Bulletin 1949, No. 5

Science teaching

IN RURAL AND SMALL TOWN SCHOOLS

by

GLENN O. BLOUGH

PAUL E. BLACKWOOD

Specialists in Elementary Science

FEDERAL SECURITY AGENCY

OSCAR R. EWING, *Administrator*

Office of Education

EARL JAMES MCGRATH, *Commissioner*

EVERY child today should have at least some understanding of the principles of modern science. The increasing complexities of the age in which we live make this imperative. For this reason, the study of science has become an essential part of the curriculum of every elementary rural and small-town school.

There can be little question that an approach which enables the child to link up the basic principles of science with his own familiar experiences at home or on the farm gives the subject a greater immediate reality than if taught by more conventional methods.

We believe that this booklet will afford a great deal of practical help to teachers of this subject.

Oscar R. Ewing

Federal Security Administrator.

UNITED STATES GOVERNMENT PRINTING OFFICE
Washington : 1949

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 20 cents

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FOREWORD

EVERY DAY our children are in contact with the results of scientific discovery. They are full of questions about the science they see and are bound to ask them in and out of school. Children in rural schools are no exception; in fact in many instances their contact with science is even more first-hand than that of city children–the weather, machines, plant and animal growth, and seasonal changes—these and many other phases of science are very real to them. How can we help our children to learn about the science around them, to think more scientifically, to solve problems more successfully, and to grow in interest and appreciation of their wonderful environment? All of us who work with children are interested in an answer to this question.

It is hoped that the teaching suggestions in this bulletin will be useful in pointing out how the resources in the immediate environment may be helpful to teachers who want to improve their science teaching, how simple experiments may be used, how day-to-day science teaching may function as a part of the total school program, and how the interests and needs of children may be taken into account in planning the science program in elementary rural schools. We hope that the bulletin may be a factor in increasing the confidence of the conscientious teacher who says, "I know my pupils need more experiences in science, and I wish I had more workable ideas about how to help fill this need."

BESS GOODYKOONTZ, *Director,*
Division of Elementary Education.

U. S. D. A. photo by Forsythe

"LOOK! HERE IS THE QUEEN BEE."

Introduction

What Is Science?

AS MEN have studied the world and all that is in it they have learned many facts about many things. They have learned how seasons come and go, what makes a full moon, how rocks were formed, how and where animals live, how electricity does work, how plants make food, and many other facts. Men have continually tested their hunches and have come up with new principles. Much of this information has been organized into bodies of knowledge. This is one way of defining science: It is the classified and organized information we have learned about things in our world. The information must be checked and rechecked until it is known to be accurate before it can rightly be called scientific information.

There is a tremendous amount of scientific information. Obviously children cannot be expected to learn more than a small part of all there is to know about their world, and they should learn it not only from books but, whenever possible, directly from a study of the natural environment. It is the process of helping children study their natural world that we call science. As children attempt to discover accurate information about their world, they are studying science. When they have obtained correct facts and groups of facts they are dealing with scientific information.

Then, too, just as scientists have had to work carefully in refining their methods of getting information, we want children to work carefully in defining their problems, in testing their hunches, and in getting information to solve their problems. This careful method of working is important to scientists and it is important to children. The method is sometimes called the scientific method. It is *a way of working to solve problems.*

Science information and scientific ways of working are useful to children, and indeed to all people, to the extent that they contribute to a better life and a better world. So it is that in this bulletin suggestions are given for rural children to consider the part of the environment that is near to them and important to them, and therefore vital in their lives. By studying the immediate environment with its real problems, children can gain significant skills and information to enrich their lives.

The Teacher of Science

In the rural school the classroom teacher is almost always the teacher of science. This has many advantages. It allows the teacher freedom and opportunity to adjust the school day so that science experiences can be worked into any part of the program where they are needed. The classroom teacher should be more familiar than anyone else with the interests and needs of her pupils. This knowledge can be taken into account in helping the pupils plan their work. The classroom teacher is in a position to offer some guidance to science activities throughout the day, whereas a special science teacher might not be able to follow through on the activity.

The primary job of the teacher is to help her pupils grow in achieving all of the purposes of the elementary school. The bulletin shows how science experiences can contribute to these purposes. The rural teacher has numerous resources for obtaining help and materials in teaching science. Many of these resources are pointed out in this bulletin. Suggestions are given for the teacher who feels hesitant about beginning to teach science.

There are teachers who have caught enthusiasm for teaching science from enthusiastic children. Good science teaching results when teachers are convinced of the importance of this area of learning, know how children learn, become familiar enough with the subject matter so that they can combine their knowledge of child growth and development with their other knowledge to the end that an enjoyable forthright learning situation results.

Just reading this bulletin won't make anybody a better science teacher. It is hoped that trying out some of the ideas and adapting them to fit specific needs, will. Just reading it won't give anyone enthusiasm for teaching science either, but using some of the suggestions in working with children may help to keep children's natural enthusiasm alive, and may help to expand it somewhat.

Science for Today

"I Think Outdoors"

"SOMETIMES when things get dull in school or when my teacher talks a lot, I just don't say anything to anybody. I just *sit and think outdoors.*" That's the way young John Horn expresses himself about school. There's something in what John says, and he's saying it to all of us who teach. How many of the pupils in our classes are "thinking outdoors" while we, their teachers, are trying to wedge their young minds into some track of thought foreign to their interests and needs?

John Horn lives in the country. He "thinks outdoors" because he lives there so much. Bored-with-school city children vary this probably by "thinking in the next block" or perhaps "in the park." The trick for the teacher in both cases is the same—*think with the children wherever they are and then either go outdoors with them or bring the outdoors in, or both.* In this bulletin let's consider ways of bringing the science that surrounds children into the schoolhouse and ways of bringing the children into first-hand contact with the world of science outside the classroom.

"All Around Me"

Let's see what it is that John Horn thinks about in school when things get dull. He lives on a 160-acre farm. He gets up very early in the morning for there are a hundred and one things to do before he gets off to school. He feeds three calves, knows how much milk and commercial feed to give them, knows how much they weigh and what they are worth. He operates a milking machine, connects up the windmill so the wind will help pump water for the stock. He hitches up the team. These are some of the things he sometimes does in the morning before school. He is learning to drive the tractor. He knows when the first blackberries get ripe down by the edge of the wood lot and can tell when a muskmelon is ready to pick.

While John waits for the school bus, he begins to think about the books under his arm and the homework he did last night. One of his assignments was to figure out a problem about trains. Train No. 1 had left town A for town B at midnight traveling 60 miles an hour, and Train No. 2 had left town B 100 miles away an hour later traveling at the same speed toward town A. The teacher or the author of the book wanted to know where the trains would meet. Last night John had read the problem to the hired man and asked him about the situation. The hired man just said, "I hope they're on different tracks!"

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Just next to the spot where John waits for the bus are eight cans of milk that will be picked up by the Meadow Milk Company before the day gets hot. John can see plenty of sense to figuring out problems about whether it's best to sell milk to Meadow's, or to separate the cream from the milk and sell that and do something else with the skimmed milk. That's part of John's thinking outdoors. That problem makes more sense than Train B and Train A.

John wasn't sure that the answer to the train problem was right, but he felt better about the language assignment. He was supposed to pick out all the nouns and pronouns in a story in a book. He got them all picked out because somebody that had used the book before had underlined them. The assignment itself didn't make a lot of sense, but it was done anyway.

On the way to school John's bus passes a pond where muskrats live. A hawk sails over the fields looking for something to eat. Some of the fields have deep gullies in them and haven't grown any crops for several years. In another field corn is beginning to ear up. Men are installing a transformer on a pole in front of Atkinson's house. One of the bee colonies in the Brown's orchard has just swarmed, and Mr. and Mrs. Brown are both out trying to urge the bees into a new hive before the queen takes a notion to go elsewhere. After the bus passes the Brown's house, it turns into Route 202 where men are lumbering off a woodlot. They are setting up a sawmill and beginning to cut trees. Any day now there will be piles of new lumber and a heap of sawdust will begin to grow. Now the bus reaches the schoolhouse.

All around John Horn and his classmates there is science. They see it everywhere. Science processes go on to furnish the food they eat and the produce they sell. The wind and the rain, the dew and the frost, the fog and the clouds, are science phenomena known to them. Animals and plants grow and reproduce and these processes are within the children's daily experiences. Electricity, heat, light, and sound serve them in various ways. By day they see the sun trail across the sky; at night they see the stars and moon. Seasons come and go effecting changes everywhere.

Can the school curriculum of rural children be complete without including some experiences that will add meaning and create more interest in this science? What can a study of science contribute to the richness of living for girls and boys in the rural elementary school? In answering these and similar questions let us think of the kind of science that functions in the lives of children in their homes and community rather than of the kind that concerns itself with details, such as whether a nutcracker is an example of the first; second; or third-class lever or whether a window shade is a translucent, transparent, or opaque object. Such facts of science as these are important, but for children they are important only insofar as they help answer questions or solve problems.

Our Intentions for Science

Facts are important, but in our science teaching it's how the facts are learned and organized that makes a big difference. A collection of isolated pieces of science may be of little value, but if these facts are put together into an organized big idea that can be of some use, their value is greatly enhanced. One of our intentions then is *to help pupils develop, in a meaningful way, some generalizations in science that will be useful in their day-to-day living.* If we really intend to accomplish this objective, the science subject matter we select, as well as how we teach it, will be influenced. For example, we can scarcely be concerned with important generalizations and still be justified in drilling to learn definitions of such terms as transparent, translucent, and opaque, or on learning the classification of levers according to the location of the fulcrum, force, and resistance. Instead of such memorization, we first attempt to decide what generalizations about light and how it travels through materials the pupils need to know in order to interpret their experiences in the environment. For example, *light travels in straight lines;* or *all green plants require light to make food;* or *light travels through some materials more easily than through others.* Then we decide how these generalizations may be arrived at so that they will be full of meaning, and so that pupils will have greater ability to make new generalizations from new experiences. For example, after repeated observation, and after careful study, the country boy may conclude (or generalize) *that young trees completely girdled by rabbits are likely to die; or that food is essential to the life of all animals;* or *that water runs more rapidly off barren soil than off grassland.*

Other illustrations of generalizations and their uses will appear later in this bulletin to give more meaning to this idea.

Another of our intentions is *to help girls and boys to become better problem-solvers.* Again, if we really wish to accomplish this we go easy on the practice of *telling the answers to the children* and try instead to use the science problems which are everywhere around them and help them set up ways to solve these problems. For example, why do the Browns keep bees in their orchard? How can you tell if a hawk is harmful or beneficial? How can we stop gulleys from forming in our fields? Why don't we plant sweet corn next to field corn? What does a transformer do? These are a few of the problems that are within eyereach of the school bus. There are many ways to help children solve these problems. (See page 7-16).

We also intend to *help pupils to grow up equipped with a scientific way of looking at things—a scientific attitude.* We want them to look at a matter from every side, to go to authorities for information, to evaluate this information and use it wisely, to be open-minded, to be tolerant of another's point of view, and to think carefully before announcing a conclusion. These are some of the elements of the scientific way of looking at things and they are not just for use in the schoolhouse. They are for use in everyday living. Again, if we really intend to accomplish this objective, we must keep one eye on it as a goal and the other on ways to accomplish it. We must be alert to every possible opportunity to insist on scientific thinking.

Then, too, we intend *to broaden the interest and appreciation of the pupils* for the wonders of the world in which they live. Since most children seem to be naturally curious concerning the things about them, the emphasis should perhaps be placed on how to keep this curiosity alive and how to broaden it. If we sincerely intend to keep curiosity alive, then the science experiences must be truly satisfying, which means that they should be as nearly first-hand as possible, alive with interest, challengingly initiated, and certainly approached nontechnically. There's much science to wonder about on the farm, in the field, by the roadside, and in the forest. The way muskrats build their houses, how corn pollen is spread, the way a transformer changes electricity, how bees carry nectar, how a tree grows from a seed—all of these are full of wonder for children, and they can scarcely be neglected if children are to be given help in understanding the world in which they live.

Briefly these are our intentions or objectives for teaching science. They cannot be achieved unless they are continually dusted off and kept alive—they must guide selection of content, methods of teaching, methods of evaluation, and any other goings on. The success of any science program must be measured in terms of how much children grow in accordance with them.

A Way to Work

"The Problems I See"

"IF I SUBTRACT 18,896 from 216,914, what's the difference?" the teacher asks. Maybe a good answer from an alert young learner would be "You've got me—what *is* the difference? I can't see that it makes much difference to me!" If the pupils in our classes always felt quite free to express themselves, it would be very helpful to know how often they would challenge the worthwhileness of some of their school experiences and with most sincere intentions, too.

