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ABSTRACT

GRADES OR AGES: K-6. SUBJECT MATTER: Science. ORGANIZATION AND PHYSICAL APPEARANCE: The guide is divided into six straight-text chapters. One chapter, which outlines curriculum units, is subdivided by grade level--primary, intermediate, or upper elementary. The guide is offset printed and spiral-bound with a paper cover. OBJECTIVES AND ACTIVITIES: A rationale and general objectives for science teaching are presented in the first two short chapters. Another chapter contains suggested curriculum units with specific suggestions for activities. Each group of activities is correlated with a scientific concept or phenomenon. A second chapter presents general guidelines for out-of-school activities such as hikes and field trips, and an appendix contains detailed descriptions of 45 experiments. INSTRUCTIONAL MATERIALS: Materials needed for the experiments are listed at the beginning of each description. Guidelines for the use of materials and resources and a list of selected references are also included. STUDENT ASSESSMENT: The guide includes sample rating forms for student reports and experiments and suggests guidelines for constructing written tests. (RT)

STRENGTHENING SCIENCE TEACHING IN ELEMENTARY SCHOOLS

The Subject Field Series
Bulletin Number C-Three

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FOREWORD

The recent breakthroughs in all scientific fields have had profound implications for the teaching of science in our public and private schools. With children exposed to the dynamics of an aerospace age and everyday living marked with increasing complexity, it is mandatory that school programs be more carefully designed. This is especially true in science education at the elementary school level. In terms of both basic content and sequential learning experiences for different age groups, classroom teachers and administrators have an obligation to review critically their present efforts in science teaching.

Strengthening Science Teaching in Elementary Schools has been appropriately named. Through the use of first printing copies it has served as a "launching pad" for various types of intensive in-service science education activities for all school personnel having responsibilities in this area.

Not since 1916, when the Office of the Superintendent of Public Instruction published the *Illinois Curriculum and Course of Study Guide for Elementary Schools*, had a revision been made of the materials pertaining to science instruction. The former Director of the Illinois Curriculum Program, Dr. Fred P. Barnes, of the University of Illinois, activated a committee to work toward a new science curriculum bulletin. The committee's work was completed through the leadership of Dr. Woodson W. Fishback of Southern Illinois University who, at the present time, is Director of Curriculum Development and the Illinois Curriculum Program.

Our appraisal of the bulletin is that it is one in which we can take real pride and find in it a wealth of suggestions for teaching science in the elementary schools of Illinois. In transmitting the bulletin to intermediate and local school officials, we recommend that you acquaint yourselves as fully as possible with the principles and supporting ideas included. Through our cooperative efforts in the implementation of this guide, further upgrading in the quality of science programs and teaching can be accomplished.

Appreciation is expressed to each member of the committee for his contributions in the development of this bulletin. Because of his diligence, persistence, and professional commitment, special recognition is made of the work of Dr. Clyde M. Brown, who served as Chairman of the Committee. Although he is credited with having written the greater part of the bulletin, words of commendation are expressed also to Mr. Harold R. Hungerford, Dr. R. J. Fligor and Dr. J. Myron Atkin, who prepared selected portions of the guide.

Mr. Carl Renshaw, Principal, Du Bois School, Springfield, Mr. Donald Streng, Superintendent of Schools, District 86, Joliet, and Mr. Richard Benson, University School Instructor, Southern Illinois University, Carbondale, are recognized for their review and selection of the science experiments and demonstrations included in Appendix A. For his ideas related to format and for designing the cover, the committee is grateful to Mr. William Bealmer, Art Consultant in the Office of the Superintendent of Public Instruction. The line drawings are the work of Mr. Marvin K. Mullins, Art Teacher, Lanphier High School, Springfield.

Besides those specifically mentioned, acknowledgment is made of all other persons who shared ideas or materials contained in the bulletin. Finally, it would have been impossible to have seen this kind of volunteer effort completed had it not been for the consideration of boards of education and institutions of higher learning in permitting the several committee members to serve the state in this manner.

In cooperation with the lay and professional groups represented on the Illinois Curriculum Council, the Office of the Superintendent of Public Instruction is pleased to sponsor and present this bulletin.

Ray Page
Superintendent of Public Instruction

PREFACE

Curriculum improvement is dependent upon a number of factors. One of these is the availability of resource materials for school administrators, curriculum directors, and classroom teachers. Beginning in 1947 the Office of the Superintendent of Public Instruction has released through the Illinois Curriculum Program numerous publications. At no time have these been prescriptive in nature. Nonetheless, they have reflected principles of education based on theory and research, and at the same time have included practical procedures for teaching.

In the subject field series for elementary schools the following are now available.

School Begins With Kindergarten
Thinking in the Language of Mathematics
Strengthening Science Teaching in Elementary Schools
Children Learn and Grow Through Art Experiences
Learning and Living Music
English Language Communication
Teaching the Social Studies

Other bulletins being developed will be concerned with health instruction, physical education, and teaching foreign languages in the elementary school.

Intended to be suggestive and thought provoking, *Strengthening Science Teaching in Elementary Schools* can lead to improvement in the quality of learning experiences children and teachers have in science. The extent to which the bulletin achieves this basic purpose depends upon the interest in and follow-up use made of it. Among some school systems the bulletin may simply supplement the excellent science materials which have already been prepared and adopted.

In school districts where over-all curriculum councils exist and where work has been done in curriculum study and reorganization, this new bulletin will find a natural setting for proper implementation. Likewise in school districts having science consultants and coordinators of curriculum the chances are quite good that these personnel will assume leadership in helping teachers note the implications of the guide for more effective educational planning and teaching.

Within communities where conditions are less favorable in terms of providing science specialists, the county and local school administrators must be looked to for initiating the study and utilization of the guide. As much as possible personnel from the Office of the Superintendent of Public Instruction will provide assistance in its implementation. Currently the science consultants, available through the provisions of the National Defense Education Act, Title III, will continue to sponsor workshops in science education throughout the state and assist in science programming at the local community level.

In the final analysis the committee who prepared this guide realized that the classroom teacher will be the one who actually tests the validity of its work. With primary emphasis on a core of teaching ideas the bulletin contains space for a teacher's notes after each chapter. It is hoped that this will motivate teachers to relay to this office ideas which may be used as grist for workshop discussions; for the preparation of supplements to accompany this guide; and to assist in periodic revisions of science education curriculum guides.

Woodson W. Fishback
Director of Curriculum Development
and the Illinois Curriculum Program

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CHAPTER I

Using the Science Guide

Major Objectives

This curriculum guide is designed to be of direct help to classroom teachers in Illinois who desire to strengthen their science teaching. The committee kept in mind the varied backgrounds of teachers responsible for science instruction. Therefore, emphasis is placed on general guidelines and a variety of information to assist teachers in their organization and development of science programs in elementary schools.

It is not the purpose of this guide to supply course outlines but rather it is intended to suggest what teachers may do in the classroom to make their science teaching more effective. The ideas presented are those which experienced teachers have utilized and have found workable in making learning not only more effective but also more enjoyable for both the teacher and the learner.

Others who may find the guide useful are superintendents in charge of instruction, principals, and curriculum coordinators. Personnel in teacher training institutions may also find the guide helpful in the pre-service training of elementary school teachers.

No course outlines or scope and sequence charts are included. Most textbook companies who publish a science series for use in the elementary schools develop scope and sequence charts built from the materials utilized in organizing their textbooks. These may be procured free of charge from representative companies, and a teacher should have one or more available.

It is recommended that teachers in an individual school system work together to develop flexible, instructional outlines of science that fit the requirements of their particular schools. The committee believes that adoption of a blanket outline for statewide use would prove to be restricting and limiting; hence, fall short of the needs of the teachers and the children. Each group is different and the problems of individual communities make an inflexible science program less dynamic than an individualized program.

It is advisable, however, for a school-wide overview to be taken in organizing a science curriculum. This necessitates careful planning for the continuing science education of the child from nursery school or kindergarten through the secondary school. Teachers are encouraged to acquaint themselves with the total school curriculum to see how the subject matter they teach complements and reinforces the children's total education.

Administrative Responsibilities

Administrators have a dual responsibility in the science program. First, they must offer supervision and guidance to their teachers conducive to the development of a sound elementary school science program. Second, they must help provide the facilities and equipment (material) which are needed to implement the program.

Coordination in the preparation of science programs should be provided either by the principals or by well-trained curriculum coordinators working with committees of classroom teachers. Best results can probably be achieved in workshop situations on released time during the regular school session or in sessions prior to the opening of school in the fall. It is also wise, when possible, to enlist the services of a science consultant, since many elementary teachers have minimal training in science, have had little in-service training in science, and are not up-to-date on many recent developments in the various science fields.

The consultant for the elementary science program should have a broad overview of science. Such an understanding is characteristic of a well-trained junior high school general science teacher. Sometimes a person who is primarily a subject-matter specialist from the fields of zoology, botany, physics, or chemistry can also prove effective. In recognition of the responsibilities of those teachers charged to work as consultants and advisors for the elementary science program, an appropriate allowance should be made in their teaching loads.

Many materials are desirable for teaching elementary science. For economy within individual schools, science supply and equipment centers should be established. In some schools the science distribution center may be combined with the film center. The center would remove, to a large degree, the needless duplications involved in individual classroom supplies.

Materials can be checked out by the teachers as needed and returned following the completion of an assignment. Where school-wide supply and equipment centers are utilized, some person should be put in charge of the center to service equipment and maintain the stock of expendable items.

An increasing number of schools are trying to meet the equipment needs of their teachers through the purchase of science kits, science packets, or mobile laboratories. There are several very fine units assembled, but all demand constant maintenance or they quickly become collections of little use. Again, one individual should be charged with surveillance to keep materials in order and in adequate quantity.

A carefully selected professional library, including science methods books and idea books, is highly desirable over and beyond the usual expendable demonstration supplies. All library materials should be readily available to the teachers of each school.

Administrators are responsible for the school program and must be kept informed. Teachers in the elementary schools must carefully plan their work and should keep the administrative staff acquainted with their science program. Only in this way can continued administrative support be expected. When principals and science consultants are made aware of special science activities, they are more sympathetic with their teachers' requests and proposals. Lack of administrative support occurs most frequently when the purpose of an activity is not outlined prior to its initiation.

TEACHER'S NOTES

CHAPTER II

Science and Why We Should Teach It

Science Defined

Science experiences in the elementary school are a part of the total education of the boy and girl. It is difficult, if not almost impossible, to isolate these experiences from the total school program. R. Will Burnett of the College of Education, University of Illinois, concludes that in the elementary schools it isn't a question of "Shall the teacher teach science?" but rather "How can a teacher avoid teaching science?"

Science is an integral part of the lives of children and each is, to a certain degree, a scientist. Insofar as he asks "what," "how," "why," and "what would happen if . . ." about his environment, the child is an investigator involved in an elemental form of research. Not only is he investigating but, if his curiosity is given direction, he is also developing basic skills necessary in the study of the scientific world. When he utilizes scientific principles and truths in solving his problems, he is a young consumer scientist or applied scientist.

In the elementary school, science has too frequently been associated with nature study. More specifically, science teaching has frequently been restricted to making collections of shells, insects, rocks, flowers or leaves. The "collecting" was the science program—the end results were "the collections." Little was discovered concerning the interaction of forces, the relationship between things and their environment, or cause and effect relationships. Dispensing unrelated facts of science that might be returned unassimilated on an objective test has also been considered too frequently by some as science teaching.

Science in the elementary school is not a collection of abstract ideas couched in big words. It should be the down-to-earth, common sense explanations and facts about the phenomena children observe around them all the time. While it is true that the horizons of awareness of young children are broadening, building an understanding of basic science principles is still a major function of the elementary school teacher.

Recent activities and discoveries, such as space travel, man-made satellites, guided missiles, atomic fission and atomic fusion, are scientific advances built upon basic science principles which man has discovered about his environment. Understanding the basic principles and the understanding of relationships are the important goals toward which teachers should strive.

The philosophy of teaching which accepts the premises (1) that children are taught with facts; (2) that they learn to use particular skills; and (3) that elementary science should create awareness, develop attitudes and build appreciations, requires an expanded definition of science.

The following three-fold definition seems consistent with the premises stated above. Science is:

1. a body of classified knowledge--all the facts that have been accumulated by man through the years which are apparently true and seem to explain the occurrence of phenomena in our natural environment.

2. a way of thinking--an attitude or a belief that things do not happen without a cause; that there is a rational explanation for those happenings which we can observe with our senses if we only have possession of adequate data.

3. a method of working--the scientific methods or the various facets of these methods which utilize specific skills necessary for working in science.

Elementary science should concern itself with those principles, facts, and problems of the biological and physical world that affect the lives of children. Science education should provide the child with an understanding of the basic concepts inherent in the world of science as well as provide him with sound attitudes toward the natural world in which he lives. The pupil should be familiar with certain skills which he can use in scientific study. His attitudes toward society and his culture should reflect an understanding of the basic problems of science and the advantages brought about by an era of scientific technology.

Reasons for Teaching Science

Before a teacher can function effectively in the area of elementary school science he must have an understanding of the basic purposes of educating children in this area. As in the other phases of the curriculum, there are specific objectives and goals related to science education. The basic purposes of the science program need be no different from those of other curriculum areas except that the subject matter, attitudes, and skills deal, for the most part, directly with science.

Teachers may find the following statements useful in answering the question, "Why teach science?"

1. We should teach science to foster and satisfy interests and to stimulate curiosity.

2. We should teach science to correct common misconceptions.

3. We should teach science to help children develop rational attitudes toward the natural world.

4. We should teach science because it is intellectually stimulating.

5. We should teach science to bring about a broader understanding and appreciation of our total environment.

Any list of intentions or objectives of teaching cannot be achieved if they are written out at the beginning of the school year and then filed away. They are vital only when they are kept constantly before the teacher and act as guides in the selection of content, methods of presentation, methods of evaluation, and other activities of the classroom.

A good teacher will ask himself three questions when teaching in a fundamental curriculum area:

1. What subject matter should be taught?

2. What attitudes should the child have toward the subject matter and its ramifications?

3. What should the child be able to do as a result of his experiences?

This bulletin advocates the development of appropriate goals and objectives in science education under the major headings of knowledge, attitudes, and skills.

Knowledge

No one can refute the importance of subject matter in the field of science. This is the factual side of science, and it is important that the knowledge imparted in the classroom be correct and appropriate for the age level of the children. As the subject of science is developed in the classroom, pupils should retain certain basic ideas or concepts which they understand and find appropriate to further their scientific education.

It should be remembered that facts alone and of themselves are inadequate ends in the modern educative experience of children. The facts taught must be well organized, have continuity, and be of value to the child. The basic ideas and facts in science are necessary building blocks on which he can proceed to a more complex and detailed study of the subject. They are a part of the picture in science education and establish continuity for him. When the child is able to relate them to stimulating intellectual problems the value of factual knowledge is greatly increased.

Attitudes

A second goal of elementary school science education should be the development of a scientific attitude toward events and objects in today's culture. It is not the function of science education to make scientists out of all children but teachers should strive to help children see situations in a scientific manner and combat superstition. The "cause and effect relationship" should be strengthened and reinforced by the teacher whenever possible. There is little doubt about the teacher's attitudes toward science being reflected in the attitudes of the children he teaches.

Other more specific attitudes should be fostered in the elementary school. The appreciation of science itself is actually an attitude toward science. When a child sees the importance of science in today's world and realizes that he uses science himself, this appreciation will surely develop. Seemingly in opposition to the above is the development of the attitude which reflects the realization that science has very definite limitations, i. e., that man's existence is not governed by scientific accomplishment alone. Since there is danger of science becoming a "religion" with some persons, it is important that children learn how to function effectively within their scientific environment.

Definite attitudes should also be developed relative to man and his relationship with his natural biological and physical environment. The expediency of economics and man's quest for monetary and scientific achievement have, to a great extent, deteriorated his relationship with nature. The basic fundamentals of conservation and esthetic appreciation are too often forgotten. The future of today's society and the well being of tomorrow's children hinge on how man uses and respects his natural environment.

Skills

In contrast with science teaching, the "doing" aspects of language arts and arithmetic are usually more clearly defined and better understood by teachers. What about the "doing" aspects of science? A clear understanding of what the child should be able to do in science will help the teacher guide himself in *organizing appropriate* experiences for and with children. The following skills are basic in science instruction:

1. Skills in making observations
2. Skills in making comparisons
3. Skills in making relevant distinctions
4. Skills in critical thinking
5. Skills in experimentation
6. Skills in investigation

The child should be able to observe accurately. What he observes should be reported accurately and he should be able to use his findings himself and communicate them to others.

The child should be able to make valid and reliable comparisons. He should be able to see likenesses as well as differences. Making comparisons is critical in understanding both the biological and physical sciences. Applications of this skill open up a world of new experiences for the child and permit him to make firsthand investigations in science.

The child should be able to distinguish between pertinent and irrelevant information (data). Are the data relevant? Can they be used? How can you tell that this information will help solve the problem? Normally, a child can find a great deal of information in an experiment relative to a problem. When he is able to determine which data are usable then he has developed the skill of distinction.

The child should be able to make intelligent use of the information already known to him. This means that the pupil should be able to think critically on a problem and come up with a relevant guess (hypothesis) as to the solution or meaning of the problem. The hypothesis is a familiar part of the experimental form of scientific method. It is not always important that the child be able to set up an experiment to find "the" answer because this is often impossible. It is important, however, that children be able to use intelligent reasoning and the concepts at their command.

If experimentation is possible it is important that the child be able to formulate and carry out experimental procedures. Again, it is not the function of elementary school science to make research scientists out of all pupils, but it is important that pupils have some idea of how to set up and conduct an experiment. There are many areas in science which are appropriate for experimentation in the elementary school. It is better for the pupil to work out a scientific problem than for him to be "spoon fed." A few examples of possible experimentation are:

1. Ways of decreasing friction
2. Effect of light on growing plants
3. Dietary needs of animals
4. Advantages of levers
5. Relationship of gravity to root growth
6. Production of physical or chemical changes

When experimentation is not possible or appropriate the pupil should have the ability to determine other suitable means of investigation. Can we study this first hand? How? Should we ask someone? Whom? Can we read about it? Where? Children must be able to see that the scientist uses various means to collect information and that his ability to find the best method of investigation enables him to be an effective scientist.

There is a strong relationship between skills and the other objectives of science education. The use of these skills will result in the discovery of fundamental facts and concepts (knowledge) by the pupil. This method of finding basic science principles has much more meaning than the mere memorization of facts. Children will accept the challenge to discover for themselves. With guidance and direction, their discoveries can be accurate and stimulating. Given this opportunity their attitudes toward science should also develop in a healthy manner which, in itself, is a basic goal of science education.

Summary

The classroom teacher needs a workable philosophy concerning science education before he can be an effective leader in this curriculum area. The committee preparing this bulletin realized that numerous lists of science education objectives have been formulated and are available. Somewhat in contrast to other lists the committee elected to present reasons for teaching science. In summary these reasons are:

1. To familiarize children with a basic body of knowledge.
   a. To acquaint children with the fundamental facts and ideas regarding our environment and the broad subject matter areas of science.
   b. To integrate the broad subject matter areas of science as much as possible so that the child can begin to see science in total perspective.
   c. To correct common misconceptions relative to science phenomena in our environment and to combat superstition.
   d. To help children understand the scientific facts and applications regarding personal health and human survival.

2. To help children develop proper attitudes toward science and the world of technology.
   a. To develop the attitude that, in the physical universe, nothing happens without a cause.
   b. To develop an appreciation for science and its potential.
   c. To develop an appreciation for the inherent limitations of science and the fact that science is not a panacea for all of man's difficulties.
   d. To stimulate a wholesome interest in science.

3. To help children acquire the basic skills of science so they will be able to study better about, and function within, a scientific environment.

4. To further an appreciation among teachers that science is an excellent *medium* through which many of the other broad objectives of the elementary school curriculum, i. e., group participation, *communicative* skills, etc., can be developed.

CHAPTER III

Problems of the Teacher of Elementary Science

Introduction

Science offers a challenge to teachers in elementary schools today that is probably greater than at any other time in our educational history. Too many teachers, however, are losing this powerful natural "interest getter" and "motivator" when they avoid this vital area in the education of their pupils. Science is around the children from the time they arise in the morning until they drop off to sleep at night. Even then the processes going on in their bodies and in the natural environment are expressions of the interaction of many of the facets of science. In spite of these facts and the great natural curiosity of children, an analysis of the offerings of the elementary schools shows the science programs to be the most neglected and frequently the most poorly taught of all the subject areas. Why is this?

In attempting to determine why science is so neglected, a poll was conducted over several years among approximately 1,000 elementary teachers enrolled in elementary school science education classes. These teachers were asked to list the problems which they experienced in teaching science in their schools. Many problems variously expressed were listed and these, when analyzed, were reduced to five major categories.

These problems, not necessarily in rank order, were:

TIME—to fit science into an overcrowded program for a classroom of children who must know reading, writing, and arithmetic before being promoted to the next grade.

SPACE—to display, to experiment or demonstrate, to store the "things" of science.

MATERIALS—supplies needed to conduct demonstrations and experiments; models and charts; and other materials which tend to make teaching more effective and meaningful.

BACKGROUND—to adequately answer the myriad of questions about phenomena that children observe; to handle and manipulate the objects or devices necessary to demonstrate or experiment; to interpret the technical language and terms in which science is expressed.

METHODOLOGY—to present materials so that maximum pupil learning is achieved; to motivate learning and develop interested participation; and to develop and utilize the abilities of the gifted without losing the interest of the average and slow learners.

In the following sections each problem is discussed in more detail. The acuteness of the problems has been examined and recommendations have been made to help reduce their impact on teachers. The techniques and methods suggested have been used successfully and may give help to others.

Time

The teachers of the elementary schools have a tremendous job trying to give instruction in the various disciplines needed by their pupils. Science, however, can be a great motivating factor for the other phases of the daily schedule. Through correlation, science can be the key to securing more successful participation in other areas, such as the language arts, social studies, mathematics and art. Burnett[1] says that science experiences in the elementary school provide intrinsic motivations, realism, and continuing interests to elementary school work of all sorts.

A child will not read a difficult book unless he is interested in it; so, challenged with science materials, he can be motivated more easily to the upper limits of his ability. When a child reports upon an experiment or demonstration, written reports have more meaning when he tells "what we used," "what we did," "what happened," and "why it happened." These reports give the teacher adequate opportunity to determine when a pupil has attained skills and mastery of English and applies them to his written work. A written assignment of this kind can be very effective with children.

Space

Inadequacy of space is a problem to a number of administrators as well as teachers. Storage problems can be alleviated by periodic house-cleaning and judicious use of a large wastebasket. Teachers face a hazard of being tagged as "string savers." Items used as illustrations which are brought in by the current group of pupils are often more significant than a possibly better specimen saved from preceding years. A small specimen may be as typical of a group of objects as a large specimen and takes up less room.

Display areas may be increased through the utilization of bulletin boards with objects and specimens that are to be shown being placed in plastic bags and mounted with thumbtacks. The plastic bags permit handling with minimum damage.

Where safety ordinances do not prohibit it, a table can be placed in the corridor outside the classroom with displays placed on it. At times when the children are passing through the halls, class members can be designated to be with the exhibits to answer questions asked by other pupils. At the close of the school day the table can be set inside the classroom for refurbishing or safe keeping.

Individual or small group experiments may be initiated at school and completed at home by the children. Reporting on successes or failures and problems of performance can be made a part of the regular science program. Many of the concepts presented can be demonstrated with simple equipment and procedures by the teachers or selected pupils.

Materials

Those teachers who rationalize their way out of teaching science because they

1. R. Will Burnett, *Teaching Science in the Elementary School*, p. 84. New York: Holt, Rinehart and Winston, Inc., 1953.

"do not have anything to work with" are getting by on false pretense. There are items which are desirable for teaching science, but only a few things are absolutely essential. Many of the more necessary items can be secured within the community if the teacher uses his imagination.

Makeshift items and scrounging for materials can contribute to an effective science program, but it is quite expensive in terms of teacher time. Children, when informed of equipment needs, can supply a surprising amount of material.

Basic supplies should be provided by the administration and made available to the teachers so that the greatest good can come of their time and energy.

Background

If the teacher's background is weak, causing him to feel insecure in handling science instruction, Blough[1] offers teachers encouragement with what might be called "seven aspirin tablets."

1. "Almost all girls and boys like science.
2. They don't expect you to know all the answers to their questions.
3. Science in the elementary school should be kept simple.
4. You can learn with the children.
5. It is no harder to teach science than it is to teach social studies or language arts or anything else.
6. Science experiences often work in naturally with the general learning going on in your classroom.
7. The first time over the ground is the hardest; a little practice in teaching science will bolster your confidence."

Blough[2] also suggests some points on how one can equip himself to handle science more adequately. These points are not listed in order of importance because each individual has needs peculiar to himself.

1. Read science material both on the children's level and on your own level.
2. Do some of the "things to do" suggested in reference books such as "going to see," observing, collecting. After you get started, you may be surprised at your own enthusiasm.
3. Do some of the science experiments yourself. They are not difficult, and many of them are very interesting.
4. Find a junior high school science teacher and ask his help. It will help each of you to know what the other is doing. You can exchange ideas and make use of each other's background.
5. Make use of your state, county or city curriculum guide or bulletin on the teaching of science.
6. Be sure to order the teacher's manuals that go with the textbooks used in your school. They are good sources of help that are too often overlooked.
7. Watch current periodicals and other publications for articles about science teaching.
8. Try to observe other teachers working with children in the area of science. You may get many good ideas in this way.

1. Glenn O. Blough, *et al. Elementary School Science and How to Teach It*, p. 4. New York: Holt, Rinehart and Winston, Inc., 1958.
2. Ibid., p. 5.

Photograph Courtesy of Richard Yohnka, Kankakee, Illinois

Children Doing Research on Reptiles

9. Avail yourself of any opportunity provided in your school to attend workshops, extension courses, or other in-service projects which can better equip you to teach science.

10. Be open-minded in your approach to teaching science.

Methodology Improvements Needed

Methodology was for some time not considered a major problem in teaching science. It has become more serious in recent years because of less specific pre-service training in how to teach science. However, the elementary teacher is not expected to be a science specialist, and well-planned in-service training activities in science education can reduce the acuteness of problems in methodology. Teachers who know and understand children and their problems well enough to guide their learning should have little difficulty in developing sound methods for teaching science.

Motivation of pupil learning is rarely a problem if the teacher is alert to pupil needs and interests. Unrealistic selections of subject areas which lie outside those expressed and felt needs may be deadening to pupil participation. A "page-to-page" teacher in science can quench a thirst for learning in the classroom or send a child to other sources for his science information. Discussions of how to teach science often reveal not methodology shortcomings but instead weaknesses in breadth of background training and experiences in the sciences. Perhaps the factors which follow are more pertinent to the teacher of elementary school science but they are also appropriate in other subject areas.

1. Determine pupil needs and interests in the field.
2. Exercise discrimination in the selection of materials to be taught.
3. Organize materials for best learning.
4. Discover motivating devices to elicit pupil participation.

A start in offsetting limitations in teaching science may be initiated by:

1. Enlisting the aid of an experienced teacher.
2. Securing the assistance of the science supervisor, the curriculum coordinator or school principal. It is not a sign of weakness to seek aid and advice.
3. Utilizing the teacher's guide for the text that is used in the grade.
4. Discovering whether there is a curriculum guide for science available in the school system.
5. Studying professional books on science education methods.
6. Keeping up-to-date by reading professional science magazines and journals.

The teacher should recognize that in any given subject or particular topic some child may well know more than the teacher about certain things, and the total of all knowledge within the class is frequently greater than the teacher's. Why not let children present these materials? The informed child can often teach both the teacher and his classmates in his area of special interests and skills. The classroom should become a cooperative enterprise where all can learn.

Individual teachers tend to feel that the problems they face are peculiar to them. It is gratifying to note from recorded experience and selected research that other teachers have been confronted with the same problems and that much headway has been made in solving them.

CHAPTER IV

Planning Elementary Science Instruction

A Point of View

Many teachers are already teaching far more science than they realize, but they are calling it something else. An analysis of the questions which pupils ask will point out that the highest percentage of them will be about some facet of science or will have a science background. Seeking to find answers to these questions can lead a teacher into science instruction.

Children's interests are easily motivated by current happenings. Thus, teachers should keep up with current events and refer to them in the development of the science activities. These incidental materials have unmistakable value, but a good science program cannot be built entirely upon them. They must be considered means of enriching a planned program of science offerings.

The planned program without the incidental experiences probably would prove somewhat sterile and unrelated to reality. Day-to-day happenings involving scientific discoveries, science applications and changes in the environment make the subject dynamic and alive. These happenings help prove that the subject of science is not static —that all is not known and that ideas about what is true change as new data are found. Children who are permitted to help plan and carry out the science program will tend to develop desirable attitudes toward science as a discipline.

Certain scientific attitudes are desirable in everyone. The teacher should strive to assure their attainment by his pupils. Teaching experiences and academic and professional training have no doubt led most teachers to develop certain desirable attitudes some of which are included in the sampling which follows.

1. A lively curiosity about the world in which we live.
2. A firm belief that there is a rational explanation for all events.
3. The belief that truth itself never changes, but that our idea of what is true is certain to change as our knowledge becomes more exact and complete.
4. An unwillingness to accept statements as facts unless they are supported by sufficient evidence.
5. The determination not to believe in any superstition.
6. The determination to make and carry through complete and careful plans for solving problems.

7. The determination always to make our observations carefully and accurately.
8. A willingness to weigh evidence to determine whether it is sound, sensible, and complete enough to justify a conclusion.
9. A determination not to jump to conclusions.
10. A preference for gathering our own facts by experimentation and observations, but a willingness to use results and facts obtained by others.
11. A willingness to change opinions or conclusions if later evidence warrants it.
12. The intention to respect other people's ideas, opinions and ways of life that may be different from our own.
13. The determination not to allow our judgment to be influenced by our own likes and dislikes.

As teachers work with children toward the attainment of these attitudes it must be realized that science content and facts will be the tools with which work is done. A carpenter's tools aid him to turn out a product of his handicraft. So may the teacher's use of teaching tools aid him in the development of a child who has desirable science skills, knowledge and attitudes.

The Elementary School Science Program

Curriculum Trends

Planning new science programs or revising programs which may have been followed for several years should take into account observable trends in science education. One of these is the trend that science instruction have more precise and definite organization at all grade levels. Both the Allerton House Conference in Illinois Report[1] and the National Science Teachers Association 1960 Convention Program emphasized the importance of current science programs being organized on a K-12 basis. Such an organization stresses a sequential program in science. The allocation of science topics may be based either on individual grade levels or by grade groups such as Primary (K-3) and Intermediate (4-6).

In Illinois[2] the elementary school science curriculum usually appears in practice in three ways. They are:

1. Incidental experiences based on children's daily interests and activities.
2. Experiences integrated or correlated with other subject areas (such as social studies, arithmetic or language arts).
3. Specific science activities which are organized and taught as separate units.

When the seventh and eighth grades have been organized as self-contained classrooms, the program has been similar to the above practices. When the seventh and eighth grades have been organized on a departmental basis, science has usually been taught as a separate subject.

A second curriculum trend represents a move toward pruning the content of elementary school science programs. The popular science program built on children's interests and correlated with social studies has been criticized recently on the ground that very little of importance in science is stressed in such programs. Some critics believe that a program structured on children's interests places too much emphasis on the uses of science in daily life: how the refrigerator works, how an automobile engine works, how a house is wired for electricity, how a house is heated, how clean water

1. Report on *The Teaching of Science in Illinois*. Allerton House Conference publication. Urbana, Illinois; College of Education, 204 Gregory Hall, University of Illinois, 1957.
2. Ibid., p. 7.

reaches the household tap. In such a program very little emphasis is placed on the scientific concepts upon which these uses of science are based.

A number of experimental programs have been initiated to determine whether an elementary school science program can be based on fundamental science principles as identified by professional scientists. One such experimental program is under the direction of Robert Karplus of the University of California at Berkeley. Another effort is being directed by J. Myron Atkin and Stanley P. Wyatt at the University of Illinois. The project in California is concerned with developing instructional materials in physical sciences primarily. The Illinois project is concerned with astronomy. It seems clear at this writing that similar projects will be initiated at other campuses within the next few years.

Each of these projects reflects dissatisfaction with a science program based solely on the social utility of science. The point is made by the principal investigators associated with these experimental projects that there is confusion in the public mind between science and technology and that an elementary school science program based on children's interests stressing the "science in daily life" theme adds to the confusion. The child may come to see "science" as a series of useful gadgets that make life more pleasant rather than an exciting intellectual activity designed to uncover fundamental knowledge about the natural world.

This basic conflict regarding the criteria for selecting content in elementary school science programs is reflected in the 1960 Yearbook of the National Society for the Study of Education.[1] Several of the scientists who served as contributors to this Yearbook point to the misconceptions created in people's minds when science is confused with the social utility to which science is put.

Many readers will recognize that this basic rationale for curriculum reconstruction in science at the elementary school level is strikingly similar to the rationale for certain curriculum improvement projects at the secondary school level. The Physical Science Study Committee was initiated for the purpose of identifying concepts for a high school course that were considered basic to physics rather than teaching how certain physical principles are put to use. The Chemical Bond Approach Committee is developing a high school chemistry course that eliminates much of the descriptive material regarding technical chemical processes. The emphasis is on basic chemistry, with the chemical bond serving as a scientific as well as a pedagogical theme. Similarly a group of biologists is at work with headquarters in Boulder, Colorado developing materials for elementary school and high school biology that reflect concepts considered fundamental by professional biologists.

In the experimental program, topics such as the following are stressed: physical forces, measuring astronomical distances, life history of a star, measuring forces, flow of energy in living systems, and determination of the age of the solar system. Within each of these topics, the emphasis is placed on how scientists have arrived at knowledge rather than the knowledge at which they have arrived.

All of these projects are characterized by close cooperation between professional scientists and individuals associated primarily with the field of education. Typically, such research is initiated on college and university campuses, but to an increasing degree, teachers in the field are being involved in the various projects. It is recognized that the basic objectives of the new programs cannot be achieved without early and prolonged participation with those most directly concerned with the day-to-day problems of teaching children, namely the classroom teachers.

1. *Rethinking Science Education.* The Fifty-ninth Yearbook of the National Society for the Study of Education. Part I. Chicago: Distributed by the University of Chicago Press, 1960.

A third observable trend with regard to elementary school science programs is the employment of science consultants. It is widely recognized that many elementary school teachers need assistance in developing strong science programs. Several school systems are furnishing this assistance in the form of resource persons called science consultants. These consultants have face-to-face contacts with classroom teachers to help strengthen the science program. In addition to planning with teachers, the science consultant does frequent demonstration teaching. In most cases, he also conducts workshops designed to make teachers feel more confident in handling scientific materials appropriate for children in the elementary school.

In most of the school systems employing science consultants, it is felt that the responsibility for planning and teaching elementary school science rests ultimately with the classroom teacher, but the teacher needs help. Typically science consultants work on a flexible time schedule in which they are free to spend most of their time with teachers who seem to need most assistance.

Since the science consultant concept is relatively new, a variety of organizational patterns are in evidence with regard to the use of such consultants. A few school districts employ science consultants on a full-time basis for teachers in grades kindergarten through six. Many more school systems employ science consultants on a part-time basis. One typical pattern has an individual teaching science on a departmentalized basis in grades seven and eight, then serving as a consultant to teachers in grades kindergarten through six. Still another pattern consists of releasing an elementary school teacher part time to serve as a science consultant within the building. This is done by freeing this classroom teacher to move around the school helping with science while certain special teachers are working with his class.

Most of the organizational patterns for furnishing resource help in the form of science consultants to elementary school classroom teachers are in the experimental stage. There is no single organizational pattern that seems to be emerging at this writing.

It is fairly safe to say that the elementary school science field is characterized today in many respects by a high state of flux. Searching questions are being asked about course content in elementary school science. School administrators are wondering about the employment of elementary school science consultants. Both with regard to course content and the use of elementary school science consultants, it is possible that the next decade will see rather dramatic changes. It is hoped that personnel concerned with problems of teaching elementary school science will be alert to emerging developments in the field with a view toward carefully evaluating the possible merits of each trend.

Selection of Content

Selection of the materials to be utilized in teaching children has been variously approached by authors of science text series. There are scope and sequence charts available from several book companies which can help in the planning of a program.

Craig[1] says that science instruction should be broad in scope to provide for growth in learning about all the major aspects of the environment—the sky, the atmosphere, the earth (including rocks, soils, and minerals)—conditions necessary to life, other living things, energy, and forces (physical, chemical, and biological), and the inventions and discoveries of mankind.

1. Gerald S. Craig, *Science in the Elementary Schools*, What Research Says to the Teacher Series, p. 7. A publication of the Department of Classroom Teachers and the American Educational Research Association. Washington 6, D.C.: National Education Association, 1957.

Is there a natural sequence in science? The answer depends upon what is thought of as natural sequence. In a number of investigations attention was given to sequence to determine if there was a rigid and absolute order of subject matter items for all children everywhere. It was learned that there were many factors which made an absolute and universal sequence in science difficult if not undesirable. Scientific knowledge and the application of this knowledge are changing so rapidly that any rigid order or sequence would constantly need revision or would become obsolete. The great variation among children and within an individual child would make an inflexible program stifling to say nothing of the difference in the teachers themselves. Motivation and interests might conceivably make an activity highly satisfactory and effective with one age level while with a similar group not so highly motivated the plan would be a complete failure for the lack of these factors.

The sequence that has grown out of these research studies indicates a kind of "normal order," but it is flexible and should be considered as suggestive only--a guide, not a regimen to be followed verbatim.

A problem or topic may come up a number of times in a child's life but the treatment accorded it will differ considerably depending upon the degree of readiness and maturity of the individual.

