DOCUMENT RESUME

ED 123 057 SE 020 405

AUTHOR Baker, Thomas H.; Reiher, John F.
TITLE Equinox. A Model for the Natural Science Education Curriculum for the Second, Third, and Fourth Grades in the Delaware Schools.
INSTITUTION Delaware State Dept. of Public Instruction, Dover.; Del Mod System, Dover, Del.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE Jul 74
GRANT NSF-GW-6703
NOTE 46p.; For related documents, see SE 019 380 and SE 020 404-407; Best Copy Available; Colored Paper
AVAILABLE FROM Mr. John F. Reiher, State Supervisor of Science and Environmental Education, Department of Public Instruction, John G. Townsend Building, Dover, Delaware 19901 (Free while supply lasts)

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS *Curriculum Guides; *Elementary Education; Elementary School Science; Grade 2; Grade 3; Grade 4; *Natural Sciences; *Science Education; *State Curriculum Guides; State Programs
IDENTIFIERS *Delaware; Del Mod System; National Science Foundation; NSF

ABSTRACT

This publication represents a model for the Natural Science Education Curriculum for grades two through four in Delaware's schools. This guide is meant to serve as a minimal standard for natural science education, but at the same time strives for maximum output of the natural science program. The guide is based on the processes of science education as well as the concepts and attitudes of the biological, physical, and earth sciences. Four basic goals have been identified and a set of terminal objectives has been established for each goal. These goals and objectives are to provide the framework for the development of district, local, building, or classroom programs. The guide lists eleven major processes of science education, suggests process ability levels, and identifies the six major concepts to be included in the natural science curriculum. Each concept grouping (concept-process-objective) is indicated in each of the major disciplines of science: biological, physical and earth sciences. The mathematics applications in the basic sciences are also indicated. A section on current educational philosophies that relate to the natural science educational program concludes this publication. (BT)

equinox

A MODEL FOR THE NATURAL SCIENCE EDUCATION CURRICULUM FOR THE SECOND, THIRD, AND FOURTH GRADES IN THE DELAWARE SCHOOLS

EQUINOX

A MODEL FOR THE NATURAL SCIENCE EDUCATION CURRICULUM FOR THE SECOND, THIRD, AND FOURTH GRADES IN THE DELAWARE SCHOOLS

Prepared By

The Delaware State Department of Public Instruction

in cooperation with the Del Mod System

July 1, 1974

--Prepared By--

Thomas M. Baker, Specialist
Del-Mod/D.P.I.

John F. Reiher, State Supervisor
Science/Environmental Education

THE STATE BOARD OF EDUCATION

OFFICERS OF THE DEPARTMENT OF PUBLIC INSTRUCTION

TOWNSEND BUILDING
DOVER, DELAWARE 19901

Kenneth C. Madden, State Superintendent
Randall L. Broyles, Assistant Superintendent, Instructional Services
Howard E. Row, Assistant Superintendent, Auxiliary Services
John J. Ryan, Assistant Superintendent, Administrative Services

Preparation of this monograph was supported by the National Science Foundation Grant No. G.W. 6703 to the Del Mod System, P.O. Box 192, Dover, Delaware 19901.

THE COUNCIL OF PRESIDENTS

THE UNIVERSITY OF DELAWARE

E. Arthur Trabant, President
Daniel C. Neale, Coordinating Council on Teacher Education
Robert L. Uffelman, Coordinator

DELAWARE STATE COLLEGE

Luna I. Mishoe, President
M. Milford Caldwell, Coordinating Council on Teacher Education
Ralph Hazelton, Coordinator

DELAWARE TECHNICAL AND COMMUNITY COLLEGE

Paul K. Weatherly, President
Ruth M. Laws, Coordinating Council on Teacher Education
Ethel L. Lantis, Coordinator

STATE DEPARTMENT OF PUBLIC INSTRUCTION

Kenneth C. Madden, Superintendent
Randall L. Broyles, Coordinating Council on Teacher Education
John F. Reiher, Coordinator

DEL MOD SYSTEM

Charlotte H. Purnell, State Director
John R. Bolig, Research Director

TABLE OF CONTENTS

WRITING TEAM

Thomas M. Baker	Del Mod/DPI Specialist
Darlene Bolig	Caesar Rodney School District
Catherine Bonney	Newark School District
Mitchell Gordon, Jr.	Capital School District
James Gussett	Del Mod Field Agent
Louisa Jones	Laurel School District
Barbara Logan	Del Mod Field Agent
Dennis Reilly	Del Mod Field Agent
Thomas F. Shaw	Mount Pleasant School District

STATE ADVISORY COUNCIL FOR SCIENCE AND ENVIRONMENTAL EDUCATION

Thomas M. Baker	Del Mod/DPI Specialist
Marie Bonner	Alexis I. duPont School District
Edward Casey	Appoquimink School District
Winston Cleland	Marshallton-Kean School District
Audrey Conaway	Cape Henlopen School District
Arthur W. Ellis	Seaford School District
Carlton Knight	University of Delaware
Barbara Logan	Del Mod Field Agent
Sister Mary Michael	St. Mary Magdalen School
Edward Raddle	Indian River School District

Artwork - Carolyn Brown

Layout - Thomas M. Baker

PREFACE

The development of a scientifically aware generation will have a major impact upon the policies and the policy-making process of a democratic society. Citizens who know their long-run, best interests are most likely to promote them through all the means at hand. Being aware is only the beginning. Once a society perceives a need and sets objectives, it then moves to allocate its available resources to the priorities indicated by the goals and objectives. As every elementary economic student knows, the basic resources of the society are natural resources, capital, and human resources. In an earlier age natural resources determined a society's wealth and welfare, especially in the fertility of its soil. Consequently, though natural resources never last their importance, capital resources, the technology to expand man's projectivity, rose to prominence.

Now we appear to be entering an age when human resources will dominate. It is a time when the most critical problems of society do not lend themselves to attack based on land, new materials, or machines. The primary tools of this society are the talents and skills of its people. Whatever its problems. the search for peace, the abolition of poverty, the prevention and cure of disease. the reduction of crime or the control of environmental quality, the solutions depend upon dedicated, talented, and well-trained people who understand and who can intelligently use whatever technological tools are available. It is the growing awareness of this new dependency that has pushed the United States economy into an educational investment which has expanded from $6 billion to $65 billion in 25 years. It is the same phenomenon which underlines the emergence of remedial man-power programs to assist those unable to compete successfully in the more sophisticated labor markets. It is the same awareness which has forced us to take a closer look as to what is currently happening in our educational programs and for us particularly the science education program.

Although science education has enjoyed a strong position in the educational hierarchy, little emphasis has been placed on the application of science to society. The major thrust in education today is "career education". As career education is considered as an inter-disciplinary activity, science is often excluded because "science teachers are so busy teaching subject matter they cannot relate to the processes of science and how science applied to the world of work".

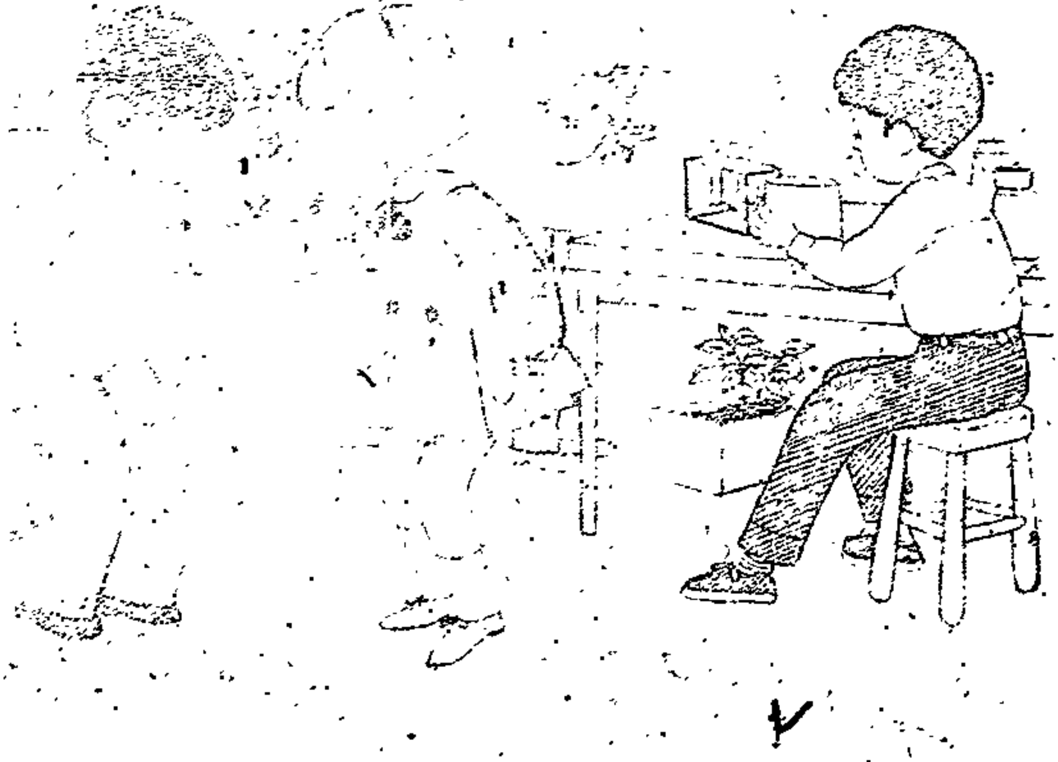
This reaction is unfortunate and highly inaccurate, because any competent science teacher is constantly attempting to make subject matter relavant and pertinent and what better way to make it more meaningful than to relate it to the world of work. If career education is education for a living, then science might rightfully be considered as the prime essential of life; thus, science career education must therefore be a very practical kind of education. How can science teachers continue to teach in ways which fail to bring practicality into science education?

