Teaching Science with Everyday Things

Second Edition

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Preface

This book is designed to be of practical help to teachers, particularly those in elementary schools, and to college students who are preparing to teach. It is intended especially for those who may lack confidence in teaching science or whose background in science may be limited.

The book requires no previous training in science, and no special or costly equipment. It does, however, call for a willingness to try new things, to explore and investigate, and to seek answers through observation and experimentation instead of merely accepting what others say. Above all, it assumes on the part of the reader a desire to help children learn by exploring and investigating the fascinating world around them.

Three underlying themes run through the book:

1 Science—both the process of inquiry and the knowledge that results—is an integral part of education.

2 All learning in science is based, fundamentally, upon firsthand experiences with real things.

3 Science experiences often need involve no unusual, elaborate, or expensive apparatus and materials.

Anyone who expects to find in this book a treatment of subatomic particles, chemical bonds, DNA, galaxies, or the earth's interior is bound to be disappointed. The material that is presented deals with things much closer at hand, things that children—and adults—can watch and touch and try for themselves. Such material hardly requires abstract formulas and complex terminology. However, this is not to say that the content of the book is of a level beneath the dignity and intelligence of college students and college graduates. On the contrary, the principles and approaches developed in the book are basic to the study of science, regardless of level.

A book of this size can, at best, merely touch on some aspects of science and on some approaches useful in helping children become interested and involved in science. Nevertheless, it does include enough subject matter and teaching suggestions to help teachers—especially those with little background—to teach science effectively and to grow in skill and confidence.

In writing this book, we have drawn upon a total of more than three-quarters of a century of experience in teaching science and science education. This has involved working closely with children from preschool on, with high school and college students, with teachers in preparation, and with teachers in service. Throughout, we have tried new and original materials and techniques, and these are emphasized in the book. Still, many of our ideas—probably more than we realize—have come from others, and we can only trust that our contributions will constitute a fair exchange.

We should like to acknowledge our indebtedness to numerous persons—mostly our teachers, colleagues, and students. We wish it were possible to thank each one individually. Perhaps our gratitude to them is best expressed by our sincere desire to share the results of their inspiration and encouragement with a larger number of teachers and, through them, with many more children.

Victor E. Schmidt
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In Explanation

POINTS OF VIEW

The first of the chapters that follow, "Points of View," may well be the most important part of the book. In it are presented some fundamental philosophical considerations and general suggestions for making science teaching, especially in the elementary grades, effective and pleasant. These "Points of View" should be reread from time to time and reconsidered frequently insofar as they apply to any particular class, school, and community.

COUNTING AND MEASURING

The second chapter deals with one of the most characteristic aspects of science—quantitative investigation. It presents important objectives and activities that relate to establishing and using units (including metric units), constructing and calibrating measuring devices, making valid approximations and comparisons, and surveying for drawing simple maps. The suggestions are applicable to various areas of science dealt with in subsequent chapters.

AREAS OF SCIENCE

The subsequent chapters relate to major areas of science. In each, an introduction is followed by a listing of some important objectives. These, in turn, are followed by suggestions of instructional activities. There is no special significance to the order of the chapters; one may begin with any of them, or anywhere within one. Consequently, the book can be used in connection with any elementary science program or text—or in the absence of either.

IMPORTANT OBJECTIVES

A sampling of important objectives, illustrative of the goals toward which science teaching should be directed, is presented for each area. The objectives listed are attainable, to some degree at least, by means of the activities suggested for that area. It should be emphasized that these objectives are stated for the teacher's guidance only. In no way does "teaching" them directly, or having pupils "mouth" them, constitute good science teaching.

INSTRUCTIONAL ACTIVITIES

Space permits the presentation of only a sampling of activities. However, these are of sufficient number and variety to illustrate sound approaches to teaching science at any grade level. They involve many of those processes and principles on which modern elementary science programs are based. Although they emphasize *doing*, this does not mean that science teaching should consist exclusively of "experiments" and neglect such activities as reading and writing.

GRADE PLACEMENT

Within each area, the activities are suggested in approximate order of increasing difficulty, roughly according to grade level. Specific grade placement is avoided, however, because this might unduly influence the teacher. For one thing, simple activities are often helpful, even in the upper grades, for children with limited experience. In other instances, pupils in the primary grades may be ready to try some things that are relatively difficult.