Craig says there is a flexible sequence from a child development point of view. A child who comes to the school for the first time brings to the classroom an experiential background in science on which the teacher may draw in guiding his future learnings. Craig has also stated that it has been recognized that large important principles or concepts in science have profound influence on the thinking of people who have gained some knowledge of them. These principles are so broad and universal that they could be used as large objectives in science teaching. The term "pattern" has been utilized by some scientists to describe such basic principles as the "vastness of space," "the age of the earth and the universe," "the universality of change," "adaptation," "interrelationship," and "variation."

The best information that we have is constantly being revised to keep up with new discoveries so the content of a science program should be under constant review. Patterns, however, seem to persist as profound, pervasive principles throughout the years in spite of revisions and changes subsequent to new discoveries. The large patterns of the universe can be used as guidelines in planning for instruction in the elementary schools. Development or growth starts with the experience from infancy on and the content of science becomes more valuable and meaningful to children when they are given the opportunity for continuous orientation with the basic patterns and the nature of the environment.[1]

Consideration of the large patterns is advantageous in that attention is placed upon themes and meanings, i.e., interpretations rather than upon a study of objects. Examination and analysis of these large patterns have resulted in an elementary school science curriculum containing an emphasis upon interpretations. This is consistent with the natural interests of children and does not require the teacher to be able to identify every object in the environment to be an effective teacher.

Incidental science and objects brought into the classroom are wonderful motivating devices but will not provide boys and girls with all the science education they need. Incidental happenings and objects may be utilized as a part of the enrichment of science and the planned program should be flexible enough to provide some time for their use.

1. Ibid., pp. 9-10.

The Allerton House committee recommended that the science taught in the elementary schools not be organized as chemistry, physics, botany, or zoology though the content of these specialized sciences should be used to solve problems real to the children. The content could be organized under such headings as:

1. Living Things
2. The Earth
3. The Universe
4. Matter and Energy
5. Man's Use of Science

In the lower grades, science experiences under these headings would be introductory in nature. In the seventh and eighth grades the work should be organized under these five headings so that each major topic receives more detailed attention.

Craig[1] recommends using the following large patterns of the universe for teaching-learning experiences:

1. The Universe is Very Large—Space
2. The Earth is Very Old
3. The Universe is Constantly Changing
4. Life is Adapted to the Environment—Adaptation
5. There Are Great Variations in the Universe—Variety
6. The Interdependence of Living Things—Interrelationships
7. The Interaction of Forces—Equilibrium and Balance

Craig[2] built a format for planning the instructional materials for a year's work that may be valuable as a guide for the individual teacher. In this plan of instruction it was recommended that the child be the center of the environment. In making an environmental survey, learning activities should be organized under the following six subdivisions:

1. Beyond the Earth
2. The Earth
3. Conditions Necessary for Life
4. Living Things
5. Physical and Chemical Forces
6. Man's Attempts to Control His Environment

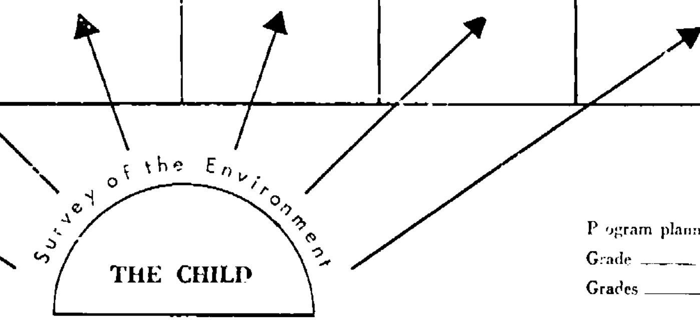
There are further possibilities of breakdown of materials under each of these subdivisions. A teacher may utilize the chart shown on the following page to insert the concepts desired for his particular grade level. Teachers of a division of the elementary school—Primary, Intermediate, or Upper Grades should work together, in order to keep repetition within the division from grade to grade at a minimum.

A desirable program of elementary science experiences can be developed by the teacher around five questions concerning our environment. Certain ideas to be studied under these questions can be drawn from the older children: hence, drawing them into the general planning. These questions are expressed as:

1. Here is our environment—what is in it and how can we understand it?
   An inventory of the community is necessary to open the eyes of the pupil to make him aware of things he contacts daily. Interrelationships between organisms and environmental factors should be stressed

1. Gerald S. Craig, *Science for the Elementary School Teacher*, pp. 93-101. Chicago: Ginn and Company, 1958 Edition.
2. Gerald S. Craig, *Science for the Elementary School Teacher*, p. 44, 1947 Edition.

Beyond the Earth	The Earth	Conditions Necessary for Life	Living Things	Physical and Chemical Forces	Man's Attempts to Control His Environment



Instructions:
Fill in five items which could be treated under each of these areas in a well rounded elementary science program.

Program planned for
Grade ________ or
Grades ________.

2. Here is our environment—how do we use what is in it?
   The use of things as we find them in nature—physical, chemical, biological are brought out.
3. Here is our environment—how have we changed it to better meet our needs?
   Utilization of the devices created by man to make a comfortable life for himself in the setting in which he finds himself brings out many of the scientific principles stressed in all the major sciences.
4. Here is our environment—how have we damaged it?
   Careless, wasteful use of our natural resources such as soil, water, minerals, wildlife, and forests have impoverished many areas and reduced their occupants to submarginal existences.
5. Here is our environment—how may we restore it?
   Development of the conservation aspects of science are brought out which will curtail the damages to our environment that have been wrought by man's occupancy. Restoration or repair methods which will return the environment to productivity should be brought out.

The 1946 Illinois curriculum guide included recommendations for selecting materials for a course of study in elementary science organized around the concepts listed below. These concepts occurred most often in the elementary science textbooks available to the schools at that time. The list was not considered complete or all inclusive. The 1946 committee suggested that it might be desirable for adaptations to be made to serve the interests, needs, abilities, and environmental experiences of the children in each school. The concepts selected were:

1. The activities of living things change with the seasons. (Primary and Intermediate Levels, only.)
2. All living things need food.
3. The air about us influences our lives in many ways. (Primary and Intermedi · Levels, only.)
4. There are many natural forces that help man.
5. Man can improve his surroundings in many ways.
6. Man has invented machines which make his work easier.
7. Energy is needed for a world at work.
8. Conservation of natural resources is necessary.
9. The earth has many neighbors in space.
10. All things are classified into orderly groups according to their characteristics.

Consideration of these concepts may be in order in planning a curriculum for current classes, since the concepts are as valid today as they were when the 1946 guide was prepared.

Organization of Content

The science content of a year's program may be organized in various ways. Many teachers feel that the authors of their textbooks know better than they what science should be taught—hence will utilize the text organization with little change. Other teachers utilize the basic outline of their textbooks but delete and supplement to meet the felt needs of their pupils. Some teachers feel that textbooks are reference books for the children they teach. They will use the books as sources of information available to all the children in seeking answers to problems.

The science program may be built around "science problems," "areas of living," or "bodies of knowledge." Regardless of the approach used the unit plan of organizing instruction has been found psychologically sound and championed as an appropriate teaching method. Therefore, in the remainder of this chapter materials have been included to clarify what is meant by the term "unit," to identify the characteristics of a well organized unit, and to illustrate how units may be organized for teaching elementary school science.

A unit consists of purposeful (to the learner), related activities developed to give insight into, and increased control of, some significant aspects of living. Teachers usually organize the subject matter to be presented around a general theme or center of interest. Rigidly following the chapter by chapter development of the textbook or adhering closely to the course of study outline will not permit much teacher-pupil planning or utilization of pupil needs in organizing instruction.

Written units are usually organized as one of three types.

1. The teaching unit—which is a briefly written unit outlining the objectives, activities, and materials to be used. They are prepared in advance of guides.
2. The resource unit or source unit—a carefully prepared series of suggestions for teachers, covering a broad area of work. It contains more material than could possibly be used and often much background material for the teacher.
3. The unit log—this is really a diary of the unit, written as the unit develops and provides an excellent basis for evaluation.

There is little agreement upon the organization of units. Most authorities feel that the individual teacher should determine the form and completeness desired. There is, however, general agreement that certain things such as objectives, the materials to be used, ideas for working with the materials and means of evaluating the results of teaching and learning should be included in the unit outline. Some unfamiliar subject areas make necessary much more detailed outlines while other well-oriented areas require very little. Some teachers in areas of special training or teachers with years of experience think through their plans and do not utilize written forms. It is well, however, to lay out the basic outline retaining the degree of flexibility necessary to vitalize the area under study.

Lee and Lee,[1] list fourteen characteristics of a good unit in any subject area.

1. Problem-centered.
2. Involved with many areas of knowledge.
3. Develops understanding of the interrelatedness of knowledge.
4. Deals with significant knowledge and understandings.
5. Deals with materials and understandings of concern to the child.
6. Directed towards the development of concepts and understandings as well as the acquiring of knowledge and skills.
7. Set up to obtain changes in the behavior of children which will result in more effective living for them.
8. Planned with the understanding of how learning takes place.
9. Planned and developed co-operatively by pupils and teacher.
10. Uses a wide selection and range of resources.
11. Provides for a wide range of experiences, learnings, and activities.

1. J. Murray Lee and Dorris May Lee, *The Child and His Curriculum*, Third Edition, p. 174. New York: Appleton-Century-Crofts, Inc., 1960.

12. Provides for continuous as well as culminating evaluation.

In considering all of the units taught during the year there are two additional characteristics with which the teacher must be concerned. They are:

13. Contributes to the total development of the child.

14. Provides for continuity in the development of the child.

A common question raised by teachers is "How do I go about starting a unit?" Developing an overview of a teaching unit is probably one of the best ways of gaining an understanding of the elements of a unit and how it should be carried out. The following steps may make the process clearer.

1. Orientation, approach, or introduction. Sufficient background must be built by some means so that the children have a basis for recognizing problems and developing guides for action.

2. Formulation of problems, or planning period. After a sufficient background has been developed for the children to raise intelligent questions, a discussion period should arise. During this time the problems and questions for further study should be raised. Some of these at least should be developed by the boys and girls giving them a share in the planning. The plan for working grows from such a discussion.

3. Working period. The working period offers the greatest challenge to the teacher. If there has been careful planning, if the work is of concern and interest to the pupils, and if the pupils know what they are to do, this portion of the unit can be very successful. The work period should be divided into two phases (a) the collection and evaluation of data—the research phase and (b) the presentation of materials, reports of readings, and research.

Some units would be concluded at this point. With others, out of this period would grow a large class activity which would be the culminating activity for the unit.

4. Culminating activities. Culminating activities are not essential but where they grow out of the work of the units they are most valuable. Such an activity might be an "open house" for parents or other classes with exhibits of work of individuals or committees or with reports of work.

5. A summary. Tying the activities used in the unit into an integrated whole through a summarization draws the unit to an effective conclusion. New units can be related to and built upon preceding ones that have been drawn to successful conclusions.[1]

Uniformity of the outline for units within a school system is desirable in that all teachers are able to understand them readily. Also if there is uniformity, a group of units on the same subject area can be drawn together for the development of resource units for help in future planning. The outline that is adopted should depend upon the phases of teaching upon which the teachers need to direct their attention. Below is an example of a suggested unit outline.

I. Overview of the unit—the main purposes of the unit should be stated briefly. The special understandings, appreciations, attitudes, and abilities to be developed should be stated also.

1. Lee and Lee, op. cit., pp. 175-188.

II. Types of learning experiences
  A. Individual experiences
  B. Group or class experiences
  C. Culminating experiences

III. Suggested problems to be developed with pupils during the class period. All may not be considered in the treatment of the unit.

IV. Materials
  A. Teacher references
  B. Pupil references
  C. Audio-visual materials and other instructional materials

V. Methods of evaluation—Techniques used will depend upon the types of problems and materials studied in the unit.

Teaching Units

During the last two decades numerous books and professional articles have discussed the unit method of teaching. Some of these have included illustrations of teaching units, many of which were developed around social studies themes.

The materials in this section are intended to provide teachers of science with selected examples of teaching units. Since the units were developed independently by different teachers, the variations in content should not be surprising. Some teachers who developed units included in this bulletin placed more stress on subject matter materials whereas others went to greater lengths in their outlining of evaluation techniques and teaching resources.

Those who use the guide should not consider the units as ones which must be taught. They may be taught in a planned sequence of units, depending on the over-all plans for a year. Screened from approximately one hundred teaching units those included will serve their primary purpose when viewed as patterns for developing other teaching units.

With the exception of the materials on teaching science at the nursery school-kindergarten level, all units follow, in general, a similar organizational pattern. The units are arranged by grade groups: N-K; Primary; Intermediate; and Upper Grades.

At The Nursery School-Kindergarten Level*

A Philosophy for Teaching Science

The science interests of preschool children should be motivated by curiosity and enthusiasm. These desirable attitudes are encouraged by appropriate, provocative materials and experiences and are protected by a friendly, understanding interpreter and guide in the person of the teacher. If the child's curiosity and enthusiasm are to be elicited by interesting experiences, he must have time and flexibility in which to explore

*Prepared by Lela Morris Phelps, Kindergarten Lecturer, University School, Southern Illinois University, Carbondale.

all possibilities. When he can experience these opportunities with a friendly group of peers, he has fun, he is inspired, and he is helped. When good things are shared, a bond is made with these things and those who have shared them. Such experiences establish attitudes in the child which are very likely to continue and to become a way of thinking and a way of approaching new experiences.

The child of three to five observes things around him. He asks "how" and "why" questions. The preschool situation offers an excellent opportunity to capitalize on this curiosity and this interest. Through nature walks, simple experiments, nature exhibits, care of pets, planting gardens, and sharing experiences, the children gain a greater awareness of their environment. They learn about the annual cycle of seasons, the nesting habits of birds, the ways of the wind the lacy beauty of snow crystals, and cloud pictures. They feel the warm sun, hear the patter of the rain, touch the spiny, pink skeleton of coral, watch the butterfly emerge from its pupa, and smell the subtle fragrance of the violet. These experiences are more meaningful because they are shared with other children of similar age and interests.

Nursery and kindergarten children need to experience and experiment rather than to be told about something. Each school and each community will offer different kinds of experiences, and those should be chosen which are closely related to the daily living of the child Even the child living in a warehouse district of a large city will be able to observe weather changes, look at snowflakes through a magnifying glass, watch beans from the grocery store germinate in a glass jar, and plant a geranium slip in a can for a Mother's Day present. The teacher should comb the school and neighborhood for possibilities and then help the children become interested in finding out about things they see.

Science experiences help language development because they give children the urge to express themselves as well as materials to talk about. Because of these common experiences they are stimulated to make up poems and stories, to paint, model or cut. Creative ability is stimulated and vocabulary is increased.

Through science experiences ideas and associations are built up, which later give the individual a clearer and better understanding of life. Many children have limited contact with growing things or pets except through their school life. Science in the nursery school fills a large place in the curriculum, providing the subject is presented in a natural manner. A child backward in joining a group at play will often enter into the making of a snow man or caring for a pet while another child, slow in entering group conversations, will break forth with a spontaneous story or song.

Nursery school experiences should satisfy a child's curiosity and should also provide that background of information needed to understand the principles he will encounter in his later contacts with nature. Nature gives the child the thrill of an explorer in a new land yet helps him relate himself consciously to the world in which he lives.

Selected Learning Experiences in Science

Activities which seem most likely to be appropriate for kindergarten children are starred. However, many of the other activities are also appropriate for the kindergarten just as some of those starred may be carried out with nursery school children. There is no definite line to be drawn.

Fall Weather

A. Science Concepts.

1. The days grow shorter in the fall.
2. The weather is cooler.

B. Suggested Procedures and Activities:

1. Talk about daylight and darkness at bedtime; at getting-up time.
2. Learn that cooler weather necessitates wearing sweaters and warmer clothes.
3. Realize that outdoor playtime is shorter.
4. Turn lights on and off as needed. Discuss why we need lights.
5. Take a walk on a pleasant September morning while sun is warm.
6. Take a walk when air is cooler noting following changes: air is cooler; sun is not so warm: grass and flowers are going to seed; birds and insects are disappearing: squirrels are storing nuts; leaves are falling.

*7. Discuss calendar and use group can make of it to record "first things", such as "first red leaf seen", "first bare tree" or "last leaf from chosen tree."

*8. Make a daily weather calendar recording the weather.

Leaves

A. Science Concepts.

1. Leaves change color in autumn.
2. The leaves fall from many trees.
3. Some leaves are red.
4. Some leaves are yellow.
5. Some leaves are brown.
6. We can rake leaves.

B. Suggested Procedures and Activities

1. Collect many leaves.
2. Sort leaves as to size, shape and color.
3. Decorate room with leaves.
4. Rake and pile leaves; walk through the dry leaves.

*5. Show how each leaf is different from any other.

*6. Press leaves for a booklet.

*7. Notice winter buds.

*8. Learn to identify three familiar leaves by their shapes: maple, oak, elm.

*9. Make spatter prints and blue prints with leaf forms.

C. Suggested References

1. *We Wonder*, Singer Science Series, p. 18.
2. *We Ask*, Singer Science Series, p. 26 and 40.
3. *Fall is Here*, Row, Peterson, and Co.

Insects

A. Science Concepts

Nursery age children learn about insects through actually catching them, holding them in their hands and placing them in a container so that they can be observed. They establish these concepts:

1. Grasshoppers can jump a long way.
2. Grasshoppers have long legs.
*3. Grasshoppers have six legs.
4. Grasshoppers are insects.
5. Grasshoppers are called grasshoppers because they hop about in the grass or fields.
6. Grasshoppers live on grass and other plants.
*7. All insects such as crickets, flies, etc., have six legs.

B. Suggested Procedures and Activities

1. Make a house for grasshoppers using two aluminum foil pans and screen wire.
2. Collect and watch grasshoppers.
3. Realize that flies, mosquitoes, and other insects are less abundant and less active in the fall.
4. Imitate grasshoppers and play music for rhythm imitated.

C. Suggested References

1. *Fall is Here, Animals Round the Year, and Animals and Their Young.* Row, Peterson, and Co.
2. *We Ask,* Singer Science Series.

Pets and Other Animals

The study of pets is particularly appropriate for use with nursery school children. For kindergarten children a study of pets may be developed using either animals of the farm or the zoo.

A. Science Concepts

1. Animals help man in many ways.
2. Man should show kindness toward all living things.
3. Many animal mothers care for their young
4. Animals need a variety of food.
5. Pets need a comfortable and safe place to rest.
6. Pets need room to exercise.
7. Animals need sunshine and fresh air.
8. Pets need a clean house.

B. Suggested Activities

1. Show pictures of pets. Discuss the points of interest each picture shows.
2. Read stories of pets.
3. Take an excursion to see pets.
4. Relate personal experiences.
5. Build pen to house pet. Most animals can be kept in a house built from an apple box and 1/4 inch screen.
6. Draw pictures of animals.
7. Paint pictures at easel.

8. Take an excursion to see mother dog and puppies, cat and kittens, hen and chicks, etc. If a child in the nursery has any one of these at home, it is exciting to have group see Johnny's very own pets.
9. Bring dog, cat, rabbit, etc. to visit school for a day.
10. Feed pets the proper food.
11. Prepare aquarium for goldfish.
12. Learn Mother Goose rhymes, such as:
    a. Bow-wow-wow
    b. Cock-a-doodle-doo
    c. Hey Diddle-diddle
    d. Higgledy, Piggledy, My Black Hen
    e. Mary Had A Little Lamb
    f. Old Mother Hubbard
    g. Pussy Cat, Pussy Cat

C. Reading Readiness

*1. Write down on reading chart all the things the children do in their care of a pet. Make this in a simple story composed by the children.

D. Stories

1. *All About Copy Kitten*, Evers.
2. *Angus and the Ducks*, Flack.
3. *April's Kittens*, Newberry.
4. *A Joke on Cinder*, Gay.
5. *Millions of Cats*, Gag.
6. *Bounce and the Bunnies*, Carroll.
7. *Make Way for the Ducklings*, McCloskey.
8. *The Little Wild Horse*, Beatty.
9. Stories from *Here and Now Stories*.
   Stories from *Told Under the Blue Umbrella*.
10. *Story of Peter Rabbit*.

E. Examples of Animals and Insects for Observation

1. For presentation in small cages:
   Mice, hamsters, chipmunks, squirrels.
2. For presentation in large cages:
   Rabbits, guinea pigs, pigeons, bantam chickens, bullfrogs, turtles.
3. For presentation in a terrarium:
   Earthworms, snails, lizards, garter snakes, small turtles, salamanders (In many cases the terrarium will have to be covered, and in other cases water will have to be provided.)
4. For presentation in insect containers (jars, etc.):
   Grasshoppers, beetles, spiders, ants, caterpillars
5. For presentation in an aquarium:
   Goldfish, minnows, polliwogs, tadpoles, water snails, crawfish.

An excellent experience in spring is to visit a small farm where children can see sheep being sheared, can see a new baby colt with its mother, baby pigs, or a new born calf. The culminating activity may be a picnic lunch and ride on a hay wagon pulled by a tractor.

Additional Science Activities for Nursery School or Kindergarten Children

1. Plant lima beans and watch development.
2. Watch sprouted potatoes grow in dark and light.
3. Plant potato cutting with an eye and watch it grow.
4. Put some seeds in water, others in soil, and others in soil and water, some in dark, some in light. Observe.
5. Bring twigs into room early in spring and watch them sprout.
6. Grow sweet potatoes and carrots in water.
7. Place stalk of celery in colored water. Observe.
8. Plant grass on sponge or wet wool flannel.
9. Observe frog eggs hatch into polliwogs and polliwogs change into frogs.
10. Make toy boats and float them on the water to observe their floating; experiment with stones, iron, feathers, and other objects to observe whether they will or will not float.
11. Experiment with a thermometer in hot, then cold water. Observe what happens to the mercury.
12. Observe the wind moving clouds, blowing the smoke, and clothes on line.
13. Make and care for an aquarium.
14. Observe both evergreen and deciduous trees.
15. Watch sand, water, balls, and other objects falling.
16. Observe the colors in nature.
17. Use stethoscope for play in housekeeping area. Let children pretend they are doctors and use stethoscope for listening to heart. Also roll up paper. Put rubber band on. Listen to heart of friend. Listen to watch. P[illegible] paper roll to ear and listen to watch.
18. Study how toys work.
19. Experiment with shadows, morning, noon and night.
20. Let children use magnifying glass to investigate.

Teaching Units for Primary Grades

*Weather**

General Objectives

1. To provide for progressive systematic pupil growth in knowledge of scientific concepts and principles.
2. To develop within the pupil scientific attitudes, leading him to rely on evidence rather than propaganda, tradition, hearsay, or superstition.
3. To develop skill in the scientific method of problem solving.
4. To develop understanding of man's relationship to his environment.
5. To provide activities which will help the pupil to develop effective work-study skills.
6. To develop an understanding of how man changes and controls his environment.

*Prepared by Doris Steinnarch, Elementary Teacher, Harrisburg, Illinois.

7. To develop an understanding of the relationship of science to the health and safety of the world.

8. To begin to acquaint the pupil with the complexity and immensity of the universe.

Examples of Specific Objectives

1. To develop an awareness of the weather and the different elements making up the weather.

2. To learn how to use a thermometer.

3. To notice the changes in the weather and what causes these changes.

4. To learn something about weather forecasting and its importance.

5. To learn how men and animals adapt themselves for living in their environment as the seasons change.

6. To develop an appreciation of the fact that even though we cannot do anything about the weather, we are constantly under its influence.

7. To acquire a new vocabulary of words and concepts.

Developmental Activities

TIME TO BE TAUGHT: Late fall or early winter. Activities suggested depend upon weather conditions.

INTRODUCTION: Call attention to bulletin board. Have title, "Weather", with room to add items as unit progresses. Call attention to science corner. See bibliography for listing of good books that should be placed in this corner.

FIRST DAY: The actual study of weather may be started by a discussion of how people get ready for winter. Some items that children will notice are:

1. Preparing the home for winter
   a. Putting up storm windows and caulking windows
   b. Putting in coal and oil
   c. Storing wood for fireplaces
   d. Protecting plants and shrubs
   e. Preparing food for winter
   f. Preparing the family clothing
2. Sudden changes in the weather
3. The beginning of any season which always receives attention in the newspaper, radio, and on television.

Ask class what they think weather is. Lead class to develop definition that weather is the condition of air around us. Next, lead into discussion of many kinds of weather.

In an informal manner, stopping to ask questions when needed, present the following information:

I. There Are Many Kinds Of Weather.

A. The sun, wind, clouds, temperature and moisture cause the kinds of weather which we have.

1. The sun gives us heat.
   Stand in the sun and then in the shade; notice the difference in the way you feel.
   a. It is warmer when the sun is shining than at night.

b. When clouds come between us and the sun, some of the sun's heat is cut off.
c. It is warmer in the sun than in the shade.

2. Some days are windy.
   a. The wind has force. Stand in the wind and in a protected spot, notice the difference.
   b. The wind blows in certain directions. Use the school flag or a direction finder to demonstrate this.
3. Some days are rainy.
   Bring pictures of clouds that bring moisture.
4. Snow is ice crystals.
   Catch and observe snowflakes if possible. If not, cut out paper snowflakes.
5. Sleet and hail are frozen rain.
   Examine sleet or hailstone if possible.
6. Some days are cloudy.
   Hold a piece of waxed paper between child and light to demonstrate how clouds cut off sun's rays.

B. The kinds of weather we may have are:
   1. Sunny
   2. Cloudy
   3. Warm, hot, cool, cold
   4. Foggy
   5. Rainy, snowy (hail and sleet)
   6. Windy

OPTIONAL: Read poems: *Fog* by Rachel Field or *The Fog Horn* by Edith Newlin. Start a weather calendar indicating the kind of weather each day.

ASSIGNMENT: Have the children look up these things for next day: Use Science corner—these questions came from listed books.

1. What is a cloud?
2. How do clouds differ?
3. What makes it snow?
4. What is hail?
5. What makes it rain?
6. How is dew formed?
7. What makes frost?
8. What is sleet?

SECOND DAY: Have individual reports on questions that children were assigned to look up for class. Present the following material in an informal discussion modified lecture method interspersed with questions to bring material to level of children.

II. The Weather Changes with the seasons.

A. The seasons are summer, autumn, winter, and spring.
B. Weather varies from season to season.
   1. Compare weather calendars from previous years.
   2. Notice and discuss the changes that come during the school year.
   3. Put seasonal activities pictures on bulletin board.
   4. Notice the changes in the sun and the changes in the length of day and night during the seasons. Sample question: Was it darker this morning when you got up than when you got up the first day of school?
   5. Show pictures of dress and activities during the four seasons of the year. Put them on bulletin board.

C. Weather varies within a season.

1. The weather may change during the day or from day to day.
   a. Record the weather at the beginning of the day and at the end of the day. Notice the change.
   b. A thermometer is used to measure temperature—Learn how to use the thermometer. It will be a good reason for counting by 2's.
      1). Heat causes the liquid in the thermometer to rise
      2). Cold causes the mercury to go down in the thermometer. Place an ice cube on thermometer- then warm it with fingers. Observe and discuss.
      3). Take temperature indoors and outdoors. Observe difference.
   c. Make a large thermometer of oak tag. Use red and white ribbon for the mercury. Fix the thermometer so that the ribbon can slide up and down. Set it with the morning temperature and change it before leaving in the afternoon.
2. Men study the weather and can tell the kind that will likely come.
   a. Tell children to listen to the weather forecast on the radio.
   b. Notice and clip the weather forecast from the newspaper. Check with local conditions for accuracy. Put on bulletin board.
   c. The Weather Bureau helps us.
      1). warns fishermen and airplanes of storms
      2). warns farmers of frost
      3). warns people of dangerous highways and streets.
   d. Make morning sky, wind, and temperature observations and predict the weather for the latter part of the day.

THIRD DAY: Continue same method of instruction. Review a few main principles of weather and seasonal weather changes.

III. Weather Influences Travel, Work, and Play.

A. Travel is dangerous when roads are:

1. Icy
2. Flooded
3. Foggy
4. Covered with snow
   a. Learn that salt melts ice. Melt ice cube with salt.
   b. Observe use of salt, sand, and cinders on city streets.

B. Weather affects work.

1. Outdoor work stops in storms, rain, or snow.
   a. Discuss kinds of work men do outside—logging, fishing, farming, road building, road and street repair, and building.
   b. Many men and machines work to clear roads after storms.
      1). Ice and snow
      2). Broken trees

C. Weather affects play.

1. Wind is needed to fly kites and to make pinwheels go.
2. Dry weather is best for jumping rope and games of ball.
3. Snow is necessary for coasting and making snowmen.

OPTIONAL: Draw pictures of "Fun in the Snow or on Ice"

FOURTH DAY: Continue same approach or technique of presenting material. Review main principles of work already covered.

IV. What is Done About the Weather?

A. We change our plans to suit weather.

1. People dress and protect themselves according to weather. Make chart showing correct apparel.
2. People change activities according to weather.
   a. Discuss seasonal work and play
      1). Farming, etc.
      2). Sports, etc.

B. Additional fuel supplies are used in winter.

C. Air-conditioning and various types of electric fans are used in summer.

SUMMARY: Show film, *One Rainy Day*, Coronet, 11 minutes.

This film shows how a storm begins with winds, clouds, thunder, and lightning; what the rain does for soil, plants, cities, and people. Suddenly, the storm stops and a rainbow appears—an excellent way to end a unit on weather.

Appoint committees to be responsible for different things for visitors the next day. Let first graders come and see displays and hear ideas learned during unit.

FIFTH DAY: First Grade Visiting Day

Bulletin boards are arranged with charts, weather forecasts, etc.
Charts on wearing apparel are developed.
Oak tag and real thermometer shown with demonstration on how to read them.
Amateur "style show" of correct dress to suit weather.
Science corner with suitable books.
Show indoor and outdoor work and play.
Art exhibit of pictures drawn about this unit (also snowflakes).
Demonstrations: Melt ice cube with salt. Hold wax paper between child and light to show effect of clouds.
Show weather calendars.
Poems to be recited or read:

Who Has Seen the Wind by Christina Rossetti
The Wind by H. Elliot
The Wind by Marion Doyle
Rain by Robert Louis Stevenson
Lots of Rain by Vivian Gouled
Clouds by Helen Wing
Little Cloud, Little Cloud by Myrtle Blassing

Evaluation

The best evaluation of science instruction is an ongoing questioning as the unit develops. It is difficult to give a teacher-made test to children at this age level. However, a vocabulary spelling test could be given of words such as these: temperature, cold, warm, forecast, winter, spring, autumn, rain, snow, hail, sleet, wind, flood, and crystal.

In attempting to assess the pupils' growth in relation to instruction in science, the teacher may use the following questions as a checklist:

1. Is he able to observe and report on his observations?

2. Is he extending his experiences into the related unknown?
3. Is he interested? Does he enjoy living with science?
4. Can the pupil define a problem? Can he understand the problem clearly?
5. Can he solve problems?
6. Can he distinguish fact from superstition?
7. Does he "wonder why" for everyday phenomena?
8. Is he developing an appreciation of the world in which he lives?
9. Are the children more aware of changes in the weather?
10. Do they comment on it more frequently, and with greater accuracy of expression?
11. Do the children show interest in repeating the experiments in the unit?
12. Do they show increased skill and confidence in handling materials?
13. Do the more imaginative suggest variations in the experiments?
14. Do the children bring in evidences of continued interest in the weather; for example, drawings of weather phenomena, news pictures of storm damage, and weather reports?
15. Are the children somewhat less resistant to the idea of being properly dressed for the weather?
16. Do they show any awareness that rules of health and safety are not simply arbitrary adult commands?

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*Living Things**

Suggested Time: Six weeks; one semester; or three weeks for each season, depending upon the teacher's viewpoint about the science program for the entire year.

I. Objectives

A. General—anticipated

1. To develop interest in the immediate environment.
2. To give knowledge of the habits of wild animals and interrelationship among them.
3. To develop the habit of careful observation of the environment.
4. To introduce the pupils to the use of the scientific method of solving problems.
5. To give knowledge through an understanding of principles and generalizations contained in the material.

B. Specific

To develop a knowledge and understanding of:

1. The changes in the environment and in the length of day and night that are indicative of changing seasons.
2. Some of the preparations made by living things for seasonal changes.
3. Some of the ways in which seasons and weather influence living things.
4. The life cycle of some plants in relation to the seasons of the year.

*Prepared by Clara Brown Young, Mc Clure, Illinois.

5. The ways land and water plants and animals have adapted themselves to the places which they live.
6. Special features that living things use to protect themselves.
7. How weather affects the activities of living things.
8. How living things adjust to the four seasons.
9. The reasons why some living things find different homes in different seasons.
10. Living things that are harmful to one another.

II. Methods and Materials

A. Initial activity—get the pupils interested.

Suggested approaches:

1. Discussion of a recent movie featuring living things.
2. An attractive bulletin board.
3. A talk by a teacher or chairman of the science department, zoo, etc.
4. Showing of a movie.
5. An attractive backdrop or large mural.
6. An attractive book exhibit.
7. Reading books or poetry.
8. Questions as guides for stimulation, for focusing of attention and gathering information. Examples:
   a. What good animal stories have the children read? Ask for reports.
   b. Do they have pets or plants at home? What kind? Have them tell about them.
   c. Of what use are plants and animals?
   d. Name some harmful living things.
9. Take a field trip through a place of plants and animals.
10. Visit a science building or science room of a school.
11. Start an aquarium or terrarium in the classroom.

B. Sequence of activities:

1. What do we need to know about the seasons?
   a. The year has four seasons: autumn, summer, winter, and spring.
   b. The days grow gradually longer and the nights shorter in spring.
   c. In fall the days grow gradually shorter and the nights longer.
   d. Days and nights are about equal length at the beginning of spring and autumn.
   e. Summer days are warm and winter days are cold.
   f. Spring and autumn have cooler days than summer.
   g. It rains in summer and snows in winter.
2. How does summer affect living things?
   a. Plants grow rapidly on warm summer days.
   b. Summer rains help plants grow.
   c. Summer is a growing time for plants.
   d. Animals are active in summer.
   e. Animals adapt to summer conditions.
   f. Sunshine is good for our bodies.
3. What changes can be seen in living things during autumn?
   a. Leaves change color and fall from trees.
   b. Living things get ready for winter in many different ways.
   c. There are many seeds on plants.
   d. Many plants produce fruit in autumn.

e. Some insects undergo changes in form.
f. There are few flowers but many seeds in the garden.
g. Autumn is the harvest time.

4. What changes and preparations can be seen in living things in winter?
   a. Animals are less active in winter.
   b. Some animals remain active during the winter, some hibernate, others migrate to a warmer climate.
   c. Homes must be heated in winter.
   d. Many animals have heavier coats.
   e. People wear heavier clothing.
   f. It is difficult for wild animals to get food in winter.
   g. Plants that live from year to year need some protection from winter cold.
   h. Some trees stay green all winter.
   i. Snow protects plants and seeds.
   j. Plants outdoors stop growing.
   k. Bird food is scarce in winter.

5. In what ways do living things change in the spring?
   a. Many baby animals are born in the spring.
   b. Animals that hibernate become active.
   c. Birds return and build their nests.
   d. Spring is the time for planting.
   e. Many changes take place in plants.
   f. Insects come out of their winter habitat.

6. How do animals help each other?
   a. Some kinds of animals called social animals live and work together in colonies.
   b. Some animals such as ants and aphids are mutually helpful.
   c. Some animals grow up in family groups.
   d. Some animals join in groups for hunting and protection.
   e. Some animals are food for other animals.

7. How do plants help each other?
   a. Some plants climb on others to reach sunlight.
   b. Decayed plants enrich the soil and thus help other plants.
   c. Parasitic plants get food and water from other plants.
   d. Some plants furnish shade and protection for other plants.

8. How do men and animals help plants?
   a. Bees and other insects carry pollen from one flower to another.
   b. Birds eat destructive insects.
   c. Earthworms cultivate the soil.
   d. Animals scatter seeds.
   e. Man protects and improves plants.

9. How do plants help us?
   a. All of our food comes directly or indirectly from plants.
   b. We use plants for food, clothing, rubber, wood and medicine.
   c. Plants hold the soil in place and thus help prevent floods and dust storms.

10. How do animals help us?
   a. Animals furnish materials for food, clothing, and other by-products.
   b. Some animals work for us—others protect us.
   c. Some animals destroy plants and animal insects.
   d. Some animals make good pets.

11. How do plants help animals?
    a. Plants help animals by providing food.
    b. Plants help animals by providing shelter.
12. How do living things harm one another?
    a. Some insects are great enemies of man, animals, and plants.
    b. Animals use either plants or other animals for food.
    c. Some plants are poisonous to animals.
    d. Some kinds of plants (bacteria) cause disease in other plants, and in animals.
    e. Stronger plants take food materials, sunlight, and water from weaker ones.
13. How can we conserve living things that help us?
    a. We raise and take care of plants and animals on the farm or ranch.
    b. Conservation of living things means their wise use and protection.

III. Evaluation

A. Through various methods and techniques, measure child's ability to recognize plants and animals in his immediate environment, with an understanding of how they live and what they mean to man.
B. Observe child's interests and participation in nature hobbies.
C. Notice changes in attitudes toward opinions and superstition.
D. Note evidences of child's widening interest.
E. Check for growth in powers of scientific observation.
F. Has the class gained in:
    a. Ability to work together because of their activities in connection with this unit?
    b. Understanding of some of the ways in which seasons and weather influence living things?

IV. Culminating Activities

A. Have an exhibit of the work done during the unit.
B. Have a flower pageant, make costumes and have tableaux, songs, and dances.
C. Give oral reports on some phases of animal or plant life.
D. Give a play with plants and animals as characters.
E. Recite some poems about living things.
F. Make an aquarium or terrarium in the classroom.
G. Visit the zoo.