Are we at present utilizing, to the fullest possible extent, the potentialities of our pupils to help us select the problems in science and in other areas of learning that are of real concern to them? Most of us would agree that we are not. Is it true that the most exciting and effective learning situations in our schools come about when the needs and interests of pupils are considered and when the pupils themselves have been active in suggesting the problems to be considered and in planning ways to solve them? Most of us would say, "Yes." Let's not construe this to mean that we study only those things which children suggest and that the children "always do just what they want to do." It means rather that the teacher and pupils *together* decide on the problems, then each contributes something toward the ultimate solution. In many instances, given a chance, children will bring problems to school that are interesting and challenging to them—provided, of course, their classes meet in an atmosphere that encourages this type of activity.

What makes an atmosphere in which pupils feel free to propose problems and activities? Certainly it is one in which children derive satisfaction from such participation—or from having brought to school some science material to show to the class for discussion. Certainly it is more likely to come where the opinions of pupils are respected by the teacher and the fellow classmates. And it is surely augmented when the teacher *encourages* pupils to show originality and expects them to participate in selecting problems for study.

On the other hand, there are many interesting problems in their environment which children have never encountered. They cannot show interest in things they do not know exist. Here the teacher gives assistance in suggesting possibilities.

The sense underlying the foregoing discussion is not confined to science. It is true of the entire elementary school program. Our whole program could stand a good stiff fumigation to kill off the extraneous material that has little or no bearing on the lives of children and make room for the meaningful to flourish.

On the following pages there is an account of two science problems studied in rural schools, one on the primary-grade level, the other on the intermediate-grade level. The primary experience described illustrates an *incidental happening* used to promote science learning for a brief series of lessons. The intermediate one is a *planned experience* carried on for a longer period of time.

An Incidental Experience in the Primary Grades

The beginning — It is early spring in one of the Northern States. For several days a deep blanket of snow has covered the ground. Now it is melting. The children played out of doors during the noon recess and someone noticed freshly chewed rings around young saplings growing at the end of the school ground. Bark had been chewed from many of the young trees. This observation is reported when the third grade meets for science activities after lunch.

"Let's go out and see the trees," some of the children who did not make the observation suggest.

"We can do that," the teacher says. "But, first, let's talk a little more about what you have seen. Did any of you look very closely at the tree bark?"

Several hands are raised, "Tell us just what you saw."

Children report: "It looks as if an animal gnawed the rings. It must have been a very tall animal to get way up there. The rings are 3 feet from the ground."

"That is very curious," the teacher says. "I wonder if an animal really did make the rings in the trees."

Others ask: "Why would an animal eat bark from the tree? What kind of an animal ate the bark? Will it hurt the trees?"

Solving the problem — These questions are recorded on the board, and the pupils go out to observe the trees to learn more. They examine the marks on the trees, notice that the marks are on only one kind of tree. No one can identify the kind of tree. Several pupils volunteer to try to identify it by using a book in the library. Pupils decide to observe elsewhere to see if other trees have similar rings around them. Several pupils plan to ask their fathers about it.

Since the regular science work going on in grade 3 is a study of water evaporating and condensing, the pupils spent some time observing places from which water evaporates out of doors.

At the beginning of the next science class, the committee that volunteered to identify the trees reports that the trees are young poplars. The teacher helps to check this conclusion to see if it is accurate. Several pupils report that they have observed other trees that have these rings. Some observed them along the way home, others reported having seen them on their farms. "My father says that the bark has been chewed off by rabbits," someone reports. Another pupil says, "My father says that, too, and he says that rabbits hopped along on the hard crust of the snow and ate the bark for food because what they usually eat was covered up by the snow." The teacher reports, "I called Mr. Leapert, the County Agricultural Agent, and he said the same thing." "My dad says the rabbits have girdled the tree," another pupil volunteers. "What's that?" someone asks. No one seems to understand the meaning of the term, and the teacher asks for volunteers to find out. Two boys volunteer. The class advises them: "Look in agriculture books and science books and in the encyclopedias. Find out if it will kill the tree, and find out what we can do to save our trees."

This brief description illustrates one way to handle an *incidental* science experience. The regular science work went on as usual. Enough was done with the current interest in the trees to satisfy the curiosity of the pupils and there was opportunity for careful observation and investigation.

A Planned Experience in Intermediate Grades

The following is a description of science work carried on in a sixth-grade class in a Michigan rural school one spring when the teacher was inspired to capitalize on the activities related to planting that were soon to go on in the community. This was a *planned* experience carried on as part of the regular course in science, but was adapted to the needs, interests, and abilities of the pupils involved.

Long before spring actually comes, children in the country anticipate it. The mail brings seed catalogs. Coldframe fixtures get renovated. Seeds that have been saved from last year are examined. There are all sorts of other indications that the season of growing things is on the way.

One day early in March the pupils had a discussion about the advanced preparations for spring planting that would soon be in full swing in the community. They listed several: Seed orders being prepared, seeds planted in coldframes, fertilizer spread in field, seed potatoes, and other crop seeds being examined and prepared.

"Why don't we plant a school garden?" someone asked. "Well, why don't we?" the teacher answered. That marked the beginning of an immediate science interest of the pupils.

First steps — The teacher thought through some of the possibilities and decided that the following guides to planning were important for them to keep in mind:

> The garden idea should develop into something bigger than just planting a few rows of radishes in a corner of the schoolyard and eating them some day for lunch. It should be broad enough to involve some of the fundamental problems concerning growing things.

The study should involve planning, problem-solving, and evaluating results by the pupils and teacher.

There should be opportunity for working together, assuming responsibility, and getting satisfaction from a job well done.

The project should be practical.

Parents of the children should be aware of the project, and the resources of the community should be used as much as possible.

The venture should have such results as these:

* * * the pupils will become more and more observing and more appreciative of the living things in their environment.

* * * the pupils will grow in ability to solve problems successfully and become more scientific in their way of thinking.

* * * the study will help the children grow as individuals able and wishing to live more democratically with each other.

Working together — The preliminary thinking just summarized represents some of the considerations of the teacher before he began to work and plan with the pupils. These general considerations and intentions are used to guide the planning and the procedure.

In order to give a clearer picture of how the experience progressed, the general procedure is described in the form of a diary by the teacher.

March 10. — Today we went into the schoolyard to explore the possibilities for a school garden. The ground is mostly thawed out, but the grass still looks dead. We walked over the school ground to decide where the garden might be located. And then one of the boys said: "This soil won't grow anything. It's poor." That statement set us off on a discussion, and the pupils raised several important problems. We went inside to talk about them and to make a blackboard record of them: "What's in soil that plants use?" "If this soil isn't good for a garden, why isn't it?" "How can we find out?" "What can we do about it if it isn't good for a garden?" "Is the soil the same all over the school ground or is one place better than another for the garden?"

After some discussion we listed these questions on the board and I said, "If the answers are as good as these questions, they will give us a good start. How shall we answer them?" The following suggestions were made: Get some soil and examine it. Read to find out what soil is made of. Bring samples of different kinds of soil to school. Find out if anyone can help us test the soil to discover what it needs. Bring some of the soil in and try to grow some different kinds of plants in it. Get some pamphlets from the State Agriculture Department that will tell us about soil. Ask at home to find out if the soil on our farms has ever been tested. Look in our science books to see what they say about soil.

NOTE: Not all of these suggestions were made at one time. We kept our

"I CAN DRIVE THE TRACTOR MYSELF. SEE, IT'S QUITE EASY."

list of questions and the list of ways to find answers and added to each list from time to time.

March 14. — Today during our language period we composed a letter to be sent to the State Department of Agriculture to get information about soil and its treatment. Frank Moore knows our County Agricultural Agent and volunteered to telephone him for information. Someone suggested that we invite the County Agent to come to our school and help us with the problem of finding out about the soil for the garden. After Frank telephones, we will consider the possibility of inviting the agent to talk with us.

During the science period we examined samples of soil that have been brought in. The samples came from Ruth's farm, from Frank's garden at home, from a place where they are excavating for a house, and from a woodlot across from the school. We had some aquarium sand left over and someone suggested that we put a sample of that with the others. We compared the samples and looked carefully at them under a reading glass that I brought from home. We spread the samples out on white paper and looked at the soil to see if we could tell what it is made of. The soil from the wood-

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lot interested the pupils for they discovered roots and tiny seeds in it. They decided to put some of the woodlot soil into a flower pot, water it, and set it in one of our sunny windows to see if any of the seeds and roots would sprout. Several pupils are looking through our science and agriculture books in school and in their home libraries, and through farm journals and bulletins to find material to answer their questions about soil. They are applying what we learned in language arts about locating information in books, periodicals, and in other sources.

March 17. — Some of our library material about soil is assembled. Frank has talked with the County Agent and says that he will come to our school if he is invited, and if we let him know in advance what we want him to do. A committee is drafting a letter inviting him to come. The class suggested that the letter include the list of questions.

Children have discovered experiments about soil which they are planning to set up. One is to show how different kinds of soil hold water; another to show what harrowing does to prevent evaporation of water. Today we spent our reading period trying to find answers to the questions on soil. We used the information gained in reading to discuss the questions. Several new problems concerning soil came up: What minerals are in the soil? How did they get there? Is our soil acid or alkaline? How was the soil made? These questions were added to our list and will be sent to the County Agent who we hope will help us if we do not find the answers ourselves. Someone suggested that he could help us check the answers we found and might also help us with our experiments.

March 20. — The letter to the County Agent was sent today. It contained a list of questions and requested that he help us test our soil to find out if it is good for a garden. We have left the date and time up to him. The bulletins we ordered came. There is one on soil conservation. John David says his father knows a lot about strip farming that is described in the bulletin and about other ways to keep the topsoil from being washed away. The pupils suggested that we ask Mr. David to come to school. Today Priscilla said, "I thought we were going to plan our garden." I was about to go into an explanation when Philip said, "Priscilla, we *are*, but first we need to know if the spot's worth planting and, if it isn't, what we can do about it." That took care of that.

March 23. — Mr. David sent us several pamphlet references on soil conservation, and sent word that he is willing to come to school some day to talk to us. There are several green things coming up in the pot of soil from the woods. An acorn that was in the soil is beginning to sprout. A discussion of this and of the other growing things has resulted in several questions about how seeds sprout. We listed the following: What's inside a seed? How does a seed begin to grow? What conditions are best for seed growth? Why do some seeds not sprout? What happens to a seed as the plant grows out of it? These questions, the pupils decided, could best be answered by experimentation, so we took each of the questions and worked out a procedure for an experiment to find the answer. The procedure was set down in steps. For example, the question "What's inside a seed?" was to be answered by:

1. Bringing several different kinds of seeds from home (large ones like corn, bean, or sunflower seeds).
2. Soaking the seeds overnight.
3. Taking the seeds apart carefully and examining each part.
4. Looking at the insides with a reading glass.
5. Using books to help find the names of the parts.

For each experiment the pupils decided what materials they would need and where they could be found. Seeds and other similar materials are being brought from home. (We have accumulated flower pots, glass tumblers, plates, blotting paper, and other materials on a science shelf which some of the boys made). The class had divided itself into small groups each with an experiment to do. Each group elected a chairman and is dividing up the duties, such as bringing material, setting up the experiment, looking up references, and making records.

March 26. — A letter came today from the County Agent. He is coming the day after tomorrow. The pupils were interested in the letterhead on the agent's stationery, and that led to a discussion of what the State Department of Agriculture does, who pays for it, how it is organized. Our social studies time was taken up with the discussion. This discussion was so interesting to the pupils that we are going to "skip ahead" in our social studies plan and study our county government and its relationship to the State. It comes later in the year in our general plan anyway. They have several questions about these matters to ask the County Agent when he comes. We spent some time discussing how Mr. Leapert, the County Agent, should be introduced to the group, and how we could learn the most from him. The pupils decided that since Frank Moore knows Mr. Leapert, he might introduce him. That will be good experience for Frank and the idea made sense to everyone. The pupils who are doing experiments are planning to show some of them to Mr. Leapert and ask him about them.

March 28. — Mr. Leapert came today. I talked with him briefly before he began, telling him a little about the age and general abilities of the children. After Frank introduced him, several of the pupils brought him up to date on their activities on the project. The pupils had written their questions on the board to help guide his discussion. Here are the questions which the pupils wrote down to be answered:

What do plants use from the soil?
Why is some soil not good for growing plants?

How do soils differ from each other?
How can soil be improved so that it will grow better crops?
What are minerals and how do they get into soil?
How is soil made?
How do they test soil?
Is our soil on the school ground good enough to raise a garden?

