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Concepts in SCIENCE

TEACHER'S EDITION

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TEACHING ELEMENTARY SCIENCE: A SOURCEBOOK FOR ELEMENTARY SCIENCE world, in a culture that puts an extraordinary premium on scientific thought and on scientific production. It is sensible to predict that most jobs in the future, including that of teaching, will call for scientific orientation of one degree or another. Contemporary-minded teachers must teach science because society demands it. Helping children to undertake a progressively more sophisticated intellectual activity is a central function in teaching, and creating productive situations—that is, the learning environment—is the teacher's day-to-day responsibility. It is, in many respects, an awesome one. Which situations—of all the countless ones that might be created—is the teacher to select? How is she to cope with the incredible diversity of scientific information, and indeed, with the diversity of children themselves?

From the time children are born, they watch, smell, feel, and listen: they are sentient to the objects and processes of the world. What they know largely derives from their senses and from their perceptions and from the number and kinds of experiences they have had. They acquire meaning, whether true or false, from many kinds of experience—in the classroom, in backyard play, in the streets, in the kitchen, in solitary reflection. They ask questions and examine things and ask still more questions. Because among individuals sensory perception varies and because human experiences vary in both kind and number, no two children begin school with the same knowledge, or with the same set of experiences. It cannot be presumed, therefore, that within the school framework they will move with equal speed or along precisely similar lines of growth. Some kind of provision has to be made to accommodate children of varying experience and of varying ability, and that provision is not alone concerned with the broader questions of homogeneous grouping in schools or of an ungraded curriculum; it is also concerned with providing a scientifically sound structure of learning and teaching science that enables children to uncover the concepts of science in an orderly (though not overly prescriptive) way and at a pace of their individual competency.

A structure in the teaching of science is needed not only to accommodate the phenomenon of diversity in children but also to manage the diversity of the content of science. Scientific research papers are currently being published at the rate of 67,000 words a minute! That amounts to a body of information that would fill eleven sets of a thirty-volume encyclopedia every twenty-four hours. Quite obviously, unless an attempt is made to evaluate, to select, and to sort new information into some kind of structure for the classroom, teachers will fall further and further behind. There is, moveover, the necessity to recognize that scientific knowledge, while it proceeds from facts, is not in itself the mastery of facts. Facts become meaningful, and the awareness of facts ultimately becomes productive, when they are perceived within the structure of basic concepts. We may modify George Gaylord Simpson's definition of science slightly. *Science is the exploration of the material universe for the purpose of seeking orderly explanations of objects and events, explanations that must be testable*. The products of science—which are its orderly explanations and the technology that results from the particular application of them—are the results of certain processes. The processes comprise the observation and examination of data including experimentation, the formulation of explanations by means of inventing hypotheses and stating theories, and the testing of the explanations. But the product of all this, the explanations, leads inevitably to other explorations and still other explanations. There are ends in science, but there is no end to science itself.

In their activity, scientists engage in concept-seeking and in concept-forming, and as a matter of course, in concept-testing. This is clearly a function of scientific inquiry. But what do children do when they are engaged in scientific activity? They explore the material universe (observe a plant grow, observe an object move down an inclined plane, observe a balloon that has been untied shoot through the air) and they seek orderly explanations of the objects and events they observe. They also investigate, and where possible, they might even experiment (although in a school context it is most difficult for students to perform an experiment in the *pure* sense simply because all the variables are difficult to control). They verify the data obtained from observations and they seek to interpret the data. They seek to predict results on the basis of the knowledge they have gained. They attempt to uncover explanations that reliably relate seemingly disparate or "discrepant" objects and events, and that will make prediction of other events possible. They, too, are engaged in understanding concepts of science and in applying them to the world about them.

Identifying the basic concepts of science is not the discrete task of the teacher. The teacher has the right to expect that she will be given help in identifying concepts and in forming a structure for the teaching of science, and this is a shared responsibility that the Concepts in Science authors and publisher, and the scientists and teachers who have advised them, have accepted. They recognize that school is time-binding, that work goes on in a certain time span—grades, terms, years—and that many teachers share in the development of each child. They know that a teacher must have a notion of what school experiences children have had before they come into her ken, as well as what will follow once they leave her. The need for a curriculum in science which gives the teacher scope and flexibility is plain enough; what is sometimes not so plain is the need for a curriculum that has a scientifically sound and pedagogically sound structure. We have attempted to give structure to the teaching of science during the first nine years of schooling by informing the processes of science with an understanding of the concepts of science. We have, in short, sought to identify and define a structure that is not only verifiable scientifically but also viable (practical, productive) in teaching children. The conceptual approach is central, in our view, to both aims, both to sound science and sound teaching.

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A Modern Science Curriculum

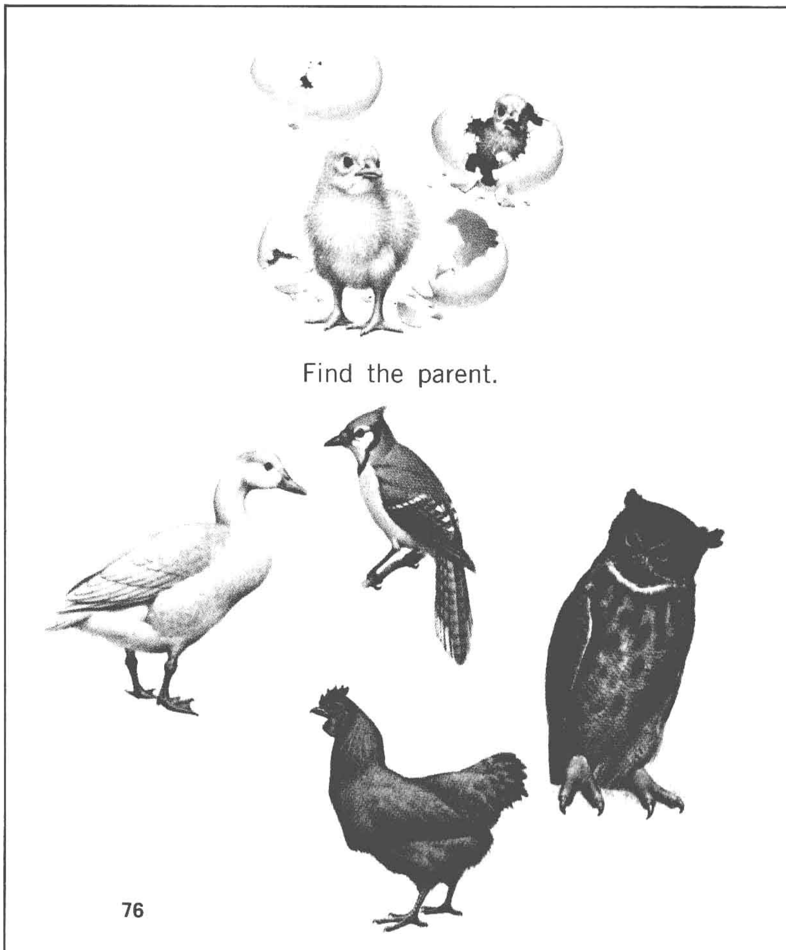
Early in the twentieth century the school curriculum in the United States tended to be content-centered, or disciplinary. During the twenties and thirties this curricular approach gave way to a so-called child-centered approach; the emphasis was shifted—this is overstated for purposes of simplification—from the subject to the learner. Today, still another shift is occurring as content is being placed in a stronger and more relevant role in the curriculum. More and more the emphasis is placed on the interrelationship, more specifically the interaction, between the discipline and the pupil in the learning act. Again with some oversimplification, the contemporary curriculum can be said to be process-centered. Certainly this is apparent in science teaching, and the advance of this kind of curriculum has been most directly aided by the involvement of scientists in the elementary and secondary schools. They have been enormously helpful in proposing a teaching structure for the early school years of science study.

