Keeler, Douglas; And Others

Science; Elementary Pilot Project.

Farmington Public Schools, Conn.

[68]

161p.; A Noah Wallace Income Fund Project

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Curriculum Guides, Elementary Grades, Elementary School Science, Elementary Science Curriculum

GRADES OR AGES: Elementary grades. SUBJECT MATTER: Science.

ORGANIZATION AND PHYSICAL APPEARANCE: The first half of the guide is divided into seven phases which appear to be consecutive. Commercially published units listed in these phases are then described briefly in a list which occupies the second half of the guide. The guide is xeroxed and spiral-bound with a paper cover.

OBJECTIVES AND ACTIVITIES: Concepts to be learned and specific behavioral objectives are listed at the beginning of each phase. These are followed by a list of suggested units. A very brief description of the activity is included in the unit description listed in the second half of the guide.

INSTRUCTIONAL MATERIALS: All units in the second half are commercially published. A separate list gives names and addresses of publishers. In addition, several appendices list field trip possibilities, publishers of elementary science materials, film distributors, and equipment and supply distributors.

STUDENT ASSESSMENT: A sample "Science Progress Form" for reporting student progress is included in the guide. (RT)
A Noah Wallace Income Fund Project

Farrington Public Schools

Farrington, Connecticut
SCIENCE CURRICULUM STUDY COMMITTEE
1967-1968

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The committees wish to thank Dr. Joan D. Kerelejza, Coordinator of Instruction, for her guidance in this project. Thanks also are extended to the Noah Wallace Fund Income Advisory Committee for making this curriculum study possible.
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Today's science program is a far cry from what typified science study as recently as ten years ago. The former emphasis upon mastery of factual information, upon reading a single text, and upon teacher demonstrations watched by the entire class has been superseded by a dynamic, resourceful investigation of natural phenomena. Today's elementary and secondary student within the classroom is an active seeker of the truth in just as legitimate a manner as is the scientist within his laboratory.

Active student involvement in the study of science characterizes the program developed for the Farmington Schools. At all levels, students are taught by a "discovery," laboratory-centered approach in which they probe, measure, dissect, calibrate, record, evaluate, and predict in order to gain an understanding of the ways in which a scientist interprets the world and a familiarity with the processes which he employs. Each child for himself discovers anew the wonder of man's attempt to understand the unknown.

Another fundamental emphasis in the Farmington program is on helping students acquire the thinking patterns essential to scientific investigation. The "scientific method" is seen as a constellation of methods involving many sub-sets of related skills which students must master to gather and interpret scientific data with understanding. Basic skills or processes particularly appropriate to the discipline of science were identified in this summer's study, and learning situations for children were developed.

A third basis for the elementary and the secondary programs is the development of certain key scientific concepts, beginning with the child's immediate physical environment and extending to sophisticated ideas of relativity. Surgeoning factual information in the discipline has forced the establishment of a criterion for competence other than the mastery of a relatively small body of essential content. When one is faced with the prospect that the amount of scientific factual knowledge will double every seven years, no particular content remains sacrosanct. The Farmington program stresses basic scientific concepts and suggests many specific contents that best seem to develop these concepts. Making an informed professional choice from among a variety of contents became the task of the curriculum study committee. It was a matter of selecting the content most appropriate for teaching the basic concepts.

Finally, just as there is no invariable content that all children must master, so is there no single type of instructional material that can benefit every child. The teacher must have available many types of instructional tools and devices - not a single text but many texts; not one microscope, but many microscopes.

At both the elementary and the secondary levels, the pilot programs in science developed for trial during this coming school year reflect provision for active student participation within the classroom or the laboratory, emphasize a teacher-guided discovery approach to learning, stress student acquisition of basic thinking processes in the discipline of science, identify basic concepts that can be taught with a variety of contents, and require the availability of many types of instructional materials.
The writing committee first identified basic processes essential to the discipline of science and the fundamental concepts about science which would help children understand the world about them. These concepts would serve as building blocks for advanced science study in the secondary schools. The committee felt that content should be selected from the child's immediate environment and experience.

This year, science teachers in the elementary school will have available the plant study units developed last summer for the primary and intermediate levels and a new organization for the science program reflected in the guide. So much excellent new science material is now available commercially that the writing committee felt it advisable to organize this material around the framework of a total elementary science program. As a result, commercial materials have been carefully reviewed and chosen to fill slots in the general program. In this way, the committee will be able to determine the suitability of these materials as recommended and will also be able to locate areas for which we will need to prepare our own units. As far as possible, basic concepts are emphasized and objectives are stated in terms of what students should be able to accomplish. As much flexibility as possible has been encouraged. Learning activities are open ended so that teachers can modify or supplement as needed. The use of many resource materials is anticipated; no basic materials are used. Teachers should feel free to capitalize on the interest and curiosity of a particular group of children. Hopefully, suggestions in the guide will serve only as a basic core from which the teacher works.

The secondary program was considered as one in which students gradually refine fundamental scientific processes and concepts begun in the elementary program as content becomes more specialized. The ultimate goal is to develop a non-graded program which will enable students to make meaningful contact with the ideas of science as these are taught through laboratory experiences. With a laboratory-centered program, all students should see science as a discipline of process and inquiry rather than as a body of facts that must be learned.

In the transition years of the junior high school, the concepts and assumptions acquired through laboratory experiences should reveal nature to be dynamic and varied. The junior high school student should think of the world and the phenomena in it as consisting of sets of relationships rather than of absolutes. The program should continue to give students experiences with many areas of science. As a result, the curriculum study committee recommended that additional biological studies be included in the junior high school program to counterbalance the heavy emphasis on the physical sciences. The writing committee prepared two biological units for the first-year program. It also suggested that modification of the existing physical science sections be made by introducing parts of the Introduction to Advanced Science and of the Introduction to Physical Science courses. The portions of the new program prepared this summer will be used with pilot classes this school year.

The senior high writing committee completely revamped the existing Introduction to Advanced Science course. Revisions were made on the basis of four years of classroom experience. This group is anticipating the preparation of a truly non-graded science program for the high school level over the next two years and looks upon this curriculum as a transitional one.
As groups of teachers and administrators earnestly struggle with philosophical and practical considerations in the preparation of any new curriculum, the tendency to become entrapped in immediate concerns is always a danger. If the Farmington science curriculum is to be outstanding, teachers must not lose sight of its ultimate aim - the sustaining of the feeling of wonder as students probe into the unknown. We can all profit from the lesson taught by Whitman's learned astronomer:

When I heard the learn'd astronomer,
When the proofs, the figures, were ranged in columns before me,
When I was shown the charts and diagrams, to add, divide, and measure them,
When I sitting heard the astronomer where he lectured with much applause in the lecture room,
How soon unaccountable I became tired and sick,
Till rising and gliding out I wander'd off by myself,
In the mystical moist night air, and from time to time,
Look'd up in perfect silence at the stars.

For the Committee,
Joan D. Kerelejza
INTRODUCTION

Children today live in a new world of science, and it seems to be getting "newer" every day. There are new discoveries, new medicines, new ways of doing things, new kinds of jobs. We are living in a very dynamic and exciting time of history. A science curriculum must keep pace with the world of its children. Therefore, new goals and new instructional materials based upon the needs of a changing society, strongly influenced by science, characterize today's elementary-school science programs. The conceptual curricular materials suggested in this guide differ from conventional science programs in rationale, implementation in the classroom, and content. They are based on new ideas of how children learn and thus require changes in the way science is taught.

Learning is exciting. It moves, it breathes, and it becomes larger under a microscope. In order to enhance this new world of science, children should be allowed the freedom to create, to become actively involved in their own learning, and to become responsible for their learning endeavor. The classroom will become a laboratory where each child assumes the role of a creator, a discoverer, an operator -- and not simply a passive listener. The classroom will be noisier, messier, and more stimulating for both child and teacher. To teach this new approach to science, a teacher need not have a strong background in science. The teacher need only be aware of individual differences and be totally sensitive to the process of education. He will become adept as he talks with fellow teachers, as he observes his children's total involvement, and as he begins to find in the new world of science a fascinating and illuminating biography of life.

This curriculum is based on the integration of life science, earth science, and the physical sciences. Its basis lies in its construction, a construction that places complex experiences, broader treatment, and greater depth in higher levels but intrinsically depends on lower levels for a solid base. It is difficult for children to understand the knowledge of science without an awareness of how that knowledge was formed. The processes of science developed in this curriculum provide young people with thinking tools applicable not only to science but to life in general. These processes include:

1. Observation
2. Classification
3. Measurement
4. Communication
5. Interpretation of data
6. Drawing inferences
7. Setting up experiments
8. Making predictions
The units in this curriculum have been trial tested, have the support of the National Science Foundation, and are consistent with present-day learning theory. It is the hope of this committee that science is not taught in isolation from the total curriculum. Many of the suggested units can be correlated with language arts, math, social studies, physical education, music, and art. Supplemental units, such as Tangrams, Geo Blocks, and Attribute Games, can be used at every level and should remain in the classroom for a child with free time.

The guide contains a list of resources which is not complete. A teacher may add his own, or if he is developing his own materials, he should list them so that future revisions can make the list more complete. It is hoped that teacher-devised units may find their way to this committee.

Science Curriculum Improvement Study (SCIS) units explore many areas of science, based on both a development of skills and concepts. SCIS maintains active student participation. The vocabulary in these units is more scientific than in many of the other units recommended. SCIS maintains, too, outstanding background information for the teacher. Elementary Science Study (ESS), on the other hand, leaves the teacher to his creative instincts. It is hoped that by contrasting the two types of units, teachers will have an interesting and lively framework for class activities. Some of the units suggested are still in preparation, but are scheduled for commercial publication during the school year 1968-69.

In closing, this committee suggests that manuals and materials be kept in a central location in the school when not actively in use in the classroom.

"I hear and I forget
I see and I remember
I do and I understand."

Education Development Center
Programs Funded by National Science Foundation

American Association for the Advancement of Science (AAAS)
600 Madison Avenue, New York, New York 10022

Elementary-School Science Project (ESSP)
University of Illinois

Educational Development Center, Inc.
55 Chapel Street, Newton, Massachusetts 02160

Science Curriculum Improvement Study (SCIS)
University of California, Berkeley, California 94720

Elementary Science Study (ESS)
Educational Development Center, Inc.
55 Chapel Street, Newton, Massachusetts 02160

Science Curriculum Improvement Study (SCIS)
University of California, Berkeley, California 94720

Minnesota Mathematics and Science Teaching Project (MNMAST)
720 Washington Avenue S.E., Minneapolis, Minnesota 55414

Xerox Corporation
600 Madison Avenue, New York, New York 10022
Phase D

Concepts  When energy and matter change from one form to another, the total amount of energy and matter remains unchanged.
A living thing is the product of its heredity and environment.
The universe is in constant change.

Subconcepts
Matter is characterized by certain properties by which it can be described and classified.
Living things may differ in structure, but they have common needs and similar life activities.
There are daily changes on earth.

Suggested Units

MINNEMAST
Watching and Wondering
Curves and Shapes

MINNEMAST
Describing and Classifying
Using Our Senses

MINNEMAST
Introducing Measurement
Introducing Symmetry
Observing Properties

Teacher-Devised Units

Supplementary Units: Phase D

Supplemental units which meet behavioral objectives of this phase. These units may be used separately or in conjunction with other units.

Elementary Science Study
Mirror Cards
Attribute Games
Pattern Blocks
Tangrams
Geo Blocks
Lights and Shadows
Curious Gerbils
Growing Seeds

American Association for the Advancement of Science  Part A
Teacher-Devised Units
Phase D

Behavioral Objectives

The child should demonstrate the ability to:

- identify a number of objects.
- name similarities and differences based on such characteristics as color, size, shape, weight, smell, texture, taste, temperature, and sound.
- classify objects on the basis of what they do and how they react.
- measure by comparison.
- recognize simple geometric shapes and curves.
- classify spatial relationships in terms of direction: up, down, near, far, right, left.
- exercise intuitive thinking as a result of his experiences with individualized science materials.
- solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Phase I  PHYSICAL SCIENCE

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

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

Subconcepts

1. A net force is needed to start, stop, or change the direction of motion.

2. Energy must be used to set an object in motion.

- 1 Matter is characterized by certain properties by which it can be identified and classified.

- 2 Matter commonly exists as solids, liquids, and gases.

Suggested Units

Science Curriculum Improvement Study
Material Objects

MINNEMAST
Observing Properties

Teacher-Devised Units

Supplementary Units:
Supplemental units which meet behavioral objectives of this phase. These units may be used separately or in conjunction with other units.

MINNEMAST
Introducing Symmetry
Describing Locations
Measurement with Reference Units
Using Our Senses

Elementary Science Study
Attribute Games
Geo Blocks
Creature Cards
Tangrams
Cardboard Carpentry
Mirror Cards
Musical Instrument Recipe Book

American Association for the Advancement of Science
Teacher-Devised Units
Behavioral Objectives

The child should demonstrate the ability to:

- observe and record changes in matter; i.e., metals, gases, woods.
- act upon and experiment with objects in the solid, liquid, and gaseous states.
- describe the relationship between changes in observed properties and a time sequence; i.e., the changing of a solid to a liquid.
- recognize and describe an event or a series of events in terms of their occurrence in time.
- communicate observations by way of charts, graphs, and worksheets, as well as make precise verbal descriptions.
- verify observations by repeating the activity.
- exercise intuitive thinking as a result of his experiences with individualized science materials.
- solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Phase I  LIFE SCIENCE

Concept C - Living things are interdependent with one another and their environment.

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

E - Living things are in constant change.