The County Agent showed them how to test soil and talked to them about the different kinds of soil. He told them about the progress that had been made in building up the soil on the farms of the community. Several pupils asked about their own farms. He discussed with them some of the ideas about soil conservation, and John told him that his father might come to school to tell the pupils about strip farming. Mr. Leapert thought that John's idea was fine. It turned out to be a good idea to have on the board the questions that the children wanted answered, because they kept coming back to them. That kept everybody on the track. Although the pupils had already figured out partial answers to some of the questions, they were interested in comparing their knowledge with what Mr. Leapert told them. It became evident that it was a good idea to have him come now instead of at the beginning of the study because the pupils' backgrounds were much better for understanding him. To answer the last question (the one about the suitability of the soil for a school garden), Mr. Leapert asked the pupils to go out on the school ground with him. On the school ground the children and I helped Mr. Leapert arrange the group into a large circle so everyone could see and hear. Then he told us about the quality of the soil in the school ground and about what it needed to build it up into a good garden spot. He suggested that the pupils think carefully about *why* they wanted to have a garden. He also suggested that they might like to consider the possibility of transplanting from nearby places some of the native shrubs and trees that will grow on the school ground and help to beautify it. He told them that some of these shrubs would thrive on the school ground when tomatoes, radishes, and other vegetables wouldn't.

March 29. — Mr. Leapert's visit resulted in holding a special meeting of the group to decide what to do. In summary, here are some of the results of his visit and some of the remaining steps taken as the study progressed:

1. We decided that it was impractical to have a school garden because it would take more money, time, and energy than we had to have a successful one on the kind of soil we have. It might be a good project if our soil were better and we had someone to tend it in summer.

2. We decided that the things we had learned about soils and growing plants could be applied at home when the children work in their gardens.

3. Several of the pupils said they would ask for a small section of the family garden at home to use for themselves. They would bring to

school some of the things which grew in the garden for use in the school lunch and as science material.

4. It was decided to substitute for the garden a project to beautify the school grounds with native plants, shrubs, and small trees from various places in the community. In this connection the pupils received further help from the County Agent and from their parents. The County Agent helped them to select the shrubs and small trees to use, and two of the fathers came to school to help transplant the growing things.

5. The experiments with growing things in different kinds of soil and under different growing conditions were continued. Pupils brought examples of growing things to school for study and observation. The science learnings were closely tied up with transplanting materials to the school ground.

6. As a result of the study of growing plants, the children instituted a "plant exchange" in school in which many adults as well as pupils participated. Parents and pupils who had plants and seeds which they were willing to exchange for some other kinds advertised on our school bulletin board. As a result, iris roots were exchanged for strawberry plants, peony roots for cabbage plants. Many other exchanges were made. This afforded a fine opportunity for studying how plants reproduce, how they should be cared for when transplanted and transported, as well as other similar problems.

Checking our results. — How can we add up the accomplishments of an experience such as this? How have children grown as the result of it? How nearly have the intentions we had in mind (see pages 5 and 6) been realized?

There is still much to learn about how to evaluate the contribution of science, as well as of other subjects, to the general growth and development of children. It is desirable for children to help evaluate their own work. It is probably true that children have not participated sufficiently in evaluating results and thus have been unable to profit by their experiences. As we work more with children in carrying on evaluation, our knowledge of evaluation procedures will increase. The following brief account is included to illustrate one way in which children and teacher together looked over their progress and accomplishments after their experience in science. The teacher and pupils kept referring to the original purposes of the study as they attempted to evaluate.

"Now that we have finished our science work for the present at least, let's look back over what we have done and try to see how well we did it," the teacher said. "To help us remember, let's list some of the most important things we did." Here are examples of the things the children listed: Searched for reading material; did some experiments from books; thought of experiments of our own; made some trips; listened to talks. "Now," the teacher continues, "what are some of the things we learned?" The pupils suggested such things as:

1. We learned things about soils and growing plants.
2. We learned ways to find answers to our questions.
3. We learned more about how to find information in books and pamphlets.
4. We learned more about how to write letters requesting materials.
5. We learned how to do experiments carefully so they would give us the correct results.
6. We learned how to work together better.

Each of these items and similar ones were discussed in somewhat the following manner. Using number 1 as an example, "What things about soil and growing plants have we learned?" the pupils listed ideas. Here are a few of them:

ABOUT PLANTS:

1. There are many different kinds of plants on the earth.
2. Plants are adapted to their environments.
3. Plants need certain physical conditions in order to grow and reproduce.
4. Plants and animals are dependent on each other.
5. Plants reproduce in many different ways.
6. Green plants manufacture food from raw materials, from the air and water. Sunlight, or very strong artificial light, is essential to this process.
7. We depend on plants for many essentials—all of our food, except for a few minerals and water, come directly or indirectly from plants.
8. We need to conserve the useful plant life on the earth.
9. Vegetables which grow in poor soil are not as healthful as vegetables that grow in good soil.

ABOUT SOIL:

1. Our soil will not raise a good garden.
2. Some soil has more minerals in it than other soil.
3. Yon can test the soil to find out if it has minerals in it.
4. Cultivation prevents rapid evaporation of water from the soil.
5. Grass and trees help protect the soil from washing away.
6. Much of the land in our community is not suited for cultivation; it makes good pasture with careful management, reseeding, and fertilizing; it is suited for growing trees; it washes easily and has

fairly steep slopes; the Conservation Service calls this Class VI land.

Some of these are relatively unimportant items, others are important principles in science. The pupils were asked to pick out the ideas they thought were quite important and these were listed—"Science ideas that we want to remember." After the discussion of the "things we learned," the teacher said, "Which things did we do best? Which ones do we need to work harder on if we do them again?"

Through such a conversational evaluation as this, pupils become more and more conscious of the purpose of their activities; they grow in ability to recognize when they are doing good work as well as understanding where improvement is desirable; the teacher learns something about the ability of pupils to analyze a situation for its good and poor points. These are but a few of the desirable outcomes that result from a periodic check up to see "how we are doing."

Science in the Elementary School Program

The foregoing examples show how science information and methods of working can contribute to the study of significant problems in the rural school. They show, too, some of the ways the various learning skills—reading, writing, speaking, for example—are developed in connection with a science study. A good science program must contribute its share to developing these and the other essential learning skills. It must by all means do its share in achieving the broad purposes of the elementary school program.

The purposes of the elementary school have been stated in various ways. One of the most important is to help children gain the ideals, understandings, and skills essential to becoming good citizens. This involves giving them the basic skills of reading, writing, and arithmetic, as fundamental tools for gaining information. In addition it means giving them an opportunity to identify and understand social procedures and problems. It means giving them opportunities to participate both in suggesting solutions and carrying out their suggestions. It means helping children become sensitive to the needs of individuals and groups.

In school and out, children should have help in recognizing and practicing the human relationship skills which are necessary for living in a democracy. Among these are cooperation, selection of leaders for what they have to offer or can learn in a particular job, and group planning. The rural school offers great opportunity for children to work together in real life situations where these skills can be developed. An obligation of the rural school is to provide conditions in which optimum physical and mental health of children is possible, and it should give children information and skills for developing such health. Also the school should help children develop wholesome interests for their leisure time.

These general aims of a good elementary school should be furthered by the science experiences children have and no science program can be effective without keeping them in mind.

It is, therefore, necessary to gear the *intentions* we hold for teaching science into the broad purposes of the elementary school. How we teach science, what content the children need, what activities are most useful to them, how we help children plan and evaluate their work, all must be shaped in accordance with these broad purposes.

But what does it mean to say we must gear purposes of science into the broad purposes of the elementary school? For example, how shall we teach science so that it will help children to be better citizens? If the teacher herself selects all of the content, organizes it, decides how it is to be learned, and makes all other decisions, how are children to grow in ability to organize, to plan, and work together? If we agree that being able to plan and work together is one of the attributes of a good citizen, certainly we must make plenty of provisions for children to plan and work together. In this connection there is a distinct difference between exercising leadership as a teacher and dictating from behind the desk. The teacher, as a leader, may make initial steps to create interest, open possible avenues of procedure, and then be a helper. Because of her experience she is able to exercise some guidance, but she has also learned to be silent at the proper time. Children learn to be responsible citizens through *being* just that in science projects as in other school activities. So in teaching science, let's give many real opportunities for children to plan together, make decisions, make mistakes, decide how to rectify them, recognize their successes, set up new procedures, and evaluate the results.

Another example: How shall we teach science so that it will contribute toward growth in learning to use tools for gaining information? Certainly not by *telling* the children the answers to every question they may ask, or by telling them always to *read* the answer. How do we gain information on science? Going back to the project described we gain it by experimenting, by observing, by asking people who know, be reading, by looking at motion pictures, and in other ways. Again, how do pupils learn when to use these ways and when to depend on their results? They learn through practice in deciding on plans to follow, then through trying out their proposed plans, then evaluating the effectiveness of their efforts. Gradually, through practice, pupils grow in their ability to use the tools available for gaining knowledge—but this is true only if we help them. Every area of subject matter has a definite contribution to make here if we give it a chance.

These examples, as well as the preceding descriptions of children's classroom activities, show that experiences in science along with experience in the other areas of learning exist primarily for the purpose of realizing to the fullest possible degree the objectives of elementary education.

Science to Meet Children's Needs and Interests

Saturdays in September

Ned's Saturday. — "I'm Ned. I live on a farm in Michigan. I'm 10. I get up at 6:30 on Saturday morning to help my dad. Our milking machine is on the blink, so we milk 10 cows without it. I only milk 1, though. They tested our cows for TB yesterday. (I wonder how they do the testing.) The butter fat in our milk is up again. We get more money for the milk, and dad says it's because of our new feed. (I wonder how they test milk for fat.) I take the cows to pasture after breakfast. Today in the lane I saw hundreds of swallows sitting on the fence wires. They are going south. (I asked dad how these birds find their way south. He doesn't know.) I helped clean up the barn, and dad and I moved 3 bales of hay outside because this morning when we opened one of them it was hot inside and all black. Dad says the hay was baled too green and might catch on fire and burn the barn. Dad says that's spontaneous combustion, but he didn't explain any more about it. (I wonder what that means.) I helped dad set out some new peach trees. We wrapped the trunks of the trees with burlap to keep rabbits from eating the bark off them. Dad says rabbits may girdle them. (I wonder what girdling does to a tree.) In the afternoon we dug some late potatoes, and I saw some small green balls growing on the plants. Dad says they are potato seeds, but we don't plant them. We plant the potatoes themselves. (I'd sort of like to know why we don't plant the seeds.) Our new deep freeze was delivered this afternoon, and dad let me watch the men unload it. They used levers and rollers to unload it. One of the men lifted one whole side of the freeze with a lever. (I'd like to know how a man can lift such a heavy weight with a lever when he can't lift it without one, and how electricity can keep a deep freeze cold.)"

These are only a few of the science things Ned wonders about on a September Saturday. If Ned's school experience is worth its salt, at least some of these questions will come to school. Other children in the community in all probability share many of them. If so, shouldn't they have an opportunity to do some exploring to satisfy these interests?

Girls who live in rural environments also have many experiences that involve scientific principles.

Patricia's Saturday. — "I am Patricia. I live on a farm. This morning I helped Mother with the breakfast. I used a pyrex frying pan. You can set it on an open flame. (I wonder how they can make glass like this.) We

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opened a can of homemade tomato juice. It was spoiled. Mother says it probably hadn't been sealed tightly. (I wonder why that makes any difference.) After breakfast I used our electric iron. The cord is frayed. A fuse blew out while I was ironing. (I wonder what happens when a fuse blows out.) We put our bed pillows out in the sun so they would puff up. (I wonder what the sun does to the pillows.)

"This afternoon we washed some towels and used a new kind of water softener. Mother says the water is very hard and that we need water softener to help make suds. (I would like to know what it is that makes water hard and how water softener can change it.)

These are but a few of the examples of science that exist in the environment of girls who live in rural areas.

Identifying Needs and Interests

Ned and Patricia attend our rural schools. They are curious children who have a desire to know about things around them. Many children are like this. Many more would be, if they had just a little stimulation from the adults who live and work with them. Children develop more and varied interests when the ones they already have are given attention in a satisfying way.

Children have a real need for information about many of the things that are of interest to them. They have need for a change in attitude about some of their interests and a need for learning a method to find answers to their questions. Some of the needs are apparent to teachers and parents; some are not. Some are easy to identify; some are not. Some are immediate; others are more remote. Some concern the children as individuals; others concern them as members of a family or of a larger group.

Whether needs and interests are immediate or remote or whatever else may be said about them, we still have far to go in identifying them and in learning how to take them into account in our curriculums in a satisfactory way. Certainly we must all develop a keener sense of awareness of them.

How can we identify those needs and interest of children which a study of science can satisfy? Is our way of working with pupils conducive to helping pupils express their interests and needs? Do we give pupils an opportunity to express their interests? Do we study children to discover their needs? And then are we making real effort to adjust our plans to any discoveries we make? These are questions we need to study continually.