All too often science students ask "Why do I have to learn that? I don't need it." This is especially true of terminal students who need to be better prepared for the cold hard world in which they will suddenly sooner or later be thrust. It is also true in many cases of college-bound students who consider science as a foundational course material. Many science educators are constantly and diligently seeking innovating ideas to teaching the subject matter. Unfortunately, their efforts are focused on the subject matter or course content rather than on the students. It is better if they seek ways to stimulate the students in their desire to learn. We contend that if teachers would make existing programs relevant, then students would act positively. How does one make a science relevant for the non-academic student when it is difficult enough to maintain the interest of those who may need or want the science courses, but to those who neither want or need it, is is almost impossible.

Science instruction as related to the career education philosophy becomes the answer to many of the problems in teaching today. It is an excellent way to make science relevant, practical, and interesting. It can stimulate the terminal student because he can make use of it without the need of detailed theory. By the same token, it can be used to teach theory and principles to academic students so that it may be understood easily and applied immediately.

In this approach natural science instruction is and must be focused on the student. One of the major goals in science teaching is to have the student develop the process of making decisions. There are invariably rights and wrongs when it comes to making decisions but as citizens we must make decisions. There may well be no real right or wrong for the simple reason that the product must suit the needs of the buyer. These needs may well vary from one individual to another. What might be emphasized in career science is how to evaluate products in light of needs. The goal should be to investigate awareness and relate to self through logical principles of evaluation. Here every person uses the so-called scientific method without really being aware of it for what it is.

We have provided this guide to assist the teachers of natural science, grades K-12, by providing the framework for the development of their local district, building, and classroom program This should also serve as the framework for the pre-service and in-service training of teachers by the higher education institutions.



THE REASON FOR NATURAL SCIENCE EDUCATION

The purpose of the natural science education program for Delaware's students is to lead to the sequential development of a scientifically literate person. Although this is considered to be the central purpose of natural science education, a single or "best way" of pursuing this goal cannot be specified. The diverse nature of schools, students, and teachers necessitates a variety of programs and approaches.

***To develop a scientifically literate citizenry, the State Board of Education recommends that:

*every student K-12 have an opportunity for many natural science experiences every year.

*that the K-12 natural science experience takes into consideration individual differences of students and reflects the students' emotional, ethnic, moral, geographical, and economic background.

*every teacher of natural science be supplied with adequate facilities, equipment, supplies, and the time to utilize these at the various grade levels of the student.

*that natural science be presented as a unified discipline, integrated and coordinated with other disciplines, such as mathematics, social science, economics, political science, reading, and communication skills.

*increasing emphasis be placed on science processes, conceptional schemes and values, and less emphasis on factual information.

*direct experiences with the natural world or in laboratory (hands on) activities should comprise the major portion of the science program.

*textbooks should facilitate inquiry, rather than being written to replace laboratory (hands on) experiences. The use of recorded material (other media as well as printed material) should be integral parts and dependent upon laboratory experiences. (The materials used will not discriminate against the ethnic, moral, geographical, or sexual background of students.)

*natural science education programs include environmental education that interrelates natural phenomena, environmental influences, science, technology, social implications of science and technology, and economic considerations.

*natural science education programs incorporate the philosophy of career education; emergency preparedness, health (drug and sex) education, but this is not the sole curricular area responsible for these philosophies.

*opportunities for the professional growth of teachers of natural science be considered an integral part of natural science education programs so that teacher's own deeper insights can be brought to bear on the science programs designed for scientific literacy.

*the achievement of scientific literacy should be the basis for setting objectives; for selecting content, learning experiences, methodology, and for developing a system of evaluation.

This guide is meant to serve as a minimal standard for natural science education but at the same time strive for maximum output of the natural science program. The guide is based on the processes of science education as well as the concepts, and attitudes with terminal objectives in areas of the biological, physical, and earth sciences, at the learning levels of K-1, 2-4, 5-8, and 9-12. These are not the day-by-day activities or materials to be used in the accomplishment of the terminal objectives. The development of this aspect of the curriculum is the responsibility of the classroom teacher, students, and coordinated by the building or district curriculum specialists and the State Department of Public Instruction.

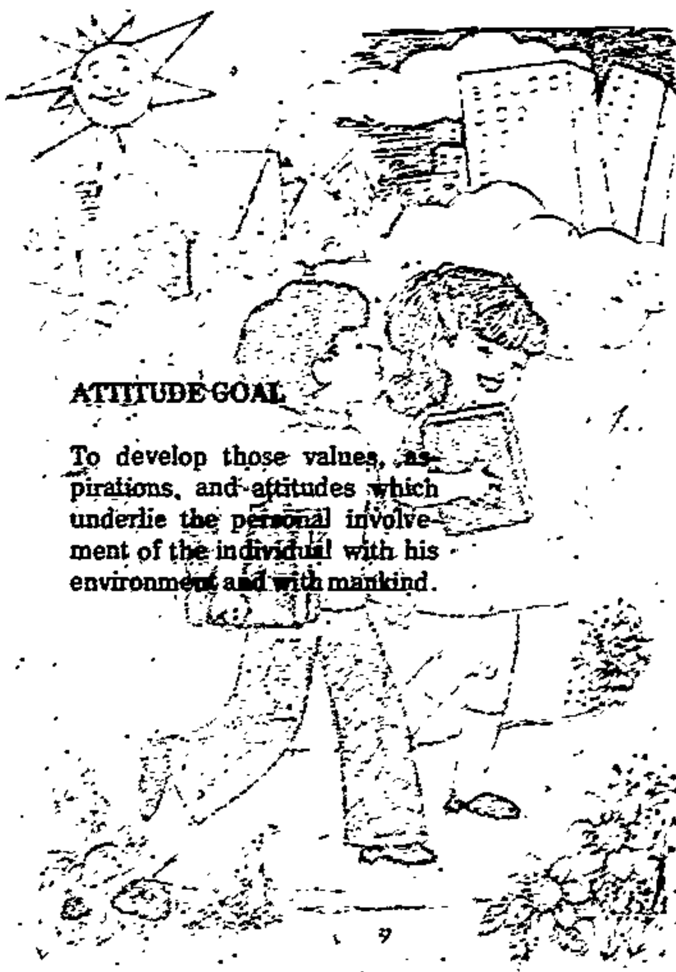
PHILOSOPHY OF NATURAL SCIENCE EDUCATION FOR DELAWARE'S SCHOOLS

When a student completes his experience in Delaware's schools, he should have reached a level of proficiency in these four basic goals.

> **Attitude Goal:** To develop those values, aspirations, and attitudes which underlie the personal involvement of the individual with his environment and with mankind.
>
> **Rational Thinking Goal:** To develop the rataional thinking processes which underlie scientific modes of inquiry.
>
> **Skills Goal:** To develop fundemental skills in manipulating materials and equipment and in gathering, organizing, and communicating scientific information.
>
> **Knowledge Goal:** To develop knowledge of specifics, processes, concepts, generalizations, and unifying principles, which lead to further interpretation and diction of objects and events in the natural environment.

In order to attain these goals, a set of terminal objectives have been established. Each terminal objective is a culmination of a student's science achievement from kindergarten through his high school experience.

The following pages identify the four basic goals and their terminal objectives to serve as a framework for the development of your science program.



ATTITUDE GOAL

To develop those values, aspirations, and attitudes which underlie the personal involvement of the individual with his environment and with mankind.

The student has a critical attitude toward unsupported inferences, hypotheses, and theories.

The student is intrigued by objects and events in his environment.

The student appreciates the interrelatedness of science, technology, and society.

The student willingly subjects his data and ideas to the criticism of his peers.

The student is aware of and responds in a positive manner to beauty and orderliness in his environment.