Subconcepts

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<tr>
<td>C - 1</td>
<td>Living things are affected by their environment.</td>
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<tr>
<td>C - 2</td>
<td>Living things depend on their environment for the conditions of life.</td>
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<td>C - 3</td>
<td>There are characteristic environments, each with its characteristic life. (habitat)</td>
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<td>C - 4</td>
<td>Living things capture matter from the environment and return it to the environment.</td>
</tr>
<tr>
<td>D - 1</td>
<td>Living things may differ in structure but have common needs and similar life activities.</td>
</tr>
<tr>
<td>D - 2</td>
<td>Living things reproduce.</td>
</tr>
<tr>
<td>D - 3</td>
<td>Related living things reproduce in similar ways.</td>
</tr>
<tr>
<td>E - 1</td>
<td>There are different forms of living things.</td>
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<tr>
<td>E - 2</td>
<td>Forms of living things have become extinct.</td>
</tr>
<tr>
<td>E - 3</td>
<td>Living things grow and develop in different environments.</td>
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<tr>
<td>E - 4</td>
<td>The environment is in constant change.</td>
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Suggested Units

Science Curriculum Improvement Study
Organisms

Elementary Science Study
Brine Shrimp
Butterflies
Budding Twigs
Growing Seeds
Curious Gerbils
Eggs and Tadpoles

MINNEAST
Living Things in Field and Classroom (Teacher's Handbook)

Teacher-Devised Units
Phase I  LIFE SCIENCE

Behavioral Objectives

The child should demonstrate the ability to:

- observe changes in living things such as guppies and plants, and describe their properties.
- observe and distinguish between various phases of change; i.e., egg to adult, seed to mature adult.
- recognize that animals have certain characteristics in common: they can move from place to place; they breathe and eat food; they grow and reproduce their own kind.
- recognize interdependency between animals and their environments.
- exercise intuitive thinking as a result of his experience with individualized science materials.
- solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Phase I  

**EARTH SCIENCE**

**Concept F - The universe is in constant change.**

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Behavioral Objectives

The child should demonstrate the ability to:

- manipulate and classify different kinds of objects; i.e., metals, gases, woods, liquids, rocks.
- recognize and describe material objects in his own environment.
- describe the properties of observed objects in terms of shape, color, texture, density, and hardness.
- apply the concept of material to the task of sorting a collection of objects; i.e., rocks, metals.
- communicate observations by way of charts, graphs, and worksheets, as well as make precise verbal descriptions.
- verify observations by repeating the activity.
- recognize and describe an event or a series of events in terms of their occurrence in time.
- arrange similar objects in serial order according to some property; i.e., length, texture, size.
- distinguish between changes of day and night, weather and seasons.
- exercise intuitive thinking as a result of his experience with individualized science materials.
- solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Phase 5 - PHYSICAL SCIENCE

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

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

Subconcepts

A - 1 A net force is needed to start, stop, or change the direction of motion.
A - 2 Energy must be used to set an object in motion. There are many forms of motion.
A - 3 Energy can change from one form to another.
A - 4 Objects interact and show evidence of their interaction.
A - 5 Subsystems store energy and transfer it as changes occur within a system.
A - 6 A whole, its parts, and their interrelationships make up a system.

B - 1 Matter (an object or a thing) is characterized by certain properties by which it can be identified and classified.
B - 2 Matter commonly exists as solids, liquids, and gases.
B - 3 A change in the state of matter is determined by molecular motion.
B - 4 In chemical or physical changes, the total amount of matter remains unchanged.
B - 5 Matter in a system may be mentally or physically subdivided, rearranged, or changed in appearance without destroying the identity of the system so long as no matter is added or omitted.

Suggested Units

Science Curriculum Improvement Study
Interaction

Elementary Science Study
Sink or Float
Drops, Streams, and Containers
Spinning Tables
Changes

MINNEMAST
Investigating Systems

Teacher-Devised Units

Supplementary Units: Phase S
Supplemental units which meet behavioral objectives for this phase. These units may be used separately or in conjunction with other units.

MINNEMAST
Introducing Measurement
Introducing Symmetry
Describing Locations
Measurement with Reference Units

Elementary Science Study
Mirror Cards
Attribute Games
Tangrams
Primary Balancing
Cardboard Carpentry
Structures
Creature Cards
Geo Blocks
Musical Instrument Recipe Book

American Association for Advancement of Science Part C

Teacher-Devised Units
Behavioral Objectives

The child should demonstrate the ability to:

- observe and identify changes in matter as a result of interaction of objects such as battery and bulb, bromothynol blue and vinegar, roller skate and magnet.
- identify solids, liquids, and gases as in a pencil, water, and air.
- use common measurement instruments to compare areas and volumes, scales and units of measurement, relationship of points, lines and angles.
- make two-dimensional drawings of three-dimensional objects.
- recognize and record changes that occur during an experiment such as the interaction of copper chloride and water.
- recognize that the matter in a system is conserved even though the objects change in arrangement or appearance; e.g., the dissolving of a candy sphere in water or the interaction of copper chloride solution and aluminum.
- construct and operate a system; i.e., pulley, electric circuit.

* exercise intuitive thinking as a result of his experience with individualized science materials.
* solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Phase S  LIFE SCIENCE

Concept C - Living things are interdependent with one another and with their environment.
D - A living thing is the product of its heredity and its environment.
E - Living things are in constant change.

Subconcepts

C - 1 Living things depend on their environment for the conditions of life.

C - 2 There are characteristic environments, each with its characteristic life.

C - 3 Living things capture matter from the environment and return it to the environment.

D - 1 Related living things reproduce in similar ways.

D - 2 Living things are related through possession of common structures.

D - 3 A living thing reproduces itself and develops in a given environment.

D - 4 Living things have the capacity to produce an enormous number of offspring.

E - 1 There are different forms of living things.

E - 2 Forms of living things have become extinct.

E - 3 Living things grow and develop in different environments.

Suggested Units

Science Curriculum Improvement Study
Life Cycles

Elementary Science Study
Eggs and Tadpoles
Budding Twigs
Butterflies
Maggots
Erine Shrimp
Curious Gerbils
Growing Seeds
Mosquitoes

Farrington Unit on Plants

KINNEST
Living Things in Field and Classroom
(Teacher's Handbook)

Teacher-Devised Units
Behavioral Objectives

The child should demonstrate the ability to:

- observe and distinguish characteristic changes in the life cycle of living things such as frogs, budding twigs, butterflies, mealworms, plants, and crickets.
- observe and classify living and non-living objects.
- identify environments that are necessary for the growth and development of living things.
- exercise intuitive thinking as a result of his experience with individualized material.
- solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Phase S  EARTH SCIENCE

Concept F - The universe is in constant change.

Subconcepts

F - 1 There are daily changes on earth.

F - 2 There are regular movements of the earth and the moon.

Suggested Units

Elementary Science Study
Where Is the Moon?
Mobiles
Rocks and Charts
Lights and Shadows
Sand

Talcott Mountain Science Center
Rocks
Volcanoes

Children's Museum Planetarium

Teacher-Devised Units
Behavioral Objectives

The child should demonstrate the ability to:

- observe and record changes in spatial relationships of light and shadows; moon, planets, sun, and earth.
- observe and classify rocks.
- identify a number of time intervals such as minutes, hours, days, weeks, months, seasons, and years.

* exercise intuitive thinking as a result of his experiences with individualized science materials.
* solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Phase C  PHYSICAL SCIENCE

Concept A - When energy changes from one form to another, the total amount of energy remains unchanged.
B - When matter changes from one form to another, the total amount of matter remains unchanged.

Subconcepts

A - 1 Energy can change from one form to another.
A - 2 A loss or gain of energy affects molecular motion.
A - 3 Systems contain subsystems, or systems contained within another system.
A - 4 Objects interact and show evidence of their interaction.
A - 5 Subsystems store energy and transfer it as changes occur within a system.

B - 1 Matter is characterized by certain properties by which it can be identified and classified.
B - 2 Matter commonly exists as solids, liquids, and gases.
B - 3 A change in the state of matter is determined by molecular motion.
B - 4 In chemical change, atoms react to produce change in molecules.
B - 5 In chemical and physical changes, the total amount of matter remains unchanged.
B - 6 Matter in a system or subsystem may be mentally or physically subdivided, rearranged, or changed in appearance without destroying the identity of the system or subsystem so long as no matter is added or omitted.

Suggested Units

Science Curriculum Improvement Study
Systems and Subsystems

LINNHEAST
Investigating Systems
Exploring Symmetrical Patterns

Elementary Science Study
Mystery Powders
Changes
Drops, Streams, and Containers
behavioral Objectives
The child should demonstrate the ability to:

- measure by using common units of measure such as inches, centimeters, quarts, or records.
- measure values and record length, area, volume, time duration, and time order.
- use symbols for comparisons and apparent equalities.
- make distinctions among perimeters, areas, and volumes.
- use centimeter and inch grid sheets.
- recognize variables; identify their effects, such as temperature, time intervals, nature, and number of objects in a system, distance and time; and control these variables.
- record data by use of histograms.
- recognize observable changes within a system as evidence of interaction.
- manipulate a number of materials: magnets, syringes, vials, and electric circuits.
- recognize that systems of another system make up subsystems.
- identify connected subsystems in a system of electric circuits.
- distinguish a solution from other mixtures.
- separate undissolved solid substances from a liquid by a filtering process.
- predict that dissolved solid materials can be recovered from a solution by evaporation.
- obtain crystals from a solution by evaporation.
- identify the residue of solutions after evaporation.
- construct different systems and subsystems.
- recognize different sources of energy.
- describe melting of solids, boiling and evaporation of liquids, and liquefying of gases.
Suggested Units

Sand

Sink or Float

Teacher-Devised Units

Supplementary Units: Phase C

Supplementary units which meet behavioral objectives for this phase. These units may be used separately or in conjunction with other units.

Elementary Science Study

- Trigrams
- Creature Cards
- Attribute Games
- Structures
Behavioral Objectives

associate a certain fixed temperature with melting.

Distinguish between samples of liquid Freon and water.

Plan and conduct experiments where one variable is changed.

Compare properties of sand to those of other substances.

Use sand to time, count, measure, and weigh.

Explore color and texture in making of pictures, sculpture, and jewelry.

Observe that the balance act is dependent on the properties of the objects which are being weighed.

Order objects in his environment according to their weight.

Sort objects which float and sink by changing a variable.

Devise ways to make objects that float, sink, and those that sink, float.

* Exercise intuitive thinking as a result of his experiences with individualized science materials.

* Solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Subconcepts

Suggested Units

Mirror Cards
Cardboard Carpentry

The Chemistry of a Lemon
The Chemistry of Soap
Plants Are Like That
Puttering with Paper
Rocks and Rills
Take a Balloon

American Association for Advancement of Science Part
Phase C  PHYSICAL SCIENCE

Behavioral Objectives
Phase C  LIFE SCIENCE

Concept C - Living things are interdependent with one another and with their environment.
D - A living thing is the product of its heredity and its environment.
E - Living things are in constant change.

Subconcept:
C - 1 Living things depend on their environment for the conditions of life.
C - 2 There are characteristic environments, each with its characteristic life.
C - 3 Living things capture matter from the environment and return it to the environment.
C - 4 Living things are dependent on a particular environment.
C - 5 The capture of radiant energy by green plants is basic to the growth and maintenance of all living things.
C - 6 A number of similar organisms living and reproducing in a given area make up a population.
C - 7 The relationship of different populations living in the same area makes up a community.

D - 1 Related living things reproduce in similar ways.
D - 2 Living things are related through possession of common structure.
D - 3 A living thing reproduces itself and develops in a given environment.
D - 4 Living things have the capacity to produce an enormous number of offspring.
D - 5 Living things tend to overpopulate.

Suggested Units
Science Curriculum Improvement Study
Populations

Elementary Science Study
Pond Water
Euglena
Peas and Particles
Eggs and Tadpoles

Farmington Unit on Plants

MINNEFAST
Living Things in Field and Classroom

Teacher-Devised Units
Behavioral Objectives

The child should demonstrate the ability to:

- identify various populations of living things and explain how and why they comprise a community.
- recognize that different populations of plants and animals live together in the same area.
- recognize that numbers of organisms in any one population can increase or decrease and that the change in numbers is dependent on two factors: (1) reproduction within each population, and (2) relations among different populations.
- state and demonstrate the difference between predator (hydra) and prey (Daphnia).
- recognize that populations of living things (dragonfly nymphs) compete for food.
- recognize that duckweed plants grow from an older larger duckweed plant in a type of budding.
- make conclusions as a result of evidence obtained by his experiments.
- construct a complex terrarium.
- recognize that the source of all human food is either plant or animal.
- identify and classify organisms under the categories "plant-eater" and "animal-eater."
- identify parts of a plant.
- record observations of living things by drawing pictures.
- recognize some ways in which predators catch their prey (keen eyesight and swift, decked teeth) and some ways in which prey escape being eaten (hiding, flying away, freezing).
- recognize that some animals are both predator and prey.
- illustrate predator-prey relations, by a drawing.
- identify the linear food relationship among animal-eaters, plant-eaters, and plants.
Phase C  LIFE SCIENCE

Subconcepts

E - 1 There are different forms of living things.
E - 2 Forms of living things have become extinct.
E - 3 Living things grow and develop in different environments.
E - 4 The environment is in constant change.
E - 5 Living things living in an environment compete for food.

Suggested Units

MNNEMAST
Exploring Symmetrical Patterns
recognize that green plants are the origin of all food chains.

recognize that a population would increase rapidly if reproduction continued normally without any deaths.

recognize that food chains interconnect to form a food web.

construct a complex aquarium.

count organisms in a population.

record on charts numbers of organisms in a given population.

prepare hypothesis about causes for the disappearance or growth of living things in a population and community.

design experiments to test hypothesis about causes for the disappearance or growth of living things in a population or community.

discuss and describe his observations of life in aquaria and terraria.

present and discuss findings as a result of his experimenting.

observe feeding behavior of aquaria and terraria animals.

use various instruments to assist in observation, including microscopes, hand lenses, medicine droppers, etc.

infer that mother plants are offspring from larger parent plants of the same species.

recognize symmetry in nature, music, poetry, and art.

recognize turning symmetry (rotational symmetry), repeating patterns (translational symmetry), and symmetry about a line (bilateral symmetry).
Subconcepts

Suggested Units

Exploring Symmetrical Patterns
Behavioral Objectives

- make the necessary tests and comparisons for the three types of symmetry studied.
- exercise intuitive thinking as a result of his experiences with individualized science materials.
- solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Phase C  EARTH SCIENCE

Concept F - The universe is in constant change.

Subconcepts

F - 1 There are daily changes on earth.
F - 2 There are regular movements of the earth and the moon.
F - 3 The motion and path of celestial bodies are predictable.
F - 4 Position and motion of an object can be perceived, described, and recognized only with reference to other nearby objects.
F - 5 Position and motion are relative to reference points.