V. Suggested Activities

A. Direct learning experiences.

1. Study of plants
    a. Just before winter comes, dig up a piece of sod from a place where the grass looks brown and dry. Put the sod in a flat dish in a sunny place and water it. Watch the grass begin to grow.
    b. Plant seeds in two pots. Water one pot, but not the other. See which seeds grow.
    c. Plant seeds in two pots. Keep one pot of beans, for example, in the room and water it. Keep one in the ice box or a cold place and water it. Compare the results and form conclusions.
    d. Place a stalk of celery or a carrot in a glass of water. Put a teaspoon of red ink in the water. Let the celery stand in the sunlight. At the end of two hours take the celery out and see what has happened and why.
    e. Place bean seeds between pieces of moist blotting paper or towel paper and notice changes in seeds.

f. Plant some apple, peach, maple, elm and plum seeds in the fall. Watch to see how long it takes each to grow.
g. Fill a glass jar with earth. Plant peas or beans in the earth, but right next to the glass of the jar. Observe the growth of these plants.
h. Plant bulbs such as narcissus or tulip. Observe the changes that take place.
i. Take the children out into the neighborhood to see the produce of the fall gardens and the plants growing by the wayside.
j. Make a collection of bright colored autumn leaves. Compare colorings and shapes.
k. Make a collection of seeds which have wings to help them travel through the air. Examples are maple, elm, ash and box elder seeds.
l. Make a collection of seeds which have parachutes on them. Examples are cattail, dandelion and milkweed seeds.
m. Cut the stem of several kinds of plants lengthwise and across. Compare their construction for supplying food to the plant.
n. Bring in garden seeds such as beans, peas, corn and wheat. Soak overnight. Examine them and cut open the larger ones to find the baby plant. Determine where the food is stored.
o. Arrange flowers for classroom and consider them during the year when flowers are most plentiful.
p. In early spring place branches of apple, forsythia, willow, maple, poplar, or plum trees in water and watch the buds develop.

2. Study of animals

a. Collect caterpillars and watch how they prepare for winter.
b. Watch for birds that travel in flocks, noticing the time of year when such flocks are seen.
c. Make a collection of different kinds of nests.
d. Send for silkworms, and watch their development.
e. Observe bees around fruit blossoms or near a clover field.
f. Bring in cocoons, care for them until spring, and note what happens. Watch a moth change as it comes out of a cocoon.
g. Dig down into an ant hill in late fall to see whether any ants can be found.
h. Watch the ants in an ant hill to see how they help each other. Establish an ant colony in the classroom.
i. Learn the names of birds that visit feeding shelves in winter.
j. Make a trip to a beaver colony to watch the beavers at work.
k. Observe activities of pets brought to the classroom.
l. Watch the mother dog, cat, hen, duck, robin, horse, etc. Note how they take care of their babies.
m. Set up an aquarium in the school room.
n. Observe some group of social animals such as beavers, honey bees, wasps, or ants, to find out how they work together.
o. Hunt for examples of hibernation of insects in late fall or winter. Look in hollow trees, under loose bark, in cracks in walls, etc., for hibernating butterflies, moths, flies or other insects.
p. Visit a zoo, museum, taxidermist, or anyplace where animals may be seen.
q. Observe earthworms in a box or jar in the school room.
r. Observe bird shapes, arrangement of feathers, and wing length.
s. Secure samples of wood which have been inhabited by termites.
t. Keep pets in the room for a short period to learn how to care for them.

3. Study of plants and animals
   a. Build a terrarium for a frog, turtle or salamander.
   b. Plan a field trip to observe at different seasons, flowers, ferns, trees, seeds, and varieties of animal life.

B. Vicarious learning experiences
   1. Show the film *Autumn on the Farm* which shows how the changing seasons affect plants, animals, farm life and farm activities.
   2. Show the film *Spring is Here*, which shows the early signs of spring, such as spring flowers, frogs, eggs, woodchuck coming out of hibernation, birds feeding their young, chicks hatching, elks shedding antlers, new arrivals at zoo, squirrel family, bear cubs and young fawn.
   3. Show the film *Animals of the Woods* to note how wild animals live.
   4. Report happenings in the community such as planting gardens, pruning and planting trees.
   5. Display pictures of animals that live in herds such as buffaloes, reindeer, wild horses and antelope on the bulletin board.
   6. Make a bird chart recording when different birds return.
   7. Make posters, picture books and charts of living things in relation to the unit such as parts of plants used for food, plants that provide materials for clothing, etc.
   8. Make a drawing of seasonal changes and discuss what the picture tells.
   9. Make feeding shelves for birds for home and school and observe habits of birds.
   10. Construct an observation house for an ant colony.
   11. Make a collection of seeds for comparisons.
   12. Plan an exhibit of animal products such as fur, ivory, pearl, feather, felt, and leather.
   13. Make a group scrapbook of pictures and stories of animals that help man.
   14. Collect pictures of wild animals that are used for food such as ducks, geese, deer, bears, elk, antelope, frogs, squirrels and rabbits.
   15. Collect pictures of
       a. Animals that are protected by changing coloration.
       b. Animals that kill other animals for food, and in turn are killed by their own enemies.
   16. Work in small groups making a detailed picture story of any subtopic such as insects change in autumn, animals and plants in our school yard change, fur bearing animals make changes.
   17. Make a sand table project and invite parents and other guests to see it.
   18. Have an exhibit in some public place displaying creative material (booklets, drawings, poems, etc.).
   19. Make a panorama of seasonal activities.
   20. Give class reports summarizing activities carried on in connection with the problem.

C. Creative learning experiences
   1. Find and read short stories in books and magazines on the problem.
   2. Introduce a newspaper clipping on groundhog day developing a scientific attitude with the children debunking superstitions about animal life.
   3. Compose poems and stories about living things.
   4. Tell stories of their observations or own experiences about animals.
   5. Write up experiences in booklet form for future reading.
   6. Review records of experiments carried on in connection with the problem.

VI. Bibliography and Other Resources

A. Books for the teacher:

Allen, Arthur A. *The Book of Bird Life.* New York: D. Van Nostrand Company, Incorporated, 1939.

Allen, Gertrude E. *Everyday Birds.* Boston: Houghton Mifflin Company, 1943.

Ashbrook, Frank G. *Blue Book of Birds, Yellow Book of Birds, Green Book of Birds, Red Book of Birds.* Racine, Wisconsin: Whitman and Co., 1946.

Buck, Margaret Waring. *Animals Through the Year.* Chicago: Rand McNally and Co., 1945.

Comstock, Anna Botsford. *Handbook of Nature Study.* Ithaca, New York: Comstock Publishing Company.

Hylander, Clarence J. *The World of Plant Life.* New York: Macmillan Company.

Kroeber, Elsbeth, and Wolff, Walter H *Adventures With Living Things.* Boston: D. C. Heath and Company, 1945.

Parker, Bertha M. *Living Things.* Evanston, Illinois: Row, Peterson and Company.

Patch Edith M., and Howe, H. E. *Through Four Seasons.* New York: Macmillan Company.

Pauli, Wolfgang F. *The World of Life.* Boston: Houghton, Mifflin Company, 1949.

Williams, Samuel H. *The Living World.* New York: Macmillan Company, 1937.

Any good general biology or general science book for high school or junior high school.

B. Books for children:

Blough, Glenn O. *An Aquarium.* Evanston, Illinois: Row, Peterson and Company, 1950. 36 p.

Blough, Glenn O. *The Insect Parade.* Evanston, Illinois: Row, Peterson and Company, 1949. 36 p.

Blough, Glenn O. *The Pet Show.* Evanston, Illinois: Row, Peterson and Company, 1948, 36 p.

Blough, Glenn O. *Useful Plants and Animals.* Evanston, Illinois: Row, Peterson and Company, 1948. 36 p.

Harpster, Hilda T. *The Insect World.* New York: The Viking Press, Incorporated, 1947. 211 p.

Jenkins, Dorothy H. *The Children Make a Garden.* Garden City, New York: Doubleday and Company, Incorporated, 1936. 70 p.

McKay, Herbert. *Easy Experiments With Plants.* Fairlawn, New Jersey: Oxford University Press, 1931. 98 p.

Morgan, Alfred. *A Pet Book for Boys and Girls.* New York: Charles Scribner's Sons, 1948. 36 p.

Parker, Bertha M. *Adaptation to Environment.* Evanston, Illinois: Row, Peterson and Company, 1948. 36 p.

Parker, Bertha M. *Animals of the Seashore.* Evanston, Illinois: Row, Peterson and Company, 1950. 36 p.

Parker, Bertha M. *Animals We Know.* Evanston, Illinois: Row, Peterson and Company, 1950. 36 p.

Parker, Bertha M. *Dependent Plants.* Evanston, Illinois: Row, Peterson and Company, 1949. 36 p.

Parker, Bertha M. *Domesticated Plants.* Evanston, Illinois: Row, Peterson and Company, 1948. 36 p.

Parker, Bertha M. *Fishes.* Evanston, Illinois: Row, Peterson and Company, 1950. 36 p.

Parker, Bertha M. *Garden Indoors.* Evanston, Illinois: Row, Peterson and Company, 1949. 36 p.
Parker, Bertha M. *Plant and Animal Partnership.* Evanston, Illinois: Row, Peterson and Company, 1948. 36 p.
Parker, Bertha M. *Plant World.* Evanston, Illinois: Row, Peterson and Company, 1948. 36 p.
Zim, Herbert S. *Plants.* New York. Harcourt, Brace and Co., 1947. 393 p.

C. Suggested textbooks:

Beauchamp, Wilbur L., Crampton, Gertrude, and Gray, William S. *Look and Learn* (Curriculum Foundation Program) Chicago: Scott, Foresman and Company, 1955. 72 p.
The Wonderworld of Science Series. (Revised Edition.) New York: Charles Scribner's Sons, 1957.
Elementary Science Books for Grade School, Junior Scientist Series, Grades 1-6. Chicago: Rand McNally and Company, 1955.
Science Series. Chicago: J. B. Lippincott Company, 1956.
Schneider, Herman and Nina. *Heath Elementary Science Series.* Boston: D. C. Heath and Company, 1959.

D. Teaching aids and materials:

1. Booklets, pamphlets, pictures, and posters: Sources:

American Forests Products Industries, 1319 Eighteenth St., N. W., Washington 6, D. C.
American Humane Education Society, 180 Longwood Avenue, Boston 15, Massachusetts.
American Nature Association. 1215 Sixteenth St., N. W., Washington 6, D. C.
Brooklyn Botanic Garden, Elementary Education Department, 1000 Washington Avenue, Brooklyn, N. Y.
F. E. Compton and Company, 1000 North Dearborn Street. Chicago 10, Illinois.
Ed-U-Cards Company, 248 West 23rd Street, New York 1, New York.
Informative Classroom Picture Publishers, 40 Ionia Avenue, N. W., Grand Rapids 2, Michigan.
National Science Teachers' Association, 1201 Sixteenth St., N. W., Washington 6, D. C.
Training Aids, Incorporated, 7414 Beverly Blvd. Los Angeles 56, California.
Western Pine Association, Yeon Building, Portland 4, Oregon.
Westinghouse Electric and Manufacturing Company, School Service, 306 Fourth Avenue, Pittsburgh 30, Pennsylvania.

2. Films:

Animal Neighbors (Coronet) (Sound) (Color) 10 minutes.
Animals Growing Up (EBF) (Sound) 10 minutes.
Autumn On The Farm (EBF) (Sound) 11 minutes.
Common Animals of the Woods (EBF) (Sound) 11 minutes.
Plant Growth (EBF) (Sound) 11 minutes.
When Winter Comes (Coronet) (Sound) (Color) 11 minutes.

Producers and Distributors:

(Cor) Coronet Instructional Films, 65 East South Water Street, Chicago 1, Illinois.

(EBF) Encyclopedia Britannica Films, Incorporated, 1150 Wilmette Avenue, Wilmette, Illinois.

(LF) Library Films, Incorporated, 25 West 45th Street, New York 19, New York.

(YA) Young America Films, Incorporated, 18 East 41st Street, New York 17, New York.

3. Filmstrips:

Animal Homes (PS)
Animals and Their Young (PS)
Animals Around the World (PS)
Common Animals of the Woods (EBF)
How Animals Are Protected From Their Enemies (SVE)
How Animals Get Food (Long)
How Animals Grow Up (Long)
Animals and Their Young (SVE)
A Home for Water Plants and Animals (PS)
Balance Among Living Things (PS)
How Plants Live and Grow (PS)

Producers and Distributors of Filmstrips:

American Council on Education, 744 Jackson Place, N. W., Washington, D. C.
Eye Gate House, 330 West 42nd Street, New York 18, New York.
Jam Handy Organization, 2900 E. Grand Blvd., Detroit 11, Michigan.
Long Filmslide Service, 944 Regal Rd., Berkeley, California.
Row, Peterson and Company, 1911 Ridge Avenue, Evanston, Illinois.
Popular Science Publishing Company, 363 Fourth Avenue, New York 10, New York.
Society for Visual Education, Incorporated, 1345 Diversey Parkway, Chicago, Illinois.
Visual Sciences, 599 N. Street, Suffern, New York.

Since filmstrips are available in such large quantities, it is suggested that the local school system make a selected choice of materials for the children.

4. Encyclopedias:

Britannica Junior
Childcraft
Compton's Pictured Encyclopedia
World Book

*Preparations for Winter**

I. Main Problem: What problems are encountered in preparing for winter?

II. Sub-Problems

A. Why do leaves of trees turn different colors and then drop off in autumn?
B. How do birds prepare for winter?

*Prepared by Lucille Cole, Elementary Teacher, Harrisburg, Illinois.

C. What must animals do to insure a safe winter?
D. How do we meet the coming hardships of winter?

III. Objectives

A. To enhance acquaintance with life through observations of man, plant life, and animal life.
B. To determine why birds fly south in autumn.
C. To study the changes in leaves and trees.
D. To gain an appreciation of the art in nature.
E. To become familiar with selected science terms such as annual, perennial, and hibernation.
F. To learn about the survival problems of animals and plants in winter.
G. To acquire an understanding of how people prepare for their living comfort and health in winter.

IV. Subject Matter

A. Why do leaves of trees turn different colors and then drop off in the fall?
 1. Three chief pigments in green leaves.
  a. Yellow
  b. Orange
  c. Green
   1). Most abundant
   2). Dominates other colors so they are hidden
   3). Produced only in sunlight
 2. Complete or partial disappearance of green pigment.
  a. Lack of sunlight
  b. Low temperature
  c. Dryness
  d. Injuries and diseases of various kinds
 3. Result of complete or partial disappearance of green pigment.
  a. Yellow and orange colors appear
 4. Some leaves turn red.
  a. Not due to pigment in leaves
  b. New color formed in cell sap
  c. Due to mild autumn temperature, not frost
   1). Accompanied by bright sunshine
   2). On cloudy autumn days leaves will likely show less red brilliance.
 5. Nature cuts leaves from the branches.
  a. Thin cork-like plate is between base of leaf and tree.
   1). Later two or more plates form.
    a). Tightly stuck together
    b). Suddenly plates fall apart
   2). Leaf now falls to the ground.
  b. What happens to the plates after the leaf has fallen?
   1). One remains to cover wound on tree.
    a). Look for little plate when examining scar on twig.
    b). Plate on twig prevents scar from "bleeding" or losing sap after leaf has fallen.
   2). Another plate remains on base of leaf.

c. Why little plates appear when they do.

1). Plates are formed while leaves are green--stick together tightly and leaves cannot fall off.

2). Conditions occur to make plates separate causing leaf to fall such as:

a). Low temperatures

b). Less sunshine

c). Dry weather

6. Change of color and falling leaves take place in autumn:

a. Colors change first

b. Leaves fall next

7. Why leaves fall:

a. Leaves make food

1). Need plenty of sunshine

2). Need much water

a). For manufacturing food

b). Leaf must be full of water to function properly

c). To carry finished food from place to place in plant

3). Constantly drawing up more water than they need

a). Tiny openings in underside of leaf to let water escape

b). Trees must be careful of their water supply in winter because they are so large and use so much.

4). Can only make food during warm sunny months

a). Weather gets colder, leaves work more slowly, and at last stop.

b) Even though they stop work they continue to send off water. Water is scarce in winter; trees cannot afford to lose that water.

5). Trees drop leaves in order to save moisture.

a). Water cannot escape through thick bark.

B. What is meant by annual and perennial?

1. Plants do not grow outside in the winter or in the cold climates.

a. Starve to death.

b. Roots cannot draw up sufficient water if ground is frozen.

2. Annuals die and seeds are left for new plants.

3. Perennials live on food stored away in roots and stems.

C. How do birds prepare for winter?

1. Migration:

a. Summer homes and food are buried under snow.

1). Fly south to warmer climate

2). Fly to places where there is food

b. Instinct makes them migrate at the right time.

c. Fly in flocks by day and night

1). Journeys usually are long and tiresome; birds rest between stages of flight.

2). Dangerous journey; may hit high wires or buildings.

2. Some birds remain in winter.

a. Do not mind cold, if dry.

b. Must have food supply.

c. Grow extra warm coat of feathers.

D. What must animals do to have a safe winter?

1. Dangers of cold winters.
   a. Animals must fight against deep snows and strong winds.
   b. Huge snowbanks block homes and keep animals from getting out to hunt food.
   c. Scarcity of food causes more animals to die from starvation than from freezing.
2. Ways in which animals find food and safety in winter.
   a. Brightly colored berries, seeds, unpicked fruits, mosses, buds, nuts, tender roots and branches, insects in bark of trees, smaller animals, food which friendly people provide.
      1). Winter animals often great thieves; farmer must guard grain, vegetables, and seeds.
   b. Fewer animals to eat food.
      1). Birds fly south.
      2). Frogs and turtles spend winter in mud holes.
      3). Snakes and toads crawl underground.
      4). Woodchucks spend winter in tunnels underground.
      5). Chipmunks, skunks, and bears have long winter naps.
      6). Muskrats and beavers stay in homes which they have built for the winter.
   c. Colors of most animals in winter protect them from enemies. White and gray cannot be seen well against snow and gray of earth and trees.
      1). Squirrels' coats turn from brown to gray.
      2). Rabbits become nearly white.
      3). Weasels turn from reddish-brown to white with black tip on tail, called ermine in winter.
      4). Chickadees are black and gray.
      5). English sparrows turn from brown to gray.
3. Hibernation:
   a. Means a long winter sleep.
   b. Animals must get plenty of food to eat during autumn months.
      1). Food makes them fat.
      2). Helps to keep them alive during their long sleep.
   c. Animals that hibernate
      1). Woodchucks hibernate all winter:
         a). As weather becomes colder woodchucks become more sluggish.
      2). Bears find dens in which to sleep all winter.
         a). Find honey and other foods to make them fat so they do not starve in winter.
      3). Raccoons sleep all winter.
         a). Eat plenty of food in autumn.
         b). Layer of fat under skin takes place of food.
         c). Fur and fat together keep raccoon warm.
      4). Striped ground squirrels
         a). Must eat a great deal to fatten themselves.
         b). Also store food underground so that when they awake in spring they have food.

c). Dig holes in ground straight down for several inches; then turn sharply. As they dig on in they make many more turns; will sleep in one room all winter; other rooms are used for food storage.

5). Badgers sleep all winter.

a). In autumn they sleep heavily.

b). Fat helps them keep alive.

6). Bats travel to warm places to sleep.

a). Go into caves or buildings for protection from snow.

b). Many hang from ceilings close together to keep warm.

c). Wake up now and then but just make funny squeaky noises.

d). If bat goes to sleep without being fat it will die before spring; at death their claws loosen and bats drop.

e). One can make a noise and poke them but they will continue to sleep; it is a much heavier sleep than ours.

4. Animals that do not hibernate:

a. Beavers do not sleep all winter.

1). Remain in their dams.

2). Store plenty of food for winter.

3). Strengthen the dam so that it will not break when stream is frozen and ice pushes against it.

b. Porcupines sleep a great deal in winter but do not hibernate.

1). In autumn and winter hunt for salt.

a). Go near houses to find wood or leather with salty taste.

b). If they find an ax or other tool which someone with sweating hands was using, they will chew the handles to get the salt.

2). Porcupines are too lazy to climb trees in which to sleep.

a). Crawl into holes under rocks.

b). Dig holes in deep snow.

c. Chipmunks do not sleep all the time.

1). Can climb trees but never live in them.

2). Busy in autumn storing seeds and nuts in little rooms in underground burrows for winter food.

a). When hungry they go to these pantries and get food.

3). When very cold they sleep for several days at a time.

d. Gray squirrels are active all winter.

1). In autumn store away all kinds of nuts, small pine cones, and seeds for winter food.

2). Dig hole in ground with front teeth, drop nut into hole; press nut down with nose, cover with dirt.

a). Bury each cone, nut and seed in a different hole.

b). Can smell buried food even when ground is covered with snow.

c). Bury more nuts than needed; nuts may eventually start new trees.

3). Do most work during the daytime, sleep at night.

4). In autumn they may be seen gathering nuts and burying them by moonlight.

e. Flying squirrels do not hibernate.

1). Must find nuts, seeds, and grain to eat all winter.

2). Do not put all food in one place.

f. Opossums do not sleep all winter.

1). Eat so much in autumn that they get very fat.

2). Always slow animals, but in autumn are very slow.

3). Sleep for days at a time; then look for food.

4). Playing opossum; if an opossum is curled up asleep at the front of a tree and a dog comes along and awakens it, opossum does not run but stiffens its muscles and lies perfectly still even though dog may turn it over with his nose; when dog leaves, opossum relaxes its muscles, gets up and climbs a tree.

E. How do people prepare for winter?

1. Heavier diet.

a. Eat more meats and hearty foods in winter.

b. Eat plenty of hot foods.

2. Wearing apparel.

a. Wear coats, hats, and gloves.

b. Girls wear woolen dresses, skirts, sweaters; boys wear heavy trousers, jackets, sweaters, etc.

c. Wear warmer underclothing.

3. Ways to have warm houses.

a. Heating our homes.

1). Hot air heat

a). Large pipe brings air in from outdoors and sends it over blazing coals in iron furnaces.

b). Fresh air becomes hot and rises through pipes throughout the house.

c). Heated air flows out into the rooms through small iron gratings called registers.

2). Hot water heat

a). Round furnace made of strong iron and wrapped in a fireproof coat of asbestos to keep in heat.

b). Water boiler attached to furnace; water heated almost to boiling point.

c). Pipes carry hot water from furnace to radiators throughout house.

3). Steam heat

a). Furnace looks like hot water furnace but boiler is made so that steam instead of hot water can flow through the pipes.

b). Can burn oil which is better than coal since it is cleaner and leaves no ashes.

4). Fireplaces; by burning wood room gets additional heat.

b. Keeping out small currents of air from around the windows and doors

1). Weather-stripping around the windows and doors

2). Putting up storm windows and storm doors

3). Putting up heavier curtains and drapes

V. Suggested Approaches

A. Class discussions of children's daily observations.

B. Display of books and other illustrated materials around classroom and on reading table.

C. Walk through woods to observe changes in nature.

VI. Class Activities

A. Make booklets of drawings and paintings showing signs of autumn.
B. Write a play and present it to children of classroom.
C. Prepare a table of models showing man, animals, birds, and plants preparing for winter.
D. Carry out some of the following experiments:
   1. Demonstrate the heat in rays of sun by holding a magnifying glass in the sunlight so that the converged light rays center on back of child's hand.
   2. Put red ink into a glass of water. Put white flower in glass. After day or so flower will turn pink or red. Water goes up through stem into flowers and leaves.
   3. Put nuts and seeds on a tray or stand. Place outdoors. Watch for birds, squirrels, chipmunks, etc. Observe what they do with the nuts and seeds.
E. Make blueprints of leaves; wax some leaves.
F. Examine leaves and twigs for leaf scars.
G. Try to find food storage bins used by various animals.
H. Take review test on unit. This test would be given to upper third graders only. Examples of test items follow:

VII. Unit Test on Preparations for Winter

Part A. Underline the correct answer.

1. In the autumn birds fly
   north   west   east   south
2. Plants which live all winter long store their food in the
   stems   flowers   leaves   seeds
3. Hibernation means
   a long walk   a long animal
   a long lea   a long sleep
4. In the autumn people begin to
   put screens on the windows   open the doors
   turn off the heat   put storm windows up
5. Annuals are plants which live
   for three years   for three months
   all year round   in spring and summer
6. Perennials are plants which live
   in the winter   all year round
   at night   in the summer

Part B. Put the name of the animal in the correct column.

	Hibernates	Does Not Hibernate
Beaver		
Chipmunk		
Porcupine		
Badger		
Woodchuck		
Bat		
Gray squirrel		
Striped ground squirrel		
Raccoon		
Flying squirrel		
Bear		
Opossum		

Part C. Choose the correct words from the list below and write them in the blank spaces.

Birds which______fly______in the fall. They go to look for______homes and more______.

The birds which do not fly away in the winter have a hard time finding food to eat. We must help them by putting______and______ on stands for them. These birds grow______coats of______for the cold winter.

fat	south	crumbs	warm
feathers	migrate	food	heavier

Part D. Choose the correct words from the list below and write them in the blank spaces.

We______our homes by using______ and______. We put up storm windows to keep out the cold______. By eating______foods and______foods, such as______ we make ourselves stronger. We should wear______clothing; ______and______are a great protection against the cold.

fireplaces	air	hot	furnaces
sweaters	warm	hearty	meats
heat	coats		

Part E. Choose the correct answer from the list below and write it on the blank line.

Animals that do not______may______for ______food away for the long______. Some store ______and______in their homes. These homes are called______. Some animals______their food in different places.

seeds	hide	burrows	winter
store	nuts	sleep	hibernate

Part F. Choose the correct answers from the list below and write them in the blank spaces.

There are three chief colors in green leaves. There is more______ than any other color. When the green color disappears______and ______appear. Nature cuts______from the branches. A thin______is between the base of the leaf and the______. After the leaf has fallen one plate remains to cover the______on the tree and it forms a______. Another plate remains on the______of the leaf.

base	green	leaves
twig	scar	plate
yellow	wound	orange

Part G. Answer the following questions.

1. Why do birds fly south?
2. Why do animals hibernate?
3. Why do leaves turn different colors in autumn?
4. Why do leaves fall?
5. Name some things people do to prepare for winter.

VIII. Instructional Materials

A. Books:

Out of Doors. Craig and Baldwin. Boston: Ginn & Company.
Winter Comes and Goes. Syracuse. New York: The L. W. Singer Company.
Science Stories Book II. Beauchamp. et al. Chicago: Scott, Foresman and Company.
The Wonderland of Science. Knox. Books I and II. New York: Charles Schribner's Sons.
Do You Know. Janet Smalley. New York: William Morrow and Company.
Red, Blue, Green, Books. Ashbrook. Racine, Wisconsin: Whitman Publishing Company.
Birds. Ruby Murphy. Racine, Wisconsin: Whitman Publishing Company.
Cattail House. Phoebe Erickson. Chicago: Children's Press, Inc.
Look and Learn: All Around Us; How Do We Know? Chicago: Scott, Foresman and Company.
Play With Plants. Millicent E. Selsam. New York: William Morrow and Company.
Bear Cubs and Their Mother. Charlotte Barske.
Story and Verse for Children. M. B. Juber. New York: Macmillan Company.
Listen and Sing. The World of Music Series. New York: Ginn & Company.
The Music Hour, Kindergarten and First Grade Book in Series. New York: Silver Burdett Company.

B. Filmstrips:

Gray Squirrel
Black Bear Twins
Common Animals of the Woods
Life and Work of the Beaver
Opossums to Bats to Picet Pins

C. Films:

Common Animals of the Woods
Gray Squirrel
Black Bear Twins
Birds of North America
Autumn on the Farm
Winter on the Farm
Beaver
Let's Look at Animals
Autumn Is an Adventure
Insects
Squeak, the Squirrel
Chucky Lou: Story of a Woodchuck
Seasonal Changes in Trees

Teaching Units for Intermediate Grades

*Immunization**

Suggested Time: Two weeks (30 minutes daily)

I. General Objectives

A. To learn how we control disease.
B. To know and understand the importance of immunization.

II. Specific Objectives

A. To learn the meaning of the word "immunization."
B. To learn how we can control disease through immunization.
C. To learn and understand why it is important to protect our bodies from disease.
D. To learn and understand how a microscope works.

*Prepared by James Neeley Stewart, Elementary Teacher, Carbondale, Illinois.

E. To learn that when we protect ourselves from disease we are also helping people in our family and community stay well.
F. To learn how germs are spread.
G. To learn what communicable diseases can be controlled by immunization.
H. To learn why we should cover our mouths when we sneeze or cough.
I. To learn why we should wash food before eating it.

III. Materials

A. Posters

1. Immunization—Made by teacher
2. Coughing—County Tuberculosis Association
3. Sneezing—County Tuberculosis Association
4. Washing hands—County Tuberculosis Association

B. Films:

1. *Defense Against Invasion*
2. *How Disease Travels*

C. Resource Person

1. Doctor or nurse from the county health department.

IV. Instructional Methods

A. Lecture

Doctor or nurse from county health department.

B. Discussion

1. After the doctor or nurse is finished talking let pupils ask questions on topics not clear to them.
2. After the doctor or nurse has left, discuss what he or she has talked about.
3. Discuss field trip to city garbage disposal area.
   a. What they are to look for.
   b. Explain that this is a breeding place for flies, rats, mosquitoes and other harmful insects and bacteria.
   c. Explain how insects and rodents carry harmful bacteria.
5. Explain why it is important to cover your mouth with a handkerchief or tissue when sneezing or coughing.

C. Field trip

Visit a city garbage disposal area.

D. Demonstrations and experiments

1. Squeeze bottle filled with water. This shows direct contact, and the importance of using a handkerchief or tissue to cover the mouth.
2. Petri dish experiment
   Cough into a petri dish of agar—cover and let stand for a day—observe growth of bacteria in dish.

E. Activities:

1. Learn words
   Bacteria, fungi, virus, micro-organism, microscope.
2. People to know
   a. Louis Pasteur   b. Robert Koch
3. Draw a picture of the different colonies of bacteria observed in the petri dish.

4. Write a theme about what was seen on the field trip.
5. Examine a microscope. Explain how it works.
6. Observe under a microscope impurities in water that has been exposed for a period of time.

V. Procedure—Two weeks

A. First day—Introduction

1. Put on the bulletin board the word "IMMUNIZATION" and a large question mark.

Immunization?

2. A discussion should take place after everyone has seen the bulletin board.
3. What does the word mean? Why is it important to everyone?
4. Preview film—*Defense Against Invasion.*

B. Second day

1. See film *Defense Against Inva ion.*
2. Discuss concepts that are shown and discussed in film such as:
   a. The importance of immunization
   b. Ways in which disease enters the body
      1). Through the mouth
      2). Through the nose
      3). Through breaks in the skin
   c. How quickly invading organisms multiply
3. See the film again. This time discuss the meanings of such words as:
   a. Invasion
   b. Vaccination
   c. Immunization
   d. Formula
   e. Veins and arteries
   f. Bacteria
   g. Microscope

C. Third day

1. Change the bulletin board.
   Put up posters from the County Tuberculosis Association on coughing, sneezing, and washing hands.
2. Do "squeeze bottle" demonstration.
   a. Fill squeeze bottle with water. Explain that when you cough or sneeze, a fine spray is discharged similar to the one given off when squeezing the bottle.
3. Discuss the posters on the bulletin board.

D. Fourth day

1. Discuss and demonstrate the petri dish experiment.
   a. Cough into a petri dish of agar.
   b. Cover and let stand for a day.
   c. Observe growth of bacteria colonies in the dish.

2. Learn words
   Bacteria, fungi, virus, micro-organism, microscope
3. Discuss the contributions of Louis Pasteur and Robert Koch.
4. Draw a picture of the different colonies of bacteria observed in the petri dish.

E. Fifth day
1. Observe under a microscope the impurities in the water brought in by the pupil.
2. Explain why we should not drink from open cisterns and wells.
3. Examine the microscope, and explain how it works.

F. Sixth day
1. See film *How Disease Travels.*
2. Discuss the film.
3. Discuss what we may expect to see on the field trip to the city garbage disposal area tomorrow.

G. Seventh day
Take trip to city garbage disposal area.

H. Eighth day
1. Write a theme about what was observed on the field trip.
2. Discuss how disease bacteria might be carried and spread from the garbage disposal area.
   a. By flies and mosquitoes
   b. By rats and other rodents

I. Ninth day
1. Explain and discuss why we should always wash food before eating it.
   a. The possibility that flies or rats have come into contact with it
   b. Also sprays are used on foods in some areas.

J. Tenth day
1. Summarize the two weeks' activities by letting different members of the class talk on the subject they were most interested in.
2. Read some of the best themes written about the field trip.
3. Have another showing of the film *Defense Against Invasion.*
4. Invite parents to attend school.

VI. Evaluation—Ways to Evaluate the Unit

A. Written tests covering subjects in the unit.
B. The teacher should observe the children to see if any new habits or attitudes have been formed.
C. Check on the pupils to see if they have enlarged their vocabularies. The best way to do this is to see if they know the meaning of such words as immunization, microscope, micro-organisms, etc.

VII. Resources

A. Film—*Defense Against Invasion* (12 minutes, color) Walt Disney Cartoon, available from the Department of Public Health, State of Illinois.
B. Film—*How Disease Travels* (10 minutes) available from Institute of International Affairs, 499 Pennsylvania Avenue, N. W., Washington 25, D. C.

C. Illinois Tuberculosis Association, 730 South Sixth Street, Springfield, Illinois.

D. Encyclopedias
   1. Britannica Junior
   2. World Book

*The Solar System**

Specific Objectives of this Unit

1. To further acquaint the children with the solar system and the affects that it has upon our earth. This involves specific basic understandings such as the following (from the section titled, "What do we need to know about the sun?"):
   a. The sun is our source of light and heat.
   b. The sun is necessary to life.
   c. The sun is a ball of hot gases.
   d. The temperature at the surface is about 11,000°F.
   e. Iron, lead, tin, and other substances found on the earth are found on the sun in the form of gases.
   f. The diameter of the sun is more than 100 times that of the earth.
2. To present all concepts in such a manner as to contribute as much as is possible to the general objectives for the science program as previously outlined.

Length of this Unit

The length of time to be devoted to this material will of course be determined by the situation at hand. By broadening or narrowing the scope of activity in any or all of the subtopics, the teacher may adjust this material to his particular needs.

I. The Problem

What do we need to know about the solar system?

II. Significance of the Problem

The child should know about the solar system and its relationships.

A. A study of the solar system answers certain basic questions concerning:
   1. The earth
   2. Other planets
   3. The sun
   4. The moon
   5. Space travel

B. Our earth is a member of the solar system and the other planets and especially the sun and moon influence it in regard to:
   1. Weather
   2. Tides
   3. Time
   4. Seasons
   5. Light and heat

C We are on the threshold of a new age—one of exploration in space—and the children should have a background of facts and understandings in order to adjust to the changes that will surely result.

*Prepared by Robert E. Rea, Graduate Student, Southern Illinois University, Carbondale.

III. Anticipated Learning Outcomes

To develop a knowledge and understanding of:

A. The earth in relation to the solar system.
B. The other planets including the sun and the moon in relation to the solar system.
C. The fundamentals of space travel.

IV. Solution of the Problem

A. Content that may be used in solution of the problem.

1. What do we need to know about the earth?
   a. What is the earth's orbit?
   b. How does the earth's rotation cause night and day?
   c. How does the earth's tilt cause seasons?
   d. How fast is the earth moving?
   e. How do we tell time?
   f. What is the relation of the earth to the rest of the solar system (size-distance)?
   g. What are some of the theories concerning the earth's origin?
   h. What is the effect of the gravitational pull of the other members of the solar system upon the earth?
2. What do we need to know about the moon?
   a. What is the moon?
   b. What are some theories concerning the origin of the moon?
   c. Where does the moon get its light?
   d. What causes the phases of the moon?
   e. Why is life impossible on the moon?
   f. Why is the moon sometimes visible during the day?
   g. What is the relation of the moon to eclipses?
   h. Why do we see only one side of the moon?
   i. What is the relative size of the moon to the earth?
   j. How far away is the moon?
   k. How is the earth different from the moon?
   l. How does the moon affect the earth?
3. What do we need to know about the sun?
   a. What is the sun?
   b. What are some theories concerning the origin of the sun?
   c. How hot is the sun?
   d. Where does the sun get its heat and light?
   e. How big is the sun?
   f. How far away is the sun?
   g. Why doesn't gravity pull the earth into the sun?
   h. How is the sun different from the earth?
   i. How does the sun affect the earth?
   j. What is vitamin D and why is it important to our health?
4. What do we need to know about the other planets?
   a. What are planets?
   b. How many planets are there?
   c. Where did the planets come from?
   d. What are other planets like?
   e. What is the effect of the gravitational pull of the other planets?
   f. What is the effect of the gravitational pull on the other planets?

g. From what source do the other planets get their light?

h. What is the relation of the other planets to the sun and earth? (size-distance)

i. What are the differences in rotation and revolution of the other planets?

j. Are conditions on any of the other planets favorable to life?

k. What are asteroids or planetoids?

5. What do we need to know about space travel?

a. What are the possibilities of space travel?

b. What principles of travel would be used in space?

c. What would the conditions of a space trip be like?

d. What are the special problems likely to be encountered in space travel?

e. What are the satellites teaching us?

f. How fast would a space ship have to travel?
1). Seven miles per second—"speed of release."
2). Influenced by the distance to be traveled.

g. Which planets are we likely to visit?
1). Those which are near enough.
2). Those which may be suitable to life.