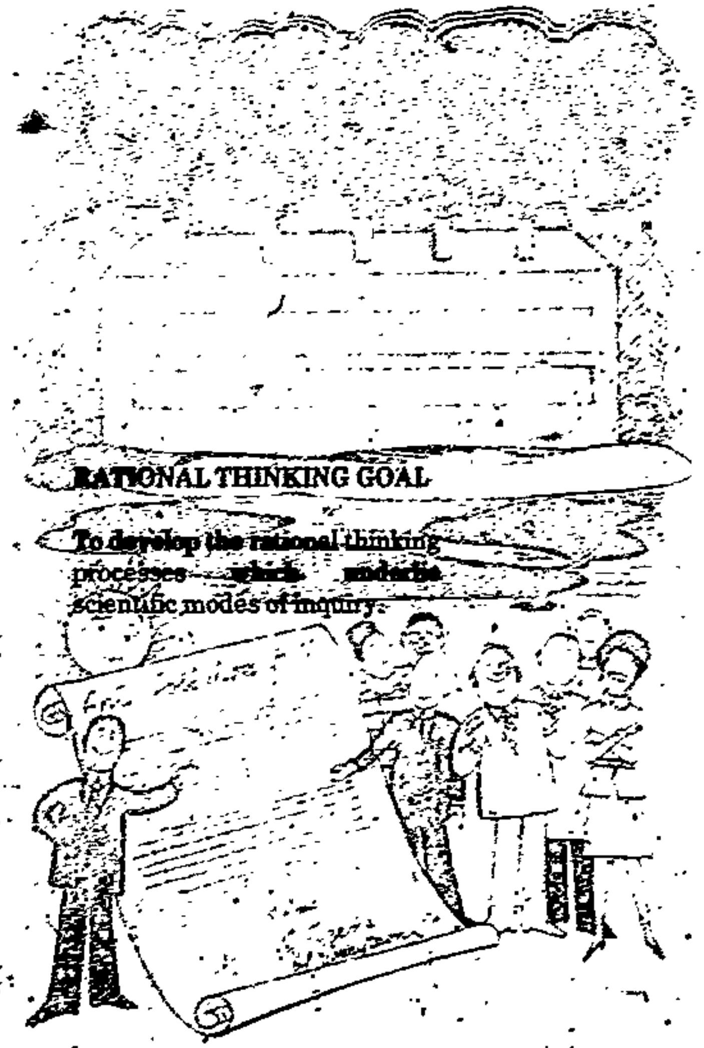
The student conducts and reports the results of his scientific investigations in an honest and objective manner.

The student recognizes the limitations of scientific modes of inquiry and the need for additional, quite different approaches to the quest for reality.

The student habitually applies rational and creative thinking processes when attempting to explain discrepant events; when trying to find relationships among seemingly unrelated phenomena and when seeking solutions to science-based problems.

RATIONAL THINKING GOAL

To develop the rational thinking processes which underlie scientific modes of inquiry.



The student formulates tentative statements (inferences, hypotheses, theoretical models) to identify and explain natural phenomena.

The student draws inferences from data and distinguishes between empirical data and inferences.

The student formulates and tests predictions derived from inferences, hypotheses, graphic, and theoretical models.

The student identifies the variables which may materially influence a given interaction in a system and find ways to control and manipulate the identified variables.

The student generates relevant data to verify or define inferences, hypotheses, and theoretical models.

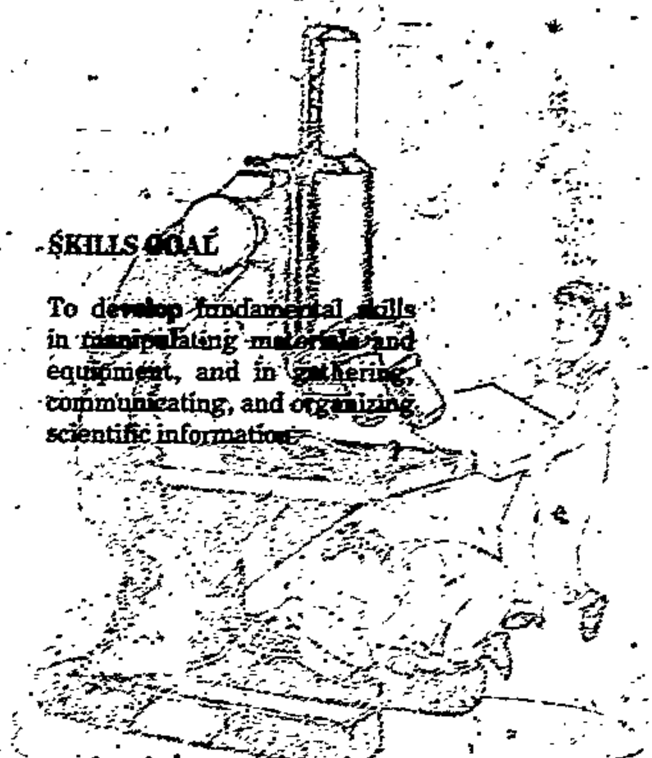
The student senses the existence of discrepant events and problems which arise when he is investigating natural phenomena.

The student uses the processes described under this goal, requisite manipulative, and communication skills and attitudes, and his functional understanding of the concept(s) involved to design, carry out, and report the findings of an experiment.

The student selects criteria for and develops classification systems and uses his systems and those of others to classify given objects and events.

SKILLS GOAL

To develop fundamental skills in manipulating materials and equipment, and in gathering, communicating, and organizing scientific information.



The student communicates with others, orally and in writing, in a manner that is consistent with his knowledge of scientific conventions and that facilitates the learning of his readers or listeners.

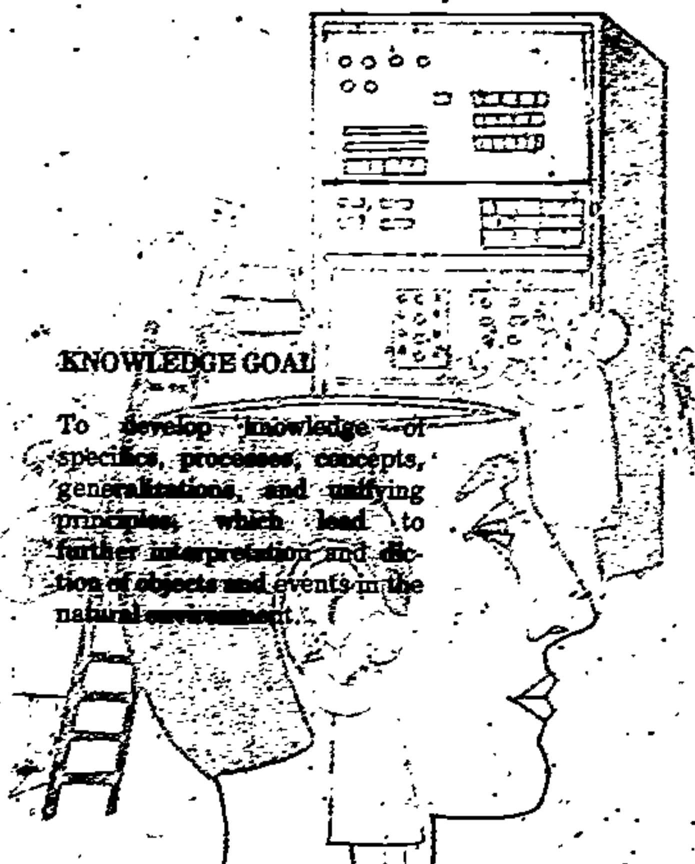
The student records observations accurately and organizes data and ideas in ways that enhance their usefulness.

The student gathers descriptive and quantitative information needed for developing or testing inferences and hypotheses by means of purposeful, objective observations of things and events.

The student constructs and handles laboratory apparatus in a skillful manner, giving due attention to accident prevention.

The student gathers needed data, which have been generated by others from a variety of sources.

The student demonstrates a knowledge of specifics — facts, convention, sequences, classifications, and criteria.



KNOWLEDGE GOAL

To develop knowledge of specifics, processes, concepts, generalizations, and unifying principles, which lead to further interpretation and diction of objects and events in the natural environment.

The student demonstrates a knowledge of the relationships between science and society.

The student demonstrates a knowledge of concepts, generalizations, and unifying principles.

The student knows the major processes and procedures which are employed in scientific inquiry.

PROCESSES OF SCIENCE EDUCATION

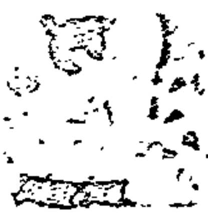
In order to determine the level of achievement of students in Delaware's public schools, a set of minimum objectives has been established. Each of these objectives is based on one or more processes that give a definite indication of a student's progress.

PROCESS ➡ OBJECTIVE

Following is a list of the eleven major processes that have been identified which includes the great majority of student activities that are appropriate for K-12 school experiences. Along with the term associated with each process is a short descriptive paragraph to help clarify the intended meaning of the terms.

These processes are not listed to imply use of the program, Science, A Process Approach (AAAS), but are the processes used for any natural science or environmental education program.

PROCESS - Observing



Observations can be made in a variety of ways using all of the senses. Where direct sense experience is not adequate for making needed observations, indirect methods are used. Objects and events may be observed with respect to many qualities and quantities. When observations are made to accumulate data from which inferences will be drawn, the precision of the observations is critical. Precision is often improved by making quantitative observations. Observations are influenced by the experience of the observer.

PROCESS - Classifying

Classifying is the grouping or ordering of phenomena according to an established scheme. Objects and events may be classified on the basis of observations. Classificational schemes are based on observable similarities and differences in arbitrarily selected properties. Classificational keys are used to place items within a scheme as well as to retrieve information from a scheme.

PROCESS - Inferring

Inference, while based on observations, requires evaluation and judgment. Inferences based upon one set of observations may suggest further observation which in turn requires modification of original inferences. Inference leads to prediction.