Suggested Units

Science Curriculum Improvement Study
Relativity

MINNEAST
Describing Locations
Measurement with Reference Units

Elementary Science Study
Spinning Tables

Teacher-Devised Units
Behavioral Objectives

The child should demonstrate the ability to:

- discriminate small differences in relative position, distance, direction, and arrangement of objects.
- be independent in organizing a problem.
- describe the position of objects or systems in the classroom.
- state and demonstrate that objects used to help describe other objects are called "reference objects."
- describe position relative to himself.
- describe position relative to other objects.
- describe position of objects or systems relative to another system.
- use composite terms for describing directions.
- construct reference frames from paper.
- measure distances by use of paces.
- identify the direction from which the picture of a system was taken.
- identify relative position of objects from a photograph.
- use a specified reference frame for describing relative position.
- describe position by use of landmarks.
- recognize and describe changes of relative position.
- interpret changes of relative position as relative motion.
- choose reference frames for the description of relative motion.
Phase 6

Earth Science

Subconcepts

Suggested Units

- Elementary Science Study
- Mobiles
- Optics
- Rocks and Charts
- Where Is the Moon?
- Sand
Phase C  

**Behavioral Objectives**

- recognize and describe relative motion qualitatively.
- choose reference frames for describing relative motion.
- make pictorial representations of relative motion.
- measure by using reference standards such as clips, corks, and pendulums.

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- experiment with balance by making constructions that are pleasing to the eye.

---

- recognize and analyze properties of light by direct experiments.
- recognize the interaction of light with transparent objects and objects that act as mirrors.

---

- observe and classify rocks.
- communicate observations by way of charts, graphs, and worksheets, as well as make precise verbal descriptions.

---

- observe and record changes in spatial relationships of light and dark; moon, planets, sun, and earth.

---

- compare properties of sand to those of other substances.
- use sand to time, count, measure, and weigh.
- explore color and texture in making of pictures, sculpture, and jewelry.
Phase C  EARTH SCIENCE

Subconcepts

Suggested Units

Talcott Mountain Science Center
Rocks
Volcanoes

Children's Museum Planetarium
Behavioral Objectives

* exercise intuitive thinking as a result of his experience with individualized science materials.

* solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.
PHYSICAL SCIENCE

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

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

Subconcepts

A - 1 Energy must be used to set an object in motion.

A - 2 Energy can change from one form to another.

A - 3 A loss or gain of energy affects molecular motion.

A - 4 Energy must be applied to produce an unbalanced force, resulting in motion or change of motion.

B - 1 A change in the state of matter is determined by molecular motion.

B - 2 Matter consists of atoms and molecules.

B - 3 In chemical or physical changes, the total amount of matter remains unchanged.

Suggested Units

Science Curriculum Improvement Study
Position and Motion
Approaches to Equilibrium (In preparation)

Elementary Science Study
Pendulums
Spinning Tables
Optics

Elementary Science Study
Gases and Airs

Elementary Science Study
Whistles and Strings

Elementary Science Study
Balancing
Phase 0  PHYSICAL SCIENCE

Behavioral Objectives

The child should demonstrate the ability to:

- use rectangular coordinates to describe position.
- infer properties of motion from tracks left by moving objects.
- analyze and describe tracks made by spheres colliding with each other and with fixed objects.

- devise simple experiments which indicate the presence of air.
- collect evidence of the interaction of objects with air.
- conduct experiments involving the use of controls, such as experiments with steel wool and "candle air" compared with "room air," and identify variables which are manipulated and those which are constant.

- construct a simple stringed instrument and play a simple tune, using the instrument.
- investigate tubes that make sounds when blown into and experiment with these materials to make different sounds.

Identify problems involving balance and make use of various strategies to solve the problems.

Understand intuitively moments of force and center of mass.

Predict outcomes in terms of asymmetric balance and counterbalance.
Supplemental Units:

- Elementary Science Study
  - Sink or Float

- Elementary Science Study
  - Mystery Powders

- Elementary Science Study
  - Solids and Solutions

- Talcott Mountain Science Center
  - Light Spectra

Teacher-Devised Units

Supplementary Units: Phase 0

Supplementary units which meet behavioral objective for this phase. These units may be used separately or in conjunction with other units.
Phase 0 PHYSICAL SCIENCE

Behavioral Objectives

1. Observe that the balance act is dependent on the properties of the objects which are being weighed.
2. Order objects in his environment according to their weight.
3. Sort objects which float and sink by changing a variable.
4. Devise ways to make objects that float, sink and those that sink, float.

- Identify properties of various substances by taste, smell, touch, and comparison with known substances.
- Use indicators to detect the presence of certain substances such as heat, iodine, and vinegar.
- Record and chart the results of experiments with various substances.
- Identify the composition of some mixtures by using various indicators.

- Predict and verify through experiment the solids which dissolve in water and those which do not.
- Determine how much salt will dissolve in a given amount of water.
- Observe and predict changes of the water level when solids dissolve in water.

* Exercise intuitive thinking as a result of his experiences with individualized science materials.
* Solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Supplementary Units: Phase 0

MINNELEAST
- Describing Locations
- Measurement with Reference Units

Elementary Science Study
- Attribute Games
- Creature Cards
- Mirror Cards
- Tangrams
- Peas and Particles
- Pattern Blocks
- The Chemistry of a Lemon
- The Chemistry of Soap
- The Last Tree Bird
- Plants Are Like That
- Puttering with Paper
- Rocks and Rills
- Take a Balloon
Phase 0  PHYSICAL SCIENCE

Behavioral Objectives
Concept C - Living things are interdependent with one another and with their environment.
D - A living thing is the product of its heredity and its environment.
L - Living things are in constant change.

Subconcepts
1. Living things depend on their environment for the conditions of life.
2. There are characteristic environments, each with its characteristic life.
3. Living things capture matter from the environment and return it to the environment.
4. The capture of radiant energy by green plants is basic to the growth and maintenance of all living things.
5. Living things are adapted by structure and function to their environment.
6. Green plants get the matter for growth from water, soil, and air.

- 1 Living things are related through possession of common structure.
- 2 A living thing reproduces itself and develops in a given environment.
- 3 An organism needs food for growth.
- 4 All living things have inborn behavior that adapts them to their environment.

Suggested Units
Science Improvement Curriculum Study
Environmental Influence
Elementary Science Study
Brine Shrimp
Behavior of Mealworns
Frog Water
Euglena
Butterflies
Mosquitoes
Eggs and Tadpoles
Growing Seeds
Curious Gophers
Pudding Twigs
Microgardening
Crabfish

Farmington Unit on Plants

Further
Living Things in Field and Classroom
Elementary Science Study Changes
Behavioral Objectives

The child should demonstrate the ability to:

- prepare slides for use under a microscope and use the process of staining.
- observe and record the structure, habits, and locomotion of an organism such as a realworm.
- conduct experiments exploring the response of an organism to a certain stimulus.
- report the behavior of an organism such as a realworm to experiments in following an obstacle course.

- identify some of the plants and animals found in ponds and observe the interactions of these plants and animals.

- discuss things that change and make some prediction about what will happen to things that are left alone.

- list his predictions of the ways in which things will change if put into containers.

- identify types of changes occurring.
D - 5 Behavior may be inborn or learned.
D - 6 A living thing may be adapted to different environments.

E - 1 Living things develop and grow in different environments.
E - 2 The environment is in constant change.
E - 3 Living things have changed over the ages.
behavioral Objectives

understand natural changes with things that change without man's intervention.

understand that growth and decay are part of the same cycle of life.

discuss, record, and classify some changes.

understand that timing is involved in spontaneous changes.

exercise intuitive thinking as a result of his experience with individualized science materials.

solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
EARTH SCIENCE

Concept F - The earth is in constant change.

Subconcepts

F - 1 There are regular movements of the earth and the moon.
F - 2 The motion and path of celestial bodies are predictable.
F - 3 The point or area in space actually occupied by a physical object or into which it is placed is its position.
F - 4 Objects change place or position.
F - 5 Position and motion of an object can be perceived, described, and recognized only with reference to other nearby objects.
F - 6 Position and motion are relative.

Suggested Units

Science Curriculum Improvement Study
Position and Motion

Elementary Science Study
Where Is the Moon?

Mapping
Behavioral Objectives

The child should demonstrate the ability to:

- identify and use measurement of distance in miles, centimeters, and millimeters and measurement of direction in terms of degrees.
- use rectangular coordinates to describe position.
- infer properties of motion from tracks left by moving objects.
- describe tracks by using rectangular coordinates.
- analyze and describe tracks made by spheres colliding with each other and with fixed objects.
- identify and record regular movements of the earth and the moon.
- observe and record changes in special relationships of light and shadows; moon, planets, sun, and earth.
- identify a number of time intervals such as minutes, hours, days, weeks, months, seasons, and years.
- describe his environment through the use of symbols, grids, and landmarks.
- map various land features such as hills, streams, and cliffs.
- represent three dimensions in two.
- show the relative position of objects in space.
- estimate shape and size of objects in the environment.
- make scale drawings.
Subconcepts

Suggested Units

Optics

Science Research Associates
Earth's Atmosphere Laboratory
Weather and Climate Laboratory
Solar System Laboratory

KIRIEAST
Describing Locations
Measurement with Reference Units

Talcott Mountain Science Center
Stars
Planets

Children's Museum Planetarium
Teacher-Devised Units
Behavioral Objectives

recognize and analyze properties of light by direct experiments.

recognize the interaction of light with transparent objects and objects that act as mirrors.

exercise intuitive thinking as a result of his experiences with individualized science materials.

solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Concept A - When energy changes from one form to another, the total amount of energy remains unchanged.

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

Subconcepts

A - 1 Energy can change from one form to another.
A - 2 A loss or gain of energy affects molecular motion.
A - 3 Energy must be applied to produce an unbalanced force, resulting in motion or change of motion.
A - 4 The amount of energy gotten out of a machine does not exceed the energy put into it.
A - 5 To move an object, energy must be applied to overcome the pull of gravitation.
A - 6 Every action has an equal and opposite reaction.

B - 1 Matter commonly exists as solids, liquids, and gases.
B - 2 Matter consists of atoms and molecules.
B - 3 A change in the state of matter is determined by molecular motion.
B - 4 In chemical change, atoms react to produce change in the molecules.
B - 5 In chemical or physical changes, the total amount of matter remains unchanged.
B - 6 In nuclear reactions a loss of matter is a gain in energy. The sum of matter and energy remains constant.
B - 7 When any two parts of a system behave differently when treated with the same test substance, they are not the same kind of material, nor are they the same phase.
The child should demonstrate the ability to:

apply the concept phase of matter to materials he judges to be uniform and homogeneous.

apply schlieren tests and drop tests as evidence of uniformity or lack of uniformity in liquids and for the existence of one or more phases.

recognize volume and mass as measures of amount of substance and apply them in making solutions reproducibly.

recognize new phases forming when solutions are mixed.

recognize reproducibility in reactions between solutions.

apply concentration as a measure of relative amounts of the components in a solution.

relate the color of cobalt chloride in water solution both to the concentration and to the total amount of the cobalt chloride in the solution.

compare the weight of some systems before and after reactions producing new phases.

distinguish between the solids and solutions which are electrical conductors and those which are not.

recognize the forming of new phases at electrodes in electrically conducting liquids.

recognize different kinds of gases and identify several kinds by their reactions with test substances.

expect conservation of matter in gas-producing reactions as well as in other reactions.

recognize some gaseous solutions.
PHYSICAL SCIENCE

Subconcepts

Suggested Units

Energy (In preparation)

Elementary Science Study
Batteries and Bulbs
Behavioral Objectives

- Use what he has already learned to make predictions.
- Investigate at his own rate in the direction dictated by the materials and by the limits of his imagination.
- Make generalizations that come out of his actual experience with the materials. (For example, a coil of wire in a complete electrical circuit acts as a magnet.)
- Check his experiments, compare, discuss results, and propose explanations.
- Evaluate his predictions upon completion of experiments to find out new ways to use familiar learnings.
- Use wire stripper, compass, magnets, electromagnets, prediction sheets, and galvanometers.
- Understand how circuits function by wiring and drawing simple and complex circuits, using standard symbols.
- Invent or improvise materials needed for experiments.
- Predict what will happen in a standard-symbol diagram of circuits and check his prediction by constructing the circuit.
- Chart and graph experiment results to show comparisons of various combinations of wire, bulbs, and batteries.
- Construct a simple battery and bulb.
- Develop standards for comparison. (For example, brightness of bulbs)
Phase V  PHYSICAL SCIENCE

Subconcepts

Suggested Units

Kitchen Physics
Sink or Float
Dipping Birds

Pendulums
Behavioral Objectives

perform experiments to isolate and explore the nature of some properties of liquid.

identify these properties and formulate ideas about them.

observe, formulate questions, make predictions, design and perform experiments, collect and analyze data.

recognize and correct earlier misconceptions.

assemble and use simple equipment, such as a balance, tensiometer, and hydrometer.

assemble equipment by using directional worksheets.

accept uncertainty and some unsolvable questions.

make comparisons that require the use of balances and the measurement of volumes.

use balances to check his notions of relative weights of objects in the classroom.

observe that the balance act is dependent on the properties of the objects which are being weighed.

order objects in his environment according to their weight.

sort objects which float and sink by changing a variable.

devise ways to make objects that float, sink and those that sink, float.

identify and analyze simple properties of pendulums.

recognize objects in his environment that demonstrate the principles of pendulums.

demonstrate the loss of motion and transfer of energy through the use of pendulums.

construct pendulums and devise experiments that might offer solutions to problems.

take measurements, using standard units of measure.

devise his own measurement tools for comparison.
Suggested Units

Mystery Powders

Gases and Airs

Balloons

Ice Cubes
Heating and Cooling
Colored Solutions
Teacher-Devised Units
Phase V  PHYSICAL SCIENCE

Behavioral Objectives

Identify properties of various substances by taste, smell, touch, and comparison with known substances.

Use indicators to detect the presence of certain substances such as heat, iodine, and vinegar.

Record and chart the results of experiments with various substances.

Identify the composition of some mixtures by using various indicators.

Conduct experiments involving the use of controls.

Identify variables which are manipulated and those which are constant.

Prepare and collect gases.

Identify properties of gases.

Devise tests which enable him to distinguish between common gases.