QUESTIONS FOR PUPILS

Examples of questions that may be asked of pupils are printed in *italics*. These questions are intended to arouse curiosity and to encourage careful investigation, close observation, and clear thinking. Of course, the suggested questions may be modified and augmented as circumstances require. In general, no answers to them are given, because investigation, observation, and thought—not the book or the teacher—should be the source of the answers.

SOURCES OF MATERIALS

Practically all the items needed for the suggested activities are commonplace and easily available. Many can be salvaged from waste; others may be purchased locally. However, substitute items—perhaps suggested by pupils—often serve equally well, or even better. Occasionally, changes in products or packaging may make some things unavailable; but then, if one considers what qualities made the original items suitable, one can probably find replacements.

SOURCES OF ASSISTANCE

Custodians, high school science teachers, older students, and parents often can provide materials and assistance. However, one should be careful that such persons, in trying to be helpful, do not hinder good teaching. At times they may tend to introduce unnecessarily elaborate equipment or too-complex subject matter and terminology. Or—perhaps even worse—they may "give away" answers prematurely and thus discourage thought and investigation.

POSSIBLE DIFFICULTIES

On occasion, one of the suggested activities may not "work." This could mean that something *new* has been discovered. Or it could be that the materials or techniques used are different from those which the authors had in mind. Generally it is wise to try things oneself, first, with no pupils present. Then, in case of difficulty, one should reread the directions carefully, paying special attention to the materials and techniques suggested—and try again!

Contents

Chapter 1

Points of View

SCIENCE AND CHILDREN

Children live in a world in which science has tremendous importance. During their lifetimes it will affect them more and more. In time, many of them will work at jobs that depend heavily on science. As voters, they will have a voice in making many decisions that involve science—for example, concerning energy sources, pollution control, highway safety, wilderness conservation, and population growth. As taxpayers, they will pay for scientific research and exploration. And, as consumers, they will be bombarded by advertising, much of which purports to be based on science.

Therefore, it is imperative that children, the citizens of the future, become functionally acquainted with science—with the process and spirit of science, as well as with its facts and principles. Fortunately, science has a natural appeal for youngsters. They can relate it to so many things that they encounter—aquariums, flashlights, tools, echoes, and rainbows.

Besides, science is an excellent medium for teaching far more than content. It can help pupils learn to think logically, to organize and analyze ideas. It can provide practice in communication skills and mathematics. In fact, there is no area of the curriculum to which science cannot contribute, whether it be geography, history, language arts, music, or art!

Above all, good science teaching leads to what might be called a "scientific attitude." Those who possess it seek answers through observing, experimenting, and reasoning, rather than blindly accepting the pronouncements of others. They weigh evidence carefully and reach conclusions with caution. While respecting the opinions of others, they expect honesty, accuracy, and objectivity and are wary of hasty judgments and sweeping generalizations. All children should be developing this approach to solving problems, but it cannot be expected to appear automatically with the mere acquisition of information. Continual practice, through guided participation, is needed.

TEACHING SCIENCE

What does it mean, to teach science? The words may seem clear enough. It is possible, however, that they do not convey to the reader the full sense of what the authors have in mind.

Science may be defined as a body of organized knowledge concerning living things, stars, rocks, chemicals, energy, and the like. Actually it encompasses much more than this. Besides *content*—the facts, principles, laws, theories, and hypotheses—science also includes *process*—the observation, experimentation, meditation, imagination, prediction, and other means by which the content is arrived at. And further, science is associated with certain characteristic attitudes and appreciations, among them curiosity, objectivity, honesty, and an abiding sense of wonder.

Teaching is commonly thought of, in the main, as passing on knowledge, but it involves more than this, and certainly more than telling and showing. Ideally, it consists of setting up situations in which learning cannot help but take place. And this learning includes not only the acquisition of facts and concepts, but also the development of skills and habits and of attitudes and appreciations. In this broad sense, teachers inevitably become learners, too, at times—and perhaps can best think of themselves as the senior members of learning teams!

Above all, teaching science should not be envisioned as primarily the presentation of momentous discoveries and esoteric concepts—of dinosaurs, atomic particles, the conversion of matter to energy, and such. Generally it can better be accomplished, in its fullest sense, by means of experiences much closer at hand. Pupils—and teachers—can themselves investigate, for example, the change in sound as water fills a glass, or the apparent shift in position of a coin beneath the glass. Good science, both content and process, can readily be taught with everyday things.

