alarm clock or our electric clock was invented. The Chinese used a water clock like the one in the picture below. All the water dripped from the top pail in an hour. Some other people used an hourglass. The sand flowed from one glass into the other in one hour. Others used a notched candle as a clock. It took one hour for the candle to burn from one notch to the next.

Our modern clocks tell the time better than these old clocks did. But even our newest clocks sometimes are incorrect. Many times each day we hear the correct time given on the radio. We check our clocks to see if they are correct.

The radio stations get the correct time from master clocks in Washington, D.C. These clocks are checked several times each day by scientists who know how to keep them just right. The scientists check them with the master clock which is our spinning earth.
Look carefully at the map at the top of this page. This map shows you the time zones in North America. Find the place where you live. In which time zone do you live? There is one hour's difference in time as you travel from one time zone into the next. If you travel to the east, you lose an hour. If you travel to the west, you gain an hour as you go from one time zone to the next.

Children in Philadelphia start to school three hours before boys and girls in Vancouver, Canada, do. This is because Philadelphia is east of Vancouver and turns toward the sun first. When it is 8 A.M. in Philadelphia, it is 7 A.M. in Chicago, 6 A.M. in Denver, and only 5 A.M. in Vancouver. When it is 3 P.M. in Vancouver, it is 4 P.M. in Denver, 5 P.M. in Chicago, and 6 P.M. in Philadelphia.
When it is noon in St. Louis, it is before noon in the time zones west of it. And it is after noon in the time zones east of it.

When it is midnight in Memphis, Tennessee, what time is it in Albuquerque, New Mexico? in Seattle, Washington? in Buffalo, New York?

If you travel from Washington, D.C., to Los Angeles, in what direction are you going? You would have to set your watch three different times on the trip. Which way would you set it? Remember you are traveling west.

Now suppose you travel from Vancouver, Canada, to Atlanta, Georgia. In which direction are you traveling? You will again have to change your watch three times. Would you turn your watch ahead, or would you turn it back? If you need help, use the map on page 75.
The Earth Takes a Long Trip

Here is another experiment to try: Stand at the side of your teacher's desk. Spin around in one spot several times. Now, as you spin yourself around, start walking around the desk, too. Keep on walking and turning until you are back to the place where you started.

You have made one complete trip around the teacher's desk. In that time you spun around and around many times.

Our earth does something much like this. While it makes a long journey around the sun, it rotates many times. It keeps turning and turning as it travels around the sun.

There is another way to understand the trip that our earth takes. Draw a large oval on the floor with a piece of chalk. Let one child stand inside the oval and near the center of it. This child is the sun. Let another child be the earth. This child walks around on the chalk line. He walks to the east. He keeps spinning around as he walks. When he has gone once around the sun, a year has passed.

Another way to say this is that the earth revolves around the sun. Once in about every 365 days the earth makes one complete trip. That is why our earth year is just about 365 days long.
Inside the Earth

We live on the outside of the land part of our earth. Here we build our homes and work and play. We know many things about this part of the earth.

Above us and all around us is air. In fact, we live at the bottom of a great ocean of air. This ocean of air stretches above our heads for miles and miles. We know many things about the lower part of the atmosphere because we have flown into it.

What about the inside of our big earth? How much do we know about it?

No one has ever gone through the solid part of the earth from one side to the other. This is a distance of about 8000 miles. But scientists have made many explorations below the surface of the earth. They have gone down into deep mines. They have lowered cameras deep into the oceans and taken pictures there. They have flown over volcanoes and looked into the cones. They have pounded and listened to the earth’s surface, much as your doctor listens to your chest when you have a cold.

Yes, scientists have found out many things about the inside of the earth, even though our deepest mines are not more than 3 or 4 miles deep.
Not all of us will be able to take a trip into a mine, but many of us can find places where fresh holes are being dug.

Is there a place near you where workmen are digging a hole and getting ready to build a new building? Or perhaps a new road is being built nearby. The new road may be cut through a hill.

Go to one of these places if you can. Look at one side of the newly dug hole. About how deep is the top layer of soil? Are plants growing in it?

What is below the top layer of soil? Is there some coarser material beneath it? Do the roots of any plants reach down into this second layer?

Below the layer of coarse material you may see solid rock. This rock may be of different kinds and colors. Do you find any plants growing in this material?

You may see several layers of rock, each one different. You will learn more about these rock layers as you read pages 211 through 232 in this book.

Now you know a little about what is just below the surface of the land part of the earth. But what about the rest of those 8000 miles? Suppose we find out more about them.
Oil, Gas, and Water Are inside Our Earth

In many places over our continent thousands of barrels of oil are pumped out of the earth each day. If you drive along some parts of the western coast of North America, you can even see oil derricks out in the ocean. Here oil is being pumped from near the surface of the earth under the ocean.

In many places natural gas is piped into homes and used for heating and cooking. This natural gas comes from inside the earth. Some comes from near the earth's surface. Some comes from deep inside the earth.

There are many things we do not yet know about the inside of the earth. People who have studied our earth know there are places near the surface that are very hot. Yellowstone Park has some of these places in it. In this national park hot water shoots out of geysers and bubbles out of hot springs.

Of course we do not know whether the inside of our earth keeps on getting hotter and hotter right to the center of it. But it is believed that the inside of the earth is very, very hot.
When Volcanoes Erupt

Every once in a while you hear of a volcano erupting. Volcanoes are mountains that sometimes send forth hot gases and rock materials. The rock may be so hot that it has melted. It cools and becomes solid again as it flows down the sides of the mountain.

Volcanoes do not keep on shooting hot gases and rock into the air all the time. In fact, there are very few volcanoes that erupt often. Most of them stay quiet.

Not long ago a new volcano rose up out of a cornfield in Mexico. The ground felt warm around the farmer’s feet. He heard rumbles which sounded much like thunder. Suddenly the earth ahead of him broke apart and began to rise. Hot, melted rock called lava shot away up into the air. Within a week’s time the mountain called Paricutín had started to form. The farmer could no longer grow corn on this part of his farm.
Now you know that some places inside the earth are hot enough to melt rocks. How hot would that be? Do you think you could melt rocks by boiling them in water? No, rocks do not melt in boiling water. Rocks melt at a very much higher temperature than that of boiling water.

Do you now think of the inside of our earth in a different way? It isn’t just solid rock. It isn’t just rock that stays put in one place. There are large pools of hot, melted rock called magma. This magma sometimes flows from the pools out into cracks in the rocks all around. Or it may come to the surface of the ground, as it did when the volcano Paricutin was formed.

You may have heard of other volcanoes. There is a famous one in Italy. It is called Vesuvius. Once, long ago, it erupted and destroyed two cities. It is still an active volcano today.

There is a famous volcano in Hawaii that has erupted many, many times. Have you read about it?
When Earthquakes Happen

You have seen that magma from the inside of the earth will force its way up against the crust of the earth. When it does this, it may either pour out as lava or lift up hills or pile up rocks.

There are other kinds of changes caused by flowing magma. Sometimes, as magma flows, it causes the earth’s surface to shift. When a part of the surface shifts into a new position, an earthquake happens. Flowing magma is one cause of earthquakes.

Earthquakes help us to understand a little more about the inside of the earth. There are earthquakes somewhere almost every day. This means that rocks inside the earth keep moving much of the time. In some places the rocks may wrinkle, or fold, or they may buckle or break.

We know about these earthquakes because of a machine which records them. This machine is called a seismograph.

Most earthquakes do very little damage. But every once in a while an earthquake causes great damage. Buildings may be shaken down. Sometimes fires start, and buildings are burned. Sometimes, too, people are hurt.

People who have studied the earth know where earthquakes are likely to occur. Buildings in these regions are now built in a special way. They are built so that earthquakes cannot damage them easily.

Earthquakes most often occur in the mountains under the sea, and sometimes volcanoes erupt there, too. When one or both of these things happen, giant waves of water may be started. As these giant tidal waves reach land, they may do much damage.
More for You to Talk about and Do

1. It is interesting to think about how people come to believe what they do. Long ago people believed the sun traveled around the earth. What did they see happening every day that made them believe they were correct?

2. Scientists keep studying our earth. They keep finding out new truths about it. The new truths often prove that earlier ideas were not correct. Try to find out what people who lived long ago believed about the earth. Try to find out what the Indians, the Greeks, and the Egyptians believed. Can you tell your classmates about an idea that you once thought was true, but that you now know to be false?

3. The next time you take a ride on a merry-go-round, think of this: You ride around and around the music box in the center. Suppose you think of the music box as the sun. You are making a trip around it as you ride on your horse. This trip is similar to the trip the earth makes around the sun once in about every 365 days.

4. Jane lives in Quebec, Canada. She likes to listen to the football game in Pasadena, California, on New Year’s Day. The game begins at 2 p.m. Pacific time. When should Jane turn on her radio in Quebec? The map on page 75 will help you.

5. How many trips has the earth made around the sun since you were born? When you are fourteen years old, how many trips will the earth have made during your life?
6. Use a globe and a flashlight and see if you can explain to your class exactly what causes day and night.

7. See if you can locate a sundial near your school. Ask to go there and have the fun of learning how a sundial is used for telling time.

8. Try to make a simple water clock. Use a tin can. Punch a little hole in the side of it near the bottom. Fill the can with water. Let the water drip out slowly into a dish. Time the dripping to see just how long it takes for all the water to drip into the dish. Did it take a half-hour? If so, you have made a half-hour water clock.

9. There are many other ways in which people who lived long ago told time. They sometimes used shadow sticks. They looked at the lengths of the shadows and knew about what time it was. When the shadow that the stick cast was shortest, the time was about noon. When the shadow was longest, the time was early in the morning or late in the afternoon.
The Air We Live In
The Air Is Part of the Earth

We live at the bottom of a great ocean of air. We breathe air. We walk around in it. We push it aside as we ride our bicycles to school. Sometimes we call this ocean of air around us the atmosphere.

The atmosphere is part of the earth. It is just as real a part of the earth as the land we live on and the water we swim in.

There are three parts to the earth. The land is part of the earth. The water is part of the earth. The atmosphere is part of the earth, too.
We know that it is about 8000 miles through the land part of the earth. The air part of the earth goes all around the outside of this great ball of land and water. The air surrounds it much as the skin of an apple surrounds the rest of the apple.

Scientists do not agree about how far the ocean of air extends out from the land-and-water part of the earth. Some believe that air extends a few thousand miles out into space. Perhaps there is some air even as far as 10,000 miles out from the earth. Are you surprised at this?

We know that the air is thickest near the land-and-water part of the earth. As we go farther away from this part of the earth, the air gets thinner and thinner.

Have you ever had a ride in an airplane? Some airplanes can now fly several miles out into space. Some planes fly so far from the land that passengers need to wear oxygen masks when they travel in them. The air is so thin out there that extra oxygen is needed for breathing.

Airplanes that travel far out into space are now being made so that extra oxygen can be sent right into the cabins. Then passengers do not need to wear oxygen masks. The extra oxygen needed flows right into the cabins from tanks.
Air Is Everywhere

Did you ever stop to think where air is? We know it is all around us. We breathe it. We can feel it as we run fast. We can see leaves being blown about in it. Our flag waves in it.

We know there is air inside us because we breathe it in and out again. We watch animals breathe. So we know there is air in them.

Do plants use air? The answer is yes. There are many very small holes, or openings, on the underside of leaves. These small openings are places where air goes into the plant.

Suppose you spread some cold cream or other greasy material over one leaf of each of several plants. The grease will get into, or clog, the openings in these leaves.

Now watch the plants. Do the leaves with grease on them begin to lose their green color after a few days? Later do they get yellow and fall off?

If you wipe off the greased leaves before they turn yellow and drop off, they will be able again to take in air through their many small openings. They will now become green again.
We know there is air in water. We can see the air in water by heating some water in a pan. At first tiny bubbles of air gather around the sides and bottom of the pan. As the water becomes warmer, there are many, many tiny air bubbles to be seen.

Because there is air in water, some plants and animals can live there. All living things use air. Those that live in water must be able to get air from it.

Is there air in soil? You can find out by pouring a glass of water upon a pot of soil or upon dry soil in your schoolyard. Do you see bubbles? These are air bubbles. The air comes out and makes room for the water to go into the soil.

There is air in cloth. The tiny holes in cloth are full of air. Hold a piece of thick cloth against your lighted flashlight. Can you see the holes? Air fills these holes.

We sometimes say air is everywhere. But is it? It is all around us. It is in the water we drink. It is in the soil, where plants grow. It is in cloth.

It seems to be everywhere. It is all around us. But does it fill all space? As we grow older, scientists may be able to answer this question for us.
Air Is a Real Thing

How can we prove that air is a real thing? We cannot see it; so we cannot look at it to prove that it is real. Let’s try to prove it another way. Float a cork in a bowl of water. Now push a drinking glass down over the cork and into the water. Push the glass to the bottom. What happens to the cork? Why does it go down?

Try the experiment again. This time crumple up a paper towel inside the glass. Does the cork keep going down as you push the glass down?

The air in the glass pushes the cork down. Feel the paper inside the glass, and you will find that it is dry. Why does the paper stay dry? Air fills the inside of the glass. It keeps the water from coming into the glass. The paper does not get wet, because the water cannot get into the glass and wet it.

Here is another experiment for you to try: Put a paper bag on the edge of a table. Place a book on top of it. Now almost close the end of the bag between your thumb and fingers, and blow into it. What happens to the book? Did you raise the book from the table?

Now put two books on the empty bag. Can you blow enough air into the bag to raise two books from the table? Try raising more books.
How Hard Does Air Press?

Here is another fact about air: It is always pressing. Even when there is no wind, air is always pressing.

But why, then, can’t we feel air pressing on us? It presses against our hands and head and legs. It presses against our eyes and arms and toes, just as it pressed against the books. Why don’t we feel it?

Air presses on every part of everything. It presses on the top. It presses on all sides. It presses on the bottom. Because the pressure is equal on all sides of us, both inside and outside our bodies, we do not feel air pressing on us.

Air presses; but how hard? Let’s find out. You will need your scales for weighing. Put one book on the scales. How much does it weigh? Now add more books until you have 15 pounds of books on the scales.

Lift the pile of books off the scales. They are quite heavy. They are as heavy as 15 pounds of sugar. They are as heavy as a baby who weighs 15 pounds.

The air presses as hard as that on each square inch of everything. It presses with a force of about 15 pounds on each square inch.
Now use your ruler and make a square on the blackboard. Make it 1 inch on each side. We call this square on the blackboard a square inch because it is 1 inch on each side.

Next make some 1-inch squares of paper. Cut them out. See how many inch squares of paper you can fit on the back of your hand. Did you find room for six squares?

We know the air is pressing with a force of about 15 pounds on each square of paper. The air, then, must be pressing with a force of six times 15 pounds, or 90 pounds, on that part of your hand.

Air presses as hard as that on every other part of your body too, both inside and outside. It presses with a force of about 15 pounds on each square inch of everything.

You would think we could surely feel air pressing. But as you have already read, it is pressing in all directions all the time. It pushes up. It pushes down. It pushes sideways.

Air presses on all sides with equal pressure. So we do not feel air pressing against us.
Changing the Pressure of Air

Sometimes air presses more on things than at other times. By heating and cooling air, we can change its pressure. Here is a way to prove that air pressure sometimes changes:

Boil an egg until it is hard and cool it. Then take off the shell. Place the egg at the top of an empty quart milk bottle. Does it fall in? Remove the egg.

Now crumple a little paper and put it down into the neck of the milk bottle. Ask your teacher to set it on fire and push it away down inside the bottle with a stick.

Now place the egg on the top of the bottle while the paper is still burning. Watch the egg. Does it go into the bottle?

Why did the egg go into the bottle? First, there was a fire inside the bottle. This fire warmed the air inside a little.

The warm air spread out and filled more space. We say air expands when it is warmed.

As the warm air spread out, or expanded, some of it came out of the top of the bottle. We had not put the egg into the opening yet. So there was less air in the bottle.
Less air inside the bottle meant less pressure inside the bottle. Then we put the egg at the top of the bottle. No more air could go into it. And the air inside the bottle was pressing with a force of less than 15 pounds on each square inch.

But the air outside the bottle was pressing with a force of about 15 pounds on each square inch of egg. The pressure on the outside of the bottle was greater than the pressure on the inside. The outside air pushed the egg into the bottle.

We can get the egg out of the bottle by again changing the pressure of the air inside. Blow air into the bottle as the girl is doing in the picture.

Blow hard into the bottle. Now you have put more air inside the bottle than it had before. You have now increased the air pressure inside the bottle. This air presses harder against the egg in the neck of the bottle than the air outside is pressing. Out pops the egg.
Proving that Air Expands When It Is Warmed

Here is one way to show that air expands when it is heated: Fit a balloon over the mouth of a Pyrex nursing bottle. Does the balloon hang limp?

Now hold the bottle in both hands to warm it. Or you may warm it by setting the bottle on a warm radiator or in a pan of hot water. Watch the balloon.

Does the balloon fill out? Why is this? No more air could get into the bottle. The air inside must have expanded as it was heated.

Here is still another way to show that air expands when it is heated: You will need a metal pan, a candle, and a quart milk bottle.

Heat the bottom of the candle and stand the candle in the center of the pan. Be sure that the candle sticks to the pan.

Pour about 2 inches of water into the pan. Now light the candle and place the milk bottle over it quickly.

Why does the water rise in the bottle? Did you see some bubbles? The air inside the bottle expanded as it was warmed. As it expanded, air bubbles escaped from the bottle through the water in the pan.

Also, the candle used part of the air in burning. Now there was less air inside the bottle than outside.

The pressure of the outside air pushed the water up into the bottle. The water took the place of the air that had escaped or that had been used by the candle as it burned.
We are now ready to understand why air moves about. The temperature of the air differs in different places. You may already know that this is true in your schoolroom. Air near the ceiling is usually warmer than air near the floor. You can prove this for yourself.

Put a thermometer on a low table and leave it there for ten minutes. Read it. Now hang the thermometer somewhere high in your schoolroom. Leave it there for ten minutes. Read it again. Was the air near the ceiling warmer than the air near the floor?

This is what happens inside your schoolroom: When your schoolroom is heated, the cool air near the radiator, stove, or air vent becomes warm. As the air becomes warm, it expands. And as the air expands, it also becomes lighter. Then this lighter air is pushed up toward the ceiling by cooler, heavier air.
Yes, air moves because some air is heavier than other air. Cool air is heavier than warm air. So warm air is pushed up by cool air.

Cool air over cool water takes the place of lighter, warm air at the beach. That is why in summer it is often much cooler at the beach than it is at home.

The air under the shade trees in the yard is cooler, and heavier, than the air right around it out in the sun. It takes the place of the lighter, warm air. That is one reason why you feel cool when you sit in the shade.

So it goes! Air over the cooler places of the earth becomes cooled. It becomes heavy too and sinks toward the ground. As it sinks, it takes the place of the lighter, warm air near the surface of the earth.

Air is always moving. It moves because of these differences in temperature and pressure. Sometimes the air moves very fast. Then we say there is a strong wind.
At other times the air moves ever so little. Then we say there is no breeze at all. Yet, even so, some air is moving. Air is always moving a little.

This moving air can do work for us. When air moves, windmills which pump water may turn. Sailboats may be blown across a lake. Our clothes dry quickly when air moves as they are hanging on the line.

If you have a coal furnace, have you ever noticed your father open the draft on the furnace when he wants to make the fire burn more brightly? This lets cool air move into the furnace, which quickly takes the place of the lighter, hot air. Really your father makes a breeze inside the furnace when he opens the draft.

If you have learned, how to build a good campfire, you know that you must leave spaces between the sticks at the bottom. Then cool air can move into the fire, and this makes a breeze, or draft, of air currents in the campfire.
Sometimes air moves very fast. Then we say there is a dangerous windstorm. Windstorms do great damage. They sometimes blow buildings down. They sometimes tear roofs off barns and uproot trees. Winds like this are blowing very fast. Sometimes they blow 70 to 100 miles an hour.