Identify and demonstrate the effect of different surrounding atmospheres on the weight of gases.

Determine sources of carbon dioxide.

Use histograms, charts, and tables to record weights of gases and liquids.

Construct simple weighing devices.

Exercise intuitive thinking as a result of his experience with individualized science materials.

Solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Supplementary Units: Phase V

Supplemental units which meet behavioral objectives for this phase. These units may be used separately or in conjunction with other units.

Elementary Science Study
- Whistles and Strings
- Mirror Cards
- Attribute Games
- Creature Cards
- Tangle Trimmers
- Structures
- The Chemistry of a Lemon
- The Chemistry of Soaps
- The Last Tree Bird
- Plants Are Like That
- Puttering with Paper
- Rocks and Hills
- Take a Balloon

Teacher-Devised Units
Phase V  PHYSICAL SCIENCE

Behavioral Objective:
Phase V  LIFE SCIENCE

Conceot C - Living things are interdependent with one another and with their environment.

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

E - Living things are in constant change.

Subconcepts  Suggested Units

C - 1  Living things depend on their environment Suggested Units
      for the conditions of life.
      Elementary Science Study
      Zones

C - 2  Living things capture matter from the
      environment and return it to the environment.

C - 3  The capture of radiant energy by green plants
      is basic to the growth and maintenance of all
      living things.

C - 4  All living things depend on a continuous supply
      of oxygen.

D - 1  Living things are related through possession
      of common structure.

D - 2  A living thing reproduces itself and develops
      in a given environment.

D - 3  The cell is the unit of structure and function;
      a living thing develops from a single cell.

D - 4  Cells are specialized for different functions.

D - 5  Cells reproduce themselves.
Phase V    LIFE SCIENCE

Behavioral Objectives

The child should demonstrate the ability to:

- identify and classify different kinds of bones according to their function and structure.
- associate bones and the size of animals from which they originated.
- use scientific names of bones.
- assemble a skeleton from a pile of bones.
- make precise verbal descriptions of bones and their functions.
- make two-dimensional drawings of three-dimensional objects.
- devise projects and experiments on assembling bones into skeletons.
- prepare bones (cooking) for assembling.
- dissect a small animal (fish).
- identify bones from owl pellets.
- recognize the function and location of joints in humans and animals.
- manipulate bones and devise experiments that lead to tentative conclusions about bone structure and function.
- make gross recognition of various bone structures through the use of x-rays.
- identify and classify bones (mammals, birds, reptiles, etc.).
- recognize the connection between an animal's diet and its tooth structure.
Subconcepts

E - 1 Living things grow and develop in different environments.

E - 2 The environment is in constant change.

E - 3 Living things have changed over the ages.

E - 4 The adaptation of an animal to its environment can be understood by relating bone structure to the function served.

E - 5 The single-celled organisms that developed in the early seas gave rise to the many-celled organisms of later ages. Adaptation to the environment produced more complex structures.

Suggested Units

Small Things

Pond Water
Euglena

Eggs and Nymphs
Butterflies
Mosquitoes
Phase V  LIFE SCIENCE

Behavioral Objectives

use a simple and a compound microscope.
prepare a specimen for viewing.
use stains to assist in distinguishing cell structure.
investigate and compare cell structures and their functions.
examine a variety of living and non-living substances and decide which ones are composed of cells.
assemble and use a simple balance.
measure amounts of water contained in some materials.
compare and contrast experimental findings with those of his classmates.
determine how much growth of yeast cells has occurred during a specific time period.

identify and describe individual animals and plants that live in pond water.
device experiments that test the effect of various stimuli on pond-water life and report his findings accurately.
recognize the complicated interaction of living things such as demonstrated by pond-water organisms.
observe and identify stages in life cycles of various organisms.

ask questions that he can answer from his own observations.
recognize the relationship of the growing tadpole, frog, or insect to its environment.
Subconcepts

Suggested Units

Earthworms

Microgardening

Crabfish

Farming Unit on Plants
Phase V  LIFE SCIENCE

Behavioral Objectives

prepare slides for use under the microscope and use the process of staining.

observe and record the structure, habits, and locomotion of the organism.

conduct experiments exploring the response of an organism to various stimuli.

recognize the complicated interaction of living things such as demonstrated by molds.

observe and grow molds and bacterial colonies.

recognize that molds and bacteria are extremely small microorganisms that reproduce and carry on all the life processes.

examine the details of mold structure and make comparisons among different kinds of molds.

set up experiments, sorting variables and using controls, to show the factors that influence the growth of molds.

recognize that a social order exists with crayfish.

infer that a social order exists with other animals.

observe feeding habits of crayfish and distinguish parts used in eating.

design experiments to test behavior of crayfish.

identify the life cycle of crayfish.

identify similarities and dissimilarities in sizes and shapes of leaves, stems, and roots.

recognize differences in color, shades, and patterns.
Phase V    LIFE SCIENCE

Subconcepts

Suggested Units
Farmington Unit on Plants (continued)
Behavioral Objectives

recognize differences in texture, such as: rough, smooth, moist, dry, fuzzy, prickly, slippery, sticky.

recognize differences in odor and taste (caution).

classify regularities or sets of leaves, stems, and roots.

use standard units and tools of measurement.

use a self-designed system of measurement.

use units of measurement to measure space/time relationships in leaves, stems, and roots.

make oral, written, and graphic descriptions about leaves, stems, and roots.

identify the subjectivity and limitations of data.

make tentative conclusions about leaves, stems, and roots based on strong circumstantial evidence.

identify problems related to leaves, stems, and roots and set up procedures to test inferences.

identify results in support or rejection of hypotheses about leaves, stems, and roots.

recognize the need to modify testing procedures when required.

make predictions based on objective data and testing of leaves, stems, and roots.

apply processes and concepts to unfamiliar situations.

observe similarities and dissimilarities in the different types of life processes.

identify the parts of a plant where the life processes occur.

classify plants in terms of similarities and differences in life processes and structure.

use measuring units and tools to evaluate life processes.
Phase V
LIFE SCIENCE

Subconcepts

Suggested Units

Science Curriculum Improvement Study
Food (Energy) Transfer (in preparation)

METHIST
Living Things In Field and Classroom

Teacher-Devised Units
Phase V  LIFE SCIENCE

Behavioral Objectives

- make accurate oral, written, and graphic descriptions of life processes.
- identify the subjectivity and limitations of data concerning life processes.
- make tentative conclusions about life processes based on strong circumstantial evidence.
- identify problems related to life processes and set up procedures to test inferences.
- identify the results of testing for life processes in support or rejection of hypotheses.
- recognize the need to modify testing procedures when necessary.
- make predictions based on objective data and testing of life processes.
- apply processes and concepts to unfamiliar areas.

- exercise intuitive thinking as a result of his experiences with individualized science materials.
- solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Phase V  EARTH SCIENCE

Concept F - The universe is in constant change.

Subconcepts

F - 1 There are regular movements of the earth and the moon.

F - 2 There are seasonal and annual changes within the solar system.

F - 3 Motion and path of celestial bodies are predictable.

F - 4 Bodies in space (as well as their matter and energy) are in constant change.

Suggested Units

Elementary Science Study Project
Charting the Universe

The Universe in Motion
Phase V  EARTH SCIENCE

Behavioral Objectives

The child should demonstrate the ability to:

- estimate size and distance without the use of direct measurement.
- make a scale drawing as a representation of a real object or objects; i.e., the solar system.
- develop his own system for measuring distance.
- use a compass, protractor, range finder, and telescope.
- solve for an unknown circumference, diameter, or radius.
- sight objects from two fixed points.
- estimate the daily motion of the sun, moon, and planets.
- recognize that everything in the universe moves.
- locate an object or a specific point on the earth or in space, using compass direction and angular height.
- plot the motions of the moon and the sun.
- recognize some of the major constellations.
- use a star map and gnomon.
- draw ellipses.
- measure in astronomical units, charts, and tables.
- state and demonstrate laws of planetary motion.
Suggested Units

The Universe in Motion (continued)

Elementary Science Study
Optics

Elementary Science Study
Mapping
Outdoor Mapping

Elementary Science Study
Where Is the Moon?
Behavioral Objectives

state and demonstrate the differences between straight-line motion and curved motion.
identify the colors of a continuous spectrum and an absorption spectrum.
describe the sun's function and structure.
identify behaviors of light and demonstrate their effect on astronomical phenomena by use of the spectroscope.
describe the characteristics of a star.
recognize and analyze properties of light by direct experiment.
recognize the interaction of light with transparent and reflective objects.
describe his environment through the use of symbols, grids, and landmarks.
map various land features such as hills, streams, and cliffs.
represent three dimension in two-dimensional form.
show the relative positions of objects in space.
estimate shape and size of objects in his environment.
make scale drawings.

observe and record changes in spacial relationships of light and shadows; moon, planets, sun, and earth.
observe that there is an order and regularity of the stars, planets, sun, and moon.
record the movements of the moon, using as reference points familiar objects in his environment.
**Sub-concepts**

- Elementary Science Study
  - Rocks and Charts

- Elementary Science Study
  - Snowflakes

- Scientific Research Association
  - Earth’s Atmosphere Laboratory
  - Weather and Climate Laboratory
  - Solar System Laboratory

- Talcott Mountain Science Center
  - Astronomy
  - Geology
  - Meteorology

- Children’s Museum Planetarium

**Teacher-Derived Units**
Behavioral Objectives

- observe and classify rocks.
- communicate observations by way of charts, graphs, and worksheets, as well as make precise verbal descriptions.
- exercise intuitive thinking as a result of his experiences with individualized science materials.
- solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Phase E  PHYSICAL SCIENCE

Concept  A - When energy changes from one form to another, the total amount of energy remains unchanged.
        B - When matter changes from one form to another, the total amount of matter remains unchanged.

Subconcepts

A - 1  Energy can change from one form to another.
A - 2  A loss or gain of energy affects molecular motion.
A - 3  Energy must be applied to produce an unbalanced force, resulting in motion or change of motion.
A - 4  The amount of energy gotten out of a machine does not exceed the energy put into it.
A - 5  The energy gotten out of moving electrons is never greater than the energy put into making electrons move through a circuit.
A - 6  A transfer of electrons from one object to another gives them potential energy; when the electrons move, they have kinetic energy.

I - 1  In chemical change, atoms react to produce change in the molecules.
P - 2  In chemical or physical changes, the total amount of matter remains unchanged.
B - 3  A loss of matter is a gain in energy. The sum of the matter and energy remains constant.

Suggested Units

Science Curriculum Improvement Study
Electricity (in preparation)
Gravitation (In preparation)
Periodic Motion (in preparation)  
Elementary Science Study
Batteries and Bulbs
Phase E  PHYSICAL SCIENCE

Behavioral Objectives

The child should demonstrate the ability to:

- use what he has already learned to make predictions.
- investigate at his own rate in the direction dictated by the materials and by the limits of his imagination.
- make generalizations that come out of his actual experience with the materials. (For example, a coil of wire in a complete electrical circuit acts as a magnet.)
- check his experiments, compare, discuss results, and propose explanations.
- evaluate his predictions upon completion of experiments to find out new ways to use familiar learnings.
- use wire stripper, compass, magnets, electromagnets, prediction sheets, and galvanometers.
- understand how circuits function by wiring and drawing simple and complex circuits, using standard symbols.
- invent or improvise materials needed for experiments.
- predict what will happen in a standard-symbol diagram of circuits and check the prediction by constructing the circuit.
- chart and graph experiment results to show comparisons of various combinations of wire, bulbs, and batteries.
- construct a simple battery and bulb.
- develop standards for comparison (for example, brightness of bulbs).
Subconcepts

Suggested Units
- Kitchen Physics
- Sink or Float
- Dipping Birds

Advanced Units
- Bobbing Birds
- Balancing Beads
- Ziggurat Zingers
Behavioral Objectives

- perform experiments to isolate and explore the nature of some properties of liquid.
- identify these properties and formulate ideas about them.
- observe, formulate questions, make predictions, design and perform experiments, collect and analyze data.
- recognize and correct earlier misconceptions.
- assemble and use simple equipment, such as a balance, tensiometer, and hydrometer.
- assemble equipment by using directional worksheets.
- accept uncertainty and some irresolvable questions.
- make comparisons that require the use of balances and the measurement of volumes.
- use balances to check his notions of relative weights of objects in the classroom.
- observe that the balance act is dependent on the properties of the objects which are being weighed.
- order objects in his environment according to their weight.
- sort objects which float and sink by changing a variable.
- devise ways to make objects that float, sink and those that sink, float.
- identify and analyze simple properties of pendulums.
- recognize objects in his environment that demonstrate the principles of pendulums.
- demonstrate the loss of motion and transfer of energy through the use of pendulums.
- construct pendulums and devise experiments that might offer solutions to problems.
- make measurements, using standard units of measure.
- devise his own measurement tools for comparison.
Phase E  PHYSICAL SCIENCE

Subconcepts

Suggested Units

Optics

Gases and Airs

Balloons

Teacher-Devised Units

Supplementary Units: Phase E

Supplemental units which meet behavioral objectives for these phases. These units may be used separately or in conjunction with other units.

Elementary Science Study
Balancing
Mobiles
Whistles and Strings
Mirror Cards
Attribute Games
Phase E   PHYSICAL SCI ENCE

Behavioral Objectives

- recognize and analyze properties of light by direct experiment.
- recognize the interaction of light with transparent and reflective objects.
- conduct experiments involving the use of controls.
- identify variables which are manipulated and those which are constant.
- prepare and collect gases.
- identify properties of gases.
- devise tests which enable him to distinguish between common gases.
- identify and demonstrate the effect of different surrounding atmospheres on the weight of gases.
- determine sources of carbon dioxide.
- use histograms, charts, and tables to record weights of gases and liquids.
- construct simple weighing devices.

* exercise intuitive thinking as a result of his experiences with individualized science materials.
* solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Supplementary Units:  Phase E

Elementary Science Study (continued)
Creature Cards
Tangrams
Structures
The Chemistry of a Lemon
The Chemistry of Soap
The Last Tree Bird
Plants Are Like That
Puttering with Paper
Rocks and Hills
Take a Balloon

Teacher-Devised Units
Phase 5  Physical SCIENCE

Behavioral Objectives
Phase E  LIFE SCIENCE

Concept C - Living things are interdependent with one another and with their environment.
D - A living thing is the product of its heredity and environment.
E - Living things are in constant change.