B. Suggested activities.

1. Introducing a study of the solar system.

a. Make a display consisting of a number of the children's level books in the bibliography at the end of this unit. Display the books at some convenient place in the room sufficiently in advance of the time planned to start the study to allow the children to look them over (may be as much as one or two weeks depending upon the amount of time children will have to browse through the books). Encourage the interest the children will begin to show.

b. Display a bulletin board consisting of current articles and/or good pictorial material concerning the solar system a day or two in advance of the time planned to start the study.

c. Use one of the films listed in the film section of this unit to arouse interest about the solar system.

2. Direct or concrete learning experiences.

a. Outdoor observation of the sun and moon by day and the moon by night.

b. Demonstration of night and day. Use the globe and a flashlight as the globe rotates on its axis the light from the flashlight representing the sun lights one side while the other side is in darkness.

c. Demonstration of solar and lunar eclipses. In a darkened room use flashlight and two balls representing the earth and sun to represent a *solar* eclipse. Let earth ball pass between the moon and sun to represent a lunar eclipse.

d. Experiment showing phases of moon. To represent the moon use a basketball. To represent the sun use a flashlight. Darken the room and turn on the flashlight. Hold the ball at arm's length higher than the light. Your head represents the position of the earth. Move the ball around your head. The phases of the moon will be reproduced.

e. Construction of a sun dial. Make a clock face and place in the center of this face an object that will cast a shadow. This object may be made out of cardboard or a pencil may be used.

3. Vicarious learning experiences.

a. Keep a chart of the times of sunrise and sunset each day to observe the lengthening and shortening of the days during the summer and winter seasons. (Information can be obtained from radio, newspapers, or television.)

b. Construct a bulletin board of current events and/or pictorial material concerning the solar system.

c. Use films to introduce the study and/or to gain more information after the unit has been started.

d. Collect materials for demonstrations and experiments.

e. Use photographs, slides or slidefilms of the sun, moon, and planets to gain more information or to maintain interest.

f. Visit an observatory if possible.

g. Listen to radio programs concerning space travel, the solar system, and astronomy.

h. Watch television programs concerning space travel, the solar system, and astronomy.

i. Construct a chart showing the phases of the moon. Get data from texts or encyclopedia. The chart is the outgrowth of the experiment on the phases of the moon.

j. Construct a solar system model. A model of the solar system gives better meaning to the relationship of the objects in it. Such a model may be simply drawn or made with cut-out planets and sun on the first scale given below or it may be made with planets formed of papier-maché on the second scale suggested for a 15-foot wall space. These may be hung on wires or fastened to a board along the wall. It is important to note the different scales necessary for size and distance and to explain the reason for this.

Scale for drawing solar system on 24-inch art paper:

Distance scale—1 inch=250,000,000 miles

Size scale—1/16 inch=about 4,000 miles

Planet	Distance from Sun	Size (Diameter)
Mercury	3/32 inch	1/16 inch
Venus	5/16 inch	2/16 inch
Earth	1/2 inch	2/16 inch
Mars	3/4 inch	3/32 inch
Jupiter	2-1/4 inches	1-5/16 inches
Saturn	4-1/4 inches	1-1/16 inches
Uranus	8-7/8 inches	1/2 inch
Neptune	14 inches	9/16 inch
Pluto	18 inches	7/16 inch

Scale for making solar system in a room 15 feet square.

Distance scale—1 foot=250,000,000 miles

Size scale—1 inch=8,000 miles

Planet	Distance from Sun	Size (Diameter)
Mercury'	1-3/4 inches	1/4 inch
Venus	3-1/4 inches	7/8 inch
Earth	5 inches	1 inch
Mars	6-1/2 inches	1/2 inch
Jupiter	2 feet	11 inches
Saturn	3 feet 3 inches	9 inches
Uranus	7 feet	3-7/8 inches
Neptune	11 feet	3-1/2 inches
Pluto	15 feet	7/16 inch

k. *Construction of a small telescope.* Ask the local optometrist for help. Secure two convex lenses (may be obtained from an optometrist) which will give a magnifying power of twenty. With a twenty-power lens one may be able to see the rings of Saturn and moons of Jupiter. The focal length of the front lens divided by that of the back lens should equal twenty or more, for example: 40 and 2, 20 and 1, or 30 and 1½. Secure two cardboard tubes, one a little longer than the focal length of the eyepiece and small enough to slide into the end of the larger tube. Paint the insides dull black. Cut rings of heavy cardboard that will slip into the larger tube. When the glue is dry, place the objective lens on the ring. Put the other ring on top of the lens. Glue it tightly. Do the same to the smaller tube, using the other lens. Fit the smaller tube inside the larger one until you get the proper focus by looking through the telescope at a distant object.

l. Compile a group notebook showing experiments, charts, pictures, clippings, drawings, and reports developed throughout the unit.

m. Arrange committees to formulate material into a form useful to future classes.

n. Develop a program for an audience in which reports, demonstrations, experiments, and collections are shown or explained by individuals or committees.

4. Abstract learning experiences:

a. Have the children use the library in finding answers to their questions.
b. Include oral and written reports and round table discussions.
c. Write letters to different sources for additional information.
d. Read stories, legends, and myths concerning the subject.

C. Evaluation

1. Should be a continuing part of all activity.
2. Culminating activities may permit evaluations of accomplishments.
3. Evaluation procedures and standards are determined by the objectives set up at the beginning of the unit.
4. Observe the children to see if they have become "solar system conscious."
5. Use various types of tests throughout the unit to determine if functional learning is taking place.

V. Teaching Resources

A. Films:

*The Big Sun and Our Earth**
Depths of Space
Doctors in Space
Earth and the Seasons
*Energy from the Sun**
Frontier to the Space
Man and The Moon
*The Moon**
*The Moon and How it Affects Us**
Ocean Tides
Our Mr. Sun
Solar Energy
*The Solar Family**
*The Solar System**
The Space Scientist
The Sun
The Sun and How it Affects Us
*The Suns Family**
Tides
*A Trip to the Moon**
*The Starry Universe (Filmstrip)**

*Available from the film library at Southern Illinois University on a rental basis.
Sources of the others may be obtained from the Educational Film Guide, Volume 1954-1958 and the Annual Supplements.

B. Pamphlets and bulletins:

Haskin Service, 1200 I Street, N.W., Washington 5, D.C.—*Astronomy Today*, 1952.

American Meteorite Museum, P.O. Box 146, Sedona, Arizona—*Chips From the Moon* 1947.

Field Enterprises Educational Corporation, Merchandise Mart Plaza, Chicago 54, Illinois—*Earth; Star*, 1957.

Field Enterprises Educational Corporation, Merchandise Mart Plaza, Chicago 54, Illinois—*Space Travel and Guided Missiles*, 1957.

Maryland Academy of Science, Enoch Pratt Library Building, 400 Cathedral Street, Baltimore 1, Maryland—*Graphic Time Table of the Heavens* (Annual).

Science Research Associates, Incorporated, 57 West Grand Avenue, Chicago, Illinois—*Operation Moon*, 1955.

Science Research Associates, Incorporated, 57 West Grand Avenue, Chicago 10, Illinois—*Rockets Into Space*, 1955.

C. Books for teacher:

Abbot, C. G. *The Earth and Stars*. New York: D. Van Nostrand Company, Incorporated, 1946.

Blough, Glenn O. et al. *Elementary School Science and How to Teach It*. New York: Holt, Rinehart and Winston, Inc., 1958.

Caidin, Martin. *Vangard*. New York: E. P. Dutton and Company, Incorporated, 1957.

Craig, Gerald S. *Science for the Elementary School Teacher*. Boston. Ginn & Company, 1947.

Gamow, George. *The Birth and Death of the Sun*. New York: The Viking Press, 1940.

Goodwin, Harold L. *The Science Book of Space Travel*. New York: F. Franklin Watts, Incorporated, 1954.

Hoyle, Fred. *The Nature of the Universe*. New York: Harper & Brothers, 1950.

Ley, Willy. *Rockets, Missiles and Space Travel.* New York: The Viking Press, 1951.

Leyson, Burr W. *Man, Rockets and Space.* New York: E. P. Dutton and Company, 1954.

Marshack, Alexander. *The World in Space: The Story of the International Geophysical Year.* Camden, New Jersey: Thomas Nelson and Sons, 1958.

Richardson, Robert S. *Exploring Mars.* New York: McGraw-Hill Book Company, Incorporated, 1954.

Richardson, Robert S. *Second Satellite.* New York: Simon and Shuster, Incorporated, 1957.

Richardson, Robert S. *Planet Earth.* New York: Simon and Shuster, Incorporated, 1957.

Skilling, W. T., and Richardson, R. S. *Sun, Moon and Stars.* New York: McGraw-Hill Book Company, Incorporated, 1946.

Whipple, F. L. *Earth, Moon, Planets.* Massachusetts: The Harvard Press, 1952.

Books for the children:

Benedick, Jeanne. *The First Book of Space Travel.* New York: F. Franklin Watts, Incorporated, 1954.

Blough, Glenn O, and DePencier, Ida B. *How the Sun Helps Us.* Evanston, Illinois: Row, Peterson and Company. 1950.

Branley, Franklyn M. *Mars.* New York: The Thomas Y. Crowell Company. 1955.

Branley, Franklyn M. *Experiments in the Principles of Space Travel.* New York: The Thomas Y. Crowell Company, 1955.

Clarke, A. C. *Going Into Space.* New York: Harper and Brothers, 1954.

Clarke, A. C. *The Exploration of the Moon.* New York: Harper and Brothers, 1954.

Coombs, Charles. *Skyrocketing into the Unknown.* New York: William Morrow and Company, Incorporated, 1954

Del Ray, Lester. *Rockets Through Space.* Philadelphia: John C. Winston Company, 1957.

Frank, R., Jr. *Experimental Planes.* New York: The Thomas Y. Crowell Company, 1955.

Frost, Frances. *Rocket Away.* New York: (Whittlesey House) McGraw-Hill Book Company, 1953.

Gailant, Roy A. *Exploring Mars.* New York: Garden City Books. 1956.

Gallant, Roy A. *Exploring the Moon.* New York: Garden City Books. 1955.

Gallant, Roy A. *Exploring the Universe.* New York: Garden City Books, 1956.

Gamow, George. *The Moon.* New York: Abelard-Schuman, Ltd., 1953.

Gaul, Albro T. *The Complete Book of Space Travel.* New York: World Book Company, 1956.

Goodwin, H. L. *Real Book About Space Travel.* New York: Garden City Book Company, 1952.

Lewellen, John. *The True Book of Moon, Sun, and Stars.* New York: Alfred A. Knopf and Company, 1957.

Lewellen, John. *You and Space Travel.* Chicago: Children's Press. 1951.

Leyson, Burr W. *Man, Rockets and Space.* New York: E. P. Dutton and Company, 1954.

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Moore, Patrick. *The Boy's Book of Space.* New York. Roy Publishers, 1956.
Moore, Patrick. *The Worlds Around Us.* New York: Abelard-Schuman, Ltd., 1956.
Neurath, Marie. *Speeding into Space.* New York: Lothrop, Lee and Shepard Company, 1954.
Parker, Bertha M. *The Earth's Nearest Neighbor.* Evanston, Illinois: Row, Peterson and Company, 1950.
Parker, Bertha M. *The Sky Above Us.* Evanston, Illinois: Row, Peterson and Company, 1946.
Parker, Bertha M. *The Sun and Its Family.* Evanston, Illinois: Row, Peterson and Company, 1950.
Poole, Lynn. *Your Trip Into Space.* New York: (Whittlesey House) McGraw-Hill Book Company, 1953.
Ross, Frank Jr. *Space Ships and Space Travel.* New York: Lothrop, Lee and Shepard, 1954.
Wilkins, H. Percy. *Clouds, Rings and Crocodiles.* Boston: Little, Brown and Company. 1955.
Wyler, Rose. *Planet Earth.* New York: Abelard-Schuman, Ltd., 1952.
Zim, Herbert S. *The Sun.* New York: William Morrow and Company, 1953.

*Reproduction of Plants**

I. General Objectives

A. To acquire a simple understanding of ways in which plants reproduce.
B. To learn the part flowers play in reproduction.
C. To acquire a knowledge of ways in which seeds and fruits are useful to man.

II. Specific Objectives

A. To learn the different parts of flowers and some of the other parts of the plant.
B. To learn how seeds are formed in flowers.
C. To learn the ways in which plants reproduce other than by seeds.
D. To learn how pollen is carried.
E. To learn the different parts of the seed.
F. To learn how seeds travel.
G. To learn how seeds and fruits are useful to man other than in reproduction.

III. Basic Understandings

A. Flowers are the part of a flowering plant that produces seeds.
B. The parts of a flower are the petals, sepals, pistils and stamens.
C. Stamens produce pollen: pistils produce ovules.
D. A grain of pollen must join the ovule before it can become a seed.
E. Pollen is carried by the wind and by insects.
F. Many plants produce seeds.
G. Every seed is made up of a tiny plant, some food for the plant, and a seed coat.
H. Plants have their seeds in many different kinds of seed packages.
I. Most seeds die before they find a place to grow.
J. Seeds travel in different ways.
K. We eat many kinds of seeds and fruit.
L. We use flowers for decoration in our homes and yards as well as for food.

*Prepared by Ruth Huller Schoen, Elementary Teacher, Christopher, Illinois.

IV. Suggested Approaches

A. Film or slides of flowers or seeds.
B. Experiments or demonstrations with seeds of a fruit.
C. Use riddles about seeds, flowers, or fruit.
D. Conversation as a result of a bouquet of flowers brought to the teacher.
E. A visit to a flower garden or nursery.
F. Poems, stories or songs about a seed or flower.
G. A new kind of flower brought to school.

V. Suggested Guide

A. Sexual reproduction in plants

1. Parts of the flower

a. Motivation

1). Use some large pictures of different flowers.
2). Bring some flowers to class and start a discussion.

b. Understandings

1). The parts of the flower are the sepals, petals, pistils, and stamens.
2). Sepals protect the petals, pistils and stamens until the flower opens.
3). Stamens produce pollen.
4). Pistils produce ovules.
5). Not all flowers have all four of these parts.
6). Before an ovule can become a seed, a grain of pollen must join it.

c. Suggestions

1). Show the parts of the flower on a chart or diagram.
2). Show the parts on the real flower---breaking off the different parts. (Use a tulip, a peach blossom or a tiger lily.)
3). Have the children touch the stigma.
4). Cut open the pistil to show the ovules.
5). Make a collection of pictures of flowers for the bulletin board.
6). Use microscope to examine the ovules and other parts of the flowers.

2. Travel of pollen

a. Motivation

1). Make grains of pollen out of yellow clay.
2). Ask children of what use the bright color and sweet odor of a flower might be.

b. Understandings

1). Pollen travel from the stamen to the pistil where little tubes begin to grow from the pollen.
2). The pollen material in the grain flows through the tube into an ovule in the ovary.
3). The pollen grains are carried from one plant to another by the wind and by insects.
4). Sweet odors and bright-colored petals attract insects who carry the pollen grains.
5). Many flowers have their petals arranged in threes or in fives.

c. Suggestions

1). Use a diagram to show how pollen travels to the ovule.

2). Visit a hive of bees and watch them bring back bags full of pollen.
3). Watch flowers in their own yards and have them keep a list of insects and other animals visiting them.
4). Make a chart of names of flowers with sweet odor and pretty colors for attracting pollen carriers.
5). Examine pollen grains under a microscope.
6). Examine a flower that is fading to see if pollen sacs are still full of pollen.
7). Try to find flowers with different kinds and numbers of sepals and petals.

3. Seeds: What are they?

a. Motivation
1). Show seeds of different kinds.
2). Ask for suggestions on how they are different and alike.

b. Understandings
1). All seeds do not look alike.
2). Seeds differ in color, size, and shape.
3). A seed has three parts: the tiny new plant, the food stored around it, and the seed coat that protects it.

c. Suggestions
1). Show movie *Seeds Grow Into Plants.*
2). Show them the parts on a diagram.
3). Experiment: Soak seeds of different kinds in water for several hours. Take off the seed covers and find the little plants inside the seeds—a bean seed for example.
4). Experiment: Put seeds of different kinds in a saucer with moist blotter. Cover saucer with plates of glass and watch the seeds sprout.
5). Make a collection of seeds. Glue on cardboard with pictures of flower next to them, put them in cellophane envelopes, or in a divided box.

4. Packages of seeds

a. Motivation
1). Bring some seed packages to school for them to see.
2). Ask them if they can name some ways that seeds are packaged.

b. Understandings
1). Plants have their seeds in different kinds of packages.
2). There are different names for these packages: pods, berries, melons, burs, cores, and gourds.

c. Suggestions
1). Show class examples of "seed packages." Open the packages.
2). Use pictures of packages and help children identify them.
3). Count the number of seeds in different packages.
4). Make sure the children all have an example of some package to count or touch.

5. Seed travel

a. Motivation
1). Remind them of experiences that they or their mothers have in trying to keep the weeds out of the garden.

2). Ask the cl...en . y have ever come out of the brush or weeds with seeds on their socks.

3). Read them a story about the travel of a certain seed.

b. Understandings

1). Not all seeds travel in the same way.

2). Seeds have many ways of traveling:

a). Float through the air

b). Are shot out of the pods

c). Jump for short distances

d). Float on the water

e). Travel along the ground

f). Are carried by birds and animals

g). Are carried on boats, trains, cars, wagons, or airplanes.

c. Suggestions

1). Use ripe seed pods of balsam. Touch the pods and watch them shoot out the seeds.

2). Take seeds from milkweed pods and blow them around.

3). Make blueprints of seeds that have parachutes.

4). Make a chart indicating ways seeds have of traveling.

5). Put seeds with wings, parachutes, and nothing in a pan of water to see which float and which sink.

6). Notice how a coconut is protected from an ocean journey.

7). Show class a walnut and ask class how it might travel.

8). Use a piece of heavy cloth (woolen) and test seeds to see which kinds hold on best.

9). Drop locust pods on table to see them coast.

10). Show the film *Seeds and Seed Travel.*

11). Use riddles about seeds.

12). Read stories about seeds and their travels.

B. Asexual reproduction

1. Motivation

a. Bring in a potato plant just dug up or ask a child from a farm to bring a plant. Ask the children how they think the plants were started.

b. Show them a movie on the different methods of reproduction besides by seeds.

2. Understandings

a. There are many ways in which plants reproduce using only one parent.

b. New plants can grow from stems sent out from the mother plant. either on the surface or underground.

c. Plants can grow from the end of a leaf.

d. New plants can grow from roots or bulbs.

e. Grafting is used to reproduce new plants.

f. Some plants grow new plants from tiny bits called spores.

3. Suggestions

a. Show a movie or slides of ways plants reproduce asexually.

b. Show them how plants grow from:

1). Bulbs—onions, lilies

2). Cuttings—coleus, geranium

3). Leaves—African violet
4). Grafting—roses, fruit trees
5). Spores—ferns, mosses, mushrooms
6). Runners—strawberries
7). Roots—sweet potatoes
8). Plant pieces, buds—Irish potatoes

c. Have children start some plants on their own at home or in the school room.
d. Have discussions about the plants they have at home.
e. Use charts or diagrams to show the different ways plants grow.
f. Have a field trip to someone's garden.

C. Usefulness of flowers, seeds, and fruits.

1. Motivation

a. Bring a nut or fruit to class and talk about it.
b. Ask children if they know why the seeds are important to them.
c. Read them a story about the usefulness of some of our seeds, fruits, and flowers.
d. Provide them with reading material on the subject or give them reference pages and books.

2. Understanding

a. We eat many of our seeds such as: nuts, cereals, coffee or cocoa, some vegetables, and seasoning seeds.
b. Seeds grow into foods and flowers.
c. Men earn a living growing seeds, fruits, and flowers.
d. Fruits are eaten by both man and animals.
e. Flowers supply us with food such as the cauliflower and the broccoli.
f. Flowers furnish us with seeds.
g. Flowers help us to get honey.
h. Flowers are used for decoration in the home and in the yard.

3. Suggestions

a. Make a list of fruits that are eaten, a list of seeds that are eaten and also the flowers.
b. Make a collection of each.
c. Read about the uses of each.
d. Use diagrams and pictures of each.
e. Show a movie about the uses of each.

VI. Experiments or Demonstrations

A. Plant seeds in sawdust and observe the growth of the young plant.
B. Dig up a small clump of grass, shake off the soil and rinse the roots. Find separate little plants or joints.
C. Put sweet potato in a jar of water, with pointed end down. Cover sweet potato with water half way up. Put it in a warm, dark place. It will show in ten days. When vine begins, put in sunlight.
D. Cut open an onion and examine it.
E. Soak some lima beans and then split them open. You can see the baby plant with its two seed halves and its tiny root.
F. Soak several seeds overnight and then lay them on a flat piece of cotton. Place cotton between two pieces of glass. Tie string around glasses to hold in place

and set on end in a dish of water. Cotton becomes moist. Set dish in a sunny warm place. Watch it grow and keep a record.

G. Plant an onion bulb in a shallow glass dish. Put pebbles around to hold it up. Use just enough water to cover part of the bulb. Keep it at this level. When roots form, take it out of the warm, dark place.

H. Cut a bit of stem from a coleus plant and place it in a glass of water in a sunny place. Roots will grow from the cutting. Then plant it in a pot with soil and sand.

I. Fill a dish with damp sand and push the stem from an African violet leaf into the sand. Cover the dish with a glass jar. Roots grow down into the sand from the base of the leaf.

J. Leave a piece of bread outdoors all day. Then place it in a glass jar. Put a wet blotter in the jar, too. Screw on the metal cover and put it in a warm place. Blue and black mold will form.

K. Plant onion seeds and an onion bulb and see which grows faster.

L. Other experiments are found in the suggestions under the suggested guide.

VII. Other Activities

A. Make a collection of flower pictures for the bulletin board.

B. Make a large collection of different fruits and separate them into different types of seeds and fruits.

C. Make a trip to watch a hive of bees bring back pollen.

D. Watch plants growing in the garden and list the insects and animals visiting the flowers.

E. Gather buds of different kinds of flowers.

F. Read poems, stories, and riddles about the different flowers, fruits, and seeds.

G. Collect fruits and seeds that have good ways of traveling.

H. Make a chart showing the different parts of a flower.

I. Make a collection of nuts.

J. Visit a fruit market or grocery store or a flower shop.

K. Report on favorite fruits.

L. Examine seed and flower catalogs.

VIII. Correlating Activities

A. Music—Sing songs about the flowers or fruit.

B. Arithmetic—Make up problems using seeds, flowers or fruit. Have children count seeds in seed packages.

C. Language Arts—Learn new words, spellings and meanings concerned with the unit. Write thank you notes and letters for field trips or to friends about the unit. Make up stories or poems.

D. Art—Decorate the bulletin board with drawings of different flowers and fruit or pictures of them.

E. Physical Education—(outside)—Play games using the names of different fruits and flowers.
Inside—Use riddles and have the children guess what they are. Blindfold the pupils and give them a fruit to guess.

F. Geography—Learn about the different kinds of plants growing in different climates.

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X. Visual Aids

A. Charts
   1. Parts of flowers
   2. Different flowers
   3. Different fruits
B. Diagrams on paper or blackboard showing the travel of pollen to the ovary
C. Pictures of fruits, seeds, and flowers
D. Models of seeds and fruits and flowers
E. Use of the seeds, fruits, and flowers themselves
F. Films or slides

Seeds Grow Into Plants	*Garden Plants and How They Grow*
Seed Dispersal	*Planting Our Garden*
Flowers at Work	*Food From Our Garden*

Teaching Units for Upper Grades

*What Is Matter?**

I. Introduction

This unit should introduce a series of units concerning matter and its various aspects. It should bring out how all matter is alike and how each form differs. In addition, some simpler changes which matter undergoes should be explained. Finally, a simple explanation of the composition of matter should be made. In every case, all information should be related to the everyday life and experiences of the pupils. This unit should require about ten days of work.

II. General Objectives

A. To realize that matter is anything that takes up space and has weight.
B. To understand that different materials may be recognized by definite characteristics.

*Prepared by Stanley L. Evans, High School Science Teacher, New Athens, Illinois.

C. To appreciate the molecular theory as an explanation of many facts concerning matter.

D. To develop some ability in handling equipment and properly observing experiments.

E. To realize how a knowledge of matter and its properties may be applied to everyday situations.

III. Specific Objectives

A. To show that all matter takes up space and has weight.

B. To show that all materials are matter.

C. To demonstrate that all solutions are clear, cannot be filtered, and are uniform throughout.

D. To show that suspensions are mixtures which do not follow the rules laid down for solutions.

E. To teach that solvents are materials that dissolve other materials.

F. To show that some materials are insoluble.

G. To explain that a theory is an idea which is accepted as true.

H. To explain that all matter is made up of molecules.

I. To explain that molecules are in constant motion and that there is empty space between them.

J. To show that the molecular theory explains why matter acts the way it does.

K. To show that solids have a definite shape and volume.

L. To show that liquids have a definite volume but no definite shape.

M. To show that gases have neither shape nor volume.

N. To show that solids and gases will dissolve in liquids.

O. To teach that a solution is a mixture.

P. To teach which solvents are effective on certain solutes.

IV. Developmental Activities

A. Teacher activities:

1. Present an idea of the number of materials in the world.
2. Initiate discussion of how man uses various materials.
3. Point out how solids, liquids and gases resemble each other.
4. Point out how solids, liquids and gases differ.
5. Perform demonstration experiments to emphasize these properties.
6. Lead discussion on the results of the experiments.
7. Initiate discussion of common solutions and suspensions.
8. Explain how solutions are made and used.
9. Exhibit some common solutions and suspensions and, if possible, make some of these in class.
10. Test various solutions with filter paper and effect of light.
11. Help class test various materials for solubility.
12. Make an ammonia fountain to show solubility of gases in liquids.
13. Point out that certain materials may be identified by their characteristics.
14. Demonstrate the test for starch with iodine.
15. Help class test various solvents for stain-removing ability.

16. Present the molecular theory of matter as simply as possible.
17. Lead a class discussion bringing out the important points as they apply to the pupils.

B. Pupil activities:

1. Compile a list of common materials.
2. Take part in a discussion about the properties of matter.
3. Observe demonstrations showing the characteristics of matter.
4. Observe and assist in experiments showing the characteristics of the states of matter.
5. Check at home to see how many solvents are commonly kept there.
6. Observe solutions exhibited by the teacher and write a short paper on differences between solutions and suspensions.
7. Experiment to test validity of observations.
8. Bring various stained materials and check solvents for dissolving ability.
9. Help check various solutes for solubility.
10. Observe an *ammonia* fountain and write an explanation of this experiment.
11. Take part in class discussion on molecular theory of matter.
12. Draw some illustrations to show the arrangement of molecules in different states of matter, in solutions and in suspensions.
13. Take part in a general review of the unit as a whole.
14. Take a unit test.

V. Instructional Materials

A. Outline of material to be covered.

1. Introduction
   a. There are innumerable materials in the world.
   b. The study of matter is chemistry.
   c. This unit concerns what we know about matter.
2. How all matter is alike.
   a. All matter takes up space.
   b. All matter has weight.
   c. Energy neither has weight nor takes up space.
3. The states of matter
   a. Solids have a definite shape and volume.
   b. Liquids have a definite volume but no definite shape.
   c. Gases have neither a definite shape nor volume.
4. Physical changes that matter undergoes
   a. Matter may be changed from one state to another.
   b. Mixtures are two or more materials put together.
   c. Solutions are molecular diffusions.
   d. Suspensions are mixtures of two states of matter.
   e. Solvents are materials that will dissolve other materials.
   f. Water is our best solvent.
5. The molecular theory of matter
   a. All matter is made of small particles called molecules.

b. All molecules are constantly in motion.
c. There is empty space between molecules.
d. Molecules are so small that they are only visible with an electron microscope.

B. Important terms

1. Matter
2. Solid
3. Liquid
4. Gas
5. Volume
6. Solution
7. Suspension
8. Solvent
9. Dissolve
10. Soluble
11. Molecule
12. Molecular Theory
13. Theory
14. Filter
15. Insoluble
16. Fact

VI. Demonstrations and Useful Materials

A. Characteristics of matter
1. Materials: Balance, weights, brick, bottles with different shapes, water, basketball, air pump, cork.
2. Principles: Weigh and measure each item showing whether they do or do not change. This may be used to show the properties of all matter and also to show the difference between the states of matter.

B. Solutions
1. Materials: Coffee, copper sulfate (or potassium permanganate), salt, 3 beakers, 3 test tubes, filter paper, water, funnel.
2. Principles: Make solutions with the above and check them for the characteristics of typical solutions.

C. Suspensions
1. Materials: Starch, iodine, water, 2 test tubes, filter paper, funnel.
2. Principles: Make a starch suspension; demonstrate iodine test for starch. Show how suspensions differ from solutions.

D. Solvents and solutes
1. Materials: Tar, butter, 6 test tubes, carbon tetrachloride, alcohol, water.
2. Principles: Test solubility of the tar and butter in the 3 solvents. At the same time any other solvents or solutes may be tested. The students may be asked to bring their own samples of stains.

E. Ammonia fountain
1. Materials: Ammonium chloride, calcium hydroxide, 2 flasks, one-holed rubber stopper, glass tubing, pan, water.
2. Principles: Make ammonia by heating the ammonium chloride and calcium together. Immerse end of flask in water and ammonia will dissolve. Phenolphthalein may be added to water and this will show just which part of the water dissolves the ammonia.

VII. Evaluation

A. Give a pretest and then compare scores on same questions after completion of the unit.
B. Carry on a general class discussion and review of the material.

C. Give an examination on completion of the unit.

1. The test should be designed in terms of the objectives stated at the beginning of this unit.
2. The type of test used may vary depending upon the materials studied and the learners.

D. Daily work

E. Ability displayed in performing and appreciating experiments.

1. Have pupils shown ability in handling equipment?
2. Have pupils been able to understand and explain what the experiments do?
3. Some short written and oral reports on the experiments should be made.

F. Let pupils try to apply concepts gained to new situations.

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Weed and Rexford. *Useful Science.* Chicago: John C. Winston Company, 1931.

Collier's Encyclopedia. New York: P. F. Collier & Son Corporation, 1950.

*Prehistoric Life**

This unit is designed to give pupils an introduction to prehistoric life. The main emphasis is on dinosaurs, but plants and other animals are included. Weather, the character of the land, and mountain building are also touched upon. Material on volcanoes and mountains is also included should the children's interest turn in this direction.

I. General Objectives

A. To satisfy interest and stimulate curiosity about ancient life.

B. To create the awareness of:

1. What early animals were like.
2. What early plants were like.
3. What dinosaurs were like.
4. How the earth's surface has changed.

II. Specific Objectives

A. To help the children learn:

1. That modern life developed from ancient life.
2. That changes in the earth, plants, and animals have been extremely slow.
3. What the different kinds of dinosaurs were.
4. In what kind of places dinosaurs lived.
5. Why ferns grew so large.
6. What fossils are and why they are important.
7. How rock layers are formed.
8. How volcanoes are formed.
9. That physical changes in the earth influenced the development of plant and animal forms.
10. That many plants and animals that once lived on the earth have entirely disappeared.

III. Basic Understandings

A. About living things:

1. Complex living things developed from simple living things.
2. Life on earth must change as conditions change.
3. We can learn about ancient life by studying things now alive.
4. Once the world was new with no living things; our earth has changed greatly.
5. Plants, animals, and land forms here today may not have been here years ago.
6. Plants appeared on the land before the animals because they can make food from air and water and soil; large animals needed the plants to eat.
7. The first plants were tiny.

*Prepared by Joyce Irene Bishop, Elementary Teacher, Bloomington, Illinois.

8. The largest of the ancient plants were ferns, which were as big as trees and had no flowers.
9. Huge ferns once lived as far north as South Dakota, because the weather was warmer then.
10. The weather became warmer and rainier, and cycads grew everywhere; they had big, showy flowers.
11. Among the first animals were scorpions, shellfish, worms, and many kinds of corals.
12. Some of the first animals that were solid enough to be found in rocks were the sponges.
13. Fishes and amphibians then appeared, some of which were very large.
14. The trilobite was a strange animal that looked something like a big, jointed, flat bug.
15. Some ancient animals (crinoids) looked like flowers made of rock.
16. The animals with shells are important because they formed most of the limestone rock found upon the earth today.
17. Much warm rain fell forming many swamps, which were perfect homes for reptiles.
18. We know about ancient reptiles, because their bones have been found in stones, and footprints have been found.
19. Dinosaur is the name given to some of the ancient reptiles.
20. Some dinosaurs were very large; others were very small.
21. Tyrannosaurus rex, "king of the tyrant reptiles," was the most terrible of them all.
22. Brontosaurus, "thunder reptile," was even larger; he had a small brain and a helping "brain" and was a plant-eater.
23. Some dinosaurs (Stegosaurus) had large, bony plates along their backs and rows of spikes on their tails.
24. Triceratops had three sharp horns and a thick, bony hood on his skull to protect his neck.
25. Some dinosaurs had scales or scale-like skin.
26. Some walked on four legs, others on two; and still others had no feet, but had flippers which helped them swim and long necks to dive down for food.
27. Some could fly; their wings were more like those of bats than birds.
28. Dinosaurs are now extinct, probably because of changes in climate.
29. The first birds were the size of crows and had reptilian jaws and teeth.
30. The mastodon, which looked a little as our elephants do today, is now extinct.
31. The most ancient horses were about the size of dogs.
32. Bones of giant buffaloes were preserved in the tar pits near what is now Los Angeles.
33. Saber-toothed tigers, fierce wolves, giant vultures, and giant lions came to the tar pits to eat the buffaloes, camels, ground sloths, and mammoths, all of which were plant eaters.

B. About fossils, rocks, and volcanoes:

1. Stories can be told in stone.
2. Prints were made in mud or sand, which changed to stone.
3. Layers of rock remain in the order in which they settle from water.
4. The fossils in rocks begin with the simplest farthest down, the most complex nearest the top.

5. Rocks formed later contain larger animals than are thought to have developed from the simple animals.
6. Many fossils are found in coal.
7. Bones and prints of sea-dwelling animals might be found in limestone, since limestone is formed at the bottom of a sea.
8. Petroleum formed during the age of reptiles.
9. Inside the earth it is very, very hot.
10. Hot liquid rock (called magma) under pressure from the earth's interior is pushed up to the surface and gradually builds a volcanic mountain.
11. Active volcanoes were much more common millions of years ago.
12. Other kinds of mountains are domed mountains, folded mountains, and block mountains.

IV. Suggested Approaches

A. Read an appropriate story.

B. Discuss experiences or things which the children have brought to school.

1. Fossils
2. Pictures of fossils from magazines, newspapers, and advertisements
3. Newspaper article about recent discovery of a fossil
4. Petrified wood from a vacation trip
5. Pictures of early man

V. Suggested Guide

A. Introduce the unit by reading a newspaper or magazine article about a recent discovery of a bone or fossil.

B. Motivate the pupils by showing pictures of ancient life.

C. Table of contents

1. Early life
   a. No life
   b. Primitive life
   c. The Paleozoic Age
2. Middle life
   a. The dinosaurs
   b. Marine reptiles
   c. Flying reptiles
   d. The first birds
   e. The mammals
   f. Advances in the plant kingdom
   g. Rocky Mountain evolution
3. Recent life
   a. Duckbill and spiny anteater
   b. Marsupials
   c. Placentae

D. Suggested materials (see also VI - X):

1. Fossils and skeletons
2. Pictures
3. Charts
4. Books

VI. Experiments and Demonstrations

A. With a pin, make a hole near the cap end of a toothpaste tube. Press the other end of the tube. Does the toothpaste flow up out of the hole? (Yes) This is a tiny example of what pressure can do to a soft material. When tremendous pressure forces magma to break through the earth's crust we have a volcano.

B. Sift a little soil into a jar of water every morning and let it settle. Observe the layers formed.

C. Observe a plant growing under water and one growing in soil to discover "What does the land plant need that it would not need to live under water?" and "How would the water plant have to change to live on the land?" Expose the water plant to the air or plant it in the soil. Observe what happens. Do similar experiments with water animals and land animals.

VII. Other Activities

A. Find and bring to class

1. Pictures of ancient lizards
2. A live lizard
3. Rocks that are made in layers
4. Fossils in coal or limestone
5. Petrified wood

B. Visitors:

1. An archaeologist
2. A zoologist
3. The state geologist
4. One who has a hobby of collecting rocks or fossils

C. Field trips:

1. To the museum
2. To a nearby stone quarry, gravel pit, or ocean shore to find fossils
3. To a place where a highway cuts through a hill to observe rock layers

D. Miscellaneous:

1. Make handprints in clay.
2. Make a "fossil" of a leaf or shell in plaster.
3. Make a large chart showing plants and animals that lived in the different eras.
4. Make a collection of feathers, shells, rocks, or fossils.
5. Start a classroom museum.
6. Arrange pictures of plants and animals in the order they appeared on the earth.
7. Look at pond scum through a microscope.
8. Make special reports on such subjects as
   a. Animals found in the La Brea tar pits

b. Petrified forests

c. Mammoths

d. Fossil expeditions

e. The duck-billed platypus

f. The development of the horse

VIII. Correlating Activities

A. Art

1. Make models of dinosaurs in clay or papier-mache.

2. Make a diorama of a prehistoric scene.

3. Draw or paint pictures of ancient plants, dinosaurs, birds, amphibians, or mammals.

4. Make a model (that really works) of a volcano. Use a wooden base and skeleton covered with screening. Model volcano with mixture of wheat flour paste, water, and asbestos powder. Paint it. Fill crater with crystal ammonium bichromate. See the following reference for details: Sternig, John. "Table Top Volcano," *The Science Teacher*, (April, 1957), 124-125.