EVERYDAY THINGS

Such things as paper clips, marbles, cardboard, scraps of wood, and rubber bands constitute a veritable reservoir of materials for teaching science. They cost little or nothing and yet are often better than expensive equipment for providing worthwhile learning experiences. They encourage youngsters to become involved and to use their ingenuity, rather than merely to read about things, listen, and look on. Already familiar to pupils, commonplace things like these are not likely to block or distract their thinking in the way that strange and complicated apparatus often does.

Many useful odds and ends are available in quantity, enabling all children to participate in investigations, rather than limiting them to watching demonstrations. Such items permit experiments to be repeated and modified easily. Generally obtainable on short notice, they seldom necessitate requisitions, administrative approval, and the delays that too often postpone the arrival of commercial equipment beyond the interest span of children.

With everyday things, pupils need not stop learning science at the close of school, since such items usually are also available around the home. There the children can repeat the experiences they had in school and then continue with their own ideas and with suggestions from books. Parents, too, may become involved, thus increasing their understanding—not only of science, but also of the school's program.

Everyday things can help to provide for individual differences among children—differences in interest, attitude, creativity, dexterity, and academic aptitude. They can be as intriguing and challenging to slow learners and poor readers as to gifted pupils. They enable youngsters to learn with their hands as well as with their minds; yet they place no ceiling on ingenuity or industry.

GROWTH OF A CONCEPT

A child observes and experiences things and incorporates some of what he or she observes and experiences into a complex mental structure referred to as a *cognitive structure*. This structure is composed of many subordinate, but interrelated and interconnected units or *concepts*. The concepts within the structure usually begin as simple mental images, but in time they become elaborate and inclusive. The concept "ball" is an example.

Suppose that a baby learns that "ball" is something round, red, and bouncy. Weeks or months later, "ball" is also yellow, bouncy, and spherical. (The spherical character may have been included from handling the ball.) A few years later, "ball" may include such characteristics as multicolored, plastic, and common at beaches. And still later, "ball" may include a hard, not-very-bouncy object batted about by a group of older children or adults in a game. Each of these observations may, in turn, be incorporated into the child's constantly expanding, ever more inclusive concept of what "ball" is.

This ever-changing, ever more sophisticated, ever more inclusive concept, "ball," may take years to develop. Its development requires many experiences and countless observations. Depending upon the child, and upon the observations and experiences the child takes part in, "ball" may remain fairly simple, or it may include Christmas tree ornament, globe, surface/volume relationship, toy, and curled-up kitten. Still, it is a relatively simple concept—not one ordinarily left to the school to develop.

Some children may grasp a concept in a fairly inclusive, if tenuous, form at the outset. Others will develop a concept in a step-by-step, sort of linear fashion. Each child is an individual in that no two will have the same set of experiences or share the same set of observations en route to a particular concept. The teacher should recognize that a concept, however simple it may seem, can be a relatively complex structure, with many possible interpretations by the child.

When a teacher suggests to a learner, "It is like a ball," the teacher must remember that a concept as simple as "ball" already has countless faces. Saying "It is like a ball" to children and hoping that this clarifies something that the children do not understand may actually not clarify at all. It may serve only to suggest spherical, colored, bouncy, or toy, when in fact the teacher may have in mind one end of the upper leg bone, or femur.

Thinking of concepts, and how concepts develop in children, can be an aid to a teacher. However, it is an aid only if the teacher appreciates how tortuous the growth of a concept can be, and how different the same concept can be in the minds of different children.

SEQUENCING CONCEPTS

Seemingly simple concepts such as "ball," complex though they really may be, usually are beyond a teacher's responsibility for teaching. They are preschool concepts. Other, more complex concepts or conceptual structures, such as "life cycle," may be part of a required program and thus part of a teaching responsibility. How efficiently a conceptual structure is presented and learned often depends upon how its supporting concepts are sequenced.

First, it is helpful to consider what are some supporting concepts that go to make up a conceptual structure. For example, the conceptual structure "life cycle" may depend upon an understanding of the following concepts, for even rough comprehension:

"living"	"organism"
"growth"	"adult"
"egg"	"stage"
"seed"	"cycle"

Each of these is anything but simple. Each suggests many observations and experiences over months or years for a child to understand it. The larger, more inclusive structure, however, will be only a word if it cannot be anchored in a reasonable understanding of these supporting concepts.