PROCESS - Predicting

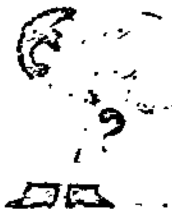
Prediction is the formulation of an expected result based on past experience. The reliability of prediction depends upon the accuracy of past observations and upon the nature of the event being predicted. Prediction is based upon influence. Progressive series of observations and, in particular, graphs are important tools of prediction in science. An experiment can verify or contradict a prediction.

PROCESS - Measuring

Measuring properties of objects and events can be accomplished by direct comparison or by indirect comparison with arbitrary units which, for purposes of communication, may be standardized. Identifiable characteristics which can be measured may be interrelated to provide other quantitative values that are valuable in the description of physical phenomena.

PROCESS - Communicating

In order to communicate observations, accurate records must be kept which can be submitted for checking and rechecking by others. Accumulated records and their analysis may be represented in many ways. Graphical representations are often used since they are clear, concise, and meaningful. Complete and understandable experimental reports are essential to scientific communication.

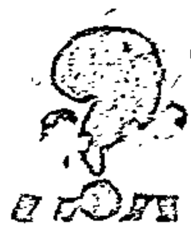


PROCESS - Interpreting Data

Interpreting data requires the application of other basic process skills -- in particular, the processes of inferring, predicting, classifying, and communicating. It is through this complex process that the usefulness of data is determined in answering the question being investigated. Interpretations are always subject to revision in the light of new or more refined data.

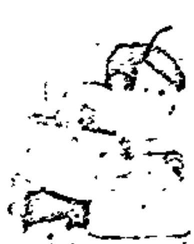
PROCESS - Making Operational Definitions

Operational definitions are made in order to simplify communication concerning phenomena being investigated. In making such definitions it is necessary to give the minimum amount of information needed to differentiate that which is being defined from other similar phenomena. Operational definitions may be based upon the observable characteristics of the phenomena and upon the operations to be performed. Operatonal definitions are precise and, in some cases, based upon mathematical relationships.



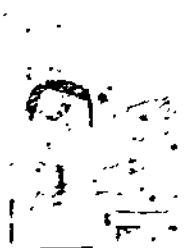
PROCESS - Formulating Questions and Hypotheses

Questions are formed on the basis of observations made and usually precede an attempt to evaluate a situation or event. Questions, when precisely stated, are problems to be solved through application of the other process of science. The attempt to answer one question may generate other questions. The formulation of hypotheses depends directly upon questions, inferences, and predictions. The process consists of devising a statement which can be tested by experiment. When more than one hypothesis is suggested by a set of observations, each must be stated separately. A workable hypothesis is stated in such a way that, upon testing, its credibility may be established.



PROCESS - Experimenting

Experimenting is the process of designing data-gathering procedures as well as the process of gathering data for the purpose of testing a hypothesis. In a less formal sense, experiments may be conducted simply to make observations. However, even here there is a plan to relate cause-and-effect. In an experiment, variables must be identified and controlled as much as possible. An experimental test of a hypothesis is designed to indicate whether the hypothesis is to be accepted, modified, or rejected. In designing an experiment, limitations of method and apparatus must be considered.



PROCESS - Formulating Models

Models, whether physical or mental, are devised on the basis of acceptable hypothesis or hypothesis that have yet to be tested. Models are used to describe and explain the interrelationships of ideas. In many cases the model implies new hypothesis; if testing these hypothesis results in new information, the model must be altered to include it.

Each of these processes have different levels of difficulty that are based on the age and ability levels of a particular student. With this in mind, the following are the minimum acceptable proficiency levels for students completing the grade levels covered by this guide in a Delaware school.

PROCESS ABILITY LEVELS

MINIMUM STANDARDS AT THE COMPLETION OF FOURTH GRADE

Observing

Making observations without inference.
Repeating observations as a means of improving reliability.
Using measurement as a means of refining observations.
Ordering events chronologically.

Classifying

Developing arbitrary one-stage classificational schemes where all included objects of phenomena may be put into mutually exclusive categories.
Using quantitative measurements as criteria for grouping.

Inferring

Demonstrating that inference is based upon observation.
Separating pertinent observations upon which given inferences are based from those which are extraneous.
Developing an inference from a set of related observations.
Developing a series of inferences from a set of related observations.

Predicting

Using a series of related observations to predict an unobserved event.
Using quantitative measurement as a means of improving the accuracy of predictions.

Measuring

Ordering objects in terms of magnitude of properties by using measuring devices without regard for quantitative units.
Comparing quantities such as length, area, volume, and weight to arbitrary units.
Comparing time to units developed from periodic motions.
Using standard units for measurement (the metric system).
Selecting one system of units for all related measurements.

Communicating

Recording observations in a systematic way.

Interpreting Data

Selecting data pertinent to the question asked.
Processing raw data to expose trends or relationships.

Making Operational Definitions

Distinguishing between operational definition and general description.
Selecting characteristics of a phenomena suited to use in operational definition.

Formulating Questions and Hypotheses

Separating questions which can only be answered philosophically from those which can be answered from experience.
Answering questions confined to the observations which can be made.
Restricting questions to those that demand only a positive or negative response.

Experimenting

Identifying observations which are relevant to an experiment.
Distinguishing useful from extraneous data.
Describing the problems involved in making desired observations.

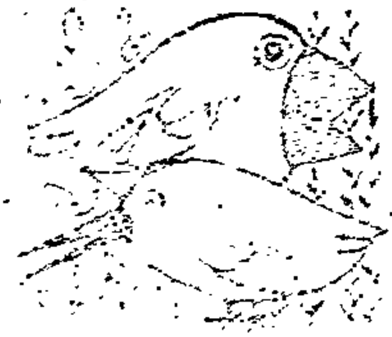
Formulating Models

Distinguishing between models and reality.
Explaining observed phenomena by using models devised by others.

CONCEPTS OF SCIENCE EDUCATION

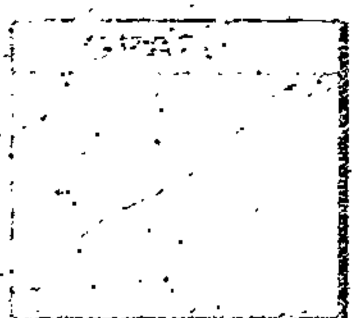
Concept ➡ **Process** ➡ **Objective**

Moving up the ladder each process is based on a conceptual scheme, thus allowing each objective to be developed under the concepts. Six major concepts have been identified for inclusion in the natural science curriculum in Delaware's K-12 schools. These concepts are defined as follows:



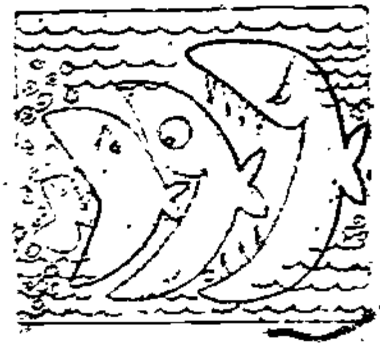
Diversity: The vast number of natural phenomena which can be observed display a wide variety of similarities and differences.

Change: Our environment, living and nonliving, microscopic and macroscopic, is constantly undergoing change.

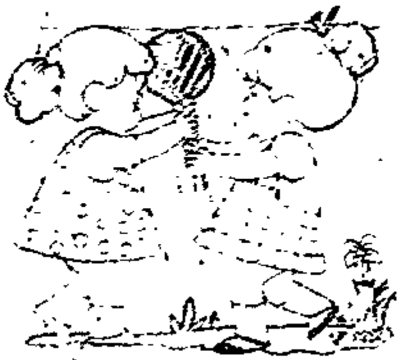


Continuity: There is constancy in cause-and-effect relationships which precludes any abrupt reversal in natural phenomena.

Interaction: The interactions of living and nonliving matter in an environment and the resulting change of energy determine the nature of the environment.



Organization: Systematic relationships exist in natural phenomena. Systems within systems comprise the universe.



Limitation: Natural phenomena are limited by the fundamental nature of matter and energy. There is an overall tendency toward equilibrium in an environment.

Curriculum Area ➡ Process ➡ Objective

Each concept grouping (concept-process-objective) is indicated in each of the major disciplines of science: biological, physical, and earth sciences. The mathematics applications in the basic sciences are also indicated.

Environmental education is not a separate content area of the natural science programs, it is part of the biological, physical, and earth sciences, with implications for the social sciences.