In day-to-day living with pupils, situations arise that give us clues to their interests and needs. *Pupils ask questions* about things that happen at home. Examples: Why does putting salt on icy steps melt the ice? How does putting alcohol in a car radiator keep it from freezing? *Pupils bring in clippings from newspapers.* Examples: An item about a harmful insect that is currently doing much damage in the fields and gardens. An item about new deep-freeze lockers being installed in the community. *Pupils show curiosity by discussing a current happening in the community.* Examples: Lightning strikes a barbed wire fence and kills some cows. Some of the shallower wells in the community run dry during a drought. *Pupils discover materials which interest them in their free reading time in school.* Examples: An account in a weekly newspaper of a new airplane. Pictures of a new fabric for dresses in a weekly magazine. *Pupils bring things to school.* Examples: a deserted bird nest, sea shells, seed pods, etc. *Pupils encounter problems as they work and play.* Examples: Trying to dig a big rock out of the school ground. Emptying a pool with a siphon.

These are a but a few of the situations in which it is possible to find leads into science experiences of interest to the pupils. In some cases the exploration will be brief—an incidental experience. It may consist of an individual investigation and of bringing back a report to the class. In other cases interest may warrant a more detailed study—a planned experience.

On the following pages we have attempted to describe science that seems to fit some of the interests and needs of girls and boys in rural areas. Situations which may arise that show the interest or need are indicated briefly in each case.

Science Enriches Rural Living

I. Comfortable and Efficient Home Life.

This broad area might include information and experiences of a wide variety not mentioned here. The following examples are some of these related to the use of *heat, light* and *electricity* in the home:

Heat. (Should be a nontechnical study of the uses and effects of heat. A few of the situations which may lead to a study of heat are suggested here.)

1. Pupils want to know why opening a window at top and bottom is desirable in ventilating a room.
2. Pupils notice that snow stays unmelted on the roofs of some houses and not on others, and are curious to know why.
3. In autumn double windows are placed on schoolhouse, and pupils ask why this helps keep the rooms warmer.
4. Pupils ask how a thermometer tells temperature.
5. A pupil reports that his home is being insulated and brings a sample of rock wool to school. Pupils are interested to know how insulating keeps a house warm in winter and cool in summer.
6. Pupils bring hot cocoa in a thermos bottle and want to know how the bottle can keep things hot or cold.

Many similar examples of instances where pupils observe effects of heat might be cited. Home heating, school heating, methods of cooling, ways to conserve heat are all in the experience of rural girls and boys.

Light. (A brief consideration of the problems involved in understanding the phenomenon of light—how it travels, its effects on things, how it lights our homes, and how we see.)

1. Pupils bring a magnifying glass to school to use in examining small things and are curious about how it makes things appear larger.
2. Prisms from an antique hanging lamp are brought to school. Pupils wonder how it is possible to see "rainbows" by looking through these prisms.
3. New light fixtures are installed in school and their effectiveness is tested by use of a light meter. Pupils want to know about light and its effect on eyes.
4. Pupils reflect bright sunlight into the eyes of other pupils by use of a mirror. Teacher explains that this is a bad practice and pupils are interested to know why.
5. Pupils notice that goldfish in a round bowl look larger than they actually are, and are curious to know why.
6. Pupils wonder what causes a rainbow.
7. Farmers use electric lights and windows to improve conditions for chickens and livestock. How?
8. Pupils notice that corn grows better on a southern slope than on a northern one.

These instances show the kinds of things in the immediate environment that pupils seem to be curious about with respect to light.

Electricity. (A nontechnical treatment of the simple problems involved in understanding how electricity comes to farm areas and how it is controlled and used efficiently and safely.)

1. Pupils report installation of a transformer in the community and want to know what it is for and something about how it operates.
2. A fuse blows out in school and must be replaced. Pupils are interested to know what the fuse does.
3. Lightning rods are being installed on a new barn near the school, and pupils want to know how they work.
4. Teacher's car will not start. Battery is "dead." Pupils are interested in how a battery can make electricity.

5. Windchargers are used to generate electricity in a community home. Pupils are curious to know about it.

These are but a few of the instances that have actually happened in rural schools and seem to indicate the appropriateness of studying the nature and sources of electricity, how it travels, its uses, hazards connected with its use at home, in school, and around the farm.

II. Understanding the Weather, the Sky and the Seasons.

Weather. (Elementary concepts of the causes of different kinds of weather, changes in weather, weather forecasting, and work of the weather bureau.)

1. The weather bureau forecasts a sudden frost. Pupils ask how frost can be forecast.
2. Roads become almost impassable in spring. Pupils are interested in what happens to cause this. Is it really because "the frost is coming out of the ground?"
3. Pupil brings a newspaper clipping which says certain individuals have forecast a severe winter because certain animals seem to have unusually heavy fur and are storing much food. Pupils get into a discussion of the accuracy of the statements and about the relationship between living things and their physical surroundings. Opportunity to stress scientific attitudes.
4. Pupil brings mechanical weather forecaster to school to test its accuracy. They are interested in how it operates. This testing provides another opportunity for the use of scientific attitudes.
5. Pupils notice rings around the moon and wonder what causes them.

The effects of weather on living things is continually evident to children, especially in rural areas. Frost, snow, hail, and rain come and go. Smudge pots are set up to combat frosts. Floods result from excess rain and snow. Drought destroys crops. These things directly influence children.

Astronomy and the Seasons. (Ideas concerning the heavenly bodies: what they are, their distances away, and their influence on us.)

1. The question about planting root vegetables during certain phases of the moon is raised by pupils. They are interested to know if the idea has merit.
2. A pupil brings a horoscope to school and pupils ask if it is possible to foretell the future by the stars.

3. Pupils note the changing amount of daylight as the seasons change. They ask why the days vary in length.
4. Pupils wonder what the Milky Way is.
5. Pupils read about sun spots and ask about them.
6. Pupils notice that the Big Dipper is not in same position every night and ask why.
7. Pupils see meteors ("falling stars") and wonder about them.

The foregoing examples are a few of the experiences that may result in explorations in astronomy. There are many more which the teacher and pupils may identify.

III. Working with Machines and Equipment.

Simple Machines. Rural pupils will know a great deal about machines because of their close contact with so many of them. However, their interest and knowledge can be extended by considering such problems as are suggested by the following activities:

1. Pupils have observed their fathers moving heavy objects on rollers.
2. A block and tackle is used to put hay in the barn.
3. Pupils have observed the use of wheels—on sewing machines. wagons, cream separators, grindstones, etc.
4. Wood is split by using axes and wedges.
5. Grease and oil are applied to axles of machinery and to other surfaces.
6. Automobile jacks are used to lift cars, and jack screws are used to lift buildings.
7. Crowbars are used in numerous ways on the farm.

IV. Effective Use of Soil and Other Natural Resources.

There are many sources of material available for conservation activities in school, consequently only a brief discussion is included in this bulletin. No science curriculum could be complete without considerable emphasis on conservation. Science study can explain the "why" of conservation so that the desired action will be more meaningful to individuals. Certainly there is need for more functional teaching of the principles of conservation. It should begin early in the grades. Everything possible should be done to make the ideas of conservation real to pupils by graphic presentations such as first-hand observations, performance of experiments which illustrate, and use of motion pictures and slide films. The following incidents may lead into meaningful activities in conservation.

Conservation of Soil and Water

1. Pupils observe terracing projects going on in neighboring fields.
2. Pupils note that water in a nearby river is very muddy after heavy rains.
3. One pupil reports that his well at home has gone dry.
4. Pupils see erosion effects in the fields and along the roadside.
5. A pupil reports that his father is buying commercial fertilizer for his fields. Another reports that alfalfa helps the land.

Conservation of Plant and Animal Life

1. Children may observe or read about a forest fire in the community, or State, and then study causes of such fires, how they may be prevented, what the results are, and what every citizen's responsibility is concerning them.
2. Dutch elm disease or other fungus or insect enemy of trees invades a community or section of the State. Pupils investigate cause, prevention, measures to combat such enemies, and learn how scientists discover facts in cases such as this.
3. Some farmers burn off the grassland in the fall. Is this a good or bad practice?
4. Fish and game laws of the State are studied for information about why laws are required, who makes them, why they should be observed, and how research is done to determine the necessity of such laws.
5. Pupils notice how new plants, including weeds, gradually grow in a burned-over woods. This leads to a discussion of the "balance in nature" and interdependence of plants and animals.
6. Pupils wonder about DDT—when and how it should be used.

The above suggestions are a few examples of the kinds of situations which may arise in rural schools to prompt a study of conservation. The following list of activities illustrates some of the things children in rural schools have done in connection with the study of the various phases of conservation: Collected newspaper clippings dealing with local and State conservation problems and studied their implications; observed and studied need for various kinds of conservation in the county; arranged talks on conservation by the county agricultural agent and other interested and informed persons; planted trees and cared for them; fed the useful birds in winter; and saw motion pictures dealing with conservation.

V. *Keeping Healthy and Safe.*

Keeping Healthy

Presumably, in many cases at least, health education exists as a separate course, but there is more than a little relationship between the fields of health education and science. An elementary scientific explanation of the meanings involved in good health practices may make a good deal of difference to learners. For example: A study of bacteria, how they grow, reproduce, and spread can make more graphic the reason for not touching your lips to the drinking fountain when you drink or for not using a "community" cup for getting a drink. Or, finding out about the different elements in food and learning of what the body is composed contribute to understanding why it is important to eat a balanced diet. The following classroom happenings may be used to promote science study that will contribute meaning to good health practices.

1. Health posters indicating basic foods are received in the school. Pupils study them and want an explanation of why it is essential to eat certain foods even though you may not enjoy them.
2. Pupils read about proper way to ventilate a sleeping room and are interested to learn why ventilation is important and how it is accomplished. They devise scientific experiments to understand the principle of ventilation.
3. A pupil cuts his finger. The teacher administers first aid and there is discussion about why the cut must be kept clean, how the injury will heal, and what things could delay the body in repairing itself. Pupils grow bacterial cultures and learn about how bacteria develop inside the body.
4. The pupils investigate the scientific diets provided for their fathers' thoroughbred livestock or their 4-H Club calves.
5. A pupil reports that an outstanding scientific achievement for 1948 was the discovery of several new antibodies which are effective against typhus, Rocky Mountain spotted fever, typhoid fever, and other diseases. The use of powdered penicillin for colds was reported. These reports led to a study of disease prevention and cure.
6. Pupils ask what things should be raised in their gardens to give them the essential energy and vitamins for good health.

Safety

The study of safety should become a course of action that will result in safe living for pupils and adults in the community. As in the case of conservation, there is much material already available on the subject of safety. Safety precautions with reference to fire, traffic, home, school, and community accidents are essentially the same in any place and a rural environment is no exception. Certain aspects, however, may deserve special emphasis.

1. A barn or other building burns in the community and the pupils discuss the cause or possible causes and consider methods of assuring safety against fire loss in their own homes and farm buildings and in the community generally.
2. An accident with a tractor occurs in the community. Pupils learn about the cause of the accident, discuss how it might have been prevented, and relate descriptions of other accidents. They keep a record of various accidents in school, on the playground, at home, on the school busses and elsewhere, and then devise safety rules for observance.
3. The bus driver is disturbed about conduct of pupils in the school bus because he says it may be the cause of an accident. Pupils discuss conduct related to getting on and off busses, conduct on busses, method of crossing road and of walking on highway. Pupils and teacher prepare a set of acceptable rules for transportation safety.

As in the case of conservation and health, these are but a few of the instances useful in promoting consideration of safety education. More and more, activities that make safety real in the lives of children are essential in our curriculum. A few samples are: Listing places where accidents occur at home, school, and playgrounds, and learning how to avoid the causes; investigating home and school for possible fire hazards and correcting them; learning the location of fire extinguishers and how to operate them or identifying adults to contact for help; learning where and how to contact fire department or other assistance in case of fire; and planning for fire drills and putting plans into action.

Resources: "Across the Way and Down the Road"

WE ARE continually being urged to use the resources at hand to make our curriculum more vital and meaningful to girls and boys. Very often subject matter and methods of instruction seem to make things near at hand seem foreign and far away because we try to teach without relating them to the children's experiences. A list of all of the possible resources in a rural area would be endless. No two regions would contain the same possibilities.

Resources of the type suggested in this chapter are useful in at least three ways. One, they inspire observing pupils to ask more questions; two, they serve as sources for finding the answers to the questions; and three, they serve to make the science concepts more real.

The Resources

The following pages include some typical examples of local resources as well as suggestions for their use.

A gravel pit or stone quarry may be useful in these ways: Learning how the surface of the earth has changed over a period of years; seeing an example of how man uses materials from the earth; learning how observations of geological materials help scientists learn about the age of the earth and the changes in climate; seeing how machines are designed and used to serve man; finding fossils to use in a study of animals of the past.

Possible ways to use:

—take a field trip to observe and gather materials.