Such winds sometimes sink ships at sea. They push ships that are anchored along the shore far up on the land. They may even blow bridges down. Perhaps you have been in such a windstorm. If so, you know how much power the wind has.

Most of the time, however, the air moves gently. It moves inside our houses. It moves from outdoors into our schoolroom and makes us feel cool and comfortable.

Try to find out from your custodian how the air in your schoolroom keeps moving. He will show you how air enters and leaves your classroom. Moving air helps us to keep comfortable.
Using Air Pressure

We use air pressure in many ways. It works for us. Air pressure helps to keep airplanes up. The picture below shows you how air currents flow over and under the curved wings of a plane.

Can you see that there is a place above the wing where there is very little air? The pressure here is less than it is on the bottom of the wing. Air currents lift the wing of the plane by pushing from below.

Parachutes use air pressure, too. When a flier jumps from his plane, he falls through the air very fast. But he pulls a cord to open his parachute.

As the parachute opens, his speed of falling becomes less. This is because, as he falls, the air pressure on the undersurface of the open parachute is greater than the pressure on the top surface.

The weight of the flier makes him continue to fall, but the air pressure on the undersurface of the parachute causes him to fall slowly. With an open parachute the flier can float gently down to the ground.
Did you ever see a perfume atomizer like the one in the picture? When you press on the bulb, a stream of air and perfume comes out of the hole in the top. Can you find out how this atomizer uses air pressure?

When you drink your milk through a straw, you use air pressure. First, you pull air out of the straw by sucking on the straw.

As you keep on sucking, the milk is pushed up into the straw. The milk rises in the straw because the air pressure on the top of the glass of milk pushes the milk up into the empty straw.

There are other ways in which we use air pressure. We use it in bicycle tires and in automobile tires. We put a great deal of air in tires. This makes them hard. We say we compress the air in our tires. Can you think of other ways in which air pressure is used?
What Is Air?

As yet we have not said what air really is. Let’s find out now.

Do you know what a gas is? Air is really a mixture of gases. Suppose we could see what was in a quart jar of air. Here is what would be there:

About four fifths of it would be nitrogen.

About one fifth of it would be oxygen.

There would be just a pinch each of carbon dioxide, neon, helium, and some other gases in the quart jar. There would be water vapor and dust in it, too.

As you can see, most of the air is nitrogen. We breathe this nitrogen into our bodies. But we make no use of it.

We just breathe the nitrogen right out again. We breathe out most of the other gases too—all except the oxygen.

We use the oxygen part of the air. We breathe it into our lungs. Here it goes into the blood. Then the blood carries the oxygen to all parts of the body. All parts of the body need this gas. We could not live more than a few minutes without oxygen.

As you have been reading about air, have you come to know what a very important part of the earth it is? Air makes life possible. We can ride on air. We can make air work for us. Air is as important a part of the earth as are the land and the water.
1. John and Tony had been on a hike. The ranger had helped them to build a campfire. They built the fire in a place that had been made safe. They cooked hot dogs. Before they started for home, they needed to put out the fire. They used sand to do this. Why will sand put out a fire?

2. Look at the pictures below and find the places where air gets to the fires. Would the fires burn without this air? Try to find out what gas in the air is used when fire burns.

3. If you blow up a balloon out of doors on a cold day and then go inside your house where it is warm, what might happen to the balloon? Try it and see.

4. Suppose you were asked to tell your friends where the atmosphere is. What would you say? Would it be correct to say, “It goes clear out to the moon”? Would it be correct to say, “It is around the earth like a blanket”? What else could you tell your friends?
5. You have learned three important things about air:

   It presses against things.
   It expands when it is heated.
   Cold air is heavier than warm air.

These three facts help us to understand why air moves.

Here is another experiment to help you to know about the movement of air: Find a wooden box like the one in the picture below. Cut two holes in one side of the box and place it with this side up. Cut both ends off two small tin cans. Place a can over each hole. Put a short candle in the box just under one hole. Light the candle. Then cover the open side of the box with a piece of glass.

   Now light a splinter of wood. Let it burn a moment and then blow it out. Hold the smoking splinter over the can that has no candle beneath it. What happens? Why?

   Next hold the smoking splinter over the can with the candle beneath it. Which way does the smoke move now? After doing this experiment, what can you tell your class about how air moves?
The Sounds We Hear
Sounds and More Sounds

Mercy, what a clatter! My, what a racket! Oh, what a screech!
Clang goes the bell! Buzz goes the doorbell! Zing goes the arrow! Quack goes the duck! And boom goes the drum!
Each sentence above describes a different kind of sound. Most of them are familiar sounds. Have you heard them many times? Do you know what makes these sounds?
What Makes Sounds?

You can find out about what makes sounds by doing these experiments:

Place your ruler flat on your desk so that some of it sticks out past the edge. Hold the ruler firmly with one hand, just as the girl is holding it in the picture. Now push down hard on the other end of the ruler. Then let go quickly. What do you hear? What do you see?

Hold the end of your pencil lightly in your fingers. Go about the room tapping it against things. You may tap the blackboard, the window sill, your book, and the metal radiator. What do you hear?

Hum a tune. While you are humming, hold your hand against your throat. What do you hear? What do you feel?

Now try this: Stretch a rubber band between your two hands. Have someone pluck the band with his finger. Watch carefully. What do you see? What do you hear?

These experiments should help you to understand what makes sounds. Did you see the rubber band moving back and forth? Did you feel something moving inside your throat? And did you feel your pencil moving in your hand? Try each experiment again and watch for the moving part.

Sounds are made when something moves back and forth. We say that things that move in this way vibrate. The ruler vibrates. The pencil vibrates. The rubber band vibrates. Something in your throat vibrates. Yes, sound is made when something vibrates.
How Do You Hear Sound?

You may wonder how sounds reach you. Sometimes you are a long way from the place where the moving thing is. You can hear a train coming down the track while it is still far away. You can hear a cow moo away down in the barnyard. You can hear the fire siren away over on the other side of town. How does sound travel to your ears?

This experiment will help you to answer the question: Get a pan of water. Drop a small pebble into it. Do you see circles of ripples, or waves, all around the place where the pebble sank? The pebble made the water around it move.

Air moves in somewhat the same way as the ripples did. You cannot see the air moving, but it moves all the same.
When you tap with a pencil, the moving pencil makes the air around it vibrate. When you pluck a rubber band, the moving rubber band makes the air around it vibrate. This vibrating air keeps making the air farther away from the pencil and the rubber band vibrate. At last the air right next to your ear is vibrating, too.

Sound travels through air to your ear. What then? By using a drum, you can understand what happens when air reaches your ear.

If you do not have a drum, you can make one. Stretch a piece of an old inner tube tightly over the open end of a nail keg or a wooden pail. Fasten it with a piece of wire as you see it done in the picture.

Now tap the drum with your hand or with a drumstick. Do you hear the sound? You made the drumhead vibrate when you hit it.
Inside your ear there is a drum. We call it an eardrum. Of course you cannot see this drum. You can see only the outer part of your ear. There are middle and inner parts which you cannot see.

The eardrum is a piece of membrane stretched tightly across the middle part of your ear. It vibrates as air strikes it. The eardrum makes other parts inside your ear vibrate.

A message from these moving, or vibrating, parts reaches your brain. Your ear and your brain work together. Together they tell you what you are hearing.

Now tap your drum again. Touch it lightly after you hit it. You can feel it vibrate. Your eardrum vibrates in the very same way. It vibrates as moving air hits it.

Yes, we hear sounds because something vibrates. The head of the drum vibrates, and we hear the sound it makes. A rubber band vibrates, and we hear the sound of it. A fire siren vibrates, and we hear the sound it makes. Sounds are vibrations which travel to our ears.
High Sounds and Low Sounds

All the musical instruments on this page make sounds. Yet no two of them sound alike. The big bass viol makes a deep, low sound. But the small violin makes a high, shrill sound. A banjo and a ukulele do not sound alike. They sound quite different.

The big bass drum makes a lower sound than the small snare drum. Why do you suppose some sounds are high and other sounds are low?

Let’s think about the drums first. See how large the drumhead of the bass drum is. See how small the drumhead of the snare drum is.

When you strike the head of the big drum, it vibrates. When you strike the head of the snare drum, it vibrates, too. But these two drumheads move, or vibrate, at different speeds.

The big drumhead vibrates more slowly than the small drumhead. The sound it makes is a low sound. The small drumhead makes a high sound.
We call this highness and lowness of sounds pitch. The small snare drum has a higher pitch than the large bass drum.

The piano may help us, too. Ask your teacher or mother to open the piano case. Look at the wire strings inside. Some of them are short. Some are long. Some are thick. Some are thin. You will notice that the longer strings are thicker than the shorter ones.

Now press down the key which goes with the shortest string. Do you hear a high sound?

Next press down the key that goes with the longest string. Do you hear a low sound?

These two strings vibrate at different rates. Each other string of the piano vibrates at a different rate. The longer, thicker strings vibrate more slowly than the shorter, thinner strings. The longer, thicker, slow-moving strings make low sounds. The shorter, thinner, fast-moving strings make high sounds.

Yes, some sounds are high, and some sounds are low. The highness and lowness of sounds you hear are called pitch.
Let's look at the violin or the bass viol. Perhaps someone who knows how to play one of these instruments will play for you. Watch where he places the fingers of his left hand.

Watch him move the bow across the strings near the middle of the instrument. Does he move his fingers on the strings? Do you hear the pitch change as he moves his bow across the strings?

Perhaps you would like to listen to the sound from only one string at a time. Ask the player to play on only one string.

As the player moves his finger along that string, what do you hear? What did the player do? As he moved his fingers up and down along the string, he made the moving part of the string longer or shorter. When he moved his finger down toward the center of the violin, he made the moving part of the string shorter. As he moved his finger away from the center of the violin, he made the moving part of the string longer.

The shorter the string, the higher the pitch. The longer the string, the lower the pitch.
Making a One-String Fiddle

Some children have had fun making a one-string fiddle of their own. You may want to make one and play it.

First, get a wooden box that is not too big. A cigar box is a good size. Cut a round hole in the lid. Then tape the lid down tightly all around the edge.

Nail a wooden handle on the box just as you see it in the picture. Pound two nails in the places shown. Fasten one end of a fine wire to one of the nails. Wind a few loops of the wire around a spool. Then stretch the wire tightly and fasten it well to the second nail.

Now pluck the string just as it is. Then, as you continue plucking, move the finger of your other hand up or down along the string.

As you change the length of the moving part of the string, what happens to the pitch? Let others in your room try it. Does the same thing happen each time? If someone has a violin bow, try moving it across the string. Does the same thing happen now?

Why does the pitch change? The string vibrates faster when it is short. The pitch is higher when the string vibrates faster. The pitch is lower when the string vibrates more slowly.
You may want to change the wire on your fiddle. Use a heavier wire. Stretch it between the nails and around the spool. Fasten it well. Now try playing it.

My what a difference! Now your fiddle sounds more like the big bass viol. It has a much lower pitch. But why?

Compare the thickness of the two wires. Which string makes the higher sound? Which one makes the lower sound? The thick wire vibrates more slowly than the thin wire. So the pitch is lower.

Another way to change the pitch of your fiddle is to stretch the wire tighter. Use the spool for this. When you pull the wire tighter around the spool, you change the rate at which the wire vibrates. Look at the picture to see how to do it. Now play on your fiddle. What has happened to the pitch?

Now you know three ways to change the pitch of your fiddle. Of course you also know that these are three ways of changing the rate of vibration. You can change the pitch by changing the length of the string. You can change the pitch by using a thicker or a thinner wire. You can change the pitch by stretching the string a little tighter.
Loud Sounds, Soft Sounds

Some sounds are loud. Some sounds are soft. A cat’s purr is a soft sound. A police siren makes a loud sound. A mouse’s squeak is a soft sound. A foghorn makes a loud sound.

Let’s see why some sounds are so loud that they hurt your ears and others are so soft you can hardly hear them.

Suppose you use your drum again. First, tap it lightly. Now tap it with more force. Which sound is louder? Yes, the last sound is louder. This is because you hit the drumhead so hard that it set more air around it vibrating.

Sounds are soft when only a little air is vibrating. Sounds are loud when a great deal of air is vibrating.

117
Try clapping your hands lightly. Is the sound you hear soft? Now clap your hands again. This time clap them harder. What happens? Why was this last sound loud?

Ask someone to go into a corner of the room and face the wall. Ask him to whisper someone’s name ever so softly. Did anyone hear the name? If not, you know that his whisper was so soft it did not set enough air in motion to reach your ears.

Try again. Keep trying until the person whispers loudly enough for you to hear. You will hear when the air waves that have been set in motion by the speaker reach your ears.

As you walk home from school today, listen to the sounds. You may hear a song sparrow, or a mocking bird may be singing in a treetop. You may hear the gentle rustle of a leaf falling to the ground. You may hear the ripple of water as it flows along in the brook. These are all soft sounds.

The heavy rumble of a train may startle you as the express roars past. The shrill wail of a fire engine may make you cover your ears. You may hear a dog bark as you pass his house. These are loud sounds.
You may want to find out more about sounds. Go out to the playground at a time when only your class will be there. Ask someone to stay in the center of the playground. Now ask four other children to stand in the positions shown in the picture above.

The child in the center blows a whistle, beats a drum, or rattles a rattle. Ask each of the four other children whether or not he heard the sound.

If these children heard, ask them to move farther away from the child who is in the center. Have the children keep moving away.

Ask each child to describe the sounds he heard as he moved away. Did the sounds get softer? Did the sounds change pitch?

Here are three things to remember:

1. The harder you tap an object, the louder the sound.
2. The more lightly you tap an object, the softer the sound.
3. The closer you are to the source, the louder the sound.
Making a Telephone

The children in the picture above are making a toy telephone. They are making it from two small tin cans and a piece of strong string.

First, they punched a tiny hole in the bottom of each can. Then they waxed the long piece of string with an old piece of candle. They will put the string through the holes in the cans and tie a knot at each end so that the string cannot pull out through the holes.

Now they are playing telephone. In the picture below Bob is talking into the can. He has it close to his mouth. Bill is listening. He is holding his can close to his ear. The string is stretched tightly.
Bill and Bob seem to be having fun. Bill looks as though Bob were telling him something interesting. No one else can hear their secret.

The air inside Bob’s can is vibrating. These vibrations are going along the tightly stretched cord. The cord makes the air in Bill’s can vibrate. This air carries Bob’s message to Bill’s eardrum. That is why he can hear what Bob is saying.

Your telephone in your own home works in much the same way. You talk into your telephone to your friend. However, your voice does not travel over the wire to your friend’s house. Instead, the sound waves of your voice cause a metal disk inside the mouthpiece to vibrate.

A current of electricity travels over the wires. The vibrations of the metal disk in the mouthpiece cause the electric current to become strong some of the time and weak some of the time. This electric current causes a metal disk inside the receiver to vibrate in the same way. Thus your friend hears what you say as you speak into the mouthpiece of your telephone.
Vibrations Travel through Many Things

We know now that sound is vibration. We sometimes say that sound travels to our ears. What we really mean is that vibrations travel to our ears.

We know we can hear the sound of a branch breaking because the air around it vibrates. When these vibrations reach our ears, we hear the sound of the branch breaking.

Do vibrations travel through metal? One afternoon, at Bob’s home, Bob and Bill tried an experiment to find out.

Bob went down into the cellar and stood near the water pipes. Bill went into the bathroom upstairs, where the same water pipes were.

Bob tapped lightly on the pipes in the cellar with a metal hammer. He asked Bill to answer back if he heard any sound.

Bill tapped three taps on the pipes in the upstairs bathroom. That was his answer to Bob. Both boys now knew that vibrations do travel through metal.
Do vibrations travel through wood? Try this and see: Hold a yardstick near your ear. Have someone hold a watch at the other end of the stick. Can you hear it tick? Can you hear it better when you hold the watch the same distance away, but not near the stick?

Try putting the watch at many places on the yardstick. Try putting it on other wooden objects. Can you hear through wood? Can you hear better through wood than through air?

Do vibrations travel through soil? Try this and see: Get two empty cardboard tubes. Hold a watch at the bottom of one tube and listen.

Now close the end of one tube and pack it full of soil. Hold the watch at the bottom of first one tube and then the other. Can you hear the ticking more clearly through the tube with the soil in it? Do vibrations travel better through soil than through air?

Can vibrations travel through water? If you have ever swum under water or dived into it, you may know the answer. Yes, vibrations travel well through water.

A sound under water is much louder than the same sound would be in the air. Vibrations travel better through water than through air. They also travel better through wood, metal, and soil. Air is really not a very good conductor of sound vibrations.
What Is an Echo?

Tony and Pete were fishing. They were away down in the valley between two high, steep hills. Tony said, "Hey, Pete, I bet you can’t do this." He put his hands up to his mouth and shouted, "Hello, hello, hello."

They listened. Soon they heard a soft answer: "Hello, hello, hello." Then Pete tried it. They listened and heard the soft answer again.

They were hearing an echo. The sound of their own voices came back to their ears.

Tony and Pete had set air moving when they shouted. The moving air waves had hit against the side of a hill. The air waves could not go forward. So they had bounced back to the boys’ ears.
Sometimes you hear an echo when you are between tall buildings. The moving air bounces back to your ears. It strikes the tall walls and bounces back. You hear your own voice again.

The same thing can happen in a tunnel or under a bridge or in a court between two apartment houses. Try it and see.

Here are four statements that are worth remembering:

1. We may hear sounds when gases vibrate. Air is a mixture of gases.
2. We may hear sounds when liquids vibrate. Water is a liquid.
3. We may hear sounds when solids vibrate. Wood, metal, and soil are solids.
4. Vibrations travel more easily through liquids and solids than they do through gases.
MORE ABOUT SOUND

1. Try this with a kitchen fork. Strike the prongs of the fork against the felt of a blackboard eraser or your rubber heel. Do not hit it against your desk. Then quickly put it near your ear. Do you hear the sound of the vibrating fork? Do it again. You can use a tuning fork instead of a kitchen fork, if you have one. The vibrating prongs of the tuning fork will make a louder sound.

2. Here is another experiment you may do with a fork: Stick a threaded needle into a cork. Knot the thread and hold it so that the cork and needle are free to swing. Strike the fork against your rubber heel. Now hold the fork as it is being held in the picture. What happens to the cork? Why does it move?

3. Many animals make sounds. Some sing, some croak, some hammer against trees, and some make sounds by rubbing their legs and wings together.

Below are pictures of some animals that make sounds. Can you find out how these animals make the sounds they do?
4. These musical instruments all make sounds. The next time you have a chance to listen to an orchestra, try to find out what parts vibrate to make the sounds. See if you can discover how changes are made in the sounds of each instrument.

5. It is fun to play the game of Echo. Find different places in your neighborhood where echoes are heard easily. A good place is in a tunnel or between two tall buildings or between two tall hills. Try to find out why echoes are easily made in these places.
How Plants Grow
Plants That Grow from Seeds

Did you ever stop to wonder why there are so many plants on this earth? Almost any place you go, you will find some kinds of plants. Yet if there were no way for new plants to start growing, the earth would soon have no plants on it.

Many plants that you see every day grow from seeds. Corn and wheat grow from seeds. So do beans and peas. The big oak tree in the forest grew from a small acorn. An acorn is really a seed. The red and white clover in the fields grew from very tiny clover seeds.

If you were asked how plants start to grow, you might answer, “They grow from seeds.” But not all new plants start that way. It will be fun to find out about several other ways. Because you may have thought of seeds first, let’s begin with them.

129
Where Seeds Are Found

When you bite into the fruit of the peach tree, you find one large seed in the middle of it. When you bite into the fruit of the apple tree, you find several small seeds. When you cut open the fruit of the watermelon plant, you find many, many seeds.

Most seeds grow inside the fruit of plants. Often we think of fruit as growing only on such plants as orange and apple trees. But the pod full of peas is the fruit of the pea plant. The cucumber that you eat is the fruit of the cucumber plant. The ear of corn is the fruit of the corn plant, and the tomato is the fruit of the tomato plant.