Subconcepts

C - 1. Living things capture matter from the environment and return it to the environment.
C - 2. The capture of radiant energy by green plants is basic to the growth and maintenance of all living things.
C - 3. Living things are adapted by structure and function to their environment.
C - 4. Bacteria and plants without chlorophyll depend on other organisms for their food.

C - 1. A living thing reproduces itself and develops in a given environment.
C - 2. The cell is the unit of structure and function; a living thing develops from a single cell.
C - 3. The characteristics of a living thing are laid down in a genetic code.

C - 1. Living things grow and develop in different environments.
C - 2. The environment is in constant change.
C - 3. Living things have changed over the ages.
C - 4. Changes in the genetic code produce changes in living things.

Suggested Units

Science Curriculum Improvement Study
Ecosystem (In preparation)
Natural Selection (In preparation)

Elementary Science Study
Small Things

Microgardening
Phase E  LIFE SCIENCE

Behavioral Objectives

The child should demonstrate the ability to:

use a simple and a compound microscope.

prepare a specimen for viewing,

use stains to assist in distinguishing cell structure.

investigate and compare cell structures and their functions.

examine a variety of living and non-living substances and decide which ones are composed of cells.

assemble and use a simple balance.

measure amounts of water contained in some materials.

compare and contrast experimental findings with those of his classmates.

determine how much growth of yeast cells has occurred during a specific time period.

recognize the complicated interaction of living things such as demonstrated by molds.

observe and grow molds and bacterial colonies.

recognize that molds and bacteria are extremely small microorganisms that reproduce and carry on all the life processes.
Phase E LIFE SCIENCE

Subconcepts

Suggested Units

Elementary Science Study
Microgardening (continued)

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Pond Water
Euglena

---

Eggs and Tadpoles
Butterflies
Mosquitoes

Crayfish

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Behavior of Mealworms
Behavioral Objectives (continued)

- Examine the details of mold structure and make comparisons among different kinds of molds.
- Set up experiments, sorting variables and using controls, to show the factors that influence the growth of molds.

- Identify and describe individual animals and plants that live in pond water.
- Devise experiments that test the effect of various stimuli on pond-water life and report the findings accurately.
- Recognize the complicated interaction of living things such as demonstrated by pond-water organisms.
- Observe and identify stages in life cycles of various organisms.

- Ask questions that he can answer from his own observations.
- Recognize the relationship of the growing tadpole, frog, or insect to its environment.

- Recognize that a social order exists with crayfish.
- Infer that a social order exists with other animals.
- Observe feeding habits of crayfish and distinguish parts used in eating.
- Design experiments to test behavior of crayfish.
- Identify the life cycle of crayfish.

- Prepare slides for use under the microscope and use the process of staining.
- Observe and record the structure, habits, and locomotion of the organism.
- Conduct experiments exploring the response of an organism to various stimuli.
Subconcepts

Suggested Units

Jones

Farmington Unit on Plants
Phase E  LIFE SCIENCE

Behavioral Objectives

identify and classify different kinds of bones according to their function and structure.

associate bones and the site of animals from which they originated.

use scientific names of bones.

assemble a skeleton from a pile of bones.

make precise verbal descriptions of bones and their functions.

make two-dimensional drawings of three-dimensional objects.

devise projects and experiments on assembling bones into skeletons.

prepare bones (cooking) for assembling.

make two-dimensional drawings of three-dimensional objects.

cook bones in a skeleton.

dissect a small animal (fish).

identify bones from owl pellets.

recognize the function and location of joints in humans and animals.

recognize differences in size, shape, color, and patterns.

recognize differences in texture, such as rough, smooth, moist, dry, fuzzy, slippery, sticky.

recognize similarities and dissimilarities in size, shape, color, and patterns.

recognize similarities in bone structure and function.

recognize the connection between an animal's diet and its tooth structure.
Phase E  LIFE SCIENCE

Subconcepts

Suggested Units

Farmington Unit on Plants (continued)
Behavioral Objectives

recognize differences in odor and taste (caution).

classify regularities or sets of leaves, stems, and roots.

use standard units and tools of measurement.

use a self-designed system of measurement.

use units of measurement to measure space/time relationships in leaves, stems, and roots.

make oral, written, and graphic descriptions about leaves, stems, and roots.

identify the subjectivity and limitations of data.

make tentative conclusions about leaves, stems, and roots based on strong circumstantial evidence.

identify problems related to leaves, stems, and roots and set up procedures to test inferences.

identify results in support or rejection of hypotheses about leaves, stems, and roots.

recognize the need to modify testing procedures when required.

make predictions based on objective data and testing of leaves, stems, and roots.

apply processes and concepts to unfamiliar situations.

observe similarities and dissimilarities in the different types of life processes.

identify the parts of a plant where the life processes occur.

classify plants in terms of similarities and differences in life processes and structure.

use measuring units and tools to evaluate life processes.

make accurate oral, written, and graphic descriptions of life processes.

identify the subjectivity and limitations of data concerning life processes.
Suggested Units
Farmington Unit on Plants (continued)

MIDWEST
Living Things in Field and Classroom

Teacher-Devised Units
Phase E  LIFE SCIENCE

Behavioral Objectives

- make tentative conclusions about life processes based on strong circumstantial evidence.
- identify problems related to life processes and set up procedures to test inferences.
- identify the results of testing for life processes in support or rejection of hypotheses.
- recognize the need to modify testing procedures when necessary.
- make predictions based on objective data and testing of life processes.
- apply processes and concepts to unfamiliar areas.

* exercise intuitive thinking as a result of his experiences with individualized science materials.
* solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
Concept F - The universe is in constant change.

Subconcepts

F - 1 There are daily changes on earth.
F - 2 There are regular movements of the earth and the moon.
F - 3 There are seasonal and annual changes within the solar system.
F - 4 The motion and path of celestial bodies are predictable.
F - 5 Bodies in space (as well as their matter and energy) are in constant change.
F - 6 Nuclear reactions produce the radiant energy of stars, and consequent change.

Suggested Units

Elementary Science Study Project
The Universe in Motion

Charting the Universe
The Message of Starlight
The Life Story of a Star
Behavioral Objectives

The child should demonstrate the ability to:

- estimate the daily motion of the sun, moon, and planets.
- recognize that everything in the universe moves.
- locate an object or a specific point on the earth or in space, using compass direction and angular height.
- plot the motions of the moon and the sun.
- recognize some of the major constellations.
- use a star map and gnomon.
- draw ellipses.
- measure in astronomical units, charts, and tables.
- state and demonstrate the laws of planetary motion.
- state and demonstrate the differences between straight-line motion and curved motion.
- identify the colors of a continuous spectrum and an absorption spectrum.
- describe the sun's function and structure.
- identify behaviors of light and demonstrate their effect on astronomical phenomena by use of the spectroscope.
- describe the characteristics of a star.

- estimate size and distance without the use of direct measurement.
- make a scale drawing as a representation of a real object or objects; i.e., the solar system.
- develop his own system for measuring distance.
Subconcepts

Suggested Units

Elementary Science Study
Where Is the Moon?

Optics

Hopping
Outdoor Hopping
Phase E  EARTH SCIENCE

Behavioral Objectives

use a compass, protractor, range finder, and telescope.
solve for an unknown circumference, diameter, or radius.
sight objects from two fixed points.

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observe and record changes in spatial relationships of light and shadows; noon, planets, sun, and earth.

---

record the movements of the moon, using as reference points familiar objects in his environment.
recognize and analyze properties of light by direct experiment.
recognize the interaction of light with transparent and reflective objects.
observe that there is an order and regularity of the stars, planets, sun, and moon.

---

describe his environment through the use of symbols, grids, and landmarks.
rerap various land features such as hills, streams, and cliffs.
represent three dimensions in two-dimensional form.
show the relative positions of objects in space.
estimate shape and size of objects in his environment.
make scale drawings.
Suggested Units

Elementary Science Study
Snowflakes

Scientific Research Associates
Earth's Atmosphere Laboratory
Weather and Climate Laboratory
Solar System Laboratory

Talcott Mountain Science Center
Astronomy
Geology
Meteorology

Children's Museum Planetarium

Teacher-Devised Units
Behavioral Objectives

* Exercise intuitive thinking as a result of his experiences with individualized science materials.
* Solve problems and apply familiar learnings to unfamiliar situations through analytical thinking.

* These behavioral objectives are appropriate for all phases and for all units. They are the key objectives for supplemental units where there is an absence of specific conceptual development.
DESCRIPTION OF UNITS

Units under each publisher source are listed alphabetically.
A Process Approach

The Process Approach places the student in an active and dynamic role of investigating science — using the processes of the scientist. Through the systematic use of these processes in the primary grades, the children become equipped for more complex science education in subsequent grades.

Primary Grades — observing, classifying, measuring, inferring, predicting, interpreting, hypothesizing (basic skills)

Middle and Upper Grades — formulating hypotheses, controlling variables, interpreting data, defining operationally, and experimenting.
Throughout the intermediate grades, the manuals enlarge on the process skills by means of exercises which become progressively complex (integrated skills).

The planned teaching sequence of process skills is an important element in the overall curriculum design of the project. Each unit is designed to provide a maximum of pupil involvement. In most lessons, each child works with his own materials and equipment.

Materials Needed:

All materials for this unit are available from Xerox Corporation.
Astronomy

These units can be used in conjunction with Talcott Mountain Science Center.

Book 1 - Charting the Universe

This unit deals chiefly with the measurement of size and distances of astronomical objects so that a static-snapshot model of the universe can be developed. Charting the Universe should be used with more gifted children.

Book 2 - The Universe in Motion

The Universe in Motion is concerned with how celestial bodies move in space and how these motions are observed by astronomers. The unit should be used with more gifted children.

Book 3 - The Message of Starlight

This unit turns to elements of spectroscopy and the analysis of light as an essential clue to understanding astronomical phenomena. The unit should be used with more gifted children.

Book 4 - The Life Story of a Star

The Life Story of a Star treats the interiors of stars, their energy sources, and their evolution. The unit should be used with more gifted children.

Materials Needed:

Teachers' Guide and Student's Booklet are available from the Elementary Science School Project.
Attribute Games

This unit is concerned with the development of thinking skills in children. It provides an opportunity for children to deal with problems involving classification and the relationships between classes. Such experiences can help provide the familiarity and the skill necessary for solving problems in science, social studies, mathematics, or other subjects.

These activities need not involve an entire class at once, nor need they occupy a class for an entire period. Small groups or individual children can use these during the science period or at any other time during the day.

The same materials are used, though in different ways, from kindergarten through eighth grade and beyond. Many of the activities prove challenging to adults.

The unit is divided into four units: A Blocks, Color Cubes, People Pieces, and Creature Cards. A Blocks provide the learner with experiences in shifting from the whole to its parts and back again. The materials are bounded by their defining attributes, which have a high degree of contrast. Bright colors, distinct shapes, and obvious size differences emphasize the uniqueness of each of the A Blocks, while they also make it possible to group materials into sets having properties in common.

Color Cubes involve six values of only one attribute.

People Pieces are another set of blocks with attributes which are not so easy to distinguish.

Creature Cards, drawings on paper, introduce a large variety of values for children to discover.

The units are stimulating and challenging and provide excellent supplemental or enrichment activities.

Materials Needed:

Teacher's Guide
Materials
Problem Cards
Stickers

The Teacher's Guide and materials for this unit are available from Weuster Division, Laurel Hill.

Materials are also available from Selective Educational Equipment.
The Balance Book

The unit describes how young children can explore and gain an understanding of the world of balance and weight by balancing things—large and small, heavy and light, on the playground and in the classroom. The purpose of the exploration is to acquaint children with this world at a time in their development when hand and manipulative learnings are most important. Equal-arm balances, walking boards, four-foot balance boards, and an assortment of materials and objects, from crayons to people, provide the opportunity.

Materials Needed:

- Teacher's Guide
- Teacher's Kit
- Six-Student Kit

The Teacher's Guide and materials are available from Webster Division, McGraw Hill.

Kits and separate items from each kit are available from Selective Educational Equipment.

Gases

This unit provides children with an opportunity to prepare and collect gases, to discover some of their properties, to examine tests which enable one to distinguish some of the common gases from one another, and to see the effect of different surrounding atmospheres on the "weight" of gases.

Materials Needed:

- The Teacher's Guide is available from Webster Division, McGraw Hill.
- Materials are available from Selective Educational Equipment.
Batteries and Bulbs

Batteries and Bulbs is an introduction to the study of electricity and magnetism. There are many experiments done with simple equipment. The unit consists of four books.

**Book 1 - Circuits I**

The unit basically introduces batteries and simple circuit-making.

**Book 2 - Circuits and Magnets**

Children are introduced to some of the properties of magnets and to some of the relationships between magnets and circuits.

**Book 3 - Circuits II**

The unit involves work with more complex circuits, Nichrome wire, and other batteries. Investigations by children enliven suggested experiments.

**Book 4 - Guide to Books on Electrical Circuits and Magnets for Elementary Schools**

This guide contains a complete listing of children's books that will enrich the Bulbs and Batteries unit. Listed alphabetically by title, they include survey books, experimental books, and historical and biographical books.

**Materials Needed:**

- Teacher's Guide (one each of four guides)
- Class Kit

Available from Webster Division, McGraw-Hill.

The Class Kit and separate items from the kit are available from Selective Educational Equipment.
In the course of this unit the children will learn many facts about bones, particularly the skeletal system. Pones gives children a chance to become familiar with a variety of bones, to notice similarities and differences among them, and to experience the satisfaction of making skeletons. Pones provides possible activities and leaves day-to-day procedures to one's discretion.

Materials Needed:

- Teacher's Guide
- Pones Picture Book
- How to Make a Chicken Skeleton
- Picture Packet for Bones
- Class Kit for Bones
- Cat Skeleton
- Dog Skeleton
- Rabbit Skeleton
- Trays for Bones
- Mystery Bones
- Film Loops
  - X-Ray Motion Pictures: Head and Neck
  - X-Ray Motion Pictures: Shoulder
  - X-Ray Motion Pictures: Knee and Elbow
  - X-Ray Motion Pictures: Hand
  - X-Ray Motion Pictures: Foot

All materials are available from Webster Division, McGraw Hill. Film loops, kits, and separate items from kits are available from Selective Educational Equipment.