—hear a talk by the owner telling how the place was discovered, how the materials are marketed, what safety precautions are used, etc.

A woods near the school may be useful in these ways: Discovering changes that animals and plants make as the seasons change; studying habits of plants and animals; finding out where animals live; seeing how animal and plant life depend on each other; seeing how physical surroundings, such as moisture, temperature, and amount of sunlight affect living things; finding examples of useful and harmful animals and plants; appreciating the wonders of nature; studying various phases of conservation.

Possible ways to use:

—take a field trip to observe and collect materials.

—bring selected materials into the classroom.

A burned-over area (roadside, field, woodlot) may be useful in these ways: Discovering the effect of burning on plants and animals; studying the causes of the fires; arousing interest in ways of preventing such fires if they are harmful; learning ways of stopping such fires if they are started; observing how life starts again in such areas; noting over a period of time how long it takes to rehabilitate such an area; seeing the effects burning has on erosion of such an area.

Possible ways to use:

—visit the area to examine results of fire.

—collect and examine materials damaged by fire.

A nearby field may be useful in these ways: Finding evidences of erosion to see how it starts and how it may be prevented; noting various adaptations which plants make to their environment, such as leaf arrangements, root length and arrangement, and leaf texture; observing various kinds of insects to see how they are adapted to the environment, how they are useful or harmful, and how the harmful ones are being destroyed; observing (if the field is being cultivated) how plants are cared for to provide moisture; noting different amounts of moisture in high and low parts of the field; seeing how the vegetation differs where there is more moisture.

Possible ways to use:

—visit field to observe plants; dig some up and bring them back for further study.

—collect insects for closer observation and study.

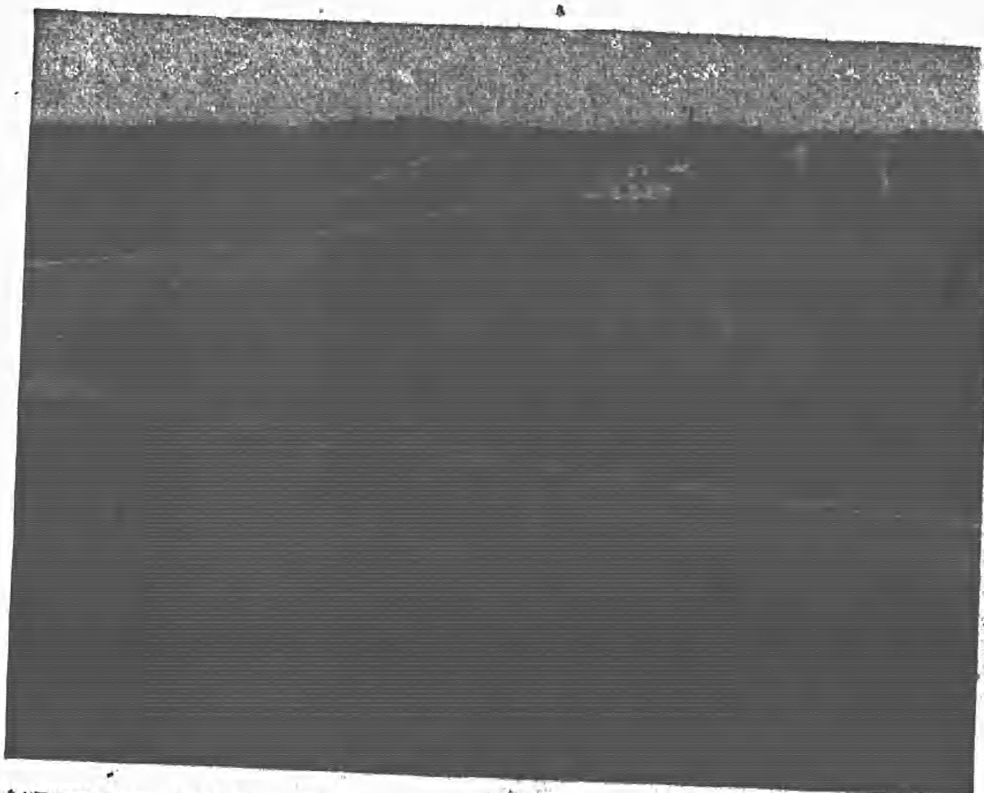
—ask qualified adult to discuss problems of weed and insect control with class.

—find out how drain tiles are laid.

A new building being constructed may be useful in these ways: Seeing how electrical wiring is installed; seeing how building is insulated; seeing what different materials are being used; examining samples of soil dug from the basement and comparing it with garden soil; seeing where well is located and how it is constructed; learning how sewage is disposed of.

Possible ways to use:

—collect examples of building materials for study—electrical wires showing different kinds of insulation, rock wool and other kinds of insulating materials, samples of soil, etc.



"THIS IS WHAT I SEE FROM THE BUS WINDOW ON MY WAY TO SCHOOL."

—talk with workmen who are wiring the house, installing heating system, or doing other similar types of work.

—observe the procedure for locating and drilling well if there is to be one.

—examine plumbing, cesspool, and location and installation if indoor plumbing is to be used; if outdoor toilet is used, find out where it is located in relation to the water supply and why this location was selected.

A saw mill may be useful in these ways: Learning how trees are selected for cutting; finding out how young timber is protected; learning which kinds of trees are considered most valuable and why; observing the use of machines; learning how lumber is made and cured; observing changes in animal and plant life when an area has been cut over.

Possible ways to use:

—visit the sawmill to observe the procedures.

—bring back samples of wood to see growth rings.

—walk through woods to observe how trees are being cut.

—examine various machines being used to observe how they help workmen.

A farm (buildings and immediate area surrounding them) may be useful in these ways: In observing various ways of preserving and storing food; caring for animals; growing garden vegetables and flowers; observing the use of machines in house, field, barn, garden, orchard; observing how buildings and grounds are made from fires and how accidents are prevented.

Possible ways to use:

—visit farm to observe science applications.

—let pupils report examples of scientific facts and applications they have observed at home.

A vegetable and flower garden may be useful in these ways: Studying how plants get enough light, moisture, and the other essentials for growth; learning how ground is prepared for planting, how plants are transplanted, and how seeds are dispersed; studying how flowers are self- and cross-pollinated and how seeds sprout and grow; learning what kinds of soil are suitable for the growth of different kinds of plants and how the soil is tested; observing how plants store food and how plants change with the seasons.

Possible ways to use:

—visit the garden to observe plants and methods of growth.

—make collections of seeds and fruits that show methods of dispersal.

—sprout seeds in the schoolroom to learn more about how plants grow.

—perform experiments with plants to see the effects of light, temperature, and moisture in growth.

—plant a school garden (if practical) to learn more about how plants grow.

An apiary may be useful in these ways: observing how bees are cared for; learning how hives are constructed and how prepared for cold weather; learning what happens when bees swarm and how they are handled safely, and how bees are helpful to man; observing bees at work and learning how the life inside a hive goes on; seeing an example of social insects and of insects that are useful to man.

Possible ways to use:

—visit apiary to observe various activities.

—talk with beekeeper to learn about bees and how they live.

—observe dead bees under a reading glass or microscope.

A tree on the schoolground may be useful in these ways: In observing seasonal changes, leaf arrangements, bud formation, and growth; seeing bird life and nests and learning of the usefulness of birds.

Possible ways to use:

—observe tree at intervals and discuss observations.

—cut small branches and study them more closely.

An orchard may be useful in these ways: Learning how plants are transplanted, sprayed, and pruned; seeing relationship of plants to useful (bees), harmful (scales, aphids), and other insects; seeing an example of man's use of plants to supply food; observing the effect of sudden changes of temperature or other weather phenomena on plant growth.

Possible ways to use:

—visit orchard to observe trees at different times of year.

—mark certain flowers and observe what happens as season progresses.

—collect and study insects and fruit damaged by insects.

A creek and a pond may be useful in these ways: Observing kinds of plant life and the adaptations of stems, roots, leaves, flowers and fruit to moist environment; learning how animals are adapted for life in or near water and contrasting this with land animals; observing how these animals and plants change as seasons change; observing the food-getting and home-building habits of the animal life.

Possible ways to use:

—visit area to observe science applications indicated above.

—collect specimens of plants and animals for further study.

The roadside may be useful in these ways: Observing animal homes and animal methods of food-getting and of caring for young; observing various forms of plant life to see adaptations to environment, such as methods of seed dispersal and changes under conditions of drought or excess moisture; studying relationships between plants and animals (plants and insects, for example); studying examples of erosion and methods of preventing it. If the road cuts through a hill, pupils can observe the difference between top soil and subsoil, see the depth of the top soil, and understand more clearly the importance of saving it from being washed away.

Possible ways to use:

—visit area to observe examples given above.

—collect samples of topsoil and subsoil, try to grow plants in each and note results.

—collect seed-dispersal specimens.

People in the community. — There are other people in the community besides the County Agent who can be of help. For example, many parents have traveled extensively; some are experts in animal husbandry; some are expert homemakers; some can contribute experiences about hunting, trapping, and fishing. There is an electrician and a mechanic in nearly every community. People are usually pleased to be asked to help school children with their problems, and the practice of using adults in the community to help in school may be a very beneficial practice to all concerned.

Using These Resources

The value of any of these resources depends on how skillfully they are used. Each resource should be used for a definite purpose or purposes: To help solve a problem, to make a scientific principle more meaningful and graphic, to increase the appreciation of the usefulness and wonder of science. In preparing for a trip, the teacher and children should have clearly in mind a definitely stated problem or problems. The teacher and perhaps a small committee of pupils should go first to the place to be visited by the class to determine its suitability and accessibility. Any visit made without definite plans and purposes is bound to be almost a total loss. This holds true also in using a person in the community as a source of information.

Whenever the pupils plan to seek information from someone in the community, it is important to make sure that he understands the purpose of the visit, and that he keeps his explanations easy enough for them to understand.

In every case when children leave the schoolhouse to visit a place or when an outsider comes to school, it is essential that pupils discuss their responsibilities for acceptable conduct. A lot of good public relations have gone down the drain when some class members are undisciplined in public or when they are an unattentive audience to a speaker who has been invited to their school.

Follow-up discussions to make use of the material are essential and should be carefully planned. Appropriate data should be used in solving the problem, and written records may be made of the findings whenever it seems likely that the children will have a use for the records.

It is generally conceded that most schools are not yet making full use of the community resources available. We are likely to overlook many common things about us even though we say glibly "science is a study of the environment." The science in our rural school is not necessarily being best taught where there are cabinets full of costly equipment. The science is being best taught where children and teachers are aware that they are living in a world of science and that the materials for its study are near at hand.

How Children Learn Science

"WE LIKE SCIENCE best when we are doing something about it," children say. And that's understandable. There are many different kinds of things children can do to help themselves understand science. These things also add to their enjoyment of learning. All children seem naturally to do a great deal of exploring in their environment. They turn over stones, watch tadpoles in the drainage ditch, follow with their eyes the seemingly erratic flight of a butterfly. These experiences contribute to the total knowledge children have of their world. Children should be given encouragement to make more observations of this sort, and to observe as accurately as possible, but such observations may be random and unguided unless there is planning. Let's examine the things we *plan* with children in light of the purposes we hold important, and let's not have activity just for the sake of something to do.

In a previous section the description of experiences with a "soil" problem illustrates some of the more common ways through which children learn science—they experiment, they read, they take field trips, they use visual aids, they observe, they interview persons, and engage in other appropriate activities.

Experimenting

Experimenting, if done thoughtfully, is a natural way to discover. Experimenting is done most successfully if we remember: to keep the experiments simple, to use common materials, to have everyone aware of a definite purpose for the experiments, and to have pupils themselves perform the experiment whenever possible. Here are some guideposts for experimenting.

1. ***Experimenting should cause thinking.*** — Experiments should be conducted so that they will cause pupils to think. An experiment in which the teacher *tells* the pupils everything obviously gives no food to nurture growing minds.

2. ***Experiments are for a purpose.*** — By all means, children should be conscious of the purpose for performing an experiment. It is often desirable to write the purpose on the board in a simple direct form. This comes about easily when the experiment is done to solve a problem which the pupils themselves have raised. Certainly, the problems should be children's problems insofar as possible, and should not be performed by using a textbook in the manner in which a cook uses a recipe book.

3. *Careful planning is essential* to successful experimenting. Appropriate materials must be assembled (by the children, if possible), a plan of procedure must be set up, the plan must then be accurately followed to insure that the results can be depended upon. Less "jumping the gun" and more "hey, wait a minute, let's take another look at this," should be the motto in grade-school science experiments.

4. *Let children perform the experiments.* — Insofar as possible, children themselves should perform the experiments. They may work as individuals or as groups depending on the type of experiments and the amount of material available. Experiments involving use of fire or other possible dangers, or experiments of a complicated nature, if used at all, should be performed by the teacher.