The berries you eat are fruits, too. The red strawberry is a fruit, with its seeds scattered over its surface. The blueberry is the fruit of the blueberry plant. Can you name other kinds of berries?

Some berries are really many tiny fruits clustered together. The next time you see red raspberries or other berries, look at them and see whether they are single fruits or clusters of fruits.
Where Seeds Form on Flowering Plants

Wherever you live, there will be some plants near you that grow from seeds. Many of the plants that grow from seeds are flowering plants.

Some flowering plants are easy to name. Many that grow in your garden have beautiful, bright flowers. It is easy to know that these plants are flowering plants because their flowers have such bright petals.

Most vegetables and grains are flowering plants, too. Many trees have flowers, but you may never have noticed these flowers. The flowers of some trees and those of some other plants have no petals. They are not so bright and beautiful as flowers with petals. They are hard to see.

As the petals of flowers dry up and fall, you will be able to see the seeds forming. They form at the bottom of the flowers. They have been forming while the plant was blossoming.

You may have a chance to watch beans or peas grow. Can you see that the pods are growing larger? Sometimes the seeds are so large that you can count them in a pod before it is opened.
Inside a Seed

It is fun to watch seeds grow. No matter where you go to school, you can experiment with growing plants from seeds. If your school is in a city, you may want to grow some plants indoors and some plants outdoors.

You can grow some of your seeds in water and some in soil. Here are some things you may wish to do so that you may find out more about how plants grow from seeds.

Get a package of Lima-bean seeds at a seed store. Soak them overnight, so that the hard, outside coat becomes soft.

Take this outside coat off a few seeds and split the seeds down the middle. Now look carefully and see if you can find a tiny new plant on one of the parts of each seed you have opened.

This is the only part of the seed that can grow into a new plant. The rest of the seed is food, which the young plant uses as it starts growing. You may wish to look for tiny plants inside some other kinds of seeds, too. Soak and split corn, pea, or pumpkin seeds. Look for the new plant that has formed inside each seed.

132
How the Young Plant inside the Seed Grows

Now that you know that there is a young plant inside each of your Lima-bean seeds, you will want to watch these young plants grow. You may be able to watch them grow by doing this:

Soak several seeds overnight and then lay them on a flat piece of cotton. Place the cotton between two pieces of glass. Then tie string around the pieces of glass to hold them in place. Carefully set the pieces of glass on end in a dish of water as shown in the picture. The cotton will become moist from the water in the dish.

Now set the dish in a sunny warm place in your schoolroom. Watch to see what happens. You will want to keep a record of what happens. Your record might be kept somewhat like this:

<table>
<thead>
<tr>
<th>Our seeds were planted on March 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>We saw the young plants March 4</td>
</tr>
<tr>
<td>The roots grew 1½ inches the first week</td>
</tr>
<tr>
<td>The stems grew ½ inches the first week</td>
</tr>
</tbody>
</table>
Growing New Plants

Here are some ways in which some of you might like to experiment:

1. Get a sponge. Place it in a shallow dish of water. Sprinkle grass seed over the top of the sponge. Be sure to keep the sponge damp. Soon you will see tiny plants growing. Each tiny plant grew from inside one seed. Keep a record of your experiment.

2. Get several 2-inch flowerpots. Fill them with good soil. Plant two seeds of corn in one, two grapefruit seeds in another, two cotton seeds in another, and two lemon seeds in a fourth. If you cannot get these seeds, use whatever seeds you have at hand. Keep the soil damp. Set the pots in warm, sunny places and watch the plants grow. Each plant grew from a tiny plant inside the seed.

3. You may wish to see just what is happening to seeds each day as they grow. Fill a wooden box or milk carton with good soil. Plant several of the same kind of seed in the soil. Each day carefully dig one seed out of the soil. Look at it. Keep a record of what is happening each day.

4. The next time your mother serves an alligator-pear salad, ask her for the pit. This pit is the seed of the alligator pear. Take off the brown, outside coat.
Place the seed in a glass jar partly filled with water. Keep the jar in a dark place while the roots are growing. It will take the roots several weeks to grow.

Bring the jar out of the dark place when the roots are well started. Now you will have to wait again. One day, however, the big seed will begin to split open. Then you will be able to see the stems and leaves of the new plant growing inside. Keep a record of this experiment too.

5. Sometimes you may wish to plant seeds in water. Later you may wish to put the young plants in soil. You can use flowerpots or tin cans filled with soil. Punch holes in the bottoms of the tin cans, so that when you water your plants, the extra water can drain out. Your plants will grow for a long time, now that they are planted in good soil.

From these experiments you will find out that a young plant starts growing when water and warmth and food are near it. Food stored around it in the seed is used first. Then the plant's roots grow down into the soil. Its stems and leaves grow up into the light.

The plant gets water from the soil through its roots. Food for the plant is made in its green leaves.

The tiny plants inside some seeds grow quickly. Rye, grass, bean, and radish plants grow quickly. The tiny plants inside some other seeds grow slowly. Grapefruit and lemon plants inside seeds grow ever so slowly.

Seeds are really wonderful things. The plants inside some of them can live in the seeds several years and can stand heat and cold. If the seeds are put in water or soil and kept warm, the plants inside begin to grow.
Growing Plants from Roots

This may seem odd to you: many of the plants that form seeds can start new plants in other ways too. Sometimes stronger plants can grow from the roots or stems or leaves of a plant than from the seeds of that plant.

You may wish to try growing new plants from roots. One root that you can grow is a sweet potato. Did you know that a sweet potato is really a root?

Look at the picture and place your sweet potato in a glass as shown there. Only part of the sweet potato should be in water. But be sure the pointed end of the sweet potato is kept covered with water. New, smaller roots will grow from this end. If you set the jar in a dark place for a few days, the roots will get a better start. Add water as you need to.

The sweet potato will first put out small roots, which grow in the water. Then it will send out stems and green leaves above the surface of the water.

You might like to grow a new dahlia plant from the root of an old plant. Plant the dahlia root out of doors if you have space to do so. Then it will grow and flower there. Or plant the root in a large flowerpot if you wish to grow it indoors.

It is fun to grow new tops from beets or carrots. Both these vegetables are roots. Cut 2-inch pieces off the top ends of the roots. Stand the pieces in a shallow bowl with pebbles and water in it. The pebbles help to hold the pieces in place. In a little while you will see leaves growing out of the tops of the roots.
Growing Plants from Stems and Leaves

New plants grow from the stems of some plants. You may wish to experiment with these plants too. There are several kinds of stems that you may use. The white potato you eat is called a tuber. A tuber is really an underground stem. The onion you eat is called a bulb. It is really a stem, too.

It is easy to watch new plants grow from an old potato. Choose a potato with white sprouts growing on it. The sprouts grow out of the places called eyes. The eyes of the potato are buds. They are the only places where the new plants can start growing.

Now cut the potato into pieces. Be sure you cut it so that there is an eye or a sprout in each piece. Plant the pieces of potato in small flowerpots indoors or in a garden spot outdoors. A new plant will grow from each eye or sprout.

You may also wish to grow a new plant from an onion bulb. Place the bulb in a shallow glass dish. Put pebbles around the bulb to keep it standing up. Now put just enough water in the dish to cover part of the bulb. Keep the water at this level. Put the dish in a warm, dark place for a couple of weeks, so that roots can begin to grow. Then bring the dish with the onion bulb out into the bright sunlight. Now green leaves will start to grow.
Here is another way to use stems to grow new plants: Cut a bit of stem from a geranium or from a coleus or an ivy plant. Such pieces of stems are called cuttings.

Place the cutting in a glass of water. Keep it in a sunny place. Roots will grow from the cutting. When this new plant has many roots, you may want to put your growing plant into a flowerpot with sand and soil in it. The sand helps to keep the soil from packing around the roots.

Later on you should put your plant in good soil. The plant will keep growing for a much longer time in good soil.

It is fun to grow new plants from the traveling stems, or runners, of strawberry or raspberry plants. You may be able to get a strawberry plant with which to experiment. The plant will send out a traveling stem called a stolon. New roots and stems will grow on the stolon at every other joint. You can grow many new plants from one strawberry plant.

New plants sometimes grow from leaves. This is true of the African violet. If you buy one African-violet plant from the florist, in time you can grow many new plants from it.

Pick a leaf with the stem attached to it. Fill a dish with damp sand and push the stem of the leaf down into the sand. Cover the dish with a glass jar. Roots will grow down into the sand from the base of the leaf.
The leaves of the snake plant will also grow into new plants. Cut one leaf crosswise into several pieces. Stand each piece in damp sand and cover the pieces with a glass jar. New plants will form where the leaf touches the sand.

Another kind of plant that will grow from a leaf is the walking fern. The tips of some of the leaves of the walking fern bend over and touch the damp soil. They send down roots and form new plants.

**Growing Plants from Grafting**

There is still another way to grow new plants. It is called grafting. Fruit trees are often grown in this way. Buds or stems from an apple tree that produces fine, sweet apples have been grafted to another apple tree whose fruit is not so sweet. Branches will soon grow, and the apples on these branches will be nice, sweet apples.

Rosebushes are also sometimes grafted. A cutting of one rosebush is sometimes fastened to the cut stem of another rose plant. The two will grow together. The cutting will use the roots of the old plant and can then bloom sooner. It does not have to wait for new roots to grow.
Growing Plants from Spores

Some plants have no flowers. These plants do not make seeds. They grow new plants in other ways. They grow new plants from tiny bits called spores. Most spores are so tiny that they can't be seen one at a time. They can be seen only through a microscope or when many of them grow together.

Ferns grow new plants from spores. If you can go to a woodsya place where ferns grow, you will see small yellow or orange or brown dots on the underside of some of the fern leaves. These are spore cases. Each case has many spores in it. If any of these spores fall where they can get warmth, air, and moisture, they will grow into small plants with tiny roots.

Mosses grow from spores, too. If you can bring some mosses into your classroom, you may be able to grow more mosses from the spores. Keep the mosses in a glass terrarium like the one in the picture below.
Have you seen mushrooms or puffballs? These are plants that grow from spores. After a wet season you often find mushrooms and toadstools growing on the school grounds or the lawn near your home.

There are millions of spores in the air all the time. They start growing into plants when they find a good spot in which to grow. They need damp and warm places in which to grow.

You can grow spores on a damp piece of bread if you wish. Leave a piece of bread outdoors all day. Then place the bread in a glass jar. Put a wet blotter in the jar, too. Then screw on the metal cover, so that the bread will stay damp.

Put the jar in a warm, dark place. Be sure to keep the blotter wet. After several days you will see blue and black mold growing on the bread.

You can grow another plant from spores. It is mildew. Dampen a piece of old cloth and roll it up in a piece of heavy paper for several days. Be sure the cloth stays damp. Put in a warm, dark place. After several days unroll it and see if there is mildew on it. Mildew is a plant that grows from spores.
YOU MAY WANT TO DO THESE THINGS

1. Look carefully at the pictures above and find the spore cases, ready to open and spread millions of spores, from which new plants will grow.

2. If there are wintergreen plants growing near you in the woods, you can start new plants from their underground stems. Do not bring more than one plant indoors. You may be able to watch new plants grow every few inches along the stem of your plant.

3. Go for a walk to a place where ferns and mosses grow. Look for the spore cases of these plants. Bring one or two of these cases back to school. Try to grow new plants from these spores.

4. Examine some cones from pine or spruce or other evergreen trees. Do not pick them off the tree. If the cones are green, they are closed. The seeds inside them are not ripe yet. When the cones turn brown, they will open. Then the ripe seeds will fall to the ground. Some of these seeds will grow into new evergreen trees.
5. You may wish to see whether a new plant will grow best from seeds or from other parts of the old plant. You might try growing onions from seeds and onions from bulbs. You could grow a white potato from a piece of an old potato which has an eye in it. And you might like to grow a white potato from seeds. Potato seeds form on some old potato plants. They are called potato balls.

Keep a record of your experiments. Notice which plants grow best from parts of plants and which grow best from seeds.

6. If you cut a stem from a pussy-willow tree or a forsythia bush and put it in water, it will take root. Then you can plant it outdoors and watch it grow.

7. A rex-begonia plant can be grown from a begonia leaf. Cut the large veins which you see on the leaf. Lay the leaf underside up on damp sand. Peg the leaf down with toothpicks. Cover it with a jar to keep the moisture in and put it in a sunny place. New plants will grow where the veins of the leaf were cut.

8. Seeds are different in size and shape. They differ, too, in the ways they are spread about. Your class might like to make a study of the many ways seeds travel. If you take a walk in the park in the autumn, you may see that seeds travel in several ways. It may surprise you to learn of the many, many ways in which seeds travel. Make a list of them.
Learning about Animals
Many Kinds of Animals

Take a walk around your neighborhood. You may be able to see many kinds of animals. Some may be crawling. Some may be flying. Are some walking? Are others swimming?

Are some of the animals you see small? Are others large? Are some “in between” in size?

Watch to find out what the animals that you see on your walk are eating. Are some of them eating plants? Are others eating animals?

Look closely at the coverings of the animals near you. Do some have long fur or hair? Do others have short hair? Do some animals have feathers?

All the animals in the world are alike in some ways. All of them are different in some ways, too. Let’s find out about ways in which animals differ.
Some Animals Have No Bones

Have you ever watched an earthworm? It moves its body as it crawls about. When you put it on your fish-hook, it moves very fast. How soft it is! This is because it has no bones in its body.

The earthworm is one of the millions of animals that you know that have no bones. Some of this group of boneless animals are very tiny. Some are larger. All of them have soft bodies.

Many of these tiny animals cannot be seen unless you look at them through a microscope. Some of these tiny animals live in ponds and streams. Others live in sea water. Still others live in the soil. Sometimes some of these tiny animals get into our blood and make us ill.

An amoeba is a tiny animal. It is smaller than the period at the end of this sentence. It lives in moist places. It is one of the many, many small animals without any bones.
Sea Animals with Soft Bodies inside Hard Coverings

Many animals living in the oceans, lakes, and rivers belong to the group of animals that have soft bodies. This picture shows you some of the soft-bodied animals that live in salt water.

These water animals are protected by hard outside coverings. They are safe from many of their enemies when they are inside their hard coverings.

Notice that these animals do not look alike. They have different shapes. They are different in size and color, too.

However, they are all alike in one way. They have soft bodies inside their hard coverings.

Starfish are not fish. Sea cucumbers are not vegetables, and sea lilies are not flowers. They are all animals. Each one of these has a soft body inside a hard covering.

Sometimes you find the hard coverings of sea animals washed up on the shore. When a sea animal dies, the soft part of its body may be washed away by water. All that you find are the hard coverings of these animals.
Sea snails and other water snails eat tiny plants and animals that they find floating in water or fastened to stones in the water.

The snail has only one part to its shell. This is true also of the sand dollar, abalone, and many other sea animals. Abalone shells are very beautiful. They are larger than clam shells. They are found along the Pacific coast.

Some other sea animals, such as scallops and oysters, have two parts to their shells. The two parts of the shell open and shut on hinges. They open, and the animal inside can get food and air and water. They close, and the animal inside is safe from many enemies.

The shells of many sea animals are very beautiful in color. It is fun to find them when you go to the beach to swim. Have you ever gathered shells at the beach?

People use many sea animals for food. Perhaps you have eaten oyster stew. It's good. Clams and crabs and scallops are good to eat, too. Have you ever tasted any of these kinds of sea food?

Have you ever watched a snail? It is an interesting animal. A snail has a foot, which it can stick out of its shell. It crawls along on this foot in search of food.
Insects Have Soft Bodies, Too

Swat that fly! Kill that mosquito! Poison the fleas on your dog! Watch those busy ants building their homes. See the honeybee, with its legs full of pollen. Watch the beautiful moth coming out of its cocoon.

Animals, animals, animals! Millions of them! Flies, bees, beetles! Ants, butterflies, and moths! Let’s take a look at some of them.

First, count the legs of each one. One, two, three, four, five, six legs. Yes, that’s one way in which these animals are alike. Each one has six legs.

Now count the parts of the body of each one. Can you find three main parts to each body? First, find the head. Next find the middle part of the body. This part is the thorax. Now find the third part. This part of the body is the abdomen.
Now look carefully at the two feelers, which stick out of the sides of the heads of these animals. Can you find them?

All the animals pictured above are alike in certain ways. They all have six legs, three body parts, and feelers. Whenever you find other animals like these, you will know they belong to the same group. They are called insects.

There is still another way that these animals are alike. They have coverings on the outside of their soft bodies.

Some have harder coverings than others. The coverings of mosquitoes and moths are thin and not so hard as the coverings of many kinds of beetles.

The world is full of insects. They are found almost everywhere. They can live in hot places and in cold places. Many live in water. Many live on land.

Some insects look much the same when they are young as when they are grown up. Young crickets look much like grown crickets. Of course they are small when they first hatch from eggs, and they have no wings.
Some young insects change their looks as they grow. Young moths and butterflies change as they grow. When they are first hatched, they look like worms. They eat and eat. Then they go into a resting stage.

Now changes take place. These changes take place inside a case, or covering, that each insect makes for itself. Grown-up moths and butterflies finally come out of these cases. The grown-up insects have wings, three body parts, six legs, and two feelers.

So far you have been reading about soft-bodied animals. All insects belong to this group of animals. Millions of other tiny animals are also part of this group. Many sea animals belong to this large group of animals, too.
Animals with Skeletons

All the animals you have been reading about are alike in at least one respect. They all have no bones in their bodies. Now let's read about another large group of animals.

These animals are alike in at least one respect, too. They all have bones in their bodies. You will read about frogs, fish, snakes, and lizards. You will read about ducks, turkeys, and robins. You will read about skunks, pigs, and cats.

These all belong to the group of animals that have bones. The bones are joined together into a framework, which holds up their soft bodies. This framework is called the skeleton of the animal.
How Are Fish Alike?

Have you ever watched your father clean a fish? Did you see the backbone of the fish? This is part of the skeleton of the fish. Almost all the other bones of the fish are joined to it.

No matter what kind of fish your father is cleaning, it will have a backbone and other bones joined to it. This is the framework of the fish. All the bones of the fish make up its skeleton.

Fish are alike in other ways too. They can live only while they are in water. They die soon after they are brought out of water. Fish can breathe only in water. They breathe through gill slits, which are on each side of their heads.

Water has air in it. A fish gets air for breathing from the water. Water goes in through the mouth of the fish. As it flows out over the gills, the fish breathes the air that is in the water.
There are other ways in which fish are alike. Almost all fish are covered with scales. All of them have fins and a tail.

There is still another way that all fish are alike. They are all cold-blooded animals. This does not really mean that their blood is cold all the time. Sometimes, however, their blood is colder than ours.

The blood of cold-blooded animals is usually about the same temperature as the air or water in which they live.

If the air or water becomes colder, then the blood of the animal becomes colder. If the air or water becomes warmer, then the blood of the animal becomes warmer.

So, you see, cold-blooded animals might be called by another name. They are, too. They are often called variable-temperatured animals because the temperature of their blood varies, or changes.

Now do you see how fish are alike? They live in water. They all breathe through gills. Their blood changes temperature. They all have skeletons.
What Are Reptiles?

There is another group of animals called reptiles. Do many of them live near you? Do any snakes live nearby? Do you ever see any turtles crawling around your schoolyard? Do you live near places where alligators or crocodiles live? Are there any lizards near your home?

All these animals are reptiles. The animals of this group are alike in certain ways. In the first place, they are all cold-blooded animals, just as fish are.

In the second place, their bodies are usually covered with scales or a hard shell, and they have skeletons. Every turtle you are likely to see has a hard shell. Every snake you will see has scales. Every alligator has thick, strong scales. Also, each of these animals has a skeleton inside its body.

Reptiles are all alike in another way too. They breathe with lungs, much as we do. Many of them live both in and out of water. But they cannot breathe under water. They have to keep their noses above water much of the time in order to breathe.