GOALS & TERMINAL OBJECTIVES

⬇

CURRICULUM AREA

⬇

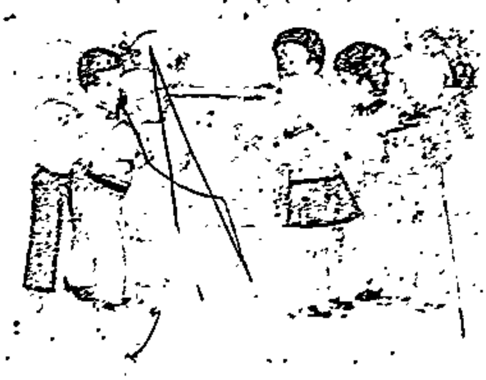
CONCEPT

⬇

PROCESS

⬇

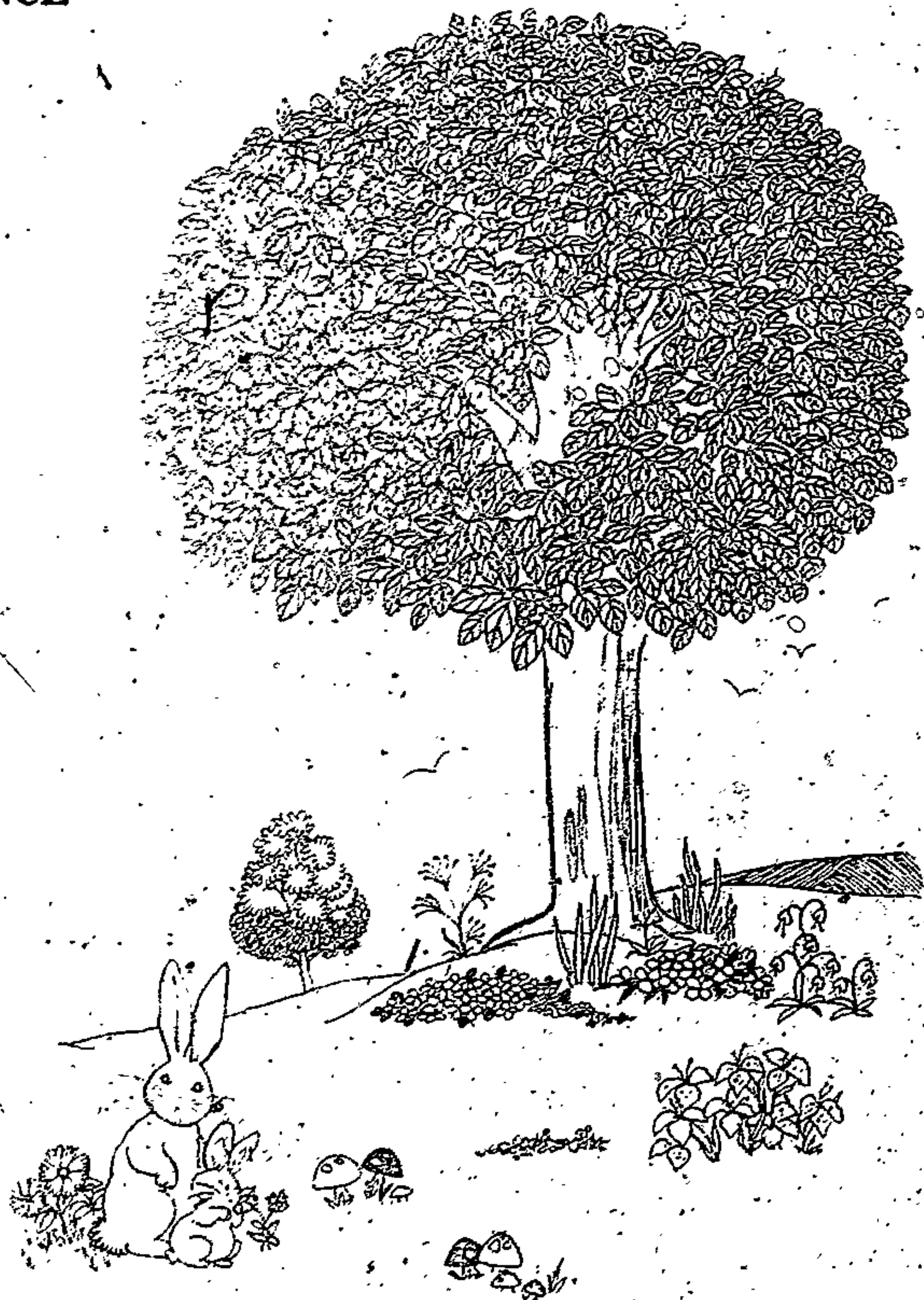
OBJECTIVE



When all this is completed, and the basic objective achieved, the student is then on his way to reaching the long range goals and terminal objectives that should be achieved before graduation.

On the following pages you will find the concept groupings listed under their specific curriculum areas. It is hoped that this will help to serve as a guide in planning for and implementing natural science education in the classroom.

BIOLOGICAL SCIENCE



CONCEPT DIVERSITY

> The vast number of natural phenomena which can be observed display a wide varitety of similarities and differences.

Observing Classifying Communicating Making operational definitions	Distinguish between vertebrate and invertebrate animals.
Observing Classifying Communicating	List several ways that seeds and pollen are randomly dispersed.
Observing Classifying Communicating Making Operatinal definitions Formulating questions and hypothesis Experimenting	Describe the relationship of variables in an investigation.

CONCEPT CHANGE

> Our environment, living and nonliving, microscopic and macroscopic, is constantly undergoing change.

Observing Classifying Communicating	Identify and describe animal and plant responses to changes in their environment.

CONCEPT CONTINUITY

> There is a constancy in cause-and-effect relationships which precludes any abrupt reversal in natural phenomena.

Observing Inferring Communicating Formulating models	Describe a simple food chain and/or web.

Observing Classifying Predicting Communicating Experimenting Formulating models	Describe and demonstrate the functions of roots, stems, and leaves of plants.
Observing Classifying Predicting Communicating	Describe the effect of soil, water, and light on the parts of plants.
Experimenting Observing Classifying Inferring Predicting Communicating Interpreting data Experimenting	Identify local sources of pollution and illustrate how each is dangerous to our health.
Observing Classifying Inferring Predicting Communicating	Identify and classify various kinds of drugs and describe their effects on simple organisms.
Observing Classifying Communicating Making operational definitions Formulating questions and hypothesis Experimenting	Describe the relationship of variables in an investigation.

CONCEPT INTERACTION

> The interactions of living and nonliving matter in an environment and the resulting change of energy determine the nature of the environment.

Communicating Interpreting data Making operational definitions Experimenting	Describe the role of photosynthesis in the life of a plant.

Observing Classifying Inferring Predicting Communicating Interpreting data Experimenting	Identify local sources of pollution and illustrate how each is dangerous to our health.
Observing Classifying	Identify and describe animal and plant responses to changes in their environment.
Observing Inferring Communicating Formulating models	Describe a simple food-chain and/or web.
Observing Classifying Inferring Predicting Communicating	Identify foods eaten describing the relationship to the plant or animals from which they come.
Observing Classifying Predicting Communicating Experimenting Formulating models	Describe and demonstrate the functions of roots, stems, and leaves of plants.
Observing Classifying Predicting Communicating Experimenting	Describe the effect of soil, water, and light on the parts of plants.
Observing Communicating Making operational definitions	Identify the cell as the basic structural unit of all living things.

CONCEPT ORGANIZATION

> Systematic relationships exist in natural phenomena. Systems within systems comprise the universe.

Observing Classifying Inferring Predicting Communicating	Identify and classify various kinds of drugs and describe their effects on simple organisms.

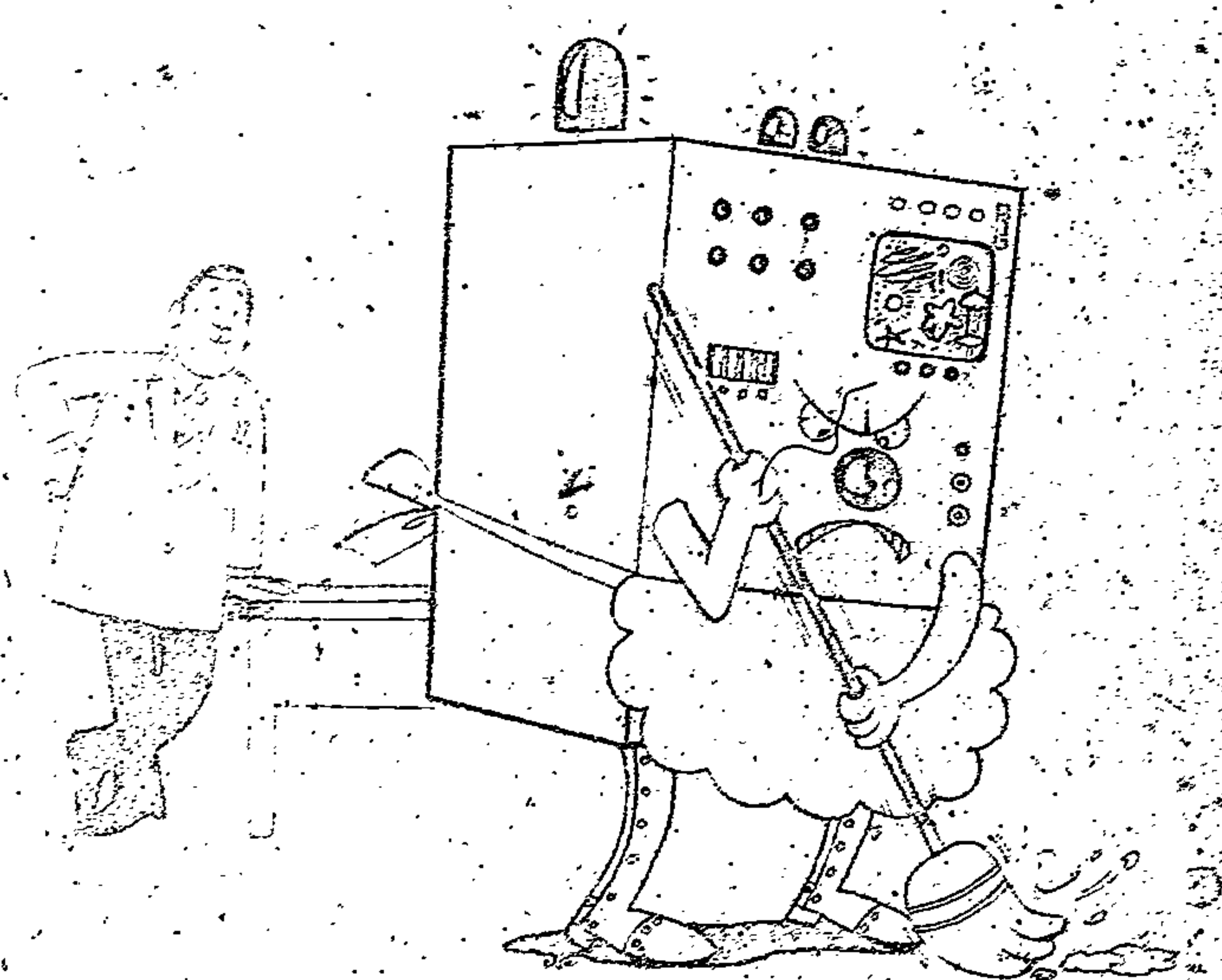
Communicating Experimenting	Describe and practice safety measures common to any experiment.
Observing Inferring Communicating Formulating models	Describe a simple food chain and/or web.
Observing Classifying Predicting Communicating Experimenting	Describe and demonstrate the functions of roots, stems, and leaves of plants.
Observing Classifying Communicating Making operational definitions	Distinguish between vertebrate and invertebrate animals.
Observing Making operational definitions	Identify the cell as the basic structural unit of all living things.