5. *Children can devise experiments.* — Many times children themselves can originate experiments to answer their questions. These are often the most satisfactory from every point of view. Contrary to the belief of some teachers, experiments need not always be complicated, nor need they have been previously described in a science book—sometimes they are; sometimes they're not.

6. *Follow the directions.* — Experiments should be performed carefully, and exactly according to the directions, either the directions from books or those originated by the class.

7. *Controls are important.* — Pupils should learn the value of using a control when they perform an experiment so that their results will be more dependable. For example: Suppose children are attempting to discover whether or not leaves of plants give off water. They set up the usual experiment of covering a plant with a glass jar and shutting off the soil from contact with the air in the jar. The next morning droplets of water are found on the inside surface of the jar. The children immediately decide that they have discovered the answer to the problem. But how can they be sure that the water did not come out of the air in the jar? They can't. But suppose they assemble another set of apparatus exactly like the first—a plant pot, a glass jar, soil, etc., but without a plant. The jars are placed side by side and observed. This time if water appears on the inside surface of the jar with the plant in it and does not appear on the other jar's surface, the water must have come from the plant leaves. Such a procedure of controlled experimentation is essential if experiments are to assume their full meaning as activities for children. In this connection it is essential that the experiment be tried more than once before conclusions are drawn. (*See also* item 9.)

8. *Use simple apparatus.* — Simple rather than complicated apparatus is more appropriate for use in experiments in the elementary school. Intri-

cate pieces of apparatus borrowed from high-school laboratories often detract from the real point of the experiment.

9. ***Don't jump to conclusions.*** — Pupils should exercise caution in drawing conclusions from an experiment. They cannot prove anything from having performed an experiment once. They must hold their findings tentative until more evidence—either from additional experiments performed by themselves or from authentic books—has been found. Results should be accurately and completely stated and in some cases recorded in a carefully written paragraph. Pupils should most certainly not generalize on insufficient experimental evidence.

10. ***Apply findings to everday life.*** — As many applications as possible to everyday life situations and problems should be made from an experiment. This is a difficult step, but it is one of the most important reasons for studying science in the first place. When an experiment has been performed, only the first step has been taken. For example, after pupils have experimented with rusting iron, they may want to see how things may be kept from rusting. An experiment is set up involving a wet, unpainted nail and a similar nail covered with a layer of paint. The experimenters note that the unpainted nail rusts and the other one does not. Now in a real life situation how is this principle applied? In school? At home? On the way to school and elsewhere? The experiment was done to make the idea real. The applications must be made to see how important this idea is and how useful. Problems arising from real life situations that result in experimenting to find the answer are probably the most successful of all classroom activities.

Helping children to learn through doing their own experiments is, then, not a difficult job. Pupils should realize that they are experimenting not to discover information for the first time, as is the case with real scientists, but for the purpose of *understanding* scientific ideas more clearly.

Reading

Reading ranks high in the list of ways in which children learn science. Unfortunately some courses in science deteriorate into reading periods to the exclusion of all other activities. That is bad. But since reading is one of the ways to learn science, it deserves thoughtful planning if it is to be an effective tool. Accurate material on the reading level of the various class members must be available, and there must be guidance to help pupils read it. The following considerations in using reading material are important:

1. ***Fact and fancy.*** — The science class is a logical spot for children to learn to differentiate between fact and fancy in their reading. That is, they should come to know that some books are written for enjoyment; others are sources for gaining knowledge. They should learn to challenge the authen-

ticity of the materials they read. They should learn that the date of copyright and the authorship are important in judging material. They should learn to exercise care in drawing conclusions about material. For example, checking one fact in a reference with an authentic source does not necessarily indicate that the book is accurate. Finding an error on a printed page may be an enlightening experience for a pupil, for through this he may learn the valuable lesson that just because something appears in print does not necessarily mean that it is accurate.

2. ***Reading with a purpose.*** — Reading should be done with a definite purpose in mind, i.e., to check a pupil's own conclusion, to find information, to find out how to perform an experiment, to answer a question or to solve a problem, or for some other definite purpose.

3. ***Read from several sources.*** — A variety of sources of reading material on a given topic is generally desirable because through several sources, more information is obtained and varying points of view may become apparent.

4. ***Taking notes.*** — It is often necessary and desirable for science pupils to do individual reading as a type of simple "research." Under such circumstances careful note taking is essential so that an accurate report may be given to the class. This is an important aspect of reading in science.

5. ***Selecting the material.*** — Selection of appropriate reading material is a prerequisite to success in reading activity. This is largely the responsibility of the teacher, but the help of the children is also desirable. Material which is too difficult, or which is too easy, or which is inappropriate because it does not answer the children's questions is discouraging when offered to children. Slow-learning pupils or pupils with reading difficulties need special attention in selection of their reading materials.

Reading is a learning tool of which all science teachers should be aware. Developing skill in reading and learning in science can go hand in hand. But reading is only one of the ways to learn science. To overemphasize its use is to ignore some of the essential purposes of teaching science.

To learn science, to enjoy it, and to make it functional in the lives of girls and boys, it must leave the pages of a book and get into their daily experience. The textbook will serve as an excellent guide. Problems will be raised by the pupils and teacher together. Ways to solve the problem will be decided on by the group. Then, reading may be, and almost always is, one of the ways which is extremely useful. Pupils cannot experiment or observe or find out through an interview everything they need to know. The textbook will supply much of the needed information, but that doesn't mean that "we will open our book to page 18 and read to 24 and then talk about what we have read."

Observing

Observing is another essential activity in all science teaching, and pupils should grow in their ability to observe more accurately and thoroughly. Through the use of their senses, children can come to experience many things. Feeling the texture of materials or the heat from an electric wire attached to a dry cell, seeing cloud formations and the changes in lengths of shadows, listening to birds, and many other similar observations are an important part of their science work. They make the learning more vivid. The following verbs give a key to the many opportunities for observing: Touch, lift, smell, weigh, taste, measure, watch, and find.

Children observe to determine the characteristics of things, to see the changes in growing things, to learn the habits of animals, and to see the results of experiments, but they must learn to do so with ever-growing accuracy and to report their observations carefully enough to be reliable.

This ability to observe accurately and to report the observations correctly is a part of all of the activities in science. Experimenting is a total loss without it; field trips and visual aids cannot be effective without it. Much is to be learned from our daily surroundings if we can train ourselves to be more careful in our observations. Pupils who have experience with this method of learning early in their school experience have a running start on those who do not.

Taking Field Trips

Making excursions to gain information for solving problems and developing appreciation is an important activity in elementary science. Unless well planned and motivated, trips such as those described earlier in this bulletin can result in a headache for the teacher, a field day for the children, and bad public relations for the school because of the "monkeyshines" of poorly directed children.

Children should make excursions with definite purposes in mind. They should go for the purpose of answering questions that are best settled by first-hand observation of the kind which trips can furnish. By all means, pupils should be aware of the purpose of the trip. The person who is to act as guide should know in advance what the children want to see and learn, and the teacher should make a before-hand trip to see the place for herself and to talk with the guide. She should then be alert to assist the guide in keeping the group together, and in making sure that there is plenty of opportunity to see and to ask questions.

Excursions should be made an integral part of a study under consideration and not just something to do. Field trips can be of inestimable value to a science program; or they can be, and sometimes are, useless boondoggling.

It is probably safe to say that more time should be spent getting ready for an excursion, and in making deductions from it, than on the actual excursion itself.

Using Visual Aids

Another way in which pupils learn science is to see it pictured in motion or otherwise. Much has been said about the desirability of using visual aids in connection with grade-school science teaching. Without the use of some of the aids now available, a science course is incomplete, but much depends on how the aids are used. Motion pictures and slide films are among the many useful helps. There are others equally important.

If motion pictures or slide films are used, here are a few essentials to be considered:

1. *Select films carefully.* — The selection of a film is important just as is the selection of a book. Films designed for use at higher levels are generally useless for elementary pupils. A film which is too difficult is likely to confuse young pupils. Films should be selected which deal directly with the problem under consideration and that are prepared for specific levels.

2. *Preview the film.* — Films should be previewed by the teacher and a committee of pupils to determine fitness for showing and to make proper preparation for use. Previewing a film helps to determine the purpose for which the film may be wisely used and when it is to be shown—at the beginning, middle, or end of a unit of study—or at more than one of these times as the case may be.

3. *Purpose should be clear to the class.* — The class should be prepared before seeing the film. Pupils should know what to look for in the film and know why they are seeing it.

4. *See the film more than once.* — It is often desirable to have a class see a good film more than once—especially if it presents basic concepts to be remembered.

5. *Discuss the film.* — The follow-up discussion of a film is essential. During such discussion, questions are asked, ideas clarified, and further explanations made.

6. *Films for a purpose.* — Effort should be made to help pupils realize that the films are not shown as entertainment but for the purpose of learning.

Motion pictures and slide films are not the only types of visual aids useful in elementary school science. The use of pictures from magazines and other similar sources is often overlooked. In many schools, teachers, pupils, and parents have, in cooperation, assembled an excellent teaching collection of pictures. Pictures that show how animals grow, how they are adapted to their environment, where they live, and what they eat are examples of such collections. Pictures that show how we use electricity, machines, lenses, and various kinds of power are other examples. The important thing to remember is that these collections should be made to show certain important ideas and not be just a collection of pretty pictures. A file of such pictures may be kept so that they are readily accessible.

Models are often useful in making ideas clear, and they should be used chiefly for that purpose. There are many instances of model making in elementary science classes which are almost entirely a waste of time. For example, making a wax model of the parts of a flower at the elementary school level is hardly to be considered appropriate since a detailed knowledge of flower structure is not essential to any learnings at this level. Anyway, a real flower can easily be obtained for study. On the other hand, rather difficult concepts about the solar system can be more easily understood by use of a model of the solar system. A model will give an idea of relative sizes and of distances between the planets, help pupils to gain a better idea of the relative size of the sun and moon, and to learn about the orbits of the members of the solar system. The purpose of model making should be carefully considered just as the construction of any other instructional aid. Building model weather instruments, making balancing toys or an electric questioner are other construction activities that contribute toward understandings in elementary science.

There are, as we have seen, several types of activities through which pupils learn science. The selection of an activity depends on what is to be accomplished. Let it be activity for promoting understanding, interest, and appreciation and not just activity for the purpose of having something going on. An activity should make a science principle or idea more graphic, more interesting. Certainly, it must give pupils a chance to be active in the sense of participating with their minds as well as their hands.

Helps for the Classroom Teacher

WHEN TEACHERS take into account questions and other evidences of interests of children in planning the school program, they are bound to be confronted with teaching science. They see that the program is not complete without it. Most teachers are anxious to do a better job and, once having decided to teach science, are willing to find the answers to questions along with the children. This is a first step. And yet to feel secure, many teachers feel the need for more science information as well as other help to do a better job.

The following suggestions have been found useful by many teachers:

1. The teaching of science is not so unusual as you think. It's no harder to teach than social studies, language arts, or arithmetic. In some ways it's easier because it deals with concrete things and often reaches the real interests of the children.

2. To help gain confidence start your science teaching by selecting questions, problems, or units with which you feel most at home. If some of your college science training, a hobby, or an intense personal interest has given you background in some special field, use that knowledge or interest to determine your choice of what to study. It may give you the start you need. Later it will be easier to follow children's leads. Children can always enter into the planning, even if the original idea came from you as the teacher.

3. Don't expect to know the answers to all of the science questions children ask you. If you plan to wait until you do, you'll never begin teaching science. Teachers *tell* children too much anyway. If you know children, and know how to help them learn, half of your teaching battle is won. Don't be afraid to *learn with* children. Let them set up plans for finding the answers to their problems and then you act as a guide and learn with them. Of course, you need to know *some* subject matter, but you don't need to be a science specialist. The next few items give suggestions to help you build up some science background.

4. After a unit or area of science study has been decided on, read some of the basic science textbooks that are on the learning level of the pupils you teach. Read these lower-grade books, and then get some good general science or biology textbooks (the kind used in junior high schools or tenth grade) and read them. Here you will find some of the science subject-matter background essential for teaching young children.

5. Do some of the experiments and other activities that are suggested in these books so you'll have the *feel* of the material. These simple science experiments are not half as complex as you may think they are.

6. Do some of the "things to do" that the books suggest—trips to take, observations to make, experiments to do, collections to make. Seeing is both believing and inspiring, and it is much easier to get your pupils interested in and excited about the town's filtration plant if you yourself have seen how wonderful it is.

7. Talk with a junior highschool or a highschool science teacher and enlist his help. Secondary science teachers often can give you teaching ideas, suggest experiments, and help provide materials and books. Science is their special field, and they are usually full of helpful ideas.

Remember that it's the unfamiliar that's likely to make you timid, so give yourself as much first-hand experience as you can with the science material. Following the four preceding suggestions is almost sure to make you confident enough to tackle a new science unit.