Perhaps you have seen only the head of a turtle sticking out of the water. Now you know why this is necessary. A turtle must come to the top of the water to breathe air.
Learning about Amphibians

The animals pictured on this page all belong to the same group. They are all amphibians. These animals belong in a group by themselves because their bodies change so greatly as they grow up.

Amphibians look one way when they are young and another way when they grow older. They live in the water when they are young. They breathe through gills then. Later on they change. Then they can live on land and breathe through lungs, just as reptiles do.

Frogs lay their eggs in water. Have you ever seen a jellylike mass of frog’s eggs in water? The young that hatch from these eggs are called tadpoles.
As tadpoles hatch, they swim about in fresh water. They keep growing. The picture on this page shows you how they change as they grow. Look carefully and point out the changes that take place as frogs grow.

Toads lay their eggs in water, too. Have you ever seen eggs like the ones in this picture? These are toad’s eggs. They hatch into tadpoles. Tadpoles swim around in the water and eat and grow larger. When they change from tadpoles to toads, their way of breathing changes. Now they no longer live in water. They live on land and breathe with lungs.

You may find toads in your garden. They eat many insects that harm garden plants. Always welcome toads in your garden. They are your helpers.

Amphibians are alike in other ways. They are cold-blooded animals, just as reptiles and fish are. They have skeletons inside their bodies. They have skin instead of scales.
Birds Are Warm-blooded Animals

The animals you have been reading about move in many ways. Some hop. Some walk. Some crawl. Some fly. Birds are like some insects in the way they move. Most birds fly, too.

All birds have two wings and two legs. Some birds are great fliers. Many of them travel long distances. On the other hand, some birds fly but little and others not at all, even though they have two wings. Penguins and ostriches cannot fly at all.

Many children are surprised to learn that chickens, turkeys, geese, and ducks are birds. We get used to thinking of birds as wild animals that fly a great deal. We forget that tame birds can fly, too.

If you live in the country, your mother may sometimes chase the chickens or turkeys out of the garden. She says, “Shoo, shoo!” Away they fly out of the garden. But they fly only a short distance even then. Many times they only spread their wings and run. Can you guess why?

Birds are alike in another way. They are warm-blooded animals. This means that their bodies are always about the same temperature. They do not change temperature as cold-blooded animals do.
A bird’s body does not become colder when the air around the bird becomes colder. The body does not become warmer when the air around the bird becomes warmer.

A bird has about the same temperature all the time, unless it becomes ill. Then it may have a fever, and the temperature will be higher.

Normal bird temperature is higher than your normal temperature. When you are well, your body temperature is between 98 and 99 degrees. Normal bird temperature is between 102 and 110 degrees.

Sometimes we speak of warm-blooded animals in another way. We say that they are constant-temperatured animals. We say this because their body temperatures stay about the same all the time.

There is one special way that birds are different from all other animals. They have feathers. No other kind of animal on earth has this kind of covering.

Have you ever seen very young robins being fed? They are so helpless. They have only a little bit of fuzz covering their skins. As they grow older, the fuzz gets all covered up by feathers. How different young ducks look! They are soft and fluffy. Soon after they hatch, they leave the nest and run around. They do not need to be fed, as young robins do. They can feed themselves almost as soon as they hatch.
What Are Mammals?

The animals pictured on this page belong to the same group. They are all mammals. Mammals are like many other animals because they have strong skeletons. In this respect they are like frogs and birds and snakes.

All mammals are like birds in one way. All birds and mammals are warm-blooded animals. Their body temperatures do not change as the temperature of the air or water around them changes. The body temperature of dogs and cats, robins and kingfishers, stays about the same all the time.

Mammals, however, are different from birds in one very special way. Young mammals feed upon milk from their mothers’ bodies.

Have you seen young kittens or puppies getting milk from their mothers? Have you seen a young colt or a young calf getting milk from its mother?

Elephants, whales, bears, deer, and rabbits are all mammals. The young all feed upon their mothers’ milk. Can you name other animals in this group?

Rabbit and young

Dog and puppies
There is another way in which you can know mammals. They have hair on their bodies. Sheep have woolly hair on their bodies. Horses have long manes of hair on their necks and shorter hair all over the rest of their bodies. Cows, seals, and dogs have hair on their bodies, too.

Think of the animals you have seen in the zoo or in the circus. Can you tell which animals belong to the mammal group? Do tigers and lions have hair? Do monkeys and wolves have hair on their bodies? What other animals do you know that have hair on their bodies?

The young of most mammals are born alive. They are not hatched from eggs, as birds, frogs, and lizards are. Many of the young mammals are helpless when they are first born. They need good care. They need protection and food and a nice warm place to sleep.

Have you ever seen young puppies sleeping very close together at the side of their mother? The heat from their bodies helps to keep all of them warm as they sleep. Have you seen young kittens or pigs sleeping in much the same way?
Some young mammals are carried around by their mothers until they are old enough to take care of themselves. The picture shows you how a young kangaroo is protected while it is young. How should you like such a pouch in which to travel?

Most mammals are land animals. Seals and walruses and whales, however, are mammals, too. They live in water. But they must come to the surface to breathe. They breathe with lungs.

What fun it is to watch a sea lion swimming in its pool! A sea lion is a kind of seal. You will notice that every few minutes it comes to the top of the water. It sticks its nose above the surface. It breathes that way.

Whales and porpoises live in the ocean. They are mammals. They breathe with lungs. That is why you may see them at the surface of the water. They must get air to breathe into their lungs.

Ask your teacher to write on the blackboard all the ways that mammals are alike. Be sure to tell her about how they breathe, their body temperature, and their covering of hair. What else should she write?
MORE ABOUT ANIMALS

1. Divide into groups in your class. Each group may then make a chart or a booklet about an animal group. Be sure one group of children takes reptiles, another birds, another mammals, and so on. You may wish to list some of the animals that belong in your group. You may wish to list ways in which all animals in your group are alike. You may wish to draw pictures and write stories about how certain animals live. Tell about how they grow up, what they eat, and where they live.

2. Snakes live in many places. Most of them are harmless. In fact, most of them are very helpful animals. They eat mice and other animals that are pests. There are only a few kinds of poisonous snakes in North America. You should learn to recognize these snakes, so that you can protect yourself from them. The pictures on this page show you what they look like. Study them with care.
Working with Electricity
Using Electricity Every Day

Did you ever stop to think of how many ways there are in which electricity is useful to you? You turn on the switch, and your room lights up. You pick up the telephone receiver and talk to your friend. You turn a button, and your radio brings you a concert.

In the morning your mother brings you two golden-brown pieces of toast hot from the toaster. My, they are good! She also brings you a glass of cold milk from the electric refrigerator.

Yes, electricity is used in many ways every day. Your life is quite different because of it.

165
What’s inside a Dry Cell?

You can learn a great deal about electricity by working with it at school. You will use a dry cell in your work. A dry cell makes only a little electricity at one time.

It is safe for you to work with electricity made inside a dry cell. There is not enough electricity made in one dry cell to harm you.

Did you ever wonder what a dry cell looks like inside? Have you ever opened one to see? Some children think there is electricity inside a dry cell. Let’s open one and look inside.

You will need a hammer or a can-opener, a chisel, and a saw. You will need some big sheets of newspaper too. Open your dry cell on a newspaper. This will make it easier to clean up after your work.

First, take the paper off the dry cell. This outside paper cover protects the dry cell.

Now comes the hard work. Cut the metal can down the side. Use your hammer and chisel or your saw to do this. The metal can is made of zinc. This metal can is useful in making electricity.
All around the inside of the metal can you will probably find some moist blotting paper. And then you will see a black, powdery paste. Right down through the center of the dry cell you will see a black carbon rod.

At the top of the dry cell are two connecting screws. One screw is fastened to the zinc can. The other is fastened to the carbon rod.

The top of the dry cell is sealed. This is to keep the inside of the dry cell from really becoming dry. The black, powdery material stays moist.

The black, powdery material is a mixture. It is a chemical mixture. The chemicals touch the carbon rod and the zinc can.

But where is the electricity? The dry cell is apart, and there is no electricity inside it.

Dry cells do not store electricity inside them. They make, or produce, electricity only when a complete path is provided along which the electricity can move. Then the chemicals and the carbon rod and the zinc can, all working together, set electricity free.
Making a Path for Electricity

You will want to know how to make a path so that a dry cell can make electricity move. The picture shows you how to make such a path.

The wire you will need is called bell wire. This is copper wire. The dry cell is a No. 6.

Do you see that the ends of the wire are bare? Scrape the covering off both ends of the wire you are using. Connect the two ends of the wire to the two screws, or posts, of the dry cell. Now you have made a path, or circuit. The materials inside the dry cell begin to work together to make electricity move along the path, or circuit.

The electricity travels out of the dry cell through the copper bell wire and back into the dry cell again. There is a complete path, or circuit, through which the electricity can travel. Can you point out this complete circuit? Use your pencil to follow the path.

You will want to remove the wire from the posts as soon as possible. The wire will get very warm if you leave it connected. There might be danger of your burning yourself. You should remove the wire also so that your dry cell will not wear out.
Making a Bell Ring

You may want to use the electricity that the dry cell is setting free. You can use it to ring a bell.

This time use two pieces of bell wire. Fasten one end of each wire to a screw of the dry cell, as shown in the picture below. Be sure to fasten the ends well. You want them to be fastened tight in order to make a good path along which electricity may move.

Now fasten the free end of each wire to a post of the bell. Does your bell ring?

This time you have made the bell part of the circuit. Now electricity travels from the dry cell through one wire to the bell. Then it travels through the bell and back to the dry cell again through the other wire. It travels along the whole circuit.
Making a Bell Stop Ringing

Of course you don’t want the bell to keep on ringing and ringing. Let’s stop it. Take either end of a wire away from the screw to which it is fastened, and the bell will stop ringing. Fasten it again. The bell will begin ringing all over again.

What a bother it is to fasten and unfasten the wire! It takes so long. Here is an easier way to do it: Use a push-button switch.

Cut one of your wires in two. Scrape a little covering off the two cut ends of the wire. Fasten these ends to the screws of the push button.

Now press the button down with your finger. The bell rings. Take your finger away, and the bell stops ringing.

This time you have made the push button a part of the circuit. Why, then, does the bell ring only when you push the button down? Let’s look inside and see.
What's inside a Push Button?

The pictures on this page show you how a push button works. The first picture shows the outside of it. The second picture shows you what is inside a push button. The third picture shows you what happens when you push the button down.

When you push down on the button, you make a complete circuit. You push the brass spring down, and a piece of metal on it touches the metal below. Electricity can now travel through the circuit you have made. It goes along the copper wire through the push button into the bell and back to the dry cell again.

When you take your finger away, the piece of metal on the brass spring no longer touches the metal below it. There is now no path for the electricity to travel through. We say the circuit is broken. The bell stops ringing.
Paths for Electricity

Some things make good paths through which electricity can move. You have been using copper wire for your experiments. We say copper is a good conductor of electricity because electricity can travel through it more easily than through other materials.

Many metals are good conductors. Iron and steel are good conductors. Your scissors and jackknife are good conductors. Your mother's darning needle will conduct electricity.

Fortunately for us, many things are poor conductors of electricity. An electric current cannot travel easily through air. Air is a poor conductor.

Electricity cannot travel easily through rubber or leather or wood or glass. Objects made of these things are poor conductors of electricity.
You and Electricity

You can be a path for electricity. That is why you should know how to use it safely.

The dry cells you use at school are not dangerous. They do not make enough electricity to give you even a little shock. You need not be afraid to use dry cells for your experiments.

The electric current that lights your home is very strong. If you touched the bare wires that carry your house current, the electricity would travel through your body. You could get badly shocked. So do not touch bare wires that carry your house current. It is very dangerous to do that.

Let us see how electric cords are made to protect you from danger. Look at the cord of your electric toaster or floor lamp. Pick it up and notice how it is made.

The outside covering of your cord may be cloth or plastic or rubber. These coverings are poor conductors of electricity. We call poor conductors insulators. We say we use insulated wire for electric cords.

The inside of your cord is interesting. Look at the picture below. You see there are two wires inside your cord. Each wire is covered with material that is a poor conductor of electricity.
When you worked with dry cells, your two wires were separate. But the wires in your electric cords at home are wrapped together. They look better that way, and they do not tangle as easily. They are safer too, for there is a double layer of insulation around them.

Suppose you saw an old electric cord that looked like the one in the picture above. Would it be safe for your mother to use? What should be done about old and worn cords at home?

Are there some electric cords in your home that are covered with plastic or rubber? These coverings are waterproof. Do you know why it is a good idea for the coverings of electric cords to be waterproof? The reason is that water is a good conductor of electricity.

Notice the electric cord on your mother’s washing machine. You will find that the insulation on this cord is of waterproof material. It is safe for your mother to use this cord when she is washing the clothes. If the cord gets wet by mistake, this covering keeps the water from getting inside the cord. If there were no such waterproof covering, the electricity might travel out of the wire through the wet insulation. The electricity would go into your body if you happened to touch the wet cord.

Always be sure that your hands are dry when you turn on a light or touch an electric appliance. Now that you know that you can be a path for electricity, will you be more careful?
What Is a Short Circuit?

Here is another thing we should remember about electricity: it always travels along the easiest path. That is another reason why electric wires are insulated. Insulation keeps the electricity inside the wire, where it should stay.

Sometimes the insulation wears off a wire. Then there may be trouble. The picture shows you what may happen. The bare wires may touch each other and become very warm. This is a short circuit.

Look carefully at the wires in the picture. Can you see that they touch each other at the place where they are bare?

Now look at the light. It isn’t on. And no wonder. The electricity is traveling along an easier path. It isn’t traveling into the light. It is only going to the place where the bare wires touch each other and then back to the dry cell again. The electricity travels along the short path. We say there is a short circuit.
Using Electricity to Make a Magnet

Do you know that you can make a magnet by using electricity? It is a special kind of magnet. We call this special kind of magnet an electromagnet. To make one, you should first find a large nail. Get as big a nail as you can. The bigger it is, the better.

Now wind a long piece of covered wire around your nail. Leave some wire at each end. Scrape the insulation off the ends of the wire and connect one end to a post of the dry cell. Now hold the other end of the wire to the other post of the dry cell. Hold a paper clip near the end of the nail. What happens? Try a bobby pin. Will it pick that up, too? Try a thumbtack. What happens?

You have made the nail into a magnet by using electricity. You have made a path, or circuit, along which electricity can move easily. The electricity traveling through the coil of wire makes the nail into an electromagnet.

Now break the circuit by taking one end of the wire away from the dry cell. What happens? Will the nail pick up paper clips or thumbtacks or bobby pins now?

The nail is no longer an electromagnet, because no electricity is traveling through the wire. It is just a plain nail again. Or, anyway, it will soon be. Right at first the nail may keep a little magnetism. It may keep enough to hold one paper clip for a short time.
You may wish to add a switch to your circuit. Then you can turn the electromagnet on and off easily. Do it just as it is done in the top picture on this page. The switch in this picture is called a knife switch because it closes like a jackknife. But you might use any other kind of switch instead.

Now do some work with your electromagnet again. You can do this by closing the knife switch. This completes the circuit. Electricity moves through the wire and makes the nail into a magnet. Try to pick up many things with it.

Whenever you wish, you can open the switch. Now try again to pick up, with your electromagnet, all the things which you picked up before. What has happened? The nail is no longer an electromagnet, because you broke the circuit when you opened the knife switch.

You may want to make a stronger electromagnet. The pictures on this page show you two ways to do it. Try each way and see for yourself how to make a stronger electromagnet. Keep opening and closing the switch from time to time so that the wires do not become hot.
Where Do We Use Electromagnets?

Now that you know how electromagnets are made, you may wish to find out about their use. Are they any good? Where do we use them? Let’s look inside an electric bell.

Can you see the two spools of wire? Do they remind you of the wire that you wound around the nail to make your electromagnet? That’s what they are, an electromagnet. They are the electromagnet in your bell.

Many electric things you use today work because there is an electromagnet inside them. Your mother may use an electric mixer when she is making a cake for you for your birthday. She may also use it to mash potatoes.
You may have a motor that came with your toy building set. You may use your motor to lift objects or to pull trucks.

Perhaps your father has a motor on his workbench. He may run many of his tools with it. He may use it for sawing wood or making furniture.

Below is a picture of a motor that some children made. Can you find the coils of wire? They become electromagnets when electricity travels through them. They make the motor run.

Yes, there is always an electromagnet inside each electric motor. That is what makes the motor run.
Bob and Nancy have made a simple telegraph set. Their set has an electromagnet in it. Each time Bob presses on the key, the circuit is completed. The electromagnet attracts a piece of metal, and this makes a clicking sound. By means of these clicks Bob is sending a message to Nancy.
These men are using an electromagnet in their work. The big, round piece of metal on the end of the crane is an electromagnet. With it the operator picks up heavy pieces of iron and loads them into a flatcar.
THINKING ABOUT ELECTRICITY

1. Sometimes we forget that the use of electricity has changed our ways of living. Make a chart showing ways of living before electricity and now.

<table>
<thead>
<tr>
<th>Now</th>
<th>Before electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric lamp</td>
<td></td>
</tr>
<tr>
<td>Electric stove</td>
<td></td>
</tr>
<tr>
<td>Electric toaster</td>
<td></td>
</tr>
<tr>
<td>Electric washer</td>
<td></td>
</tr>
</tbody>
</table>

2. Mary’s family has just moved into a new home. Mary told her friends that the new house was completely modern. She said, “Almost everything works by electricity.” What did Mary mean by her statement?

3. Look inside a flashlight. Can you trace the circuit in it?

4. Ask your father to take you to the garage or filling station when he is going to have water put in the car battery. The battery makes electricity. The battery uses chemicals to make the electricity that starts your car and lights its headlights.

5. Electricity is a kind of energy that is used to do work. It is used to run trains. It is used to run washing machines, in which your clothes are washed. It is used to run the vacuum cleaner, which helps you to get your rugs clean. All of us use energy from electricity to do much work for us.
6. Some of the items listed below are good conductors of electricity. Others are poor conductors. Make two lists, showing good conductors in one and poor conductors in the other.

| cloth | plastic | straw | silver |
| brass | aluminum | glass | rubber |
| copper | feathers | silk | wood |

7. Here are some rules for safety. Why are they good rules?
Do not touch loose wires hanging down from buildings or poles. If you should see a wire hanging in this way, you should tell a grownup about it at once.
Be sure to keep all cords used on electric appliances in good repair.
Be sure that your hands are dry whenever you touch an electric-light switch.
Use dry cells whenever you want to make the electricity you use in your experiments.

8. Can you find the fuse box in your home? Try to find out what fuses are for.

9. Thomas Edison made the first successful electric-light bulb. Read about how he did it.

10. Can you tell whether the bell is ringing?

11. Can you tell why the light is not on?
The Waters of the Earth
Oceans, Lakes, and Streams

As you look about you, you might think that most of the earth is dry land. You may be surprised to discover how much of the earth’s surface is water.

Look carefully at a globe or a map of the world and find the four great oceans. These oceans make up most of the water part of the earth. Do you see how they are connected? Together they form one mighty ocean, which surrounds all the lands of the earth.

Do you see lakes and rivers on your globe or map? Small as they seem, they cover many, many square miles of the earth’s surface.

Perhaps now you do not find it hard to believe that only about one fourth of the surface of the earth is dry land. All the rest is water, and most of this water is the mighty ocean.

185
Life in the Ocean

Have you ever stopped to think about the many, many plants and animals that live in the oceans of our earth? Some of these float about in the water. Some animals crawl, some swim, and others fasten themselves to rocks, piers, or boats.

Some build up great reefs of rock, called coral, upon the ocean floor. In time these reefs of coral may rise out of the ocean and become islands.

Some of these plants and animals are among the largest things now living. The blue whale is the largest animal on our earth today. Iodine kelp, a seaweed found in the Pacific, sometimes grows several hundreds of feet long. It is one of our largest living plants.