Within the various disciplines of science—biology, chemistry, physics, geology, etc.—data accumulates and changes at a bewildering rate. Change is constant. Yet the concepts of science—which are a patterning of facts and the statements of the relationships between observable events and objects—are relatively stable. In a changing world, concepts offer, for this and other reasons, a reasonable foundation for the building of a science curriculum. They are, in a true sense, guides as well as aids to learning.

All of us have the task of sorting out events that come to our awareness in haphazard sequence. All of us have the task of discovering which of the objects and events we perceive are significant and which are not. To bring order out of our haphazard perceptions, we tend to seek a grouping of likenesses among a number of objects and events perceived; in short, we tend to seek concepts. To form a concept, we assort or group objects and events according to their attributes and properties, and we define categories. An example of what is meant by the "attributes" of an object or event will be useful.

A stone has shape, color, weight, and the like; these are some of the attributes of a stone. A bird also has shape, color, weight. Yet there are other attributes of the stone—for example, immobility and hardness which we recognize as part and parcel of "stoneness." A bird, on the other hand, has mobility, it has feathers, it has egg-laying propensities, and it has a certain structure (from beak to tail)—these and other attributes we recognize as essential to "birdness." In forming a concept, the brain selects those essential attributes (those which discriminate one object from another) which signal the whole configuration of the object or event. Thus the weight of an object is generally not an essential or discriminatory attribute; an attribute of a weight of one pound might apply to a one-pound chicken or a one-pound stone. But "feather" or "beak" is a signal, or cue, for categorizing or concept-forming. It is a signal of the whole concept of "birdness" and it enables us to fill in certain other essential attributes.

Now in learning, the *act of concept-forming* enables an individual to infer; from a few signals or cues he can infer a significant grouping, or category, of like attributes. These signs or cues can be related to *objects* (stones, birds, simple machines) or to *events*, such as the changing of one form of energy to another (for example, the friction of the hands resulting in heat, or the reproduction of organisms, or the splitting of an atom). A specific example in the teaching of a concept, in developing the ability in children to group the like attributes of an event, can be given here. Suppose we wished to create situations through which children would uncover the events that can be grouped within the concept: *Organisms (living things) reproduce their own kind.* This is precisely the objective of Unit Eight in *Concepts in Science 1*. A series of fifteen lessons is organized in a sequence in which situations are created whereby children come to *associate* an entire set of attributes of this event: *organisms reproduce their own kind.* Even if children were to undertake the analysis of only the four problem-picture situations shown, they would be engaging in the selection of essential



attributes of the event. This would enable them, in turn, to predict the event from one signal, say an egg. But the text suggests activity after activity—insect eggs are collected, chicken eggs are allowed to hatch, bird's nests are observed, fish are bred in an aquarium, the relationship of adult to young (dog to puppies, cat to kittens) is observed and analyzed. Perhaps you would care to examine Unit Eight now for a fuller exposition of the way the text assists the teacher in creating situations through which children engage in concept-seeking and concept-formation. But, of course, the text is only part of a very rich program of science in which process is central (see page T–10).

In brief definition, then, *a concept is a mental construct; it is a grouping of the common elements or attributes shared by certain objects and events.* Once a concept is attained, economy in future learning is also attained. For by engaging in the processes of concept-formation, the learner is active in selecting the essential attributes of the complete event, such as "organisms reproduce their own kind." And the learner is enabled to predict an entire sequence of events, or an entire set of characteristics or properties, from a small number of cues or signs. Thus a bird's egg, or an insect's cocoon, is a cue signalizing an entire event.

Defined in other words, a concept is a network of inferences stemming from observation of objects and events, resulting in the selection of common elements, or like attributes, among the objects and events under observation. Identifying and organizing the common, or like, attributes result in a significant category or grouping. That significant category is a concept. A concept is practical and useful because the perception of a small number of attributes, cues, or signals, brings the whole object or event into satisfying recognition. To repeat, an egg brings to mind the object (the bird) and the event (reproduction).

Because we are teaching small children, it is well to *group* experiences in a way which will enable teachers to plan their work sequentially. Hence we have ordered the *concept structure of the curriculum you have in hand.* It provides for small blocks of experiences, dealing with objects and events with similar attributes which young children can handle. We have attempted, moreover, to develop a curricular structure which bears some correspondence to the school year, day, and period. Further, for purposes of readier facility in planning the work of the first six years of elementary school, we have grouped a given series of concepts under a still larger category which we call a *conceptual scheme.*

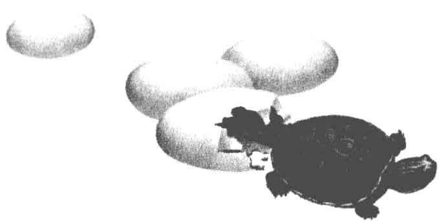
A study of Unit Eight in *Concepts in Science 1* will show that while the unit is built around a *concept*, each lesson is built around a subordering of the concept, identified as a *subconcept.* Thus (p. 76)

Concept for Unit 8:
Organisms (living things) reproduce their own kind.

Subconcept Lessons 1, 2, 3:
Some animals reproduce their own kind through eggs laid externally (a study of reproduction of birds, reptiles, insects).