8. If you have the opportunity, enroll in an extension course or in a campus class in the teaching of elementary science offered by a nearby university or teachers college. Insofar as possible try to work on materials which will be useful in teaching science in your own school.

9. Let pupils experiment. This is one way children learn science and they like it. Use children who are especially interested or informed on a given topic to lead out in experiments along lines of their special ability. Give different children the opportunity to experiment. What happens in the experiment can be discussed by the teacher and pupils and everyone can learn together from the experience. (See pages 34 and 35 for help in doing experiments.

10. Don't feel too handicapped because you lack materials. Children can bring from home almost everything you actually need. What they can't produce, you can get at the dime or hardware store, borrow from the high-school science department, find in the schoolyard, get from the school custodian, or let the children make. Expensive, complicated apparatus is worse than useless in the elementary science class. It is likely to be confusing and to draw attention to itself rather than to the problem at hand.

11. Talk to other grade teachers about what things they have found successful, and be ready to share your experiences with them. Such an exchange is often a great help.

12. Make every use possible of the teachers' manuals that accompany your textbook in science. Teachers' manuals are usually packed with teaching ideas that have been tested and found good. They are often helpful even if you are not following the text for which the manual has been prepared.

13. Keep track of your science material, your notes on teaching, your plans, etc., so you can use them at a future time and so that other teachers may borrow them. The second time over a unit is easier, especially if you have access to the material you used before.

The Materials of Instruction

USING THE OUT-OF-DOORS—the plant and animal life of the neighborhood, the land and sky, the creeks and the ponds—has been encouraged throughout this bulletin. Emphasis has been placed on the importance of making use of *all* available resources in the community. This is equally true of materials and apparatus which are needed for science demonstrations or experiments. Whenever possible, they, too, should be obtained from local sources.

Most science experiments in the elementary school are simple and rightly so. The equipment needed is, therefore, simple. Children can find in their homes most of the equipment and materials required. Home-made or simple equipment often serves the purpose better than more elaborate, purchased equipment. Moreover, the home "equipment" is something the children are using everyday and usually need to know more about.

Some materials, of course, will not be available in the children's homes and may need to be purchased from a 10-cent store, drug store, or hardware store. There are a few materials such as pyrex test tubes, prisms, and rubber tubing which are not easy to get from local sources. It may be necessary to order such materials from a scientific supply house. It is usually more economical for several schools to place their orders together when ordering supplies from scientific supply houses. The county supervisor or county superintendent in most instances will have suggestions for helping rural classroom teachers obtain the supplies needed.

The following list suggests materials which are useful in teaching elementary science. Careful planning will enable schools to obtain these materials over a period of a few years. It must be stressed that it is not necessary to have all of these materials before beginning a science program.

Obtainable From Local Sources

The following list of materials is composed of items available from local sources (home, 10-cent store, drug store, etc.). Some items, such as the kitchen tools, musical instruments, will, of course, be used for only a short period of time and returned; others will become a part of the permanent equipment of the classroom.

I. Living Things

An aquarium (stocked with fish, snails, water plants, etc.).

Larvae of different kinds.

Cocoons and chrysalids.

"WE FOUND EVERYTHING WE NEEDED FOR OUR TERRARIUM WHEN WE MADE A TRIP TO BROWN'S WOODS."

A terrarium (stocked with growing plants, etc., a suitable place to keep a small turtle, a frog or salamander, or small snake).

Seeds (bean, corn, etc.).

Growing plants (geranium, ivy, begonia, cactus, sweetpotato vines, etc.).

An ant observation house.

II. Glassware

Fruit jars.
Milk bottles.
Glass tumblers.
Lamp chimneys.
Cups and saucers.
Pieces of window glass which may be cut into small-sized pieces.
Flower pots (various sizes).
Small mirrors.

III. Miscellaneous

Safety matches.
Scissors.
Teaspoons and tablespoons.
Rubber bands.
Tin cup.
Ball of string.
Scraps of different kinds of metal (zinc, aluminum, copper, etc.).
Worn-out dry cell.
Electrical appliances out of repair, e.g., extension cord, hot pad, etc. (for examination).
Paring knife and table knife.
Colored chalk.
Blotters.
Balls.
Wire—steel and copper.
Flashlight.
Scraps of different kinds of cloth (silk, wool, cotton, etc.).
Burned-out light fuses of various kinds.
Burned-out light bulbs.
Worn-out electric motors.
Candles of various lengths.

Mechanical toys illustrating machine principles.
Pans of various shapes and sizes.
Hot plate.
Needles.
Tack puller.
Tongs.
Egg beater.
Rubber balloons.
Cellophane (clear and colored).
Cages for pets.
Sand, clay, loam, humus.
Globe and map of the world.
Medicine dropper.
Yardstick.
Chalk boxes.
Nutcracker.
Wedges.
Thermometer.
Musical instruments of various kinds.
Gummed labels.
Red ink.

IV. Construction Materials

Nails, tacks, screws.
Paints and varnishes.
Hammer, pliers, file, screw driver.
Glue and paste.

V. Chemicals

Soda.
Starch.
Sugar.
Marble chips.
Lime for lime water.
Vinegar.
Table salt.
Parraffin.
Ammonia.
Iodine.
Dyes.

Obtainable From Supply Houses

The following materials are for use in the subject units as indicated. The list is relatively complete though the units can be taught without having every item in the list.

I. Electricity and Magnesium

Piece of lodestone.
Pair of bar magnets.
Large horeshoe magnet.
U-Magnet.
Knitting needles.
Shaker of iron filings.

Magnetic needle.
Magnetic compass.
Glass friction rod.
Hard rubber friction rod.
Electric lamps and sockets (small).
Fur for rubbing friction rods.
Colored pith balls for static electricity.
Demonstration electric motor.
Telephone receiver.
Telephone transmitter.
Dry cells.
Insulated copper wire.
Electric push buttons.
Electric bell.

II. Air and Weather

Glass barometer tube with well and medicine dropper for filling barometer tube with mercury.
Mercury (3 pounds needed).

III. Sound and Light

Tuning fork.
Concave and convex mirror.
Color rotator to show the results of mixing colors.
Prism.
Reading glass, 2-inch diameter.

IV. Fire and Heat

Boy Scout fire drill set.

Ball and ring apparatus to show that metals expand when heated.

Compound bar or bimetal strip to show that some metals expand more than others when heated.

Apparatus to show that heat travels faster in some metals than others.

Apparatus to show that some substances conduct heat better than others.

V. General Supplies and Apparatus

Iron ring stand (large size).

Clamp for ring stand.

Iron ring with clamp for fastening on ring stand.

Wire gauze with asbestos center for placing over rings or tripod.

Iron tripod.

Forceps for handling heated objects and chemicals.

Tongs for lifting hot objects.

Iron spoon for heat and chemical work.

Alcohol burner or Bunsen burner (Bunsen burners are usable only with gas).

Rubber tubing for Bunsen burner, one-fourth-inch inside diameter (needed only if gas is available), 4 feet.

Corks: Bag of assorted sizes, 12-26.
Bag of assorted sizes, 0-11.

Test tubes, 6x¾-inch (pyrex).

Test-tube clamps.

Test-tube brush.

Test-tube holder (for 12 tubes).

Glass tubing, 6-millimeter outside diameter.

Rubber tubing to fit glass tubing, 3/16-inch inside diameter.

Pyrex flask, 1-pint size.

Battery jar, small-sized.

Battery jar, large-sized.

Glass funnel, 100-millimeter top diameter.

Glass graduate, 100-cubic-centimeter capacity.

Thermometer, double scale (both centigrade and Fahrenheit).

Pyrex beakers (several in a nest).

Powdered iron.

Petri dishes (for growth of bacteria).

Litmus paper.

Powdered sulphur.

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Elementary Science

The books in this list are selected to help the elementary teacher in the rural school become familiar with content and methods appropriate for science in the elementary school.

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This is a "know-how" guide for beginning and for improving elementary science teaching.

CRAIG, GERALD S. *Science for the Elementary School Teacher.* New York, Ginn & Co., 1946. 551p.

Contains discussion of method as well as complete development of subject matter for teacher's background and a suggested sequence of meanings in science for the elementary school.

——— *Science in Childhood Education.* New York, Bureau of Publications, Teachers College, Columbia University, 1944. 86p.

Practical suggestions for teaching science, including discussion of objectives, philosophy, and use of community resources.

CROXTON, W. C. *Science in the Elementary School, Including an Activity Program.* New York, McGraw-Hill Book Co., 1937. 454p.

Presents discussion of methods of teaching, aims, teacher's preparation, evaluation of results. Contains details of many activities appropriate in the rural school.

HEISS, E. D.; OBURN, E. S.; *and* HOFFMAN, C. W. *Modern Methods and Materials for Teaching Science.* New York, The Macmillan Co., 1940. 351p.

Contains a section on principles of science teaching, one on materials and devices for teaching science, and one on sources of materials for teaching science.

NATIONAL SOCIETY FOR THE STUDY OF EDUCATION. Thirty-first Yearbook. Part. I. *A Program for Teaching Science.* Bloomington, Ill., Public School Publishing Co., 1932. 370p.

Contains a treatment of trends in science teaching and indicates recommendation for further work. Includes present practices, criticism of practices, contributions of science teaching.

———Forty-Sixth Yearbook, Part. I *Science Education in American Schools.* Chicago, University of Chicago Press, 1947. 296p.

Large section devoted to science in the elementary school, including organization of the curriculum, materials and methods, judging the results, use of resource materials, and improvement of instruction.

NOLL, VICTOR H. *The Teaching of Science in Elementary and Secondary Schools.* New York, Longmans, Green & Co., 1939. 238p.

Contains material on general methods, curriculum, and testing.

PITLUGA, GEORGE E. *Science Excursions into the Community.* New York, Teachers College, Columbia University, 1943. 154p.

Describes techniques for planning and conducting excursions, and gives specific examples of excursions in areas of health and safety, home life, and controlling natural environment for human needs.

Science Instruction in Elementary and High School Grades. Publication of the Laboratory Schools, the University of Chicago, Chicago, Ill., 1939. 232p.

Contains a curriculum in science with a report of the underlying philosophy.

SLAVSON, S. R., *and* SPEER, R. K. *Science in the New Education.* New York, Prentice-Hall, Inc., 1934. 396p.

Places special emphasis on elementary school science, including trends, children's interests, objectives, current practices, and methods.

This is Science. Bulletin of the Association for Childhood Education, Washington, D.C., 1945. 43p.

Contains practical material useful to teachers of elementary science.

State Science Guides in Elementary Science

The science guides listed here are published under separate cover from the general elementary curriculum guides of these States.

CALIFORNIA STATE DEPARTMENT OF EDUCATION, Sacramento. *Science in the Elementary School.* 1945. 416p.

FLORIDA STATE DEPARTMENT OF EDUCATION. *Teaching Science in the Elementary School.* Tallahassee, the Department, 1947. 88p.

KANSAS STATE SUPERINTENDENT OF PUBLIC INSTRUCTION. *Teacher's Guide to the Kansas Elementary School Program of Studies. Science.* Topeka, the Department, 1940. 129p.

NEW YORK. UNIVERSITY OF THE STATE OF NEW YORK. *Elementary School Science. A Syllabus for Elementary Schools.* Albany, N.Y. University of the State of New York Press, 1942. 182p.

NORTH CAROLINA STATE SUPERINTENDENT OF PUBLIC INSTRUCTION. *Science for the Elementary School.* Raleigh, 1941. 115p. (Publication No. 227)

OHIO STATE DEPARTMENT OF EDUCATION. *Science Education for the Elementary Schools of Ohio.* Columbus, the Department, 1946. 192p. (Curriculum Bulletin No. 3)

OREGON STATE SUPERINTENDENT OF PUBLIC INSTRUCTION. *Tentative Guide to Science for Oregon Schools.* Part I. Elementary and Junior High School Grades. Salem, 1941. 101p.

SOUTH CAROLINA STATE DEPARTMENT OF EDUCATION. *Suggestions for the Teaching of Science in the Twelve-year School Program.* Columbia, the Department, 1946. 115p.

TENNESSEE STATE DEPARTMENT OF EDUCATION. *A Science Program for Elementary Schools, Grades One, Two, and Three;* and *A Science Program for Elementary Schools for Grades Four, Five and Six.* Nashville, the Department, 1944. 63p. and 66p.

UTAH STATE DEPARTMENT OF PUBLIC INSTRUCTION. *Science Supplement to a Teaching Guide for the Elementary Schools of Utah.* Salt Lake City, the Department, 1946. 99p.

Rural Education

The books listed here tell how successful rural school programs can be carried on, or describe special resources in rural communities. Most of the books show how science experiences can be incorporated into the rural or small school program.