Yet some of the plants and animals that live in the ocean are among the smallest living things on earth. They are so tiny that you can see them only through a microscope. They are so tiny that thousands and thousands of them might be found in one cup of ocean water.

As you ride through the waves of the blue-green waters of the ocean in your speedboat, the animals below you may swim, walk, or crawl to safety. Some hide in the mud, under rocks and shells. Others hide in the seaweed. Still others dig down deep into the sand and hide there. There they are safer from their many enemies. Let’s find out about the strange and beautiful life in the ocean.
Tiny, Tiny Sea Life

We shall call the top two hundred feet or so of the ocean its surface. It is in these surface waters that many, many tiny plants and animals live.

Someone has said that these waters are the vegetable gardens of the ocean. That is very nearly the truth. For billions of tiny plants live here. To make their food, they need the sunshine that comes through the water. The plants float about unseen near the surface of the ocean.

Sometimes this top part of the ocean is called by another name. People often speak of it as the nursery of the ocean.

And so it is. For it is here that many, many sea creatures lay their eggs. It is here, too, that the young of many sea animals live. They are the animal part of the tiny, tiny life of the ocean.

What better place could there be for a nursery for the young! Just by opening their tiny mouths, they may be able to get a whole meal of green vegetables.

These billions and billions of tiny, living plants and animals are called plankton. Plankton is a very important part of the life of the ocean. It furnishes food for almost all the larger animals that live in the ocean.
If something were to happen to this living mass of plant and animal life, there would be a real food shortage in the ocean. For even the whales feed upon the plankton of the ocean.

Here is the way it works: some whales eat huge fish, which eat large fish, which eat medium-sized fish, which eat small fish, which eat smaller fish, which eat tiny fish, which eat plankton. My, what a tale!

You may be surprised to learn that there is plankton in the surface water of all the oceans. There is more of it in cool and cold ocean water than there is in warm ocean water. Even the cold Arctic Ocean has a great deal of plankton in it. Sometimes the plankton is so thick that people say the water is soupy.
The narrow strip of water between Alaska and Russia is one of these places. This is called Bering Strait.

Sometimes we hear a farmer talk about how many bushels of corn or potatoes he raised on an acre of land. But did you ever think that an acre of ocean water could also give a good crop?

One scientist tells us that if an acre of surface ocean water were strained of its tiny sea plants and sea animals, this crop would be as important as the crop from an acre of land.

In 1947 six men built a raft of nine logs. They set out from Peru, South America, and traveled over 4000 miles across the Pacific. They finally reached the South Sea Islands.

These men tell about crossing soupy water where plankton was very thick. At night it shone in the darkness.

As plankton floats about in the surface water of the ocean, much of it is eaten by the animals there. But some of the tiny creatures in the plankton die and sink toward the bottom of the ocean. As they sink, they may be eaten by deep-sea animals.

The plankton that settles on the bottom of the ocean becomes part of the great ooze that covers the ocean floor. The tiny bones and shells of animal plankton are part of the material out of which some limestone is formed.
How interesting the seashore is! Twice each twenty-four hours the water of the ocean reaches far up on the land. We say that it is high tide then.

Twice each twenty-four hours the ocean water withdraws along the shore. We say the tide is going out. Just before the water turns and begins to come in again, we say it is low tide.

At high tide much of the shore is covered with salt water. At low tide the region from which the water has withdrawn becomes part of the land.

The animals are awake and busy as the salt water brings food in to them at high tide. The rest of the time they are protected from the dry air in ways which, as we shall see, keep them from drying out.

This region between the tides is a place of great change. The plants and animals that live there have to be able to live through both wet and dry times.

You might think that there are only a few living things on the seashore. But this is not true. Many plants and animals make the shore their homes.
Along Rocky Shores

You may have seen barnacles fastened tightly to rocks along the shore. These little animals fasten themselves to rocks or boards or docks. In this way they keep from being washed out to sea.

A barnacle shell looks like a tiny volcano. It has steep sides with a door on top. The barnacle closes its door as the tide goes out.

At high tide the barnacle opens its door and waves feathery feelers about in the water. These feelers catch whatever food floats past.

As the tide goes out again, the barnacle closes the door and keeps it shut until the next high tide.

Sometimes you may also find another kind of animal fastened right beside barnacles. These animals are mussels. They are fastened to rocks or wood by hundreds of tiny threads.

At high tide mussels open their shells and feed upon the tiny plants and animals that go by. After a fine feast they close their shells and wait for low tide and drying-out time.

The next time you go to the shore, look for places where barnacles and mussels might live. See if you can find out more about these little animals.
Perhaps you have seen crabs hurrying to good hiding places as the tide goes out. There are many kinds of crabs along the shore. It is fun to watch them move sideways looking for food, which they catch in their two claws. They aren’t very fussy about what they eat. Almost any plant or animal, dead or alive, will do.

As a crab grows, its shell gets too small. So it walks out of it. Now it must hide and wait for its new, soft shell to grow hard.

A hermit crab has a different trick. It crawls into an empty shell that once belonged to another sea animal. When it is little, it may use the empty shell of a small snail.

When the hermit crab grows larger, it chooses a larger shell for a home. You will often see these crabs crawling over rocks, eating plants that grow there.

Perhaps you have seen beautiful objects in the water that look for all the world like flowers. They may be white or orange or yellow or purple. These objects are often found on rocky shores.

But watch out! These are not harmless flowers. They are animals. These little animals, called sea anemones, wave their flowerlike feelers back and forth and catch food with them. The feelers sting whatever floats, crawls, or swims within easy reach.
Oysters also live in this region between the tides. They fasten themselves to rocks along the shore and open their shells at high tide. They feed upon plants and animals that float past.

You will also find starfish along the rocky shore. They move about over the rocks, fastening themselves by their feet when the need arises. Starfish eat mussels, oysters, and many small fish. They pull open the shells of mussels and oysters by fastening their feet to them. Each year starfish destroy many, many oysters in this way.

To prevent this, some fishermen fence in their oyster beds. Then the starfish cannot get to the beds. Other fishermen use a starfish mop and drag it back and forth over oyster beds. The starfish get caught on the strings of the mop and are pulled out of the water.

Here, too, in this region between the tides, you will find limpets. At high tide the limpet travels about on nearby rocks and eats bits of seaweed that it finds there. But as soon as the tide goes out each limpet settles down into its home in a hole in a rock. It pulls its shell down tight and waits for high tide.
Along Sandy Shores

So far we have been reading about creatures that live on rocky shores. But what about sandy beaches? Are they the same?

No, these shores differ a good deal. It is here that you may sometimes dig holes and play in the cool, wet sand. It is here you may run out and splash about in the waves.

Have you ever seen a row of dead-looking, brown seaweed near the high-water mark all along a sandy beach? On this seaweed live small beach fleas and other insects, which may bother you as you eat your picnic lunch nearby.

Not far away you may see a great many little humps of wet sand. Under these many humps are small snails, ready to drill holes into clams if they find any.

What on earth is that big-headed, short-tailed creature crawling at the edge of the water? That's a horseshoe crab looking for a meal of worms or perhaps for a place to lay its eggs.

If you look closely at the wet sand, you will almost surely see bubbles coming out of it. At low tide most of the animals along a sandy beach are buried in the sand.

But although you cannot see the animals under the sand, some of them can see you. Some creatures have eyes at the ends of short stalks. At a moment's notice they dig holes in the sand and bury themselves. No one can see them.

But how clever! Those eyes on the ends of stalks stay right at the top of the sand. They can see all that is going on.
Along Muddy Shores

Perhaps you have seen seashores on which you would not like to play. There are many such shores. Black, muddy places they are. If you step on them, your feet sink into the soft mud. These places are sometimes called mud flats.

Mud flats are the homes of soft-shelled clams, which your mother may use for clam chowder. Sometimes these clams are called long-necks because of a long tube, or neck, out of which water comes as you walk near. This water comes up from the clam, which is buried a foot or more deep in the mud. You would have to dig deep to catch the clam.

Here also you will find many kinds of crabs. Along the muddy flats blue crabs walk out of their small, hard shells and wait for their soft, new shells to grow hard.

Spider crabs covered with seaweed dart around on the muddy flats. They can bury themselves quickly when you come near. Buried safely in the mud, they watch you as you walk along.

Many sea worms live here, too. They bury themselves in the mud flats at low tide. At high tide they come out of their holes in the muddy flats and eat. But as soon as the tide goes out, they bury themselves again.
Beyond the Reach of the Tides

In the shallow waters offshore there is still another world of life. Here, along with some of the animals you have just been reading about, many free-swimming creatures live.

Fish by the hundreds swim about in the shallow water. Here they find food and lay eggs.

Some of them feed near the top of the water, eating plankton. Others swim near the bottom, feeding upon the many creatures that live there.

It is in these offshore waters that fishermen, sitting in boats, wait for fat fish to bite the bait on their fish-hooks. It is here that men may set lobster pots to trap big lobsters, whose meat some people call “the best of all sea food.”
Out in the Open Ocean

The giants of the salt water live out in the open ocean. Among these are the whales. Some of these huge monsters grow as long as a seven-story building is tall.

A whale comes to the top of the water to breathe. It has lungs instead of gills. That is why it must come to the surface of the water often. Sometimes people see it spout water into the air as it breathes.

Many, many other animals grow to great size in the waters of the open oceans of the earth. They swim over miles and miles of water, eating plants and animals that happen to swim across their paths.

You may be surprised to learn that there are plants out in the open ocean. You will remember that plankton floats on the top of the ocean almost everywhere. In many places seaweed reaches up from the bottom of the ocean. In other places seaweed floats in the surface waters. This is true in the Gulf Stream of the Atlantic Ocean. There is much seaweed in this part of the surface water.

197
On the Dark Ocean Floor

As you travel across the top of the open ocean in a big ship, you may not stop to think of how the land looks far below you. But suppose that you could ride along the bottom of the ocean in a jeep.

Your jeep would have to go down steep, steep slopes into deep, dark valleys. These valleys are so deep that the highest mountains of the earth would sink out of sight if they could be placed down in them. We believe the deepest valleys to be about 7 miles deep.

Some of the time your jeep would travel across level plains. Some of the time it would have to go into low speed in order to reach the tops of great, tall mountains.

The highest mountains in the ocean stick up above it. We call them islands. Can you find some mountain islands on your world map? The Hawaiian Islands are really tops of mountains that stand in water. Cuba and Puerto Rico are also the tops of some great mountains that rise out of the waters of the oceans.

Yes, the land under the ocean has valleys, hills, mountains, and many flat plains, just as the land around the ocean has.

Imagine what it would be like to ride in a jeep through a deep ocean valley. Think of a place about 7 miles from the place where you are standing right now. Then imagine that you are riding in your jeep with as many miles of water as that above you.
Your jeep would have to have its headlights on as it traveled on the deep ocean floor. For even in the daytime it would be as dark as midnight. Sunlight shines through only the top 600 to 1000 feet or so of the water of the ocean.

There are no plants living on the floor of the deep, dark ocean. The plants of the ocean live in the top few hundred feet of water. Because plants need light in order to grow, they cannot live below this depth. Yet these dark valleys do have some living things in them. They are the homes of many strange-looking fish.

Some of these fish carry dimly glowing lights on their bodies. These lights are sometimes on feelers that rise above the heads of the fish. Sometimes they are in rows along the sides of their bodies. Aside from these dim lights there is not one speck of light at the bottom of the deepest parts of the ocean.

All these deep-sea animals have large, powerful jaws and teeth. They need them because they all eat only animal food. This is truly a place where animals eat each other up.
Mineral Riches of the Ocean

Animal, vegetable, mineral. These three words are used when you play the game called Twenty Questions. It is now no secret to you that the waters of the ocean are full of plants and animals. But you may never have thought of the minerals that are there, too.

Many metals and minerals are found in ocean water. You may wonder how they came to be in the ocean. The swift waters of small streams and large rivers dissolved them as it passed over the places where the rocks and minerals were.

To be sure, they were not dissolved quite as a lump of sugar or a teaspoonful of salt dissolves. It takes a long, long time to dissolve even a little bit of metal or mineral. Little by little, year after year, running water has dissolved minerals and metals over which it flowed.

These bits of minerals and metals are so tiny that we cannot see them as we look at water. Your mother sometimes knows they are there. Ask her to show you the inside of her teakettle. Is there a coating of something on the bottom?

This coating may be a mineral called lime. If you shake the empty kettle, pieces of the coating will break loose. The mineral was dissolved in all the water that your mother had put into the kettle. As the water boiled, the mineral was left.
Salt is one of the minerals found in ocean water. You can get it out by evaporating some of the water in shallow pans. Small bits of salt are left in the pans after the water has evaporated. If you live near the ocean, try this and see.

There are factories where salt is removed from salt water. On the shores of Great Salt Lake in Utah you can see such factories. Here salt water is being changed to fresh water.

Scientists are at work trying to find better ways of removing salt from water. This work is very important because not only is the salt useful to us, but the fresh water may be of great value. When better ways are found of changing salt water to fresh, the water of oceans and salty seas can then be used for irrigation. Lands that are now too dry to be farmed may be made to grow crops.

Have you ever heard your dad talk about magnesium? It is one of the metals that is used in making airplanes. It is strong and light in weight. Much of the magnesium that is used to make airplanes is taken from sea water.

The muddy ooze at the bottom of the ocean holds tons and tons of useful minerals. Perhaps it won’t be too long before scientists find ways that are practical for getting them out.
Life in Ponds and Lakes

Now we are going to take a look at the world of life in fresh-water ponds and lakes. This world of life is quite different from the salt-water life that you have just been reading about.

Around the outer rim of many ponds and lakes you may see cattails growing. Some of them grow right out in the shallow water. Their roots reach down into the muddy bottom. Their tall, brown spikes stretch up into the sunshine above the water. They look for all the world like an army standing, ready to march off.

Here, too, are some of the other plants you see in the picture below: reeds and bulrushes and marsh grass. Some of these plants have lovely purple, white, or yellow flowers on them.

All these water plants might be called waders because they seem to wade in the water. Parts of each plant stand high above the surface of the water.

A little farther out from shore are the plants that might be called floaters. Their roots are in the mud at the bottom of the pond. Their leaves and flowers float on the water. Water lilies are floating plants. At the ends of their long stems are flowers and large, flat, green leaves. These float on the surface of the water.
Other floating plants are found in the fresh water of ponds and lakes. The roots of these plants too are in the mud at the bottom of the pond. Their broad leaves and lovely flowers float on top of the water.

A little farther out from shore are the plants that grow under the water. You may have seen some of these plants if you have gone out in a rowboat. Their tall stems and leaves move back and forth just under the surface of the water. Fish lie near such plants, for these are good hiding places for them.

Sometimes there is a green scum on top of the water. This is like the scum that may form in your school aquarium at times. It is really fresh-water plankton. Many water animals feed upon it.

Perhaps you have noticed many dragonflies flying around you as you have stood near the shores of a pond or lake. These shores are their homes. In their younger days the dragonflies are called nymphs. The nymphs do not look much like the grown-up dragonflies.

Dragonfly nymphs live in waters of ponds or lakes. They have mouths which open quickly to scoop up whatever food they find in the water. When they become grown-up dragonflies, they live along the shores nearby.

Some of the other insects you will find in the pond have long legs and stride, or walk, over the top of the water without falling in. That is a stunt you cannot do! But water-striders can do just that.

One water creature hangs bottom side up on the top of the water. Have you ever seen this funny sight? Look for these upside-down insects next time you go to a pond. They are called back swimmers.
“Croak, croak, croak!” Yes, that’s a big bullfrog over among the lily pads, calling to its mate.

“Peep, peep, peep!” Yes, that’s the shy little peeper, or tree toad, calling to its mate. My, what a chorus! It’s spring at the pond.

Soon frogs and toads will be laying thousands of eggs in the water. The eggs float in a jellylike mass. After several days small, funny-looking animals with large heads and little tails eat their way out of the jelly. These are tadpoles. They will grow and become toads or frogs.

If you look closely, you may see turtles sunning themselves on a log. Turtles live both on land and in water. They lay their eggs on land. As the young turtles hatch, they go to the water and find tadpoles and snails to eat.

There are fish in many fresh-water ponds and lakes. Sunfish, yellow perch, and other fish hide under the water-lily pads. Have you ever caught any?

You may also have seen muskrats and minks swimming about in fresh-water ponds. Muskrats build their houses of sticks, stems, and roots of water plants. These houses stick up out of marshy places like little, round-topped wigwams. They are about five feet high. Inside is a little room with a dry floor above the water level.
Life in Streams

The water in streams flows along from mountains and hills to the sea. Sometimes it moves swiftly. Sometimes it moves slowly. Sometimes it flows over rocky places. And sometimes it flows over sandy places.

The same kinds of plants that we found in ponds are found along the banks of slow-flowing streams, too. They cannot grow out in the swift water.

We find in swift-flowing streams many of the same kinds of fish that live in fresh-water lakes. At the mouth of these streams, where the water flows more slowly, we are likely to find a goodly number of them.
Many people like to fish. It is really a very pleasant way to have fun. Your whole family can pack a lunch and go off together for a day in the open air and sunshine.

Places to catch fish are not as easy to reach as they once were. You may have to go farther and farther away from home in order to find a good fishing place.

The streams nearby may be almost fished out. That is to say, there may not be many fish left in those streams. Is this the case where you live?

Do you ever hear older people say, "Fishing is no good around here any more"?

Many things may have happened. Perhaps the water in these streams has become polluted. But other things may have happened, too.

Some people are careless when they fish. They catch more fish than they can eat. Yet they keep right on fishing and fishing.

Others are careless about the size of the fish they keep. Instead of carefully putting small fish back, they keep all they catch.
It doesn’t take long for careless fishermen to spoil a stream for fishing. Pretty soon fishermen say, “There are no fish in this stream.”

Have you ever heard of fishing laws? They are made to keep careless fishermen from spoiling a stream for fishing.

Each state and province has its own fishing laws. These laws tell you when you may fish for certain kinds of fish. They tell you how large your fish must be. They also tell you the number of fish you may catch in any one day.

These laws are made to help to keep fishing good for everyone who likes this sport.

Here is another way that fishing is being improved: Fish hatcheries are stocking streams with young fish. Stocking streams with fish means putting small fish into the waters where they may grow bigger.

These hatcheries raise thousands and thousands of young fish. When the fish are large enough, they are carried to lakes and streams and carefully let go.

Some of the streams that were spoiled for fishing are now becoming good fishing streams again. They are being stocked with young fish from hatcheries. Hatcheries keep raising fish and putting them into streams each year.
Rivers Are Roadways

The large rivers often seem to be roadways that many deep-sea fish use when migrating. At certain times of the year eels are found in many, many rivers.

Eels live in fresh-water ponds and lakes for six or seven years. Then they swim down the rivers and out to sea.

Salmon also use many rivers as roadways. Millions of shiny salmon live and grow up in the ocean. When they are full grown, they begin the long and dangerous trip upstream.

Salmon swim against swift currents, leaping dangerous rapids and waterfalls. Many of them die on the way upstream.

Salmon fisheries are built at the mouths of many big rivers. As the salmon migrate upstream, millions and millions of them are caught and canned for us to eat.

These salmon fisheries are the most important of all river fisheries. Each year the value of this industry alone runs into millions of dollars.

The next time you go to the store for your mother, look for the shelf where cans of salmon are kept. Read the labels, and you may find out where some of the salmon fisheries are located.

When you stop to think about the waters of the earth, do you now know how very important they are to all living things?
SOME THINGS TO THINK ABOUT AND DO

1. Is there a place nearby that you can visit to see the plants and animals that live in water? You may see many more of them than you have read about here. The waters of the earth are the homes of so many interesting and different kinds of living things. Talk about some of the ones you have seen.

2. You will want to help keep the water in ponds and streams and lakes free from anything that would kill the plants and animals that live in them. What can you and your classmates do to help?