B. Library

1. Look for material for special reports.

2. Read books listed in the bibliography.

C. Mathematics

1. Measure the classroom or part of the building to get an idea of the approximate size of dinosaurs.

2. Figure the cost of making a model volcano and any other projects undertaken.

D. Reading

1. Read about volcanoes, mountains, rocks, and minerals.

2. Read about archaeology.

3. Read about early man.

E. Writing

1. Write stories about ancient life.

2. Write a letter to the curator of the museum to ask him for information or to thank him for information received.

3. Write for published materials on dinosaurs or other topics of special interest.

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X. Bibliography for Pupils

A. Textbooks:

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B. Other books:

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XI. Audio-visuals

A. Films (available from Southern Illinois University Library, Carbondale, Illinois, unless other sources are given)

Earthquakes and Volcanoes. (I, J, color, 13 minutes)

Fossils: Clues to Prehistoric Times. (I, J, S, 11 minutes)

Pompeii and Vesuvius. (I, J, S, C, color, 11 minutes)

Prehistoric Animals of the Tar Pits. (I, J, S, 20 minutes)

Prehistoric Times: The World Before Man. (I, J, S, 11 minutes)

Volcano. (color) University of California, Extension Department, Los Angeles 24, California.

Volcanoes in Action. (J, S, C, 11 minutes)

B. Filmstrips: (available from Southern Illinois University Library, Carbondale, Illinois, unless other source is given)

The Coming of Reptiles. (I, J, S, color)

Discovering Fossils. (I, J, S, color)

Rise of Dinosaurs. (I, J, S, color)

Age of Mammals. (I, J, S, color)

Lizards. (I, J)

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The World We Live In: Part III. Face of the Land. (J, S, C, color)

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The World We Live In: Part VI. Age of Mammals. (J, color)

C. Miscellaneous:

1. Display of books (see bibliography for pupils)
2. Fossils
3. Skeletons
4. Pictures from magazines or other sources
5. Chart of plants and animals in each age

TEACHER'S NOTES

CHAPTER V

Making Teaching Effective

Motivation of Learning

The term "motivation" is very inclusive; literally, it means causing something to move. The motivation of children implies that teachers must create situations which will produce learning activity on the part of the children. Learning should be an active experience for the learner, and, if the stage is set properly, pupils cease to be passive. Mediocre pupils have succeeded because of interest and enthusiasm, while talented ones have failed for the very lack of these factors. Psychologists claim that motivation is the central factor in every learning process and that the most essential thing to know about human nature is the force, the drive or urge that makes people think, feel, and act as they do.

Einstein stated that "behind every achievement lies the motivation which is the foundation of it." Individuals differ greatly in their motivations, and a teacher's understanding of these differences is of great importance in the educational program of the school.

There is a natural interest in science to be found in boys and girls which gives a drive to learning. Teachers who recognize this feature in their pupils and capitalize upon it find a natural motivating influence in almost all areas of the educative process.

One of the prime reasons for difficulty in the motivation of pupils is the need for greater motivation on the part of teachers. This is particularly true in the teaching of science since many elementary school teachers have had insufficient training in this subject matter field.

In recognition of this limitation, a group of supervisors at Southern Illinois University developed a successful program[1] on motivation. This program utilized an acrostic built from the letters in the word MOTIVATE. The following words fitted into the acrostic suggest teacher activities which should result in increased pupil interest and improved learning.

An example of how the acrostic can be correlated with an actual teaching unit has been supplied by Vera Quigley, an elementary teacher in the Public Schools of Bloomington, Illinois.

1. Program developed by Mabel Lane Bartlett, Clyde M. Brown, Gordon K. Butts, and Clarence Stephens.

ACROSTIC (How to Motivate)	TEACHING UNIT (Why Did The First Graders' Fish Die?)
M - MOVE—Teacher seeks new incentives and new activities to meet the interests and needs of the pupils; gets something started.	The first grade children asked the fourth grade class to equip an aquarium for their room since they had already built one and the attempts of the first graders had failed. Three children who had had experience in setting up the room aquarium were selected for this purpose. One week later the committee reported that the fish were dead. The children were interested in determining the cause of the death of the fish.
O - ORGANIZE—Plan the material so that the teacher knows where he is, where he is going, and what he will encounter enroute.	The teacher got ideas from children as to what they thought might have been the cause of death. Answers received included: Committee did not follow directions, fish were sick when bought, maybe there was something wrong with the water. First step in plan was to check these three possibilities by interviewing the committee; persons in charge of pets at the store where the fish had been bought; and a parent who worked at the city water plant. This led to experimenting with the kinds of water to be used. Children planned to equip four aquaria with water from the lake, a cistern, aged faucet water, and faucet water freshly drawn. Plans were made to observe these over a period of time. Problems encountered: Temperature, feeding, caring for sick fish, protecting baby guppies, oxygen supply and presence of carbon dioxide.
T - TEMPT—Place the materials in settings which challenge the energies and minds of the boys and girls.	Circumstances made this problem appropriate. The fourth graders were anxious to help the first graders to whom they felt superior because of age, knowledge and experience.
I - INTEREST—Consider the interest patterns of the children and help them to satisfy their curiosity.	The children's original experience with their own aquarium; their love of animals and disappointment in seeing the fish die; and the teacher's ability to see a chance for setting up a suitable experiment and to get the pupils to desire to carry it out were necessary for starting this experiment.

V - VITALIZE—Make the learning experience dynamic and vibrant.	Letting pupils interview adults who were involved at the store and at the water works made the pupils see that this was important and that more than one factor could be responsible for the death of the fish. Challenging the pupils to keep new fish alive kept them aware of conditions and new ideas.
or	
VISUALIZE—Portray the materials through visual aids.	Doing this experiment in the classroom and keeping the records and specimens before the pupils keeps them interested and will reinforce learning.
A - ANTICIPATE—Look ahead to the possibilities that might develop and make plans to meet the questions and problems that arise.	When asked to have the fourth grade class set up the aquarium both teachers had to anticipate the possibility that the group might not want to do this. Their approach had to motivate the pupils. When the chance for experimentation came, the fourth grade teacher had to gain more knowledge on conditions necessary for raising guppies, to give the pupils direction for interviews, and prepare to control conditions for the aquaria.
T - TREAT—Put into action varied teaching processes.	Setting up hypotheses is the first step children need to take in solving a problem. Finding information from books and people is a second step. Finding out for themselves by experimentation is a subsequent step. Keeping accurate records of events is a habit children need to acquire early. Analyzing their findings leads to logical thinking. Preparing reports offers opportunities to strengthen communicative skills.
E - EVALUATE—Utilize varied techniques of evaluation to determine how effective the teaching has been.	Results of daily observations may be recorded and reported, with a consequent increase in the ability of pupils to express in written and oral language that which they had observed. Additional behavior changes might be determined by other evaluative techniques adapted to the situation.

Teaching-Learning Activities

Teachers are interested in ways in which they may make their teaching more effective. The primary purpose of the elementary science program is to help children understand the roles science and the scientists have played in bringing about a better understanding of the physical and biological factors in the environment. It is desired that children know more than the accumulated facts that appear to be true. How these facts were learned and how scientists go about increasing knowledge is also a desirable goal. Development of some concepts by the child concerning himself and his place in relationship to the world of science is a most worthy aim.

Many methods of securing increased knowledge and more active participation have been used effectively by teachers. Some ideas suggested in the following sections may prove useful in enriching your program.

Experimentation and Demonstrations

There are many opportunities to illustrate scientific phenomena and facts with simple demonstrations and experiments which are within the scope of the children both from their ability to perform and to comprehend. These demonstrations and experiments cannot be assigned to a particular grade level. The reason is that the interests and abilities of one age group one year may make an activity suitable when it may not be appropriate for another group of similar chronological age. The situation and experiential background of the pupils will help the teacher in his selection of the experiment to be used.

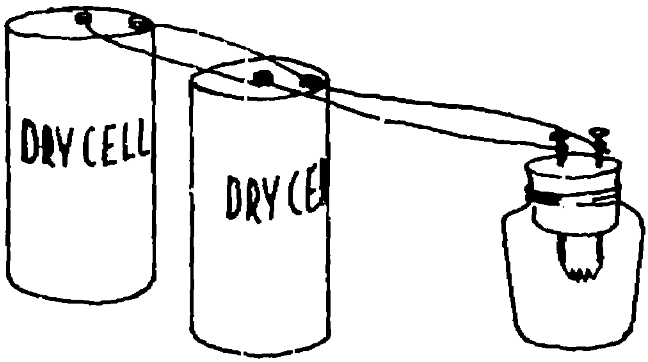
Teachers give two principal reasons for doing few or no experiments in their science programs. Lack of adequate science background is the first usually given though rationalization frequently places lack of materials in the prime spot. Both of these are excuses because teachers can learn with their pupils. Sometimes the greatest amount of learning comes from an experiment that doesn't work, and often elaborate equipment isn't needed to do experiments at the elementary school level. Many of the things needed can be procured at minimum expense from a dime store, found in your kitchen cabinet, the tool chest or borrowed from your pupils. Returning the "borrowed" items answers part of the storage or space problems.

An example of learning from an experiment that didn't work is well illustrated by a sixth grade science activity.

> Several sixth grade pupils were trying to make a light bulb using a mustard jar, a cork stopper, insulated copper bell wire, two nails and a tungsten wire filament from an old bulb. Two dry cells were used as a source of current. The nails were driven through the cork to conduct the current to the tungsten wire that connected their points. Copper bell wire ran from the dry cells to the heads of the nails. It was expected that the tungsten wire would glow; however, no noticeable glow was apparent. Why didn't the experiment work? Changing the connections on the battery from parallel to series likewise produced no success. Why didn't the experiment work?
>
> Considerable discussion developed in the group. The text was consulted to confirm the procedures used and a new attempt was made after checking the connections. Still there was no success. It was noted, however, that the nails became warmer during the experiment.
>
> A ninth grade boy from the study hall nearby was called in as a consultant. His general science training in electricity perhaps would help solve the sixth graders' problem.

The consultant checked the connections and called attention to these facts:

1. Some metals are better conductors—iron is a poor conductor—copper is a good conductor.
2. Volts are units measuring electrical pressure.
3. Amperes are units of measure of flow of electrons over a conductor.
4. A dry cell produces one and one-half volts of electrical pressure.
5. A series connection of two dry cells adds the volts of the two to give three volts but produces the amperage of one.
6. A parallel connection of two cells adds the amperes of the two but produces the voltage of one.



The children examined their model of the light bulb and checked the facts called to their attention. This question was raised, "Why use nails to conduct the current through the cork if iron is a poor conductor and probably uses so many volts of pressure to push the electrons through them to the tungsten wire?"

The nails were removed. Bell wire was pushed through the nail holes in the cork and the tungsten filament joined the two ends. After the rearrangement one dry cell was used to check the connections. No glow was apparent—a finger touched to the filament produced a slight burn and a whoop of delight. The two cells were connected in series so as to give the maximum voltage. The stopper was inserted into the bottle and the knife switch was thrown. A dull glow appeared momentarily in the tungsten filament accompanied by a gas and then the filament burned in two.

Success was achieved at this trial in that the filament glowed. The fact that the filament burned in two could be explained in a later session.

Photograph Courtesy of Southern Illinois University Photographic Service

Third Grade Pupils Make a Discovery

For a number of years there has been debate among science educators concerning the advantage of using individual experiments done by the pupils over teacher or pupil demonstrations. No agreement has been reached that conclusively makes one method superior to the other; each has strong points in its favor. The demonstration technique is less expensive in both time and materials, and also seems to allow better comprehension of concepts and principles. On the other hand, the individual laboratory method shows the development of greater resourcefulness on the part of the pupils. Perhaps utilizing either to the exclusion of the other is undesirable in science teaching today.

In conducting a class in elementary science "canned" demonstrations and recipe following can stifle interest. There is a definite value in permitting some "free-wheeling" on the part of the pupils in which problems are presented, hypotheses (hunches) concerning answers are advanced, and experiments are designed to test the hunches.

Children enjoy these periods and if time is short in the classroom, often the proposed experiments can be conducted at home or after school and reported upon by the individuals. Teachers can incorporate suggestions arising from the pupils into the flexible long-range plan. This over-all plan guarantees the inclusion of significant experiments and demonstrations. Some of the teacher planned activities may conceivably be omitted should the pupil proposals adequately treat the area under study. Problems originating with the pupils often offer challenges which teachers need to follow through.

In the elementary science classroom experiments should be done with a purpose—the teacher should use experiments to demonstrate or illustrate science principles or concepts. Many of the attempts at science experiments border on the magical or supernatural when judged by the explanation or lack of it.

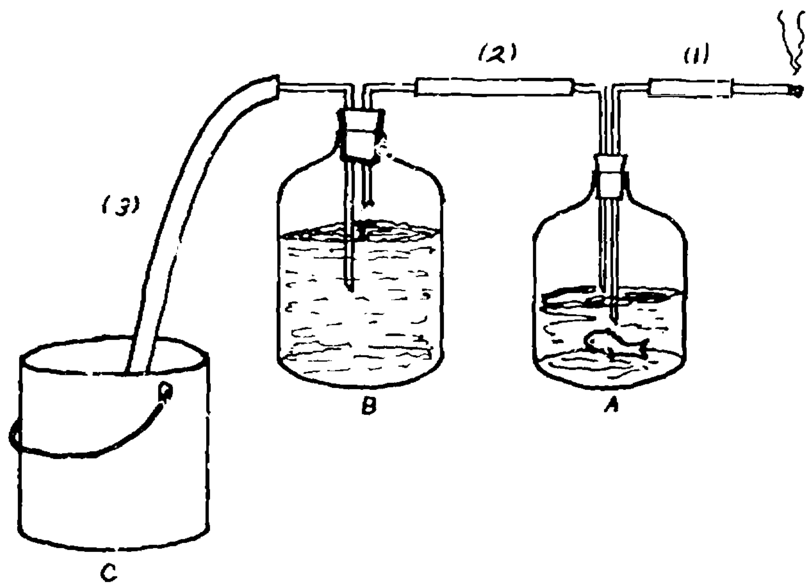
In science it is assumed that there is a logical explanation for why things happen—there is a reason. For most of the common happenings the reason for their occurrence can be explained in a fashion that can be comprehended by most of the pupils. How, why, and what are the science teacher's tool words which help get the pupils into a questioning frame of mind. Much fun and learning can be provided by getting pupils to check these questions: What did we do? What did we use? What happened? How do we know it happened? Why did it happen? What would happen if . . . .? Writing answers to these questions is a meaningful experience and will provide opportunities to further strengthen language skills.

Try these questions with the following experiment which came as a result of a seventh grade group's discussion of the subject "How do people poison themselves?" Smoking was listed as one way in which poisons may affect a person. The effects of smoking on a living animal were tested by using a fish as the test animal.

Question: How does a fish react to the materials in cigarette smoke?

Materials needed: A small live fish; a gallon jug; a smaller jug (½ gallon or quart); two two-holed rubber stoppers; several pieces of glass tubing; rubber tubing; water from the aquarium or pond; tap water; a bucket; and several cigarettes.

Procedures Fill gallon jug with tap water. Fit each rubber stopper with one short and one long piece of glass tubing (wet stoppers before inserting tubing so as to reduce friction). Fill ½ gallon jug half full of pond water and put the fish in the water. Place stoppers in jugs so that the short piece of glass is above the water level and the long piece reaches almost to the bottom of the jugs. Connect the rubber tubes as shown in the following diagram. Then fill tube No. 3 with water and allow water to siphon out of jug B. Place a lighted cigarette in tube No. 1 and watch for results.



Results: Bubbles of smoke-filled air will pass into the water of jug A. After approximately two cigarettes are burned the fish will show signs of being affected. Fish will probably die if not removed from the test situation.

Scientific Explanation: 1. Air to replace water siphoned from Jug B must pass through the cigarette into the water of jug A. From jug A air goes through tube No. 2 into top of jug B. Gravity causes the siphon to work.

2. Poisonous materials—nicotine, tar and resins—apparently will contribute to the death of the fish.

Children should be encouraged to write up results on some of the experiments which they do, but not to the extent that interest in the experiments is seriously reduced. Facts should be stated accurately and precisely though the form for reporting may be varied from time to time.

Teachers are usually willing to share with other teachers ideas they have used successfully. A file of successfully used demonstrations or experiments is a valuable asset for any teacher.

These experiments or demonstrations may *originate in* class discussions, be suggested by the text or reference books, come from current science literature provided for pupils, or be found in professional materials read by the teacher. Whatever the source, using a uniform outline for recording experiments is advised. The following outline is suggested for the elementary teacher's file of experiments.

I. Area of science treated in experiment
II. Title of experiment
III. Materials needed
IV. Procedure to be followed
V. Results expected

VI. Scientific explanation
VII. Cautions

A space for follow-up experiments suggested by the results and class discussions can make the experiment file an ever-growing aid to teaching.

Classified lists of experiments which are available commercially will give essentially the same information (see "Supplemental Teaching Resources" in Appendix C). However, a more personalized file of activities and experiments that have been found to "work" is more meaningful to the elementary science teacher in implementing his science program than complete dependence upon a classified list.

Following is an example of a successful experiment using the outline described above. Other experiments and demonstrations are listed in Appendix A.

(FRONT)

Area: Chemistry

A Crystal Garden

Purpose: To observe the chemical change that takes place in this garden and new molecules made.

Materials Needed: Coke or small pieces of brick, saucer, salt, water, laundry bluing, mercurochrome, household ammonia.

Procedure: Mix together in a bowl 4 tbsp. salt, 4 tbsp. water, 4 tbsp. laundry bluing, 1 tbsp ammonia, and a few drops of mercurochrome. Pour this mixture over the pieces of coke or brick which are in a saucer. Place the saucer in a place where it will not be disturbed. Watch for crystals to grow in your garden.

Results: A chemical change takes place in this garden and new molecules are made. They will start to form within one-half hour. If allowed to stand for two days, they will grow and grow, and may spill over the edge of the dish.

(REVERSE)

Scientific Explanation: The growth is made of salt crystals, which form as the liquid evaporates. The coke, brick pieces, or coal soaks up the liquid and carries it to the surface from which it evaporates leaving the salts behind. The deposit continues to grow because each little crystal formed is likewise able to carry the liquid through itself and to the surface. The liquid is now evaporated from the surface of the crystals leaving more crystals behind.

When the growth stops, a teaspoon or so of ammonia will start the growth again. You may want to preserve your garden by allowing it to dry. This isn't a very good idea though, for the crystals become very fragile when they dry and they are apt to crumble.

Field Trips

The purposes of field trips are similar to the purposes of the remainder of the science program, i.e.: to create awareness, attitudes, and appreciations and to foster increased understanding.

Field trips can well be the highlights in an elementary science program. Seldom does an administrator fail to give sanction to a teacher's proposal for a trip when he finds that proper plans have been made for it. A field trip is more than an outing taken to entertain pupils and should never be undertaken unless there is a reason for going and the reason should be well understood by everyone involved.

Those things that can be done best in the classroom should be done there and those that can be done best on the outside should be dealt with outside. The planned field trip is a very valuable method for bringing life into the science program. Through "going to see" activities science materials can be made more meaningful.

There are numerous occasions for taking children on field trips but each trip should be planned to do or see specific things or closely related things, such as: to study a certain type of rock formation; to search for fossils; to collect seed pods; to watch a brick mason work; to collect water samples; or to see the effect of water erosion following a heavy rain. The purpose of each trip should be definite and the pupils should be aware of the purpose.

Prior to taking the trip, detailed plans should be made and the children briefed about what will be expected of them on the trip. It is advisable for the teacher alone, or with the help of a small planning group, to preview the area to be visited prior to taking the class trip even though the same trip for the same purpose was undertaken the preceding year. The beautiful little brook of last year may have been diverted into a culvert during the summer, ruining the area for the purposes planned. Nothing is more embarrassing than to find that what was to be seen is no longer available when the group arrives at the spot.

It is not necessary nor perhaps desirable to take lengthy trips with the younger elementary school children. One of the best trips might be a safari no greater than a city block's distance from the school. E. Lawrence Palmer, formerly of Cornell University, has said that within five times the length of the teacher's desk from the front door of the school there is enough material to keep the teacher busy for a year in science, if he can only recognize it. Teaching opportunities frequently overlooked might include some of the following:

1. A miniature river system originating at the downspout.
2. Loss of topsoil in either sheet erosion or small gullies.
3. Influence of plant cover in slowing up run-off (note debris on the uphill side of plants).
4. A small weed patch showing different kinds of weeds and leaf patterns and particularly the effect of the rosette pattern of growth of dandelions on surrounding plants.
5. Weathering factors and effect upon masonry and paint.
6. Insect types prevalent in the area—many times dead insects are found under an exit light that burns all night or in the globe surrounding a bulb.

Photograph Courtesy of Harold Hungerford, Principal, West Junior High School, Kankakee, Illinois

Collecting Fishes in Exline Creek, Kankakee County, Illinois

Sometimes well-groomed lawns with orderly exotic shrubs or asphalted playgrounds stretch the imagination considerably. Usually however, within the radius of a few blocks of the school there is much to open the eyes of boys and girls concerning the world of living things and their activities.

Frequently, activities related to man's applications of science to the problems of living things are also available.

Most effective use of the field trip is assured when the activities are planned with the children. These hints may help make your trip a successful science experience.

1. Be sure that there is a real reason for going and that the children recognize the reason.
2. Be sure that details of the trip have been carefully worked out with the group and that administrative approval has been secured.

3. Be sure to take a preview trip to determine that what is wanted is available.

4. Be sure to check upon social amenities in a group activity and recognize the part that each individual plays in the success of the endeavor.

5. Be sure the trip fits into the group's activity program—is not just an outing.

6. Be sure that the specific responsibilities of individuals or small groups are understood.

7. Be sure that time is allowed for a follow-up of the trip. Important results come from discussions and the recording of information. Applications of the information gained about specific problems and questions are best attained in the classroom.

An example of a good plan for a trip to a charcoal kiln made by an eighth grade class in Southern Illinois indicates what can be done by a group under guidance. This trip was developed as a part of the science, language arts and social studies activities of the group. The plan for this trip was presented at an Instructional Materials Conference at Southern Illinois University and received favorable comments as an example of teacher-pupil planning.

*A Charcoal Kiln Trip**

I. Pre-Planning

A. Getting approval of the administration

B. Securing permission from the parents

C. Planning for a preview trip

D. Taking preview trip

E. Arranging with owner for group to come

II. Introduction to Class

A. Display of charcoal and coke

B. Discussion of differences (source, processing, cost, uses)

C. Planning tentatively for the week's work about the production of charcoal

III. Planning

A. Listing questions about the production of charcoal
Example: For what is the chimney used?

B. Listing spelling words and new vocabulary such as acetone, wheelbarrow, adsorb

C. Discussing possible sources of information (library materials, dictionary, reference books, people, trip itself)

D. Reviewing trip behavior standards on campus, in bus, at the kiln

*Planned and carried out at University School, Southern Illinois University, under the supervision of Mabel Lane Bartlett, Associate Professor of Education.

IV. Working Period

  A. Finding information
  B. Sharing information
  C. Writing and organizing facts (making posters, compiling vocabulary list, making "Do you know?" list)
  D. Taking trip
  E. Making pictures of trip
  F. Studying spelling words
  G. Defining new words
  H. Using other subject areas for enrichment of trip

V. Culmination

  A. Appraisal of trip with reference to objectives
  B. Writing thank you letter to kiln owner

VI. Sources of Information

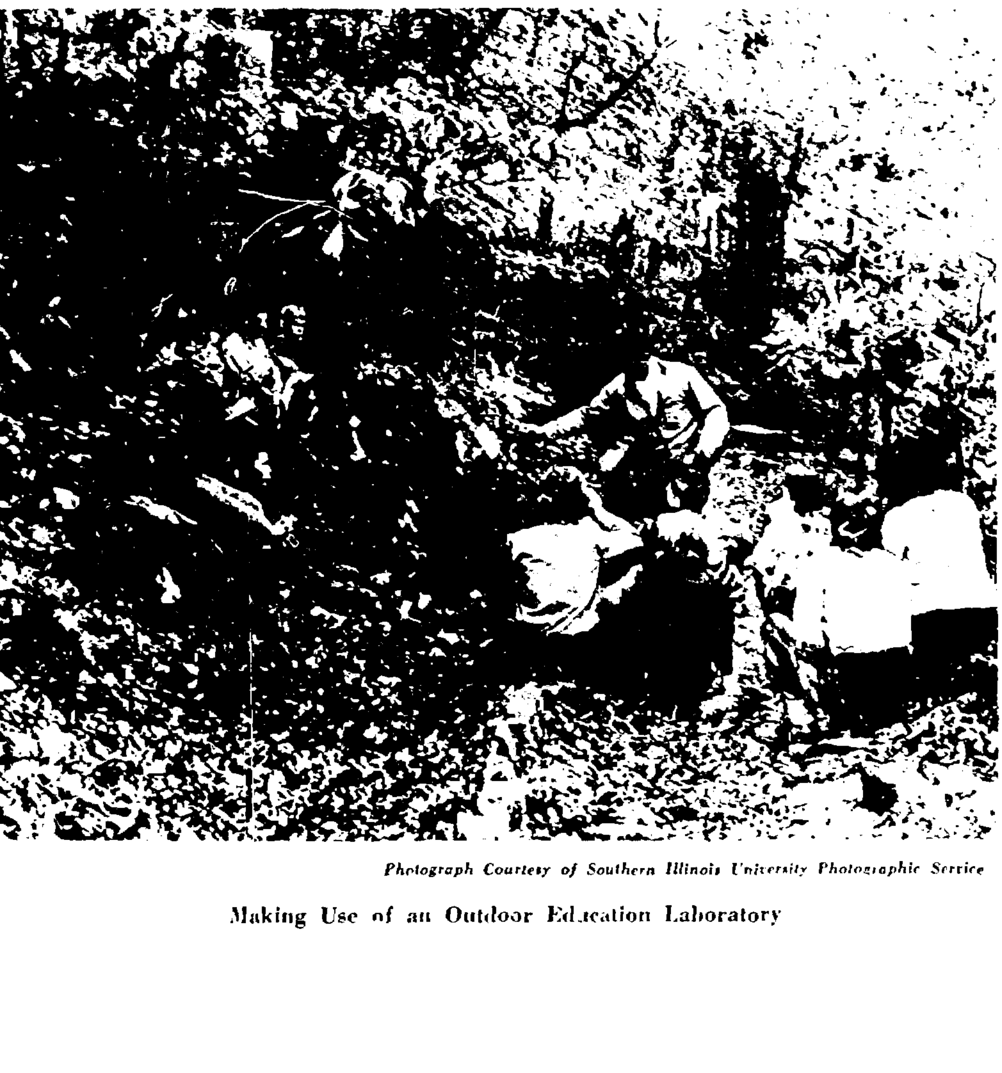
  A. Encyclopedias
  B. Recent high school chemistry books
  C. Films and filmstrips
  D. Resource persons

Nature Hikes

A nature hike is a trip which is taken to see what there is to see, and differs from field trips which are designed to observe one or a few specific things. Arrangements and plans made prior to the hike should be similar to those for a field trip in regards to administrative approval and social amenities or group behavior. A preview trip to determine the types of things available for observation and study is advisable, so that the teacher may adequately brief himself in anticipation of the questions the children will raise.

Collections need not be made on these trips, though samples may be taken where collecting is permitted. If specimens may be taken on the trip, it is recommended that these be considered as class property rather than individual trophies. A small specimen also may be as representative as a large one and makes display and storage less of a problem. An inexpensive camera and color film for making slides or pictures can be an excellent way to document the trip for follow-up study.

Hikes at monthly intervals over the same routes to see the same things in order to show how seasonal changes may affect them are effective. Through observations made on hikes, cause and effect relationships can be admirably portrayed.



Photograph Courtesy of Southern Illinois University Photographic Service

Making Use of an Outdoor Education Laboratory

A nature hike can and should place high premium on incidental things which arise and should be a leisurely conducted activity with some time for individual exploration and discovery. Safety factors, however, must be kept in mind at all times.

To some teachers, taking a class into the out-of-doors away from the safety of the four walls of the classroom can be a terrifying experience because of the magnitude of the unknown. Take heart, however, for little bits of information gained soon add up to a greater sense of security.

The teacher who is new in a community may wish to have someone quite familiar with the field trip area assist with the first trip into a given area.

With some of the good nature guides now available: scout manuals; the materials in current magazines or bulletins (see Appendix C); and the ideas and leadership potential among helpful parents and friends, a teacher's knowledge can be improved until he feels relatively secure.

Everything seen on a field trip or nature hike does not have to be pointed out. In time, and with more experience, more and more can be brought to the attention of the children.

The great variety of things possible for children to find on a routine nature hike can stump the so called "experts" Hence, it is no disgrace for the teacher to say, "I don't know." As time passes and experience is gained, the things he does know will increase. No individual can be expected to know all the answers, but with the children a teacher can say, "I don't know but let us see if we can discover the answers." Consulting authorities may confirm your findings, or identification by means of pictures can be used in the absence of skill with complicated keys.

Nature hikes should lead to desirable changes in behavior such as:

1. Greater appreciation of the out-of-doors.
2. Greater recognition of individual responsibility for community and private property.
3. Greater respect for the rights and privileges of others.
4. Greater recognition of interrelationships between living things and their environment.
5. Greater desire to share knowledge with others.
6. Greater realization that facts learned in the classroom are applicable in the out-of-doors.

The wonderful things of the world are not always over the horizon. Children should be made aware of the many marvelous things available close at hand. Help them to realize that a nature hike is an invitation to "Stop," to "Look," and to "Learn."

Observation Areas

The establishment of an area near the school which can be observed at regular intervals throughout the school year can prove to be quite rewarding for teachers and pupils. Such an area may be a group of trees, a clump of either wild or cultivated shrubs, a grassy plot, or a field. Observing the responses the plants and possible animal inhabitants of the area make to their total environment arouses and helps sustain interest in science.

Making careful observations is one of the desirable outcomes of an elementary school science program, and the observation area can provide opportunities for the children to organize and write down an account of what they have seen. Also, they may develop "hunches" or hypotheses concerning why the changes they have observed have occurred. An observation area will permit the teacher to teach interrelationships between organisms and to develop the concepts of a community of living things.

An activity of this type would need more time in the spring or autumn when changes are occurring most rapidly. Less frequent visits are necessary in the winter when the plant life is in a more or less dormant state.

In art, mathematics, and language arts instruction, the classroom teacher can utilize the observation area to motivate children's learning equally as well as in science education.

Some activities related to a study of science in a sample observation area are:

1. Forcing flower and leaf buds to develop in the classroom by bringing in cuttings of twigs with dormant buds.
2. Identifying and studying plants of the area.
3. Identifying and studying animals of the area.
4. Studying fall leaf coloration and the falling of leaves.
5. Studying soil, soil water, and erosion.
6. Studying types of plants, i.e., annual, biennial, perennial; herbaceous and woody; or monocots and dicots.
7. Studying inhabitants of the plant litter on the surface of the soil and those in the topsoil.
8. Studying weather and its influence including temperature, rainfall, and wind.
9. Studying seasonal effects on shadows cast by a permanent post or sundial.
10. Studying pollution of water, air and soil.
11. Studying the day and night sky.
12. Studying the effects of contraction and expansion.

A concerted study of a restricted area can be most enlightening to a group of children who tend to deride those things which are close at hand.

Field Science Problems

One of the best methods of developing the scientific skill of observation as well as giving the pupil training in basic research is through the study of problems in the field. Field science is currently being utilized in parts of Illinois to give upper elementary pupils a real opportunity to study science in its natural surroundings. It differs from the normal use given an observation area in that it is concentrated field effort carried out on a block of time basis during the school year or as a summer school activity. It differs from the currently popular "Outdoor Education" approach in that it is strictly science and basically problem centered.

Science studied in the field enables the pupil to establish a close relationship with areas of science not conducive to study in the ordinary classroom situation. A teacher, working with pupils, may propose a problem that can be handled only in the field. Such a problem may be linked with geology, aquatic biology, forest or prairie ecology, or conservation. For example, a class may elect to survey the different kinds of vertebrate animals to be found in, or close to, a particular stream. This does not have to be extensive. It is more important to observe habits of a few species rather than to collect many.

A problem of this kind will necessitate a great deal of field work as well as classroom time. Pupils will need to work out techniques for collecting fish, amphibians, and reptiles. They must become proficient in identifying their collections. Specimens can be preserved, labeled, and placed in a reference collection. Life cycles and interrelationships between living things should be noted. A careful recording of observations is essential and from all accumulated data a report should be written.

In performing the above activities, the pupil will become very familiar with many of the techniques in science as well as gain a better understanding and appreciation of his own local area.

Field science calls for careful planning, but it has proved to be an excellent technique for enriching elementary science programs. Only through field work can the children be brought close to many specific and important areas in science instruction. At the elementary school level field science is just beginning to be an accepted technique, but more and more teachers and administrators are learning to appreciate its potential.

Science Displays

Children like to share what they learn and through science displays they may not only share what they have discovered, but also may achieve a degree of success and acclaim from their peers. It should be kept in mind that the "display" idea is not the end result of the science program, but a m ns of continued learning. Care must be exercised to see that the artistry and beauty are not the only criteria used in selecting those science materials that are placed on exhibition. Ideas, both individual and group, merit consideration in a science display, and the "showing" exercise may be a culminating activity for the group.

Several kinds of exhibits can serve as teaching devices at any grade level. Those that are prepared by pupils as projects in connection with science clubs are usually carefully done and are appreciated by fellow pupils. If the work is good, it should be displayed temporarily or given a permanent place for the year.

As a class develops a study topic, a group may prepare an exhibit to be displayed for a time, and then, if room is available, stored along with other projects until near the end of the year. Living displays should not be overlooked. At the year's end a fair of science exhibits may serve to summarize the year's work and clinch the learning experiences. Thus the displays may be helpful in both teaching and reviewing phases of the work.

Exhibits may be used in the classroom though it is often desirable to place them in display cases in the corridors or in other locations available to many children. A few exhibits may become permanent, such as those found in a school's museum, while others may be used to stimulate interest and then changed or discarded. Any exhibit displayed too long detracts from its worth. Dust covered exhibits of previous years' science work hold little interest for a new class no matter what the degree of nostalgia the teacher places upon his prizes. Janitorial services must be rendered to even the current exhibit if it is to be kept in order.

The list of materials worthy of exhibit in a class depends to a great extent upon the imagination and ingenuity of the teacher and the pupils. Almost all science activities lend themselves to display. Care should be taken that the class motto does not become "Show and Blow" instead of "Share and Learn."

Using Instructional Materials

Visual Materials

To many teachers, using audio-visual aids means "showing a film." They fail to realize that many other devices available to them fall under the category of audio-visual materials. The more frequently used visual aids include chalkboards, charts, diagrams, pictures for the bulletin board or opaque projector, models, and specimens, as well as motion picture films, filmstrips, and colored or black and white slides. When live or preserved specimens are used, children have opportunities to have direct experiences, whereas the experiences are vicarious when motion pictures, filmstrips or slides are used. Any of these are good aids to teaching when used properly, but it must be realized that they are supplements to good teaching and not substitutes.

Film specialists in the use of audio-visual materials agree that the term "movie" should not be used for classroom educational films since the term connotes entertainment instead of instruction. Likewise, these authorities feel that there is need for careful teacher preparation prior to showing films or filmstrips. This preparation should include a preview of the film to determine its timeliness in the science program activities, the level for which it was prepared, and the areas on which the class will need some orientation to assure the maximum comprehension and values from the showing. A study of the brief commentary in the film catalog from which the film is ordered does not remove the need for a preview. Specialists on the use of instructional materials say there is no excuse for showing a film that has not been previewed. Ideally this is true but with film rentals, previewing sometimes presents a booking problem.

Careful use of the study guides which most film producers provide to accompany educational films will help to make instruction more meaningful. A great part of the value of a film is lost if there is no time allotted for a follow-up discussion by the pupils. Discussion helps to fix important points or ideas portrayed and may even make a re-showing of the film desirable.

The motion picture films are readily available from film libraries at colleges or universities of our state, commercial libraries, museums, such as those located in Chicago and Springfield, and from educational service units in various industries. Sources of science films, some free or inexpensive, are listed under *Selected References and Resources,* Appendix C.

Several publishers of textbook series for elementary science have developed lists of films to accompany and supplement their books. These lists are usually available to the teachers upon written requests when the school stationery is used.

Many teachers feel that filmstrips are among the most valuable visual materials available to them. They can use them at various levels by supplying the commentary most appropriate for their particular groups. Teachers who use filmstrips should assume that the viewers are unable to read; hence, the teacher must read the legends of the filmstrip. Such a reading permits teachers to govern the speed of projection and to edit the written materials as they see fit.

Filmstrips on a wide range of science subjects are available, some of which are correlated with books produced by publishing companies. Numerous filmstrips are distributed free of charge by the educational divisions of large companies. Care should be exercised when utilizing these to weigh the propaganda elements and to determine whether the time involved in the showing is compensated with learning pertinent to the planned science curriculum.

A relatively recent addition to the projection devices available to teachers is the inexpensive instrument for previewing filmstrips. These small units have an electric bulb for illuminating the filmstrip as it is rolled behind a frosted glass. This device is simple to operate and can be placed in the science corner with filmstrips for use by the individual pupil.

Specialists in the field of audio-visual materials recommend that schools purchase filmstrips since they are relatively inexpensive. On the other hand, motion picture films are expensive, and for economy, the purchase of such films is recommended only by large school systems which have occasion to use each film purchased many times each year. Utilization of films from rental libraries is probably the most economical practice for both large and small schools.

A list of some sources of science filmstrips, free and inexpensive, may be found in Appendix C.

The chalkboard is probably the most widely used of all visual aids and probably needs no treatment here other than to say that teachers do not need to be artists to make effective use of this teaching aid. Charts, models, and diagrams receive somewhat more emphasis in the pre-service education of teachers, and therefore are not discussed in this guide.