In sequencing the supporting concepts, the need for one to help explain another should be considered. The concept "electromagnetism" would mean little or nothing to someone who did not understand the concept "magnet." Similarly, the concepts "living," "growth," "organism," "adult," "reproduction," and so on are imperatives for a child who is en route to learning the larger, more inclusive structure, "life cycle."

In teaching about life cycles, that of the fruit fly, *Drosophila,* often is used. Some children think that the adult *Drosophila* is merely a baby fly and that it will grow larger as it gets older. It comes as a surprise to learn that when a fly emerges from its pupal case, it is as big as it will ever get. Big flies must be different from little flies! The concept "adult" must have something to do with "stage," not size.

It is this constant refinement of concepts by the child that leads to enlarging, correcting, and refining the larger, more inclusive conceptual structure. In sequencing the supporting concepts, the teacher can be of great help to the learner. For example, in teaching "life cycle," the concept "circle" may be important. This needs modification, since to complete a circle is to come back to the *same* place. To complete a *cycle* is to return to a similar, but not identical, *stage*. Thus teaching about "cycle" suggests an anchoring concept, "stage." It is in such fashion that a sequence of concepts is planned.

Not all children learn concepts in the same order. Also, what seems to be an efficient order for teaching may not always be the most efficient order for learning. Working out supporting concepts, however, and a reasonable order for teaching them, helps to develop an instructional strategy, makes a teacher more aware of the needs of children, and helps to ensure that important portions of the larger structure are not overlooked.

OBJECTIVES AND OUTCOMES

To be really effective, science teaching—like all teaching—must have clear objectives. Both content and approach should lead to worthwhile outcomes. Neither should be chosen merely on the basis of tradition or just for the sake of novelty.

The more clearly teachers define their purposes, the better and more satisfying their teaching will be. In fact, once definite objectives have been decided upon, planning how to attain these objectives, and how to evaluate the extent to which they have been attained, is greatly facilitated. For example, if one goal is to have pupils be able to connect simple electric light circuits, the choice of materials and methods becomes obvious. If another goal is to have them appreciate the importance of checking measurements, the approach again becomes clear.

In each chapter of this book are listed some objectives. These are grouped in three categories, the order of which indicates the authors' judgment of relative importance. For example:

Attitudes and Appreciations

There is a beautiful orderliness in the motions and changes in the appearance of the sun, moon, and stars.

No creature is, in itself, harmful or beneficial; it is so only in terms of how it affects human well-being.

Skills and Habits

Making a simple magnetic compass, and using it to determine direction

Working with others in carrying out an investigation and in gathering and analyzing data cooperatively

Facts and Principles

Sounds differ in pitch, and this depends upon the rate of vibration, or frequency.

Although earth features such as mountains are continually being changed, the basic materials are not destroyed but are used over and over again.

PLANNED PROGRAMS

Although firsthand experiences, supplemented by vicarious ones, are basic, for good science teaching these experiences can hardly occur in a haphazard, unrelated fashion. They need to be part of a planned program. For one thing, a teacher should be able to expect that in the previous grades the class has had certain experiences and has attained certain goals, on which to build.

To present such a program is not a purpose of this book. Many good programs are already available—in textbook series, state courses of study, and curriculum guides developed by committees of teachers. Some of these programs are outstanding in that they:

1 Have clear and worthwhile objectives—including those that deal with attitudes, appreciations, and skills, in addition to the usual objectives involving knowledge—together with numerous practical suggestions for helping pupils attain these objectives

2 Are sequential, suggesting simple skills and ideas to be developed in the lower grades in accordance with the ability and interest of the children and gradually introducing more complex processes and materials as the pupils grow in maturity and experience

3 Deal with content that is well suited to children instead of crowding down into the grades material from high school and college courses—including highly abstract concepts that have no place in the elementary school

4 Include a good balance of material drawn from the physical, biological, and earth sciences, with no major gaps or pointless repetition and so coordinated with the entire instructional program that science is not isolated from other subjects

5 Require ample time for science—just as for reading, social studies, and mathematics—to permit a wealth of experiences, coupled with reflection, discussion, and fun

FIRSTHAND EXPERIENCES

Firsthand experiences are, in the final analysis, the basis of all learning. A person's education rests, fundamentally, upon direct contacts with the environment—through seeing, hearing, feeling, smelling, tasting, and other sensory channels.