3. Try to find out if anything is being done in your community to help people take pride in keeping streams or lakes or the ocean free from pollution. Are there any sewage-disposal plants being planned or built? What else can be done to make your community a better and safer place in which to live? What can you do to help?

4. What interesting shapes these shells have! Some shells have two parts. Others have only one part. What beautiful colors they are, too! No two of them are alike in size or shape or color. Each of these shells once had a living sea animal inside it.
Studying Rocks and Minerals
Where Are Rocks and Minerals?

Do you live where you see many rocks and minerals? Minerals are the materials which make up rocks. As you walk to school, you may kick rocks with your feet. At the beach you may pick up flat rocks and skip them over the water. As you climb a mountain, you may wonder at the strange rock shapes you see.

Have you ever looked down into a canyon dug out by a swift-flowing river? There you often see beautiful colors in the rocks along the steep banks. Or perhaps you have gone down inside an underground cave. There you may have seen rocks that hung like icicles from the roof of the cave.

Rocks and minerals are so common in many places that you may not think much about them. But rocks and minerals are very important in our lives.
Learning about Minerals

There are many kinds of minerals. Some are very common, and others are quite rare. Minerals are formed inside the earth. They are formed as hot materials inside the earth cool.

You might compare these hot materials with the cooky batter which your mother makes in your kitchen. If she wants to make white, sugar cookies, she uses certain materials. If she wants to make brown, chocolate cookies, she uses other materials.

The hot materials inside the earth differ in different places. Some materials form one kind of mineral. Other materials form another kind. That is why there are many kinds of minerals on our earth.

You can make some mineral crystals this way: Fill a cup about half full of boiling water. Add several spoonfuls of rock salt to it. The salt will dissolve in the water. After it cools a little, pour it into a glass. Now hang a piece of string above the glass so that the end of the string falls into the water.

Do not move the string for about three weeks. At the end of that time you will find that crystals of salt have formed on it. You have made mineral crystals. Salt crystals, like the ones you have just made, form inside the earth in many places. Your mother uses some of these crystals to season your food.
Most minerals are made up of crystals. These crystals are of different sizes. They have different shapes too. Each kind of mineral has a crystal shape of its own.

Salt crystals are usually boxlike in shape. Some minerals form crystals that have six sides. Others form crystals with eight sides. Other minerals have other shapes.

Sometimes minerals have large crystals. Sometimes they have small ones. When materials which contain minerals cool quickly, the mineral crystals are small. When the materials cool more slowly, the mineral crystals that form are somewhat larger.

You may wish to try making large and small crystals. You can do it in this way: Dissolve a tablespoonful of salt in about a half cup of boiling water. Put some of your salt water in a shallow dish and let it cool very slowly in a warm place. Put the rest of your salt water in another dish. Set it in a cool place.

Leave the dishes alone for several days. Crystals will form as the water evaporates. Are the mineral crystals that formed in one dish a little larger than those that formed in the other dish? Did larger crystals form in the dish that you put in a warm place?
Mineral crystals inside the earth form in much the same way. Larger mineral crystals form when the materials that contain minerals are cooled slowly. Smaller mineral crystals form when the materials that contain the minerals are cooled quickly.

Sometimes the materials cool so quickly that crystals do not form at all. This sometimes happens when lava from a volcano cools very, very quickly.

Some minerals are harder than others. We sometimes say that a mineral is soft. But this does not mean that it is soft like cotton or mashed potatoes. Soft minerals are not as soft as that.

Have you ever tried to scratch a mineral with your fingernail? Minerals that can be scratched with your fingernail are called soft minerals.

The lead in your pencil is a mineral. See if you can make a scratch on it with your fingernail. Now try scratching a piece of blackboard chalk. It is a soft mineral, too. Can you scratch it with your fingernail?
Some minerals are too hard to be scratched with your fingernail, but they can be scratched with a penny. Others are so hard that they cannot be scratched with a penny, but they can be scratched with a knife blade. Still other minerals are so hard that they will make a scratch on a piece of glass.

A diamond is a mineral. It is the hardest mineral we know. It is one of the minerals that will make a scratch on a piece of glass.

Minerals may be almost any color. Some are pink. Others are gray. Some are black. Others are purple or red or green. Still others are blue. People who study minerals use color as one way of telling one mineral from another.

Can you find most of the colors mentioned here in the minerals near the place where you live? Perhaps you never thought of minerals as having so many colors.

Yes, minerals differ in many ways. They differ in size and shape of crystals. They differ in hardness. Some minerals are hard. Some minerals are soft. They differ in color too.
Some Common Minerals

Some minerals are found in many places. These are the common minerals. You can see these minerals in Canada. You can see them in Colorado. You can see them in Mexico. You can see these common minerals in other places on our earth.

Feldspar is the name of a very common group of minerals. You will be almost sure to find some around where you live. Feldspar is found in many, many rocks.

One thing that helps us to know feldspar is the way it breaks when hammered. The picture above on the left shows that it breaks into very thin, flat pieces. When you look at the surfaces of these pieces, you see that they are pearly.

Feldspar is a hard mineral. You could not scratch it with your fingernail. You could not scratch it with a penny.

You may want to try scratching feldspar with a piece of glass. Most feldspars are too hard to be scratched by a knife, but they can be scratched by a piece of glass.

Feldspar may be of different colors. The most common kinds are pink, white, gray, and yellow. One kind of feldspar is green. But green feldspar is found in only a few places.

Quartz is the name of another kind of common mineral. You have probably seen it also. It is found in many, many rocks.

Sand is usually made of quartz crystals. When you walk barefoot in the sand at the beach, you are really walking in quartz crystals. The sand you made mud pies with when you were smaller probably had quartz crystals in it, too. Does this help you to know how common quartz is?
Quartz crystals may be of different colors. Many of them are clear, like glass. Some quartz crystals are rose-colored. Still others may be smoky or milky. One kind of quartz is purple. It is used in jewelry. Purple quartz is called amethyst. Have you ever seen any jewelry with amethyst in it?

Quartz is one of the hard minerals. It is hard enough to make a scratch on a piece of glass.

Mica is another common mineral. It is found in many, many places. You may sometimes see it in rocks around you. It often sparkles in the bright sunlight.

Mica is a soft mineral. Usually you cannot scratch it with your fingernail, but you can always scratch it with a penny. You can sometimes separate layers of micas with your fingernail. You can peel off layer after layer if the piece of mica is big enough.

One layer of mica is thin enough to see through. It may look almost as clear as a piece of glass. Sometimes mica is not so clear as that. It may be black mica.

You may have seen pieces of mica in the door of a coal stove. The little windows in the door are made of mica. You can look through these little windows of mica and see the fire burning brightly inside the stove.
From Plants to Coal

Coal is a mineral. Do you know the story of how it was made? The story goes something like this: Long, long ago great, hot, wet jungles like the one you see here covered some parts of the earth. Giant ferns, tall trees, and other plants grew in these jungles. These giant plants died and fell into the swamps, where they were buried deep in the mud. Here they stayed for a long, long time.
As time went on, more plants grew tall and died and fell into the mud. Layer upon layer of plants piled up in the muddy ooze of the swamps. The top layers of dying plants pressed on the layers below them. The ferns, trees, and other plants were squeezed together and cemented by the mud.

What was once living material was now being made into the hard, rocklike material which we call coal. Perhaps you have seen pieces of coal which have prints of fern leaves in them. These prints are called fossils. They are pictures of leaves that grew on the trees which were buried in the coal-making swamps.

Sometimes pictures of sea shells are found in coal, too. These fossils show that salt-water animals were once trapped in the muddy places where coal finally formed. The places where these swamps formed were once part of the ocean bottom.

This story of how coal was made may seem strange to you. Plants that once lived on our earth now heat some of our homes. They run some of our ships at sea, too. Yes, once-living plants made the rocklike coal we use today.
Learning about Rocks

Rocks make up the solid part of the earth. They are mixtures of minerals. One piece of rock may have quite a few kinds of minerals in it. Or it may have only one or two minerals in it.

Look at a piece of rock. See if you can find different kinds of minerals in it. The different colors in the rock may help you to know that it has different kinds of minerals in it.

Rocks may be formed in at least three different ways. Some of the rocks near your schoolhouse were probably formed in each of these three ways. Let’s find out about the three main groups of rocks.

220
Finding Out about Fire-made Rocks

The rocks of the first group that we shall read about have all been made by heat. They were heated deep inside our big, round earth.

Rocks made in this way are called igneous rocks. We call them igneous or fire-made rocks because they are really made by heat.

The materials in this kind of rock were once hot and liquid, or molten. They were in huge basins, or pools, inside our earth. Quartz, feldspar, and mica were some of the minerals in the mixture. There were other minerals in this liquid, too. This hot liquid mixture is called magma.
The heat inside the earth may come from many sources. One of these may be the great pressure and weight of the solid materials of the earth. They are packed and pressed so tight that heat may result.

Another source of heat may be that certain minerals act upon one another and make heat. There may be other sources of heat, too.

At any rate, the inside of the earth is very hot. It is so hot in many places that solid rock melts and becomes magma.

The magma moves upward toward the surface of the earth. Some magma reaches the surface of the earth when volcanoes erupt. Just why magma moves upward no one really knows.
Some people who have studied this problem believe that the molten mass may melt the rocks above it. Also, we know that there are gases and steam inside the earth. These come out as a volcano erupts. Some people believe that these gases and steam can press hard enough on the rock layers to cause them to give way. This also would make room for the molten mass to move upward.

Really only a little of the great molten masses of rock ever reaches the surface. Much of it flows beneath the surface of the earth, upwards and sideways, and is pressed into cracks between solid layers of rock. Here it cools and hardens and becomes rock.
Granite forms only when magma cools very, very slowly. As magma cools, the minerals in it separate from one another and form crystals. The mixture of minerals which hardens into granite always has quartz and feldspar in it. It usually has two other minerals in it also.

As you look at a piece of granite, you usually think it looks speckled. It has different colors in it. The feldspar and quartz crystals in it may be pink or white or gray or green.

The magma that flows out of a volcano is called lava. It is liquid rock. As it cools, it becomes hard, fire-made rock.

The pictures on this page show you some kinds of fire-made rock. One piece looks like glass. Another piece has many little holes in it. It may make you think of the egg white on top of lemon pie. Both these kinds of rock were once lava, or liquid rock.

Granite is one of the most common igneous, or fire-made, rocks. It is always formed underground. None of it flows out of a volcano, as lava does.
Sometimes shiny crystals of mica are mixed in with the other minerals in granite. The black specks in granite may be crystals of black mica. Or they may be crystals of a black mineral called hornblende.

Granite is a hard rock. It is used for many purposes. Look around where you live and see if you can find granite being used.

Many bridges are made from granite rock. Are there any bridges in your neighborhood that are made of granite?

Often you will find monuments in parks and along roadsides. Some of these will probably be made of granite.

They may look different from the granite used in bridges. The granite used in monuments usually has been polished, so that it looks smooth and shiny.

Granite is used in many buildings too. Are there any buildings in your neighborhood that are made partly of granite? It is a useful rock because it is so hard.
Finding Out about Sedimentary Rocks

Most of the rocks in the second main group have been formed under water. Day after day brooks, streams, and rivers run along and finally empty into the oceans. Day after day the waters of these thousands of streams carry small bits of rock and soil into lakes, seas, and oceans.

Every time it rains, the streams get brown and dirty. Rain brings loose material from the fields to the streams. During rainy times streams carry much loose rock and soil down to the oceans.

As the streams empty into the lakes, seas, and oceans, they drop much of their load. The heavy pebbles and loose gravel drop first. They drop near the mouths of the rivers. Lighter material, sand and clay, is carried farther out before it is dropped.

Year after year and century after century soil and pebbles keep being carried out to sea. There they are dropped to the bottom.

These layers of material become heavier and heavier. The materials get packed and pressed together. Finally, after many, many centuries, they become so tightly packed that they are rocks.
Rocks formed in this way are called sedimentary rocks. They are made from material, or sediment, dropped on lake and ocean floors.

Most sedimentary rocks are formed under water. But some sedimentary rocks are formed in another way. Some are formed by the winds. The winds may carry bits of soil and sand about. Finally, they deposit them. These deposits may in time develop into sedimentary rocks.

You can do an experiment and see how some sedimentary rocks are formed. Put a handful of soil and pebbles into a glass jar half full of water. Screw the top on well. Then shake the jar. The water will become muddy.

Now set the jar on the table and watch to see what happens.

Does the heavy material settle first? How long does it take for the water to become clear again? Can you see layers of soil in the bottom of the jar?

Of course the layers of soil in your glass jar do not turn to rock. They are not packed hard enough for that. There is not enough pressure. But you can see how layers of loose material are laid down on the ocean floor.

You may wonder how the rock that was formed under water gets out from under it. How does it get into your schoolyard? How does it get into the park in the city? Some of it may be found on the tops of mountains. Some of this rock may be found in your flower garden if you have one. How did it get there?
Do you understand that mountaintops may at one time have been under water? Do you understand that your schoolyard may at one time have been under the sea? The very spot where your home now stands may once have been under water, too.

Land may move upward when earthquakes shake the earth. It may also move upward when volcanoes erupt. Other strong forces inside the earth may move the land upward, too.

Waters of lakes and seas may dry up also. The rock layers that were once below water are now on top of the ground.

Many, many places that are now dry were once covered by the waters of lakes, seas, or oceans. Do you suppose the place where you live was once under water at the bottom of the sea?

One kind of sedimentary rock is made mostly of sand grains. It is called sandstone. It may have been made from small bits of sand carried by water and finally dropped to the ocean floor.

It may also have been made by bits of sand carried about by winds and finally dropped in one place. The beautiful sandstone rocks of Zion Canyon in Utah were formed in this way.

Sandstones of many colors are found in many parts of the world. The Grand Canyon of the Colorado River is cut through layers of many-colored sandstones.

Shades of red, orange, yellow, blue, and purple make this great canyon one of the most beautiful sights you will ever see. The different colors come from different materials in the rock. Iron is one of these materials.
You can sometimes tell sandstone from other rocks by the way it feels. You can often feel the grains of sand. You can often break it into pieces by pressing it in your hands. It is a soft rock.

You remember that as streams flow into the sea, pebbles drop to the bottom of the sea first. They form coarse rock. You can see coarse rock called conglomerate in the picture at the right. You may find a piece of conglomerate rock sometime. It may have quite large pebbles cemented into it. You will know that it was formed under water.

Sediment that is very, very fine is carried farther out to sea before it is dropped. Clay and mud dropped to the ocean floor form a rock called shale.

You can tell shale when you see it because it looks like hardened clay and mud. It is always in layers. The layers in shale help you to know that it was made under the sea. Sometimes it is easy to split the layers of shale apart.

Look and see if there are any banks of shale near your home. Roads are often cut through hills. Sometimes when you drive through the hills, you can see shale banks on each side of the highway.
Limestone is another kind of sedimentary rock. One kind of limestone is formed from the shells and bones of sea animals. Shells of clams, snails, and other sea animals drop to the ocean floor. Down through the years millions of shells and bones of sea animals have piled up under the water.

Finally, the many, many layers of these shells and bones were packed and pressed tightly together. They became rock called limestone.

Another kind of limestone may be seen around hot springs and geysers. The water that shoots out of the ground has lime in it. The water falls to the ground and evaporates or runs away. Soft rock forms from the lime that was in the water. It is found all around the edges of geysers.

If you have been to Yellowstone National Park, you may have seen this soft limestone rock all around Old Faithful and other geysers and hot springs there.

Yes, limestone may form from bodies of sea animals. It may also form from lime that is in water.
Finding Out about Made-Over Rocks

You have been reading about two of the three ways in which rocks are formed. Now let's read about the third way.

You remember that igneous rock is rock made from magma, which formed inside the earth. Sometimes the magma flowed upward and sideways and was pressed between layers of rock around it. But sometimes there were no cracks into which the magma could flow. When this happened, the pressure became so great that the rocks themselves became changed.

Sometimes rocks were changed by pressure or heat. Other rocks may have been changed by water. Whole layers of rock were often folded and changed. We say the rocks were made over. Changed, or made-over, rocks are called metamorphic rocks. Look carefully at the picture on this page. Can you see that the rock layers have been folded?

You may want to know how some of the rocks you have been reading about change. Look at the pictures on the next page to find this out.
New Rocks from Old

- Granite changes to gneiss.

- Limestone changes to marble.

- Sandstone changes to quartzite.

- Shale changes to slate.
Minerals We Eat

This idea may seem funny to you. But every time you sit down to eat your supper or lunch or breakfast, you eat some kinds of foods that contain minerals. You have been reading about minerals in the earth. Certain substances in our food are called minerals, too.

We might almost say, “Please pass the iron,” when we ask for a second helping of lamb chops and potatoes. We might almost say, “We eat iron,” as we eat a handful of raisins. Liver, prunes, eggs, and lean meat are rich in iron, too.

Of course we do not eat a piece of iron when we eat these foods. What we really mean is that we eat food containing iron.

When we drink a glass of cold milk, we drink a liquid that has calcium in it. Calcium is needed for building good bones and teeth. When we eat a cheese sandwich for lunch, we are eating foods that contain minerals our bodies need.

Do you enjoy a nice piece of broiled fish with lots of butter on it? Fish and butter also contain minerals that the body needs.

The minerals in your food were part of the food that the plants and animals which you eat used. You eat the food and get the minerals. You need only a little of each of these minerals, but you cannot stay healthy without calcium, iron, and other minerals.
Minerals We Wear

Not only are minerals eaten by us, but some of them are worn. Much of our jewelry is made of metals and minerals.

We use gold, copper, and silver for rings, necklaces, pins, and earrings. Crystals of quartz, rubies, garnets, and diamonds are often set in one of these metals. This makes the crystals more beautiful.

People of all countries, and of ancient as well as modern times, have used jewelry.

The Indians of the southwestern part of the United States are well known for their handmade silver jewelry, set with beautiful, blue mineral crystals.

Diamonds and rubies are called precious stones because they are less common minerals. Others are called semi-precious stones because they are much more common. Garnets and purple quartz are semi-precious stones. They are found in many places.
1. Rocks take a long, long time to form. They help us to understand that our earth is old. It is old enough for rocks to have formed under the sea. It is old enough for hot liquid material inside our earth to have cooled and hardened. It is old enough for parts of the earth to have risen above the sea. It is even old enough for rocks that have formed inside our earth to have been heated and melted and hardened again. Yes, rocks help us to know that our earth is very old.

2. Look around in your neighborhood and think and talk about what your part of the earth may have been like long, long ago. Are there any mountains to talk about? Are there any swift rivers flowing toward the sea? Are there deep canyons that were made by swift-flowing streams?

3. There may be some place near your school where men are working on a road or starting a cellar hole for a new building. Can you go there several different times as the men dig deeper into the ground? Look carefully and talk about the different kinds of rocks that you see there. What do these rocks tell you about the earth where you live?

4. The minerals you eat help you to grow strong and healthy. The pictures below show you some foods that supply minerals to your body.

- Foods containing calcium
- Foods containing iron
- Foods containing iodine and salt
Using Materials Wisely
"Waste Not, Want Not"

The saying above is one that you have heard many times. It has to do with using materials wisely. It has to do with being sure to save some of our minerals and other materials for the people of tomorrow.

People all over the world have sometimes not been very careful about using materials wisely. They have wasted water by polluting it. Many plants and animals that live in water die when it becomes polluted. People have sometimes wasted good topsoil by poor ways of farming. They have sometimes wasted forests by cutting down many, many trees. Fires due to carelessness destroy many forests, too.

People have also wasted the treasures inside the earth. These materials include coal and iron. They include oil and natural gas too.
Using Water Wisely

Water is very important to all living things on earth. Perhaps you live in a place where it rains or snows often. There is no shortage of water where you live.

But how about the many places on this earth where there isn’t enough water? It rains only a little each year.

When you live in places where water is scarce, you know how important water really is. Plants do not grow well. Grass wilts. Animals have to be watered from deep wells. Water has to be pumped from these wells.