Subconcept Lesson 4:
Some animals pass through a cycle of change from egg to adult (a study of changes during the life cycle in the moth).

Note that the concept for Unit 8 is the first of a series of six concepts subsumed under a conceptual scheme: *Organisms are the product of their heredity and their environment.*



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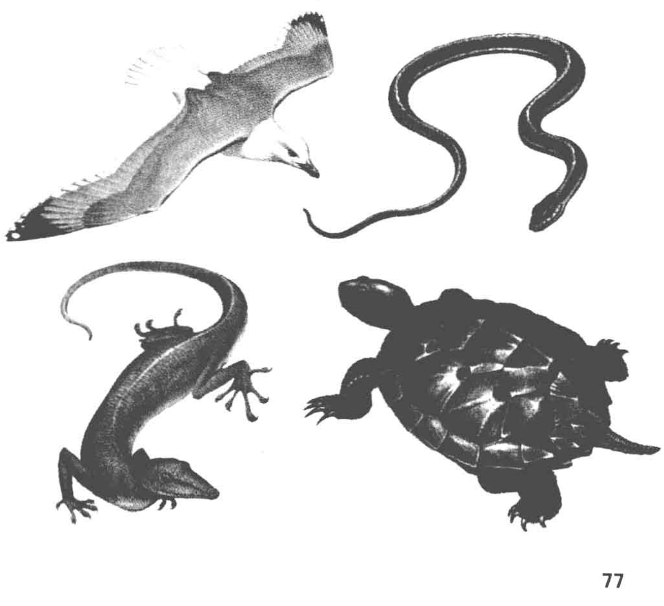

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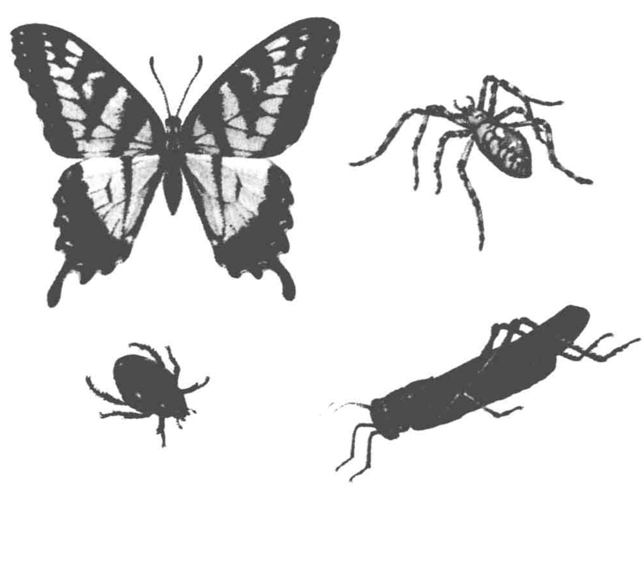
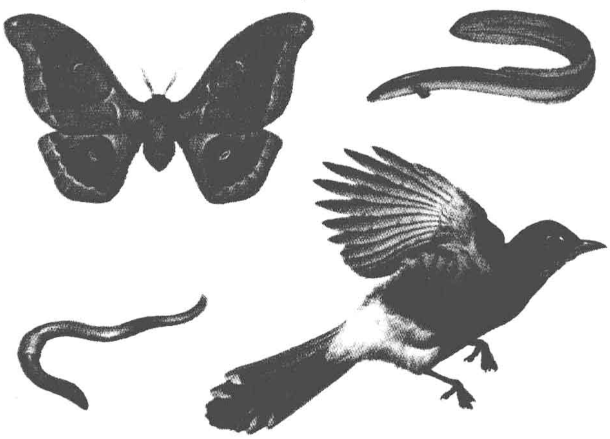


Conceptual schemes provide, we believe, a framework within which the teacher can provide experiences that will lead students to participate in the processes of science—in observation and in interpretation—and emerge with the products of sciences, which are testable explanations of the workings of the material world. This seems to be a large order. It is. The authors and publisher have spent eight years in the preparation of the curricular organization and materials in this program. They have tested its performance during hundreds of hours in typical classrooms. It is their belief that the conceptual approach is a feasible one that will produce excellent results. In an ultimate sense, their aim is to help the teacher produce an interaction between discipline and student, between the subject and the learner. For this reason, content is never skimped. For each grade there is a hard core of content or subject matter that exceeds more than even the bright child will be able to encompass in the time he is generally allowed.

What has been done in this program, then, is to lay out a framework of conceptual schemes through the first six years of schooling. The framework is capacious. It does not fix the teacher or the student into an inflexible curriculum. On the contrary, it gives the teacher freedom to plan a variety of experiences and it gives the student freedom to plot his own experiences. In both instances, however, the experiences will be ones which are relevant to a search for meaning rather than for the random acquisition of facts. In a real sense, understanding is made simpler for children when they are able to conceptualize—to see patterns in their environment, to group objects and events on the basis of their common elements. A program that accomplishes this is essentially an economical one, economical in the time that is spent in learning. Because, as has been said earlier, concepts remain relatively stable, concepts provide an organization of information that is itself relatively stable. New observations, new data, variant experiences can all be fitted into the conceptual framework.*

Find the parent.



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Teachers in St. Mary's County, Maryland, have been experimenting successfully with an elementary science curriculum based on conceptual schemes. Their course of study, initially developed by a curriculum committee, is now in its sixth year of development. Similar courses of study have been developed by other schools and school systems, particularly the Nova School, Fort Lauderdale, Florida.

If we interpret the psychology of learning with any degree of acuity, then we assume that it is important for children to learn in "wholes." In this sense, concepts are "wholes." Moreover, if we accept the definition that education should result in a change of behavior in the student, then an understanding of concepts will provide a person with intelligent means of deciding among alternatives. The conservation of natural resources; the support of public health programs; the questions of population growth; the fallacies in ethnic discrimination—all these are civic and social matters that confront a contemporary person. He is better able to judge what he perceives, and better able to support what he believes, when he understands the basic scientific concepts. The teaching of science ought to do more than dispel ignorance and superstition; it ought to help provide means by which a human being can comprehend what is today known but still unseen or still not widely operative. Exploration of the moon is a certainty, even though it has not yet happened.

The *Concepts in Science* series is an elementary science curriculum which attempts to reflect commonly accepted and basic ideas of contemporary scientists, cognitive psychologists, and teachers. It is a systematic organization of instructional materials. It is also a laboratory-centered program. The framework of six conceptual schemes provides a learning sequence that is shown, in broad outline, on the chart on pages T–8 and T–9. The sequential development is represented on the chart as horizontal threads called *concept levels*, which increase in complexity as one advances from one level to the next.