Brine Shrimp

Brine Shrimp is a simple unit exploring the living habits and life cycle of a small salt-lake crustacean. By raising brine shrimp, watching their development, and performing simple experiments with them, students can become acquainted with some of the problems confronted by living organisms.

Materials Needed:

- Teacher's Guide
- Film Loops
  - Brine Shrimp I
  - Brine Shrimp II

Available from Webster Division, McGraw Hill.
Budding Twigs

This unit gives children an opportunity to examine in the classroom the structure of twigs and the development of buds forced into bloom out of season. Through observation and dissection, children become aware of the varieties and complexities of plant construction. As the study progresses, they design experiments to answer their questions.

Budding Twigs has been used primarily with children ages 8-12. It is suggested that these activities be planned as a late winter and early spring unit.

Materials Needed:

The Teacher's Guide is available from Elementary Science Study, Educational Development Center, Inc.

Butterflies

Butterflies deals with the life history of a butterfly, demonstrating the endless cycle of birth, growth, and death, and the continuity of life from one generation to the next. The dramatic transitions a butterfly makes from one stage to another help sustain high interest even in very young children. Since butterflies are easy to handle and raise, it is hoped that each child will have his own creature to study in school and carry home at night, thus assuming some personal responsibility for its survival. This unit helps the child observe and question, two important aspects of scientific inquiry.

Materials Needed:

Teacher's Guide
Film: Life of a Butterfly (16 mm., silent, color, 18 min.)
Film Loops: Black Swallowtail Butterfly
Egg-Laying, Larvae, and Pupa
Preparing to Pupate
Emergence

The Teacher's Guide and materials for this unit are available from Webster Division, Harcourt Brace and World.
Cardboard Carpentery

Cardboard Carpentery is really a resource for teachers showing the myriad of constructions that can be made for the classroom out of tri-wall cardboard. Chairs, boats, houses, portable blackboards, carts, shelves, and dozens, to name just a few, can be made simply and inexpensively by enthusiastic teachers.

Materials Needed:

- Manual is available from Elementary Science Study, Educational Development Center, Inc.
- Tools for use with this unit will be available in the fall of 1968 from Selective Educational Equipment.

Changes

Children predict what things will change when left by themselves. They also consider things that will not change. Children are able to verify their predictions through observation; e.g., food becomes gummy and wet metal rusts. It is hoped that children will develop their own sense of biological and physical changes.

Materials Needed:

- Teacher's Guide is available from Webster Division, McGraw Hill.

Colored Solutions

This unit attempts to introduce children to some phenomena which will lead them to experiments associated with the ideas of density and the layering of liquids. Various concentrations of salt solutions identified by color are used.

Materials Needed:

- Teacher's Guide and materials are available from Webster Division, McGraw Hill.
- Materials are available from Selective Educational Equipment.
**Crayfish**

Through observation, children will become familiar with the habits and habitat of crayfish. Each child will learn, from what he sees, how the crayfish feels, and will discover through experiments the ways of life of crayfish. The care of crayfish in regard to handling, housing, and feeding is listed for the teacher. Since each child will "own" his own crayfish, commercial suppliers are listed in the Appendix.

**Materials Needed:**

- Teacher's Guide
- Live Crayfish

See Appendix for live crayfish suppliers. Connecticut Valley Biological Supply Company is the best local supplier. Teacher's Guide is available from Webster Division, McGraw Hill.

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**The Curious Gerbil**

This small booklet on caring for gerbils can be used either by the teacher for motivating class discussions or by interested students. Feeding, housing, and reproduction are included, as well as games gerbils can play.

**Materials Needed:**

The booklet is available from Webster Division, McGraw Hill. *How to Raise and Train Gerbils* is available from Selective Educational Equipment.

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**Dipping Birds**

This unit is to be used after *Kitchen Physics*. It capitalizes on phenomena of absorption and capillarity and the equilibrium which may be reached between these processes in blotters and other absorbent material. There is an accurate description of how to construct a "dipping bird."

**Materials Needed:**

The Teacher's Guide is available from Elementary Science Study, Educational Development Center, Inc.
Eggs and Tadpoles

The purpose of this unit is to encourage an interest in all living things through exploration of frog eggs and tadpoles. Each of the purpose is achieved through observation. In the classroom children discover for themselves the life cycle of the frog.

Materials Needed:

The Teacher's Guide is available from Webster Division, McGraw Hill.

Teacher's Guide

Film Loops:  
- Frog Egg I  
- First Cell Division to Early Neural Fold  
- Frog Egg II  
- Development of Body Regions  
- Frog Egg III  
- Continued Development to Hatching  
- Frogs: Pairing and Egg-Laying  
- Artificial Fertilization of Frog Eggs  
- Frogs: Pituitary Preparation  
- Tadpoles I  
- Tadpoles II

Films:  
- Frog Development: Fertilization to Hatching  
  (16 mm., silent, color, 12 min.)  
- Frog Development: Hatching Through Metamorphosis  
  (16 mm., silent, color, 9½ min.)

The Teacher's Guide, films, and other materials are available from Webster Division, McGraw Hill.

See Appendix for distributors of live frog eggs.
Euglena

Using the unit as a guide, teacher and children can grow the pond-water organism Euglena quite simply. Euglena is intended to follow up the casual viewing they have done in the Small Things unit. It is essential for children to have worked with microscopes before beginning Euglena. Growing and examining cultures is an important part of this unit.

Materials Needed:

Teacher's Guide is available from Webster Division, McGraw Hill.

Gases and Airs

Gases and Airs is a laboratory investigation into some properties of gases and the interaction of air with "things" in the environment. The activities, which involve the use of controls, are designed to acquaint children with an area of science and a scientific approach to solving problems. Some activities included in Gases and Airs are the "burning candle" and "egg-and-bottle" experiments.

This unit is suggested for use with children ages 9-12.

Materials Needed:

Teacher's Guide
Teacher's Kit
Six-Student Kit
Worksheets

Film Loops: Candle Burning I
            Candle Burning II
            Candle Burning Techniques
            The House and the Candle

The Teacher's Guide, films, and other materials are available from Webster Division, McGraw Hill.

Film loops, kits, and separate items from each kit are available from Selective Educational Equipment.
**Geo Blocks**

Geo Blocks are a set of hardwood blocks with a range of sizes and shapes designed to give children experience with geometric shape and also to stimulate their interest in linear measure, surface area, and volume relationships. They encourage children to gain experience in manipulating geometric objects — experience which they can relate to informal interests as well as to academic subjects.

It is recommended that the blocks have a permanent place in the classroom and that children be allowed to work with them during activity periods and in their free time.

Activities include building, counting, making shapes, making slopes, grouping, finding; surface area, finding volume, and making rules.

**Materials Needed:**

The Teacher's Guide and materials for this unit are available from Webster Division, McGraw Hill.

Materials are also available from Selective Educational Equipment.

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**Growing Seeds**

Children gather and plant small objects, some of which prove to be seeds. As seeds sprout, children can follow through measurement the growth of the plant. Children learn to answer their own questions about growing seeds. Included is a list of materials for Part One—What Are Seeds? What Do They Do? and Part Two—Deciding How Fast Seedlings Grow.

**Materials Needed:**

Teacher's Guide
Class Kit
Film Loops: Bean Sprouts
Plant Growth Graphing

The Teacher's Guide and materials are available from Webster Division, McGraw Hill.

Film loops, the Class Kit, and separate items from the kit are available from Selective Educational Equipment.
The developmental teaching is aimed at problems of heat transfer and loss by using various heat sources and materials.

**Materials Needed:**

The Teacher's Guide is available from Elementary Science Study, Educational Development Center, Inc.

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**Kitchen Physics**

This is a unit drawn from the child's environment. Experiments can travel from school to home and vice versa. The major emphasis is for the child to acquire an awareness of the world of science matching his level of understanding and operation by using equipment and materials found in today's kitchens.

The subject is approached by studying liquids: how they form puddles and droplets, how they fall and break up, are absorbed, evaporate, mix, and dissolve. The student assembles and uses simple equipment.

**Materials Needed:**

- Teacher's Guide
- Teacher's Kit
- Six-Student Kit
- Worksheets
- Film Loops: Leading of a Water Column, Water Rise in blotter strips of graded width, Water Rise in blotter strips exposed and enclosed

Teacher's Guide, film loops, and other materials are available from Webster Division, McGraw Hill.

Film loops, kits, and separate items from kits are available from Selective Educational Equipment.
Lights and Shadows

This unit is an illustrated guide for teachers, showing all kinds of experiences children can have with lights and shadows. Activities include the following: drawing shadows, playing shadow tag, performing shadow plays, exploring symmetry, using mirrors and puddles, making silhouettes, using flashlights to form shadows, following sun shadows, and other interesting inventions of both students and teachers which explore appropriate concepts.

Materials Needed:

Teacher's Guide for this unit is available from McGraw Hill.

Mapping

A map is any symbolic representation, a pattern, a guide, a description. A map can take many forms to transmit its information. Mapping games require children to transfer information from one form or medium to another, or from one person to another. This unit includes perception, estimation, manipulation, and photography.

Materials Needed:

The Teacher's Guide is available from Elementary Science Study, Educational Development Center, Inc.

Nealworms

Parts of the Nealworm unit may be used with 5-, 6-, and 7-year-old children as they study living things. The entire unit is most appropriate for 10-, 11-, and 12-year-old students.

Children are given the opportunity to extend their skills of scientific inquiry by studying the behavior of mealworms. Activities range from watching mealworms to controlling variables as children experiment with them.

Materials Needed:

Teacher's Guide
Set of Six Illustrations
Live Nealworms

The Teacher's Guide and illustrations are available from Webster Division, McGraw Hill.

See Appendix for distributors of live mealworms. The Brockton Worm Hatchery is the best local supplier of mealworms.
Microgardening

Children are introduced to a world of microscopic living things very different from the trees, shrubs, wild flowers, and other plants with which they are familiar. Study of molds through growth and the use of microscopes will help the children gain some appreciation of the importance of molds and other microorganisms in the natural cycle of growth and decay.

Materials Needed:

- Teacher's Guide
- Illustrated Handbook of Some Common Molds
- The Microgardening Cookbook
- Class Kit

The Teacher's Guide and materials are available from Webster Division, McGraw Hill.

The Class Kit and separate items from the kit are also available from Selective Educational Equipment.

Mirror Cards

The materials for this unit are a box of cards and four mirrors. The box of cards contains twenty-one different sets of cards printed with colorful pictures or patterns. The activities are designed for a few children to use at a time. In general, the activities involve trying to match the picture on another card by using a mirror to reflect some part or all of the picture.

The activities provide direct experience with several mathematical and physical concepts. The child will acquire some grasp of what a mirror can and cannot do, and through his early experience he will gain a basis for understanding more geometric concepts, along with concepts of symmetry and optics.

Materials Needed:

- The Teacher's Guide and materials for this unit are available from Webster Division, McGraw Hill.

Mirrors are available from Selective Educational Equipment.
Children of any age explore the laws and problems of balance and weight by making mobile constructions. The activities help to develop a child's awareness of symmetry and motion.

Balancing activities found in the EES publication The Balance Book will enrich the project of making mobiles.

Materials Needed:

The Teacher's Guide is available from Webster Division, McGraw Hill.

EES

Mosquitoes

Though not written in the usual unit form, but rather as a "working paper," this unit contains information on raising mosquitoes from larvae, ideas and experiments, and descriptions of experiments scientists have performed on mosquitoes. Included is a list of materials needed.

Materials Needed:

The Teacher's Guide for this unit is available from Elementary Science Study, Educational Development Center, Inc.

EES

Musical Instrument Recipe Book

In preparation

Materials Needed:

The Teacher's Guide will be available from Elementary Science Study, Educational Development Center, Inc.
The unit stresses the identification of "powders" by using senses. The unit deals with the properties of various substances and the use of indicators in detecting their presence.

Materials Needed:

Teacher's Guide
Class Kit

These materials are available from Webster Division, McGraw Hill.

The kit and separate items from the kit are available from Selective Educational Equipment.

Optics

Optic activities, in which many different materials are used, acquaint children with the ideas of reflection, refraction, color, and variations of optical path. Experiments with narrow and broad light beams, multiple reflections, colored shadows, and refraction through water lenses are devised and explained.

Optics has been used with children ages 8-12 but is adaptable to all levels.

Materials Needed:

The Teacher's Guide is available from Webster Division, McGraw Hill.

Outdoor Mapping

Outdoor Mapping helps the child represent the physical world in a variety of ways, chiefly through mapping it. This unit helps a child describe his environment with the help of symbols, grids, and landmarks. This unit should be viewed as supplemental to Mapping.

Materials Needed:

The Teacher's Guide is available from Elementary Science Study, Educational Development Center, Inc.
Pattern Blocks

The unit consists of a set of wooden blocks in the shapes of regular polygons, with each shape painted its own color. Many patterns and designs can be made with the blocks. Pattern design and arithmetic relationships can easily be seen.

Materials Needed:

Teacher's Guide

The Teacher's Guide and blocks are available from Webster Division, Houghton Mifflin.

Blocks are also available from Selective Educational Equipment.

Peas and Particles

This is a unit on large numbers and estimations. Its purpose is to give children an understanding of what large numbers mean through informal activities. Although we use large numbers in work or conversation in our daily lives, most of us lack a feeling for "how many" these numbers really represent. Children will learn to round off numbers quickly and will realize that quick estimation frequently will be sufficient to serve as a rough check on detailed calculation.

Materials Needed:

The Teacher's Guide is available from Webster Division, Houghton Mifflin.
This unit uses a frame that supports two pendulums. Working in pairs, children compare the effects of length of string, weight of bob, and amplitude. They find out how long to make the strings in order to double, triple, and quadruple the pendulum's period.

**Materials Needed:**

- Teacher's Guide
- Eight-Student Kit
- Class Kit
- Film Loops:
  - Sand Pendulum I: Drawing Lines, Circles, and Ellipses
  - Sand Pendulum II: Drawing on a Turntable
  - Sand Pendulum III: Drawing on a Traveling Table
  - Sand Pendulum IV: Slowing Down
  - Sand Pendulum V: Pouring Sand into Soda Straws

The Teacher's Guide, film loops, and other materials are available from Webster Division, McGraw Hill.