BATHURST, EFFIE G. *Your Life in the Country.* New York, McGraw-Hill Book Co., 1948.

"This book is both a story and a study for young people who live in the country," a book on consumer education dealing with real and important problems of rural people.

BOWEN, GENEVIEVE. *Living and Learning in a Rural School.* New York, The Macmillan Co., 1944. 324p.

How a teacher and her pupils planned for a rich program in a rural school. Tells how science can be worked into an already crowded program.

CLAPP, ELSIE R. *Community Schools in Action.* New York, The Viking Press, 1939. 429p.

A description of the rich and developing program of a successful community school.

Community Resources in Rural Schools. Washington, D.C. National Education Association, 1939. 109p. (Yearbook 1939, of the Department of Rural Education)

A rich source of suggestions for making use of community resources.

Conservation Education in Rural Schools. Washington, D.C., National Education Association, 1943. 114p. (Yearbook 1943, of the Department of Rural Education)

Cites many examples of good rural school conservation activities.

LAMKIN, NINA B. *Health Education in Rural Schools and Communities.* New York, A. S. Barnes & Co., 1946. 191p.

Newer Types of Instruction in Small Rural Schools. Washington, D.C., National Education Association, 1938. 144p. (Yearbook 1938, of the Department of Rural Education)

WEBER, JULIA. *My Country School Diary.* An Adventure in Creative Teaching. New York, Harper and Brothers, 1946. 270p.

An inspiring yet realistic account of the day-to-day school activities—failures and successes—over a 4-year period of a teacher with real concern for the growth of her rural pupils in functional knowledge and in skill in democratic processes.

WOFFORD, KATE V. *Teaching in Small Schools.* New York, The Macmillan Co., 1946. 399p.

Has excellent suggestions on such topics as studying the children, grouping children for instruction, directing activity periods, taking excursions, and understanding the community.

Science Experiment Books for Children

Children and teachers often can devise their own experiments, but sometimes specific and detailed help is needed. This help may be obtained from other teachers or students or from books of experiments. Every teacher and group of children will find an assortment of experiment books of great value. In this reference list are examples of the experiment books for children now available.

AREY, CHARLES K. *Science Experiences for Elementary Schools.* New York, Bureau of Publications, Teachers College, Columbia University, 1942. 98p.

Written originally for elementary teachers, this manual has also proved useful in the hands of children from the third grade up. It has suggestions for experiments on the air, the earth's surface, magnets, electricity, plants, heat, light, and the seasons. Grades 3-9.

BAER, MARIAN E. *Without Fire: A Book of Experiments.* New York, Rinehart & Co., Inc., 1946. 39p.

A collection of things for children from 6 to 10 to do without using matches or knives. The experiments are all interesting. Children should be encouraged to think through the explanations. Grades 1-5.

BEELER, NELSON F., *and* BRANLEY, FRANKLIN M. *Science Experiments.* New York, The Thomas Y. Crowell Co., 1947. 115p.

"Try it and see for yourself" is the theme of this collection of experiments on a variety of topics such as disappearing ink, bending light, spontaneous combustion, jet propulsion, and the telephone. Grades 3-8.

BRUCE, GUY V. *The Children's Play-at-Science Series:* Book I—*World of Air and Water*, 96p.; Book II—*Heat, Fire and Fuels*, 75p.; Book III—*Magnetism and Electricity*, 86p.; Book IV—*Sound, Light and Water*, 87p. Newark, N. J., State Teachers College.

These are manuals of experiments described in detail for elementary and junior grades.

FREEMAN, MAE, *and* FREEMAN, IRA M. *Fun With Chemistry.* New York, Random House, 1944. 48p.

More than 2 dozen easy experiments in chemistry. Each experiment is illustrated with full-page photographs. Grades 3-9.

———*Fun With Science*. New York, Random House, 1943. 60 p.

The full-page photographs add to the usefulness of this book which includes simple experiments on things at rest, things in motion, liquids, sound and music, heat, electricity, light and sight. Appropriate for children 8 to 12. Grades 3-9.

GARRISON, CHARLOTTE G. *Science Experiences for Little Children*. New York, Charles Scribner's Sons, 1939. 111p.

This book describes a wide variety of science activities, including care of schoolroom pets, experiments with growing things, and study of the stars and the seasons. A section on materials for science experimentation will help the teacher plan a study of magnets, magnifying glasses, thermometers, mirrors, and several other objects. Written especially for the teacher of primary grades.

GORDON, BERTHA F. *Prove It Yourself*. Dansville, N.Y., F. A. Owen Publishing Co., 1928. 255p.

Consists mostly of directions for making devices with which to experiment with magnetism, electricity, light, sound, chemicals, the air, simple machines, etc. Explanations about why things work as they do are included. Grades 5-9.

KEELOR, KATHARINE L. *Working With Electricity*. New York, The Macmillan Co., 1938. 111p.

This book has directions, with simple drawings, for installing lights in a doll house, attaching a doorbell, making an electro-magnet, making a telegraph set and a toy telephone. Also the history of message sending is told in a simple way. Grades 3-8.

LORD, EUGENE H. *Experimenting at Home With the Wonders of Science*. New York, D. Appleton-Century Co., Inc., 1940. 243p.

This book suggests experiments on a wide range of topics from which teachers of every grade will find help—air and air pressure, tricks with water, tricks with common things, chemical changes, home-made fireworks, electricity, and magnetism. The experiments are written with complete directions and explanations. Only household materials are required. Grades 5-9.

LYNDE, CARLETON J. *Science Experiments With Home Equipment*. Scranton, Pa., International Textbook Co., 1937. 226p.

Includes 200 science experiences which require only home equipment. All of them are clearly illustrated. Grades 3-9.

———*Science Experiments With Inexpensive Equipment*. Scranton, Pa., International Textbook Co., 1939. 226p.

The 200 experiments included are a little more advanced than those in *Science Experiments With Home Equipment*. Eighty-four of these require only home equipment and the others, inexpensive equipment. Grades 4-12.

———*Science Experiments with Ten-Cent Store Equipment*. Scranton, Pa., International Textbook Co., 1939. 226p.

The science experiments in this book will interest children in the intermediate and upper grades. Only inexpensive equipment is required.

MEISTER, MORRIS. *Magnetism and Electricity*. New York, Charles Scribner's Sons, 1930. 210p.

Gives basic information about such things as electro-magnets, telegraphs, batteries, electric motors, telephones, and the radio. Many pictures and directions make clear the know-how of building most of these electrical devices. Grades 7-12.

MORGAN, ALFRED P. *An Aquarium Book for Boys and Girls.* New York Charles Scribner's Sons, 1936. 191p.

Though not an experiment book, this is included because it will supply a frequently wanted book about how to make an aquarium. This book gives clear and accurate details. Grades 5-8.

——*Boy's Book of Science and Construction.* New York, Lothrop, Lee, and Shepard Co., 1948. 465p.

Upper-grade and high-school students will find this book a source of suggestions on how to do many experiments and how to build dozens of worth-while instruments and machines. For example, the book includes directions for making a steam turbine, a steam engine, a pin-hole camera, a weather vane, and a barometer. Grades 7-12.

——*A First Electrical Book for Boys.* New York, Charles Scribner's Sons, 1935. 221p.

Many experiments with electricity are described in detail with simple illustrations. Grades 5-9.

——*Simple Chemical Experiments.* New York, D. Appleton-Century Co., Inc., 1941. 269p.

This book with its numerous simple chemical experiments is useful to the teacher when a fifth, sixth, seventh, or eighth-grade pupil asks for an opportunity to do "chemistry experiments." Though some of the experiments might more profitably be done with the help of a science teacher, they are all "safe" for youngsters to do on their own. Grades 5-12.

——*Things A Boy Can Do With Electricity.* New York, Charles Scribner's Sons, 1938. 243p.

Numerous common applications of electricity are described, together with simple experiments and demonstrations which can be carried out by sixth-graders or above. Grades 6-12.

SCHNEIDER, HERMAN, *and* SCHNEIDER, NINA. *Let's Find Out.* New York, William R. Scott, Inc., 1946. 39p.

A picture science book with simple experiments to "find out" what happens when things are heated, how to make steam and fog, what makes airplanes fly, and the answers to numerous other questions asked by young children. Grades 1-4.

YATES, RAYMOND F. *How To Make Electric Toys.* New York, D. Appleton-Century Co., Inc., 1937. 199p.

Those who are really interested in the know-how of numerous electrical toys will find detailed directions in this book. Such instruments as telegraph sets, a loud speaker for your room, an electric alarm, a shocking-coil are described. Grades 6-12.

——*Science With Simple Things.* New York, D. Appleton-Century Co., Inc., 1940. 245p.

Numerous experiments with heat, the air, sound, water, light, electricity, and the weather. Most useful for junior high and high-school children, it is nevertheless a good reference for interested children in the upper elementary grades. Grades 6-12.

Selected Sources of Printed Materials

The sources listed here indicate available books or bibliographies, or both, on a variety of topics of importance to rural school children. Examples are given in most cases of kinds of materials available from each source listed.

AMERICAN FOREST PRODUCTS INDUSTRIES, INC., 1319 Eighteenth Street, NW., Washington 6, D.C.

School Bibliography on FORESTS, *Their Use and Conservation.* This bibliography lists all the materials available from American Forest Products Industries, Inc. It is free upon request. It tells how to order the materials.

AMERICAN RED CROSS. Washington, D.C.

First Aid Textbook. Philadelphia, The Blakiston Co., 1937. 267p.

Preventing Accidents in Our Homes and on Our Farms. Washington, D. C., The Red Cross, 1942. 29p.

AMERICAN TREE ASSOCIATION, 1214 Sixteenth Street, N.W., Washington 6, D.C.

(1) *Gabby and the Forest Fires* by Ellen C. Dowling. 10 cents.

(2) *Two Trees* by Ed Nofziger. 10 cents.

FISH AND WILDLIFE SERVICE, UNITED STATES DEPARTMENT OF THE INTERIOR.

To obtain materials from the Fish and Wildlife Service write to the Superintendent of Documents, Government Printing Office, Washington 25, D. C., and ask for Price List No. 21. From this list you can select the bulletins which fit into your study.

Other price lists which may suggest useful titles on other subjects are: No. 38, Animal Industry; No. 41, Insects; No. 43, Forestry; No. 44, Plants; No. 46, Agricultural Chemistry and Soils and Fertilizers; No. 48, Weather, Astronomy and Meteorology; and No. 51, Health.

NATIONAL AUDUBON SOCIETY, 1000 Fifth Avenue, New York 28, N.Y.

Teachers Guide, A Source Book for Advisors of Audubon Junior Clubs.

Audubon Nature Bulletin, 10 issues, $1.25 per year.

NATIONAL EDUCATION ASSOCIATION, 1201 Sixteenth Street, NW., Washington, D.C.

Safety and Safety Education: An Annotated Bibliography. 1939. 64p.

Units in Safety Education. Grades I and II, Grades III and IV, Grades V and VI.

NATIONAL SAFETY COUNCIL, 20 N. Wacker Drive, Chicago, Ill.

Accident Facts. (Annual edition). A summary of all reported accidents from most common causes.

Safety Education Methods: Elementary School.

EDUCATION SECTION, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, Washington 25, D.C.

(1) *Available Publications of the Soil Conservation Service, August 1948.*

This will help you in selecting materials to write for. Among those available are: (2) An outline for Teaching Conservation in Rural Elementary Schools; (3) An Outline for Teaching Conservation in Urban Elementary Schools; (4) An Outline for Teaching Conservation in Junior High Schools; (5) Conservation Education Report Number 4. "Bibliography—Available Literature on Conservation for Schools."

ELEMENTARY DIVISION, OFFICE OF EDUCATION, FEDERAL SECURITY AGENCY, Washington 25, D.C.

The Elementary Division has available a series of short reports in elementary education, entitled *Education Briefs* and a series of bibliographies entitled *Selected References.* Single copies of these will be sent free upon request. Examples of *Education Briefs:*

No. 1. Materials and Apparatus for Teaching Elementary Science.
No. 5. Some Types of Classroom Organization.
No. 6. Health Plays in the Elementary School.
No. 7. Good Posture for Boys and Girls.
No. 8. Types of Experiences Children Should Have.
No. 12. Experimenting in Elementary Science.

Examples of *Selected References:*

No. 1. The Primary Unit—An Aid to Children's Progress.
No. 3. Professional Literature for Teachers of Elementary Science.
No. 4. Physical Education in the Elementary School.
No. 7. Recent Publications in Elementary School Health.
No. 8. Health Songs for Primary Grades.
No. 9. Sources of Materials on Child Development and Parent Education.
No. 10. Child Growth and Development.
No. 11. Low Cost Publications on Safety.
No. 13. Arithmetic in Elementary Education.
No. 14. Science Experiment Books for Children.

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