Opaque projectors are utilized far less frequently than they merit. Many schools have these devices which have been sold to the administrators who haven't "sold" them to their teachers. The opaque projector enables a teacher to use small pictures or charts from almost any source to an advantage in the classroom. Whole pages in reference books may be projected for simultaneous study by the pupils. Three-dimensional specimens may also be enlarged upon a screen through the use of an opaque projector. These represent but a few uses of this valuable tool.

A newer device which is yet to come into its own in teaching is the overhead projector which has high versatility in the hands of an imaginative teacher. Transparencies prepared by the teacher ahead of time or commercially purchased may be used. Many drawings can be made upon the special plates as they are being projected thus permitting the pupils to see each step as it develops.

The great world of the microscopic organisms fascinates boys and girls. Microscopes usually are unsatisfactory with younger children and are too expensive for most schools to purchase in sufficient numbers for anything like adequate study. Microprojectors seem to be the answer to this problem for elementary schools. A good microprojector will magnify sufficiently most of the things which teachers desire to portray and will enable the teacher to be sure just what the pupils are seeing.

Many good microprojectors are available on the market. It is also possible to secure an attachment for most slide and filmstrip projectors which will permit microprojection of both living materials and prepared slides.

Educational television is in its infancy at this time but this medium should become an increasingly important aid in teaching. Well-planned and portrayed science programs are beamed at the nation, and science teachers should take advantage of the learning opportunities for improvement of both themselves and their pupils. Closed circuit television will probably enrich many science programs particularly in schools near large urban centers.

Keeping the science bulletin board should be a class activity rather than one carried out by the teacher alone. Interest and motivation of learning increase when teachers enlist the help of their pupils. The materials for the board should always be attractive, instructive and appropriate to the subject under discussion and the grade level of the group.

There are many values that may accrue from science bulletin board displays. Among these values are utilization or treatment of incidental happenings that might not fit well into the planned program; follow-up of past experiences either from the incidental or planned program; and motivation for future experiences. The bulletin board may be used for presenting clippings from various newspapers or magazines. It is also a good medium for displaying three-dimensional items. A display of this type is possible by using plastic bags such as those coming from the grocery store or used for packaging food in the home deep freezer.

A challenging quiz program can be developed around the use of the bulletin board and the plastic enclosed items tacked to it. A provocative sign such as "INFOR-

MATION PLEASE", placed above the display with paper for answers, and an answer box available to the children will contribute to the success of the program. Such a quiz program may be conducted by a committee of pupils responsible for preparing the displays, collecting the answers, and reporting the results periodically to the group.

Values from the bulletin board may be lost if the displays are too cluttered and lack organization; if they aren't changed frequently; if the items posted consist primarily of printed material requiring extensive reading; or if the data portrayed are beyond the pupils' level of comprehension.

Bulletin board materials should be instructive instead of "just pretty" and should be displayed for the children rather than to impress adult visitors to the classroom.

During the school year children bring all kinds of specimens to the classroom. These specimens lend themselves to handling and close observation. The motivation for bringing some of these materials arises from the course of the regular class activities. Other items are brought to school because they attract the attention of the child who wishes to share his findings. These items come under the heading of incidental materials, and examination and study of them can greatly enrich the science experiences and awareness of the children.

There are few classrooms that do not have "living things" brought in which enable the pupils to study where the "thing" lives normally, what "it" eats, and "its" relationship to other living things. Children gain attitudes and develop a sense of responsibility and respect for their living charges brought to the classroom. Dead specimens may be preserved in alcohol or diluted formalin, or they may be briefly examined prior to disposal by such means as seem advisable to the teacher.

Non-living objects can be kept for prolonged periods for study either as classroom museum specimens or as items for the science corner, table, or bulletin board. Whatever the specimen, it should be available to the child for handling and close examination. Only those things that might be dangerous to his safety or are fragile and difficult to replace should be kept from him. Materials which are kept behind closed doors or filed away for safekeeping add little of instructional value.

Encouraging pupils to bring materials to the classroom presents a problem of space for display or storage. Perhaps a wise teacher should encourage pupils to take things home after a brief "show and tell" sojourn at school. Teachers are also advised to use the wastebasket judiciously. Third grade children tend to find and bring surprisingly similar things year after year, so don't hoard too many bird nests.

Auditory Materials

A number of auditory aids allowing vicarious experiences by the pupils are used by teachers to supplement or enrich teaching. The usual auditory adjunct to teaching is the sound tract commentary with films.

There are also many excellent records on science subjects which can be utilized. Some of these are transcriptions of the songs of birds such as those distributed by the Audubon Clubs and produced by Cornell University. Some are on the physical sciences and incorporate songs and science narration which help to make learning new ideas a simpler task for the children. If there is a record library in the school or classroom and the children are free to operate the record player at their free time, some of the science records on the market are attractive enough to be selected for frequent playing. This provides an equivalent to a pleasant drill experience on the ideas portrayed.

Tape recorders, becoming increasingly popular in the schools, permit teachers to record for future use portions of their class activities or enable small groups of pupils to produce science programs for class consumption at later periods. Outstanding programs so taped may be shared by other classes or schools. Some schools have made collections of tapes which are produced commercially or have been taken from radio or television. Tape recorders are versatile and do not need professional operators. The magnetic tapes now on the market have advantages, too, in that they may be re-used numerous times by a teacher and the initial cost is relatively low.

Many radio programs on science subjects are produced by commercial companies. Radios are inexpensive and no classroom should be without access to one. Parent organizations, such as the Parent-Teacher Association or Grade Mothers, frequently are looking for projects to sponsor and can easily supply a radio for classroom use. A tape recording made of a program coming at out-of-school hours may be played at a time when it will fit conveniently into the activities of the class.

A high percentage of children today have access to television sets. Educational television stations as well as many commercial stations produce science programs which are designed for children. These programs, as in the case of sound films, must be considered as auditory as well as visual aids. A majority of these programs are available at hours when the children are out of school, but schedules produced in advance by the stations and networks will allow teachers to alert their children to outstanding programs ahead of time. Unfortunately many of these programs are on areas of science unfamiliar to the teachers, but they may be used to increase the knowledge of both the teacher and the pupils.

Library Materials

A library serves as a depository for a wide variety of teaching aids. The quality of these aids will vary widely over the state depending upon finances, facilities available, and the training and interest of the person or persons in charge.

The school librarian can be one of the most valuable members of the school staff and one to whom the children will turn for advice and guidance in searching for solutions to their problems. Solutions lie not only in standard reference books but also may be found in supplementary readers of appropriate grade levels, nature guides, pamphlet files, and resource files of pictures and clippings.

The trend of libraries to include various instructional aids means that children may go to the library to find models, charts, mock-ups and various realia and museum items. A desirable school library will frequently contain recordings, filmstrips and sources for obtaining these instructional materials.

When curricular changes are in the planning stages, the librarian may effectively aid in helping to develop an enriched program. His awareness of materials of many kinds goes beyond that of the average classroom teacher.

Classroom libraries are of necessity the only resource of this type available in many schools. This does not mean that the classroom library is not desirable in addition to a central school library if this service is available. A classroom library is as good as the teacher is resourceful. It need not be limited to out-dated resources since up-to-date and informative materials on any level are available through state agencies.

Some of the Illinois agencies supplying free service to school librarians are:

1. Illinois State Library—Springfield

Photograph Courtesy of Southern Illinois University Photographic Service

Good Books Provide Pleasure As Well As Reliable Information

2. Illinois Natural History Survey, Urbana
3. Illinois State Museum, Centennial Building, Springfield
4. Illinois Department of Conservation, State Office Building, Springfield
5. Illinois Geological Survey, Urbana
6. Illinois Department of Public Health, State Office Building, Springfield

The state supported universities and colleges may also be called upon for materials, services, and sometimes consultants or resource personnel.

Community Resources

Every community, regardless of the size or location, has a number of resources which lend themselves to an enriched science program. Some of these are natural; some man-made. It becomes the task of the teacher to recognize the importance of these resources and use them in his particular science plan. These resources can be classified under the general headings of:

1. Industries
2. Public utilities
3. Places
4. Persons

Each community differs from all others. To streamline science instruction to the needs of the individual those resources which are characteristic of a community should be studied in preference to those which would be foreign to the experience of the child.

The industries of a community are its life line. They not only afford the livelihood of the citizens but serve as a potential source of many scientific principles if profitably utilized by the schools of the community.

Some representative industries in Illinois communities are manufacturers of pianos, electric motors, glass products, farm machinery, wire fencing, furniture, pottery and pharmaceuticals.

Any alert teacher or child can add materially to this list in a short time. By following the suggestions considered under the area devoted to field trips in a previous section of this chapter, a most worthwhile experience may be had by visiting any of these concerns.

Children, especially those in the lower grades, can profit greatly from a visit to a nearby farm. Some children could conceivably experience their first contact with some domesticated farm animals. A study of the source of food suggests a challenging unit which might lead to a more mature consideration of hybrid corn and hybrid chickens. The production of each of these is an important new industry in Illinois. Study of these industries can open a vast field of knowledge unknown to the pupils a generation ago.

Public utilities in a community include the sources of the supply of water, milk, meats, fruits and vegetables; sewage treatment, trash disposal, and electrical and gas production. Each of these offers a wealth of science material that should be meaningful to the child because of its being a part of the community.

A third category of community resources is that of places. Under this heading one might conceivably study city and state parks. Some type of park facility is available in almost every part of the state. Residents in almost every community can reach a park within a few hours. These areas are especially suited for the study of geology, conservation and many other phases of science education. Some school systems are acquiring natural areas for various forms of outdoor education. Programs vary from one-day's length in the open to a week's experience.

The teacher, working with the pupils in his class, may arrange to make a detailed study of one or more of the above community resources. The approach the teacher uses should consider the scientific principles involved in the activity.

In teaching science the classroom teacher should also use resource persons of the community who have special contributions to make. Some persons may have established outstanding reputations for themselves as research workers or government employees in scientific areas. Others may have pursued hobbies extensively and intensely in selected phases of science.

Evaluation of Teaching

Nature of Evaluation

Evaluation should function in the classroom to determine the growth of pupils relative to curriculum objectives. Evaluation involves making value judgments which can, and usually do, have far reaching implications for the learners. From the standpoint of both the teacher and the pupils it is a vital part of the learning process. In all stages of learning the pupils judge their accomplishments in terms of their purposes and experiences. Through some evaluation procedures pupils may discover what they have learned and what they have failed to learn.

The importance of evaluation in terms of the life goals of the pupils is currently increasing. Recognition of abilities through merit awards, scholarships, opportunities to enter college, and other current trends are placing more demands on the evaluation program at the secondary school level. The advanced placement programs and multitrack plans of some secondary schools create a greater need for improved evaluation procedures in our elementary schools.

Evaluation Procedures

Although evaluation is frequently stressed in the culminating phases of a unit, good teaching recognizes the necessity for continuous evaluation. The methods of evaluation are many and varied depending on the types of learning experiences that are taking place. However, certain techniques of evaluation recur so frequently and are so often a part of good teaching that they need special consideration.

The evaluation procedures used in the classroom should have several general characteristics. First, they must clearly indicate to the teacher what changes in attitudes and understandings have taken place in the individuals in the class, and equally important what skills and knowledges have been mastered. Second, the evaluation procedures should indicate to the teacher the degree of success of the methods used in teaching the class. Study of the results obtained after a learning experience has been evaluated should give evidence of the ways in which this particular group learns most readily and thoroughly. Evaluation indicates possible variations in teaching methods as new learning experiences are planned. Also from such study should come some understanding of a given individual's ability to profit from a particular type of teaching.

Third, the evaluation procedures used in teaching should help a pupil gain a better understanding of himself. He should learn to understand how well he is succeeding in relation to his ability and efforts, as well as to compare his progress with the progress of other children of similar age and maturity. Obviously this calls for the development of self-evaluation skills as well as the more traditional ones commonly used.

Since the teacher is concerned with a much broader developmental pattern than a mere mastery of subject matter the procedures must also provide insight into the relationship pattern of the pupil as a part of the group. The trend toward using small study groups, group projects, and individual and group reports as teaching learning techniques emphasizes a different approach to evaluation, if differentiation of abilities and skills of those individuals comprising the groups are considered.

Finally, the evaluation of pupils must give some measure of the total achievement of the individual that can be translated into permanent school records. These records become indices of the pupil's over-all ability in school life and are accepted by society as such. Frequently they are regarded as an indication of future success or failure in certain adult-life areas. Consequently, their importance cannot be minimized.

Collecting Data for the Evaluation of Pupils' Progress

A science teacher would not use a micrometer to measure his desk nor a meter stick to measure an amoeba. In the same sense, the growth of children must be measured in acceptable ways if the potential of each child is to be discovered. At the present time many techniques and devices are crude and inaccurate, yet the use of varied devices along with the teacher's best judgment tends to give a more adequate picture of each individual than a single instrument such as the paper and pencil test. The remainder of this section is a discussion of selected evaluation procedures which can be geared to the elementary school science program.

1. Observation in Evaluation

Observation of pupils by teachers resulting in value judgments is a long established method of evaluation. The subjectivity of such evaluation is recognized by all teachers. The tendency to observe and remember quantity over and above quality in pupil behavior is also recognized. The use of checklists, rating scales, and anecdotal records helps the conscientious teacher make his subjective observations more objective. It would probably be wise to discuss the items on the checklists and rating scales with the children early in the year. Time should be spent also in acquainting the pupils with other evaluation criteria. Examples of checklists that may be used follow.

Example I

Checklist for Pupil Demonstration — Joe and Bob

	Yes	No
Understood nature of experiment		
Began work promptly		
Assembled apparatus		
Carried out experiment		
Cleaned and stored material		
Experiment completed on time		
Completed laboratory notes		
Turned in notes on time		

A checklist such as this may be completed by the teacher during a pupil demonstration, in a regular laboratory period, or in other similar situations. It may also be completed by an evaluation committee of pupils. It may be filed with the teacher's records to be consulted at the time grades are given, or serve as a basis for planning with the pupils as a means of improving future demonstrations.

Example II

Checklist for Group Report	Ron, Myrna, Bette	
	Yes	No
Group organized and ready to start on time		
Chairman set stage for report		
Reports presented		
Questions answered		
Conclusions drawn		
Summarization		

The checklist as presented here tends to indicate the absence or presence of something to be checked. It helps the teacher apply the same standard to each pupil. Recorded periodically and compared, this technique can be used by the teacher to determine whether or not a given pupil is doing better work in December than he did in September.

The rating scale is perhaps a better device than the checklist to measure quality. Two rating scales are shown here to measure the same type of learning experience. Notice that the quality of what is observed determines the rating.

The rating scale is perhaps a better device than the checklist to measure quality of performance. Rating scales illustrated in Examples III and IV measure the same type of learning experience as illustrated in Examples I and II. However, the rating scales require value judgments about pupil performance which are of a qualitative nature.

Example III

Rating Scale for Laboratory Experiment	Joe and Bob			
	Excellent	Good	Fair	Poor
Understanding nature of the experiment				
Work habits				
Use of apparatus				
Development of laboratory skills				
Care of materials				
Notes				
Completed report turned in				

Example IV

Rating Scale for Group Report	Ron, Myrna, Bette			
	Excellent	Good	Fair	Poor
Organization of group				
Chairman's introduction of report				
First Report (Myrna)				
1. Presentation				
2. Content				
3. Conclusions				
4. Questions				
Second Report (as above)				
Third Report (as above)				
Conclusions				
Summary				

The rating scale can be used to compare different pupils as well as an individual's progress month by month in the same manner as the checklist.

Pupil evaluations of his own learning activities are also helpful to the teacher. Modifications of the basic structure of the checklist and rating scale have been developed by teachers and pupils to enrich learning experiences carried out in study groups, discussion groups, and other small group activities.

The following form may be turned in to the teacher by each pupil at the conclusion of a discussion group meeting.

1. I feel that our meeting accomplished (circle one) very much; much; little; very little.
2. Our discussion was (circle one) helpful and to the point; helpful but a little disorganized; too disorganized to accomplish much; confusing.
3. Our best discussion centered around________________________
4. Our biggest weakness was________________________
5. Our next step should be________________________

One pupil in a discussion group may be assigned the task of keeping the following record for the teacher.

Participation in Group Discussion Record

—Aided discussion
**Did not aid discussion
? Doubtful Value
Q Asked questions

} Code for Keeping Record

Name of Pupil — Number of participations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sarah														
Mary														
Lou														
Lynn														

As different pupils within the group prepare reports similar to the above, the teacher begins to get a better picture of group structure. Boys and girls who participate in self-evaluation gain self-understanding. As the data on a given child continue to grow, a more adequate picture of his progress is obtained.

Closely related to the more formal type of observation done in the classroom are checking reading selections in the library, informal talks with pupils, and listening to them.

2. Teacher-Made Tests in Evaluation

Except in the early primary grades, testing is the most widely used method of evaluating pupil progress. Here again the teacher must recognize the necessity for using a testing technique that is appropriate to the type of evaluation desired. There are available to teachers many excellent books on testing techniques. Only a few outstanding factors in testing will be emphasized here. First, the teacher should have in mind definite objectives which he hopes the test will accomplish. Second, he should recognize that good test questions are difficult to prepare and should study each question he uses accordingly. Third, all types of testing contain an element of subjectivity. Consequently, the information secured on a test should be checked against that obtained through other evaluative techniques. No single test is an infallible source of information about a child. Fourth, care should be exercised in assigning grades in terms of raw scores to insure that error is kept at a minimum.

A large variety of types of questions and exercises are available to the teacher in preparing a test. Commonly used ones in the essay group are those which require discussion, description, explanation, narration, identification, and evaluation.

In using the so-called objective type items the teacher should recognize and use the type of exercise that most nearly fits his teaching objectives.

True-False items are frequently used to assess factual knowledge. For example, True or False: An anemometer measures wind velocity. This in no way tests the child's understanding of the process involved. To accomplish this with a true-false item is almost impossible. Similarly, the completion and matching items permit the teacher to cover a wide variety of factual materials in a minimum amount of time. It is possible to measure attitudes and understandings with true-false test items. However, this is difficult to accomplish but with diligence on the part of the teacher, worthwhile items of this nature can be devised. Completion and matching items, which are somewhat related to true-false items, permit the teacher to cover a wide variety of concepts at a deeper level of understanding than with true-false items. For example:

The multiple-choice item is a more difficult item and probes deeper into the pupil's understanding. For example:

Wind velocity is measured by:

1. An Anemometer 2. A Thermometer 3. A Barometer 4. All of these

Here the pupil is forced to recognize and understand the purpose of three instruments to eliminate the fourth item.

A pupil's understanding of relationships can be explored by an item such as:

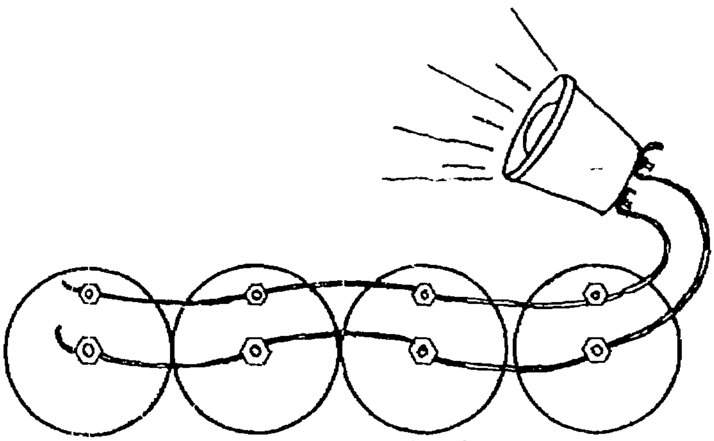
Temperature is to Thermometer as Wind Velocity is to:

1. Anemometer 2. Barometer 3. Hygrometer

The ability of the pupil to make the correct choice indicates an understanding of the similarity in relationships that exists between the different parts of the item.

Exercises such as the following can be made as complex as the learning situation requires.

John and Billy are studying electricity. They have pooled their resources and bought four dry cells, ten feet of wire, and a focused spotlight with a six-watt bulb. They plan to use these materials while camping. Before leaving home they decide to test their apparatus. First they hook up the four dry cells as follows:



On the basis of the above information do the following:

Mark "A" for statements with which you agree.
Mark "D" for statements with which you disagree.
Mark "U" for statements that you cannot answer because there is not enough information given.

_____This will give a bright focused spot of light.

_____The light will burn dimly.

_____Only a small part of the filament will glow.

By using different diagrams, introduction of new situations, and more difficult exercises, the teacher can obtain a better insight into the pupil's understanding of a number of related items. Value of answers can be varied by asking pupils to give reasons for answers, or to indicate other information needed in the case of "U" answers.

3. Written Materials Other Than Tests

Various types of written materials should contribute to the evaluation and understanding of the child. The pupil who is artistically inclined may express his interest and understanding through sketches, diagrams, and labeling and organizing displays. Formulating experiments as the result of a learning experience can give the teacher insight into the depth of understanding achieved by an individual pupil. Preparing lists of questions by children give the teacher an understanding of unlearned relationships. A child's expression of what he feels will occur next in a chain of events helps the teacher to understand his reasoning.

In summary, all the information obtained through the evaluation procedures used by the teacher should be considered in the final mark given the pupil for his work. As a part of this final marking procedure a short conference with the child in which the teacher shows him the records of his progress in groups, in laboratory experiments, in written work, on tests, and judgments of his strengths, weaknesses and abilities, can go a long way in helping him to appraise himself in a realistic way. It also helps him to understand all of the variety of achievements that are summed up in the "B" which is recorded on his report card.

Teachers Should Examine Their Teaching[1]

"In addition to evaluating pupil progress, the teacher should examine critically his approach to the teaching of elementary science. This is especially important since many teachers of elementary school children have not been adequately prepared to teach science by their pre-service training. Therefore, it might be well for each classroom teacher, each consultant, and each administrator responsible for curriculum development to ask himself such questions as the following:

1. In my teaching and in my professional studies am I concerned with the importance of science to society and of the layman's responsibility in relation to the progress and use of science?
2. Am I constantly reading, televiewing, listening, or evaluating to enlarge my store of science content?
3. Am I making science an important part of my curriculum by planning and providing sufficient time and adequate materials for it in the program? Am I emphasizing it in reporting to parents?
4. Am I becoming more confident in approaching new problems in science and learning with the children?
5. Do I make flexible, but careful, plans for science?
6. Do I scrutinize my teaching constantly to determine whether or not my goals are desirable and attainable?
7. Am I aware of the progress or lack of progress of individual children?
8. Do I consult with colleagues in an ongoing appraisal of the total program in elementary science?

"In evaluating the teaching process in relation to elementary science, consideration must be given to the degree of success attained in setting workable and reasonable goals, the use of techniques for appraising the progress of each child toward these goals, the constant self-appraisal by each teacher of his own attitudes and methods in the area of elementary science, and the ongoing evaluation of the process of evaluation itself."

1. Glenn O. Blough, "Teaching and Evaluating Science in the Elementary School," in *Rethinking Science Education*, p. 149. The Fifty-ninth Yearbook of the National Society for the Study of Education, Part I. Chicago: Distributed by the University of Chicago Press, 1960.

TEACHER'S NOTES

CHAPTER VI

In Summary: Directions For The Future

A published statement by the President's Science Advisory Committee issued from the White House, Washington, D. C., May 24, 1959 stated in part, "Four specific tasks require special emphasis today in light of our ambitions toward intellectual development. These are:

1. To build well-rounded curricula and in each subject to stress intellectual content and provide for recognition of intellectual achievement.

2. To recognize that teaching is a task of primary importance in modern society and therefore to encourage, aid, and reward competent teachers in all fields.

3. To recognize that our modern society needs human talents of a wide variety, and that it is essential that every individual be given the maximum opportunity to develop his particular talents to their utmost.

4. To understand that the advances of science and technology need special attention to the end that all citizens of modern society acquire reasonable understanding of these subjects, and that those with special talents in these fields have full opportunity to develop such talents."

In an effort to partially meet these tasks in our schools, this bulletin has been prepared. The committee reminds all users, administrators, science consultants, and classroom teachers, that the bulletin is primarily a guide of a non-prescriptive nature. Therefore, those who pick up the challenge and initiate in-service education activities pointed toward better science instruction will be acting in good faith with the committee.

Key threads which permeated the thinking of the committee are summarized in the following paragraphs.

Since there is much more to learn today than there was only a decade ago, the content and learning process in science education must reflect not only the advances in each area of science but also must be organized more efficiently if we are to accomplish our objectives. Our educational objectives can be achieved only through the reorganization and telescoping of the total curriculum at all grade levels.

The reasons for teaching science in elementary schools actually represent long-term outcomes requiring a developmental and integrated program of instruction in science covering the entire school life of children and young people. It will be necessary for local school staffs to develop over-all policies for the program as a whole and appropriate policies for each grade level. The policies evolved should insure the orderly procession, without interruption, of science learnings from the kindergarten through the twelfth grade.

Strengthening Science Teaching in Elementary Schools should encourage teachers to be creative and accept the idea of being learners and investigators with their pupils. The classroom should be organized and maintained as a "research laboratory" for solving problems and thus promote effective learning. In science education consideration should be given to the maturity levels of children in each grade. This is perhaps taken into account better through the variation in teaching approach and materials used than in terms of subject matter areas or themes, since any science area or theme may be presented at any given grade level.

A program of sound instruction in science education must be more than a series of interest-catching demonstrations and experiments. Experimentation at the elementary school level should minimize the use of equipment and emphasize the factors of locating materials, collecting information, and reporting observations accurately.

Although a rather extensive list of reference materials and science resources are included in Appendix C, teachers and pupils are urged to build their own bibliographies and lists of community resources. No teacher should feel that he is blocked in having an effective science program because he may not have immediately available all the resources listed.

Finally, since curriculum improvement is a process continuous in nature, the committee anticipated the need for revision of selected parts of the bulletin ere much time has elapsed. Therefore, the recorded observations and evaluations of the bulletin can be very helpful to those responsible for future revisions of *Strengthening Science Teaching in Elementary Schools.*

APPENDICES

A. A Collection of Science Experiments and Demonstrations

B. Additional Activities for Enriching Science Teaching

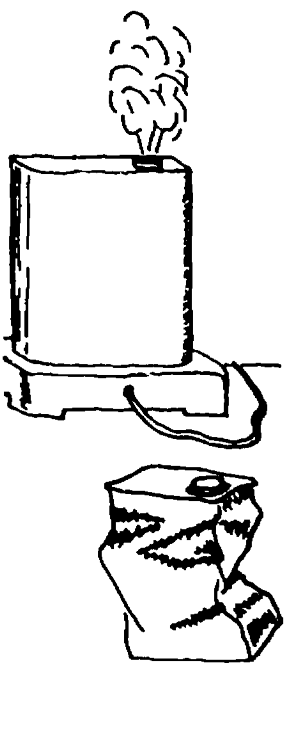
C. Selected References and Resources

APPENDIX A

A Collection of Science Experiments and Demonstrations

AIR, WEATHER, AND AVIATION

1. THE TREMENDOUS PRESSURE OF AIR



Materials:

A sealable can, a source of heat, and water.

Procedure:

1. Place a small amount of water in the can.
2. Heat the can until the water boils.
3. Remove the can from the heat and seal it.
4. Allow the can to cool.

Expected Outcome:

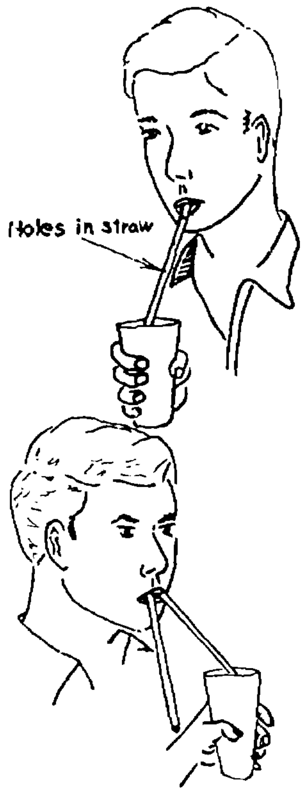
The can will deflate and be crushed and dented.

Scientific Explanation:

When the water boils, water vapor will replace the air in the can. When the can is removed from the source of heat, some of the vapor returns to water, and the cooled vapor contracts exerting less pressure on the inside of the can than does the air pressing on the outside of the can. The tremendous force of the outside air pressure on the can causes it to collapse.

Ideas for Further Exploration:

2. DRINKING THROUGH STRAWS



Materials:

Several straws, a liquid in a glass or bottle, and a pin.

Procedure:

1. Have someone drink through a straw and discuss what happens.
2. Make several holes in one straw with a pin and try to use this straw.
3. Try to drink with two straws having only one in the liquid.

Expected outcome:

Very little of the liquid will come up through the straw with holes. With one straw in the liquid and one in the air, no liquid can come up the straw.

Scientific Explanation:

When the air is drawn from the straw, pressure inside the straw is reduced and the outside pressure on the liquid forces it up the straw. The holes in the first straw permit air to rush in and replace the air sucked out therefore equalizing the pressure. When two straws are used, air coming through the one straw keeps the pressure in the mouth equal to that on the liquid. Without the difference in pressure no liquid will travel up the straw.

Ideas for Further Exploration:

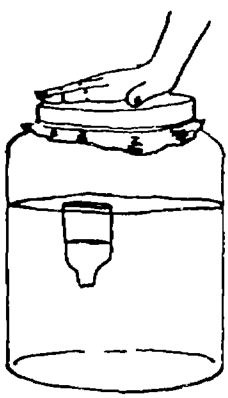
3. A DIVING BOTTLE

Materials:

A small bottle, a tall wide-mouthed bottle, a piece of sheet rubber, rubber bands and water.

Procedure:

1. Fill the large bottle almost full of water.
2. Partly fill the small bottle and experiment until it floats even with the water level, taking out a little water if it sinks, and adding a little if it floats too high.
3. When the correct balance has been found, place the small bottle in the large one and tightly cover the mouth of the large bottle with the rubber.
4. Press on the rubber with your hand and release it.



Expected Outcome:

When you press on the piece of rubber, the small bottle will sink, and when the rubber is released, the bottle will rise.

Scientific Explanation:

Pressing down on the rubber compresses the air above the water causing the pressure of the water on the air inside the small bottle to be greater forcing more water into the small bottle. The added weight of the water in the small bottle causes it to sink. When the rubber top is released, the air in the bottle can expand and push out some of the water making it light enough to rise again.

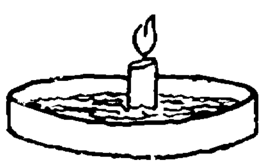
Ideas for Further Exploration:

4. THE EFFECT OF HEAT AND BURNING ON AIR

Materials:

A candle about 2½" high, a shallow dish of water, and a milk bottle.

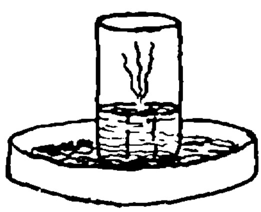
Procedure:



1. Fasten the candle to the bottom of the dish by melting its base with a match.
2. Fill the dish with water.
3. Invert the bottle over the lighted candle with the top of the bottle under water.

Expected Outcome:

Bubbles will come from the bottle and the water will rise in the neck of the bottle putting out the candle. After the candle has been extinguished the water will continue to rise.

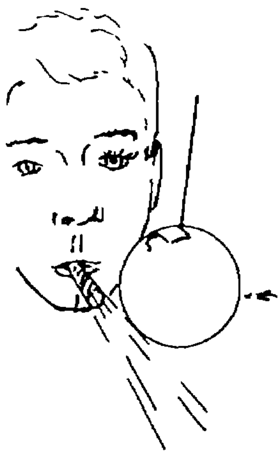


Scientific Explanation:

As the candle burns the air inside the bottle expands and some escapes in bubbles. The oxygen is also used and the materials that are produced by the burning take up less room so the water rises to fill the space until the candle is extinguished. After the candle goes out the air remaining in the bottle cools, contracts and exerts less pressure than outside air. The pressure of the air on the water in the dish therefore forces more water up into the bottle.

Ideas for Further Exploration:

5. PRESSURE OF MOVING AIR



Materials:

A ping pong ball, a piece of string, cellophane tape and a straw.

Procedure:

1. Fasten the ping pong ball to the string with the cellophane tape.
2. With the ball hanging free, blow a stream of air through the straw across one side of the ball.
3. While blowing, move the straw from side to side.

Expected Outcome:

The ball will be forced toward the air coming from the straw and will tend to follow it as it moves about.

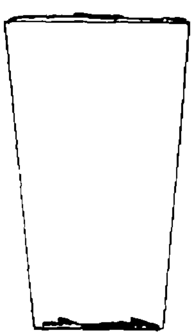
Scientific Explanation:

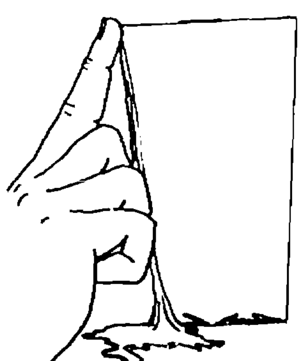
The pressure of moving air is less than that of still air. The air stream coming from the air created an area of lower pressure. The higher pressure of the still air forces the ball to follow the straw.

Ideas for Further Exploration:

WATER

6. SURFACE TENSION





Materials:

A tumbler full of water and some paper clips.

Procedure:

1. Be sure that the outside rim of the tumbler is dry.
2. Drop the paper clips into the water one by one until the water is standing higher than the rim of the glass.
3. Very carefully suspend a paper clip horizontally on the top of the water with a steady hand.
4. Touch the rim of the glass with a finger.

Expected Outcome:

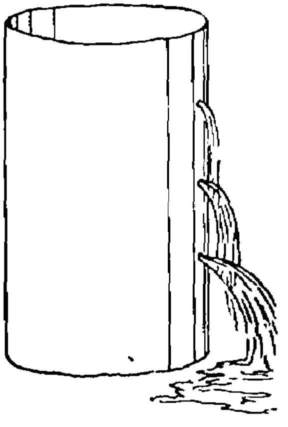
The water will rise above the rim of the glass quite a bit and hold the paper clip up as if there were a thin skin over the surface. If the rim is touched, water will begin flowing over the edge at the place touched.

Scientific Explanation:

The molecules in the uppermost layer of water are more strongly attracted to the mass of water than are the other molecules creating a concentration of molecules on the surface which acts like a thin "skin." This condition is broken by touching the water near the rim and the water spills over.

Ideas for Further Exploration:

7. WATER PRESSURE



Materials:

A tall juice can, two matches, water to fill the can, a glass dish, and a nail.

Procedure:

1. With a nail make three holes in the can one above the other. They must all be the same size.
2. Break two wooden matches and stop up the holes.
3. Put the can in the glass dish and fill it with water.
4. Pull out the match plugs.

Expected Outcome:

The water should make a larger arc coming from the bottom hole. The top hole will have the smallest arc of water.

Scientific Explanation:

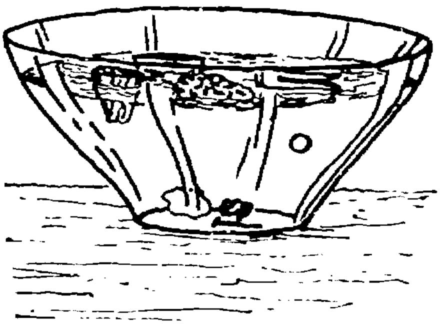
Greater pressure is exerted where water is the deepest.

Ideas for Further Exploration:

8. WHY OBJECTS FLOAT OR SINK

Materials:

A clear glass bowl, a sponge, a cork, paper, leaves, clothespin, rock, aluminum foil or other objects, and water.



Procedure:

1. Fill the glass bowl with water.
2. Place objects in the water one at a time and observe which of them float.
3. Take two pieces of aluminum foil the same size. Roll one piece up into a ball and shape the other into a little boat. Place both pieces in the water and observe.

Expected Outcome:

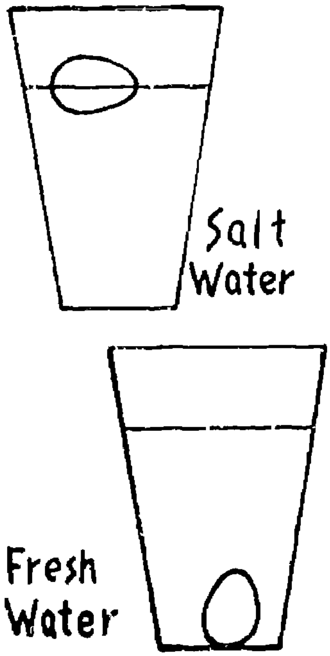
The air filled cork will float. Some objects such as paper and leaves will float until they become water soaked. Rocks and nails will sink. The aluminum foil in a ball will sink while that shaped like a boat will float.

Scientific Explanation:

Objects float in water if they are lighter than a quantity of water that would occupy an equal amount of space. Some objects sink after they become water soaked because the light air between their particles is replaced by heavier water. The boat shaped aluminum displaces sufficient amount of water to support its weight while the ball of aluminum does not.

Ideas for Further Exploration:

9. DENSITY OF LIQUIDS



Materials:

An egg, two glass containers, water and ½ cup salt

Procedure:

1. *Place an egg in water from the faucet.*
2. Add salt to water and place the egg in the salt solution.

Expected Outcome:

The egg will sink to the bottom in the fresh water but will float in the salt water.

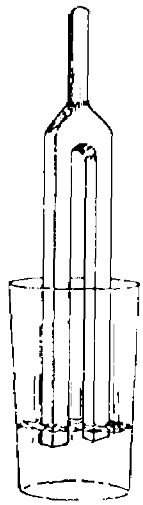
Scientific Explanation:

Salt water has a greater density than fresh water; therefore its weight is greater. The weight of the amount of salt water displaced by the egg is greater and so can support the weight of the egg. The term "weight" in the first sentence refers to the comparative weight of two equal volumes.