The National Science Teachers Association Committee on curriculum development, in "Theory in Action," † suggests seven conceptual schemes. The Committee agrees upon twelve statements. Seven of these statements discuss conceptual schemes, and five of them describe the process of science as the base for science curriculum planning. In the *Concepts in Science* series, the concepts have been grouped under six conceptual schemes, but the differences between this organization and that of "Theory in Action" is not substantial or finally consequential. The authors suggest that the content of the science curriculum could be arranged in an orderly structure under six conceptual schemes in a way that effects economy in organization, time, and effort.

* For a fuller explanation of concept-seeking and concept-forming see "Experience in Search of Meaning: A Reasonable Approach to the Teaching of Elementary Science" (to be published).

See also *A Study of Thinking* by Jerome S. Bruner, Jacqueline J. Goodnow, George A. Austin, John Wiley & Sons, Inc., New York, 1956.

† Published by the National Science Teachers Association, 1964.

A Comprehensive Program

The major conceptual schemes can be stated in somewhat arbitrary terms; no doubt, different teachers will state them differently. Certainly they would be stated differently for the scientist-specialist than for the elementary-school teacher, who of necessity teaches not only science but English and social studies. Certainly the statements may be modified and restated under different conditions, with different students and in different schools. Yet the authors have chosen to state the conceptual schemes in terms that can be used throughout the particular content and activities in the *Concepts in Science* program.

A Framework of Conceptual Schemes

The conceptual schemes and the general areas they subtend are:

1. When energy changes from one form to another, the total amount of energy remains unchanged.

Energy transformation is a common phenomenon. If you rub your hands, mechanical energy is converted to heat energy. If you burn a candle, chemical energy is converted to heat and light; and in a dry cell, chemical energy can be converted to electric energy. But whether one is concerned with burning oil in the home, gasoline in the automobile, glucose in the body, or whether one is concerned with the transfer of the energy of moving water into a flow of electrons in a conductor, the total amount of energy in any given system remains the same. This conceptual scheme is a primary concern in the discipline of physics.

2. When matter changes from one form to another, the total amount of matter remains unchanged.

The world of matter consists of a world of things, from the very large bodies—stars, planets, moons, and other celestial bodies—to the very small particles—atoms, molecules, and subatomic particles. As the matter in the universe undergoes physical change, a change of state, and chemical change, a change in form, the total amount of matter undergoing chemical or physical change in any given system remains the same. This conceptual scheme is treated within the discipline of chemistry.

3. Living things are interdependent with one another and with their environment.

Around living things everywhere, there exists an environment of matter and energy; indeed, living things cannot be considered apart from their environment. Plants depend upon their environment for their growth and development. Green plants capture energy from the Sun in the photosynthetic process; animals, in turn, transform the chemical energy of plants. And finally, all plants and animals yield their matter and energy as they die and decay. In addition, the demands of living in a given environment result in a relationship between plants and animals in communities that display definite characteristics—deserts, forests, seas, ponds, etc. For example, the sea is an environment in which ninety percent of the world's photosynthesis takes place, where complex food niches are developed, and intricate reproductive cycles operate. Understanding these interrelationships results in our ability to predict, within limits, the behavior and development of plants and animals. The conceptual scheme that describes them is a part of the study of biology.

4. A living thing is the product of its heredity and environment.

Within this conceptual scheme, one can develop the concept of an organism that lives in a kind of dynamic equilibrium. The organism is never the result purely of its heredity but of the environment interacting with hereditary factors. This is true of any specific trait. This is also important to comprehend in a human being's realization of full physical development and vigorous health. Other examples:

A red barberry is greenish unless exposed to strong sunlight.
An intelligent child needs an education.
Beets in acid soil are stunted.
A child lacking vitamin B may develop beriberi.
A potato seedling in the dark is attenuated.
A child poorly fed and poorly housed does not resist tuberculosis as well as one who lives in a more salutary environment.

The full range of the development of organisms—including the study of reproduction, genetics, growth, nutrition, behavior, and adaption to the environment—is involved in this conceptual scheme, which is the concern of several sciences: genetics, physiology, and biochemistry.

5. Living things are in constant change.

The universe changes; the Earth changes; the single organism and the species change over the ages. The concepts of adaptation over the ages, divergence in form, convergence in geographical isolation, and evolution are within the purview of this conceptual scheme, which involves genetics and ecology.

6. The universe is in constant change.

Every child today seems to know that the solar system is changing. Certainly the Earth's atmosphere is constantly shifting. The Earth is in constant motion; the Sun is in constant eruption. We note the appearance of novae and supernovae. We observe and gain evidence from Cepheid variables. We interpret the red shift in starlight to indicate an expanding universe in constant change. The change in the universe comprises a conceptual scheme that is the primary concern of geology, astronomy, and meteorology.

A Developmental Structure of Concepts

Expectedly, as the concepts in science are selected to fit the purposes of instruction in the elementary school, they seem to group themselves easily. The rationale is this: first, concepts should fall easily into a particular conceptual scheme; second, they should be ordered from the simple to the complex. "Simple" is used here in the sense that the experiences provided should be simple. Young children do not deal with a complexity of cause and effect, that is, with *multiple variables*. For example, it is fairly easy in the early grades or levels to deal with the concept *plants and animals reproduce their own kind*. On the other hand, the concept *the characteristics of a living thing are laid down in a genetic code* requires that we make available more complex experiences which are appropriate at higher levels. All this is not to imply that some children cannot deal with more complex structures even while the norm for a class is said to be a concept development at a lower level. A particular advantage of a conceptual structure in the curriculum is the provision for extended or accelerated growth in individual children. For instance, if a child seems to understand a concept at a higher level of complexity than his classmates, the teacher can determine the level of understanding by asking appropriate questions at a lower concept level (as indicated by the chart on pages T–8 and T–9). If there is a sufficient number of children who are able to deal with a higher cept level, procedures may then be modified.

The organization of a curriculum in terms of concept levels accommodates its own "multiple tracking." As a result, it is possible to have groups, or even individuals within the same class, proceed at different rates up the concept "rungs" of the conceptual "ladder." They can engage in experiences which are appropriate to their level of understanding, and at the same time communicate with groups at other concept levels. In other words, they are all on the same ladder, if on different rungs. In any event, a teacher will certainly wish to know the entire conceptual structure. You will find the structure for *Concepts in Science 1–6* in the chart on pages T–8 and T–9.