Some dry places in your country are now irrigated. Water is stored in large reservoirs behind great dams. Then the water is used when it is needed.
Sometimes a big ditch goes all along one end of a field that is to be watered. Smaller ditches run down between the rows of crops. Water is then pumped into the big ditch at the end of the field. Then the farmer opens the ends of the ditches between those rows that need water.

The ground gets well soaked, and water stands in the row ditches. Then the farmer closes the ends of the ditches. He often does this by simply pushing dirt into the end of each ditch.

Perhaps you have ridden along a road in the dry part of your country. All at once you came upon a great stretch of orchard. You looked for the irrigation ditches. You knew that these orchards could grow in such dry places only because water had been saved in reservoirs for them.

Yes, water is important. We must use it wisely. We must learn better ways to save it for later use.
Wasting the Wealth in Water

Perhaps we had better look at how well we are using the wealth of the waters of the earth. Are we taking care to use it wisely? Are we making sure that the waters of the earth will keep on being a mighty storehouse for food?

One way to find out about how wisely we are caring for our oceans, lakes, ponds, rivers, and brooks is to look around us in our own neighborhoods to see just what is happening there.

John lives near the ocean. He lives at the mouth of the Hudson River in New York City. The tides go in and out at the mouth of this great river and carry salt water far up the river.

John goes often to watch the boats in New York harbor. He likes to imagine himself as the captain of a busy tugboat pushing a great ocean liner into dock. He likes to make believe he is loading the hold of a boat with grain or ore.

Surely this harbor is a very busy place. But John sees some things which he does not like. The harbor is a dirty place. There are many wooden boxes, empty cans, bottles, boards, and other things floating in the harbor.

John doesn’t like the idea of throwing such things into the harbor. He believes that people should help to keep the water in the harbor clean.
John is right. All of us should help to keep the water in lakes, rivers, and oceans clean. First of all, it is healthier and pleasanter for all of us to have clean water to look at and swim in.

But clean water is needed most of all so that hundreds of fish and other animals can live in it.

You remember that the waters of our earth are a mighty storehouse for food. Much of this food cannot keep alive in dirty water. In fact, right now there is not nearly so much food in our lake and ocean storehouses as there once was. This is because of the way we have let the water get dirty.

Let's think a moment about John's harbor. Once New York harbor was rich in oyster beds. They reached up the Hudson River for miles. Oystermen lived along the shore and made a good living gathering oysters and selling them in nearby fish markets.

This is no longer true. The harbor has become dirty. We say the water of the harbor is polluted. The oyster beds became polluted, too. People who ate oysters from these beds became ill.

The New York City Health Department had to stop the oystermen from gathering oysters. They were no longer allowed to get oysters from the polluted beds. The beds themselves were raked and most of the oysters destroyed.
This made it hard for many oystermen. The men who used to make a living for their families by raking oysters out of the harbor and selling them now had to find other work to do.

But oysters are not the only animals that used to live in John’s harbor and are not there now.

Lobsters used to be caught in large numbers in New York harbor. Mackerel, by the millions, used to run up the Hudson River. Mackerel still run up the river, but not millions and millions of them. There are not nearly that many any more. The harbor is too polluted to suit mackerel. It is also too polluted for many other kinds of fish.

What has happened to New York harbor is serious. It will take a long time to correct matters. But New York is already at work on this job. It is building more sewage-disposal plants. John hopes that he will soon see a clean harbor when he goes to watch the boats.

This same thing has happened in many other harbors. Places once full of water animals now have fewer of them because the waters are polluted.

In some places sewage from towns and cities runs directly into streams. This, of course, pollutes all the water. Cities and towns that empty their waste materials into streams should be made to treat these materials to kill the germs which are harmful to most water plants and animals.

Only in this way can we hope to keep our streams and oceans clean enough for animals and plants to live in. Only then can the waters of the earth keep on being a mighty storehouse for food.
Coal Is a Hidden Treasure

Hidden away inside the earth is a great storehouse of treasures. They are treasures because they are so very useful to man. Our lives would be very different if no one had learned to use these treasures of minerals and other materials.

We think that it is a good thing that people learned to use the treasures which they found inside the earth. Take coal as an example. Using coal for fuel has made a great difference in our lives. Huge coal-burning furnaces do useful work.

Coal heats water to make steam to heat many homes, schools, and offices. Coal heats water to make steam to run machines which make electricity. It heats water to make steam to run locomotives.

Coal can also be made to give up the gas that is stored in it. Your mother may use this gas to cook your supper. Much of the hard coal which is mined is used to make the gas used for cooking. Does your mother cook with gas?
Did you ever hear of coal tar? It is a black, sticky liquid which comes from coal. It is used to make many useful things. The pictures on this page show you some of the products made from coal tar.

No one knows just how much coal there is left inside the earth. At one time there seemed to be enough to last for a long, long time. There is still a great deal of coal inside the earth. Also, coal is still being formed, ever so slowly, in some places on the earth. It is forming slowly in the great swamps of North Carolina and Virginia.

In these places there is a layer of peat several feet thick. If we leave it alone and do not use it, after a long, long time it will become coal.

We are in no danger of running out of coal tomorrow or next month or next year. Men who have studied our coal supplies believe there is enough coal to last thousands of years. Perhaps there is enough to last much longer.

Since we know that it takes so very, very long for coal to form, however, we need to use every bit of it wisely.

It is important to learn how to run our coal furnaces so that no fuel is wasted. We often burn more coal than is needed to keep our homes warm. When we do, we waste coal, which may be greatly needed elsewhere.
Oil Is a Hidden Treasure

Sometimes we forget how important the oil is that comes out of the ground. Yet here, again, our lives are very different because of it.

Let’s call this thick, black liquid by its right name. It is petroleum. As it comes from the ground, it is called crude oil.

You may have traveled to places where there were great derricks like the ones you see in the picture. There are many of these places scattered all over North America.

All day long the black liquid is pumped out of the ground. What a lot there is!

Yes, but we are not sure whether petroleum is still being made, deep down in the earth. When we use all that is now underground, we may have to do without petroleum altogether.
No one knows just how the oil that is stored inside the earth got there. We know that oil is found only where seas once were.

Men who have studied this subject think that oil came from the plants and animals which once lived in those seas. We know that this black oil lies trapped beneath the surface of the earth in many, many places.

Oil from the great oil fields is brought to the top of the ground and sent to refineries, where it is made into many products. Some of it is sent in huge pipelines for hundreds of miles to refineries far away. The Big Inch pipeline is thousands of miles long. It reaches from Texas to New York.

Do you know how many different products are made from petroleum? There are many. As petroleum is heated, these products are separated from the crude oil.

One product is bottled gas, which you may use on your farm or at your cottage. It is a part of crude oil. It changes from a liquid to a gas when the crude oil is heated. It is then stored in large metal bottles. Your mother may use it for cooking.

The next time you drive through the country, keep looking for bottled gas outside of farmhouses. Then think that this gas was once part of the crude oil that formed down inside the ground.

Does your mother ever send suits and coats to the cleaners? Have you smelled them just after they were returned? There is often an odor somewhat like the odor of gasoline. The odor is naphtha. Naphtha is good for cleaning clothes. It, too, was separated from crude oil.
Your mother may use a cleaning fluid at home. She may clean some of her dresses and your father’s suits at home. The cleaning fluids she uses are products of petroleum. Some of them explode easily; so they must be used very carefully.

Perhaps you live where kerosene lamps are used. Kerosene is separated from petroleum, too. Is kerosene used in your part of the country either for fuel or for lamps? Some of you may live in a house that is heated by oil. If you do, you often see a big oil truck drive up. The driver unwinds a rubber hose and fills your oil tank. We call this product of petroleum fuel oil. Instead of heating your house with a coal furnace, you use an oil-burner.

Fuel oil also runs many locomotives and ships. These locomotives and ships have diesel engines in them. Fuel oil runs these engines.

Many different kinds of oil come from petroleum. What do you do when your wagon wheels squeak? Do you get out an oilcan and oil them? Mother oils her sewing machine, and Father gets the family car oiled and greased.

Every piece of machinery that has metal parts that move has to be oiled. Tractors, refrigerators, airplanes, motorboats, busses, and sewing machines all need oil.

Now can you see why our lives are different because of petroleum?
You may live where roads are made of asphalt. When it rains, these roads are slippery. Your father has to drive very carefully on these roads. Some of the asphalt used to build roads is made from petroleum.

The shingles on your schoolhouse may be asphalt shingles. Look and see if they are.

Gasoline is perhaps the most important of all petroleum products. Every hour thousands of gallons of gasoline are being used to run engines doing all sorts of work. Each year more and more gasoline is needed. Do we have enough to last forever?

No one can answer that question and be sure he is right. No one really knows for sure just how petroleum is formed. We are not sure it is being formed today.

At any rate, people who have studied this problem believe that petroleum is being used faster than it is being formed. If this is true, we must use what we have with great care.

We have been using petroleum for only about one hundred years. During that time much has been wasted that might have been saved.

In the past, fires at the oil fields have destroyed millions of gallons of oil and gasoline. Today, however, safety devices prevent most oil-well fires.
Natural Gas Is a Hidden Treasure

Natural gas is usually stored under the ground in the same places that petroleum is stored. However, this is not always the case. Natural gas may be found in places where there is no petroleum.

When oil wells are drilled, very often natural gas is found, too. This natural gas collects in spaces above the oil pools. It is under great pressure. The oil is forced up the pipes by the pressure of the gas above it. The oil flows into pipelines, which carry it to many places.

Natural gas from these wells is piped for miles and miles. Your family may use it to heat your home or to cook your food.

Natural gas is a cheap fuel. It is a clean fuel too. We use a great deal of it. How long will the supply last? We do not know! There may be enough to last a long, long time. Men keep finding more of it as they keep on drilling for oil.

Some men who have studied this problem think that we are not finding as much gas as we once did. Let's use it wisely so that it will last a long, long while. Natural gas is such a useful fuel that we cannot afford to waste it.
Are We Using the Metals of Our Earth Wisely?

Many hundreds of years ago men made a very important discovery. They learned to obtain metals from the ground. Rock, sand, or dirt from which metal is obtained is called ore.

Copper was one of the earliest metals discovered. It changed early man's way of living a great deal. Now tools and weapons could be made of strong copper instead of wood or stone. These copper tools and weapons were better. Man moved ahead in his ways of living.

Today copper, iron, aluminum, and magnesium are some of our very important metals. We use them in making many things. We cannot even imagine all the ways in which metals have changed our manner of living. There are so many ways.

Iron is a useful metal in itself, and it is even more useful because steel is made from it. Strong frames for skyscrapers are made of steel. Long steel bridges stretch across big rivers. Part of your car is made of steel. The nails, screws, and bolts that hold many things together are made of either iron or steel. Farm tools and machines have iron and steel in them, too.

Many cooking dishes are made of iron or steel. What about your pancake griddle? What about your frying pan? Are they made of iron? Perhaps they are made of aluminum or of copper.
Copper is used in many ways today. The pipes in your house may be copper pipes. Copper does not rust easily when water gets near it. The boiler for heating your water may be copper.

Electric wires may be copper. Kettles and tanks of many kinds are made of copper. It is used in hundreds of ways.

Aluminum is also a very useful metal. It is light in weight, but very, very strong. That is why airplane factories make so much use of aluminum. An iron airplane would be much too heavy to fly.

Aluminum does not rust easily. It is often used instead of iron for water pipes. Aluminum wire is sometimes used in electric circuits instead of copper wire. Aluminum is a good conductor of electricity.

Magnesium is a very strong and light metal. Much of what we have is taken from sea water. It has many uses.

Many airplanes now are made of magnesium instead of aluminum. Your camera flash bulb, which you use to take a picture, burns magnesium. Flares dropped from airplanes burn magnesium because it gives such a brilliant flash of light, which may be seen for miles.

Tin is another metal that man uses in many ways. It is really a rare metal, not found in many places in the earth. Much food is stored in tin cans. These cans are really made of iron. But they are covered with a thin coating of tin. The tin keeps the iron from rusting and in that way helps to preserve the canned food.
How well have we used these important metals? Surely we cannot afford to waste them.

But do we? Is it a waste of iron and steel to pile car after car in junk heaps and let them rust? Is it a waste of metal to throw can after can away with the rubbish? Could we use these metals again?

The answer is yes. Tin and scrap iron can be melted and used again. They should be saved and put to good use.

Unless we do save scrap iron and use it over again, we may someday run out of iron. Then where shall we be? How then shall we build new ships and bridges and cars and skyscrapers?

Using metal wisely is worth thinking about. Save some of it for tomorrow!

You may be one of those people who say, “Why worry? Someone will come along and invent a new way to make cars and bridges and skyscrapers.”

That may be true. We now have nylon, which is used to make many things once made of silk. We now have synthetic rubber, which is used to make many objects once made of real rubber. Plastics have replaced many products. And these plastic products are excellent.

But as yet we have no good ways to replace strong steel in buildings. We have as yet no plastic to replace aluminum and magnesium in airplanes. We have no plastic to replace many useful metals.

Someday we may have such substitutes. Perhaps within the next few years we may. But until then it would seem to be good sense to use wisely the metals we have. Be sure you help.
THINGS TO THINK ABOUT AND DO

1. Perhaps you think you can do nothing about using materials wisely. Perhaps you think grownups are the only people who have to think about such things.

   But wait a minute! How about wasting food? When you waste food, don’t you really waste minerals? It was the minerals in soil that made your food grow.

   What about wasting paper? When you waste it, aren’t you also wasting minerals? Minerals in the soil were used to grow the trees that make some of the paper you use.

   What about leaving your metal wagon, skates, or bicycle out night after night? Do they rust? Rust will soon ruin things that are made of metal. Many of your toys are made of iron. You can make them last longer by taking good care of them. Keep them dry, and they will not rust so quickly.

   What about burning leaves? When you do that, aren’t you wasting minerals? The materials in leaves should be put back into the soil to keep it good.

   When you leave the garden hose running longer than you need to, aren’t you wasting materials? You are wasting the minerals that are in water. Some of these minerals run off down the gutter as the water is wasted. Using materials wisely is the business of grownups. But it is your business, too.

2. Do you live near a place where any minerals are made into products that you use every day? If so, perhaps you could visit this place and find out how these products are made.
3. You may wish to share your interest in using materials wisely. You may wish to have an assembly program and tell others in your school about some of the ways everyone can help in this matter. Be sure to tell them that they can help by using paper, food, and water wisely.

4. You are living in a very interesting time. Think of the things that are happening today. New plastics are being made to take the place of products that were once made of metals. Better ways of mining are being used all the time. Someday we may get many more minerals from the ocean.

Scientists are finding better and better methods of working with many materials. Doctors are learning how to use many minerals to keep you well. Dentists are using minerals to keep your teeth in good condition. Can you think of any inventions and discoveries that may come soon?

5. The story of how coal was formed is an interesting one. Perhaps someone in your class would like to give a report about it.

6. You might like to find out all you can about minerals in the sea. Try to find out as much as you can about how scientists are working to get these materials. Read about some of the reasons why it is so difficult to recover the minerals that are in the sea.
Science Words

This part of your book is a science dictionary. It will help you find the meanings of words which are used in your book. The page number following each word shows you on what page the word is first found.

ab'do men. The third section of an insect’s body. The first two sections are the head and thorax (p. 149).

air. A mixture of gases that we breathe. We live at the bottom of an ocean of air (p. 13).

air pres’sure. The weight with which air presses upon things. Air presses upon everything on the earth, including people (p. 92).

a moe’ba. A tiny, one-celled animal. One of the simplest forms of animal life (p. 146).

am phib’i an. An animal that lives the early part of its life in water and breathes with gills. Later it develops lungs (p. 156).

an’nu al. A plant that lives only one year (p. 45).

a qua’ri um. A tank or bowl of water in which living plants and animals are kept (p. 60).

as’phalt. A brownish-colored material produced from petroleum and also from coal tar (p. 244).

at’mos phere. The layer of gases around the land-and-water part of the earth (p. 78).

bi en’ni al. A plant that lives two years (p. 46).

birds. A group of animals that are covered with feathers (p. 21).

bud. A part of a plant which can develop into flowers, leaves, stems, or roots (p. 42).


cac’tus. A plant that grows in hot, dry desert places (p. 52).

cal’ci um. A mineral that builds strong bones and bodies (p. 233).

car’bon. A material that is part of living or dead plants and animals. Coal is mostly carbon (p. 167).

car’bon di ox’ide. One of the gases found in air (p. 103).

cas’es. Hard coverings of some plants and animals. Moths and butterflies make cases around themselves. They change inside these cases. Spores develop inside cases, too (p. 140).

cen’tu ry. One hundred years (p. 226).

chem’i cal. All material is made up of chemicals. Air, food, and rocks are mixtures of chemicals (p. 167).

cir’cuit. A path along which electricity can travel (p. 168).

cold-blood’ed an’i mal. An animal whose blood is about the same tem-
perature as the air or water around it (p. 154).
conduc'tor. Any material through which vibrations or electricity pass easily (p. 123).
conglom'er ated. A rock made up of pebbles cemented together (p. 229).
constant-tem'per a tured an'i mal. A warm-blooded animal is a constant-temperatured animal (p. 159).
coral. A small sea animal which builds a hard skeleton around its soft body (p. 186).
cur'rent. A flowing, or moving forward. An electric current flows through wire (p. 101).
cut'ting. A part cut from a plant. Roots and leaves will grow from a cutting (p. 138).

des'ert. Any part of the earth where there is not enough water for many plants to grow well (p. 52).
dis solve'. To become part of a liquid. Sugar dissolves in water (p. 212).
dry cell. Chemicals in a sealed container which will produce electricity (p. 166).

ear'drum. A thin membrane that stretches across the middle ear. This membrane makes hearing possible (p. 111).
earth'quake. Trembling, or shaking, of the ground caused by movements of the rocks near the surface of the earth (p. 83).
lec tri'c i ty. A form of energy. Electricity can do work (p. 164).
lec tro mag'net. A magnet made by winding insulated wire around a piece of soft iron. The soft iron becomes a magnet when electricity goes through the wire (p. 176).
equa'tor. An imaginary line around the earth halfway between the north and south poles (p. 7).
erupt'. To burst forth. A volcano and a geyser erupt (p. 81).
vap'o rate. To change into a gas. Water evaporates into the air (p. 52).
ex pand'. To get larger (p. 94).
ex per'i ment. A trial made to prove or disprove something (p. 9).
eyes. Buds on a white potato. New plants grow from these buds (p. 137).

feel'ers. The organs of touch of some animals. Feelers of insects stick out from their heads (p. 150).
feld'spar. A common mineral (p. 216).
fer'ti liz er. Material that is put on soil to improve it (p. 38).
fish hatch'er y. A place where fish eggs are hatched and fish are grown until they are large enough for use in stocking streams (p. 207).
flow'er. The part of a plant from which seeds form (p. 41).
force. A push or pull that tends to start objects moving (p. 92).
fruit. A seed and the materials that grow around it (p. 43).