Ideas for Further Exploration:

SOUND

10. WHAT MAKES SOUND?



Materials:

A tuning fork, a glass of water, a cork on a string and an empty chalk box.

Procedure:

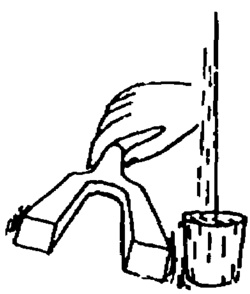
1. Strike the fork against a hard rubber object such as the heel of a shoe.
2. Place the fork in the water and observe the results.
3. Strike the fork again and hold the cork on a string against one prong.
4. Strike the fork; listen for the loudness and then place *the fork on the wooden box.*

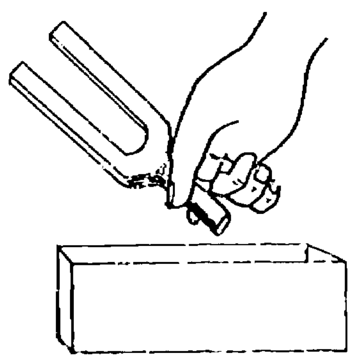
Expected Outcome:

The water will splash up when the fork is placed in it. The cork will bounce away from the fork and the sound will get louder when the fork is placed on the wooden box.

Scientific Explanation:

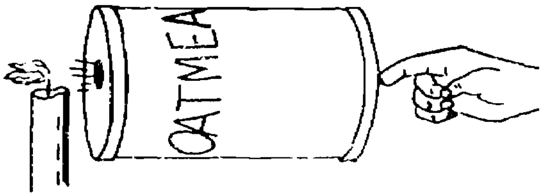
Sounds are made by vibrations. These vibrations cannot always be seen, but their presence can be assured by the splashing water and the bouncing cork. The sound becomes louder when the fork is placed on the box because the box is forced to vibrate also.





Ideas for Further Exploration:

11. SOUND WAVES



Materials:

An empty oatmeal box, a candle, matches, cellophane tape and a quarter.

Procedure:

1. Seal the lid of the box on with tape.
2. Cut a hole in the center of the bottom the size of a quarter.
3. Light the candle.
4. Aim the box at the candle and thump the lid.

Expected Outcome:

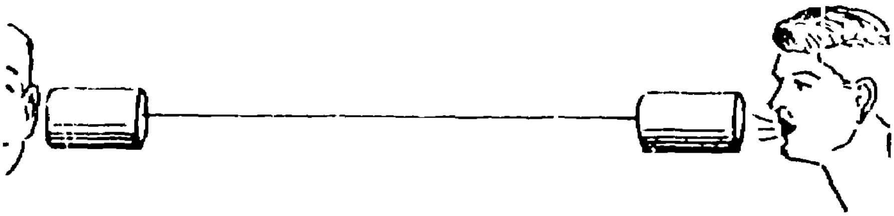
The candle will go out.

Scientific Explanation:

Thumping the lid sends out a compressional sound wave that moves the air molecules to "blow" out the candle.

Ideas for Further Exploration:

12. A TIN CAN TELEPHONE



Materials:

Two empty cans without lids, about 25' of string, and wax or paraffin.

Procedure:

1. Punch a hole in the bottom of each can.
2. Run the string through the holes in each can and tie knots in the ends of the string.
3. Wax the string by rubbing it.
4. Have two pupils hold the cans and walk away from each other until the string is pulled tight.
5. One pupil talks into one can while the other can is held near someone's ear.

Expected Outcome:

The voice of one pupil will be heard easily by the other although they are quite far apart.

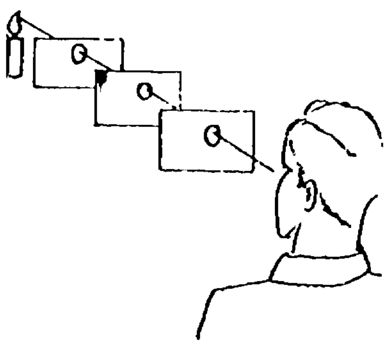
Scientific Explanation:

Talking into the can causes the bottom of the can to vibrate. The string carries these vibrations to the other can so that the bottom of that can vibrates in the same way. Sounds can be heard more clearly when traveling by the string than through the air.

Ideas for Further Exploration:

LIGHT

13. HOW LIGHT TRAVELS

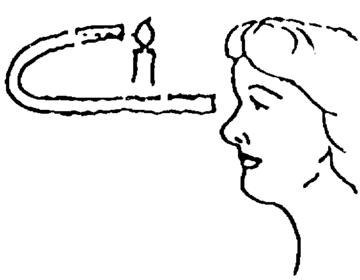


Materials:

Several pieces of cardboard, a candle, a match, a piece of rubber tubing.

Procedure:

1. Cut holes at the level of the candle flame in the pieces of cardboard and place them in a row in front of the candle.
2. Look through the holes at the light of the candle flame.
3. Move one of the cards up about an inch and try to see the candle flame.
4. Try to see the candle flame looking through a curved tube as in the diagram.



Expected Outcome:

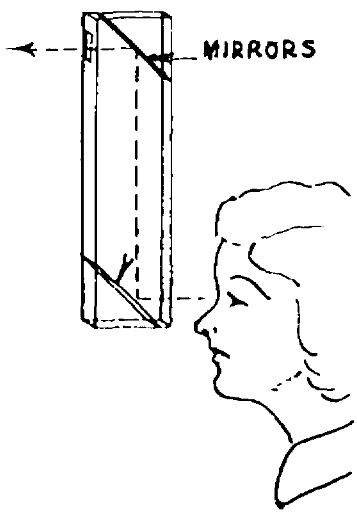
The flame cannot be seen when the card is lifted or when the tube is bent.

Scientific Explanation:

Light rays travel in straight lines through one medium such as the air and thus cannot bend around objects that lie in their path. This is also the explanation of shadows.

Ideas for Further Exploration:

14. A PERISCOPE



Materials:

Five pieces of heavy cardboard about 12 to 15 inches long and 3 or 4 inches wide, two small mirrors, and adhesive tape. A two-pound cheese box of the telescoping type may be substituted for the cardboard strips.

Procedure:

1. Fasten 3 of the pieces of cardboard together with tape to make an elongated box with a hole low on one side and at the top on the opposite side.
2. Attach the ends and attach the mirrors with tape or glue parallel to each other at a 45 degree angle.
3. Close the box by attaching the fourth side.

Expected Outcome:

Without being seen a person can look around corners and over high things with the periscope.

Scientific Explanation:

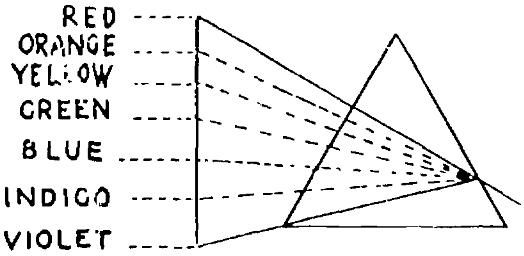
Light rays are always reflected at the same angle as they strike the reflecting surface. Therefore, the light striking the upper mirror is reflected toward the lower mirror which reflects it to the eye.

Ideas for Further Exploration:

15. A RAINBOW

Materials:

A prism, a sheet of white paper and sunlight.



Procedure:

1. Stand in front of a window with strong sunlight and place the paper on a nearby desk.
2. Hold the prism in different positions until the sunlight passes through and forms a rainbow on the piece of paper.

Expected Outcome:

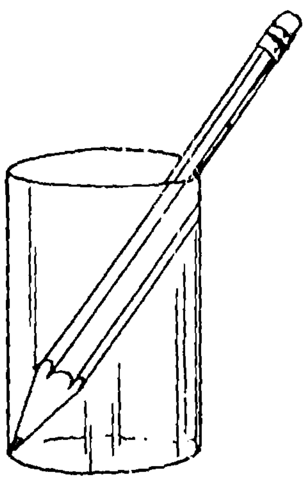
The colors red, orange, yellow, green, blue, indigo and violet will appear in that order.

Scientific Explanation:

White sunlight is composed of many colors. Because of the clearness and shape of the prism, the white light rays are bent at varying angles creating all the colors of the rainbow. In a natural rainbow droplets of water act as prisms to bend the light rays into colors.

Ideas for Further Exploration:

16. REFRACTION



Materials:

A pencil. a glass, and water.

Procedure:

1. Fill the glass with water.
2. Stand the pencil up in the tumbler so that it rests against the rim.
3. Hold the glass so that the surface of the water is level with your eyes

Expected Outcome:

The pencil will look broken at the surface, and the part under water will look larger than that above the water.

Scientific Explanation:

The rays of light from the upper part of the pencil go only through the air. The rays from the lower part must pass through water, glass, and air, which are mediums of different densities, and thus they are bent making the pencil appear broken at the surface of the water. The round shape of the water in the glass acts as a magnifying glass to enlarge the pencil.

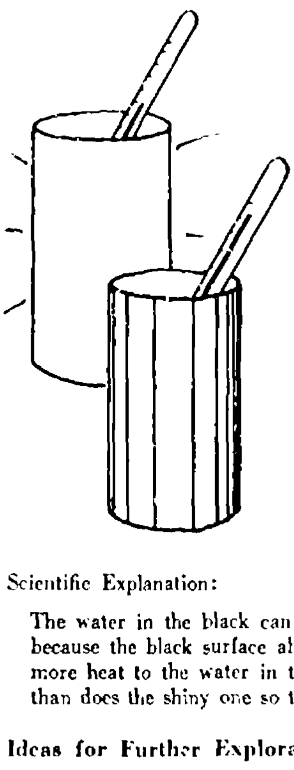
Ideas for Further Exploration:

HEAT AND FIRE

17. ABSORPTION AND RADIATION OF HEAT

Materials:

Two tin cans: one highly polished, the other black; two thermometers; some ice cubes and water.



Procedure:

1. Place water at the same temperature in both cans, put a thermometer in each can and place them in the sunshine.
2. After a period of time note the readings on each thermometer.
3. Remove the thermometer, empty the water and fill the cans again with water of the same temperature.
4. Place the same number and size ice cubes in each can and observe which cubes melt first.
5. Fill the same cans with hot water and after a period of time test the temperature.

Expected Outcome:

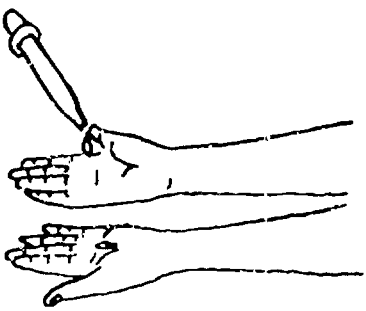
The thermometer in the black can will show a higher temperature than the one in the shiny can, and the ice cubes will melt faster in the black can. The temperature of the originally hot water in the black can will be lower after a period of time than will the water in the shiny can.

Scientific Explanation:

The water in the black can becomes warm and melts the ice cubes more quickly because the black surface absorbs the sun's radiant heat more rapidly and imparts more heat to the water in the can. The black can also radiates heat more rapidly than does the shiny one so that it cools faster.

Ideas for Further Exploration:

18. THE COOLING EFFECT OF EVAPORATION



Materials:

Water, alcohol, and two eye droppers.

Procedure:

1. Allow the water and alcohol to stand at room temperature for some time.
2. Place a drop of water and a drop of alcohol on each hand of the pupils.
3. Have them note which liquid evaporates first and which feels cooler.

Expected Outcome:

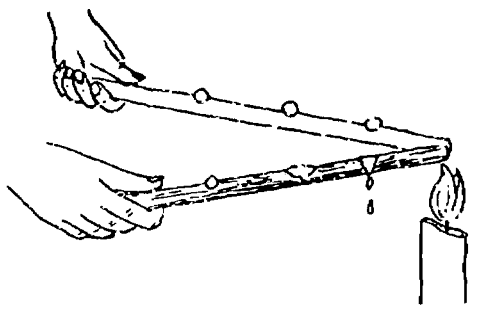
The alcohol will evaporate faster and feel cooler than the water.

Scientific Explanation:

Both water and alcohol evaporate in the air, but alcohol evaporates faster than water. When a liquid changes to vapor, it takes heat from the surface from which it is evaporating, therefore, the alcohol takes away heat faster and has a greater cooling effect than water.

Ideas for Further Exploration:

19. CONDUCTION



Materials:

A metal rod (brass curtain rod), a glass tube the same diameter as the rod, a candle, matches and wax.

Procedure:

1. By heating some wax make six little wax balls and attach the first ones about 4" from the end of the rod and tube.
2. Space the other balls along the rod and tube at about the same distance apart.
3. Hold the ends in the flame of a candle and observe the results.

Expected Outcome:

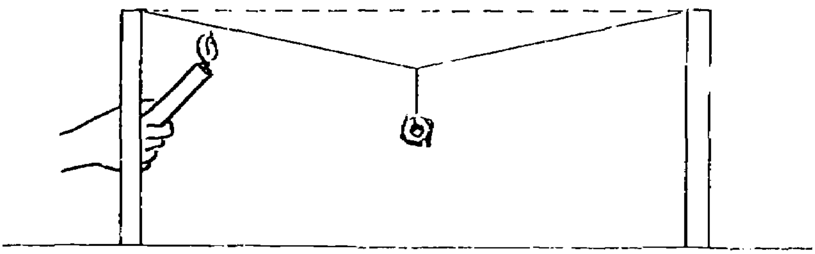
On the brass rod, wax will melt and drop off starting with the ball nearest the fire and continuing with the other balls toward the hand. The first ball on the glass rod will probably not fall off until the glass gets red hot and begins to bend.

Scientific Explanation:

Heat travels through some materials much more easily than through others. Because it conducts heat readily, brass would be called a good conductor of heat, while glass would be called a poor conductor. Other poor conductors are wood and paper.

Ideas for Further Exploration:

20. EFFECT OF HEAT ON A SOLID



Materials:

Two supports, a copper wire, a weight on a string, a candle, matches, ice, and a ruler.

Procedure:

1. Have two pupils hold the supports steady if they are not attached to the table.
2. Stretch the copper wire between the two supports.
3. Suspend a weight of any kind from the wire.
4. Measure the distance from the weight to the table.
5. Light the candle and heat the whole length of the wire.
6. Measure the distance from the weight to the table again.
7. Rub a piece of ice along the wire and measure again.

Expected Outcome:

After heating, the wire will sag and the distance from the weight to the table will be less. When ice is applied, the wire will raise the weight again.

Scientific Explanation:

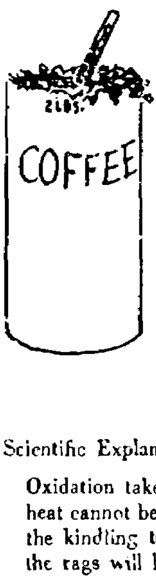
Heat causes molecules of a solid to expand while taking heat away causes contraction of the molecules.

Ideas for Further Exploration:

21. SPONTANEOUS COMBUSTION

Materials:

A 2 lb. coffee can, a small can (lid removed), a thermometer, cotton rags, linseed oil and some newspapers.



Procedure:

1. Soak the rags in linseed oil.
2. Stuff the small can three-fourths full of soaked rags and insert the thermometer.
3. Crumble newspapers in the large can and place the small can in the center.
4. Finish filling in newspapers around the small can to insulate it.
5. Keep a record of the temperature throughout the day beginning with the reading before placing the thermometer in the can.

Caution: If the experiment is to be left for a longer period of time, it should be placed where damage would not result should it burn.

Expected Outcome:

There will be a steady rise in temperature during the day. If left long enough, the rags will burst into flame.

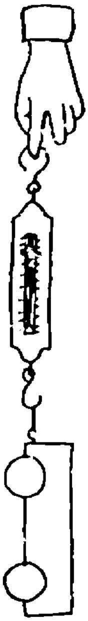
Scientific Explanation:

Oxidation takes place rapidly in oily rags, and oxidation produces heat. When the heat cannot be carried away by the air, it builds up in the interior of the rags. When the kindling temperature is reached, (the temperature at which it will catch fire) the rags will burst into flame.

Ideas for Further Exploration:

MACHINES

22. AN INCLINED PLANE



Materials:

A board about 2′ long and one about 4′ long, a spring scale and some cord.

Procedure:

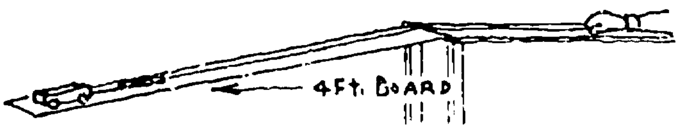
1. Load a toy wagon with some weight and weigh the wagon and load on the spring scale to determine the force required to lift it.
2. Set the short board up to a low table and haul the wagon up the inclined plane created noting the force required on the spring scale.
3. Put the longer board up to the table and haul the load up this inclined plane noting the force required.

Expected Outcome:

Less force will be required when the inclined plane is used, and the longer the plane the less force needed.

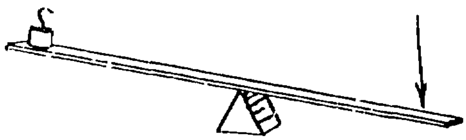
Scientific Explanation:

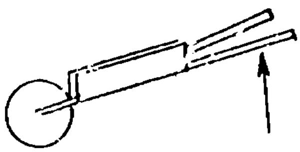
In an inclined plane less force is required but distance is sacrificed. The longer the board, the more gentle the slant and less force is needed to move the weight. However, since the load must travel much further, the same amount of work is required. Heavy objects such as pianos must often be slid up inclined planes in order to be moved

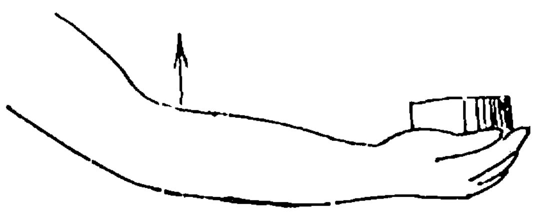


Ideas for Further Exploration:

23. LEVERS







Materials:

A stiff board and fulcrum or seesaw, a toy wheelbarrow and a weight.

Procedure:

1. Place the board over a fulcrum (some triangular object) and put the weight on one end of the board. Experiment with the weight at different distances from the fulcrum. A seesaw could be used here.
2. Examine the wheelbarrow at work and find the weight, the force and the fulcrum.
3. Lift a weight with the arm in the position pictured in the diagram and discuss the force, weight, and fulcrum in this type of lever.

Expected Outcome:

The levers will enable the students to lift heavy objects, and the weights will be easier to lift the closer they are to the fulcrum.

Scientific Explanation:

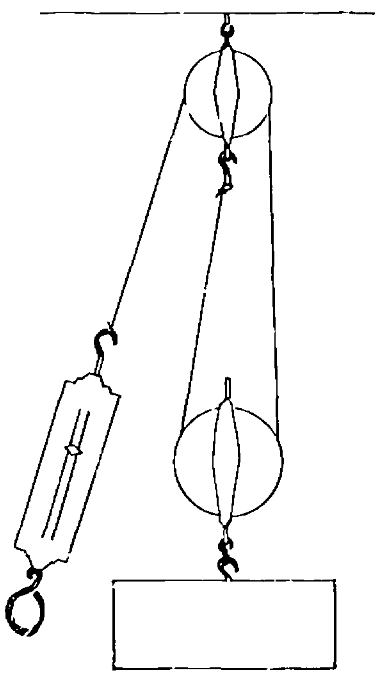
The advantage of a lever depends on the distances the small effort and the large weight are placed from the fulcrum. A long effort arm in relation to the short resistance arm offsets the small effort in relation to the large resistance. There are three types of levers according to where the fulcrum is in relation to the weight and the force. All three are illustrated in this experiment.

Ideas for Further Exploration:

24. PULLEYS

Materials:

A flagpole, 2 pulleys, some strong string and a weight.



Procedure:

1. Watch the flag being raised and note the advantage of the fixed pulley at the top of the pole.
2. Arrange two pulleys as shown in the diagram.
3. Lift the weight without the aid of the pulleys, then attach the weight to the lower pulley and lift it by pulling the rope (Spring scales could be used if available.)

Expected Outcome:

When raising the flag, the rope is pulled down to make the flag go up to a height that otherwise would be difficult. Only about half the effort will be required to lift the weight with the aid of the pulleys.

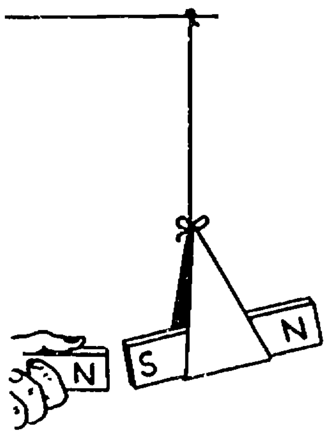
Scientific Explanation:

The pulley on the flagpole requires the same amount of force applied as is necessary to lift the weight, but it has the advantage of pulling objects to a height otherwise unobtainable. When the two pulleys are used, there are two strands supporting the weight, and the effort must move through twice the distance the weight does. Disregarding the resistance between the string and the pulley, a man could lift a weight twice as heavy with the two pulleys as he could without them.

Ideas for Further Exploration:

MAGNETISM AND ELECTRICITY

25. HOW MAGNETS ACT TOWARD EACH OTHER



Materials:

Two bar magnets with poles marked, a small sheet of paper, string, and a support.

Procedure:

1. Place one magnet on the table and try to lift it with the other magnet held horizontally with the north pole of one over the south pole of the other.
2. Reverse the poles of the magnet on top so that the south pole is over the south pole of the other.
3. Make a cradle out of paper for one magnet and suspend it from a support.
4. Experiment with the various poles to see which combinations attract and which repel.

Expected Outcome:

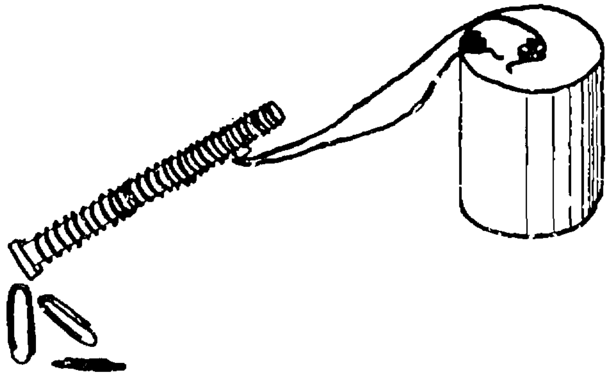
The magnet can only be lifted in the first position. The north pole will attract the south pole and repel the north pole of the other magnet. The south pole will attract the north and repel the south pole of the other magnet.

Scientific Explanation:

Magnetism is concentrated in the ends of a magnet. One end of a magnet is a north seeking pole and the other is a south seeking pole. One law of magnets is that like poles of magnets repel and unlike poles attract.

Ideas for Further Exploration:

26. AN ELECTROMAGNET



Materials:

About 6 yards of insulated wire, an iron nail or bolt, some paper clips or pins and a permanent magnet.

Procedure:

1. Try to pick up paper clips with the bolt.
2. Starting a foot from one end, wrap the wire around the bolt smoothly leaving little space between the turns. Make two layers if possible and twist the ends together to prevent unwinding.
3. Scrape the insulation off about ½ inch on each end of the wire and connect the ends to the dry cell.
4. Now, try to pick up the paper clips or pins.
5. Disconnect one end of the wire when the magnet is holding several objects.
6. Approach the poles of a permanent magnet.

Expected Outcome:

The bolt will not originally show any magnetic force. When the current is applied the bolt will act as a magnet and will pick up nails, pins, etc. However, when the current is disconnected the objects will fall off. The electro-magnet will show polarity or will attract one pole of the permanent magnet and will repel the other. The polarity of the electromagnet can be reversed by reversing the connections at the dry cell.

Scientific Explanation:

There is a magnetic field about a conductor when a current of electricity is passing through it. When a conductor is wrapped around a soft iron core such as a bolt, the magnetic field becomes many times stronger. The strong magnetism of the electromagnet depends on the electric current flowing through the wire. When the current is cut off, the electromagnet loses almost all of its magnetism.

Ideas for Further Exploration:

27. A SIMPLE ELECTROSCOPE

Materials:

A mayonnaise jar, a nail, sealing wax, a chewing gum wrapper, alcohol and cellophane tape.

Procedure:

1. Make a ½" hole in the top of the jar.
2. Melt the end of a stick of sealing wax and apply a blob around the nail about an inch from the head. While the wax is still soft, place the nail in the hole and press the wax against the sides of the hole keeping the nail centered until the wax hardens.
3. Soak the gum wrapper in alcohol; then rub the paper off and cut two strips ½" x 3".
4. Attach the strips with tape to the sides of the lower end of the nail making sure they touch the nail.
5. Give the electroscope a negative charge by touching the nail head with a hard rubber comb or vinylite record that has been rubbed with wool.
6. Bring articles near the knob to test their charge.

Expected Outcome:

If you bring a negatively charged body near the knob, the leaves will separate still farther. A positively charged body will make the leaves come together.

Scientific Explanation:

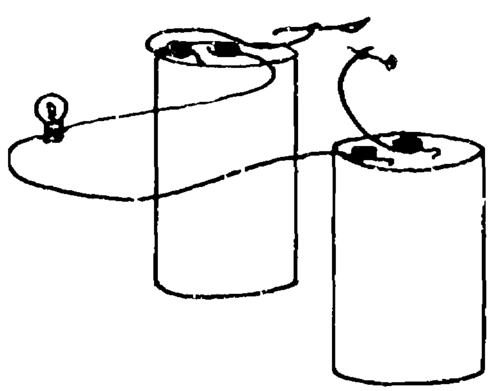
All matter is made up of atoms which have electrons moving about them. A negatively charged body has an excess of electrons. A positively charged body has a deficiency of electrons. When the electroscope is charged negatively, there are too many electrons on the leaves. A negatively charged body brought close to the knob drives more electrons from the knob down to the leaves creating a still greater negative charge making the leaves repel each other even more. A positively charged body will attract electrons from the leaves to the knob making the leaves have less electrons, so they will come closer together.

Ideas for Further Exploration:

28. WHAT MATERIALS CONDUCT ELECTRICITY?

Materials:

Two dry cells, a socket with a flashlight bulb, insulated copper wire, a rubber eraser, a stick, a nail, a brass paper fastener, a piece of glass, string, a silver spoon, cloth, etc.



Procedure:

1. Cut three wires to appropriate lengths, and take the insulation off the ends.
2. Attach the wires as shown in the diagram.
3. Touch points A and B together.
4. Hold the different materials between A and B to see if they conduct electricity.

Expected Outcome:

The light will go on if the material conducts electricity. The nail and spoon will conduct electricity while cloth, glass, wood and string will not.

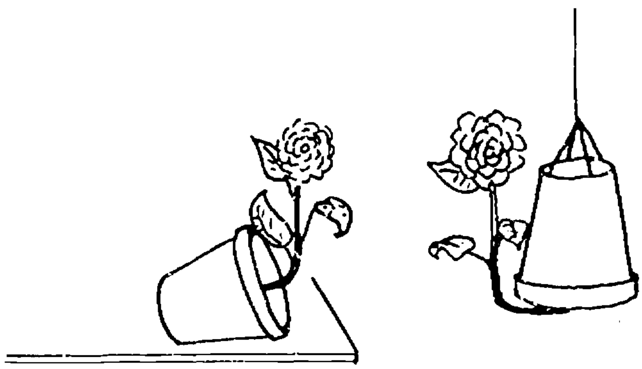
Scientific Explanation:

A cell furnishes a current of electricity if a wire is connected from one terminal to the other. When points A and B are touching the current can flow through the wire making a complete circuit. When materials that are good conductors of electricity are placed between these points, there is still a complete circuit and the light will shine. When a poor conductor of electricity is used, the current cannot flow through the wire to make the light shine.

Ideas for Further Exploration:

PLANTS AND FOODS

29. GRAVITY AND PLANTS



Materials:

Two newly sprouted plants in flower pots, wire or string and water.

Procedure:

1 Turn one pot on its side.
2. Hang the other plant upside down.
3. Place paper over the soil to keep it from falling out.
4. Observe the growth changes.

Expected Outcome:

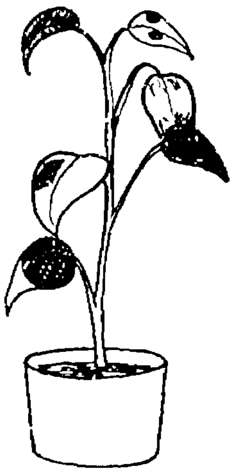
The leaves and stem will turn upward and if examined the roots will be seen to have turned downward.

Scientific Explanation:

Roots always grow toward the force of gravity while stems grow against it.

Ideas for Further Exploration:

30. PLANTS NEED AIR AND SUNSHINE



Materials:

A plant with large leaves, vaseline, a small piece of black construction paper, and paper clips.

Procedure:

1. Cut out figures in the black paper and paper clip it to a leaf.
2. Cover both sides of one leaf with vaseline.
3. Observe several days and remove the paper from the leaf.

Expected Outcome:

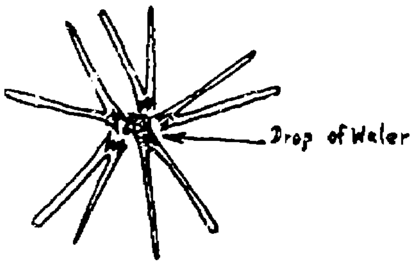
The leaf on which the vaseline was put will wither and die. The other leaf will turn yellowish brown under the black paper.

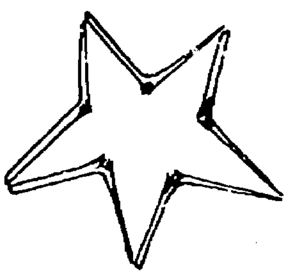
Scientific Explanation:

Plants need sunshine and air on their leaves in order to function properly. Without the green coloring matter that seems to disappear without sunlight, most plants cannot manufacture food. The leaves also have tiny openings or pores that need to take in oxygen. When the vaseline clogs these pores, the leaf dies.

Ideas for Further Exploration:

31. ABSORPTION OF WATER





Materials:

Five toothpicks, an eye dropper and water.

Procedure:

1. Break five toothpicks in half.
2. Arrange the toothpicks with the broken edges in the middle as shown in the top figure.
3. With the eye dropper drop a drop of water in the center on the broken edges of the toothpicks.

Expected Outcome:

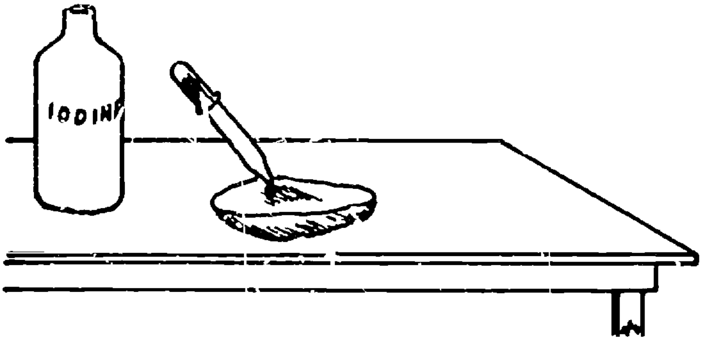
The toothpicks will straighten out slowly and form a star.

Scientific Explanation:

Capillary action causes the water to enter the dry wood cells at the bend in the toothpicks and swell the cells. This swelling tends to straighten the toothpicks, and as they all straighten and push against each other a five-pointed star is formed.

Ideas for Further Exploration:

32. WHAT FOODS CONTAIN STARCH?



Materials:

Iodine, and samples of various foods.

Procedure:

1. Test each specimen by putting a drop of iodine on it.
2. If desired, labels can be made for each food to make an interesting display or chart.

Expected Outcome:

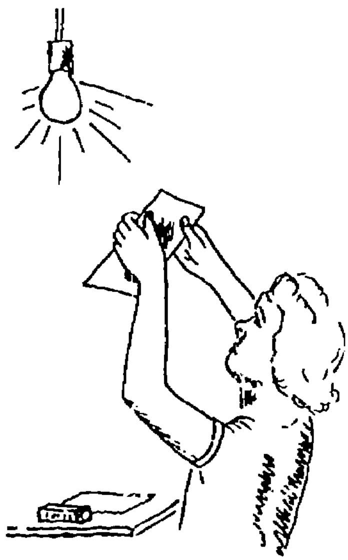
On some foods the area on which the iodine falls will turn purplish blue. On others this area will be reddish brown.

Scientific Explanation:

When some of the iodine is absorbed on the surface of a starchy food, it colors the area purplish blue. Iodine is thus a test for the presence of starch.

Ideas for Further Exploration:

33. WHAT FOODS CONTAIN FAT?



Materials:

Various specimens of food including peanuts, lard, bacon, olives, cheese and butter, and several pieces of writing paper.

Procedure:

1. Rub the food to be tested firmly on a sheet of paper.
2. Hold the paper up to the light.

Expected Outcome:

A grease spot will appear on the paper if a food contains fat. Some foods will make a larger grease spot than others.

Conclusion:

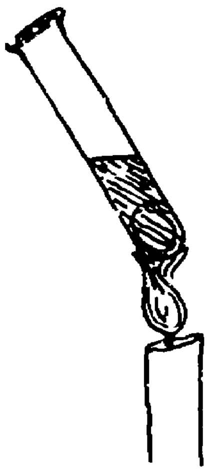
Some foods contain no fat, others very little, and some contain much. Fat in foods can be detected by rubbing the food on paper.

Ideas for Further Exploration:

34. WHAT FOODS CONTAIN SUGAR?

Materials:

Food samples, i.e. ripe apple, onion, cookie, candy, cane sugar, syrup, or honey, Benedict's solution or Fehling's solutions A and B, pyrex test tubes, pyrex beaker, and water.



Procedure:

(A small amount of Benedict's solution or Fehling's solutions A and B mixed at the time of the demonstration should be used.)

1. Place small amount of food to be tested in a test tube with a small amount of the testing solution.
2. Heat to boiling either in the beaker of water or over slow flame.
3. Note change in color.

Expected Outcome:

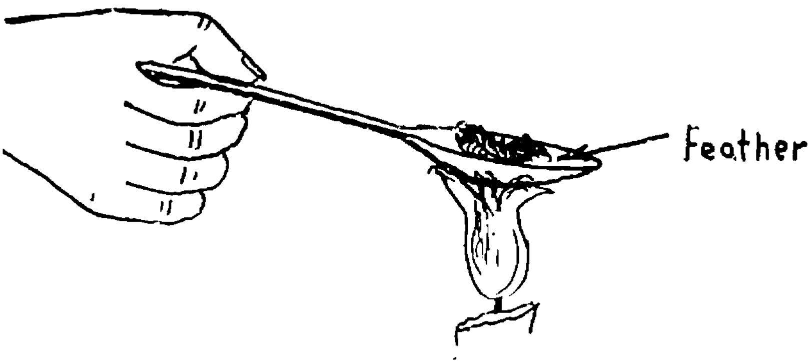
Simple sugars are also known as reducing sugars and cause the Benedict's solution or Fehling's solutions to break down releasing some copper compounds. A change to a brick red color indicates presence of the reducing sugars in the food samples.

Scientific Explanation:

1. The test solutions are compounds of copper.
2. The simple sugars are reducing agents that cause the copper compounds to undergo changes when heat is applied.
3. Cane sugar is a dissaccaride compound sugar ($C_{12}H_{22}O_{11}$) and will not show the brick red color.

Ideas for Further Exploration:

35. WHAT FOODS CONTAIN PROTEINS?



Materials:

Food samples, i.e., lean meat, egg white, beans, cheese; a few feathers or piece of wood, tongs, a spoon, a cloth pot holder and a source of heat.

Procedure:

1. Burn a few feathers and note the curling up of the material; the appearance of bubbles; and in particular, the characteristic odor.
2. Place sample of food to be tested in spoon held with heat insulating pot holder.
3. Place sample over flame and burn to crisp noting any curling, bubbles, or odor.

Expected Outcome:

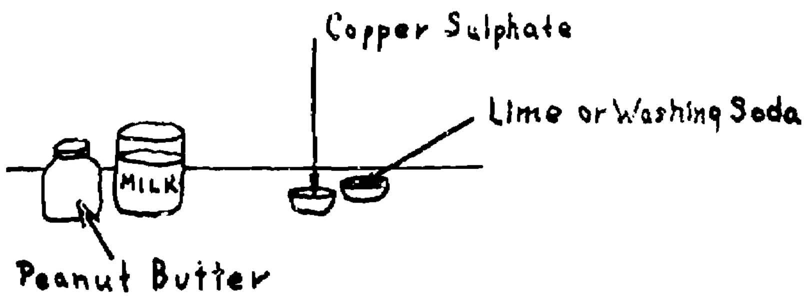
The characteristic odor of burning feathers will be given off by samples containing protein.

Scientific Explanation:

When protein substances are burned, they give off the odor of burning feathers due in part to sulphur compounds in the protoplasm.

Ideas for Further Exploration:

36. ADDITIONAL TEST FOR PROTEINS



Materials:

Copper sulfate ($CuSO_4$), lime or washing soda, water, tablespoon, glass, and food samples, i.e., milk, peanut butter, etc.

Procedure:

1. Dissolve as much copper sulfate in a tablespoon of water as possible (saturated solution).
2. Dissolve as much lime or washing soda as possible in another tablespoon of water.
3. Put a few drops of each solution in some milk and note any changes (if necessary add more lime or washing soda).
4. Stir small amounts of other food samples in one solution (copper sulfate or lime) and add the other to the sample.