The concepts which form the rungs of the conceptual ladder can be stated in various ways, but the central purpose is to organize them in graduated order so that understanding of one (in a lower level) precedes the next for purposes of greater comprehension and utilization. There is some danger, we believe, in stating a conceptual scheme (or even a concept) by a single term (for example, *energy, matter, life*). However convenient this may seem, such easy rubrics may have the effect of limiting the implications of this approach to science study.

Now, the structure for science in the first six grades of the elementary school, here given as six conceptual schemes, with the concepts given at six levels (not necessarily grades), is purely for convenience and custom. The levels, until research proves this unwise, are in a rough order of precedence. Naturally, each concept has a number of subconcepts; the development of subconcepts depends on the judgment of the teacher.

The essence of science is *investigation of the material universe*. Its goals consist of a search for meaning; indeed Albert Einstein once defined it as experience in search of meaning; it *seeks orderly explanations (conceptualizations) of phenomena, the objects and events about us*. Nevertheless, there is stubborn insistence by scientists that an orderly explanation *be testable*. If a concept is not testable, it is usually not acceptable. Science is, in short, the "art of investigation" (Beveridge's term). But one cannot investigate an object or event if the object or event is not first perceived.

This book is literally a sourcebook of situations in which children participate and perceive objects and events. In creating a learning situation, children are given opportunity to seek the attributes of objects and events and to seek hidden likenesses. In the situation described on page T–1, the third-grade children engaged in these processes: they *observed* the working of a compass; they *investigated* the relationship between magnets and compasses; they *collected* relevant data; they *described* the operation of the magnet; they *discussed* their results; they *confirmed* one another's results (through collaborating in an investigation); they *read* the work of scientists; they *reported* their results in kind of colloquium. Note the processes: observation, investigation, collection of relevant data, description of results, discussion of findings, confirmation of findings, reading the work of scientists, reporting of work, and within limits, experimentation, among others.

A Structure for

	CONCEPTUAL SCHEME A **When energy changes from one form to another, the total amount of energy remains unchanged.**	CONCEPTUAL SCHEME B **When matter changes from one form to another, the total amount of matter remains unchanged.**	CONCEPTUAL SCHEME C **Living things are interdependent with one another and with their environment.**
CONCEPT LEVEL VI	The amount of energy gotten out of a machine does not exceed the energy put into it.	In nuclear reactions, a loss of matter is a gain in energy; the sum of the matter and energy remains constant.	Living things are adapted by structure and function to their environment.
CONCEPT LEVEL V	Energy must be applied to produce an unbalanced force, resulting in motion or change of motion.	In chemical or physical changes, the total amount of matter remains unchanged.	The capture of radiant energy by green plants is basic to the growth and maintenance of all living things.
CONCEPT LEVEL IV	A loss or gain of energy affects molecular motion.	In chemical change, atoms react to produce change in the molecules.	Living things capture matter from the environment and return it to the environment.
CONCEPT LEVEL III	The Sun is the Earth's chief source of radiant energy.	Matter consists of atoms and molecules.	There are characteristic environments, each with their characteristic life.
CONCEPT LEVEL II	Energy can change from one form to another.	A change in the state of matter is determined by molecular motion.	Living things depend on their environment for the conditions of life.
CONCEPT LEVEL I	Energy must be used to set an object in motion. There are many forms of energy.	Matter commonly exists as solids, liquids, and gases.	Living things are affected by their environment.
	CONCEPTUAL SCHEME A **When energy changes from one form to another, the total amount of energy remains unchanged.**	CONCEPTUAL SCHEME B **When matter changes from one form to another, the total amount of matter remains unchanged.**	CONCEPTUAL SCHEME C **Living things are interdependent with one another and with their environment.**

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Concepts in Science

CONCEPTUAL SCHEME D **A living thing is the product of its heredity and environment.**	CONCEPTUAL SCHEME E **Living things are in constant change.**	CONCEPTUAL SCHEME F **The universe is in constant change.**	
The characteristics of a living thing are laid down in a genetic code.	Changes in the genetic code produce changes in living things.	Nuclear reactions produce the radiant energy of stars, and consequent change.	CONCEPT LEVEL VI
The cell is the unit of structure and function; a living thing develops from a single cell.	Living things have changed over the ages.	Bodies in space (as well as their matter and energy) are in constant change.	CONCEPT LEVEL V
A living thing reproduces itself and develops in a given environment.	The environment is in constant change.	The motion and path of celestial bodies are predictable.	CONCEPT LEVEL IV
Living things are related through possession of common structure.	Living things grow and develop in different environments.	There are seasonal and annual changes within the solar system.	CONCEPT LEVEL III
Related living things reproduce in similar ways.	Forms of living things have become extinct.	There are regular movements of the Earth and Moon.	CONCEPT LEVEL II
Living things reproduce.	There are different forms of living things.	There are daily changes on Earth.	CONCEPT LEVEL I
CONCEPTUAL SCHEME D **A living thing is the product of its heredity and environment.**	CONCEPTUAL SCHEME E **Living things are in constant change.**	CONCEPTUAL SCHEME F **The universe is in constant change.**	

Resources for a Comprehensive Program

The structure of science and the processes of science yield knowledge and they yield understanding but at no time could they exist without the materials of science—materials which provide the media for investigation, whether the investigation involves reading a textbook or carrying out a sophisticated experiment in the laboratory. The materials for *Concepts in Science* include the facts of science as well as the tools of science. These materials come in the form of reading matter, illustrations, manipulative objects, laboratory guides, testing instruments, and other aids to teaching.

The *Concepts in Science* series provides the whole range of suitable materials for Grades 1–9. It includes basic textbooks for the child, each accompanied by a Teacher's Edition for Grades 1–6 (a separate Teacher's Manual for Grades 7–9); Workbooks for Grades 4–9; packaged equipment for Grades 1–6 called *Classroom Laboratory;* individual investigation cards called *Invitations to Investigation;* and *Teaching Tests.* There are, moreover, books available for the teacher.

TEXTBOOKS

Each book in the *Concepts in Science* series is organized to accomplish efficiency in the learning process. Each book is designed to create an atmosphere of discovery in concept development; to stimulate personal involvement; to maintain sharp curiosity; and to lay a firm basis for intelligent action and independent inquiry. The processes of science, as well as its products, are emphasized and yet interrelated as the student participates in the act of learning. Each book is illustrated for visual interpretation of objects and events that may or may not be a part of the pupil's everday experience.