CONCEPT LIMITATION

> Natural phenomena are limited by the fundamental nature of matter and energy. There is an overall tendency toward equilibrium in an environment.

Observing Classifying Predicting Communicating Experimenting	Describe the affect of soil, water, and light on the parts of plants.
Observing Inferring Communicating Formulating models	Describe a simple food chain and/or web.
Communicating Interpreting data Making operational definitions Experimenting	Describe the role of photosynthesis in the life of a plant.

PHYSICAL SCIENCE



The vast number of natural phenomena which can be observed display a wide variety of similarities and differences.

Communicating Interpreting data Experimenting	Describe and demonstrate how speed can be increased or decreased.
Observing Classifying Measuring Communicating Making operational definitions Experimenting	Identify, order, and demonstrate by function how a simple machine can increase the ability to do work.
Classifying Measuring Communicating Experimenting	Demonstrate the use of various types of thermometers.
Observing Classifying Communicating Making operational definitions Formulating questions and hypotheses Experimenting	Describe the relationship of variables in an investigation.
Measuring	Use the metric system to describe objects in terms of mass, length, area, and volume, or use the metric system to distinguish objects in terms of mass, length, and area.
Inferring Communicating	Distinguish observations from inferences.
Observing Classifying Predicting Communicating Interpreting data Formulating questions and hypotheses Experimenting	Identify, describe, and demonstrate sound, heat, solar energy, and electricity as a form of energy.

CONCEPT CHANGE

> Our environment, living and nonliving, microscopic and macroscopic, is constantly undergoing change.

Communicating Interpreting data Experimenting	Describe and demonstrate how speed can be increased and decreased.
Observing Classifying Measuring Communicating Making operational definitions Experimenting	Identify, order, and demonstrate by function how a simple machine can increase the ability to do work.
Observing Predicting Communicating Making operational definitions Experimenting	Describe and demonstrate how a substance can change from solid, liquid, or gas (in any order).
Observing Classifying Measuring Communicating Experimenting	Demonstrate examples of the rule that heat is transferred from warmer to cooler areas or objects.

CONCEPT CONTINUITY

> There is a constancy in cause-and-effect relationships which precludes any abrupt reversal in natural phenomena.

Communicating Formulating questions and hypothesis Experimenting	Demonstrate how sound travels in liquids and gases.
Observing Classifying Measuring Communicating Experimenting	Demonstrate examples of the rule that heat is transferred from warmer to cooler areas or objects.
Observing Communicating Making operational definitions	Identify and name variables related to an investigation.

Observing Classifying Predicting Communicating Interpreting data Formulating questions and hypothesis Experimenting	Identify, describe, and demonstrate sound, heat, solar energy, and electricity as a form of energy.
Observing Classifying Communicating Making operational definitions Formulating questions and hypothesis Experimenting	Describe the relationship of variables in an investigation.

CONCEPT INTERACTION

> The interactions of living and nonliving matter in an environment and the resulting change of energy determine the nature of the environment.

Predicting Communicating Making operational definitions Experimenting	Demonstrate and describe orally the effect of friction on push-pull force.
Observing Classifying Inferring Communicating	Name and identify various sources of energy, and give examples of how each is used by man.
Observing Classifying Predicting Communicating Interpreting data Formulating questions and hypothesis Experimenting	Identify, describe, and demonstrate sound, heat, solar energy, and electricity as a form of energy.
Predicting Formulating hypothesis and questions Making operational definitions	Distinguish between hypothesis, predictions, and guesses, based on student observed data.
Communicating Experimenting	Describe the effect of gravity on objects.

CONCEPT ORGANIZATION

> Systematic relationships exist in natural phenomena. Systems within systems comprise the universe.

Observing Communicating Experimenting	Demonstrate and describe that light is composed of many colors.
Observing Classifying Measuring Communicating Making operational definitions Experimenting	Identify, order, and demonstrate by function how a simple machine can increase the ability to do work.
Measuring	Use the metric system to describe objects in terms of mass, length, area, and volume, or use the metric system to distinguish objects in terms of mass, length, and area.
Communicating Experimenting	Describe and practice safety measures common to any experiment.

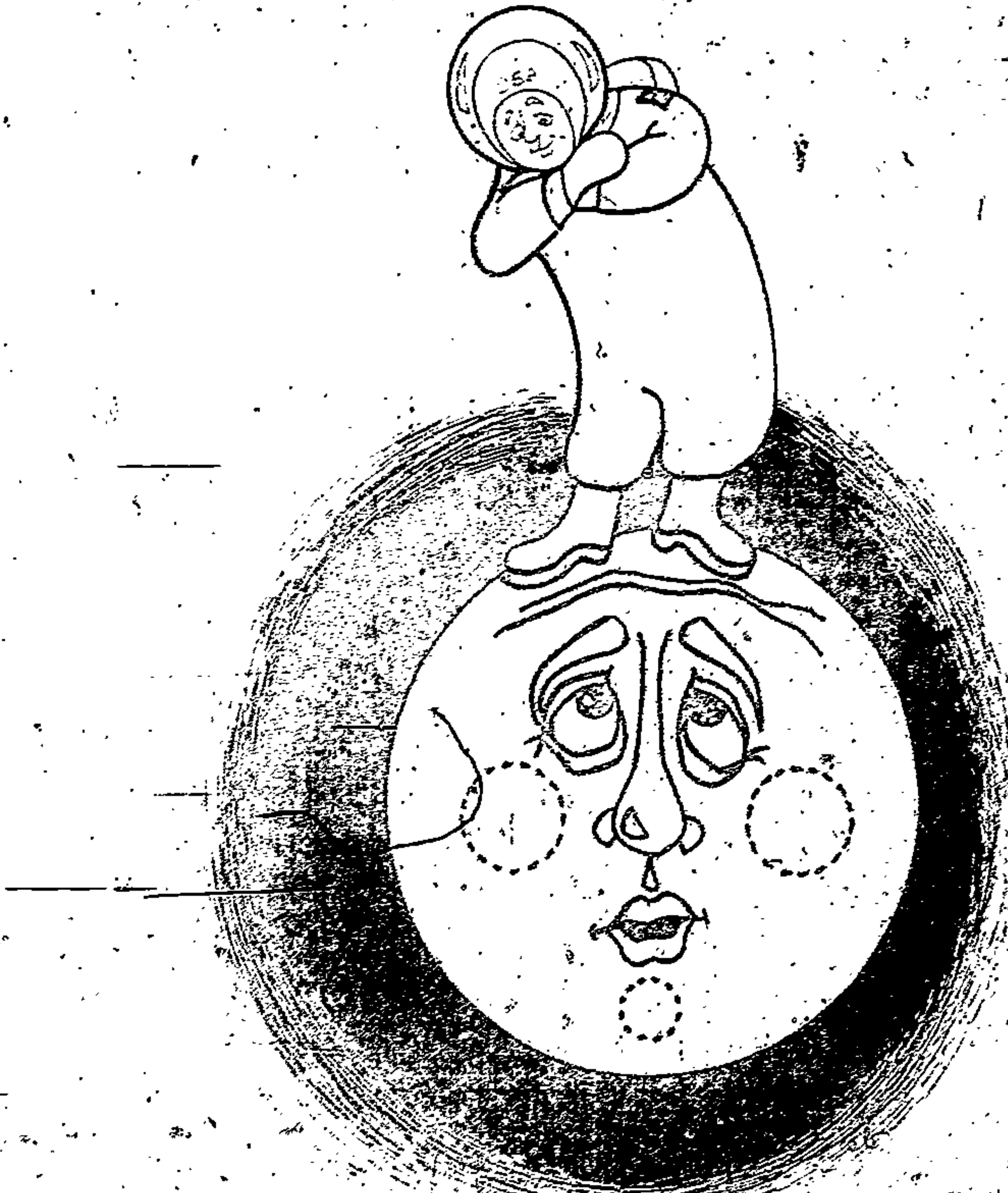
CONCEPT LIMITATION

> Natural phenomena are limited by the fundamental nature of matter and energy. There is an overall tendency toward equilibrium in an environment.