Unfortunately, all too often this truth seems to be forgotten. Too readily do we substitute books about things for the things themselves, films for field trips, and television programs for active participation. Too quickly do we tell, instead of letting pupils find out on their own. Too often do we have them memorize rather than investigate.

Of course, vicarious experiences—those which one has indirectly through the medium of others—are often highly desirable. In fact, in some cases they are the only feasible means of developing concepts. There is certainly no question of the value of books, pictures, recordings, and other instructional aids, but they can never fully replace firsthand, direct experiences.

For example, can merely reading about air pressure substitute for actually feeling it? (See "Air Push," page 33.) Does watching spots of light in a planetarium truly take the place of seeing real stars in the sky? (See "Star Shifts," page 189.) Is listening to someone tell about the delay of echoes nearly as effective as hearing and measuring this delay? (See "Sound Bounce," page 140.)

Can one convey to a child, by words alone, the fragrance of mint, the flavor of wintergreen, or the sting of nettle? How adequate a concept of snow can a youngster have who has never seen snow, felt snow, or otherwise experienced snow?

The same holds true for much of what is taught in school, be it about soil erosion, pond life, solar energy, water pollution, or the methods used by scientists. Firsthand experiences are essential to make these topics truly meaningful to children. A vast number of such experiences are possible, of which this book suggests only a sampling.

PUPIL PARTICIPATION

Inasmuch as firsthand experiences are fundamental to learning science, it follows that every child has a right to a rich variety of such experiences. Every child, therefore, should participate, and no one ought to be, or needs to be, a mere onlooker.

For example, every pupil can make and calibrate a stick balance to use whenever it is needed. (See "Calibration and Confidence," page 24.) When studying magnetism, all the children can work with their own bobby-pin compasses (page 148) rather than just watch the teacher demonstrate. Everyone can have his or her own animals and plants for close scrutiny (as in "Fish-less Aquariums," page 50). The entire class can contribute to the finding of pupils' reaction time. (See "Squeeze Play," page 20.) All can take turns in the rounding of brick pebbles (page 84).

Demonstrations should be used sparingly—chiefly to show pupils what to do or how to do it. However, they are also desirable for those few activities which are too difficult, dangerous, or expensive for everyone to try.

Having every pupil participate may, at times, raise problems, such as those of time, space, materials, storage, and behavior. These problems, however, have solutions that are often obvious if the basic purposes of the teaching are kept clearly in mind. For example:

1 Attempt to teach less, but better, and draw from science content when teaching reading, writing, mathematics, and other skills.

2 Use the playground, lawn, gymnasium, and corridor for science activities, as well as windowsills and chalk trays.

3 Make use of everyday things such as cans, pebbles, nails, and wire—collected with pupils' help, at little or no cost.

4 Keep supplies in boxes, cans, and jars, perhaps on homemade shelves, and then teach pupils to get the items as needed and to put them back.

5 Challenge pupils with interesting and worthwhile activities and there probably will be little mischief—although, perhaps, a bit more noise.

DISCOVERY THROUGH EXPERIMENT

The real essence of science is honest inquiry. Scientists discover new things because they inquire constantly into the unknown. Children, too, can discover by inquiring and experimenting. The things they find out may not be new or startling to you, but to them even small discoveries are exciting.

Many so-called experiments are not experiments at all. Instead, they are verifications of something both teachers and pupils already know. Even so, they may be advantageous for learning, just as repeated trials are desirable. Discovery through experiment is one of the best means of developing:

1 The confidence that comes by finding out for oneself
2 A willingness to try new things, even though the procedures are unfamiliar and the outcome uncertain
3 An open-mindedness that ensures acceptance of a new idea if it proves to be more valid than a former one

The most effective experiments often are those which arise from pupils' own questions instead of from a textbook or a teacher. They motivate pupils much more than artificially imposed experiments and lead to purposeful and hence more efficient pupil activity.

Children's discoveries do not always agree with what others have found. Nevertheless, their discoveries are real and should be considered true until a situation arises or can be arranged where repetition fails to verify their original findings.

When this happens, pupils' changes of mind should come from their own observations, not from adult authority. Scientists do not have a higher authority whom they can ask if their experiments "worked." Like scientists, pupils should learn to rely on what they discover through experiments, not primarily on what the teacher or book says. Their final authority should be the answer to "What does Nature have to say?"