While the full-color photographs and drawings enhance the visual quality of the textbooks, they serve the important function throughout the program of training children to observe with discrimination the pictorial representations of their physical environment. Many of the photographs are of actual performances by children and experienced teachers in the classroom.

Each book contains an abundance of investigations to help develop the main concept of a section. As the investigations are self-contained and self-explanatory, except in *Concepts in Science 1* and *2* where the directions are given by the teacher, little discussion of the investigations is given other than to suggest possible pitfalls and to advise on the most profitable time during the lesson to undertake the investigation. Actual photographs illustrate one trial investigation. Since the text does not tell what happens, the photographs serve as guides for the pupil; but the pupil must observe for himself and try the investigation. All of the investigations within the sections have been laboratory tested not only for effectiveness, but also for safety.

In addition to the investigations that are found at strategic points within the sections, there are "open-ended" investigations at the ends of the sections as well as at the ends of the units. Each investigation is an extension and addition to the pupil's initial concept formation. Furthermore, these additional investigations point up the fact that many trials are necessary to establish and confirm results of one investigation. End-of-book sections, which progress in difficulty from book to book, stimulate individual investigation that is relatively complex in observation and experience.

Each book in the *Concepts in Science* series features cumulative concept reviews and evaluations which enable the pupils to test their understanding of a concept. These reviews enable pupils, moreover, to apply their understanding to new situations, to hypothesize solutions to a variety of problems, to recognize relationships among concepts, and to infer relationships among conceptual schemes. At every step of the way the pupils are provided with experiences which help them find unity among diversity, to achieve order out of disorder in the objects and events of the world around them.

Concepts in Science builds a precise science vocabulary. Throughout the program, provision is made for growth in vocabulary as it specifically relates to science. In *Concepts in Science 1* and *2*, the teacher is encouraged to introduce new words on a science vocabulary chart to be displayed in the classroom. These same words are listed in the back of the child's text for his individual use. In Books 3 through 6, key words are introduced in boldface type and are repeated, with page references, in the glossary and index. Definitions in the glossaries increase in depth and variety of meaning from book to book.

The reading vocabulary has been carefully controlled for the grade level throughout the program, with due attention to the adequate presentation of technical vocabulary necessary to understanding concepts in science. In *Concepts in Science 3* and *4*, a pronunciation-at-sight system is used; and in the textbooks for *Concepts in Science 5* and *6*, a standard system of diacritical marking is used.

TEACHER'S EDITIONS

The Teacher's Editions to accompany the *Concepts in Science* textbooks are organized for maximum teaching effectiveness. They contain all the background information that teachers need to teach a unit with confidence and enthusiasm, which eliminates, for the most part, the necessity for further research on the part of the teacher. The conceptual structure of the curriculum is outlined clearly, and carefully selected activities and experiences are prescribed and described as effective means of concept development.

A comprehensive teaching pattern is apparent in each of the teacher's editions and is analyzed in detail in **Part Two** of the introductory material in each book. In this book, the analysis is found on pages T-14 and T-15.

CLASSROOM LABORATORY

The classroom for science should resemble a laboratory in which children actively work with objects at their own desks or tables, individually and in groups, observing, rearranging, manipulating, investigating, experimenting, testing, and discussing their findings and inferences with one another.

The *Classroom Laboratory* for the *Concepts in Science* series is a practical way of converting an ordinary classroom into a classroom laboratory. There is one each for *Concepts in Science 1–6* which is designed to fit the needs of the science curriculum by providing the materials and equipment for pupils to experience science in the classroom. It is built around the concepts of the science curriculum; it anticipates and solves the problems of classroom management, and is designed to be used by the entire class.

While an entirely optional part of the *Concepts in Science* program, the *Classroom Laboratory* deals with investigations that give pupils the opportunity to uncover the science concepts that are developed in the basic textbooks. The Teacher's Manual which accompanies the *Classroom Laboratory* is keyed by page number to the pupil's textbook. Thus, teachers know at exactly which point in a lesson it is most profitable to introduce an investigation.

Each *Classroom Laboratory* is accompanied by a Teacher's Manual. Pupil's instructions are supplied where necessary.

To provide opportunities for an entire class to experience the processes of science, the equipment and materials are supplied in multiples of six. A class of 30 pupils, for example, may be divided into six groups of five pupils, with each group performing the same investigation. There are also materials for the performance of numerous individual activities which may be used as teacher or committee demonstrations. Furthermore, the laboratory is so organized that it is possible to find any required material within a few moments and to return it easily to its proper place for future use.

While the contents of the individual laboratories differ, depending on grade level, each contains an assortment of commonly-used apparatus: beakers, test tubes, tripods, plastic tumblers, plastic dishes, and other basic materials, which can be reused whenever needed. With normal use, some depletion of parts will occur each year and a small portion of the items are consumable. Replacements are available from the publisher.

WORKBOOKS

Concepts in Science Workbooks, available for Grades 4 through 6, give pupils additional opportunity to reinforce and extend their understanding of the concepts developed in the *Concepts in Science* textbooks. Through the experiences that are provided in these workbooks, pupils review concepts and apply them in new context. New problems are introduced which are related to problems they have already studied, but which differ in some significant way from those in the textbooks. Moreover, the workbooks give additional practice in utilizing basic laboratory skills—recording observations, tabulating data, interpreting data, and drawing conclusions as well as practice in using scientific apparatus. The activities in the workbooks have been selected to provide experiences in various situations—at home, in the classroom, on a field trip, in the library, or in the laboratory; and from these experiences, pupils are called upon to organize and apply the concepts and skills initiated and developed in their textbooks. Self-testing reviews are included for additional pupil evaluation and a Teacher's Correction Key, separately available, provides suggested answers.

TESTS

Science *Teaching Tests,* prepared and screened by the Harcourt, Brace & World Science Testing Board, are available separately for *Concepts in Science 3* through *6*. The answer keys are found in the Teacher's Editions of the textbooks.

These tests, to be used after each unit in the pupil's books, go beyond the testing of facts. Like other elements in the *Concepts in Science* program, they help teachers evaluate the pupil's understanding of concepts. The questions for each test are designed to evaluate comprehension as well as retention of information. They are divided into several parts; the parts, depending on the sophistication of the concept level, are designed to test the child's ability to read for comprehension and interpretation; the ability to recall factual information; the ability to evaluate and apply concepts in new situations. They may also determine how well the pupils perceive relationships among the concepts developed. The pages in the test booklets may be assigned individually or for the entire class.