Predicting Communicating Making operational definitions Experimenting	Demonstrate and describe orally the effect of friction on push-pull force.
Observing Predicting Communicating Making operational definitions Experimenting	Describe and demonstrate how a substance can change from solid, liquid, or gas (in any order).
Observing Classifying Measuring Communicating Experimenting	Demonstrate examples of the rule that heat is transferred from warmer to cooler areas or objects.
Inferring Communicating	Distinguish observations from inferences.

Observing Classifying Measuring Communicating	Define an object using its physical properties.
Observing Classifying Predicting Communicating Interpreting data Formulating questions and hypothesis Experimenting	Identify, describe, and demonstrate sound, heat, solar radiation, and electricity as a form of energy.
Communicating Experimenting	Describe the effect of gravity on objects.

EARTH SCIENCE



CONCEPT DIVERSITY

> The vast number of natural phenomena which can be observed display a wide variety of similarities and differences.

Observing Classifying Measuring Communicating Making operational definitions Experimenting	Distinguish the various types of soil such as rocky, sandy, clay.
Observing Classifying Communicating Making operational definitions Formulating questions and hypothesis Experimenting	Describe the relationship of variables in an investigation.
Measuring	Use the metric system to describe objects in terms of mass, length, area, and volume, or use the metric system to distinguish objects in terms of mass, length, and area.
Observing Classifying Predicting Communicating Interpreting data Formulating questions and hypothesis Experimenting	Identify, describe, and demonstrate sound, heat, solar energy, and electricity as a form of energy.
Inferring Communicating	Distinguish observations from inferences.

CONCEPT CHANGE

> Our environment, living and nonliving, microscopic and macroscopic, is constantly undergoing change.

Observing Measuring Communicating Interpreting data Experimenting	Distinguish the effects of wind, water, plants, and animals on the soil.

> There is a constancy in cause-and-effect relationships which precludes any abrupt reversal in natural phenomena.

Observing Classifying Inferring Predicting Communicating Interpreting data Experimenting	Identify local sources of pollution and illustrate how each is dangerous to our health..
Observing Classifying Communicating Making operational definitions Formulating questions and hypothesis	Describe the relationship of variables in an investigation.
Experimenting Observing Classifying Predicting Communicating Interpreting data Formulating questions and hypothesis Experimenting	Identify, describe, and demonstrate sound, heat, solar energy, and electricity as a form of energy.
Observing Communicating Making operational definitions	Identify and name variables related to an investigation.
Observing Classifying Measuring Communicating Interpreting data	Describe the relationships of clouds, fog, rain, wind, and temperature.
Observing Communicating Making operational definitions Formulating models	Describe and demonstrate the movement of the earth with with respect to rotations, revolution, inclination.

CONCEPT INTERACTION

> The interactions of living and nonliving matter in an environment and the resulting change of energy determine the nature of the environment.

Measuring Communicating Experimenting	Demonstrate the use of a magnetic compass to find direction.
Observing Measuring Communicating Interpreting data Experimenting	Distinguish the effects of wind, water, plants, and animals on the soil.
Observing Classifying Measuring Communicating Interpreting data	Describe the relationships of clouds, fog, rain, wind, and temperature.

CONCEPT ORGANIZATION

> Systematic relationships exist in natural phenomena. Systems within systems comprise the universe.

Communicating Interpreting data Experimenting	Construct maps of classroom, school grounds, and other areas, and be able to describe them, utilizing the concept of north, south, east, and west.
Observing Communicating Making operational definitions Formulating models	Describe and demonstrate the movement of the earth with respect to rotations, revolution, inclination.
Observing Classifying Communicating	Identify sources of weather information.
Observing Classifying Communicating Formulating models	Compare the sun, moon, stars, planets, and their relation to the earth.
Observing Classifying Measuring Communicating	Identify, order, and describe units of time: year, month, century, decade, day, week, hours, minute, second.

Measuring	Describe objects in terms of area by superposition of arbitrary units.
Communicating Experimenting	Describe and practice safety measures common to any experiment.
Communicating Experimenting	Describe the effect of gravity on objects.
Observing Classifying Inferring Communicating Formulating models	Describe some of the interdependencies between animals, plants, and the environment.
Observing Classifying Inferring Predicting Communicating Communicating Interpreting data Experimenting	Identify local sources of pollution and illustrate how each is dangerous to our health.
Predicting Formulating hypothesis and questions Making operational definitions	Distinguish between hypothesis, predictions, and guesses, based on student observed data.
Observing Classifying Predicting Communicating Interpreting data Formulating questions and hypothesis Experimenting	Identify, describe, and demonstrate sound, heat, solar energy, and electricity as a form of energy.

CONCEPT LIMITATION.

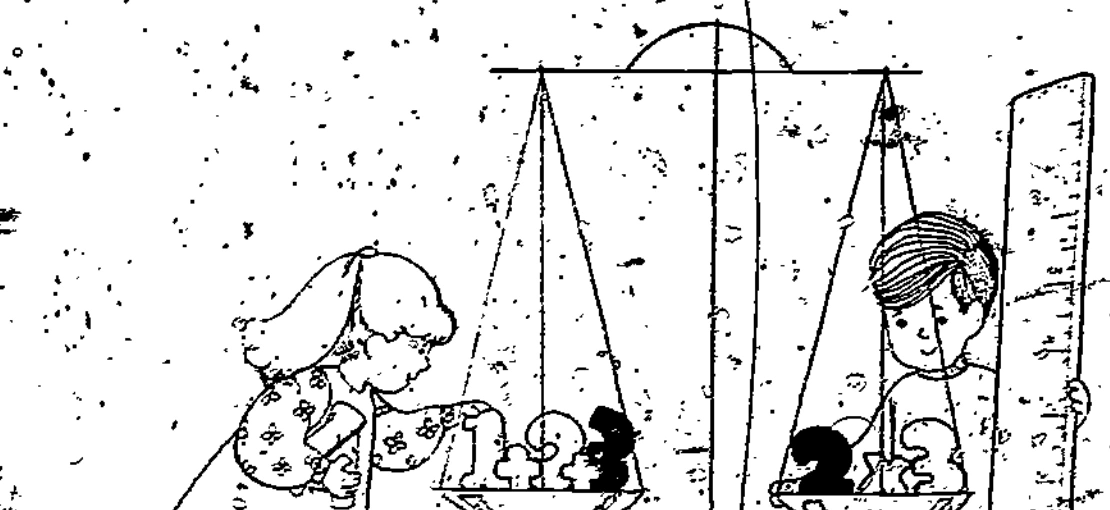
> Natural phenomena are limited by the fundamental nature of matter and energy. There is an overall tendency toward equilibrium in an environment.

Observing Classifying Communicating Formulating models	Compare the sun, moon, stars, plants, and their relation to the earth.

Observing Classifying Predicting Communicating Interpreting data Formulating questions and hypothesis Experimenting	Identify, describe, and demonstrate sound, heat, solar energy, and electricity as a form of energy.
Inferring Communicating	Distinguish observations from inferences.
Observing Classifying Measuring Communicating	Define an object using its physical properties.
Communicating Experimenting	Describe the effect of gravity on objects.

40

MATHEMATICS IN SCIENCE



CONCEPT DIVERSITY

> The vast number of natural phenomena which can be observed display a wide variety of similarities and differences.

Classifying Measuring	Order containers on the basis of volume.
Observation Classifying Communicating Making operational definitions	Describe an object using its attributes so that it can be easily identified in a collection of similar objects.
Classifying Measuring Communicating Experimenting	Demonstrate the use of various types of thermometers.
Measuring	Use the metric system to describe objects in terms of mass, length, area, and volume, or use the metric system to distinguish objects in terms of mass, length, and area.