Film loops, Class Kit, and separate items from the kit are also available from Selective Educational Equipment.

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The Pond Water unit introduces children to an exciting array of pond life. Using hand lenses and microscopes, they learn, through their own observations, about the tremendous variety of living things existing where they had thought there was nothing. They will begin to understand the complicated interactions of pond life and identify some of the many plants and animals found in ponds.

**Materials Needed:**

- Teacher's Guide
- Cards for Pond Water

Available from Webster Division, McGraw Hill.
This unit is designed to help children look closely at rocks and establish their own ways of comparing them. In addition to learning about rocks, children learn something about setting standards of comparison and designing charts which describe the characteristics of the rocks.

The Elementary Science Study Unit Attribute Games and Problems includes many classification games which can be adapted for use with rocks.

These activities have been tried successfully with children ages 7-12.

Materials Needed:

Teacher's Guide
Class Kit

Available from Webster Division, McGraw Hill. The Class Kit is also available from Selective Educational Equipment.

Sand

Children explore how sand flows, piles, and slides. They compare sand with dirt, mud, salt, and sugar. They make sand from rocks and try to make rocks from sand. They find ways to sort sand. They use sand to time, count, measure, and weigh. The children also explore color and texture in making pictures, jewelry, and sculpture.

Materials Needed:

The Teacher's Guide for this unit is available from Webster Division, McGraw Hill.

Sink or Float

The materials in this unit consist of things that sink and things that float in tap water and salt water. Children are given experiences with a variety of solids and liquids, with displacement of volumes of water, and with buoyancy. These experiences provide a framework in the development of the concept of density of solids and liquids.

Materials Needed:

The Teacher's Guide is available from Webster Division, McGraw Hill.
Small Things introduces the child to the microscopic world, to the instruments needed to make it accessible, and to the appearance and structure of living and non-living things. The child learns through working with a microscope that some things can be seen only when magnified.

Materials Needed:
- Teacher's Guide
- Teacher's Kit
- Six-Student Kit
- Worksheets
- Set of 20 Illustrations
- The Faithful Eye of Robert Hooke
- Film loops: Paramecium, Buglena, Ameoba, Budding of Yeast Cells, Elephantiasis, Stentor, Rotifer, Vorticella, Volvox, Stylonychia
- Comparative Sizes of Microscopic Animals

Available from Webster Division, McGraw Hill.

Snowflakes

This unit uses a recently developed technique of obtaining replicas of snowflakes which are caught as they fall on special plastic cement. The structure, beauty, and symmetry of snowflakes and their relationship to atmospheric conditions at high altitudes are covered in this unit.

Materials Needed:
- The Teacher's Guide is available from Elementary Science Study, Educational Development Center, Inc.
Solids and Solutions

This unit involves experimentation with solids that dissolve in water and those that do not. Later activities emphasize what happens to the water level when solids dissolve in water. The unit also includes additional information on the basic elements of crystal-growing.

Materials Needed:

The Teacher's Guide is available from Elementary Science Study, Educational Development Center, Inc.

Spinning Tables

Spinning Tables is a unit about motion and about the way moving things look when seen from different points of view.

A spinning table is a simple manageable piece of equipment with which a child can explore the paradoxical behavior of things that move in circles.

The basic equipment for each class consists of spinning tables (lazy susans that can be turned by hand) and accessories such as chalk, containers, and clay.

Spinning Tables has been taught with children ages 6-9 but can also be used with older children.

Materials Needed:

The Teacher's Guide and tables are available from Webster Division, McGraw Hill.

Tables are also available from Selective Educational Equipment.
Tangrams

Tangrams consists of pieces and cards. The tangram is an ancient Chinese invention and perhaps the oldest and most enduring of geometric puzzles. It consists of a square divided into seven geometric shapes: two large triangles, a medium triangle, two small triangles, a square, and a rhomboid. A great number of geometric and pictorial arrangements can be made with these pieces.

The activities are designed to develop thinking skills and to develop skill in dealing with basic geometric relationships. Many tangram problems are manageable by preschool children, and yet advanced problems are challenging to most adults.

Each bag of tangram pieces contains four plastic tangrams. Each package of cards contains 121 patterns which children can match by placing the tangram pieces either on or alongside of the cards.

Materials Needed:

Teacher's Guide
Cards
Pieces

The Teacher's Guide and materials for this unit are available from Webster Division, Heavrin Hill. Pieces are available from Selective Educational Equipment.
Three different kinds of printed materials are supplied with this unit. The first is a Teacher's Guide describing ways of using the materials in the classroom.

A second booklet, Where Was the Moon?, provides a daily picture record of one teacher's observations of the moon from his yard and schoolyard, at the same times of day over a month. It shows how he used his fists to measure the distance between the moon and the sun, and it asks questions that a child can try to answer by making his own predictions. This book is used as a reference, for children will want to make their own picture journals as well.

A third kind of printed material is the reminders. This series of dated notes forms a teaching schedule that children can follow with only minimal direction. Based on the monthly cycles of the moon and the positions of the bright planets, Venus and Jupiter (when one or both can be seen), the reminders give children a day-by-day guide to the sky for a given three-month period.

Where Is the Moon? offers children an informal introduction to the science of observational astronomy. They will see the moon relative to reference points on the earth and in the sky. The moon, Jupiter, Venus, some constellations, and the sun and their apparent motion should become familiar to the children by the end of their study.

Materials Needed:

- Teacher's Guide
- Student Book
- Reminders

Available from Webster Division, McGraw Hill.

Whistles and Strings

Using simple materials, children construct musical instruments and simultaneously investigate many of the basic sound-making elements of more complex musical instruments. They explore the ways in which pitch, tone quality, and the loudness of sounds can be affected by the physical characteristics of the materials and the way they are manipulated.

Materials Needed:

The Teacher's Guide is available from Webster Division, McGraw Hill.
Curves and Shapes

In this unit the students become acquainted with some properties of simple shapes and curves. The study of curves and some of their properties distinguishes simple from non-simple curves. The children participate in activities which show that simple curves may be open or closed; and if they are closed, the curve is the boundary between an inside and an outside region. Finally, the children study four special simple closed curves (the circle, triangle, square, and rectangle) both as independent shapes, such as a square drawn on paper, and as patterns formed by the outlines of objects, such as a dinner plate.

Describing and Classifying

Concept of set is introduced. The child knows he has a mother and a father; they become a set (of parents). In this unit the child defines sets by classifying and by listing; he investigates properties and compares sets by one-to-one correspondence. Sets are introduced by objects in the classroom such as blocks, and by biological objects as well. Two points are emphasized:

1) Set remains same after rearrangement.
2) Number of members of a set does not change with rearrangement or substitution.

The concepts of set are basic to both science and mathematics.

Describing Locations

Children are introduced to reference frames (see explanation SCIS Relativity) in order to describe the location of an object. This unit provides practice with spatial relations: between, above, right of, left of, north of, south of, east of, west of. To develop these concepts the children give verbal descriptions of the locations of objects in the classroom.
The unit strengthens and continues the symmetry concepts introduced in the previous units. The child observes symmetrical patterns in his environment and produces some patterns. Included are activities and tests for three types of symmetry:

1) Repeating Patterns
2) Line Symmetry
3) Rotational, or Turning, Symmetry

Introducing Measurement

Since all measurement is essentially a series of comparisons of two objects, the rudimentary comparisons begin in this unit. Length, area, volume, and time durations are compared. First two, then three or more objects are compared. From these comparisons, order is developed. No numerical work is involved.

Introducing Symmetry

This unit introduces children to observation of the symmetric patterns that exist in his environment. Observations and manipulations of a variety of actual objects by the children form the bases for most of the lessons. A child will notice the difference in body shape between the butterfly and the moth, for instance.

Investigating Systems

Children acquire the idea of "system" as any group of interrelated objects or substances. Children remove objects from a system and observe if it continues to work. Each lesson is introduced by a demonstration with the children participating. Systems studied include:

1) Holding Things Up
2) Rolling Balls
3) Inflating a Balloon
4) A Strange Red Color
5) Systems for Eating
6) Lighting a Bulb
This book serves as a handbook for the teacher in the field of life sciences within the classroom or living things accessible to the classroom. It includes a wide variety of ideas in developing teacher achievement toward instructive experiences. Chapter titles such as "Your Classroom Garden," "Your Classroom Zoo," and "When Children Bring Things In" are valuable aids in beginning a life science room.

Measuring with Reference Units

Previous measurement activities are extended to include assigning numbers by the use of various standard units. Measurement involves establishing a ranking order of objects according to the magnitude of some property. Paper clips, corks, and pendulums are used by the children. Later activities include common units such as inches, centimeters, quarts, and seconds. Other activities include work with optical illusions, counting and addition games, distinctions among areas and volumes, and clock and calendar drills.

Observing Properties

The children learn to recognize properties of objects by observing with each of their five senses and by performing special tests. Later the children group given objects according to one property and identify each group as a subset. Subsequently, children are asked to classify objects on the basis of two properties, and to identify intersections of subsets that they arrange within closed curves of yarn and on charts. Eventually comes the classification of objects on the basis of three properties.

Using Our Senses

Sense experiences involving sight, hearing, smell, taste, and touch increase the child's awareness of his senses as he uses them. The unit first explores properties of familiar objects and then produces "mystery objects."
Kindergarten children are encouraged to watch, to wonder, and to seek their own answers through discovery and testing.

The activities of the unit meet the developmental needs of a child and encourage his natural curiosity. The child explores his classroom, the school building, the playground, and the neighborhood. When he becomes confident of expressing his curiosity freely, he is encouraged to discuss and question his own wonderings. Other lessons discuss, question, and test such topics as the weather and night and day. Study of this unit provides the child with many interesting experiences that expand his powers of observation, his capacity for watching and wondering, and his verbal skills of communication.

Materials Needed:

All Teacher's Guides for MINNEAST units are available from MINNEAST. Kits and items from kits are available from Macalaster Scientific Corporation.
The Interaction unit presents a wide variety of phenomena chosen from many subject areas of physical science. Initial contact with these phenomena is afforded through common objects such as a magnet and paper clips, rubber band, and a spring, and clay. Each activity is investigated further in exploration and discovery as children work with pulley systems, photographic paper, magnetic compasses, electric circuits, and other systems.

The treatment of the concepts outlined in the guide is of particular interest. These are embraced by the systems concept and interaction concept.

The word "system" refers to a whole made up of parts. This concept is applied whenever a whole, its parts, and their interrelationships must all be kept clearly in mind. Everyone uses the systems concept informally without really being aware that he is using it. Everyone focuses his attention temporarily on parts of his environment and ignores or neglects other parts of it.

Because the matter making up a system may be subdivided, rearranged, or changed in appearance without destroying the entity of the system, it is sometimes difficult to recognize a system after such a change has taken place. (Conservation of Matter)

Matter and energy are of central concern to the physical scientist. He seeks to understand in what ways a system may store energy and how the energy may be transferred as changes occur within a system.

This unit introduces the systems concept and all the subconcepts while children are developing conservation logic.

The interaction concept is employed to provide activities that show how objects have a relationship wherein they jointly produce an effect, which is the result of their action upon each other.

Influence and interaction are abstract ideas that we cannot observe directly. Their effects are what we do observe. It is possible to reverse the reasoning so that we start with the observed effects, the evidence, and identify the interacting objects that were responsible for those effects.

The Interaction unit provides lower-level abstractions which offer excellent first-hand experiences for higher-level abstractions that students face later on.

Materials Needed:
- Teacher's Guide
- Complete Kit
- Teacher's Replacement Kit
- Student's Replacement Kit
- Student Activity Booklet

All materials for this unit are available from D. C. Heath and Company.
Life Cycles

Life Cycles is a life science unit devoted to the investigation of ecosystems by focusing on the individual organism. Children observe growth and development, they observe some aspects of reproduction, and they observe death. Seeds can be germinated and the early growth of roots can be observed. Plants can be cared for until they reach maturity and produce flowers and then seeds. Frog eggs can be seen changing into tadpoles and then into adults. Insects such as the fruit fly and the cricket can be observed going through their developmental stages, and as generation follows generation, the ideas of reproduction and death emerge.

Other life cycles aside from those used in the unit can be studied. (See suggested resources.)

Activities include experiences ranging from reproduction and growth to metamorphosis and biotic potential.

Materials Needed:

Teacher's Guide
Complete Kit

All materials are available from D. C. Heath and Company.
Material Objects

The concept that matter exists and has properties is one of the first abstractions the child is able to understand and deal with. *Material Objects* introduces the child to the fundamental concepts of objects and their properties. It leads him to manipulate, describe, compare, and change the form of samples of metals, woods, plastics, granular materials, liquids, gases, etc.

The main objective of the unit is to teach the child to recognize material objects in his own environment. The objects themselves are to be distinguished from their properties.

While dealing with material objects in this unit, the child will develop various attitudes, abilities, and skills, including habits of careful observation, a vocabulary that is useful in describing objects, methods of recording observations and experiences, and the ability to discriminate fine differences and to recognize broad similarities.

**Materials Needed:**

- Replacement Kit (for 16 students)
- Teacher's Guide
- Activity Sheets (1 set, 60 sheets)

All materials are available from D. C. Heath and Company.
Organisms is centered on a classroom model of an ecosystem—an aquarium. Some of the basic processes, interactions, and conditions that are characteristic of life are discovered as the children observe events in the aquarium, as they raise and investigate certain questions, and as the teacher and learner initiate activities. Three natural events can be expected to occur in the aquaria:

- Birth of guppies and the appearance of snail eggs;
- Growth of guppies and young snail eggs;
- Death and decay of organisms.

The concept of habitat is introduced to the children to specify the place where an organism lives.

The investigation of algae and their dependence on light provides activities for the unit. The children study feeding and defecation when Daphnia eat algae. The food web is introduced when Daphnia are in turn eaten by guppies.

The children discover that detritus originates from feces and from dead plants and animals. The contribution of detritus to soil fertility is inferred.