LABORATORY CARDS

100 Invitations to Investigate, a set of 100 ungraded laboratory cards, provide the background information, illustrations, and clues to procedure for pupils' independent investigations. The investigations are a random assortment in the biological, physical, and chemical sciences and progress in difficulty—the higher numbered investigations being more sophisticated. The cards, which are packaged in a sturdy case, are designed for those pupils who wish to pursue, beyond what is covered in the textbook, their own interest in some particular area of science, independent of their regular classroom work. Each child is encouraged to select the investigation in which he is interested, to investigate with enthusiasm and imagination, to seek answers to problems for which his textbook offers no solution. While designed for enrichment, the laboratory cards also lend themselves to the development of a science course for specially interested students and for science in ungraded programs.

SOURCEBOOKS FOR THE TEACHER

Harcourt, Brace & World publishes a number of outstanding professional books which provide supplementary information for teachers on how to plan, prepare for, and carry out a science program in the elementary school. Written by specialists in the field of science education, these books provide the "tactics and strategy" as well as the techniques for teaching elementary and high school science. They also employ the scientific and educational psychology involved in the teaching of science. You will find a list of these publications on the first page of this book.

Part Two: CONCEPTS IN SCIENCE 1

Structure and Content

Concepts in Science 1 is more than a series of related lessons. It is more than the sum of its separate parts. It is the first in a series of six books which comprise an elementary science curriculum. It is a fully sequential and articulated program in which each unit of work is dependent upon previous units already studied. Each lesson is part of a larger pattern, the section; each section is part of a still larger pattern, the unit. The unit, in turn, is part of a still larger pattern, the year's work in science.

Even a casual perusal of the two texts, the child's and the teacher's, reveals the developmental structure of the entire program. The earlier units, taught at the beginning of the school year, are shorter and more slowly paced than the units designed for later in the year. The same holds true for the first lesson in each unit. Each lesson depends on the lessons that have preceded it, and each unit builds on the units that have gone before.

Science vocabulary is cumulative. Energy, for instance, is introduced in Unit One in relation to motion. In later units, energy is reintroduced and reused in relation to evaporation, growth of plants, light from the Sun, and the development of the human body.

The conceptual schemes that are set forth in this teaching text and the concepts which serve them, lend themselves to basic experiences for children as they study the objects and events in the world around them. A concept learned in one unit is recalled and reapplied in new context in later units.

In *Concepts in Science 1*, the eleven units develop the first concept level of the six major conceptual schemes. Each unit is primarily concerned with one conceptual scheme, but in some cases there is an overlapping of schemes. The eleven units deal with a variety of subjects: motion, gravity, friction and wheels, clouds and precipitation, the rotation of the Earth, rockets and astronauts, plants from seeds, animals from eggs, growth of children, dinosaurs and fossils—to give but a partial list. Yet, to the scientist, these units are concerned with only three big categories: energy, matter, and life. These three categories may be studied at any age, in any grade, and at any level of sophistication in relation to what the authors have chosen to call the six major conceptual schemes—schemes which are basic to the child's understanding of the material universe.

Each conceptual scheme, treated at the first concept level, is basic to understanding the scheme as it is developed further at the second concept level. The conceptual schemes are not taught to the children; rather, they are the eventual goals which the learner will reach through experiences which have been selected to provide for the pupil a maximum of individual involvement in the learning process. It is a step-by-step process of concept formation throughout all the grades.

The exploration of the environment, certainly a major aim of science, does not begin in the first grade or even in kindergarten. Most young children enter school with a fund of science information (and misinformation) and a fairly well-developed pattern of behavior that has long served their need to satisfy their natural curiosity. They have had experiences, but experiences that have not always been planned in search of meaning. In school, the experiences are selected and organized in a search for meaning, for conceptual understanding.

In the first grade, teachers help children to organize and evaluate their information, and to use and improve their habits and skills of investigating. The investigating, however, is no longer the random process of early childhood, rather, it proceeds in a sequential, developmental pattern of lessons, thoughtfully and systematically organized as a science curriculum. Let us examine the pattern in *Concepts in Science 1*.

THE STRUCTURE OF A UNIT

All of the units in this text, both the child's and teacher's, have the same structure and the same component parts. It is useful to trace the development within a unit by sampling pages from this Teacher's Edition. For example, Unit One: "Making Things Move," page 1, reveals the orientation to the lessons in the unit—and similarly, to other units in the text. Unit One has been selected to illustrate the structure of a unit in which several concepts support a conceptual scheme.

THE PATTERN OF A LESSON

In each science lesson, the child has experiences that enable him to take one small, specific step toward the understanding of some important concept. After a number of lessons dealing with the same concept, the child gains in his understanding of that concept, even though he has never said or heard the concept stated in specific terms.

Like good lessons in other subjects, the daily lesson in science has three main parts:

the introduction—in which a problem is raised and curiosity is stimulated; that is, thought is linked to action

the main body of the lesson—in which the content is organized for concept development and then summarized

the reinforcement or extension of the lesson—in which a variety of activities are introduced for enrichment.

In the lessons, the children become aware of new relationships as they discover similarities among objects and events that previously may not have appeared to be related. Gradually, as the children recognize and understand some of the patterns of relationships in the universe, they build their concepts in science. The concepts evolve in the child's mind as specific steps toward understanding.

Each lesson is introduced by some activity that raises a question or poses a problem. Usually some object or objects are required for the activity. In classroom trials of the lessons in this text, it has been found that the materials listed add greatly to children's attentiveness and interest.

Once the lesson is introduced, the teacher may stimulate and guide children's curiosity by asking the pertinent questions found in bold-face type. The children are asked "Why?" To find out, they turn naturally to their science texts and continue with the main part of the lesson.

In *Concepts in Science 1,* it is not expected, especially at the beginning of the term, that children be able to read the sentences on the pages of their textbook. Even though an occasional class may be able to do so, it is suggested that first-grade teachers assume responsibility for reading the text as suggested here. Only the individual teacher can know at what point or to what degree, if any, children might participate in reading the text aloud to the class. Since comprehension of relationships leading to concept formation in science is the present goal, it is not desirable to have children puzzling and stumbling over words. When the sentences are read aloud by the teacher, first-grade children have no difficulty in comprehending the meanings. This procedure keeps the lesson moving forward at a good pace, holds the class together, and gives young children the security of the teacher in her proper leadership role.