gas. A material that does not fill a
definite space. Air is a mixture of gases (p. 80).
gill. A part of some water animals. By means of gills oxygen is taken from the water (p. 153).
graft'ing. Putting a slip, or cutting, of one plant into a cut on the stem of another plant (p. 139).
gran'ite. A common rock that has been formed by heat. It usually has feldspar, quartz, and mica in it (p. 224).
hi'ber nate. To appear to sleep during the cold weather. Animals become quiet when they hibernate (p. 22).
horn'blende. A dark-colored mineral. Hornblende is often found in granite (p. 224).
ig'ne ous rock. Fire-made rock (p. 221).
in'sect. An animal with three body parts and six legs (p. 21).
in'su la tor. A material through which electricity will not pass easily (p. 173).
ir'ri ga tion. Watering the land (p. 37).
lime'stone. One kind of sedimentary rock. It is made from shells and bones of animals or from lime in water (p. 189).
liq'uid. A material that has no definite shape. Milk, water, and gasoline are liquids (p. 125).
lung. The part of people and of many animals that takes oxygen from the air as they breathe (p. 103).
mag'na. Liquid, or molten, rock under the surface of the ground (p. 82).
mag ne'si um. A silver-white, very lightweight metal (p. 201).
mag'net. A piece of iron or steel or other material that attracts other pieces of iron or steel (p. 176).
mam'mal. A warm-blooded animal that has a backbone and hair or fur. A mother mammal feeds its young with milk from its own body (p. 160).
mem'brane. A thin sheet of skinlike tissue. The eardrum is a membrane (p. 111).
met'al. A mineral that is a conductor of electricity. Aluminum, iron, and copper are metals (p. 121).
met a mor'phic rock. Made-over, or changed, rock. Marble and gneiss are metamorphic rocks (p. 231).
mic'ca. One of the minerals often found in granite. It is a shiny mineral (p. 217).
mi'cro scope. An instrument that makes any small object look bigger (p. 140).
mig'rate. To travel at regular times from one place to another and back again (p. 25).
mil'dew. A small plant that grows from spores. Mildew may grow on damp clothes (p. 141).
min'er al. Almost any material in the earth. Quartz and feldspar are minerals. Some minerals are dissolved in water (p. 200).
mold. A tiny plant that may grow on old or damp plant and animal material. Mold sometimes grows on stale bread (p. 141).
mol'ten. Melted by heat. Rocks can be heated to a molten, or liquid, state (p. 221).
naph'tha. A product of petroleum often used in cleaning (p. 246).

oil re fin'er y. A place where many products are made from crude oil (p. 246).

ooze. The material on the floor of the deep ocean. It is made of remains of plants and animals, pebbles and volcanic ash (p. 189).

ox'y gen. A colorless gas that makes up part of the air (p. 88).

per en'ni al. A plant that lives more than two years. Trees are perennials (p. 44).

pe tro'le um. A thick, dark-colored liquid that forms inside the earth (p. 245).

pitch. The highness or lowness of a sound. It is caused by the vibration of an object (p. 113).

plank'ton. The tiny, living plants and animals that float on or near the surface of water. Many water animals feed on plankton (p. 187).

plas'tics. Man-made materials that can easily be made into different forms. Nylon is a plastic. Cloth, bristles, and toothbrush handles are made of nylon (p. 173).

plas'tics. Man-made materials that can easily be made into different forms. Nylon is a plastic. Cloth, bristles, and toothbrush handles are made of nylon (p. 173).

pol lut'ed. Unclean. Polluted water is not safe for most living things (p. 206).

pum'ice. A volcanic rock (p. 224).

quartz. A hard, shiny mineral found in many rocks. Granite usually has quartz in it (p. 216).

queen bee. The mother bee (p. 31).

rept'ile. A cold-blooded animal with scales or a scalelike covering. A reptile breathes with lungs all its life (p. 155).

res'er voir. A storage place for water (p. 37).

re volve'. To turn around another object. The earth revolves around the sun (p. 77).

ro'tate. To turn around on itself. The earth rotates once every twenty-four hours (p. 77).

run'ner. A slender branch that grows out over the surface of the ground from a parent plant. A new plant may grow at the end of or at joints on a runner (p. 138).

sand'stone. A kind of rock formed under water or by wind deposits. It is made of sand (p. 228).

sap. The watery juice of a plant (p. 39).

scales. Thin, flat pieces of material that fit over one another to form the covering of most reptiles and fishes (p. 154).

sci'en tist. A person who has studied science carefully for a long time (p. 68).

sea a nem'o ne. A small water animal that looks more like a plant than an animal (p. 192).

sea'son. One of the parts into which a year is divided. Summer is one of the seasons of the year (p. 4).

sea'weed. Any one of many plants that grow in the sea (p. 60).

sed i men'ta ry rock. Rocks made from material, or sediment, dropped by wind or water (p. 226).
seis'mo graph. An instrument that records earthquakes (p. 83).
sep a ra'tion lay'er. A layer of cork that forms at the place where the stem of a leaf joins the twig (p. 39).
sew'age. Waste material of all kinds, carried off through a sewer (p. 209).
short cir'cuit. An accidental touching together of two bare wires causing an electrical current to take a shorter path than it would otherwise have taken (p. 175).
skel'e ton. The bones or hard covering of an animal (p. 152).
soil. The top layer of ground (p. 38).
sol'id. Any material that keeps its shape (p. 125).
sound. Vibrations heard through the ear (p. 106).
spines. Sharp growths on plants or animals. Many cacti have spines (p. 52).
spore. A tiny part of certain kinds of plants from which new plants form. Ferns grow from spores instead of seeds (p. 140).
star'fish. A spiny-skinned, many-armed, sea animal. Most have five arms (p. 147).
sto'lon. A runner, or branch, of a plant that takes root at the tip or at joints and forms new plants. Strawberry plants grow from stolons (p. 138).
tem'per a ture. The measure of the heat of anything (p. 6).
ter rar'i um. A tank or glass dish in which living plants and animals are kept (p. 47).
ther mom'e ter. An instrument that measures heat (p. 58).
tha'rax. The middle section of an insect’s body (p. 149).
top'soil. The layer of soil at the surface of the earth. Plants grow in this layer (p. 237).
var'i a ble tem'per a tured an'i mal. An animal whose blood changes temperature with its surroundings (p. 154).
vein. A part of a leaf which holds tubes that carry liquids (p. 143).
vib'rate. To move back and forth rapidly (p. 108).
vol ca'no. A mountain that sometimes shoots out melted rocks and gases (p. 78).
warm-blood'ed an'i mal. An animal whose body temperature is about the same all the time (p. 158).
work'er bee. One of the bees in a hive. Workers do most of the work of the hive (p. 31).
zinc. A bluish-white metal. Zinc is used to make the can of a dry cell (p. 166).
Index

African violet, 138

Air
  temperature of, 6–14, 58, 62, 63, 97, 98
  part of the earth, 78, 86–105
  pressure, 92–96, 101–102, 105
  expansion of, 94–97, 105
  movements of, 97–100, 105, 109–111,
    117–118, 121–125
  gases in, 103
  as conductor of electricity, 172

Airplanes, 88, 101, 201, 251

Alligator pear, 134, 135

Aluminum, 183, 250, 251, 252

Amoeba, 146

Amphibians, 156, 157

Animals
  and seasons, 20–33
  coverings of, 30–31, 145, 147–148, 150–
  151, 154, 155, 157, 159, 161
  in water, 60, 146–148, 153–154, 157, 162,
    186–197, 199, 203–209, 237
  without bones, 146
  with hard coverings, 147–151
  with skeletons, 152–162
  cold-blooded, 154–157
  warm-blooded, 158–162

Annuals, 45–46, 49

Apple trees, 57, 130, 139

Aquarium, 60, 203

Arctic poppy, 43, 62

Arctic terns, 26

Asphalt, 244, 248

Atmosphere, 78, 87, 104

Autumn season
  beginning of, 5, 18
  animals in, 25, 28, 33
  plants in, 38–40, 44, 45

Barnacles, 191

Bears, 24, 29, 160

Bees, 31, 149, 150

Beetles, 149, 150

Begonia, 45, 143

Biennials, 46, 49

Birds, 25–29, 33, 158–159

Blueprint, making a, 48

Buds, 42, 43, 47, 137

Bulbs of plants, 37, 137, 143

Butterflies, 31, 149, 150, 151

Cactus plants, 52, 53, 55

Calcium, 233, 235

Carrots, 40, 46, 136

Chickens, 30, 158

Chipmunks, 24

Circuits for electricity, 168–171, 175–177

Clams, 148, 195, 230

Clocks, 72–74, 85

Coal, 78, 99, 218–219, 237, 243–244

Coal tar, uses of, 244

Cold-blooded animals, 154–157

Compost heap, 49

Conductors
  of sound, 122, 123, 125
  of electricity, 172–174, 183, 251

Conglomerate rock, 229

Constant-temperatured animals, 159

Copper, 168, 171, 172, 183, 250, 251

Coral, 186

Cows, 30, 160, 161

Crabs, 148, 192, 194, 195

Crickets, 150, 151

Crystals, 212–217, 224, 225, 234

Cuttings of plants, 138, 139

Dahlia, 131, 136

Day and night, 15–19, 70–72

Desert plants, 52, 53, 55

Diamonds, 215, 234

Dogs, 30, 160, 161

Dragonflies, 203
Drum, 110–113, 117, 119
Dry cell, 166–169, 173–177, 183
Ducks, 28, 30, 152, 158, 159

Eardrum, 111

Earth
shape of, 66–68
motion of, 69–71, 77, 84
as a clock, 73–76
land part of, 78, 79, 87, 88, 185, 220
inside of, 78–83, 212, 214, 221–224, 228, 231, 237, 243–246, 249
air part of, 78, 86–105
water part of, 88, 184–209
rocks and minerals of, 211–235
metals of, 250–252
Earthquake, 83, 228
Earthworms, 146
Echo, 124–125, 127
Eels, 33, 208
Electric bell, 169–171, 178, 183
Electricity
working with, 164–183
pathways for, 168–177
conductors of, 172–174, 183, 251
insulators for, 173, 174
dangers of, 173–174, 183
energy of, 182
Electromagnet, 176–181
Equator, 8–12, 14–16, 18, 19, 36, 43
Evaporation, 52, 201, 213, 230
Evergreens, 12, 39, 56, 59, 142
Expansion, 94, 96, 97

Fall season. See Autumn season
Feathers, 30, 145, 159, 183
Feldspar, 216, 221, 224
Ferns, 139, 140, 142, 218, 219
Fertilizer, 38, 49
Fiddle, one-string, 115–116
Fire-made rocks, 221–225, 231
Fish
migration of, 29, 208
skeletons of, 152–153
gills of, 153–154
as cold-blooded animals, 154, 155
food for, 187–189, 196, 199
in salt water, 189, 196, 199, 208
in fresh water, 203–208
planning for, 206–207, 241–242
Fish hatcheries, 207
Flowers, 41–43, 45–47, 53, 131
Food
stored by plants, 36, 37, 44, 47, 132, 135
of sea animals, 148, 187–194, 196, 197, 199
of mammals, 160–161
minerals in, 233, 235, 253
Fossils, 219
Fresh water
plants in, 60, 202–205, 209
animals in, 146, 157, 203–209
Frogs, 22, 23, 32, 152, 156, 157, 204
Fruit, 43, 47, 130, 139

Gases
in the earth, 80, 81, 223, 237, 249
in the air, 103, 125
from coal, 243
from petroleum, 246
Gasoline, 248
Geysers, 80, 230
Gills, 153, 154, 156
Golden plover, 26
Grafting, 139
Grand Canyon, 228–229
Granite, 224, 225, 232
Grass, 41, 43, 63, 134, 135
Growing new plants
from seeds, 129–135, 142, 143
from roots, 136
from stems, leaves, 137–139, 143
by grafting, 139
from spores, 140–142

Hair, 30–31, 145, 161
Heat
of seasons, 6–19

261
from straight and slanting rays, 9–14, 16, 18, 19, 36
and plants, 52–57, 62
inside the earth, 80–82, 212, 214, 221–224, 231, 235
and expansion, 94–98
Hibernation, 22–24, 32
Hornblende, 224, 225
Horse, 30, 161
Hourglass, 74
Igneous rocks, 221–225, 231
Insects, 21, 31, 149–151, 203
Insulation, 173–175, 176
Iron, 228, 233, 235, 237, 250–253
Irrigation, 37, 201, 238, 239
Jungle plants, 54, 55, 218
Kangaroo, 162
Kelp, 60, 62, 186
Kerosene, 247
Land of Midnight Sun, 19
Land part of the earth, 78–79, 87–88, 185, 220
Lava, 81, 83, 214, 224
Leaves
and seasons, 36, 38–40, 42–45, 47, 49
color of, 39, 89
blueprint of, 48
compost heap of, 49
of desert plants, 52
of jungle plants, 54–55
of fresh-water plants, 61, 202–203
growing plants from, 138–139, 143
Lichens, 59
Lima beans, 132, 133
Limestone, 189, 230, 232, 249
Lobsters, 196, 242
Lungs, 103, 155–157, 162, 197
Made-over rocks, 231, 232
Magma, 82, 83, 221–224, 231
Magnesium, 201, 250, 251, 252
Magnetism, 176–181
Mammals, 160–162
Metal
and sound, 121, 122, 123, 125
and electricity, 172, 180, 181
in ocean water, 200–201
use of, 234, 250–252, 253
Metamorphic rocks, 231, 232
Mica, 217, 221, 225
Migration, 25–29, 33, 208
Mildew, 141
Minerals
in ocean, 200–201
in rocks, 211, 216–217, 220–225
crystals of, 212–217, 224, 234
and coal, 218
in food, 233, 235, 253
use of, 234, 253–254
Mold, 141
Moss, 59, 61, 140
Moths, 31, 149, 150, 151
Mountains, 58–59, 83, 198, 227–228
Musical instruments, 112–116, 127
Muskrats’ houses, 204
Mussels, 191, 193
Naphtha, 246
Natural gas, 80, 249
Nights and days, 15–19, 70–72
Nitrogen, 103
North America
seasons in, 5–17, 18, 38, 41, 43
animals in, 33, 163
plants in, 38, 41, 43, 44, 52–53, 56–60
time zones in, 75–76
oil derricks in, 80, 245
North pole, 8, 14, 19
Ocean
animals in, 60, 147–148, 153–154, 162, 186–197, 199, 208
plants in, 60, 186–189, 197, 199
size of, 185
plankton in, 187-189, 196, 197
floor of, 189, 198-199, 226-230, 235
shores of, 190-195
minerals in, 200, 201, 254
Oil
  wells for, 78, 80, 245, 248, 249
  products from, 246-248
Onions, 37, 40, 137
Oxygen, 88, 103
Oysters, 148, 193, 196, 241, 242
Parachute, 101
Perennials, 44-46, 49
Petroleum. See Oil
Piano, 113
Pike's Peak, 58-59
Pitch of sounds, 112-116
Plankton, 187-189, 196, 197, 203
Plants
  and seasons, 34-49
  food stored by, 36, 37, 44, 47, 132, 135
  growth of, 36-47, 50-63, 128-143
  length of life of, 44-46
  location of, 50-63, 186-189, 202-205, 209, 218-219
Plastics, 173, 174, 183, 252, 254
Polar bears, migration of, 29
Pollution, 206, 209, 237, 240-242
Ponds, 60-61, 202-205, 208
Potatoes
  white, 36, 37, 40, 137, 143
  sweet, 56, 136
Pressure
  of air, 92-96, 101-102, 105
  inside the earth, 222-223, 231, 249
Push buttons, how they work, 170, 171
Quartz, 216, 217, 221, 224, 234
Rays, straight and slanting, 9-14, 16, 18, 19, 36
Reptiles, 155, 157, 163
Reservoirs, 37, 238, 239
Rivers, 29, 208, 226, 240-242
Robins, 25, 26, 33, 152, 159
Rocks
  layers of, 79, 223, 226-230, 231
  melted, 81-83, 221-224, 231, 235
  minerals in, 211, 216-217, 220-221, 224, 225
  igneous, 221-225
  sedimentary, 226-230
  conglomerate, 229
  metamorphic, 231-232
Roots, 45-46, 53, 55, 133, 135-139, 202-204
Salmon, migration of, 29, 208
Salt, 200, 201, 212, 213, 235
Salt water
  animals in, 60, 146-148, 162, 186-197, 199, 208
  plants in, 60, 186-189, 197, 199
Sandstone, 228, 229, 232, 249
Scales, on fish, reptiles, 154, 155
Sea. See Ocean
Sea anemones, 192
Sea animals, 60, 146-148, 152-153, 162, 186-197, 199, 208
Seals, 29, 162
Seashores, 190-195
Seasons
  description of, 4-19
  and animals, 20-33
  and plants, 34-49
Seaweed, 60, 186, 193, 194, 197
Sedimentary rocks, 226-230
Seeds, 43, 45, 46, 49, 129-135, 142, 143
Seismograph, 83
Sequoia trees, 44
Sewage disposal, 209, 242
Shadow stick, 85
Shale, 229, 232, 249
Sheep, 30, 161
Shells, 148, 189, 191-193, 195, 209, 219, 230
Short circuit, 175
Skeletons of animals, 152-155, 157, 160
Snails, 148, 194, 230
Snakes, 22–23, 152, 155, 160, 163
Sound
  and vibrations, 108–127
  traveling of, 109–111, 118–119, 121–125
  pitch of, 112–116
  loudness of, 117–119
  conductors of, 122–123, 125
South America
  seasons in, 18
  plants in, 54–55
South pole, 18
Spores, 140–142
Spring season
  animals in, 21, 25, 28, 30, 31
  plants in, 38, 39, 42–47
Starfish, 147, 193
Stems
  underground, 36, 37, 137, 142
  of desert plants, 52
  of fresh-water plants, 61, 202–203
  growing new plants from, 137–138, 142–143
Stolon, 138
Streams of water, 205–207, 226
Summer season
  description of, 5–12, 15–18
  animals in, 21, 23, 25, 26, 29–31
  plants in, 36, 37, 39, 44–46, 52–57
Sun
  rays of, 9–14, 16, 18, 19, 36
  rising and setting of, 16–17, 69
  and movement of earth, 69–71, 77, 84
Sundial, 85
Tadpoles, 156, 157, 204
Telegraph, 180
Telephone, 120, 121
Temperature
  of air, 6, 10, 11, 58, 62, 63, 97
  of blood, 154, 158–160
Terrarium, 47, 140
Thermometer, 8, 58, 97
Tidal wave, 83
Tides, 190–195
Time, 72–76
Time zones, 75–76
Tin, 251, 252
Toads, 22, 23, 156, 157, 204
Trees
  evergreen, 12, 39, 56, 59, 142
  in seasons, 38–39, 41–44, 47
  seeds of, 129–131, 142
  grafting of, 139
Turtles, 22, 23, 32, 66, 155, 197, 204
Variable-temperated animals, 154
Vibrations, 108–127
Violin, 112, 114
Volcanoes, 78, 81–83, 214, 222–224, 228
Warm-blooded animals, 158–162
Wasps, 31, 149
Water
  and irrigation, 37, 201, 238–239
  and plants, 52, 53, 55, 60–61, 186–189, 197, 199, 202–205, 209
  movement of, 83, 109
  part of the earth, 88, 184–209
  air in, 90, 153
  as conductor of sound, 123, 125
  animals in, 146–148, 153–154, 162, 186–197, 199, 209, 241
  minerals in, 200–201, 253, 254
  pollution of, 206, 209, 237, 240–242
  and rock formation, 227–231
Water clock, 74, 85
Weasels, 31
Whales, 162, 186, 188, 197
Wind, 63, 98–100, 227, 228
Winter season
  description of, 5–8, 10, 13–19
  animals in, 21–26, 29–31
  plants in, 39–47
Woodchucks in winter, 23
Zinc can, 166–167

PRINTED IN THE UNITED STATES OF AMERICA
<table>
<thead>
<tr>
<th>Date Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCT 2.5 1963</td>
</tr>
<tr>
<td>DEC 2 RETURN</td>
</tr>
<tr>
<td>OCT 2.5 1963</td>
</tr>
<tr>
<td>DEC 2 RETURN</td>
</tr>
<tr>
<td>OCT 2.5 1963</td>
</tr>
<tr>
<td>OCT 2.5 1963</td>
</tr>
<tr>
<td>OCT 2.5 1963</td>
</tr>
<tr>
<td>OCT 2.5 1963</td>
</tr>
<tr>
<td>OCT 2.5 1963</td>
</tr>
<tr>
<td>OCT 15 RETURN</td>
</tr>
<tr>
<td>OCT 23 RETURN</td>
</tr>
<tr>
<td>OCT 28 RETURN</td>
</tr>
<tr>
<td>OCT 28 RETURN</td>
</tr>
<tr>
<td>OCT 28 RETURN</td>
</tr>
</tbody>
</table>