Materials Needed:

Teacher's Guide
Equipment Kit

All materials are available from D. C. Heath and Company.
In this unit the children carry on experiments, try out new concepts as aids in thinking, and apply their reason to what they have observed. They are also expected to exercise their imagination. Through their own experiments the children will study interactions in which new kinds of materials appear while old ones disappear. Thinking about these phenomena, the children find that a new concept, Phase of Matter, is helpful. Thus they can describe and talk about the different phases without having to know more about the materials than they can observe directly. Phases of Matter is a concept central to the unit. The different kinds of observed material are different phases, and each kind of uniform material is a phase. If the materials in any two parts of a system behave differently when treated with the same test substance, they are not the same kind of material—they are not the same phase. Many experiments with liquids and gases are performed.

Materials needed.

Teacher's Guide
Materials in preparation

All materials for the unit are available from D. C. Heath and Company.
This unit switches emphasis away from the individual organism and focuses on the population and the community. Other units are easily adaptable to the development of concepts at this level. (See outline.)

A population is the number of the same kind of organisms living and producing in a given area.

The concept of community involves a relationship among different populations that live in the same area. Some animals eat plants; others eat animals. In any community the eaters and the eaten are linked together in a food relationship called a "food chain," which in turn develops into a food web.

Students are provided the opportunity to learn through their own behavior by handling objects and by experimenting with them. They have direct contact with the organisms about which they are learning.

Activities include the study of reproduction within a population and of food relations among different populations. Also included in the unit is the study of Daphnia, hydra, gammarus, planaria, and dragonfly nymphs, as well as various plant populations, and their role in the conceptual development at that level.

Materials Needed:

Teacher's Guide
Materials in preparation

All materials for this unit are available from D. C. Heath and Company.
The unit is designed to follow Relativity. Position and Motion follows a cycle of preliminary exploration, invention of specific concepts related to reference frames, and discovery of the usefulness of the concept. The unit is divided into five parts, each consisting of two to four chapters. The objectives of each part are directed toward increasing the children's understanding of reference frames by involving them in problems where they must use them.

Materials Needed:

- Teacher's Guide
- Materials in preparation

All materials for this unit are available from D. C. Heath and Company.

The matters of concern in Relativity are the position and motion of objects. The basic concept is that position and motion of an object can be perceived, described, and recognized only with reference to other nearby objects. These other objects, to which the position and motion are related, are said to form a reference frame, and one speaks of position or motion of the original object relative to the reference frame.

Some topics covered include landmarks, perspective, change of relative position, definition of relative motion, and reporting relative motion. The magic "Mr. O" directs his attention at the objects chosen, he "knows" where all these objects are located, and he always describes their position relative to himself.

Materials Needed:

- Teacher's Guide
- Complete Kit
- Teacher's Replacement Kit
- Student's Replacement Kit
- Student Activity Booklets

All materials for this unit are available from D. C. Heath and Company.
The unit, intended to follow Interaction, opens with an extensive review of that unit. Part Two introduces the subsystems concept and includes experiments used by the students. The overall structure of the unit can be viewed as a cycle of exploration, invention, and discovery in relation to the subsystems concept. Particular attention has been paid not only to concept development, but also to developing the children's skills in manipulating experimental equipment, in reporting observations, in making predictions, and in comparing data.

The unit presents a wide variety of phenomena chosen from many subject areas of physical science. Children work with varied materials such as: electric circuits, solutions, crystals, liquid and gaseous Freon, thermometers, and Whirly Bird Pendulums.

Materials Needed:

Teacher's Guide
Complete Kit
Student Activity Booklets
Replacement Kit

All materials for this unit are available from D. C. Heath and Company.

Note:

SCIS materials that are in preparation are expected to be commercially available during the school year 1968-69. Trial teaching additions of SCIS units may be purchased directly from SCIS.
The museum staff will be glad to work with teachers in helping to develop various types of units for the study of the newest facility--the planetarium. Loans and exhibits are available.

For information see Mr. Russell Harding, Director of Planetarium.

Farmington - Green Plants - Elementary Science

Prepared by Farmington teachers and consisting of organizational procedures and activity cards, the unit covers three basic concepts: Plant Structure, Plant Physiology, and Plant Ecology. The unit is based on the "discovery" approach and is used with children from 5-12 years of age.

Science Research Associates

Earth's Atmosphere Laboratory
Weather and Climate Laboratory
Solar System Laboratory

Learnings in Science Laboratories provide opportunities for children in elementary school to learn by observing and inquiring--just as scientists do. Planning, predicting, and experimenting, each child learns how to analyze and draw his own conclusions. Each laboratory contains for the student: Research Booklets, Record Books, Key Cards, and Key Model Booklets; and for the teacher: Teacher's Handbook, Instructional Aid Booklet, Laboratory Picture Chart, and Content Guide Chart.

Materials Needed:

The Earth's Atmosphere Lab, the Solar System Lab, and the Weather and Climate Lab can be obtained from Science Research Associates. Class Kits are included.
The Talcott Mountain Science Center is a regional facility designed to assist towns in bettering their science programs. It provides assistance in all areas of science, but we have recommended its use chiefly in the earth sciences.

The outstanding staff at the Center is very enthusiastic and subscribes to the philosophy of science teaching we are espousing in this guide. The resources at the Center appear limitless, and the cooperative staff provides teachers with excellent ideas and interesting programs.

TISC units which have been recommended in this guide may be used at many levels because of the varied sources of materials and flexible staff.

Teachers may arrange programs, such as field trips to the Center, visits to the school by staff members of the Center, or continuous programs, by contacting the Center. For information see Director Donald La Salle.
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<th>Successfully met behavioral objectives for this phase (refer to guide)</th>
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1. Observation  
2. Classification  
3. Measurement  
4. Communication  
5. Interpretation of facts  
6. Drawing inferences  
7. Setting up experiments  
8. Making predictions  
9. Application of processes to unfamiliar situations

Other Units

Comments

Comments

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Dallas Jones Productions, Inc., 430 West Grand Place, Chicago, Ill.
Pat Dowling Pictures, 1056 South Robertson Boulevard, Los Angeles, Calif.
Educational Horizons, 3015 Dolores Street, Los Angeles, Calif.
Farmington Film Library, West District School
Film Associates of California, 11557 Santa Monica Boulevard, Los Angeles, Calif. 90025
Films, Inc. (see Encyclopaedia Britannica Films, Inc.)
Gateway Productions, Inc., 1859 Powell Street, San Francisco, Calif.
Jam Handy Organization, 2821 East Grand Avenue, Detroit, Mich. 48211
Peter Hollander, 80 Ellery Street, Cambridge, Mass.
Indiana University, Audio-Visual Center, Bloomington, Ind.
International Film Bureau, Inc., 332 South Michigan Avenue, Chicago, Ill. 60604
Journal Films, 909 Diversey Parkway, Chicago, Ill. 60614
National Educational Television (see Indiana University)
Official Films, Inc., 776 Grant Avenue, Ridgefield, N.J.
Rampart Productions, 401 Taft Building, Los Angeles, Calif.
Tabletopper Productions, 111 East 6 Street, F.O. Box 706, Carson City, Nev.
United World Films, Inc., 1445 Park Avenue, New York, N.Y. 10029
* University of Connecticut A. V. Center, Storrs, Conn.
Young America Films, Inc. (see McGraw-Hill Book Co.)

Filmstrip Distributors

Stanley Bowmar Company, Inc., 12 Cleveland Street, Valhalla, N. Y.
Canadian National Film Board, 1271 Avenue of the Americas, New York, N.Y.
Children's Press, Inc., 1224 West Van Buren Street, Chicago, Ill. 60607
Creative Education, Inc., 240 North Milwaukee Avenue, Libertyville, Ill.
Curriculum Materials Corporation, 149 South Racine Street, Jackson, Mich.
Encyclopaedia Britannica Films, Inc., 425 North Racine Avenue, Chicago, Ill.
Eye Gate Productions, Inc., 116-01 Archer Avenue, Jamaica, N. Y. 11435
Filmstrip House, 122 Park Avenue South, New York, N.Y. 10016
International Visual Education Services, Inc., 300 South Racine Avenue, Chicago, Ill.
Jam Handy Organization, 2821 East Grand Avenue, Detroit, Mich. 48211
Moody Institute of Science, 12000 East Washington Boulevard, Whittier, Calif.

* Many films are available at a small rental charge.
**Equipment and Supply Distributors**

<table>
<thead>
<tr>
<th>Company</th>
<th>Address</th>
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<tbody>
<tr>
<td>Aloe Scientific</td>
<td>1831 Olive Street</td>
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<tr>
<td></td>
<td>St. Louis 3, Mo.</td>
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<tr>
<td>Biological Supply Company</td>
<td>1176 Mount Hope Avenue</td>
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<tr>
<td></td>
<td>Rochester, N. Y.</td>
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<tr>
<td>Brockton Worm Hatchery</td>
<td>Mrs. Eleanor Sylvester</td>
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<tr>
<td></td>
<td>18 A Fuller Street</td>
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<td></td>
<td>Brockton, Mass.</td>
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<tr>
<td>California Biological Service</td>
<td>1612 W. Glencoe Boulevard</td>
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<td></td>
<td>Glendale, Calif.</td>
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<tr>
<td>Cambesco Scientific Company, Inc.</td>
<td>212 Western Avenue</td>
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<tr>
<td></td>
<td>Boston, Mass. 02135</td>
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<tr>
<td>Carolina Biological Supply Company</td>
<td>Elan College, N. C.</td>
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<tr>
<td>Central Scientific Company</td>
<td>1700 Irving Park Road</td>
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<td></td>
<td>Chicago, Ill.</td>
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<td>Conn. Valley Biological Supply Company</td>
<td>Valley Road</td>
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<td></td>
<td>Southampton, Mass.</td>
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<tr>
<td>Creative Play Things, Inc.</td>
<td>Edinburg Road</td>
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<td></td>
<td>Cranbury, N. J. 08512</td>
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<tr>
<td>Denoyer-Geppert Company</td>
<td>5235 Ravenswood Avenue</td>
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<td>Chicago, Ill.</td>
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<tr>
<td>Edmund Scientific Company</td>
<td>Barrington, N. J.</td>
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<tr>
<td>Fisher Scientific Company</td>
<td>717 Forbes Avenue</td>
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<td></td>
<td>Pittsburgh, Pa.</td>
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<tr>
<td>General Biological Supply House</td>
<td>761 East 69 Place</td>
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<td></td>
<td>Chicago, Ill.</td>
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<tr>
<td>H.C. Hazel and Sons</td>
<td>Eustis, Fla. 32726</td>
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<tr>
<td>Hall Corporation</td>
<td>210 South Fourth Street</td>
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<td></td>
<td>St. Louis, Mo.</td>
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<td>Company</td>
<td>Address</td>
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<tr>
<td>Key-City Corporation</td>
<td>10297 Tefta Avenue, Long Island City, N.Y.</td>
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<tr>
<td>Macalaster Scientific Corp.</td>
<td>Waltham Research and Development Park, 186 Third Avenue, Waltham, Mass. 02154</td>
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<tr>
<td>Macalaster Bicknell, Inc.</td>
<td>181 Henry Street, New Haven, Conn. 06511</td>
</tr>
<tr>
<td>Marine Biological Laboratory</td>
<td>Woods Hole, Mass.</td>
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<td>Michigan Scientific Company</td>
<td>P. O. Box 1005, Ann Arbor, Mich.</td>
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<tr>
<td>National Biological Supply Company, Inc.</td>
<td>2225 South Michigan Avenue, Chicago, Ill. 60616</td>
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<tr>
<td>New York Biological Supply Company</td>
<td>609 West 51 Street, New York, N.Y.</td>
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<tr>
<td>A. J. Nystrom and Company</td>
<td>3333 Elston Avenue, Chicago, Ill.</td>
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<tr>
<td>Oregon Biological Supply Company</td>
<td>1806 S. E. Holgate Boulevard, Portland, Ore.</td>
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<tr>
<td>E. H. Sargent and Company</td>
<td>1601 West Foster Avenue, Chicago, Ill.</td>
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<tr>
<td>Scientific Glass Apparatus Company</td>
<td>Bloomfield, N. J. 07003</td>
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<tr>
<td>Scientific Supplies Company</td>
<td>173 Jackson Avenue, Seattle, Wash.</td>
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<tr>
<td>Scientific Education Equipment</td>
<td>3 Bridge Street, Newton, Mass. 02155</td>
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<tr>
<td>Southern Biological Supply Company</td>
<td>517 Decatur, New Orleans, La.</td>
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<tr>
<td>Standard Scientific Supply Corp.</td>
<td>808 Broadway, New York, N. Y.</td>
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<tr>
<td>Stansi Scientific Company</td>
<td>1231-41 North Honore Street, Chicago, Ill. 60022</td>
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<tr>
<td>Arthur L. Thomas Company</td>
<td>Vine Street at Third, P.O. Box 779, Philadelphia 5, Pa.</td>
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<tr>
<td>University Apparatus Company</td>
<td>2229 McCoe Avenue, Berkeley, Calif.</td>
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<tr>
<td>Ward's Natural Science Establishment, Inc.</td>
<td>P.O. Box 24, Beechwood Station, Rochester, N.Y.</td>
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<tr>
<td>The Welch Scientific Company</td>
<td>1515 Sedgwick Street, Chicago, Ill.</td>
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<tr>
<td>Western Laboratories</td>
<td>826 Q. Street, Lincoln, Neb.</td>
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</tbody>
</table>
E.S.S. Films and Film Loops

The following distributors are currently marketing E.S.S. film loops:

Association Instructional Materials
600 Madison Avenue
New York, New York 10022

Kaydee Films, Ltd.
National Instructional Films
58 East Route 59
Nanuet, New York 10954

Kacalaster Scientific Company
186 Third Avenue
Waltham, Mass. 02154

Modern Talking Picture Service, Inc.
1212 Avenue of the Americas
New York, New York 10036

Popular Science Publishing Company
A-V Division, Inc.
355 Lexington Avenue
New York, New York 10017

The Ealing Corporation
2225 Massachusetts Avenue
Cambridge, Mass. 02140

Universal Education and Visual Arts
221 Park Avenue South
New York, New York, 10003

Webster Division
McGraw-Hill Book Company
Manchester Road
Manchester, Missouri 63011

The following classroom films can still be rented from the SDC Film Library, 55 Chapel Street, Newton, Massachusetts 02160.

Gases and Airs in the Classroom
How to Make a Mealworm Pack Up
A Small Things Classroom
Classrooms in Transition
Another Way to Learn