Some of the important understandings that can come from a lesson are listed in brief statements. It is not expected that children will or should be able to express these ideas as they are expressed, or that every child, or even any child, will reach all of the understandings. Specific comprehension will vary naturally from class to class in relation to the mental maturity of the children. The main ideas are listed to serve as guide posts for the teacher, who, in her creative and intelligent way, will use them as she helps children to understand the concept according to their separate abilities.

Some of the activities, it will be noted, are appropriate as assignments or projects for individuals or small groups. Some are suitable for broadening and deepening understanding of the concept by the entire class. Some are suggested for use during art, math, or language time. Still others, the field trips, take the entire class out of the classroom and into the neighborhood for journeys of exploration and discovery.

Since the teacher will be starting with Unit One, a brief analysis of the first lesson (see pages T–14 and T–15) in that unit (rather than from some other unit) will serve to explain the headings of the main sections and help in developing an approach to teaching the lesson. The teacher may then proceed to use the suggestions with confidence and pleasure.

Closing the Lesson. A good science lesson rarely ends at the close of the science period. One of the criteria used by teachers in evaluating the effectiveness of their teaching is the enthusiasm with which children continue to observe and investigate on their own. The lesson, then, serves to point the way and to give meaning to children's continuing observations and investigations in their daily lives.

The first lesson in Unit One deals with *mechanical* energy used to set objects in motion. The four succeeding lessons deal successively with *electric* energy, *chemical* energy, and the energy in moving wind and moving water. These lessons are presented in the same teaching pattern as you will find for other lessons in other units.

Closing the Unit. The last section of each unit (see page 9), titled *Summary and Evaluation,* consists of a single lesson. The teacher will note that the central ideas of the lessons in the unit are brought together in a brief statement for her guidance. In the child's text, the corresponding page is titled "The Big Idea." This concluding lesson provides opportunity for review of vocabulary, summary of understandings, and evaluation of children's comprehension of the concepts of the entire unit.

These "Big Idea" lessons are designed for oral presentation in an atmosphere of self-appraisal. Children review their understanding. In our observation, they make statements which, even at a first level of understanding, come very close to the conceptual statement. They study and discuss pictorial problem situations, have games and word drills, browse through and reread the pages they have studied in the unit, and are encouraged to note and appreciate their growth in science. This growth is, of course, individual. But all the children come to some understanding of the concept. They can and do share an understanding of the world they have explored, each to his own capacity.

At the End of the Year's Work. Following the eleven units is an end-of-book section titled "Stories for a New View: Changes We See." These stories might be used as additional lessons for reinforcement. Page-by-page lesson plans are included, as they are for all pages in the text. Alternatively, the stories might be used as independent reading for the exceptional child who is able to read and work things out for himself. Or they might be read aloud by the teacher and discussed informally with the class. However they may be used, the stories were written to be enjoyed by the children as they apply the concepts they have learned to new situations and discover new relationships in the world about them.

For all the children, the text, carefully ordered in concepts, growing in complexity as the child grows in maturity, provides a series of firm foundation stones on which they may be guided to a firmer understanding of the higher ordering of concepts in *Concepts in Science 2.*

Each science lesson, then, permits the child

1. to explore the material universe (through a "mix" of activity)

2. to seek orderly explanations of the objects and events explored (the explanation is in an assertion we have called a *concept*)

3. to test his explanations (through a variety of activities).

The teacher's art is an individual one; the child's learning activity is an individual one. Nevertheless, the teacher's art is congruent to the scientist's when the child—in the teacher's hands—explores his world and, because of the teacher's great skill and understanding, is not crushed by the immensity of it.

Each lesson, in short, becomes an experience in search of meaning. A new concept of the way the world works becomes part of the child's equipment. He grows.

UNIT ONE: MAKING THINGS MOVE

CONCEPTUAL SCHEME
When energy changes from one form to another, the total amount of energy remains unchanged.

Children live in a world of motion: toys move, balls are thrown, planes fly overhead, rockets blast off, cars and trains whiz by, electric washing machines and all the other household appliances hum and buzz as energy makes things move. Children bring to class a wealth of experience with energy in many forms. Through the activities in Unit One, they are helped to become aware of the relationships between energy and motion.

The Conceptual Scheme. The total amount of matter and energy in the universe remains constant. For the purposes of the first grade, we have isolated the concept of energy for emphasis. As the child grows in experience, he will be given the opportunity to observe the relationship between matter and energy. New forms of energy may be discovered and used, as happened with the development of atomic energy; but the energy was there all the time. Man did not create it; he merely discovered and released it. Man, as scientist, does not really discover something "new": he discovers a relationship not previously understood.

Energy is used, but is never "used up." Energy in one form may be changed to energy in another form. For instance, the energy from the falling water at Niagara is changed to electric energy. We then use the electric energy as it is changed to heat energy (in a toaster) or light energy (in a lamp) or mechanical energy (in a power saw).

The major conceptual scheme involves far more, of course, than young children need be concerned with. It is useful to keep the major scheme in mind and use it as a framework for the lessons in this unit. Questions will certainly arise beyond the scope of the lessons in Unit One; then the conceptual scheme also serves as anchor.

The major concept in Unit One is that energy is used whenever something is made to move. The concept is not, of course, taught directly but is discovered by the children gradually through their experiences in the lessons in the first unit. Other concepts about energy will be developed later. In the early grades the concepts and subconcepts concerning matter and energy are "seeded" in order to give the children a broad base for exploring the interaction of matter and energy in the universe.

The **title of the unit** indicates, in language for the child, the subject matter of the unit.

At the top of the page that introduces each unit to the teacher, the **conceptual scheme of the unit** is stated in scientific terms.

The **subject matter and activities of the unit** are selected for and related to the natural interests and activities of children.

The conceptual scheme is **interpreted for the teacher.** It is related to familiar occurrences (to the observations that children make and to the kinds of questions alert children ask).

The information on the introductory page, though brief and specific, goes considerably beyond the first-grade level. It is recognized that teachers have many claims on their time and energies. It is hoped that the **background information** that precedes each unit will render unnecessary any further research on the teacher's part before beginning to teach the unit with confidence and enthusiasm.

Section 1: Sources of Energy

CONCEPT
Energy must be used to set an object in motion or to alter its motion.

The **title of the section** states for the teacher the **topic** that is dealt with in the lessons in that section. It is a convenience for the teacher. Each section is, for the most part, primarily concerned with one major concept which is stated directly under the section heading. Each of the lessons develops a subconcept, stated directly under the lesson number.

The **concept** is the same for all of the lessons in this first section. Often, the lesson also has a subconcept, which is a subdivision of the main concept.

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