CONCEPT CHANGE

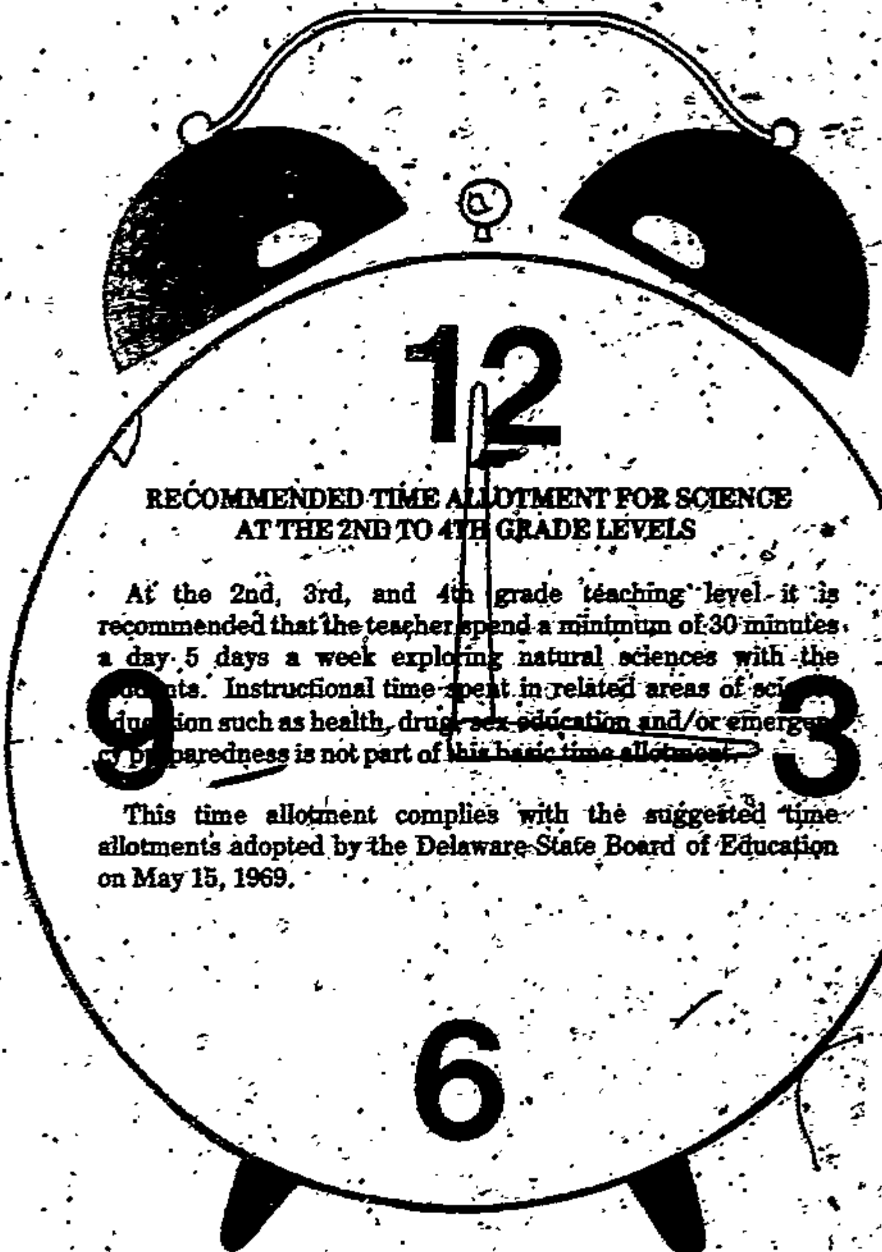
> Our environment, living and nonliving, microscopic and macroscopic, is constantly undergoing change.

Observing Predicting Communicating Interpreting data Experimenting	Describe and interpret raw data and make comparisions of events using student observations.

CONCEPT ORGANIZATION

> Systematic relationships exist in natural phenomena. Systems within systems comprise the universe.

Observing Classifying Measuring Communicating	Identify, order, and describe units of time: year, month, century, decade, day, week, hours, minute, second.
Measuring	Use the metric system to describe objects in terms of mass, length, and area.
Measuring	Describe objects in terms of area by superposition of arbitrary units.



RECOMMENDED TIME ALLOTMENT FOR SCIENCE AT THE 2ND TO 4TH GRADE LEVELS

At the 2nd, 3rd, and 4th grade teaching level it is recommended that the teacher spend a minimum of 30 minutes a day 5 days a week exploring natural sciences with the students. Instructional time spent in related areas of science education such as health, drug, sex education and/or emergency preparedness is not part of this basic time allotment.

This time allotment complies with the suggested time allotments adopted by the Delaware State Board of Education on May 15, 1969.

Requirements For Teaching Science

REQUIREMENTS FOR TEACHING SCIENCE AT THE ELEMENTARY LEVEL

The elementary teacher should possess a background of science information. It is suggested that teachers in the elementary school have background in the following areas of science education.

A. Interaction of Environmental Factors

The teacher will be able to describe observed interactions of living and nonliving matter in science areas such as electricity, magnetic fields, and biological realms.

B. Conversion and Conservation of Energy

The teacher will be able to demonstrate the conversion of energy from one form to another and describe what is meant by energy conservation.

C. Growth and Reproduction

The teacher will be able to describe growth and reproduction in plants and animals including man.

D. Evolution and Genetics

The teacher will be able to describe the terms evolution and genetics and construct inferences about the benefits of each to man.

E. The Development of Scientific Ideas

The teacher will be able to describe the unknowns of science as well as the knowns and the relationships of the various scientific disciplines to each other.

F. Social Implications of Science

The teacher will be able to state evidence of changes in society and culture that have resulted from the products of scientific work.

CURRENT EDUCATIONAL PHILOSOPHIES THAT RELATE TO THE NATURAL SCIENCE EDUCATION PROGRAM

Right to Read [Science and Reading]

It is our belief that every area of the elementary school curriculum, including natural science, should contribute to the reading program. Children's experiences in science should help them learn how to read in other areas. Conversely, as children develop general reading and communication skills these will contribute to their development in natural science.

Reading is essentially the recognition of relationships between symbols and objects or events.

The emphasis in the natural Science program is on first-hand experiences with concrete materials. Children handle and study rocks, plants, animals, magnets, etc. These are concrete objects and primary experiences to which symbols can be related. Words and sentences take on meaning for childen when they signify objects that they have handled and experiences in which they have taken part.

Thus the natural science program is an integral part in building a sound reading and communication skills program.

Career Education

The main thrust of career education is to prepare all students for a successful life of work by increasing their options for occupational choice, by eliminating barriers - real and imagined to attaining job skills, and by enhancing learning achievement in all subject areas and at all levels of education.

Career education recognizes critical decision points at which students must be prepared and equipped to decide whether to pursue a job, seek further education, or choose some combination of both.

The implementation of the world of work ideas should be an intrinsic part of any science curriculm. The development of curriculum materials including this idea is recommended and the focus of career education at the elementary lever (K-4) is Carrer Awareness; Middle or Junior High School level (5-8) is career exploration, and Senior High (9-12) the world of work.

Health Education

In depth health education as such is not considered part of the natural science program. This is an area where there are basic relationships to the biological sciences, but the proper way to bathe, brush teeth, and cut fingernails is not natural science as such.

Drug Education

The importance of learning about drugs, their use and abuse is essential. The education of students in this area draws a fine line between natural science and health education. The natural science objectives are not specifically realted to drug education. There are basic relationships with the physical (chemistry) and biological sciences.

Emergency Preparedness

This is an area of importance in preparing the student to be a productive member of the community. The natural science objectives are not specifically related to emergency preparedness. There are basic relationships for the application of the earth sciences.

Field Trips and Outdoor Education

The outdoor classroom has a multitude of opportunities for natural science education programs. The use of the immediate area about the school for application of the various aspects of natural science education is strongly recommended. A guide as to how to utilize these areas has been prepared by the Department of the Interior, and the local soil conservation groups in cooperation with the State Department of Public Instruction. Copies of this guide are available from the office of the State Supervisor of Science and Environmental Education.

The use of field trips to various locations in the State and the surrounding areas is recommended when the field trip is an integral part of the learning situation. There is a great deal of planning and preparation required if the field trip is to be a meaningful experience. The field trip should provide an excellent means for the application of natural science to the other learning areas such as social studies, art and communication skills. (We should note that a field trip requiring a two hour bus ride, then spending a half hour at a site and a two hour return trip has questionable value).

Science Fair

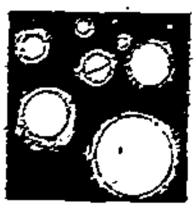
The display of student projects and activities is an excellent method of building interest in the natural science program among the students and parents of a particular school or school district.

Particularly in grades K-6 judging should not be conducted for the award of prizes in any form. Each student should receive some type of recognition for his efforts.

The fair should not be just for natural science, but be a multidiscipline event where the talents and efforts of the students in all areas are presented.

Non-science Theory in Science Instruction

Throughout his recorded history, man has been vitally concerned to find out all that he can about his universe. He has explored it in many ways, raised questions about it, designed methods by which he could increase and organize his knowledge, and developed systems to aid him in understanding and explaining his own origin and nature and his place in the universe. Among these systems are philosophy, religions, folklore, the arts, and science.



Science is the system of knowing about the universe through data collected by observation and controlled experimentation. As data are collected, theories are advanced to explain and account for what has been observed. The true test of a theory valid in science is threefold: (1) its ability to explain what has been observed; (2) its ability to predict what has not yet been observed; and (3) its ability to be tested by further experimentation and to be modified as required by the acquisition of new data.