LEISURELY LEARNING

Learning in science should not be hurried. For children to try things, make observations, weigh evidence, come up with alternative explanations, and think of additional examples takes time. If they are to mull over ideas, discuss them with classmates, and test them in new situations, they cannot be rushed.

There seems to be an increasing tendency to cover a large and set amount of material in the grades—a result, undoubtedly, of our concern with measuring pupil performance. This leads to emphasis on the skills of reading and mathematics and on the recall of facts—all relatively easy to test. However, it often results in reducing the time devoted to science—especially to the *process* of science. And the development of this, in particular, is too important to be hurried.

Pupils need time to have firsthand experiences and to think about what they themselves do, instead of merely reading about things and watching what others do. They must have ample time to practice skills such as designing experiments, measuring and recording data, working in groups, thinking critically, and communicating clearly. They must be allowed time to brainstorm and be creative, to develop worthwhile attitudes and appreciations, and above all to enjoy science.

It may be frustrating to let pupils flounder a bit in their search for knowledge and understanding—especially to teachers who know or think they know the answers. Yet, just as a mystery story is spoiled by giving away the solution, the imperfect attempts of children to find out for themselves may be spoiled by telling the answers. Telling saves time—and unfortunately some teachers are more eager to save time than to open minds. However, much of the enjoyment and value of learning science lies in the search, not in the answers!

MEANS OF MOTIVATING

Perhaps the greatest secret of being a good teacher is the knack of getting children to want to participate in learning. Thus motivated, they learn without being coerced because then learning is fun. They may not even realize that it is taking place.

This is not to say that learning need be, or should be, effortless. However, even hard work is fun if it is satisfying. Think of the physical exertion during a ball game, and the mental effort in solving a puzzle or playing checkers.

Pupils become motivated when they participate in activities that are rewarding to them. The rewards, however, must be obvious and immediate; long-range goals have little meaning for young children. The teacher, nonetheless, must keep the ultimate aims in view, realizing that these can be attained, in part, by having pupils do things that are intriguing to them.

Learning experiences with built-in motivation include:

Engaging in physical activity involving large muscles (See "Broomstick Pulleys," page 122, and "Squeeze Play," page 20.)

Watching things move, especially with rapid or repeated motion (See "Reaction Carts," page 125.)

Seeing, hearing, or otherwise sensing pleasant (or unpleasant) things (See "Pebble Jar," page 82, and "Scrap-wood Music," page 135.)

Exercising control over phenomena—making things happen (See "Diving Dropper," page 59, and "Needle Poles," page 149.)

Being surprised or fooled by unusual or unexpected happenings (See "Air Push," page 33, and "Big Finger," page 164.)

Solving puzzles and problems, both physical and mental ones (See "Night Lights," page 154, and "Super Solution," page 73.)

Making estimates and predictions; then seeing how close these are (See "Shadow Motion," page 188, and "Limb Lift," page 48.)

Competing in contests that offer good chances for success (See "Ice-Melting Contest," page 175, and "Goodness! Book of Records," page 106.)

KEEPING RECORDS

"Lest We Forget" might well be the title of a class notebook in which pupils keep detailed records of experiments and other activities. An honest, complete record of observations can be examined at any time to see what really happened. It is surprising how different from the written record a recollection can be!

Some activities, such as "Layers in Logs" (page 47), do not call for extensive record keeping. Others suggest specific ways of keeping records. Drawing silhouettes of "Brick Pebbles" (page 84) encourages pupils to observe more carefully. In "Squeeze Play" (page 20), a column of numbered trials and times is needed for a graph from which the class can generalize. In "Stone Sizes" (page 86), the record is the collection of the objects themselves. In "Thunderstorm Paths" (page 38), the record is a series of numbered marks on a map. Regardless of the manner in which they are made, records serve a single important purpose—to provide an efficient, orderly reminder of pupils' observations.

Some records, such as those of temperature and moisture, may not seem important at the time but are useful in answering questions that arise later. Questions themselves often are worth recording, because they may suggest a different method of procedure or a test of ideas.

Once records are made, they should be used. Pupils soon lose any sense of purpose in record keeping if their records become busywork and are not evaluated at the end of an activity.

By having pupils keep records, even simple ones, from the first grade on, you will help them to make record keeping a habit and an essential part of almost any science activity. Then when they ask, "How do we know?" or "What is the evidence?" their records will give the answer.