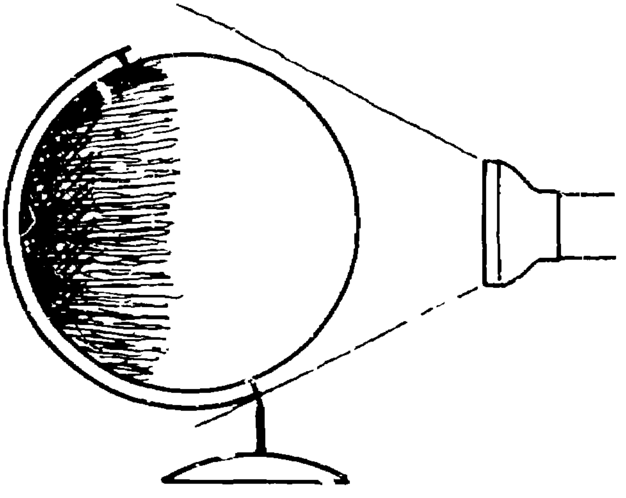
Expected Outcome:

When solutions of copper sulfate and lime or washing soda are combined in the presence of a protein a violet color is produced.

Ideas for Further Exploration:

THE EARTH AND THE UNIVERSE

37. NIGHT AND DAY



Materials:

A source of light, a globe and chalk.

Procedure:

1. Place a chalk mark on the globe where you live.
2. Darken the room and shine the light on the globe.
3. Turn the globe slowly from west to east.
4. Turn the globe again having one pupil tell what he would be doing in the different stages of rotation

Expected Outcome:

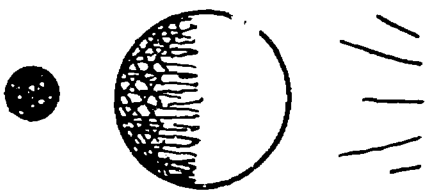
The pupils should gain an understanding of the causes of day and night.

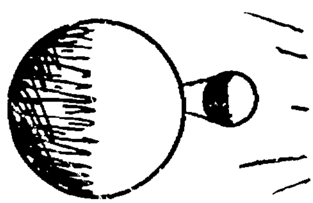
Scientific Explanation:

The earth rotates on its axis at about 750 miles per hour and makes a complete turn every 24 hours. Since the earth is ball shaped and revolves or travels around the sun, only the half of the earth facing the sun can be lighted. Periods of daylight and darkness are different throughout the year because of the inclination of the earth's axis.

Ideas for Further Exploration:

38. AN ECLIPSE





Materials:

A globe, a source of light, a tennis ball and a hat pin.

Procedure:

1. Set the globe in front of the light which represents the sun.
2. Stick a hat pin into the tennis ball and revolve the ball around the earth as the moon.

Expected Outcome:

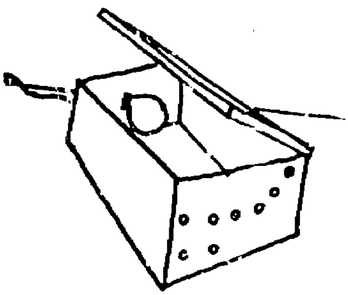
1. When the moon falls within the shadow of the globe, a lunar eclipse occurs.
2. When the moon comes between the sun and the earth, there is a solar eclipse visible to only a small area on the earth.

Scientific Explanation:

The shadow of the earth causes a lunar eclipse because the moon shines only from light reflected from the sun. When the earth is in the way, the sun's light cannot strike the moon. The shadow of the moon causes a solar eclipse, which is very short and can only be seen in a small area because the sun is so vast and the moon so small. An eclipse does not occur often because the earth, sun and moon are not often in a line in the same plane.

Ideas for Further Exploration:

39. A STAR BOX



Materials:

A shoe box, an electric lamp, pieces of cardboard, and a pin.

Procedure:

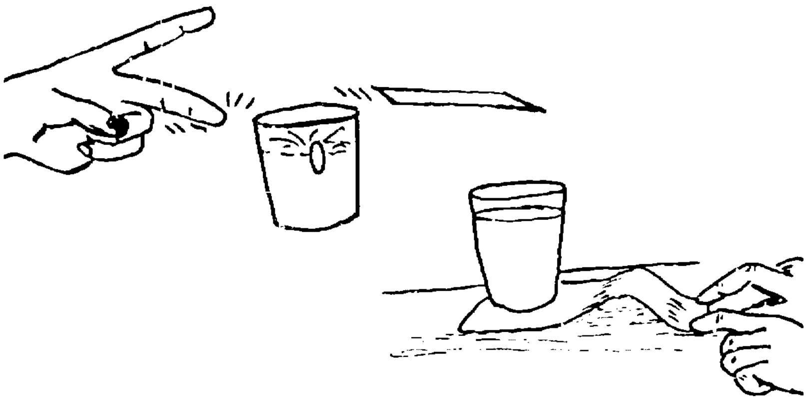
1. Leave the cover on the box and remove one end.
2. Cut cardboard the size of the end of the box and punch holes in it to represent a constellation.
3. Cut a hole in the other end of the box and place an electric light on an extension cord through the hole.
4. Darken the room and hold the constellation cards over the open end of the box.

Expected Outcome:

Many pupils will find enjoyment and satisfaction in learning to identify various constellations. Their imaginations may be stimulated and they may enjoy hearing the myths and legends concerning the stars.

Ideas for Further Exploration:

40. INERTIA



Materials:

A glass, a coin, a thin smooth card, a piece of typing paper and water.

Procedure:

1. Rest the card on the top of the glass and place the coin on top over the mouth of the glass.
2. Shoot the card off the tumbler with your middle finger.
3. Fill the glass with water and place it on a piece of paper about 2" from one end.
4. Take hold of the end of the sheet of paper with both hands and push the paper toward the glass until there is a big bend in the paper; then jerk the paper toward you quickly.

Expected Outcome:

The coin will drop into the glass and the glass will remain in place when the paper is pulled out from under it.

Scientific Explanation:

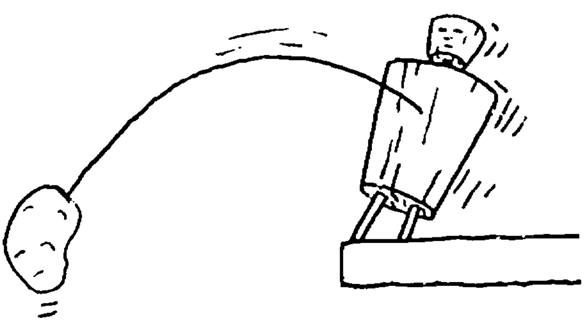
Inertia is the tendency of an object to keep moving in a straight line or in a state of rest. When you strike the card quickly, you overcome its inertia but not that of the coin, and when the card shoots out, gravity pulls the coin down. The tumbler is heavier than the paper and so more difficult to put into motion. A quick jerk of the paper does not overcome the inertia of the glass of water.

Ideas for Further Exploration:

41. A CORK FISHERMAN

Materials:

A coat hanger, a large cork, a small cork, several wooden match sticks and a potato.



Procedure:

1. Give the large cork "legs" and a "neck" with match sticks and place the small cork on top of the neck for a head. A face may be painted on this cork.
2. Form a piece of coat hanger into a fishing line and attach one end to the large cork and hook the potato with the other end.

Expected Outcome:

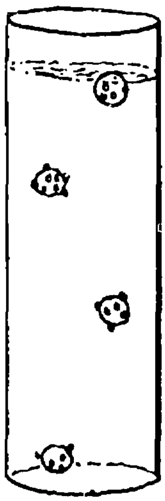
The fisherman will rock back and forth on the edge of a book or table.

Scientific Explanation:

The center of gravity (concentration of weight) is in the potato and as long as it is below the point of support, the fisherman will balance easily.

Ideas for Further Exploration:

42. DANCING MOTH BALLS



Materials:

Baking soda, moth balls, crystals of citric acid, a tall glass jar or glass, water and food coloring or ink.

Procedure:

1. Fill the jar almost full of cold water and dissolve two or three tablespoonfuls of baking soda in the water and add coloring.
2. Put several moth balls in the jar.
3. Add several crystals of citric acid.

Expected Outcome:

The mothballs will first sink to the bottom. When the citric acid is added, they will rise to the surface one by one and then sink and rise again.

Scientific Explanation:

Moth balls are only a little heavier than the solution. When the citric acid is added, carbon dioxide is formed and collects on the moth balls making the balls light enough to rise to the surface where the bubbles of carbon dioxide escape into the air.

Ideas for Further Exploration:

APPENDIX B

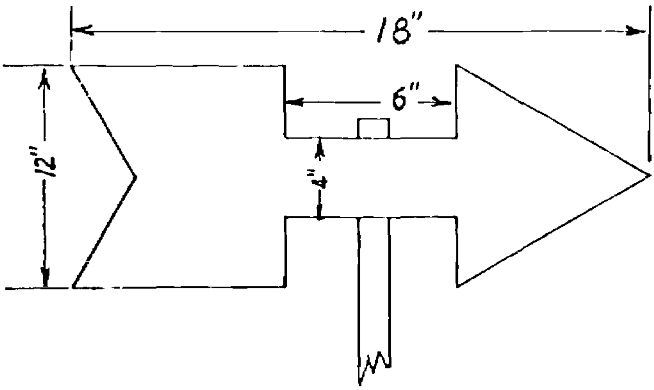
Additional Activities for Enriching Science Teaching

Simple Weather Vane

A simple vane may be sawed out of a single piece of wood with a jig saw. The best plan is to procure a piece of wood free of knots and about one-fourth of an inch thick. This piece of wood should be twelve inches wide and eighteen inches long.

When the arrow has been cut out it should be smoothed down and given two or three coats of paint. At the point of balance pierce a hole through the shaft of the arrow. The vane may be balanced by cutting a deep V in the rear end and by weighting the point with sheet lead. Cut two pieces of sheet metal to act as "washers" for the top and bottom of the shaft and then pivot the vane to the top of a broomstick with a straight wire nail. A touch of oil will insure that the vane revolves easily.

Place the newly made wind vane in the open where the wind will easily get to it without being obstructed by trees or buildings. The direction toward which the arrow points will always show the direction from which the wind is blowing.



Wind-sock Weather Vane

This type of indicator is used by airports in guiding pilots of airplanes about the direction of the wind, when coming in for a landing and when taking off.

To make it, procure a stiff piece of wire about two feet long or a light hoop ten inches in diameter. If wire is used make a circle about ten inches in diameter (Figure A). Second, from a piece of lighter wire, 26" long make the hanger (Figure B) which is to be attached to the rim (A). At one end of this wire make a loop just large enough to slip over the rim. At the other end make a loop about 1½ inches in diameter. This is the part used to fasten the wind-sock to the pole after completion (See Figure B).

Third, cut a piece of cheese cloth or light muslin to the following dimensions: Three feet long, eleven inches wide at the top edge, six inches wide at the bottom edge.

Fourth, sew the top edge securely around the rim (A), overlap the sides one inch and sew firmly from top to bottom. Fifth, slip the large loop of the hanger (B) over the rim (A) and fasten it in five or six places only, to allow freedom of movement.

The bottom of the funnel-shaped sock is allowed to hang loose, with no hoop. Fasten the small loop of the hanger (B) to the top of a tall pole set in an open space.

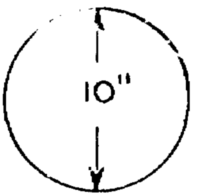


Fig. A.

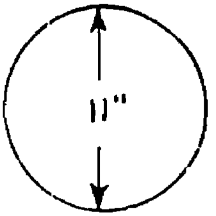


Fig. B.

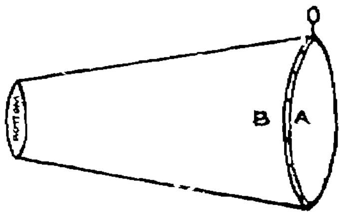
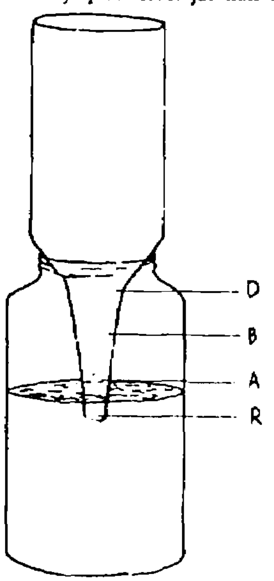


Fig. C. (Completed Wind-sock)

As the wind fills the sock, the "tail" or bottom end will point in the direction toward which the wind is blowing.

A Baroscope

To show something about air pressure and the amount of moisture the air contains fill an ordinary quart fruit jar half full of water. Next put a small quantity of water into a long-necked bottle and invert it quickly into the jar as shown in the illustration. By raising the bottle carefully just enough of the water may be let out of the bottle so that it will stand at B.



When a storm is approaching the air in the bottle will push the water in the neck down to R. When it is to be fair the water will be forced up to D. If the water is down, say to the line A in the evening and still lower in the morning, look for stormy weather. A slight lowering is natural every evening and does not have special significance. With the aid of this device and with keen observation about the direction of the wind, children can learn to predict weather some hours in advance.

How to Make and Care for an Aquarium

The schoolroom aquarium may be a very simple affair and still be effective. Almost any glass receptacle will do, glass being chosen because of its transparency, so that the life within may be observed. Tumblers, fruit jars, candy jars and battery jars are all available for aquaria. The tumblers are especially recommended for observing the habits of aquatic insects.

A. Making the aquarium

1. Place in the jar a layer of sand an inch or more in depth.
2. In this sand plant the water plants which you find growing under water in a pond or stream. The plants most available are Water-weed, Bladderwort, Water Starwort, Watercress, Stoneworts, Frog-spittle or Water-silk.
3. Place on top a layer of small stones or gravel to hold the plants in place.
4. Tip the jar a little and pour pond water in very gently at one side to two or three inches of the top; if a jelly tumbler is used, fill to within an inch of the top.
5. Let it settle for a few hours.
6. Place it in a window which does not get too direct sunlight. A north window is best; if there is no north window to the schoolroom, place it far enough at one side of some other window so that it will not receive too much sunlight.
7. To get living creatures for the aquarium use a dip net, which is made like a shallow insect net. (See Collecting Insects.)
8. Dip deep into the edges of the pond and be sure to bring up some of the leaves and mud, for it is in these that the little water animals live.
9. As fast as dipped up these should be placed in a pail of pond water so that they may be carried into the schoolroom.
10. In introducing the water animals into the aquarium it is well to put but a few in each jar so that each will have ample air and plant food.

B. Caring for the aquarium

Care should be taken to preserve the plant life in the aquarium, as the plants are necessary to the life of the animals. They not only supply the food, but they give off oxygen which the animals need for breathing. They also take up from the water the poisonous carbonic acid gas given off from the bodies of the animals.

1. The aquarium should be kept where there is a free circulation of air.
2. If necessary to cover the aquarium to prevent insects, such as the water boatmen and water beetles, from escaping, tie over it some mosquito netting, or lay upon the top a little square of wire netting used for window screens.
3. The temperature should be kept rather cool; it is better for the water of the aquarium to be no warmer than 50 degrees Fahrenheit, but this is not always possible in the schoolroom.
4. If insects or animals die in the aquarium they should be removed at once, as the decomposing bodies render the water foul.
5. To feed the animals that live upon animal food take a bit of raw beef, tie a string to it and drop it in, leaving the free end of the string outside of the jar. After it has been in a few hours, pull it out; if it remains longer it will make the water foul.
6. As the water evaporates it should be replaced with water from the pond.

How to Make a Terrarium

The same type of container suggested for an aquarium will also serve for a terrarium or indoor garden. If you do not have a glass container large enough, you may make one of old window panes. Cut six pieces for the sides, one for the bottom, and one for the top. Since a terrarium does not have to hold water the pieces of glass may be held together with strips of adhesive tape. The size of the terrarium may vary.

The following steps for arranging the terrarium are suggested:

1. Put a fairly deep layer of sand on the bottom of the container. A few large pieces of gravel or charcoal will provide drainage for the dirt and keep the top soil from becoming sour and moldy.
2. Put a thick layer of soil on the top of the sand. This soil should be fairly rich. A terrarium is more interesting when the soil is formed into hills and valleys, rather than left as a flat surface.
3. Plant the desired plants in the soil. Almost any plant that grows in the local environment may be raised in a terrarium. Violets, hepatica, wild strawberries, buttercups, seedling pines and ferns, slips of house plants and wandering Jew are suitable. Select small, well-formed specimens.
4. Arrange plants so that they form a natural-looking, miniature landscape. For example: a woodland, a marsh, low hills around a pond, or a desert.
5. After the garden is finished, sprinkle it with water and put a sheet of glass over the top. A screen cover may be used for plants which require little or no moisture.

Testing Soil

There is a simple and inexpensive method for determining whether a soil is acid and consequently whether it needs limestone. This is known as the Comber, or potassium thiacyanate test.

The test is made by placing a small amount of soil in a test tube of small glass vial and adding some of the testing solution. The soil and testing solution are then thoroughly mixed. After the soil sinks the color of the solution indicates whether the soil is acid or not. If the solution remains colorless the soil is sweet and already contains plenty of limestone. If the solution turns red, the soil is acid and the degree of acidity is indicated by the degree of redness. The necessary testing solution and more specific direction for soil testing may be obtained from the University of Illinois Soils Laboratories. The bulletin *Testing Your Soil for Acidity*, published by the College of Agriculture and Agricultural Experiment Station, University of Illinois, will be helpful.

Making Leaf Prints

In the fall or spring, the making of leaf prints gives children an interesting art activity and encourages observation of the special shapes and characteristics of the leaves of various plants. Several methods are satisfactory for schoolroom use:

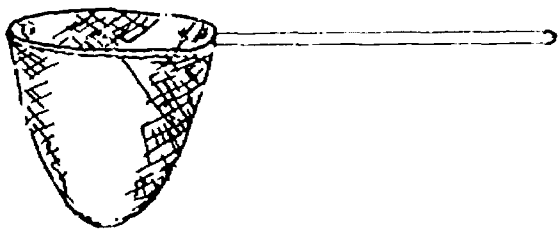
1. Arrange leaves on a piece of blueprint paper in subdued light. Lay the paper on a board, cover with a sheet of glass and place in a bright light for a few minutes, then wash the paper with water.
2. Coat one-fourth of a sheet of newspaper with lard, wiping off the excess with a cloth. Hold the coated paper over a candle until evenly sooted. Then lay a leaf on the paper, cover with a clean piece of paper and rub with tips of the fingers. Now transfer the leaf to mounting paper, again cover with a clean sheet of paper, and rub until a print of desired intensity is produced. Such prints are permanent and do not smear.
3. Attractive spatterprints may be made by using a toothbrush, water color, bluing or show card color, small piece of screen wire and the necessary paper.
4. Lay the leaf, flower, grass or other material on the paper to be painted. Arrange carefully to obtain desired pattern. Mix the paint to a thin consistency, dip the brush into the paint and draw across the screen wire, holding the wire about six inches above the paper. Experiment to secure desired results. Remove leaf after completing spatterwork.

Collecting Insects

A. Making a Net.

The wire ring to which the net is attached should be strong and springy. The bag itself must be durable yet must permit the contents to be seen easily. Mosquito netting is not desirable since it wears out quickly. Bobbinet or Bruxelle cloth is preferable since it is inexpensive and wears well. The size of the mesh will be determined by the type of insect to be captured.

The shape and size of the bag are important. The net bag must be long enough so that when an insect is captured the specimen may be kept inside the bag by turning the handle and folding the net across the wire ring. The length of the net should be approximately three times the diameter of the wire ring. The bottom of the net should not taper to a point, but should not be less than 2 or 3 inches in diameter.



B. Making Killing Jars for Insects.

1. For use by all children.

Punch two holes in the metal lid of a large-mouthed jar (pint or quart size) and run a string through the holes leaving the loop on the inside. Place a wad of absorbent cotton inside the loop, pull the ends of string tightly and tie in a hard knot. Just before taking collecting trip, saturate the cotton with cigarette lighter fluid or kerosene. The vapors of the fluid will penetrate into the breathing pores on the insects' abdomens killing them quickly.

Note: dipping insects, other than butterflies or moths, directly into a bottle of liquid kerosene quickly kills them and in addition protects them for some time from ravages of those organisms which would destroy the collections. The specimens will dry out readily after removal from the kerosene and will not be harmed in appearance.

2. For use by older children and teachers.

Make the above jar arrangements but substitute carbon tetrachloride for the kerosone or lighter fluid. The potassium cyanide killing jars used in many high school and college science classes are not recommended for use in the elementary schools since cyanide is extremely poisonous and should not be handled by children.

C. Mounting Insects.

Line a large flat box (a peach crate is good) with corrugated cardboard and cover it with plain wallpaper or construction paper. Fasten small insects to the box by thrusting a pin vertically through the body and into the corrugated paper. (If insects are to be kept over the summer a tight glass cover will be necessary to keep out moths.)

D. Drying and Stretching Large Moths and Butterflies.

As soon as the moth or butterfly is killed in the cyanide jar (do not allow it to stay in the jar overnight as it will harden) remove it carefully and stretch its wings on a stretcher made as follows:

Cut a piece of corrugated cardboard 12" x 12". On it place two one-inch piles of corrugated cardboard pieces 12" x 5½", leaving a groove of one inch between them. Fasten about the edges with gummed paper to make a compact block. Place the body of the butterfly or moth in the groove and, with the point of a pin, arrange the wings as desired. Fasten them in place with pins, placed along the marginal ribs of the wings. When well dried, pin the insect into the mounting box.

APPENDIX C

Selected References and Resources

Professional Science Education Books

Elementary School Level:

1. Blough, Glenn O., Schwartz, Julius, and Huggett, Albert J. *Elementary School Science and How to Teach It* (Revised Edition). New York: Holt, Rinehart and Winston, Inc., 1958. 608 p.
2. Burnett, R. Will. *Teaching Science in the Elementary School.* New York: Holt, Rinehart and Winston, Inc., 1953. 529 p.
3. Craig, Gerald S. *Science for the Elementary School Teacher* (Revised Edition). Boston: Ginn & Co., 1958. 894 p.
4. Croxton, W. C. *Science in the Elementary School.* New York: McGraw-Hill Book Co., Inc., 1937. 454 p.
5. Freeman, Kenneth, et al. *Helping Children Understand Science.* Philadelphia: John C. Winston Co., 1954. 314 p.
6. Greenlee, Julian. *Better Teaching Through Elementary Science.* Dubuque, Iowa: Wm. C. Brown Co., 1954. 204 p.
7. Greenlee, Julian. *Teaching Science to Children* (Revised Edition). Dubuque, Iowa: Wm. C. Brown Co., 1955. 195 p.
8. Hubler, Clark. *Working With Children in Science.* Boston: Houghton Mifflin Co., 1957. 425 p.
9. Navarra, John G. and Zafforoni, Joseph. *Science Today for the Elementary School Teacher.* Evanston, Illinois: Row, Peterson & Co., 1960. 470 p.
10. Richardson, John S., (Editor). *School Facilities for Science Instruction.* Washington, D. C.: The National Science Teachers' Association, a department of the National Education Association, 1954. 266 p.
11. Tannenbaum, Harold E. and Stillman, Nathan. *Science Education for Elementary School Teachers.* Englewood Cliffs, New Jersey: Allyn & Bacon, Inc., 1960. 399 p.
12. Wells, Harrington. *Elementary Science Education.* New York: McGraw-Hill Book Co., Inc., 1951. 333 p.

Secondary School Level:

1. Boyd, Helen W. *Successful Devices in Teaching Biology.* Portland, Maine: J. Weston Walch, Publisher, 1957. 211 p.
2. Brandwein, Paul, et al. *Teaching High School Science.* New York: Harcourt, Brace and Co., 1953. 568 p.
3. Burnett, R. Will. *Teaching Science in the Secondary School.* New York: Holt, Rinehart and Winston, Inc., 1957. 382 p.

4. Hoff, Arthur G. *Secondary School Science Teaching*. New York: Blakiston Co., 1950. 303 p.
5. Knoblock, I. W. *Readings in Biological Science*. New York: Appleton-Century-Crofts, Inc., 1948. 449 p.
6. Miller, David F., and Blaydes, Glenn W. *Methods and Materials for Teaching Biological Science*. New York: McGraw-Hill Book Co., 1938. 435 p.
7. Morholt, Evelyn, et al. *Teaching High School Science: A Sourcebook for the Biological Sciences*. New York: Harcourt, Brace and Co., 1958. 506 p.
8. Munzer, Martha E. and Brandwein, Paul. *Teaching Science Through Conservation*. New York: McGraw-Hill Book Co., Inc., 1960. 470 p.
9. Richardson, John S. *Science Teaching in the Secondary Schools* Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1957. 385 p.
10. Weaver, Richard L. *Conservation Handbook* (National Association of Biology Teachers). Danville, Illinois: Interstate Printers and Publishers, Inc., 1955. 499 p.

Yearbooks:

1. *A Program for Teaching Science*. Thirty-first Yearbook of the National Society for the Study of Education. Part I. Chicago: Distributed by The University of Chicago Press, 1932. 370 p.
2. *Science Education in American Schools*. Forty-sixth Yearbook of the National Society for the Study of Education, Part I. Chicago: Distributed by The University of Chicago Press, 1947. 306 p.
3. *Rethinking Science Education*. The Fifty-ninth Yearbook of the National Society for the Study of Education. Part I. Chicago: Distributed by The University of Chicago Press, 1960. 344 p.
4. *Science for Today's Children*. Thirty-second Yearbook of the National Association of Elementary Principals. Washington, D. C.: Department of Elementary School Principals, a department of the National Education Association, 1953. 311 p.

Science Education Bulletins

1. Blough, Glenn O. *It's Time for Better Elementary School Science*. Washington, D. C.: The National Science Teachers' Association, a department of the National Education Association. 48 p.
2. Craig, Gerald S. *Science in the Elementary School* (What Research Says to the Teacher Series). Washington, D. C.: The Departments of Classroom Teachers and American Educational Research Association of the National Education Association, 1957. 33 p.
3. Dunfee, Maxine and Julian Greenlee. *Elementary School Science: Research Theory and Practice*. Washington, D. C.: Association for Supervision and Curriculum Development, a department of the National Education Association, 1957. 67 p.
4. *The Improvement of the Teaching of Science and Mathematics in the Elementary Schools*. Greencastle, Indiana: DePauw University, 1958. 42 p.
5. *The Teaching of Science in Illinois* (Allerton House Conference on Education Report). Carbondale, Illinois: Southern Illinois University, 1957. 34 p.
6. Zim, Herbert S. *Science for Children and Teachers*. Washington, D. C.: Association for Childhood Education International, a department of the National Education Association, 1953. 53 p.

Many organizations publish bulletins and materials pertinent to the teaching of elementary school science. A letter of inquiry to these organizations will bring lists of titles and costs. Representative organizations are:

1. American Educational Research Association, 1201 - 16th Street, N. W., Washington 6, D. C.
2. Association for Childhood Education International, 1201 - 16th Street, N. W., Washington 6, D. C.
3. Bureau of Publications, Teachers College, Columbia University, New York City, N. Y.
4. National Society for the Study of Education, The University of Chicago Press, Chicago 37, Illinois.
5. Department of Elementary School Principals, National Education Association, 1201 - 16th Street, Washington, D. C.
6. National Science Teachers' Association, Washington, D. C.
7. National Association for Research in Science Teaching, Washington, D. C.
8. United States Department of Health, Education and Welfare, Washington, D. C.

Some textbook publishers produce science education materials for distribution to those who request to be placed on their mailing lists. Representative companies and a sampling of their publications are:

1. Allyn & Bacon, Inc., Englewood Cliffs, New Jersey, *Science News.*
2. D. C. Heath & Co., Boston 16, Mass., *Science Monograph., The Packet.*
3. Holt, Rinehart and Winston, Inc., 383 Madison Avenue, New York 17, N. Y., *Holt Service Bulletin Aids and Ideas in Teaching Science.*
4. Row, Peterson & Co., Evanston, Illinois, *A Monograph for Elementary Teachers.*
5. The Macmillan Co., New York 11, N. Y., *Teachers' Service Bulletin.*
6. Scott, Foresman & Co., Chicago, Ill., *Middle Grade Activities, Science Teachers' Notebook.*
7. The L. W. Singer Co., Inc., (Education Department, Singer Sewing Machine Company), New York 6, N.Y. *Singer Science News.*
8. Ginn & Co., Boston 17, Massachusetts, *Elementary School Notes.*
9. Prentice-Hall, Inc., Englewood Cliffs, N. J., *Science Newsletter.*

Supplemental Teaching Resources

Teacher Aids and Idea Books:

1. Abell, Fred H. *The How Book of Grade School Science.* Chicago: Standard Scientific Supply House, 1957. 144 experiments.
2. Atkin, J. Myron and Burnett, R. Will. Elementary School Activities Series. New York: Holt, Rinehart and Winston, Inc.
   Air, Winds, and Weather, 1958.
   Electricity and Magnetism, 1958.
   Working with Animals, 1959.
   Working with Plants, 1959.
3. Baker, Tunis. *Baker Science Packet for Elementary and Junior High School.* Upper Montclair, N.J.: Baker Science Packet. 1954.
4. Blough, Glenn O. and Campbell, Marjorie H. *Making and Using Classroom Science Materials.* New York: Holt, Rinehart and Winston, Inc., 1954. 229 p.
5. Hungerford, Harold and Drew, Robert E. *Teaching Elementary Science Without A Supervisor.* Portland, Maine: J. Weston Walch, Publisher, 1959. 286 p.
6. Lynde, Carleton J. *Science Experiences With Ten-Cent Store Equipment.* Princeton, N.J.: D. Van Nostrand Co., Inc., 1955. 276 p.

7. Nelson, Leslie and Lorbeer, George C. *Science Activities for Elementary Children.* Dubuque, Iowa: Wm. C. Brown Co., 1955. 153 p.
8. Partridge, J. A. *Natural Science Through The Seasons.* Toronto, Canada: The Macmillan Co., 1955. 522 p.
9. Parker, Bertha Morris. *Science Experiences-Elementary School.* Evanston, Illinois: Row, Peterson & Co., 1959. 272 p.
10. Parker, Bertha Morris, et al. *Basic Units* (84 basic units- primary through junior high school). Evanston, Illinois: Row, Peterson & Co., 1952.
11. Swezey, Kenneth M. *Science Tricks for Fun.* Greenwich, Conn.: Fawcett Publications, Inc., 1952. 144 p.
12. Swezey, Kenneth M. *Science Magic.* New York: McGraw-Hill Book Company, Inc., 1952.
13. *Elementary Science.* Darien, Connecticut: The Educational Publishing Corporation, 1950. 80 p.
14. *Elementary Science.* Darien, Connecticut: The Educational Publishing Corporation, Book I, 1958; Book II, 1958; Science I, 1956.
15. *Nature Studies.* Darien, Connecticut: The Educational Publishing Corporation. Book I, 1948; Book II, 1948.
16. Liljenberg, Gladys. *The Instructor Science Series* (Direct Process Edition). *Middle Grade Experiment Book I*, 1953. 24 p. and *Middle Grade Experiment Book II*, 1953. 24 p. Dansville, New York: F. A. Owen Publishing Co.
17. Cooke, Ralph J. *The Instructor Science Series* (Direct Process Edition). *Middle Grade Experiment Book I*, 1952. 24 p. and *Middle Grade Experiment Book II*, 1952. 24 p. Dansville, New York: F. A. Owen Publishing Co.
18. *UNESCO Source Book for Science Teaching.* New York: UNESCO Publications Center, 1958. 222 p.

Science Education Journals and Magazines Useful in Teaching Science

1. *Audubon Magazine.* Published by the National Audubon Society, 1130 Fifth Avenue, New York City, New York.
2. *Cornell Rural School Leaflets.* Published by the New York State College of Agriculture, Cornell University, Ithaca, New York.
3. *Elementary School Science Bulletin.* Published by the National Science Teachers' Association, 1201 Sixteenth St., N.W., Washington 6, D.C.
4. *Junior Astronomer.* Published by Benjamin Adelman, 4211 Colie Drive, Silver Springs, Maryland.
5. *National Geographic Magazine.* Published by the National Geographic Society, 1146 16th Street, N. W., Washington, D. C.
6. *Natural History.* Published by the American Museum of Natural History, 79th and Central Park West, New York 24, New York.
7. *School Science and Mathematics.* Published by the Central Association of Science and Mathematics, Oak Park, Illinois.
8. *Science Digest.* Published by Science Digest, 200 E. Ontario St., Chicago, Illinois.
9. *Science Education.* Published by the National Association for Research in Science Teaching, University of Tampa, Tampa, Florida.

10. *Science Newsletter*. Published by Science Service, 1719 N. St., N.W., Washington, D.C.
11. *Science World*. Published by Scholastic Magazine, 33 W. 42nd St., New York 36, New York.
12. *The Science Teacher*. Published by the National Science Teachers' Association, 1201 Sixteenth Street, N.W., Washington 6, D.C.

Sources of Science Reference Materials

1. *Bibliography of Books for Children*. Association for Childhood Education International, Washington 5, D.C., 1956.
2. Giles, Ruth, and Cook, Dorothy E. *Children's Catalog*. H. W. Wilson Co., New York, N.Y., 1956.
3. *Basic Science Series*. Row, Peterson & Co., Evanston, Illinois.
4. Webster Classroom Science Series. Webster Publishing Co., St. Louis, Missouri.
5. *Free and Inexpensive Learning Materials*. Division of Surveys and Field Services, George Peabody College for Teachers, Nashville, Tennessee.
6. Beuschlein, Muriel and Sanders, James M. *Free and Inexpensive Teaching Materials*, Chicago Schools Journal Supplement, Chicago Teachers College, Chicago, Illinois.
7. Beuschlein, Muriel. *Free and Inexpensive Materials for Teaching Conservation and Resource Use*. National Association of Biology Teachers, P.O. Box 2073, Ann Arbor, Michigan, 1954.
8. *Choosing Free Materials for Use in the Schools*. The American Association of School Administrators, National Education Association, Washington, D.C.
9. Fowlkes, John G. et al. *Elementary Teachers' Guide to Free Curriculum Materials*. Educators Progress Service, Randolph, Wisconsin.
10. Phillips, Brose. *Index to Free Teaching Aids*. Free Teaching Aids Co., Harrisburg, Illinois.
11. *Sources of Free and Low-Cost Materials*. U.S. Department of Commerce, Civil Aeronautics Administration, Office of Aviation Development, Washington 25, D.C.
12. Wittich, Walter A. and Hanson, Gertie L. *Educators Guide to Free Tapes, Scripts, and Transcriptions*. Educators Progress Service, Randolph, Wisconsin.
13. Illinois State Geological Survey, Urbana, Illinois.
14. Division of Forestry, Department of Conservation, Springfield, Illinois.
15. Soils Conservation Service, U.S. Department of Agriculture, 605 S. Neil Street, Champaign, Illinois.
16. Division of Conservation Education, Office of the Superintendent of Public Instruction, Emerson Building, Fairgrounds, Springfield, Illinois.
17. Illinois State Museum, Centennial Building, Springfield, Illinois.
18. Bell Telephone Laboratories. Contact the nearest Bell Telephone office.
19. National Plant Food Institute. 1700 K Street, N.W., Washington 6, D.C.
20. Federal Security Agency, U.S. Office of Education, Washington, D.C.
21. Natural History Survey Division, Urbana, Illinois.
22. Extension Service in Agriculture and Home Economics, College of Agriculture. University of Illinois, Urbana.
23. School of Agriculture, Southern Illinois University, Carbondale.
24. *Lists of Sources of Free and Inexpensive Teaching Materials*. Instructional Materials Department, Southern Illinois University, Carbondale.

Sources of Free or Inexpensive Audio-Visual Materials

Films and Filmstrips:

1. Shell Oil Co., 624 S. Michigan Avenue, Chicago 5, Illinois.
2. Modern Talking Picture Service, Inc., 3 East 54th Street, New York 22, New York.
3. Encyclopedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Illinois.
4. *Educators Guide to Free Films*, Educators Progress Service, Randolph, Wisconsin.
5. *Educators Guide to Free Film Strips*, Educators Progress Service, Randolph, Wisconsin.
6. *Free Film Source Directory*, DeVry Corporation, 1111 Armitage Avenue, Chicago, Illinois.
7. American Museum of Natural History, 79th Street and Central Park West, New York 22, New York.
8. Illinois State Museum, Centennial Building, Springfield, Illinois.
9. Division of Conservation Education, Office of the Superintendent of Public Instruction, Fairgrounds, Springfield, Illinois.
10. Illinois Department of Conservation, State Office Building, Springfield, Illinois.
11. *Educational Film Guide*, H. W. Wilson Co., 950 University Avenue, New York, New York.
12. *Filmstrip Guide*, H. W. Wilson Co., 950 University Avenue, New York, New York.
13. *U.S. Government Films for Public Educational Use*, Bulletin No. 1, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.
14. *Films and Textbook Correlations for Elementary School Science*, Young America Films, Inc., 18 East 41st Street, New York 17, New York.
15. Associated Films, Inc., 561 Hillgrove Avenue, LaGrange, Illinois.
16. Audio-Visual Aids Service, Division of Extension, University of Illinois, Urbana.
17. Audio-Visual Aids, Southern Illinois University, Carbondale.
18. Knowledge Builders Film Service, Knowledge Builders, Visual Education Building, Floral Park, New York.
19. *Motion Pictures*. Prepared and distributed by the United States Steel Corporation, Chicago Film Distribution, United States Steel Public Relations Department, 208 S. LaSalle Street, Chicago 90, Illinois.
20. Filmstrip House, 347 Madison Avenue, New York 17, New York.
21. McGraw-Hill Science Films, Text-Film Department, McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York 36, New York.
22. Coronet Films, Coronet Building, Chicago 1, Illinois.
23. Films Incorporated, A subsidiary of Encyclopedia Britannica Films, Inc., 1144 Wilmette Avenue, Wilmette, Illinois.
24. *S. V. E. Education Picture Catalog*, Society for Visual Education, Inc., 1345 West Diversey Parkway, Chicago, Illinois.
25. United World Films, 1445 Park Avenue, New York 29, New York.